Міністерство освіти і науки,
молоді та спорту України
Національний університет водного господарства та природокористування

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АНГЛІЙСЬКА МОВА

Навчальний посібник

Для студентів напрямів підготовки 6.040301 «Прикладна математика», 6.050202 «Автоматизація та комп'ютерно-інтегровані технології»

Рівне – 2012

УДК 519=111 (075)
ББК 22.19 + 81.2 Англ. я 7
В68

Затверджено вченою радою Національного університету водного господарства та природокористування.
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Воловик Л.О., Махаринець С.С., Красовська А.М.
В68 Англійська мова: Навчальний посібник. – Рівне: НУВГП, 2012. – 293 с.

Навчальний посібник з англійської мови підготовлено відповідно до Типової програми з англійської мови для професійного спілкування.

Посібник містить вступний та основний курси, граматичні таблиці та додаток з автентичними текстами, призначеними для самостійного читання та активного обговорення студентами в аудиторії, на наукових конференціях та Internet-форумах.

Посібник підготовлено для студентів напрямів підготовки 6.040301 «Прикладна математика», 6.050202 «Автоматизація та комп'ютерно-інтегровані технології», а також усіх тих, хто вдосконалює навички володіння англійською мовою та поглиблює знання у сфері обчислювальної техніки та інформаційних технологій.

УДК 519=111 (075)
ББК 22.19 + 81.2 Англ. я 7

Вступ

Сучасний інтернаціональний характер розвитку прикладної математики та комп’ютерно-інтегрованих систем потребує від майбутніх фахівців здатності ефективного спілкування англійською мовою у професійному середовищі.

Мета посібника – сформувати у студентів загальні та професійно-орієнтовані комунікативні мовленнєві компетенції (лінгвістичні, соціолінгвістичні та прагматичні) для забезпечення виконання професійних завдань та прийняття професійних рішень.

Посібник складається з 10 розділів. Вступний курс спрямовано на повторення і закріплення базової граматики та розширення загальної лексики студентів. В основному курсі підібрані тексти з різних проблем «чистої» та «прикладної» математики, а також автоматизованих систем управління.

Робота над текстами є основною формою подання та засвоєння мовного матеріалу. Це своєрідний вступ до широкої галузі математики, програмування, штучного інтелекту, гнучких виробничих систем.

Граматичний матеріал активізується за допомогою вправ із спеціальною лексикою, пов’язаною з тематикою певного розділу.

Розвиток мовленнєвих навичок є необхідним і важливим аспектом наукового спілкування англійською мовою за спеціальністю. Ситуації наукового спілкування подано у спеціально підібраних текстах і вправах, які використовуються для того, щоб навчити студентів вести бесіду в межах вказаної теми, робити усні повідомлення, складати анотації, готувати реферати та презентації.

Додаток містить професійно-орієнтовані завдання на знаходження нової текстової та відео- інформації в англомовних галузевих матеріалах (друкованих та електронних) з використанням відповідних пошукових методів.

Навчальний посібник побудовано відповідно до Типової програми з англійської мови для професійного спілкування, яка створена за сприяння Британської Ради в Україні та рекомендована Міністерством освіти і науки України (Київ, 2005 р.).

І розділ розроблено Красовською А.М.

Розділи II-IX розроблено Воловик Л.О.

Х розділ розроблено Махаринець С.С.

Автори

1.

1. **Let's get acquainted**
2. **National University of Water Management and Natural Resources Use**
3. **Massachusetts Institute of Technology**
4. **Applied Mathematics Research**
5. **Traditions and Student Activities**
6. **English tense-forms**

Grammar Revision

Indefinite Tenses (Active)[1]

Час / Tense	Стверджувальна форма (Affirmative Form)	Заперечна форма (Negative Form)	Питальна форма (Interrogative Form)
Present	I **write** He, She, It **writes** You, We, They **write**	I **don't write** He, She, It **doesn't write** You, We, They **don't write**	**Do** I **write?** **Does** he, she, it **write?** **Do** you, we, they **write?**
Past	I, He, She, It, You, We, They **wrote**	I, He, She, It, You, We, They **didn't write**	**Did** I, he, she, it, you, we, they **write?**
Future	I, We **shall write** He, She, It, You, They **will write**	I, We **shan't write** He, She, It, You, They **won't write**	**Shall** I, we **write?** **Will** he, she, it, you, they **write?**

[1] Навчальні завдання з розвитку граматичних навичок з англійської мови (теорія, тренувальні вправи, міні та рейтингові тести) для студентів 1-х курсів усіх спеціальностей РДТУ (Частина ІІ). Рівне: РДТУ, 1999. – с. 17-27.

Відмінювання дієслова to be (бути) в Indefinite Tenses

PRESENT	I	am	I	am not	Am	I	Yes,	I am.
	You	are	You	are not	Are	you		he is.
	He (she, it)	is a	He (she, it)	is not	Is	he (she, it)		we are.
	We	are	We	are not	Are	we	No,	I'm not.
	You		You		Are	you		he is not.
	They		They		Are	they		we are not.
PAST	I	was	I	was not	Was	I	Yes,	I was.
	He (she, it)		He (she, it)			he (she, it)		he (she, it) was.
	You	were	You	were not	Were	you	No,	you were not.
	We		We			we		we were not.
	They		They			they		they were not.
FUTURE	I	shall be	I	shall not be	Shall	I	Yes,	I shall
	He (she, it)	will be	He (she, it)	will not be	Will	he (she, it)		he (she, it) will
	You	will be	You	will not be	Will	you		you will
	We	shall be	We	shall not be	Shall	we	No,	we shall not
	They	will be	They	will not be	Will	they		they will not

Відмінювання дієслова to have / have got в Indefinite Tenses

<table>
<tr><td rowspan="3">PRESENT</td><td>I
You
We
They</td><td>have …
have got (~’ve got)</td><td>I
You
We
They</td><td>don’t have …
haven’t got …</td><td>Do
Have</td><td>I
you
we
they</td><td>have …?
got …?</td></tr>
<tr><td>He
She
It</td><td>has…
has got (~’s got)</td><td>He
She
It</td><td>doesn’t have …
hasn’t got</td><td rowspan="2">Does
Has</td><td rowspan="2">he
she
It</td><td rowspan="2">have …?
got …?</td></tr>
<tr><td colspan="2">! We can use ~ ’ve and ~ ’s</td><td colspan="2">with have got, not with have</td></tr>
<tr><td rowspan="2">PAST</td><td>I
You
We
They
He
She
It</td><td>had …</td><td>I
You
We
They
He
She
It</td><td>didn’t have</td><td rowspan="2">Did</td><td rowspan="2">I
you
we
they
he
she
it</td><td rowspan="2">have … ?</td></tr>
<tr><td colspan="2">! got – forms are less</td><td colspan="2">common in the past.</td></tr>
<tr><td rowspan="3">FUTURE</td><td>I
We</td><td>shall have …
(~’ll have)</td><td>I
We</td><td>shall not have …
(shan’t)</td><td>Shall</td><td>I
we</td><td>have …</td></tr>
<tr><td>You
He
She
It
They</td><td>will have …
(~’ll have)</td><td>You
He
She
It
They</td><td>will not have … (won’t)</td><td rowspan="2">Will</td><td rowspan="2">you
he
she
it
they</td><td rowspan="2">have …</td></tr>
<tr><td colspan="4">! You can say: I shall (= will) and we shall (= we will) have …</td></tr>
</table>

Continuous Tenses (Active)[1]

Час (Tense)	Стверджувальна форма (Affirmative Form)	Заперечна форма (Negative Form)	Питальна форма (Interrogative Form)
Present	I am You We are They writing He She is It	I am not You We aren't They writing He She isn't It	Am I you Are we they writing? he Is she it
Past	I He was She It writing You We were They	I He wasn't She It writing You We weren't They	I Was he she it writing? you Were we they
Future	I We shall You be writing They He will She It	I We shan't You They be writing He She won't It	I Shall we you they be writing? Will he she it

[1] Навчальні завдання з розвитку граматичних навичок з англійської мови (теорія, тренувальні вправи, міні та рейтингові тести) для студентів 1-х курсів усіх спеціальностей РДТУ (Частина II). Рівне: РДТУ, 1999. – с. 28-35.

Perfect tenses (Active)[1]

Час (Tense)	Стверджувальна форма Affirmative Form	Заперечна форма Negative Form	Питальна форма Interrogative Form
Present	I You **have** We They **written** He She **has** It	I You **haven't** We They **written** He She **hasn't** It	**Have** I you we they he **written?** **Has** she it
Past	I You We They **had written** He She It	I You We **hadn't** They **written** He She It	I you we **Had** they **written?** he she it
Future	I **shall** We You **have** They **written** He She **will** It	I **shan't** We You **have** They **written** He She **won't** It	**Shall** I we you they **have** **Will** he **written?** she it

Text A. Let's get acquainted

1. Read the text. To understand it better consult active vocabulary:

First of all, I'd like to tell you about myself and my family. I am Maksym Marchenko. Maksym is my first name and Marchenko is my surname. I am 17. In June I left school and became a student of the National University of Water Management and Natural Resources Use. I

[1] Навчальні завдання з розвитку граматичних навичок з англійської мови (теорія, тренувальні вправи, міні та рейтингові тести) для студентів 1-х курсів усіх спеціальностей РДТУ (Частина II). Рівне: РДТУ, 1999. – с. 4-10.

am a full-time first-year student of the Faculty of Applied Mathematics and Computer-Integrated Systems.

I can't say that my family is large. I live with my parents and younger brother in Rivne. It's a small provincial town in the west of Ukraine. Though I live with my parents I don't see them very often. My Mum works for advertising agency. I think her job is much more interesting than my Dad's. I get on very well with her, but sometimes she worries too much. My father is a bit of a workaholic. He works for a big company as a human resource manager. He works late hours, even weekends. He's nice but when I go out he wants me to be back by 10 o'clock. My brother Mykola is a bit weirdie. He is 15. He spends most of his time on his skateboard. He has a bunch of friends who are all crazy about it. They spend hours practising. He is fond of computer games.

As for me I've just spent my second week at the University. I have been finding my way around the University and becoming accustomed to the curricula set for us for this academic year. My life has completely changed. I'm a lark by nature and used to live according to the saying "early to bed, early to rise makes a man healthy, wealthy and wise". But now my usual daily rhythm is changing. Slowly but surely I'm becoming an owl. Not so long ago I did things more efficiently in the morning but now I can hardly wake up. I'm always hurrying. Not to be late for the first class I take a route taxi, though I live not far from the University. After classes I walk home enjoying fresh air. It usually takes me only 20-25 minutes. At home after a short rest I do my homework. Usually I have a lot of work to do. Totally exhausted I go to bed late at night.

I have always been interested in information technologies. I'm used to regarding the computer as a great scientific achievement of our time. We can use computers for so many things – chat on line, send emails, find information for our studies, find information about entertainment and travel, listen to or download music, shop, read about our interests, and certainly practise our English. Teens are more and more ready to learn English on the streets of cyberspace from their pen pals (friends) on the Internet. I'm not an exception! I also have a pen pal. His name is Mike Nilson. He is from the USA, from Boston. Mike is a second-year student of Massachusetts Institute of Technology. I can chat online with my friend thousand of kilometers away. We have much in common. At least we both like computers, mathematics, reading and music. I received an email from him yesterday where he asked to write about my

University. It goes without saying I shall send him email as soon as I'm free.

Active Vocabulary

2. Learn the following words and word-combinations to comprehend the text:

full-time student	студент стаціонару
first-year student	першокурсник
advertising agency	рекламна агенція
to get on	жити в згоді
human resource manager	менеджер з персоналу
weirdie	дивак
to be fond of …	захоплюватися чимось
lark	жайворонок
according to …	згідно з …
saying	прислів'я
slowly but surely	повільно, але впевнено
owl	сова
it usually takes me …	це зазвичай забирає
exhausted	виснажений
to mention	згадувати
teens	вік від 13 до 19 (включно)
pen pal	товариш по листуванню
exception	виняток
to have much in common	мати багато спільного
at least	принаймні
it goes without saying	певна річ

3. Are these statements true or false? If they are false, say why. Use the following phrases:

I can't agree to this statement because…
Just the contrary…
I think …
To my mind …

1. Maksym Marchenko is a school boy.
2. He is going to become a student next year.
3. He is fond of computers.

4. Maksym's Dad works for advertising agency.
5. His Mum is a bit of a workaholic.
6. She works for a big company as a human resource manager.
7. Maksym has got a younger brother.
8. Mykola spends hours practising English.
9. Maksym is living according to the saying "early to bed, early to rise makes a man healthy, wealthy and wise".
10. He always walk to the University.
11. To improve his English Maksym always tries to watch CNN news.
12. Maksym has some pen pals.
13. He has much in common with his pen pal.

4. Study the text and answer the following questions:

1. How old is Maksym Marchenko?
2. Does he study or work?
3. Where does he study?
4. Where does his family live?
5. Is Maksym's family large?
6. Who is the youngest in the family?
7. Whose job is more interesting?
8. What is Maksym's father?
9. What is Maksym's mother?
10. Why does he consider his brother a bit wierdie?
11. How long has Maksym been studying at University?
12. Is he living according to the saying "early to bed, early to rise makes a man healthy, wealthy and wise" now?
13. Why is he becoming an owl?
14. What is Maksym's attitude to the computer?
15. What are the advantages of the computer?
16. How is he improving his English?
17. What is his pen pal's name?
18. Where does Mike Nilson study?
19. What did Mike ask Maksym to do?

Text B. National University of Water Management and Nature Resources Use

Pre-text Exercises

1. Read the names of the faculties. Give Ukrainian equivalents:

Faculty of Applied Mathematics and Computer-integrated Systems;
Civil Engineering and Architecture Faculty;
Faculty of Ecology and Natural Resources Use;
Faculty of Economics and Entrepreneurship;
Faculty of Management;
Faculty of Water Management;
Hydrotechnical and Hydropower Engineering Faculty;
Faculty of Land Management and Geoinformation;
Mechanical and Heatpower Engineering Faculty.

2. Read the names of the specialities. Give Ukrainian equivalents:

Hydrotechnical Construction; Hydromelioration; Automobile Engineering; Hoisting Transport, Building and Land Reclamation Machines and Equipment; Mineral Mining Engineering; Logistics and Transport Management; Accounting and Audit; Finance; Management of Organization; Applied Mathematics; Human Resources Management and Economics of Labour; Ecology and Environmental Engineering; Land Management and Cadastre; Agrochemistry and Soil Science; Civil Engineering; Technology of Production of Building Constructions and Elements; Aerodrome and Highway Engineering; Heat and Gas supply and Ventilation; Town Planning and Development; Water Supply and Water Disposal; Automated Control of Technological Processes; Water Bioresources and Aquaculture; Architecture of Structures; Economics of Production; Heatpower Engineering; Geoinformation Systems and Technologies; Hydropower engineering.

3. Look through the email and answer the following questions:

1. What university is the letter about?
2. Is the history of the university described?
3. Are the faculties and specialities mentioned?
4. Are students’ everyday activities described?
5. Is the university campus described?

4. Read the email. To understand it better consult active vocabulary:

Date: Thu., 19 Sept. 2012 21:42:37

From: Maksym Marchenko<m.marchenko@gmail.com>

To: Mike Nilson <mison@gesp.com>

Subject: **National University of Water Management and Nature Resources Use**

Dear Mike,

Well, this is my third week at the University. Our group has already visited the University Museum. It gave me the idea of its history, structure, teaching staff, and students' life. Let me tell you about my impressions.

The history of the University began in the year 1922, with the foundation of its forerunner Hydromeliorative technical school. Five years later it became a school of higher learning known as Kyiv Hydromeliorative Institute. In 1959 it was moved to the city of Rivne and granted the status of All-Republican Institute. In December 1995 the Institute was reorganized into the State Academy. In 1998 the Academy acquired the status of a University, with the title Rivne State Technical University. In 2004 the University was granted the highest status and now its title is the National University of Water Management and Natural Resources Use.

The University has become one of the leading scientific, educational and technological centres of Ukraine. It trains engineers and research workers for different branches of national economy. It is considered to be Alma-Mater for almost 50,000 specialists who work in Ukraine and abroad. The University enjoys national and international reputation for the contribution in scientific research and training of skilled specialists.

The University currently enrolls more than 15,000 day-time and correspondence students. They study at nine faculties:

Faculty of Applied Mathematics and Computer-integrated Systems;
Civil Engineering and Architecture Faculty;
Faculty of Ecology and Natural Resources Use;
Faculty of Economics and Entrepreneurship;
Faculty of Management;
Faculty of Water Management;
Hydrotechnical and Hydropower Engineering Faculty;
Faculty of Land Management and Geoinformation;
Mechanical and Heatpower Engineering Faculty.

A modular system of academic programmes has been introduced, following the example of the world's leading technological universities. In addition to engineering degrees in various specialisms, these programmes lead to the degree of Bachelor and Master. It takes four years to complete a course leading to the degree of Bachelor, five years to gain the degree of Engineer (Specialist) and Master. Students may specialize in 28 areas: Hydrotechnical Construction; Hydromelioration; Geoinformation Systems and Technologies; Automobile Engineering; Hoisting Transport, Building, Road and Land Reclamation Machines and Equipment; Mineral Mining Engineering; Equipment of Chemical Production and Building Materials; Heat Power Engineering; Logistics and Transport Management; Accounting and Audit; Management; Applied Mathematics; Management of Labour Resources; Ecology; Land Management and Cadastre; Agrochemistry and Soil Science; Civil Engineering; Technology of Production of Building Constructions and Elements; Aerodrome and Highway Engineering; Heat and Gas Supply and Ventilation; Town Planning and Development; Water Supply and Water Disposal; Automated Control of Technological Processes; Water Bioresources and Aquaculture; Architecture of Structures.

Most of the faculties have day-time as well as correspondence departments. The term of study for day-time students lasts 4, 5 or 6 years. The academic year runs from September till June and is divided into two terms: Autumn and Spring, and it has two vacations. During the term students have to attend lectures, classes and seminars. The study of theory is usually accompanied by practical training. At the end of each term our students take exams, tests and hand in yearly projects. At the end of training they defend their diploma projects. Advanced students may defend them in a foreign language.

Today, our University has a teaching and research staff of over 700 professors, associate-professors, senior and junior lecturers, who offer many-sided and profound knowledge to their students. They are also engaged in research work. A lot of their inventions have been patented and introduced into production not only in Ukraine but abroad.

The University provides the requisite teaching, research and recreation facilities for its day-time students, postgraduates, lecturers and other staff. There are numerous spacious lecture theatres, laboratories, study rooms with up-to-date equipment, computer centres, design studios, etc.

The University campus is conveniently situated on two picturesque hills in the outskirts of Rivne. The location has the advantages of easy access to the railway and bus stations as well as to the main shopping centres, banks and cafes. The campus includes seven academic buildings; eight halls of residence, where suitable living accomodation is arranged; library and computing centres, which help students at every stage of their training; sport facilities, where students can enjoy the benefits of regular exercise. Full medical service is available in health centre.

The University offers an enormous range of arts activities. Anyone who enjoys singing and dancing can join the University choir, music, song and dance groups.

Our University, one of the prestige higher educational institutions in Ukraine, is highly rated by young people.

With best regards,
Maksym
P.S. I'd like you to write about your Institute :-)

Active Vocabulary

1. Learn the following words and word-combinations to comprehend the letter:

to be founded/foundation	заснувати /заснування
to grant the status	надати статус
to acquire the status	набути статусу
research workers	наукові співробітники
to consider	вважати
abroad	за кордоном
to enjoy reputation	мати репутацію
skilled specialist	кваліфікований спеціаліст
to enroll	нараховувати
day-time department	денне (стаціонарне) відділення
correspondence ~	заочне відділення
modular system	модульна система
to complete a course	завершити курс
to gain a degree	отримати ступінь
to last	тривати, продовжуватись
to run from ... till ...	тривати з ... до ...
to attend classes	відвідувати заняття

to be accompanied by	супроводжуватись
to take/pass exams	складати іспити
yearly project	курсова робота
staff	штат
associate-professor	доцент
profound	глибокий
to be engaged in ...	займатися
to patent	запатентувати
requisite	відповідний
recreation	відпочинок
undergraduate	студент
graduate	випускник
postgraduate	аспірант
to graduate from	закінчувати університет
lecture theatre	лекційний зал
access	доступ
hall of residence	гуртожиток
to be available	бути доступним
to offer	пропонувати
choir	хор
prestige	престиж, престижний
to be highly rated	мати високий рейтинг
maturity	зрілість
to train specialists	готувати спеціалістів
term	семестр
dean's office	деканат
to face the test	стояти перед випробуванням
forerunner	попередник
study building	навчальний корпус

2. Are these statements true or false? If they are false, say why. Use the following phrases:

I can't agree to this statement because …
Just the contrary …
I think …
To my mind…

1. The National University of Water Management and Natural Resources Use is 70.

2. It was founded in Rivne.
3. It acquired the status of a university in 1998.
4. The University trains engineers and researchers.
5. The University currently enrolls more than 25.000 students.
6. There are eight faculties at the University.
7. The University graduates can gain the degree of Bachelor, Specialist and Master.
8. They can specialize in 32 areas.
9. At the end of every academic year students defend their diploma projects.
10. The University provides the requisite teaching, research and recreation facilities.
11. The campus is situated in the centre of the city.
12. The University is highly rated by young people.

3. Study the letter and answer the following questions:
1. When was the University founded?
2. When was it moved to the city of Rivne?
3. What status did the University acquire in 2004?
4. What specialists does the University train?
5. Why does the University enjoy national reputation?
6. How many students study here?
7. How many faculties are there at the University?
8. What degrees does the University offer?
9. When does the academic year begin and finish?
10. What do the students usually do during the term?
11. What is the teaching and research staff of the University?
12. Where is the campus situated?
13. What does the campus include?
14. What activities does the university offer?

Text C. Massachusetts Institute of Technology

Pre-text Exercises

1. Read the names of the schools. Give Ukrainian equivalents:
– School of Architecture and Planning;
– School of Engineering;
– School of Humanities, Arts, and Social Sciences;

– Alfred P. Sloan School of Management;
– School of Science.

2. Read the names of the departments. Give Ukrainian equivalents:

Architecture; Media Arts and Sciences; Urban Studies and Planning; Aeronautics and Astronautics; Biological Engineering Division; Chemical Engineering; Civil and Environmental Engineering; Electrical Engineering and Computer Science; Engineering Systems Division; Materials Science and Engineering; Mechanical Engineering; Nuclear Engineering; Ocean Engineering; Anthropology; Comparative Media Studies; Economics; Foreign Languages and Literatures; History; Humanities; Linguistics and Philosophy; Literature; Music and Theatre Arts; Political Science; Science, Technology, and Society; Writing and Humanistic Studies; Biology Brain and Cognitive Sciences; Chemistry, Earth, Atmospheric, and Planetary Sciences; Mathematics; Physics.

3. Look through the email and answer the following questions:

1. What institute is the letter about?
2. Is the history of the institute described?
3. Are the schools and departments mentioned?
4. Are undergraduate academics described?
5. Is the campus described?
6. Are the most famous alumni named?

4. Read the email. **To understand it better consult active vocabulary:**

Date: Sun., 2 Oct. 2012 20:44:35
From: Mike Nilson <mison@gesp.com>
To: Maksym Marchenko<m.marchenko@gmail.com>
Subject: **Massachusetts Institute of Technology**

Dear Maksym,

Thank you for the letter. It was really interesting to read about your University. I had a rather tight day ☹. But before going to bed I decided to write about my Alma-Mater. MIT has also a Museum. I visited it last year and got some information. I think you will enjoy reading it. Today I shall write about Institute’s history, campus, undergraduate academics, and alumni.

Massachusetts Institute of Technology ranks among the best universities in the world. It is a leader in science and technology, as well as in many other fields, including management, economics, linguistics, political science, and philosophy. MIT is a private non-for- profit institution with mostly four-year programs and enrollment of 4,112 undergraduate, and 6,228 graduate students. It's motto is "*Mens et Manus* ("mind and hand")" MIT is organized into five schools which contain 27 academic departments:

• School of Architecture and Planning: Architecture, Media Arts and Sciences, Urban Studies and Planning;

• School of Engineering: Aeronautics and Astronautics, Biological Engineering Division, Chemical Engineering, Civil and Environmental Engineering, Electrical Engineering and Computer Science, Engineering Systems Division, Materials Science and Engineering, Mechanical Engineering, Nuclear Engineering, Ocean Engineering;

• School of Humanities, Arts, and Social Sciences: Anthropology, Comparative Media Studies, Economics, Foreign Languages and Literatures, History, Humanities, Linguistics and Philosophy, Literature, Music and Theatre Arts, Political Science, Science, Technology, and Society, Writing and Humanistic Studies;

• Alfred P. Sloan School of Management;

• School of Science: Biology, Brain and Cognitive Sciences, Chemistry, Earth, Atmospheric, and Planetary Sciences, Mathematics, Physics.

Among its most famous departments and schools are the Lincoln Laboratory, the Computer Science and Artificial Intelligence Laboratory, the Media Lab and the Sloan School of Management.

History

MIT has a long and glorious history. It was founded in 1861 by William Barton Rogers, a distinguished natural scientist, who wished to create a new kind of independent educational institution relevant to an increasingly industrialized America. The Institute's opening was delayed by the Civil War, and it admitted its first students in 1865. In the following years, it established a sterling reputation in the sciences and in engineering, but it also fell on hard financial times. These two factors made it a perfect fit in many peoples' eyes to merge with nearby Harvard University, which was flush with cash but much weaker in the sciences than it was in the liberal arts. Around 1900, a merger was proposed with Harvard University, but was cancelled after protests from MIT's alumni. The two schools still maintain a friendly rivalry today. In 1916, MIT moved across the Charles River to its present location in Cambridge.

MIT's prominence increased as a result of World War II and the United States government's investment in science and technology in response to Sputnik. MIT's contributions to the twentieth century advancement of science and technology include project Whirlwind, the pioneering computer built under the direction of Jay W. Forrester between 1947 and 1952, and notable for its technological achievement (including the invention of magnetic core memory), as well as for its cultural contribution to the development of personal computing.

MIT has been at least nominally coeducational since admitting Ellen Swallow Richards in 1870, if not earlier. For some years past, it has admitted slightly more women students than men. A strong female presence did not appear until 1963 when a women’s dormitory was built.

In 2001 president Charles Vest made history by being the first university official in the world to admit that his institution had severely restricted the career of women faculty members and researchers through sexist discrimination, and to make steps to redress the issue. In August 2004 Susan Hockfield, a molecular neurobiologist, was appointed as MIT's first female president. She took office as the Institute's 16th president on December 6, 2004.

Campus

MIT's 168-acre (68.0 ha) campus spans approximately a mile of the north side of the Charles River basin in the city of Cambridge. The campus is divided roughly in half by Massachusetts Avenue, with most dormitories and student life facilities to the west and most academic buildings to the east. MIT buildings all have a number and most have a name as well. Typically, academic and office buildings are referred to only by number while residence halls are referred to by name. A network of underground tunnels connects many of the buildings, providing protection from the Cambridge weather. Students agree that this maze is a welcome feature, enabling them to get from class to class without getting cold or wet. The bridge closest to MIT is the Harvard Bridge. It is the longest bridge crossing the Charles River. The bridge is marked off in the fanciful unit called the Smoot: 364.4 Smoots and One Ear. The neighborhood of MIT is a mixture of high tech companies seeded by MIT alumni combined with working class neighborhoods of Cambridge.

Undergraduates are guaranteed four-year housing in one of MIT's 12 undergrad dormitories, although 8% of students live off campus or commute. On-campus housing provides live-in graduate student tutors and faculty housemasters who have the dual role of both helping students and monitoring them for medical or mental health problems. New undergrad students specify their dorm and floor preferences a few days after arrival on campus, and as a result diverse communities arise in living groups. MIT also has 5 dormitories for single graduate students and 2 apartment buildings on campus for married student families.

MIT's on-campus nuclear reactor is one of the largest university-based nuclear reactors in the United States. The prominence of the reactor's containment building in a densely populated area has been controversial, but MIT maintains that it is well-secured. Other notable campus facilities include a pressurized wind tunnel and a towing tank for testing ship and ocean structure designs. MIT's campus-wide wireless network was completed in the fall of 2005 and consists of nearly 3,000 access points covering 9,400,000 square feet (870,000 m^2) of campus.

Undergraduate Academics

MIT utilizes a 4-1-4-based academic calendar. Its tuition and fees are $40,732 (2011-12). Admission to MIT is extremely competitive. There is a large amount of pressure in the classes, which have been characterized as "drinking from a fire hose" or "academic boot camp." Although the perceived pressure is high, the failure rate both from classes and the Institute as a whole, is low. There is a refreshing lack of so-called "weed out" classes. The anti-authoritarian nature of the school – combined with its emphasis on technical excellence and information sharing – results in a situation where faculty, upperclassmen, and fellow students are remarkably helpful even to newly-arrived freshmen. This culture of helpfulness offsets the academic stress to a certain degree. Furthermore, students are not assigned letter grades in their first semester; instead, they are graded Pass/No Record. To allow the students to gradually adjust to regular grading, second semester is ABC/No Record. For both semesters, classes that a student fails are noted on the internal transcript but erased from all external records.

Majors are numbered, and students will typically refer to their major by the course number rather than the name. For example, Electrical Engineering and Computer Science is Course 6, while Physics is Course 8. Classes within each course also have numeric identifications, which most students use more frequently than the written names. All students are required to take basic physics (8.01 and 8.02), a semester of biology, a term of chemistry, as well as calculus (18.01 and 18.02).

Most of the science and engineering classes follow a standard pattern. Typically, a professor gives a lecture that explains a concept. Then, teaching assistants lead recitations to explore fuller details, or often to provide students help on homework problems. Problem sets, given roughly weekly, are designed to enable the student to master the concept. Students often gather in informal groups to solve the problem sets, and it is within these groups that much of the actual learning takes place. Over time, students compile "bibles," collections of problem set and examination questions and answers. They may be created over several years and are often handed down "from generation to generation" – bearing in mind that "generations" of student time may be short-lived.

In many classes, the problem sets make up a relatively small fraction of the grade. The rest of the evaluation consists of performance on tests, which typically contain grueling problems that measure the students' ability to apply their knowledge, often to something *not* specifically covered in class. Problem sets and tests, even for the large introductory freshmen classes, are usually free response, hand graded, with much partial credit given to people who almost get the answer right. This is highly labor intensive, and after a test for a large class one can see a room full of teaching assistants and professors hand-grading the examinations.

The lack of machine grading and multiple-choice stems from the belief that understanding the concept is almost as important as getting the right answer. For example, students are seldom strongly penalized for making arithmetic mistakes. Test problems are intentionally extremely difficult and often clever, and are designed so that few students can obtain a perfect score. However, the awarding of partial credit can mitigate the difficulty, and moreover, many professors "curve" the scores to reflect how the class as a whole fared on the test. Most classes end with a grade distribution centered around B or C.

Alumni

Finishing my letter I can’t help mentioning the most prominent names of Institute’s alumni. Many of MIT's over 120,000 alumni have had considerable success in scientific research, public service, education, and business. Among them Chairman of the Federal Reserve Ben Bernanke, MA-1 Representative John Olver, CA-13 Representative Pete Stark, former British Foreign Minister David Miliband, Israeli Prime Minister Benjamin Netanyahu, Greek Prime Minister Lucas Papademos, former UN Secretary General Kofi Annan, physicist Richard Feynman, and former Iraqi Deputy Prime Minister Ahmed Chalabi. Prominent institutions of higher education have been led by MIT alumni. More than one third of the United States' manned spaceflights have included MIT-educated astronauts (among them Apollo 11 Lunar Module Pilot Buzz Aldrin). MIT alumni founded or co-founded many notable companies, such as Intel, McDonnell Douglas, Texas Instruments, 3Com, Qualcomm, Bose, Raytheon, Koch Industries, Rockwell International, Genentech, Dropbox, and Campbell Soup. According to the British newspaper "*The Guardian*", MIT alumni have formed 25,800 companies, employing more than three million people including about a quarter of the workforce of Silicon Valley. Those firms between them generate global revenues of about $1.9tn (£1.2tn) a year. If MIT was a country, it would have the 11th highest GDP of any nation in the world. MIT managed $718.2 million in research expenditures and an $8.0 billion endowment in 2009. As of 2011, twenty-four MIT alumni won the Nobel Prize, forty-four were selected as Rhodes Scholars, and fifty-five were selected as Marshall Scholars.

Best wishes,
Mike

Active Vocabulary

1. Learn the following words and word-combinations to comprehend the letter:

tight	напружений
alumnus	вихованець (університету)
to rank	стояти вище за інших
non- for- profit	некомерційний
enrolment	внесення до списків
motto	гасло
artificial	штучний
distinguished	видатний, відомий
to increase	зростати, збільшувати(ся)
to delay	відкладати, відстрочувати
to admit	допускати, приймати

sterling	бездоганний
to fall on …	випадати на чию-небудь долю
to merge	поглинати, з'єднуватися
to be flush with …	багатий на …
liberal arts	гуманітарні науки
to cancel	скасовувати, викреслювати
rivalry	суперництво
prominence	популярність
in response to …	у відповідь на …
under the direction of …	під керівництвом …
notable for …	визначний, видатний
contribution	сприяння, внесок
coeducation	спільне навчання
dormitory	гуртожиток
to make steps to …	зробити кроки …
to redress	виправити
to appoint	призначати
to span	вимірювати п'ядями
to refer	посилатися
maze	лабіринт, плутанина
to get cold (wet)	замерзнути, промокнути
smoot	нестандартна міра довжини (1,70 м)
tutor	молодший викладач ВНЗ
controversial	спірний, дискусійний
pressure	тиск, вплив
tuition fee	плата за навчання
grueling	виснажливий
competitive	суперницький
to perceive	розуміти, усвідомлювати
failure rate	"відсів"
to weed out	відбирати, видаляти
to offset	компенсувати
grade	оцінка
to adjust	пристосовувати(ся)
major	основний предмет
to number	нумерувати
to lead recitation	опитувати
set	набір, комплект

to compile	складати
faction	частка
to apply	застосовувати
lack	відсутність
to mitigate	зменшувати, полегшувати
revenue	дохід
expenditure	витрати
endowment	постійний дохід
to stem	походити
to fare on …	бути, поживати, вестися

2. Are these statements true or false? If they are false, say why. Use the following phrases:

I can't agree to this statement because…

Just the contrary…

I think…

To my mind…

1. Mike had a very tight day, so he would only write about MIT's alumni.

2. MIT deals with IT only.

3. It's motto is "*Mens et Manus* ("mind and hand")"

4. The Institute consists of 27 schools.

5. MIT was founded in 1865.

6. It merged with nearby Harvard University in 1900.

7. MIT's present location is in Cambridge.

8. The first woman student was admitted in 1970.

9. Charles Vest took office as the Institute's 16th president on December 6, 2004.

10. MIT's campus is168-acre (68.0 ha).

11. MIT buildings have both a number and a name.

12. When getting from class to class students usually get cold or wet.

13. Students can live off or in dormitory.

14. Campus includes some notable facilities.

15. Education at MIT is free of charge.

16. The anti-authoritarian nature of the school results in a situation where faculty, upperclassmen, and fellow students are remarkably helpful even to newly arrived freshmen.

17. Students will typically refer to their major by the course number

rather than the name.

18. Most of the science and engineering classes do not follow a standard pattern.

19. Over 120,000 people graduated from MIT.

20. MIT alumni have formed 25,800 companies, employing more than three million people.

3. Study the letter and answer the following questions:

1. Where does Mike study?
2. What kind of institution is it?
3. How long do most programs last?
4. How many students study there?
5. How is MIT organized?

History

6. When was MIT founded?
7. Who founded the Institute?
8. Where is MIT located now?
9. When did MIT's prominence increase?
10. What are MIT's greatest contributions to the 20^{th} century?
11. When did a strong female presence appear at MIT?
12. What is Charles Vest famous for?

Campus

13. What is MIT's campus area?
14. How is campus divided?
15. Which buildings are referred to by number and by name?
16. How do students get from class to class?
17. How many dormitories are there?
18. What is the role of tutors and housemasters in the dormitories?
19. Are there any notable campus facilities? What are they?

Undergraduate academics

20. What kind of academic year does MIT include?
21. What are its tuition and fees?
22. How have the classes been characterized?
23. What does the anti-authoritarian nature of the school result?
24. How are students graded in the first semester?
25. How are students graded in the second semester?
26. Are majors numbered or named?
27. What is the standard pattern of classes?

28. What are “bibles”?
29. What does evaluation consist of?
30. How do most classes end?

Alumni

31. How many people consider MIT their Alma Mater?
32. Which prominent names are familiar to you?
33. What did “The Guardian” find out?

Grammar and Vocabulary Exercises

1. Find English equivalents to the following words and word combinations in the texts of the unit:

Першокурсник, другокурсник, стаціонар, закінчити школу, жити в згоді, витрачати час на … , захоплюватися чимось, регулярно щось робити (в минулому), згідно з …, повільно, але впевнено, це зазвичай забирає, маршрутка, мати багато спільного, певна річ, відвідувати заняття, студент, випускник, гуртожиток, семестр, приватний некомерційний заклад, прийняти перших студентів, переживати фінансові проблеми, здобути бездоганну репутацію, об’єднатися з …, в результаті …, призначити на посаду, навчальний корпус, (не) жити в студмістечку, неодружені студенти, сімейні студенти, ядерний реактор, осінь, відсіяти, пристосуватися до регулярного оцінювання, слідувати стандартній схемі, пояснити концепцію(ідею), набір проблем, засвоїти, вирішувати проблему, застосовувати знання, карати, давати роботу.

2. Translate the following words and word combinations from English into Ukrainian and use them in the sentences of your own:

I can’t help mentioning; to generate global revenues; to win a prize; to obtain a perfect score; students' ability; introductory freshmen classes; t follow a standard pattern; to have numeric identifications; "drinking from a fire hose"; "academic boot camp”; failure rate; to be remarkably helpful; newly arrived freshmen; to be graded Pass/No Record; MIT's on-campus nuclear reactor; pressurized wind tunnel; towing tank; campus-wide wireless network; access points; to get from class to class; independent educational institution; an increasingly industrialized America; to be flush with cash; to maintain a friendly rivalry; to redress the issue; a fanciful unit called the Smoot**.**

3. Find in the texts synonyms for the following words and expressions and use them in the sentences of your own:

expenses, profit, proportion, mark, hall of residence, prominent, graduate, to set up a company, score, to use, first-year student, term, faculty, academic building, student, family name, to finish school, day time, to get used to …, sophomore, autumn.

4. Complete the following sentences in the context of the above information:

1. Maksym … school and became a … of the National University of Water Management and Natural Resources Use.
2. Maksym lives with his … and … in Rivne.
3. Mykola is fond of … ….
4. Maksym used to live according to the saying ….
5. I have always been interested in ….
6. We can use computers for so many things - ….
7. The history of … began in the year 1922.
8. NUWMNRU currently enrolls more than 15,000 … and … students.
9. The term of study for NUWMNRU day-time students lasts … years.
10. The campus of NUWMNRU includes ….
11. **…** is a leader in science and technology, as well as in many other fields, including management, economics, linguistics, political science, and philosophy.
12. MIT is organized into … schools which contain … academic departments.
13. MIT … … in 1861 by William Barton Rogers.
14. … took office as the Institute's 16th …on December 6, 2004.
15. … are guaranteed four-year housing in one of MIT's 12 undergrad dormitories.
15. MIT utilizes a 4-1-4-based … ….
17. The anti-authoritarian nature of the school results in a situation where ….
18. … are numbered, and students will typically refer to their major by the course number rather than the name.
19. Most of the science and engineering classes follow a … ….
20. Over120,000 of MIT’s … have had considerable success in ….

5. Find the preposition that usually follows the verbs. Use these phrasal verbs in the sentences of your own:

to work	by
to get	off
to go	for
to be crazy	with
to be fond	into
according	on
to move	out
to be divided	about
to be full	of
to penalize	to
to be accompanied	in
to merge	
to live	
to consist	

6. Put the verb in brackets in the correct tense form:

1. He (to live) with his parents in Rivne.
2. We (to spend) most of our time on skateboards.
3. My life completely (to change).
4. I (to receive) an email from him yesterday.
5. I (to send) him email as soon as I (to be) free.
6. Mykola (to practice) English now.
7. When I (to come), he (to play) computer games.
8. The University (to enjoy) national and international reputation.
9. She (to take) office as the Institute's 16th president on December 6, 2004.
10. Susan Hockfield (to be) a president for six years, when Mike (to enter) MTI.
11. 120,000 alumni (to have) considerable success in scientific research, public service, education, and business.
12. I'm sure she (to defend) her diploma project in English.
13. This group (to solve) the problem sets at 10a.m. tomorrow.
14. Don't come in. The teaching assistants and professors (to hand-grade) the examinations.
15. He (to live) in this dormitory for three years.

7. Make the sentences from Ex. 6 interrogative. Start questions with:

1. Where …?
2. Who …?
3. How …?
4. When …?
5. When …?
6. What …?
7. What …?
8. What reputation …?
9. When …?
10. How long …?
11. What … in?
12. What language …?
13. When …?
14. What …?
15. How long …?

8. Make the sentences from Ex. 6 negative.

Conversational Practice

1. Learn the following expressions relating to the communication of opinions. Translate them into Ukrainian.

- I'm of the opinion that …
- In my view …
- It strikes me as …
- I'm of the belief that …
- I've always felt that …
- As far as I'm concerned …
- I'd conclude that …
- I'm sure that …
- To my way of thinking …
- It seems to me …
- My considered view …
- I've always been convinced that …
- If you ask me …
- Mark my words! I believe that …
- I really enjoy …
- I much prefer …
- I really dislike …

2. Discuss the following questions in the context of the topics of Unit 1, using as many of the above expressions as possible. Compare Ukraine and the USA.

1. How important is a higher education for young people today?
2. How easy is it to get into university today?
3. Is it difficult to be a full-time first-year student?
4. Does a university qualification guarantee a good job?
5. Why are some universities more prestigious than others?
6. Why does the university you attend seem to be more attractive than

others?

7. What is better – morning classes or afternoon classes?

8. How do you feel University education in the USA differs from that in Ukraine?

3. Ask your friend the following questions, present the results to the whole group.

• who persuaded him/her to enter NUWMNRU.

• what he/she knew about the university while at school.

• whether he/she felt disappointed after entering the University.

• how he/she sees himself/herself in five years' time.

• what he/she considers the most important factors that make a good University.

4. Translate the following words and word-combinations:

as for me/her/him; to study at; I'm/he is/she is a first-year student; dean; dean's office; subdean/assistant dean; full-time department; refectory; tutor; academic building; to occupy; to be located; to be founded; to train; graduates; the students specialize in; laboratories; tuition fee; campus; It takes me/ him/her … to do … .

5. Interview Maksym in English. Find out what he knows about the faculty he studies at:

– На якому факультеті ти навчаєшся?

– Коли був заснований факультет прикладної математики та комп'ютерно-інтегрованих систем?

– Яких спеціалістів готує факультет?

– Які ступені отримують випускники?

– В якому корпусі знаходиться деканат факультету прикладної математики та комп'ютерно-інтегрованих систем?

– Хто ваш декан?

– Чи є заступники декана? Хто вони?

– Хто ваш куратор?

– Чи допомагає він вам адаптуватися до нових умов?

– Яка плата за навчання?

– Де живуть студенти?

– Чи далеко гуртожиток від навчальних корпусів?

– Скільки часу ви витрачаєте на дорогу?

– Скільки часу ви витрачаєте на підготовку до занять?

– Чи є в гуртожитку їдальня/читальний зал/кімната відпочинку?

– Чи подобається вам вчитися на факультеті?

6. Summarize Maksym's answers. Use the words and word-combinations from Ex. 3.

7. Compare undergraduate academics at MIT and NUWMNRU. What is common and what is different between them? Give your reasons. Use expressions relating to the communication of opinions (Ex. 1).

8. Compare campuses at MIT and NUWMNRU. What is common and what is different between them? Give your reasons. Use expressions relating to the communication of opinions (Ex. 1).

9. You have read that most of the science and engineering classes follow a standard pattern at MIT. What about your classes? Do they differ? Give reasons.

10. You have read Mike's letter. Have you got any questions? Send email. What questions would you ask?

11. Prove that:

a) NUWMNRU is one of rather old and prestige research centres in Ukraine.

b) MIT ranks among the best universities in the world. It is a leader in science and technology, as well as in many other fields.

Use the following words and phrases: I think that...; Frankly speaking...; I'd like to call your attention to...; This is my point of view...; I'm sure that ….

Writing

1. Using texts A, B, and C of Unit 1 write a presentation about student life at NUWMNRU and MIT.

Extended reading

Text D. Applied Mathematics Research

1. Read and translate the text into Ukrainian at home. If you were a student of Applied Mathematics department at MIT, which field would you choose? Present your reasons to the whole group.

Department of applied mathematics look for important connections with other disciplines that may inspire interesting and useful mathematics, and where innovative mathematical reasoning may lead to new insights and applications.

Applied Mathematics Fields

- Combinatorics
- Computational Biology
- Physical Applied Mathematics
- Computational Science & Numerical Analysis
- Theoretical Computer Science
- Theoretical Physics

Combinatorics

Combinatorics involves the general study of discrete objects. Reasoning about such objects occurs throughout mathematics and science. For example, major biological problems involving decoding the genome and phylogenetic trees are largely combinatorial. Researchers in quantum gravity have developed deep combinatorial methods to evaluate integrals, and many problems in statistical mechanics are discretized into combinatorial problems. Three of the four 2006 Fields Medals were awarded for work closely related to combinatorics: Okounkov's work on random matrices and Kontsevich's conjecture, Tao's work on primes in arithmetic progression, and Werner's work on percolation.

The department has been on the leading edge of combinatorics for the last forty years. The late Gian-Carlo Rota is regarded as the founding father of modern enumerative/algebraic combinatorics, transforming it from a bag of ad hoc tricks to a deep, unified subject with important connections to other areas of mathematics. The department has been the nexus for developing connections between combinatorics, commutative algebra, algebraic geometry, and representation theory that have led to the solution of major long-standing problems. They are also a leader in extremal, probabilistic, and algorithmic combinatorics, which have close ties to other areas including computer science.

Computational Biology

Computational biology and bioinformatics develop and apply techniques from applied mathematics, statistics, computer science, physics and chemistry to the study of biological problems, from molecular to macro-evolutionary. By drawing insights from biological systems, new directions in mathematics and other areas may emerge.

The Mathematics Department has led the development of advanced mathematical modeling techniques and sophisticated computational algorithms for challenging biological problems such as protein folding, biological network analysis and simulation of molecular machinery.

Mathematical modeling and computer algorithms have been extensively used to solve biological problems such as sequence alignment, gene finding, genome assembly, protein structure prediction, gene expression analysis and protein-protein interactions, and the modeling of evolution. As a result, researchers are now routinely using homology search tools for DNA/protein sequence analysis, genome assembly software for world-wide genome sequencing projects, and comparative genome analysis tools for the study of evolutionary history of various species. All of these widely used tools were developed, at least in part, by MIT Mathematics Department faculty, instructors and former students. Techniques and tools developed by computational biologists are widely used to drive drug development by pinpointing targets, screening molecules for biological activity, and designing synthetic molecules for specific uses.

Exciting problems in this field range include the protein folding challenge in bioinformatics and the elucidation of molecular interactions in the emerging area of systems biology. Mathematicians will likely make significant contributions to these fundamental problems.

Physical Applied Mathematics

This area has two complementary goals:

1. to develop new mathematical models and methods of broad utility to science and engineering; and

2. to make fundamental advances in the mathematical and physical sciences themselves.

The department has made major advances in each of the following areas. Researches have developed a theoretical framework to describe the *induced-charge mechanism* for nonlinear electro-osmotic flow. Their work in *biomimetics* focuses on elucidating mechanisms exploited by insects and birds for fluid transport on a micro-scale. These and other activities in *digital microfluidics and nanotechnology* have applications in biologically inspired materials such as a unidirectional super-hydrophobic surface, and devices such as the `lab-on-a-chip' and micropumps. The theory of *transport phenomena* provides a variety of useful mathematical techniques, such as continuum equations for collective motion, efficient numerical methods for many-body hydrodynamic interactions, measures of chaotic mixing, and asymptotic analysis of charged double layers. *Nanophotonics* is the study of electromagnetic wave phenomena in media structured on the same lengthscale as the wavelength, and is an active area of study in our group, for example to allow unprecedented control over light from ultra-low-power lasers to hollow-core optical fibers. New mathematical tools may be useful here, to give rigorous theorems for optical confinement and to understand the limit where quantum and atomic-scale phenomena become significant. *Granular materials* provide challenging problems of collective dynamics far from equilibrium. The intermediate nature (between solid and fluid) of dense granular matter defies traditional statistical mechanics and existing continuum models from fluid dynamics and solid elasto-plasticity. Despite two centuries of research in engineering, no known general continuum model describes flow fields in multiple situations (say, in silo drainage and in shear cells), let alone diffusion or mixing of discrete particles. A fundamental challenge is to derive continuum equations from microscopic mechanisms, analogous to collisional kinetic theory of simple fluids. On a far larger scale, they have also been remarkably successful in unraveling some of the curious *dynamics of galaxies*.

Computational Science & Numerical Analysis

Computational science is a key area related to physical mathematics. The problems of interest in physical mathematics often require computations for their resolution. Conversely, the development of efficient computational algorithms often requires an understanding of the basic properties of the solutions to the equations to be solved numerically. For example, the development of methods for the solution of hyperbolic equations (e.g. shock capturing methods in, say, gas-dynamics) has been characterized by a very close interaction between theoretical, computational, experimental scientists, and engineers.

Theoretical Computer Science

This field comprises two sub-fields: the theory of algorithms, which involves the design and analysis of computational procedures; and complexity theory, which involves efforts to prove that no efficient algorithms exist in certain cases, and which investigates the classification system for computational tasks. Time, memory, randomness and parallelism are typical measures of computational effort.

Theoretical computer science is a natural bridge between mathematics and computer science, and both fields have benefited from the connection. The field is very active, with exciting breakthroughs and intriguing challenges. The P =? NP problem is one of the seven of the Clay Millennium Problems. The recent polynomial time primality algorithm received a Clay Math research award.

MIT has been the leading center for theoretical computer science for several decades. A strong group of EECS Department faculty also works in this field and runs joint activities with the Mathematics faculty through CSAIL. The RSA cryptosystem and Akamai Technologies are two important success stories that were developed by Mathematics and EECS Department faculty.

A research group investigates active areas such as quantum computation, approximation algorithms, algorithms in number theory, distributed computing and complexity theory.

Theoretical Physics

This field studies the interplay between physical theories, the insights and intuitions obtained from them, and rigorous mathematics. This applies to many parts of physics, such as classical dynamical systems, statistical mechanics, condensed matter theory, astrophysics, elementary particle theory, gravitation, and string theory. For much of the last 20 years, the work of string theorists has stimulated important developments in geometry. Seiberg-Witten theory is one prime example, which has led to work in pure mathematics.

Text E. Traditions and Student Activities

1. Read and translate the text into Ukrainian at home. Does NUWMNRU have any traditions? What do you know about student activities at NUWMNRU? What do two institutions have in common? How do they differ? Comment on.

The faculty and student body highly value meritocracy and technical proficiency. MIT has never awarded an honorary degree, nor does it award athletic scholarships or Latin honors upon graduation. However, MIT has twice awarded honorary professorships: to Winston Churchill in 1949 and Salman Rushdie in 1993.

Many upperclass students and alumni wear a large, heavy, distinctive class ring known as the "Brass Rat". Originally created in 1929, the ring's official name is the "Standard Technology Ring." The undergraduate ring design (a separate graduate student version exists as well) varies slightly from year to year to reflect the unique character of the MIT experience for that class, but always features a three-piece design, with the MIT seal and the class year each appearing on a separate face, flanking a large rectangular bezel bearing an image of a beaver. The initialism IHTFP, representing the informal school motto "I Hate This Fucking Place" and jocularly euphemized as "I Have Truly Found Paradise," "Institute Has The Finest Professors," "It's Hard to Fondle Penguins," and other variations, has occasionally been featured on the ring given its historical prominence in student culture.

MIT has over 380 recognized student activity groups, including a campus radio station, *The Tech* student newspaper, an annual entrepreneurship competition, and weekly screenings of popular films by the Lecture Series Committee. Less traditional activities include the "world's largest open-shelf collection of science fiction" in English, a model railroad club, and a vibrant folk dance scene. Students, faculty, and staff are involved in over 50 educational outreach and public service programs through the MIT Museum, Edgerton Center, and MIT Public Service Center.

The Independent Activities Period is a four-week long "term" offering hundreds of optional classes, lectures, demonstrations, and other activities throughout the month of January between the Fall and Spring semesters. Some of the most popular recurring IAP activities are the

6.270, 6.370, and MasLab competitions, the annual "mystery hunt", and Charm School. Students also have the opportunity of pursuing externships at companies in the US and abroad.

Many MIT students also engage in "hacking," which encompasses both the physical exploration of areas that are generally off-limits (such as rooftops and steam tunnels), as well as elaborate practical jokes. Recent high-profile hacks have included the theft of Caltech's cannon, reconstructing a Wright Flyer atop the Great Dome, and adorning the John Harvard statue with the Master Chief's Spartan Helmet.

The Zesiger sports and fitness center houses a two-story fitness center as well as swimming and diving pools.The student athletics program offers 33 varsity-level sports, which makes it one of the largest programs in the US. MIT participates in the NCAA's Division III, the New England Women's and Men's Athletic Conference, the New England Football Conference, the Pilgrim League for men's lacrosse and NCAA's Division I Eastern Association of Rowing Colleges (EARC) for crew. In April 2009, budget cuts lead to MIT eliminating eight of its 41 sports, including the mixed men’s and women’s teams in alpine skiing and pistol; separate teams for men and women in ice hockey and gymnastics; and men’s programs in golf and wrestling.

The Institute's sports teams are called the **Engineers**, their mascot since 1914 being a beaver, "nature's engineer." Lester Gardner, a member of the Class of 1898, provided the following justification:

“The beaver not only typifies the Tech, but his habits are particularly our own. The beaver is noted for his engineering and mechanical skills and habits of industry. His habits are nocturnal. He does his best work in the dark”.

MIT fielded several dominant intercollegiate Tiddlywinks teams through 1980, winning national and world championships. MIT has produced 128 Academic All-Americans, the third largest membership in the country for any division and the highest number of members for Division III.

The Zesiger sports and fitness center (Z-Center) which opened in 2002, significantly expanded the capacity and quality of MIT's athletics, physical education, and recreation offerings to 10 buildings and 26 acres (110,000 m^2) of playing fields. The 124,000-square-foot (11,500 m^2) facility features an Olympic-class swimming pool, international-scale squash courts, and a two-story fitness center.

2.

1. What is an Electronic Computer?
2. Computers.
3. The Internet Computer.
4. English Word Building.

Grammar Revision

Словотвір в текстах функціонального стилю науки

Найпоширенішими способами словотвору в англомовній науково-технічній літературі є такі:

1. Афіксація (префіксація та суфіксація)
2. Конверсія
3. Словоскладання

Основні префікси та їх значення

Префікс	Значення	Приклади
un-	заперечне, протилежне	unreliable
dis-	заперечне, протилежне	disadvantage
im- (перед m, p)	заперечне, протилежне	impervious
in-	заперечне, протилежне	inadequate
ir- (перед r)	заперечне, протилежне	irregular
mis-	заперечне, протилежне	misuse
il- (перед l)	заперечне, протилежне	illogical
* anti-	заперечне, протилежне	antisocial
* extra-	зверх-, над-	extraordinary
* counter-	проти	counterwork
over-	пере-, надзвичайно	overwater,
* re-	знову, повторно	redistribution
* sub-	під, нижче	subirrigation
semi-	напів-	semiarid
* super-	пере-, зверх-	superheat
under-	недо-, нижче норми	underestimate
* inter-	між, взаємо-	interaction
* non-	не-	noninterference

Зірочкою (*) позначені префікси-інтернаціоналізми.

Основні суфікси іменників

V (verb) – дієслово, N (noun) – іменник, A (adjective) – прикметник, Num (numeral) – числівник, Adv (adverb) – прислівник.

Модель	Значення	Приклади
V+ -ment	результат дії	movement, attachment
V+ -ion	процес, назва дії, стан	erosion, irrigation, reaction
V+ -er, -or	особа/механізм, що виконує дію	sprinkler, user, creator
V+ -ing	процес, дія, стан	melting, cutting
V+ -ance/-ence	дія, стан	conveyance, performance
V+-al	назва дії	renewal, disposal
V+ -ure	дія, результат	pressure
V+-y	назва дії	delivery
V+-th	результат дії	growth
A+ -th	стан	width
A+ -ness	якість, стан	wetness
A+ -ure	якість, стан	moisture
A+-y	якість, стан	efficiency
A+ -ity	якість, стан	aridity
N+ -ist	особа, яка займається	biologist
N+ -ian	той, хто має відношення до ...	mathematician
N+ -hood	абстрактне поняття	boyhood, brotherhood

Основні суфікси прикметників

Модель	Значення	Приклади
A+ -al	якість	automatical, economical
N+-al	наявність якості	experimental
N+ -ful	наявність якості	fruitful, powerful
N+-y	наявність якості	sandy
V+ -able / -ible	спроможний щось робити	favourable, arable
V+ -ant / -ent	наявність якості	resistant, different
N/V/Num.+ -ary	наявність якості	primary, secondary
N+ -ous	наявність якості	impervious

N+ -less	відсутність якості	waterless
N+-ic	наявність якості	symbolic, characteristic
N+-ly	такий, що має якості	friendly, monthly

Основні суфікси дієслів

Модель	Значення	Приклади
N+ -ify	дія	gasify, classify
A+ -ify	дія	intensify, simplify
A+-en	дія	moisten
N+ -ize	дія	computerize, modernize
N+ -ate	дія	indicate

Основні суфікси прислівників

Модель	Значення	Приклади
A+-ly	змінює частину мови	efficiently
N+ -ward	напрямок	backward (s)
Adv.+ -ward	напрямок	upward

Конверсія

Конверсія – це спосіб словотвору, досить поширений в англійській мові, при якому від слова однієї частини мови утворюється слово іншої частини мови без зміни зовнішньої форми слова:

to stop – a stop, зупиняти – зупинка
water – to water, вода – поливати

Найбільш поширеним є утворення іменника від відповідного дієслова: $\boxed{V \to N}$:

to march – march
to run – run

Досить часто має місце і утворення дієслова від іменника: $\boxed{N \to V}$:

pump – to pump

Часто дієслово утворюється від прикметників: $\boxed{A \to V}$:

empty – to empty

Словоскладання

Складні слова утворюються шляхом об’єднання двох основ:

clipboard* – *плата кліпів, утворене від

clip ***board***

Text A. What is an Electronic Computer?

Pre-text Exercises

1. Before reading the text, read the following questions. Do you know the answers already? Discuss them briefly with other students to see if they know the answers. The questions will help to give a purpose to your reading:

– What differs greatly a computer from a calculator?

– Can you name all the structural parts of a computer in English?

– Do you know the English for “пристрій з програмою в пам’яті”, “магнітне середовище для зберігання даних”, “накопичувати і обробляти інформацію”, etc.?

2. Learn to recognize the following international words and give their Ukrainian equivalents:

electronic, computer, information, process, result, definition, instruction, code, radical, calculator, machine, program, modern, attribute, magnetic, function, control, arithmetic, calculation, basic, operation, dictate, perform, practical, detail, difference, print, problem.

Read and translate the text:

What is an Electronic Computer?

An electronic computer is a device that can accept information, store it, *process* it, and present the results of the processing in some acceptable form. A most important adjunct to this definition is that a computer is told how to process the information by *instructions,* which are stored in coded form inside the computer. A computer thus differs radically from a calculator, which can do the same thing that a computer does, except that the instructions are not stored inside the machine. The coded instructions are called *a program* (modern usage prefers the word *routine).* We therefore speak of a computer as an *internally-stored-program device.*

Modern electronic digital computers have many attributes in common. They are usually built in several units, only one of them is a computer or "processor". The other units are control, storage and input-output devices. The modern machine is more often called a computing system. These systems use semiconductors and include magnetic-core and magnetic-tape storage. Almost every digital computer has been found capable of doing more than it was originally designed to do.

Any computer or calculator contains devices for five main functions: input, storage, arithmetic, control and output. *Input* refers to the process by which information is put into the machine. *Output* is the process by which the results are moved out of the machine. *Storage* refers to the mechanism that can retain information during calculation and furnish it as needed to other parts of the machine. The *arithmetic unit* is that part of the machine, which can carry out one or more of the basic arithmetic operations on the information held in storage. Finally, the *control* refers to those parts of the machine that dictate the functions to be performed by all the other parts.

In a computer, four of the five functions are, in principle, the same as in a calculator. Most computers are electronic, so that the practical details of these functions are somewhat different. Originally input to the computer was provided by such things *as punched cards or punched paper tapes.* Storage was provided by a device such as *a rotating magnetic drum* or by *magnetic cores.* Arithmetic was carried out by various electronic circuits, as a part of the control function. Output was provided by such devices as *punched cards, punched paper tapes,* a *typewriter,* or *a printer,* which can print a complete line of information at a time. The main difference is that the instructions telling the computer what to do must be placed in storage before the computer proceeds with the solution of a problem. These instructions, which are made up of ordinary decimal digits are placed in the same storage device that holds the data.

Active Vocabulary

device	пристрій
information	інформація
accept ~	приймати ~
store ~	накопичувати ~
process ~	обробляти ~
instruction	команда (інструкція)
adjunct	додаток, доповнення

routine	програма
thus	таким чином
therefore	тому
internal	внутрішній
internally-stored-program device	пристрій з програмою в пам'яті
digital	цифровий
attribute	атрибут; характеристика, характерна ознака
unit	блок
input-output unit	блок вводу-виводу
storage	пам'ять
~ device	~ зберігаючий пристрій (накопичувач)
retain	утримувати, підтримувати; зберігати
furnish	забезпечувати, доставляти
to furnish with information	надати інформацію
arithmetic unit	арифметичний блок
carry out	виконувати
hold (held, held)	тримати, утримувати
refer to	відносити до …
to be refered to as …	називатися
perform	виконувати
in principle	в основному
provide	надати, забезпечувати
punched cards	перфокарти
punched paper tapes	паперова стрічка
drum	барабан; циліндр, що обертається
core	магнітне середовище для зберігання даних
rotate	обертати
magnetic core	«магнітний сердечник»
circuit	схема; ланцюг; маршрут
proceed	приступати; перейти до чого-небудь
make up	складати

datum (pl. data)	дана величина (дані)
decimal	десятковий

Grammar and Vocabulary Exercises

1. Study the Table of word-building means given in Grammar Revision.

2. Form words with opposite meaning by adding prefixes *un-, dis-, in-, ir-, il-* **to the proper words:**

regular, advantage, appear, important, usual, adequate, able, direct, possible, probable, productive, significant, limited, natural, relevant.

3. Form the words after the model and translate them into Ukrainian:

a) V + -ment:

to improve, to manage, to treat, to develop, to adjust, to achieve

b) V + -ion (-tion, -ation):

to consume, to distribute, to locate, to inform, to investigate, to form, to irrigate, to observe, to react, to construct, to invent, to restrict, to produce.

c) V + -er (-or):

to consume, to use, to construct, to irrigate, to produce, to build, to control, to perform, to turn, to compute.

d) A + -al:

geologic, economic, electric, mechanic, technologic, scientific.

e) V + -ing:

to design, to manufacture, to build, to understand, to start, to install.

f) A + -ly:

direct, usual, virtual, general, frequent.

g) A + -ity:

available, arid.

h) V + -al:

to remove, to renew, to dispose.

4. Define meanings of the words by their affixes. State what part of speech they indicate:

construct – construction – constructor – constructive; exist – existing; engineer – engineering; design – designing – designer; wood – wooden;

resident – residential; irrigate – irrigation; build – building – builder; produce – production – producer – product.

5. Look through the text and give Ukrainian equivalents for the following words and word-combinations:

to accept information; to process information; to present the results of processing; instructions; to store information in a coded form; internally-stored-program device; attributes; input-output devices; refer to; to retain; to provide; to carry out; control function; to print a complete line of information; to place in storage; to proceed; decimal digits.

6. Look through the text and find English equivalents for the following words and word-combinations:

приймати інформацію; зберігати/накопичувати інформацію; прийнятна форма; обробляти інформацію; команди; програма; характерна ознака; керування; пристрій; відносити до; утримувати; здійснювати; забезпечувати; схема (ел.); циліндр, що обертається; магнітне середовище для зберігання даних.

7. Look through the text and find the nouns corresponding to the following verbs and translate them into Ukrainian:

result, define, compute, process, inform, differ, calculate, instruct, control, store, operate, function, punch, print.

8. Translate into English:

1. Електронний комп'ютер – це пристрій, який здатний приймати інформацію, зберігати та обробляти її, а також видавати результати обробки в будь-якій прийнятній формі.
2. Комп'ютер радикально відрізняється від калькулятора, який може виконувати ті самі дії, що і комп'ютер, за винятком того, що команди не зберігаються в машині.
3. Сучасні цифрові комп'ютери мають багато спільних характеристик.

4. Будь-який комп'ютер або калькулятор містить пристрої для п'яти основних функцій – вводу/виводу, арифметичний блок, блок пам'яті та блок управління.
5. Арифметичний блок – це пристрій, який може виконувати

одну або більше арифметичних операцій над інформацією, яка міститься в пам’яті комп’ютера.

9. For each definition write a word from the text:

1. A device that can accept information, store it, process it, and present the results of the processing in some acceptable form.
2. The coded instructions.
3. The process by which information is put into the machine.
4. The process by which the results are moved out of the machine.
5. The mechanisms that can retain information during calculation and furnish it as needed to other parts of the machine.
6. The part of the machine which can carry out one or more of the basic arithmetic operations on the information held in storage.
7. The parts of the machine that dictate the functions to be performed by all the other parts.

Reading Comprehension

1. Review the whole text again. Outline the subject matter of the text, its components structure, topic sentences and main ideas. Use the following phrases:

– The text deals with … (speaks about, presents, shows, points out, discusses, reviews, throws light on, traces the history of, etc)

– The subject matter of the text is …

– The text can be segmented into … paragraphs.

– The first (second, third, fourth, etc.) paragraph considers … (deals with, informs of, describes, etc.)

– The topic sentence of the first (second, third, fourth, etc.) paragraph is …

– The main idea of the first (second/third/fourth, etc.) paragraph is …

– The main idea of the text is …

– The conclusion the author came to is …

– The reasons for this conclusion are …

2. Say whether the following statements are true or false. Justify your choice. Use the given phrases:

It’s right. Quite so.

I quite (fully) agree to it.

Certainly. Exactly.

I doubt that …

I don't think so.
This is not the case.
It's wrong, I am afraid.
Quite the reverse.
The definition is inappropriate.

1. An electronic computer does not differ radically from a calculator.
2. The coded instructions are called a program.
3. Modern electronic digital computers don't have many attributes in common.
4. Any computer contains devices for five main functions: input, storage, arithmetic, control and output.
5. The arithmetic unit refers to those parts of machine that dictate the functions to be performed by all the other parts.
6. Storage was provided by such a device as a rotating magnetic drum or by magnetic cores.

3. Answer the following questions:

1. What do they call an electronic computer?
2. What is a most important adjunct to the definition of an electronic computer?
3. What differs radically a computer from a calculator?
4. What is the term for a coded instruction?
5. How many units are there in a computer?
6. What is the function of the control unit, input/output, storage and the arithmetic unit?
7. What way were the input, output, arithmetic and storage units provided by?
8. What form are instructions placed in the storage device in?

Conversational Practice

1. Suppose that the information in the statement is insufficient. Repeat the statement and add your own reasoning, thus developing the idea. Use the following phrases:

There's one more thing to be noted …
I may as well add that …
Moreover …
You've omitted …
What is missing (lacking) in the statement is that …

1. A computer has essentially only three parts: a memory, an instruction processor and a data processor.

2. A datum is anything that can be an operand.

3. Memory holds both data and instructions.

4. Instructions are organized into programs, often called routines or codes.

2. Agree or disagree with the statements given below. Use the introductory phrases and develop the idea further. Use the following phrases:

That's right.
I fully agree to it.
I don't think so.
This is not the case.
It's wrong, I'm afraid.
Quite the reverse.

1. The computer models explain what people actually do when they think or perceive.

2. There must be a digital way of performing human tasks.

3. Discuss the statement. The following phrases may be helpful:

I am confirmed in my opinion that …
The statement may be confirmed by …
I can (not) be denied that …
I deny that the statement is true.

Modern computers are much faster, more complex, multifunctional and useful than most people dreamed 50 years ago.

4. Give a short summary of the text.

Text B. Computers

1. Read and translate the text:

Computers

A computer is really a very specific kind of counting machine. It can do arithmetic problems faster than any person alive. By means of electric processes it can find the answer to a very difficult and complicated problem in a few seconds.

A computer can «remember» information you give it. It keeps the information in its «memory» until it is needed.

There are different kinds of computers. Some can do only one job. These are special-purpose computers. Each specific problem requires a specific computer. One kind of computer can help us to build a spaceship, another kind can help us to navigate it. A special-purpose computer is built for this purpose alone and cannot do anything else.

But there are some computers that can do many different jobs. They are called general-purpose computers. These are the big «brains» that solve the most difficult problems of science.

Our grandparents used to think of a computer as a large machine that took up a whole room. But today computers are becoming smaller and smaller. Though these small devices are called microcomputers or minicomputers, they are still true computers.

The most important parts of a general-purpose computer are as follows:

1) memory, where information is kept;
2) an arithmetic unit for performing calculations;
3) a control unit for the correct order of operations;
4) input devices;
5) output devices for displaying the results of calculations.

The input and output devices are called peripherals.

There are several advantages in making computers as small as one can. Sometimes weight is particularly important. A modern plane carries many heavy electronic apparata. If it is possible to make any of them smaller, it can carry a bigger weight. But weight is not the only factor. The smaller the computer is, the faster it can work. The signals go to and from at a very high but almost constant speed.

Some of the first computers cost millions of dollars, but people quickly learned that it was cheaper to let a million dollar computer make the necessary calculations than to have a hundred clerks trying to do the same by hand. Scientists found out that computers made fewer mistakes and could fulfill the tasks much faster than almost any number of people using usual methods. Computers became popular. As their popularity grew the number of factories producing them also grew.

Active Vocabulary

a control unit	electric processes
advantage	fulfill the tasks
an arithmetic unit for performing calculations	general-purpose computers
apparatus	input devices
arithmetic problems	memory
brains	navigate
calculations	output devices
complicated problem	peripherals
constant speed	special-purpose computers
counting machine	specific problems

2. Answer the following questions:

1. What is an automatic computer?
2. What are the most important parts of a general purpose computer?
3. What kinds of computers are there?
4. Why do we call the computer the general purpose machine?
5. Could you name several advantages in making computers as small as one can?
6. The input and output devices are called peripherals, aren't they?
7. Why have computers become popular?

3. Reconstruct the text "Computers" into a dialogue.
The main rules governing a conversation in English:

The person who asks questions in a conversation usually controls it. Personal questions should be expressed tactfully.

Excuse me for asking.
I hope you don't mind asking, but I'd like to know more about …
Could you tell me a bit more about …?
Sorry, I don't quite understand.
What (exactly) do you mean?
Can you explain it in more detail, please?
Excuse me. Can I interrupt you for a moment?
Hold on, please.
Just a moment, please.
Don't you agree that …
Sorry, could you say that again (please)?
Sorry, could you repeat that?

Oh, you know what I mean.

Can you guess what I said, etc.

Sure.	*I know.*	*I see.*	*Really.*	*Right.*
Fine.	*OK.*	*Well.*	*Exactly so.*	*Quite.*

That's a very interesting question.

Well, let me see …

Excuse me, I'm afraid I have to be going now. It was really a pleasure to talk to you.

That's very interesting, but I don't think it's really to the point.

4. Annotate the text in English. Use the phrases:

I.

a) The title of the article is...

It is written by prof... and published in London in the

journal..., No.3, vol.4, 2011 *magazine..., No.3, vol.4, 2011* *collection of articles ... by... editorial house in 2011* *book ... by... editorial house in 2011*	on pp.3-10

b) The article... by prof... is published in the journal..., in N.Y., pp.5-10.

II.

a) The article	*deals with* *discusses* *touches* *discloses* *is devoted to*	the problem of ...

The text tells us about ...

b) Disclosing the problem the author dwells on (upon) such matters as...

The major	*points* *matters* *problems* *issues*	of the text are the following: ...

c) The author	*pays special attention to …* *draws readers' attention to …*

Much *Great* *Special*	attention is paid to...

The author	*concentrates on, focuses on* *stresses, underlines, emphasises* *points out* *dwells on (upon)* *distinguishes between* *speaks in details* *gives the classification*

III.

a) As far as I am an expert in ... I

consider *believe* *suppose* *think* *guess*	the article to be of some (great) interest for …

b)

In my opinion *From my point of view* *To my mind*	the article is of	*great* *some*	interest for

the students in applied science *the specialists in...* *a wide range of readers*

5. Discuss the statements given below. It is advisable that the group be divided into two parties, each party choosing one of the statements and working on them independently. Seek your own sources of information.

1. The history of computation and computing devices: finger reckoning → the abacus → early computers → current microcomputers and supercomputers.

2. Calculations which might take a lifetime can now be completed in hours, or even minutes, is it really the case?

Writing

Using texts A and B of Unit 2 write a presentation about the computer structure.

Extended reading

Text C. The Internet Computer

Read and translate the text into Ukrainian at home. Write an abstract (précis) of the text in English. Express your personal assessments of the vast amount of information available on the world's largest network, the Internet. Are you in favour of the Internet? Reproduce it in class.

The Internet Computer

A General Online of a Computer. There are five key parts of a computer: *the processor, the memory, the input/output, the disk storage* and *the programs. The processor* is the brain of the computer, the engine, the working part of this marvelous machine. The processor has the ability to carry out our instructions to the computer. In other words, the processor *runs (executes)* the computer programs. In *PC* (personal computer) the processor is sometimes called a *microprocessor.*

The memory is the computer's work area (workspace). The computer's memory is where all activity takes place, the size of a computer's memory sets a practical limit on the kinds of work that the computer can undertake. That is why the computers rated by the amount of memory they have, usually in *megabytes* (millions of bytes) – and sometimes in *kilobytes* (thousands of bytes).

Input/output or *I/O* – is all the way the computer *takes in* and *sends out* data. It includes input that the programmer types on *the keyboard* and output that the computer shows on *the video display screen* or prints on *the printer.*

Disk storage is a very important kind of I/O; it is the computer's *reference library,* filing cabinet and toolbox all rolled into one. Disk storage is where the computer keeps *data,* when it is not in use, in the computer's memory. Data can be stored in other ways, but disks are the most practical and important medium for storing data.

Programs (Software) are the last of the five key parts of a computer. They are what make the computer go, what brings it to life, what turns it from a heap of fancy parts into a powerful working tool. Programs are the *instructions* that tell the computer what to do.

We should take a slightly more detailed look at each of these key parts, bearing in mind that the real details will be comprehended in programming. *The processor* must have some particular and critical skills because both the program instructions to be carried out and the data, that the processor is to work on, are *temporarily stored* in the memory. The next skill is the ability to recognize and execute a series of commands or instructions to be carried out. It means the ability to tell the other parts of the computer what to do so that the processor can orchestrate the operation of the computer. All these skills mentioned are complex matters. To the processor, the *distinction* between programs and data is *vital: one* includes what the processor is to do, and the other is what the doing is done to. Not every part of the computer makes this distinction.

For you to understand your computer's processor, you must remember that the computer's memory is just a temporary space, a scratch pad, a workbench, a chalkboard where the computer scribbles while the work is being done. While the computer's processor makes a vital distinction between *programs* and *data,* the computer's memory does not – there is no difference between them – both are just information to be recorded temporarily. To the computer's memory and also to the I/O devices and disk storage, a program is just more data, more information that can be stored. In general, one can say, that all I/O devices that the computer can work with, have programmers as their real target. Everything that the computer puts out on the display screen or on the printer is intended to be seen by the people. *Disk storage* is only one kind of I/O devices that the computer can use to read data into, or write data out from its memory.

There is one key difference between disk storage and all other devices: the information on the disk can't be read or written by the programmer – only computer can do it. All other I/O devices are on the *interface* between the computer and people. Disk storage is the computer's library where it keeps its instructions programs, its raw material (data) and any other information that it needs to have on tap. Finally, *programs* tell the computer what to do. Computers "consume" programs, as fuel, but unlike the engine that burns fuel it can't use again, a computer can use a program over and over again. There is always a need for new programs. There are two very different kinds of programs – *system programs* and *application programs* – and one needs to know the difference right from the start. System programs help operate the computer; in fact, the inner workings of a computer are so complex that they cannot work without the help of system programs. An application program carries out the task that people want done. In summary, applications programs get our work done, and system programs help the computer manage itself and carry out our work.

Some of the system programs that the system *IBM* (Information Business Machine) *PC* needs to manage its operations are *permanently built into it.* These are called the *ROM programs* because they are permanently stored in Read-Only-Memory. These kinds of systems programs do the most fundamental kind of *supervisory and support work,* which includes providing essential services that all the applications programs use. These service programs are called basic Input/Output Services or ROM-BIOS, because they reside in ROM.

Bits, Bytes and *Characters.* The smallest point of computer *data* is called *a bit* – a contraction of the expression *binary digit.* We all are familiar with the 10 decimal digits – 0 through 9, that are used to express numbers while there are 10 district decimal digits, there are only *two* different bit values – zero and the one written as 0 and 1, that represent *on* and *off, true* and *false, yes* and *no.* It is the concept of the *bit* that makes *computers – information – handling machine* possible. *A word* is *16 bits,* i.e. (that is), *bytes* – the building blocks of both numbers and *the text* – character data. If we are working with numbers, then the bytes in the computer are treated as numbers, and the bit patterns in the bytes are given a numerical interpretation. When we work with *character text information,* the bytes are interpreted as *characters* that make up the written text information. Each byte represents one character of the text. There are four more basic terms concerning computer data – *the kilobyte* (K), *the megabyte* (meg), *the gigabyte,* and *the terabyte.*

Hex is simply a shorthand by *binary notation,* in which one hexadecimal digit represents four binary digits (bits), with two values 0 and 1. Hex arithmetic, of course, works like decimal arithmetic, but the value of numbers is different. The largest decimal number is 9 and the next number is 10. The largest Hex digit is F= 15 and the number after it is written 10, which has the value of 16, next comes 11 (which is 17) and so on.

Standard Numbers. Because numbers are so important to computers, let us look at the kinds of numbers that come most naturally to the PC. One might be surprised to realize that PC's natural skills allow it to work only with whole numbers – called *integers* – and rather small numbers at that (1-0). The PC can work with only two varieties of numbers – integers that are one byte in size, and integers that are two bytes, or a *word* in size. The negative numbers are represented inside the PC in a form known as *two's complement.* In decimal numbers, *zero* is written as *000 and* 1 (one) as *001.* If we subtract 001 from 001, we get 000. *Minus one* is represented as 999, minus two is 998, and so on. The positive numbers start at 000, 001, 002 and go on up to 999. The value of a number can depend on whether we interpret it as *signed* or *unsigned.* As a signed number 999 means *minus one;* as an unsigned number it means nine hundred ninety-one.

Hot Numbers. Most of our computing needs go beyond the simple integers that are native to the PC. Whether we are doing financial planning, performing engineering calculations, we are willing to have numbers more powerful than the integers. The first way to extend the range of numbers that PCs can deal with is simply to make longer integers – the most practical extra length of integer *is/our bytes,* e.g., 2,000,000,000. To handle *fractional numbers,* computers use a concept known as *floating point* – in the *floating-point computer*.

The outline of the computer structure presented, we hope, gives a good basis to start with, a springboard for diving into the details of computing power.

3.

1. Hardware – Software – Firmware.
2. Computer Crime.
3. Boolean Algebra.
4. Passive Voice[1].

Grammar Revision

Passive Voice

S + be + V_3

Час (Tense)	Indefinite	Continuous	Perfect
Present	S + am / is / are + V_3	S + am / is / are +being + V_3	S + have / has +been + V_3
Past	S + was / were + V_3	S + was / were +being + V_3	S + had +been + V_3
Future	S+ will / shall +be+V_3	—	S+ will / shall +have+been+V_3

Modals with the Passive Voice

S + can / may / must + be + V_3

[1] Навчальні завдання з розвитку граматичних навичок з англійської мови (теорія, тренувальні вправи, міні та рейтингові тести) для студентів 1-х курсів усіх спеціальностей РДТУ (Частина III). Рівне: РДТУ, 1999. – с. 18-20.

Text A. Hardware – Software – Firmware

Pre-text Exercises

1. Before reading the text, read the following questions. Do you know the answers already? Discuss them briefly with other students to see if they know the answers. The questions will help to give a purpose to your reading:

– What is meant by the term "firmware"? Have you ever met it?

– Are you sure you don't confuse microprogramming a computer with programming a microcomputer?

– Do you know what a fundamental issue is in the design of any computer?

2. Learn to recognize international words:

fundamental, design, electrical, signal, information, arithmetic, logic, computer, component, central, memory, permanent, complexity, code, hierarchy, program, instruction, elementary, idea, method, evolution, function, confusion, product, progressive, miniaturization, silicon, system, personal, classify, status, modern, control.

Read and translate the text:

Hardware – Software – Firmware

A fundamental issue in the design of any computer is how to control or steer the electrical signals that represent information. In the arithmetic and logic unit, where the actual processing of information is done, signals must be routed between various computers, adders and other components. The control system must also mediate the transfer of information between the central processor, the main memory units and the various input and output devices. In one approach, the control system is completely "hard-wired", that is, it is laid down permanently in the processor's electrical circuitry. A second approach is more flexible and in many cases less expensive. The essential idea is to reduce the complexity of the control system by recording the detailed instructions for controlling the computer in a coded form. In other words, the sequence of paths that must follow is embodied in a program, which is stored in a separate memory unit incorporated into the processor.

In the hierarchy of program that operates a computer, the instructions executed by the control system occupy the lowest and most elementary level; each instruction specifies a single functional state of the machine. Because the control instructions are responsible for such fine details, the tasks of defining and encoding them is termed *microprogramming,* thereby distinguishing it from the writing of the higher-level programs known generally as *software.* A set of control instruments – a microprogram – is written in microcode. The idea of microprogramming was conceived more than 30 years ago soon after the advent of the first computers. At the time the *hardware* needed to implement the idea did not yet exist. The method has been adopted, however, in most computers that are being built today. Evolutionary successor of the minicomputer, the microcomputer, is a set of microelectronic *"chips"* serving to various computer functions. It has opened up new realms of computer applications. In recent years a good deal of confusion has arisen about the meaning of the term microprogramming, owing largely to the advent of the microprocessor (the computer on a chip) that is at the heart of the latest products of the progressive miniaturization of silicon-based semiconductor technology. It must be emphasized that microprogramming a computer is not the same as programming a microcomputer; in principle, any computer, from the largest *"mainframe"* system to the smallest personal computer, can be designed with a microprogrammed control system. To avoid such confusion microprograms are sometimes classified as *"firmware",* thereby signifying their intermediate status between hardware and software. In most modern computers the routing of information is controlled at the lowest level by a *microprogram,* i.e., a set of stored instructions that function in place of a completely "hardwired" control system.

Active Vocabulary

firmware	вбудовані програми; програмне забезпечення, яке міститься у пам’яті ROM
issue	питання, проблема
design	проектування, конструювання, розробка
steer	управляти, керувати
represent	представляти
route	прокладати маршрут; назначати тракт (передачі інформації)
adder	суматор, модуль CPU

mediate	здійснювати що-небудь завдяки своєму втручанню
transfer	перенесення, переміщення
approach	наближення, підхід
completely	абсолютно, повністю, цілком
hard-wired	апаратний, “зашитий”
permanently	постійно
circuitry	схеми, ланцюги (pl. від circuit)
flexible	гнучкий
expensive	дорогий
essential	суттєвий, важливий
reduce	знижувати, зменшувати
complexity	складність
record	записувати
sequence	послідовність
path	маршрут, шлях (зв’язок між двома станціями (вузлами) мережі)
follow	слідувати
embody	втілювати, зображувати
incorporate	сполучати(ся), об’єднувати(ся)
hierarchy	ієрархія
execute	виконувати
specify	точно визначати, встановлювати
to be responsible for	бути відповідальним за
fine	точний
encode	кодувати, шифрувати
thereby	за допомогою цього, таким чином
distinguish	розрізнити
set	набір
conceive	осягати, розуміти
advent	прихід, прибуття
implement	виконувати
adopt	приймати, засвоювати
however	однак, проте
successor	наступник, спадкоємець
chip	мікросхема пам’яті
realm	область, сфера
application	застосування

owing	зобов'язаний
mainframe	високорівневий
signify	означати
intermediate	проміжний

Grammar and Vocabulary Exercises

1. Look through the text and find sentences with Passive Voice. Translate them into Ukrainian.

2. Give three forms of the following verbs:

to do, to lay, to know, to write, to have, to be, to build, to arise.

3. Make the following sentences Passive:

1. The control system must also mediate the transfer of information.
2. The instructions executed by the control system occupy the lowest and most elementary level.
3. Recording the detailed instructions for controlling the computer in a coded form reduces the complexity of the control system.
4. A separate memory unit stores the sequence of paths in a program.

4. Write all the English tense forms of the Passive Voice:

1. Contemporary algebra **is considered** as a mixture of much that is very old and still important, e.g. counting and newer concepts such as structures.
2. The beginnings of the development of numbers **are lost** in prehistory.
3. Complex numbers **are expressed** in the form of a number-couple.
4. The sign "+" **is used** in modern algebra only for commutative systems.

5. Use the proper tense form (Infinitive, Continuous, Perfect or Perfect Continuous) in the sentences. Make them Passive:

1. The scientists express this number as a terminating decimal *(by the end of the last century; in future; since the birth of modern civilization; usually; nowadays; for a long time; if necessary; in this particular problem)*.
2. Axiomatic inquiry brings forth new concepts in algebra *(still; from the outset; in 1873, eventually; this year; already; next decade)*.

6. Define meanings of the following words by their affixes, state what part of speech they indicate:

electricity – electrical; inform – information; process – processing; add – adder; complete – completely; permanent – permanently; circuit – circuitry; essence – essential; complex – complexity; record – recording; general – generally; program – programming; miniature – miniaturization; person – personal.

7. Look through the text and give Ukrainian equivalents for the following words and word-combinations:

a fundamental issue; to steer the electrical signals; signals must be routed; adder; mediate; the transfer of information; hard-wired; circuitry; sequence of paths; to be embodied in a program; incorporate into the processor; distinguish; conceive; advent; implement; adopt; successor; realm; semiconductor; “mainframe” system; avoid confusion; firmware; routing of information.

8. Look through the text and give English equivalents for the following words and word-combination:

вбудовані програми; проектування; управляти; назначати тракт (передачі інформації); суматор; схеми; гнучкий; суттєвий; зменшувати; втілювати; бути відповідальним за; розрізнити; набір; осягати; наступник; мікросхема пам’яті; проміжний; прихід; застосування.

9. Compose sentences with the words and word-combinations from Ex. 8.

10. Study the text and complete these sentences:

1. The control system must also mediate the transfer of information between ... .

2. In one approach the control system is completely “hard-wired”, that is, … .

3. The control instructions are responsible for ... .

4. Evolutionary successor of the minicomputer, the microcomputer, is … .

5. It has opened up new realms of ... .

6. In recent years a good deal of confusion has arisen about the meaning of … .

7. It must be emphasized that microprogramming a computer is not the same as … .

8. In most modern computers the routing of information is controlled at the lowest level by … .

11. Combine the words from the left-and right-hand columns to make word-combinations. Translate them into Ukrainian:

fundamental	state
electrical	chips
control	circuitry
flexible	issue
detailed	system
elementary	functions
functional	system
high-level	instructions
microelectronic	technology
computer	programs
semiconductor	level
mainframe	approach

12. Compose sentences with the words and phrases from Ex. 11.

13. Write an appropriate word or phrase in the following spaces:

1. In the arithmetic and logic unit signals must … between various computers, adders and other components.

2. In one approach, the control system is completely … .

3. A second approach is more … .

4. The sequence of paths that must follow … in a program, which is stored in a separate memory unit incorporated into the processor.

5. A fundamental … in the design of any computer is how to control or … the electrical signals that … information.

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steer; flexible; be routed; represent; hard-wired; is embodied; issue

Reading Comprehension

1. Review the whole text again. Outline the subject matter of the text, its components structure, topic sentences and main ideas. Use the following phrases:

– *The text deals with … (speaks about, presents, shows, points out, discusses, reviews, throws light on, traces the history of, etc)*

– The subject matter of the text is ...

– The text can be segmented into ... paragraphs.

– The first (second, third, fourth, etc.) paragraph considers ... (deals with, informs of, describes, etc.)

– The topic sentence of the first (second, third, fourth, etc.) paragraph is ...

– The main idea of the first (second, third, fourth, etc.) paragraph is ...

– The main idea of the text is ...

– The conclusion the author came to is ...

– The reasons for this conclusion are ...

2. Say whether the following statements are true or false. Justify your choice. Use the given phrases:

It's right. Quite so.
I quite (fully) agree to it.
Certainly. Exactly.
I doubt that ...
I don't think so.
This is not the case.
It's wrong, I am afraid.
Quite the reverse.
The definition is inappropriate.

1. In the arithmetic and logic unit signals must be routed between various computers, adders and other components.
2. The sequence of paths that must follow is embodied into the processor.
3. A set of control instruments – a microprogram – is written in microcode.
4. The idea of microprogramming was conceived more than 30 years ago soon after the advent of the first computers.
5. Microprogramming a computer is the same as programming a microcomputer.

3. Answer the following questions:

1. What is a fundamental issue in the design of any computer?
2. What way must the signals be routed in the arithmetic and logic unit?

3. What must the control system mediate?

4. When does one say that the control system is completely “hard-wired”?

5. How is the reducing of the control system complexity achieved?

6. What occupies the lowest and most elementary level in the hierarchy of program that operates a computer and why?

7. What is a set of control instruments?

8. What do they call a set of microelectronic “chips” serving to various computer functions?

9. Why has the term microprogramming caused a good deal of confusion in recent years?

10. Can we use the term “programmimg a microcomputer” and “microcomputer programming” interchangeably?

11.Can any computer be designed with a microprogrammed control system?

12. Why are microprograms sometimes classified as “firmware”?

13. What is the status of firmware?

14. How is the routing of information controlled in most modern computers?

Conversational Practice

1. Agree with the following statements, adding your own comments. Use the introductory phrases:

That’s right.

There is no denying that … .

There is no point of disagreeing that … .

1. A computer is a combination of computer *hardware* and *software*.

2. The *hardware* of a computer consists of a central processing unit (a memory) and peripheral equipment.

3. The basic computer *hardware* can operate only upon numeric program instructions.

4. The *software* of a computer consists of sequences (strings) of instructions that may be expressed in a variety of programming languages.

5. The writing of the higher-level programs is generally known as *software*.

6. Microprograms are sometimes classified as “*firmware*”, thereby signifying their intermediate status between hardware and software.

2. Suppose that the information in the statement is insufficient. Repeat the statement and add your own reasoning, thus developing the idea. Use the following phrases:

There's one more thing to be noted ...
I may as well add that ...
Moreover ...
You've omitted ...
What is missing (lacking) in the statement is that ...

1. In the arithmetic and logic unit signals must be routed between various computers.
2. The control system is completely "hard-wired".
3. A set of control instruments – a microprogram – is written in microcode.
4. The routing of information is controlled at the lowest level by a microprogram.

3. Express your personal view on the statement given below. Use the following phrases:

As for me ... .
As concerns ... .
As far as I am concerned ... .
What I mean to say is ... .
In conclusion, I may say ... .
To summarize the topic ... .

Software can never equal brainware.

4. Give a short summary of the text.

Text B. Computer Crime

1. Read and translate the text:

Computer Crime

In many businesses, computers have immensely replaced paperwork, because they are fast, flexible, and do not make mistakes. Computers are honest: unlike humans, they never have a bad day. Many banks advertise that their transactions are "untouched by human hands" and therefore are safe from human temptation. Obviously, computers have no reason to steal money. But they also have no conscience, and the growing number of computer crimes shows they can be used to steal.

Computer criminals don't use guns. And even if they are caught, it is hard to punish them because there are no witnesses and often no evidence. A computer cannot remember who used it: it simply does what it is told. The head teller at a New York City bank used to steal more than one and a half million dollars in last four years. No one noticed this theft because he moved money from one account to another. Each time a customer he had robbed questioned the balance of his account, the teller claimed a computer error, then replaced the missing money from someone else's account. This man was caught only because he was a gambler. When the police broke up an illegal gambling operation, his name was in records.

Some employees use the computer's power to get revenge on employers they consider unfair. Recently, a large insurance company fired its computer-tape librarian for reasons that involved her personal rather than her professional life. She was given a thirty days' notice. In those thirty days, she erased all the company's computerized records.

Most computer criminals have been minor employees. Now police wonder if this is "the top of the iceberg." As one official says, "I have a feeling that there is more crime out there than we are catching. What we are seeing now is all so poorly done. I wonder what the real experts are doing – the ones who really know how a computer works."

Active Vocabulary

account	obviously
company	teller
computer-tape librarian	temptation
conscience	to advertise
crime	to catch
customer	to fire
employee	to get revenge
evidence	to notice
flexible	to punish
gambler	to rob
gun	to steal
immensely	transaction
insurance	witness
involve	

2. Answer the following questions:

1. Why have computers immensely replaced paper work in many businesses?
2. Is it true that many banks advertise their transactions being untouched by human hands?
3. Why can computers be used to steal money if they have no reason to steal it?
4. Is it hard to punish computer criminals?
5. How did the head teller at a New York City bank manage to steal more than one and a half million dollars in last four years?
6. Why was this man caught?
7. Who tends to be more successful in computer crimes – minor employees or real computer experts?

3. Reconstruct the text "Computer Crime" into a dialogue.
The main rules governing a conversation in English:

The person who asks questions in a conversation usually controls it. Personal questions should be expressed tactfully.

Excuse me for asking.
I hope you don't mind asking, but I'd like to know more about …
Could you tell me a bit more about …?
Sorry, I don't quite understand.
What (exactly) do you mean?
Can you explain it in more detail, please?
Excuse me, can I interrupt you for a moment?
Hold on, please.
Just a moment, please.
Don't you agree that …
Sorry, could you say that again (please)?
Sorry, could you repeat that?
Oh, you know what I mean.
Can you guess what I said, etc.

Sure.	*I know.*	*I see.*	*Really.*	*Right.*
Fine.	*OK.*	*Well.*	*Exactly so.*	*Quite.*

That's a very interesting question.
Well, let me see …
Excuse me, I'm afraid I have to be going now. It was really a pleasure to talk to you.
That's very interesting, but I don't think it's really to the point.

4. Annotate the text in English. Use the phrases:

I.

a) The title of the article is...

It is written by prof... and published in London in the

journal..., No.3, vol.4, 2011 *magazine..., No.3, vol.4, 2011* *collection of articles ... by... editorial house in 2011* *book ... by... editorial house in 2011*	on pp.3-10

b) The article... by prof... is published in the journal..., in N.Y., pp.5-10.

II.

a) The article	*deals with* *discusses* *touches* *discloses* *is devoted to*	the problem of ...

The text tells us about ...

b) Disclosing the problem the author dwells on (upon) such matters as...

The major	*points* *matters* *problems* *issues*	of the text are the following: ...

c) The author	*pays special attention to ...* *draws readers' attention to ...*

Much *Great* *Special*	attention is paid to...

The author	*concentrates on, focuses on* *stresses, underlines, emphasises* *points out* *dwells on (upon)* *distinguishes between* *speaks in details* *gives the classification*

III.

a) As far as I am an expert in ... I

consider *believe* *suppose* *think* *guess*	the article to be of some (great) interest for …

b)	*In my opinion* *From my point of view* *To my mind*	the article is of	*great* *some*	interest for

the students in applied science *the specialists in...* *a wide range of readers*

5. Discuss the statements given below. It is advisable that the group be divided into three parties, each party choosing one of the statements and working on them independently. Seek your own sources of information:

1. It is easy to break firewalls. The way you break into a protected system is to fool it into making it believe you're an invited guest.
2. There are a few fundamental rules in the debugging checklist. Do you know how to debug a code? **Above all, think before acting!**
3. The hackers' activities and measures taken by state against the Internet criminals.

Writing

Write a short composition on "Microprogramming a computer is not the same as programming a microcomputer".

Extended reading

Text C. Boolean Algebra

Read and translate the text into Ukrainian at home. Sum up the main ideas of the text, following the outlines given below:

1. Boolean algebra is the algebra of sets.
2. The application of Boolean algebra to the design of computers.

3. The usage of the limited special type of Boolean algebra in cybernetics.

Express your appreciation of George Boole and write a composition "George Boole – the creator of an abstract algebra".

Boolean Algebra

One should know when and where the idea of laying down postulates for the manipulation of abstract symbols (not necessarily numbers) first occurred and who was the creator of such an abstract algebra (= who the creator of such an abstract algebra was). It occurred first in England and at about the time *of George Boole* (1815-1864), the English mathematician and logician. One can doubt whether Boolean algebra, i.e., the algebra of sets, studied largely by means of truth tables, has anything to do with computers; whether basic laws of ordinary algebra (commutative, associative and distributive) hold in Boolean algebra, etc. The most recent development in connection with Boolean algebra is its application to the design of electronic computers through the interpretation of Boolean combinations of sets as *switching circuits.* The answer to the question of what part of Boolean algebra is used so widely in cybernetics may surprise the uninitiated – the limited special type of Boolean algebra having only two elements in it which at first sight may seem impractical at all is the very one used too widely nowadays. The basic electronic device in the early computers was the vacuum tube which was turned off or on by the electric current entering the tube. Boolean logical product of two sets corresponds to a circuit with two switches *in series.* It is easy to realize when electricity flows in such a circuit – only if both the first and the second switches are closed. The logical sum of two sets corresponds to a circuit with two switches *in parallel.* The question whether electricity can flow in such a circuit has the following answer: electricity flows in such a circuit if either one or the other or both switches are closed. Telephone circuits and electronic computers are basically designed upon a system of Boolean symbolic logic.

The fundamental components of any digital computer are, thus, *switches* capable of two different states of transmission. The speed of the computer in its calculations is limited by the time, required for a switch to change states, among other factors. In general, it is desirable that a switch should consume as little power as possible. No switching computer circuit acts instantaneously. One may wonder what it means in practice. It means that there is a brief *delay* between the instant incoming signals appear on the input leads and the instant an outgoing signal appears on the output lead. In the days of vacuum-tube circuitry the delay was about 10 microseconds (millionths of a second). Some of today's circuits have a delay of the nanosecond (a billionth of a second). Large or small switching delay is a factor that affects the speed of a computation. Called delay time, it is represented by Δt. One may inquire how fast modern computers can add. Today they can add at a rate of 10 million calculations per second; it is not a limit of course. In a current electronic computer virtually all the switches are transistors, and even the fastest transistors now in use cannot be made to change states in less than about a nanosecond, or a billionth of a second. An optical device analogous to the transistor that has recently been developed can switch from one transmission state to the other in about a picosecond or a thousandth of a billionth of a second.

The three basic functions of a computer – arithmetic operations, logical operations and the storage of information or memory – are all done by devices that have two stable states. In arithmetic operations the two states represent the numerals 0 and 1 of the binary number system. In the evaluations of logical propositions the two states stand for *true* of *false.* The memory of the computer stores the results of arithmetic and logical operations in devices that occupy one of the two states. With the binary algebraic system a computer can evaluate the truth of propositions by making use of just three logical functions, which are usually referred to as the *ANDfunction,* the *ORfunction* and the *NOTfunction.* In the ANDfunction a statement is taken as true if *all* its components are true. In the ORfunction a statement is taken as true if any of its components is true. In the NOTfunction the truth value of a statement is reversed. More elaborate logical operations can be built out of the three basic functions, and so can arithmetic operations such as addition. Thus, a computer requires a device that can represent the values 0 and 1, or true or false in physical form that can be assembled into large-scale devices that perform the three logical functions. By combining transistors and other circuit elements, structures that carry out the AND, OR, or NOT functions can be assembled.

Reasonable operations are logical and math operations. Math operations include addition, subtraction, multiplication, division, taking square root, etc., and also more advanced math operations such as raising to a power, finding derivatives and integrating. Logical operations include comparing, selecting, sorting, matching, determining, the next instruction which is to be performed, etc.

4.	**1. Artificial Intelligence. It is Possible?** **2. Turing's Test.** **3. To be One with the Computer.** **4. Modal Verbs[1].**

Grammar Revision
Modal Verbs

В англійській мові є група дієслів **/can, may, must, should, need, have to..., be to.../**, які називаються модальними. Вони не мають усіх основних форм, властивих іншим дієсловам, і тому називаються недостатніми (Defective Verbs). Модальні дієслова не вживаються самостійно, а лише в сполученні з інфінітивом іншого дієслова.

Модальні дієслова не виражають дії або стану, а лише можливість, необхідність, бажаність, ймовірність, здатність виконання дії, позначеної інфінітивом.

Modal Verbs + have (done)

could have (done) is used to say that we had the ability or the opportuning to do smth. but did not do it.

*Eg.: We **could have gone** to the cinema last night but we decided to stay at home.*

couldn't have (done) is used to say that you wouldn't have been able to do it if you had wanted or tried to do it.

*Eg.: The football match was cancelled last week. Tom **couldn't have played** anyway because he was ill.*

must have (done) is used to express supposition.

*Eg.: The phone rang but I didn't hear it. I **must have been** asleep.*

needn't have (done) is used to say that someone did smth. but it wasn't necessary.

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[1] Навчальні завдання з розвитку граматичних навичок з англійської мови (теорія, тренувальні вправи, міні та рейтингові тести) для студентів 1-х курсів усіх спеціальностей РДТУ (Частина III). Рівне: РДТУ, 1999. – с. 30-31.

Eg.: Ann bought some eggs, but at home she found plenty of eggs. So she ***needn't have bought*** *any eggs.*

shouldn't have (done) is used to say that someone did a wrong thing.

Eg.: I'm feeling sick. I ***shouldn't have eaten*** *so much chocolate.*

should have (done) is used to say that someone didn't do it, but it would have been the right thing to do.

Eg.: You ***should have come*** *to the party yesterday.*

Modal Verb		Present Indefinite	Past Indefinite	Future Indefinite	Meaning
OBLIGATION	**must V**	He **must** do it. – **Must** he do it? – No, he **mustn't**. (No, he **needn't**).			Необхідність, обов'язок зробити щось.
	have to V	He **has to** do it. He **doesn't have to** do it. **Does** he **have to** do it?	He **had to** do it. He **didn't have to** do it. **Did** he **have to** do it?	He'll **have to** do it. He **will not have to** do it. **Will** he **have to** do it?	Необхідність, обов'язок, що виникає через обставини.
	be to V	He **is to** do it. He **isn't to** do it. **Is** he **to** do it?	He **was to** do it. He **wasn't** do it. **Was** he **to** do it?	He **will be to** do it. He **will not be to** do it. **Will** he **be to** do it?	Необхідність, обов'язок, що виникає через обставини.
	should V	He **should** do it.			Порада.
ABILITY	**can V**	**He can** do it. **He can't** do it. **Can** he do it?	He **could do it.** He **couldn't** do it **Could** he do it?		Можливість, вміння виконати дію.
			Could you give me a book?		Ввічлива форма прохання.
	be able to V	He **is able to** do it. He **isn't able to** do. **Is** he **able to** do it?	He **was able to** do it. He **wasn't able to** do it. **Was** he **able to** do it?	He **will be able to** do it. He **will not be able to** do it. **Will** he **be able to** do it?	Бути спроможним щось зробити.

Modal Verb		Present Indefinite	Past Indefinite	Future Indefinite	Meaning
PERMISSION	may V	He **may** do it. He **may not** do it. **May** he do it?	**He might** do it.		Дозвіл, прохання виконати дію. Припущення.
	be allowed to V	He **is allowed to** do it. He **isn't allowed** to do it. **Is** he **allowed to do** it?	He **was allowed to do it.** He **wasn't allowed to** do it. **Was** he **allowed to** do it?	He **will be allowed to** do it. He **will not be allowed to** do it. **Will** he **be allowed to** do it?	Дозвіл виконати дію.

Text A. Artificial Intelligence. Is it Possible?

Pre-text Exercises

1. Before reading the text, read the following questions. Do you know the answers already? Discuss them briefly with other students to see if they know the answers. The questions will help to give a purpose to your reading:

– Do you know what is meant by the term “artificial intelligence”?
– Do you know when the term “artificial intelligence” was adopted?
– Are we intelligent enough to understand intelligence?

2. Learn to recognize international words:

intelligence, specialist, human, hypothesis, extreme, complex, individual, prevent, problem, decade, function, absolute, sphere, logical, image, to base, to constitute, perception, to observe, to transform, decade, modeling, process, expert, program, practical, cr eative, memory, to compare, intensive, robot, enthusiast, moment, control.

Read and translate the text:

Artificial Intelligence. Is it Possible?

Some computer specialists claim that it is impossible to develop artificial intelligence in principle. The human brain is a very sophisticated system composed of billions of interconnected cells. Each cell is extremely complex in itself. A rather plausible hypothesis says that an individual cell processes the signals penetrating it like a computer. Therefore, even the most sophisticated machine we may imagine, cannot even be compared to the human brain. There is one other problem that prevents an answer in the affirmative, namely (viz.), the decade-old discovery that the two hemispheres of the human brain have different functions. Each hemisphere has its own, absolutely different method of thinking. One hemisphere thinks *logically,* the other – in images. Our thinking is based on two types of perception of the world around us – the sensual – subconscious and the conscious. What a human being is conscious of and can, therefore, express in words, constitutes only a small part of the work done by the brain.

It is impossible to observe thinking processes directly. We can only judge them indirectly, studying how information delivered to the brain is transformed. That is why so little is known about what is going on in the "imaginative" hemisphere. Without that it is impossible to develop an intelligence even vaguely resembling the brain. The world of feelings, distress or emotions, which are of such importance to human thinking and behaviour, is as yet inaccessible to us. A machine, in general, cannot think either logically or figuratively. That is a function innate only in live, highly-organized matter. Still, there are people including some well-known scientists, who believe that artificial intelligence will not only be developed but will exceed human intelligence in power. They even set the time limit for this – the early decade of the 21st century. Others try to assure that artificial intelligence has already been created. "It is the reality nowadays," they claim.

The modeling of creative processes gave birth to the term "artificial intelligence". But that does not mean that the computers possess it. The "intelligence" has been "packaged" in it by an expert who developed the program for solving some practical creative problem. Man differs from the machine in that he does not simply fulfill the programs stored in his memory but also develops them himself, depending on the goals facing him. One of the trends in "artificial intelligence" now being intensively developed is to design "thinking robots" capable of a certain amount of independent activities. Enthusiasts expect such machines to appear any moment now. But we should hope this to happen in the near future. Robots will continue to work for a long time as yet in conditions where man has to step in and take control of certain stages.

Active Vocabulary

to claim	стверджувати; заявляти
artificial intelligence	штучний інтелект
brain	головний мозок
sophisticated	складний, ускладнений
interconnected cells	взаємопов'язані клітини
plausible	правдоподібний, вірогідний
to penetrate	проникати всередину; проходити скрізь; пронизувати
therefore	тому, отже
imagine	уявляти, припускати
to compare	порівнювати, уподібнювати
to prevent	запобігати, попереджати
affirmative	твердження, заява
namely *viz. (лат. videlicet)	саме, тобто
discovery	відкриття
hemisphere	півкуля; півкуля головного мозку
thinking	мислячий, розумний; роздум, думка; погляди, концепції, мислення
perception	сприйняття, відчуття, усвідомлення, розуміння
sensual	чуттєвий
subconscious	підсвідомий
conscious	свідомий
human being	людина
constitute	складати, засновувати, призначати
to observe	спостерігати, помічати, вести наукові спостереження
to judge	вирішувати, оцінювати, судити, рахувати, вважати
to deliver	передавати
vaguely	невизначено
resemble	нагадувати
distress	горе, страждання, нещастя
behaviour (behavior)	поведінка
inaccessible	недоступний, недосяжний
innate	природний, природжений

matter	матерія, речовина
exceed	перевищувати, переходити межі
power	здатність; сила; потужність, енергія
to assure	запевняти, завіряти
to create	творити, створювати
to fulfill	виконувати, здійснювати
trend	загальний напрям, тенденція
certain	визначений, певний
stage	фаза, стадія, період, етап
to step in	увійти, включитися в справу

Grammar and Vocabulary Exercises

1. Look through the text and find sentences with Modal Verbs. Translate them into Ukrainian.

2. Insert Modal Verbs *can, may, must, should* **or their equivalents in the necessary tense-form:**

1. Information or data … be stored in the computer's memory or storage.
2. An analogue computer … to calculate by using physical analogue of numerical measurements.
3. Your scientific article on computers … be published at our University.
4. Every student of our speciality … to know what a hybrid computer is.
5. You … know the difference between the digital and analogue computers.
6. Not all math problems … be solved right away.
7. For a digital computer information … to be in the form of digits or numbers.
8. This question of extreme complication … , in my opinion, simply be ignored.
9. I … make a remark about what is meant by a "fluctuation".
10. A very large fluctuation is needed because a tiny compartment … to be passed through just where the arrows cross over between B and A.
11. The phase-space points that belong to a single compartment … to be regarded as "indistinguishable" from one another.

3. Choose the proper equivalents of the Modal Verbs:

1. She (їй доведеться) to give a reason and possible justification for the restriction.
2. We (маємо) to find a good approximation to the number π value.
3. He (йому слід) specify the conditions of the experiment.
4. They (їм дозволяють) to use a dictionary if necessary.
5. I (у змозі) to solve this difficult problem myself.
6. You (змушені) to exercise all your ingenuity and fulfil the task.
7. They (потрібно) to check all the calculations again.
8. We (нам слід) to satisfy the requirements for the solution.
9. She (не потрібно) to refer to her failure with the task now.
10. The students (повинні) to appreciate the ancient maths in a proper way.

4. Underline the affixes, state what part of speech they indicate and translate the following words into Ukrainian:

penetrating, different, thinking, logically, perception, sensual, subconscious, being, directly, imaginative, impossible, resembling, feeling, inaccessible, figuratively, highly, solving, depending, intensively, independent.

5. Give the Ukrainian equivalents of the following words and word-combinations:

hemisphere, perception, sensual, subconscious, resemble, distress, inaccessible, innate, conscious, matter, exceed, brain, interconnected cells, plausible, certain, step in, penetrating.

6. Use the words from Ex. 5 to complete the following sentences:

1. Each … has it's own method of thinking.
2. Our thinking is based on two types of … of the world around us – the … – subconscious and the conscious.
3. Artificial intelligence will not only be developed but will … human intelligence in power.
4. The human … is a very sophisticated system composed of billions of … … .
5. A rather … hypothesis says that an individual cell processes the signals … it like a computer.

7. Give the English equivalents of the following words and word-combinations:

штучний інтелект; головний мозок; складний; підсвідомий; нагадувати; поведінка; недоступний; сприйняття; взаємопов’язані клітини; півкуля; запевняти; природний; спостерігати; тому; людина; свідомий.

8. Look through the text and find synonyms to the following words and word-combinations:

complex; to assert; probable; to pass through; man; man-made; to own; to consist of; to execute; reason; to found.

9. Look through the text and find antonyms to the following words and translate them into Ukrainian:

nonsense, natural, simple, collective, ruin, reduce, phantom, weakness.

10. Combine the words from the left-and right-hand columns to make word-combinations. Translate them into Ukrainian:

computer	process
artificial	program
human	intelligence
interconnected	cells
plausible	stages
thinking	matter
highly-organized	brain
creative	specialist
certain	hypothesis

11. Compose sentences with the words and word-combinations from Ex. 10.

Reading Comprehension

1. Review the whole text again. Outline the subject matter of the text, its components structure, topic sentences and main ideas. Use the following phrases:

– The text deals with … (speaks about, presents, shows, points out, discusses, reviews, throws light on, traces the history of, etc)

– The subject matter of the text is ...

– The text can be segmented into ... paragraphs.

– The first (second, third, fourth, etc.) paragraph considers ... (deals with, informs of, describes, etc.)

– The topic sentence of the first (second, third, fourth, etc.) paragraph is ...

– The main idea of the first (second, third, fourth, etc.) paragraph is ...

– The main idea of the text is ...

– The conclusion the author came to is ...

– The reasons for this conclusion are ...

2. Say whether the following statements are true or false. Justify your choice. Use the given phrases:

It's right. Quite so.
I quite (fully) agree to it.
Certainly. Exactly.
I doubt that ...
I don't think so.
This is not the case.
It's wrong, I am afraid.
Quite the reverse.
The definition is inappropriate.

1. It is impossible to develop artificial intelligence in principle.
2. The most sophisticated machine can be compared to the human brain.
3. The two hemispheres of human brain have different functions.
4. Our thinking is based on three types of perception of the world around us.
5. We can observe thinking processes indirectly.
6. A machine, in general, cannot think either logically or figuratively.
7. Artificial intelligence is the reality nowadays.
8. The computers possess artificial intelligence.

3. Study the text and answer the following questions:

1. What is the human brain?
2. Can even the most sophisticated machine we may imagine be compared to the human brain?

3. What method of thinking does each hemisphere have?

4. What types of perception is our thinking based on?

5. Is it possible to observe thinking processes directly?

6. Why is the world of feelings, distress or emotions, which are of such importance to human thinking and behaviour as yet inaccessible to us?

7. Can a machine think?

8. Is the process of thinking a function innate only in live highly-organized matter?

9. What do some well-known scientists claim as for the development of artificial intelligence?

10. What gave birth to the term "artificial intelligence"?

11. Do the computers possess artificial intelligence? How do they solve some practical creative problems if they don't possess it?

12. What differs man from the machine?

13. What is one of the trends in artificial intelligence being intensively developed now?

Conversational Practice

1. Agree or disagree with the statements given below. Use the introductory phrases and develop the idea further. Use the following phrases:

I hold a similar view …
I share this viewpoint …
It's correct to say …
This is a convincing argument …
I see no point at all to disagree that …
There is no point in denying that …
That doesn't sound convincing enough …
Not quite so, I am afraid.
I don't think this is just the case.
I doubt it. Far from that.
Just the other way round.
Not at all. Quite the reverse.

1. Different levels of human intellect were being modeled.

2. For a long time mathematicians did not try to treat matters of perception mathematically.

3. A worker in artificial intelligence seeks to design sophisticated information-processing machines that parallel human intellectual behaviour or brain function.

4. The design of correct *AI* parallels the structure of human brain.

5. Robots – mechanical intelligence capable of operating in our own real world environment – are widely employed in science and engineering.

2. Choose the definition of artificial intelligence which, to your mind, is the correct one. Justify your choice:

1. *AI* – is a science of robots.

2. *AI* – is an experimental science which employs computer as a means of modeling to perceive the nature of the human thinking.

3. *AI* – is a science that designs machines to make what a man consider intellectual when he is making the same.

4. *AI* – is the area concerned with programming computers to behave in an intelligent way.

3. Debate the given statement. It is advisable that the group be divided into two parties, each party advocating their viewpoint. Use the following introductory phrases:

I will start by saying (claiming) that …
What I mean to say is …
You are free to disagree with me but …
My point is that …
Much depends on who (when, what, how) …
I'd like to make it clear …

The field of *AI* exhibits a recurring pattern: early dramatic success followed by unexpected difficulties and failures. This pattern occurs in all basic areas of *AI* (problem-solving, game-playing, language-translation and pattern-recognition) in two phases, each lasting roughly five years. The reasons, to your mind?

4. Give a short summary of the text.

Text B. Turing's Test

1. Read and translate the text:

Are we intelligent enough to understand intelligence? One approach to answering this question is *artificial intelligence (AI),* the field of computer science that studies how machines can be made to act intelligently. "Artificial intelligence" is the ability of machines to do things that, people claim, require intelligence. *AI* research is an attempt to discover and describe aspects of human intelligence that can be simulated by machines.

The classical experiment proposed for determining whether a machine possesses intelligence on a human level is known as *Turing's test,* after A. M. Turing, who pioneered research in computer logic, undecidability theory and *AI.* This experiment has yet to be performed seriously, since no machine yet displays enough intelligent behaviour to be able to do well in the test. Still Turing's test is the basic paradigm for much successful work and for many experiments in machine intelligence. Basically, the test consists of presenting a human being *A* – human interrogator with a typewriter-like or TV-like terminal, which he can use to converse with two unknown (to him) sources, *B* and *C* The interrogator *A* is told that one terminal is controlled by a machine and that the other terminal is controlled by a human being he has never met. *A* is to guess which of B and C is the machine and which is the person. If *A* cannot distinguish one from the other with significantly better than 50% accuracy, and if this result continued to hold no matter what people are involved in the experiment, the machine then, it is claimed, *simulates* human intelligence.

Active Vocabulary

ability	interrogator
accuracy	paradigm
approach	propose
artificial	require
attempt	research
determine	theory
distinguish	to guess
intelligence	to possess
intelligent	undecidability

2. Answer the following questions:

1. Are we intelligent enough to understand intelligence?
2. What are the two approaches to answering the question what artificial intelligence is?
3. How do they call the classical experiment for determining?
4. What research did Alan Turing pioneer?
5. Had machine displayed intelligent behaviour before Turing's test was applied?
6. What is the basic paradigm for displaying successful intelligent behaviour of a machine?
7. What does the test consist of?
8. What is the interrogator A told?
9. What is A to guess?
10. What accuracy percentage is needed to claim the machine simulates the human intelligence?

3. Reconstruct the text "Turing's test" into a dialogue.
The main rules governing a conversation in English:

The person who asks questions in a conversation usually controls it. Personal questions should be expressed tactfully.

Excuse me for asking.
I hope you don't mind asking, but I'd like to know more about …
Could you tell me a bit more about …
Sorry, I don't quite understand.
What (exactly) do you mean?
Can you explain it in more detail, please?
Excuse me, can I interrupt you for a moment?
Hold on, please.
Just a moment, please.
Don't you agree that …
Sorry, could you say that again (please)?
Sorry, could you repeat that?
Oh, you know what I mean.
Can you guess what I said, etc.

Sure.	*I know.*	*I see.*	*Really.*	*Right.*
Fine.	*OK.*	*Well.*	*Exactly so.*	*Quite.*

That's a very interesting question.
Well, let me see …

Excuse me, I'm afraid I have to be going now. It was really a pleasure to talk to you.

That's very interesting, but I don't think it's really to the point.

4. Annotate the text in English. Use the phrases:

I.

a) The title of the article is...

It is written by prof... and published in London in the

journal..., No.3, vol.4, 2011 *magazine..., No.3, vol.4, 2011* *collection of articles ... by... editorial house in 2011* *book ... by... editorial house in 2011*	on pp.3-10

b) The article... by prof... is published in the journal..., in N.Y., pp.5-10.

II.

a) The article	*deals with* *discusses* *touches* *discloses* *is devoted to*	the problem of ...

The text tells us about ...

b) Disclosing the problem the author dwells on (upon) such matters as...

The major	*points* *matters* *problems* *issues*	of the text are the following: ...

c) The author	*pays special attention to ...* *draws readers' attention to ...*

Much *Great* *Special*	attention is paid to...

The author	*concentrates on, focuses on* *stresses, underlines, emphasises* *points out* *dwells on (upon)* *distinguishes between* *speaks in details* *gives the classification*

III.

a) As far as I am an expert in ... I

consider *believe* *suppose* *think* *guess*	the article to be of some (great) interest for …

b)

In my opinion *From my point of view* *To my mind*	the article is of	*great* *some*	interest for

the students in applied science *the specialists in...* *a wide range of readers*

5. Discuss the problems. The following phrases may be helpful:

I am confirmed in my opinion that…
I will start by saying that …
My own viewpoint is that…
It can (not) be denied that…
I can't give you a definite answer yet…
As far as I am concerned…
I have reason to believe that…

A. Turing's question "Can the machine think?" should be paraphrased: "How can humans use the machines to help themselves think or learn?"

A. Turing's test still changes the imaginative people, because it is practical. Any other reason?

"We may hope that machines will eventually compete with man in all purely intellectual fields" (A.Turing, 1950.) Was Turing right?

6. Summarize the text briefly.

Writing

Using texts A and B of Unit 4 write a presentation about AI and Turing's test.

Extended reading

Text C. To be One with the Computer

Read and translate the text into Ukrainian at home. Write an abstract (précis) of the text in English. Express your appreciation of cybernetics' scope, range and applications. Give your comments and assessment of the experiment described in the text. Reproduce it in class.

To be One with the Computer

In August 1988 *a silicon chip* was implanted in cybernetics pioneer *Kewin Warwick* to check up whether it can upgrade the human body. "I, Robot, starting with myself," thus he started his narrative. "A silicon chip, implanted in my arm, allowing a computer to monitor me as I moved through the halls and offices of the Department of Cybernetics at the University of Reading, just west of London, where I've been a professor since 1988. My implant communicated via *radiowaves* with a network of antennas throughout the Department, that in turn transmitted the signals to a computer programmed to respond to my actions. At the main entrance, avoid box operated by the computer, said *"Hello",* when I entered. The computer detected my program through the building, opening the door to my lab for me as I approached it and switching on the lights. For the *nine days,* the implant was in place; I performed seemingly magical acts simply by walking in a particular direction. The aim of this experiment was to determine whether information could be transmitted *to or from* an implant. Not only did we succeed, but the trial demonstrated how the principles behind *cybernetics* could perform in real-life applications.

I am going to conduct soon a follow-up experiment with a new implant that will send signals *back and forth between my nervous system and a computer.* I don't know how I will react to unfamiliar signals transmitted to my *brain,* since nothing quite like this has ever before been attempted. But if this new test succeeds, with no complications, then we will go ahead with the placement of a similar implant in my partner. I am most curious to find out whether implants could open up a whole new range of *senses,* e.g., we can't normally process signals like *ultraviolet, X-rays,* or *ultrasound. Infrared* detects visible *heat* given off by a warm body, though our eyes can't see light in this part of the spectrum. But what if we fed infrared signals into the nervous system, by-passing our eyes. Would I be able to learn how to perceive them? Would I feel or even "see" the warmth? Or would my brain simply be unable to cope? We don't have any idea – yet. It is for the future to answer it.

The potential for medical breakthroughs in existing disabilities is phenomenally important. Might it be possible to add an extra route for more senses or to provide alternative pathways for *blind* and *deaf* people to "see" or to "hear" with ultrasonic or infra-red wavelengths? Perhaps, a blind person could navigate around objects with ultrasonic radar much the way bats do. Robots have already been programmed to perform this action and neuroscientists have not dismissed the idea for the humans. But few people, for the time being, have ever had their nervous systems linked to a computer so the concept of sensing the world around us using more than our natural abilities is still science fiction. I am hoping to change that. I plan to keep my next implant in place for a week, possibly up to two weeks. If the experiments are successful, we would then place implants into two persons *at the same time.* We would like to send movement and emotion signals from one person to the other, possibly via *the Internet.* We would also like to demonstrate how the signals could be sent over the Internet. How far could we go in transmitting *feelings* and *desires?* I want to find it out in my future experiments.

I can envision the future when we send signals so that we don't have *to speak. Thought communication* will place telephones firmly in the history books. Philosophers point to *language* in humans as being an important part of our culture and who we are. Certainly, language has everything to do with human development. But language is merely a tool we use to translate our *thoughts.* In the future we won't need to code thoughts into language – we will uniformly send symbols, ideas and concepts without speaking. We will probably become less open, more able to control our feelings and emotions – which will also become necessary, since others will more easily be able to access what we are thinking or feeling. We will still fall back on speech in order to communicate with our *newborns,* however, since it will take a few years before they can safely get implants of their own, but in the future, *speech* will be what baby talk today.

Thought-to-thought communication is just one feature of *cybernetics* that might become vitally important to us as we face the distinct possibility of being superseded by highly intelligent machines. Humans are crazy enough not only to build machines with an overall intelligence greater than our own, but deter them and give them power that matters. So how will humans cope with machines more intelligent than us? Here again, I believe cybernetics can help. Linking people via *chip implants* directly to those machines seems a natural progression, a potential way of harnessing machine intelligence by, essentially, creating *superhumans.* Otherwise, we are doomed to a future in which intelligent machines rule and humans become second-class citizens.

But once a human brain is connected as *a node* to a machine – a networked brain with other human brains similarly connected – what will it mean to be human? Will we evolve into a new cyborg community? I believe humans will become cyborgs and no longer be *stand-alone entities.* What we think is possible will change in response to what kinds of abilities the implants afford us. Looking at the world and understanding it in many dimensions, *not just three,* will put a completely different context on *how we* – whatever "we" are – *think.* I base this on my own experience with my first implant, when I actually became emotionally attached to a computer. It took me only a couple of days to feel like *my implant was one with my body.* The computer and I were not one, but neither were we separate. We each had our own distinct but complimentary abilities. With the new implant, I expect this feeling of connectedness to be much stronger, particularly when emotional signals are brought into.

From a medical viewpoint, I was pleased when the first implant was taken out, but I was otherwise quite upset – I felt as though a friend had just died. Morals and ethics are an outgrowth of the way in which humans interact with each other. Cultures may have diverse ethics, but regardless, individual liberties and human life are always valued over and above machines. What happens when humans merge with machines? Maybe the machines will then become more important to us than another human life. Those who have become cyborgs will be one step ahead of humans. And just as humans have always valued themselves above all other forms of life, it is likely that cyborgs will look down on humans who have yet to "evolve". Since childhood I have been captivated by the study of robots and cyborgs. Now I'm in a position where I can actually become one."

5.

1. The World of Hypotheses. Was Einstein Right?
2. Gravitation.
3. Revisiting the Big Bang.
4. Sequence of Tenses[1].

Grammar Revision

Sequence of Tenses

$S_1 + V_1$	(that)	$+ S_2 +$	Present/Past/Future Indefinite Present/Past/Future Continuous Present/Past/Future Perfect

$S_1 + V_2$	(that)	$+ S_2 +$	Past Indefinite / Continuous
			Past Perfect
			Future-in-the-Past

$S_1 + V_2$	what where if whether	$+ S_2 +$	Past Indefinite Past Continuous Past Perfect Future-in-the-Past

Вказівні займенники й прислівники часу в прямій мові заміняються в непрямій мові відповідно змісту таким чином:

this, these	→	that, those
now	→	then
today	→	that day
tomorrow	→	the next day
the day after tomorrow	→	two days later
yesterday	→	the day before
the day before yesterday	→	two days before
last week / year	→	the previous week / year
ago	→	before
next year	→	the next year, the following year
here	→	there

[1] Навчальні завдання з розвитку граматичних навичок з англійської мови (теорія, тренувальні вправи, міні та рейтингові тести) для студентів 1-х курсів усіх спеціальностей РДТУ (Частина III). Рівне: РДТУ, 1999. – с. 26-29.

Text A. The World of Hypotheses. Was Einstein Right?

Pre-text Exercises

1. Before reading the text, read the following questions. Do you know the answers already? Discuss them briefly with other students to see if they know the answers. The questions will help to give a purpose to your reading:

– Do you know that there exist many theories of gravitation sometimes flatly contradicting one another?

– Why is it important to understand processes in a microcosm?

– Do you know what equations are used to compute the gravitational field of space objects?

2. Learn to recognize international words:

universal, gravitation, traditional, curvature, phenomenon, cosmic, existence, process, microcosm, quantum, sensation, characterize, discussion, conference, symposium, idea, elementary, general, experiment, astrophysicist, computer, object, fundamental, problem, energy, academician, determine, homogeneous, attraction, condition, physical, electromagnetic, method, antagonistic, element, galaxy, evolution, mass.

Read and translate the text:

The World of Hypotheses. Was Einstein Right?

The universal law of gravitation is claiming more and more attention from scientists. When Newton described gravitation for the first time, he gave science the law of universal gravitation. Einstein "exploded" traditional classical notions about it, linking gravitation with the curvature of space with his general theory of relativity. In both cases gravitation was seen as a phenomenon of a cosmic scale, since gravitational fields are "perceptible" only with the existence of huge masses. Now scientists hope that it may provide a key to understanding processes in a microcosm, at the quantum level. It is at the junction of quantum and gravitational ideas that science can expect to make the most sensational discoveries. This expectation characterized gravitationalists' discussions at the 6th All-Union Gravitational Conference and at symposiums in Moscow and Leningrad (1984). What ideas do scientists have who are trying to connect the gravitational processes of the universe with the world of elementary particles?

The general theory of relativity, which is being brilliantly confirmed by experiments, the equations of which are used by astrophysicists to compute the gravitational fields of space objects, possesses fundamental difficulties which are not clarified to this day. The chief one is the problem of determining the energy of the gravitational field. In the framework of Einstein's theory this question remains a veritable "headache" for scientists. Opinions on how exactly to compute this energy invariably differ. Recently Academician *A. Logunov* and Professor *M. Mestvirishvili* advanced a new theory of gravitation, in which the energy of the gravitational field can always be determined. Unlike Einstein, Logunov and Mestvirishvili maintain that our world is homogeneous, while gravitational attractions in it are conditioned not by the curvature of space but by some physical force field like the electromagnetic field. They draw on the methods used in the field theory of elementary particles.

What is to be done with the equations of the general theory of relativity which faithfully serve science? Are they not in antagonistic contradiction with Logunov and Mestvirishvili's theory? In fact, they are not. They are perfectly consistent with it if another four equations are added. Moreover, the curvature of space, which is the main element for Einstein, plays only a secondary part in the new theory. It is interesting to note that all the experiments, which hitherto corroborated the general theory of relativity, also confirm Logunov and Mestvirishvili's theory.

So, what does the universe look like according to the new theory? Einstein's theory allows for the existence of different models of the universe – "open", "closed", etc. – but Logunov and Mestvirishvili allow for only one model. Their universe can only be "flat". This, in turn, presupposes the existence in it of some concealed, unobservable mass. Surpassing the mass of all galaxies taken together many times over, this invisible mass ensures the evolution of the universe as a flat world. As often happens with new theories, Logunov and Mestvirishvili's theory is hostilely being received by many gravitationalists. However, it is mathematically correct, not open to doubt. Nor is it at variance with known experimental data. To solve the question of which is correct – Einstein's general theory of relativity or the theory advanced by Logunov and Mestvirishvili – there will have to be more experiments.

Active Vocabulary

explode	підривати(ся), розбивати, підривати (віру, підвалини)
link	сполучати, зв'язувати
curvature	викривлення, кривизна
scale	рівень; ступінь розвитку; шкала
huge	величезний, гігантський
perceptible	відчутний, помітний
junction	з'єднання, поєднання
expectation	очікування
relativity	відносність; теорія відносності
confirm	підтверджувати
equation	рівняння
condition	обумовлювати
framework	основа, рамки, межі, структура
draw on	наступати, наближатися
veritable	справжній, істинний
invariably	незмінний, обов'язковий
maintain	містити, зберігати, обслуговувати
homogeneous	однорідний, гомогенний
attraction	тяжіння; краса; привабливість
faithfully	вірно, чесно
contradiction	спростування, суперечність, протилежність, контраст
hitherto	раніше, дотепер
corroborate	підтверджувати, підкріплювати
according to	згідно з, відповідно; пропорційно
flat	плаский, рівний
allow	дозволяти, брати до уваги
conceal	приховувати, ховати
presuppose	припускати
surpass	перевершувати; перевищувати
invisible	невидимий, незримий
consistent	послідовний, стійкий
however	однак, проте
hostile	ворожий, чужий
doubt	сумнів
hypothesis (pl. -theses)	гіпотеза, припущення

Grammar and Vocabulary Exercises

1. Look through the text and find Complex Sentences. Translate them into Ukrainian.

2. Join the two simple sentences to make a complex sentence. Mind the sequence of tenses rule:

1. I said. The successful use of computers has been reported in economy.
2. I have already said. The next generation of computers will not operate with digit numbers.
3. I was saying. Supercomputers will display wonders.
4. I have been saying up to now. Man-and-computer systems are capable of accomplishing.

3. Turn the following statements into indirect speech:

1. He said: "There is no realm of human activity in which cybernetics will have no role to play in the future."
2. He asked: "Is it difficult to say what the future holds in store for cybernetics?"
3. He claimed: "N.Wiener's definition of cybernetics is still generally being accepted."
4. He asked: "Who was the first to use the term describing the science of steering ships?"
5. He said: "N.Wiener has laid the foundations of the new science and coined the title "Cybernetics"."

4. Define meanings of the following words by their affixes:

universe – universal; tradition – traditional; gravity – gravitation – gravitational; element – elementary; sensation – sensational; discover – discovery; expect – expectation; connect – connection; general – generalization – generalized; equal – equality – equally – equation; to compute – computation – computable – computer; exact – exactly; hostile – hostilely; relative – relativity.

5. Study the text and give Ukrainian equivalents for the following words and word-combinations:

the universal law of gravitation; traditional classical notions; the curvature of space; general theory of relativity; a phenomenon of a cosmic scale; gravitational fields; huge masses; the quantum level;

sensational discoveries; the gravitational processes of the universe; elementary particles; equation; space objects; fundamental difficulties; homogeneous; gravitational attractions; physical force field; electromagnetic field; to draw on; antagonistic contradiction; consistent; presuppose; unobservable mass; surpass; experimental data; to solve the question.

6. Study the text and give English equivalents for the following words and word-combinations:

закон гравітації; традиційні поняття; викривлення простору; явище космічного масштабу; гравітаційне поле; квантовий рівень; поєднання ідей; сенсаційні відкриття; елементарні частки; гравітаційні тяжіння; електромагнітне поле; рівняння; суперечність; приховувати.

7. Give sentences in English using the following words and word-combinations:

1. “зруйнувати” традиційні класичні уявлення; 2. існування величезних мас; 3. розуміння процесів у мікрокосмосі; 4. світ елементарних часток; 5. підтверджуватися експериментами; 6. космічні об’єкти; 7. підтримувати; 8. гравітаційні тяжіння; 9. однорідний; 10. поле фізичної сили; 11. антагоністичні суперечності; 12. послідовний; 13. маса всіх галактик; 14. сумнів.

8. Combine the words from the left-and right-hand columns to make word-combinations. Translate them into Ukrainian:

universal	world
general	level
homogeneous	particles
gravitational	law
different	models
invisible	scale
cosmic	theory
quantum	mass
elementary	attractions

9. Give sentences in English using the word-combinations from Ex. 8.

Reading Comprehension

1. Review the whole text again. Outline the subject matter of the text, its components structure, topic sentences and main ideas. Use the following phrases:

– The text deals with … (speaks about, presents, shows, points out, discusses, reviews, throws light on, traces the history of, etc)

– The subject matter of the text is …

– The text can be segmented into … paragraphs.

– The first (second, third, fourth, etc.) paragraph considers … (deals with, informs of, describes, etc.)

– The topic sentence of the first (second, third, fourth, etc.) paragraph is …

– The main idea of the first (second, third, fourth, etc.) paragraph is …

– The main idea of the text is …

– The conclusion the author came to is …

– The reasons for this conclusion are …

2. Say whether the following statements are true or false. Justify your choice. Use the given phrases:

It's right. Quite so.
I quite (fully) agree to it.
Certainly. Exactly.
I doubt that …
I don't think so.
This is not the case.
It's wrong, I am afraid.
Quite the reverse.
The definition is inappropriate.

1. The universal law of gravitation is claiming more and more ignorance from the scientists.

2. Einstein linked gravitation with the curvature of space with his general theory of relativity.

3. Gravitation was seen as a phenomenon of a microcosm.

4. Gravitation may provide a key to understanding processes in a microcosm at the quantum level.

5. The most sensational discoveries resulted at the junction of quantum and gravitational ideas.

6. The scientists try to connect the gravitational process of the universe with the world of elementary particles.

7. The general theory of relativity possesses fundamental difficulties which are not clarified to this day.

8. Opinions on how exactly to compute the energy of the gravitational field do not differ.

9. Unlike Einstein, Logunov and Mestvirishvili maintained that our world is homogeneous.

10. The curvature of space which is the main element for Einstein plays a primary part in the new theory.

11. Einstein's theory allows for the existence of different models of the universe, –"open", "close" and "flat".

12. The new theory of gravitation is hostilely being received by many gravitationalists.

3. Answer the following questions:

1. Is the universal law of gravitation claiming more and more attention from the scientists?

2. Who gave science the law of universal gravitation?

3. What did Einstein do linking gravitation with the curvature of space with his general theory of relativity?

4. When are gravitation fields "perceptible"?

5. What may provide a key to understanding processes in a microcosm at the quantum level?

6. What ideas science can expect will make the most sensational discoveries?

7. What causes the difficulties in computing the gravitational fields of space objects?

8. What question remains a veritable "headache" for scientists?

9. Who advanced a new theory of gravitation?

10. What are gravitational attractions conditioned by according to Logunov and Mestvirishvili's theory of gravitation?

11. What methods do they draw on?

12. Do the equations of the general theory of relativity contradict Logunov and Mestvirishvili's theory?

13. What is the main element in the theory of relativity for Einstein?

14. What part does it play in the new theory?

15. What confirms the new theory of gravitation?

16. How does the universe look like according to Einstein's theory and the new one?

17. What does the statement that universe can only be flat presuppose?

18. What ensures the evolution of universe as a flat world?

19. How is Logunov and Mestvirishvili's theory being received by many gravitationalists?

20. How is it possible to solve the question whose theory is correct?

Conversational Practice

1. Agree or disagree with the following statements. Begin your answer with the following phrases:

I hold a similar view …
I share this viewpoint …
It's correct to say …
This is a convincing argument …
I see no point at all to disagree that …
There is no point in denying that …
That doesn't sound convincing enough …
Not quite so, I am afraid.
I don't think this is just the case.
I doubt it. Far from that.
Just the other way round.
Not at all. Quite the reverse.

1. The general theory of relativity has numerous successors and competitors.

2. When Newton described gravitation for the first time, he gave science the law of universal gravitation.

3. Einstein's theory allows for the existence of different models of the universe – "open", "closed", etc. – but Logunov and Mestvirishvili allow for only one model. Their universe can only be "flat".

4. There are a few wise scientists who decline to favour one theory of gravitation over another. They attempt to study all the theories as a class, hoping thereby to unlock some of the secrets of gravitation in an unbiased manner independent of anyone particular theory.

2. Discuss the statements trying to prove your point of view. Use the following phrases:

I have to admit that…
I have reason to believe that…
My point is that…
It seems reasonable to assert that…
Summing up the discussion…
In conclusion, I may say…
To summarize, I may say…
To summarize the topic…

1. “The scientist must order. One makes science with facts as a house with stones; but an accumulation of facts is no more science than a pile of stones is a house.” (Poincare.) Prove or disagree.
2. “Newton was not only the greatest but the most fortunate among scientists, because the science of the world can be created only once, and it was Newton who created it.” (Lagrange.) Your viewpoint.

3. Give a short summary of the text.

Text B. Gravitation

1. Read and translate the text:

Gravitation

Gravity is a force that holds together the hundred billion stars of the Milky Way. It makes the Earth revolve around the Sun and the Moon around the Earth. There are three great names in the history of man's understanding of gravity: *Galileo* who was the first to study in detail the process of free and accelerated fall; *Newton,* the first to have the idea of gravity as a universal force. However, Newton admitted that he did not know its ultimate cause ("I will not feign hypothesis") but he offered many a keen guess at the nature and mechanism of gravitation; and *Einstein,* who said that gravity is nothing but the curvature of the four-dimensional space-time continuum.

In specifying gravitation on the new geometrical view Einstein did not prove "Newton's law of gravitation" wrong but offered a refining modification – though this involved a radical change in viewpoint. We must not think of either law as right (or wrong) because it is suggested by a great man or because it is embodied by beautiful maths; we are offered it as a brilliant guess from the real universe. The changes from Newton's predictions to Einstein's, though fundamental in nature, are usually too small in effect to make any difference in laboratory experiments or even in most astronomical measurements. By reducing gravity to geometrical properties of a space-time continuum, Einstein concluded that the electromagnetic field must also have some purely geometrical interpretation. The *unified field theory,* which grew from this conclusion had rough going and Einstein died without completing it. Some scientists claim that it is very odd indeed that the theory of gravitation originated by Newton and developed further by Einstein should stand now in majestic isolation, having nothing to do with the rapid development of other branches of science. This is not the case, however. The progress in quantum mechanics, modern cosmology and astrophysics makes this claim unjustified.

Active Vocabulary

accelerated fall	property
cause	rapid
interpretation	refine
keen	to admit
keen guess	to feign
measurement	to revolve
odd	ultimate
prediction	unjustified

2. Answer the following questions:

1. What force holds together the hundred billion stars of the Milky Way?
2. How many names are there in the history of man’s understanding of gravity?
3. Who was the first to study in detail the process of free and accelerated fall?
4. Who was the first to have the idea of gravity as a universal force?
5. Whom does the phrase “I will not feign hypothesis” belong to?
6. What did Newton offer?
7. What is the definition of gravity according to Einstein?
8. Did Einstein prove “Newton’s law of gravitation” wrong?
9. What did Einstein offer?

10. Do the changes from Newton's predictions to Einstein's make any difference in laboratory experiments?

11. How did Einstein reduce gravity and what conclusion did he come into?

12. What theory grew from this conclusion?

13. Did Einstein complete it?

14. What do some scientists claim?

15. What makes this claim unjustified?

16. Which theory (hypothesis) do you favour?

17. Why are you "for" or "against" a particular theory?

18. Are the advanced hypotheses presented in the text building a bridge from the universe to the microcosm or vice versa?

3. Reconstruct the text "Gravitation" into a dialogue.
The main rules governing a conversation in English:

The person who asks questions in a conversation usually controls it. Personal questions should be expressed tactfully.

Add new phrases to the previous ones:

Let's look at the whole problem/plan, etc. from a realistic point of view.

Don't forget about the other side of this problem.

I think I've missed some details concerning ...

Could you be a little more precise/specific?

I'd like to hear more about ...

I can't give you a definite answer yet.

4. Annotate the text in English. Use the phrases:

I.

a) The title of the article is...

It is written by prof... and published in London in the

journal..., No.3, vol.4, 2011
magazine..., No.3, vol.4, 2011
collection of articles ... by... editorial house in 2011
book ... by... editorial house in 2011

on pp.3-10

b) The article... by prof... is published in the journal..., in N.Y., pp.5-10.

II.

a) The article	*deals with* *discusses* *touches* *discloses* *is devoted to*	the problem of ...

The text tells us about ...

b) Disclosing the problem the author dwells on (upon) such matters as...

The major	*points* *matters* *problems* *issues*	of the text are the following: ...

c) The author	*pays special attention to …* *draws readers' attention to …*

Much *Great* *Special*	attention is paid to...

The author	*concentrates on, focuses on* *stresses, underlines, emphasises* *points out* *dwells on (upon)* *distinguishes between* *speaks in details* *gives the classification*

III.

a) As far as I am an expert in ... I

consider *believe* *suppose* *think* *guess*	the article to be of some (great) interest for …

b)	*In my opinion* *From my point of view* *To my mind*	the article is of	*great* *some*	interest for

a wide range of readers

Writing

Using texts A and B of Unit 5 write a presentation about different hypotheses concerning gravitation.

Extended reading

Text C. Revisiting the Big Bang

Read and translate the text into Ukrainian at home. Write an abstract (précis) of the text taking into account the following questions:

Why did all the preceding cosmological theories collapse in 1989?

What does the phrase "the big bang" in cosmology mean?

Has a "black body" been already detected or located in space?

How do cosmologists picture nowadays the location of most galaxies?

Is the manned mission into the orbit aboard the space shuttle possible?

Reproduce it in class.

1. One of the most perplexing – and intriguing – questions in astronomy is just how all the stars and galaxies visible in the night sky came to be there. Theories explaining this mysterious process abound, each more exotic than the next. But not long ago, many of them collapsed as astrophysicist flashed one simple graph summarizing the first results from NASA's Cosmic Background Explorer (COBE) satellite, launched in November 18, 1989.

2. COBE's instruments show that the primordial fireball that spawned the universe – popularly known as *the big bang* – apparently was a completely smooth explosion, sending radiation evenly into the nascent universe. This is not what most cosmological theorists expected to find. They anticipated perturbations, disturbances and "lumps" that would somehow metastasize later into galaxies and other great heavenly structures. "The important conclusion is, there isn't anything else there," said astronomers."Nothing."

3. *"Zone of Mystery."* That fundamental finding, along with other new discoveries, poses an enormous conundrum for cosmologists studying the origin, evolution and structure of the universe. COBE's remarkable instrument looked back to within a year after the big bang, farther back

in time than any astronomical instrument has ever gazed before, and found nothing but smoothness (COBE looks back in time by measuring faint radiation from the big bang that pervades the universe). Yet in November, California Institute of Technology astronomers reported that they had discovered the oldest quasar – an extremely bright object in a distant galaxy – ever seen, dating from a mere one billion years after the big bang. Something obviously happened during that time – a mere blink of the eye in cosmological terms – to cause the formation of the enormous celestial structures detectable from Earth. Theoreticians at this point simply cannot explain what occurred. "It's a zone of mystery," they claimed.

4. Previous models of the universe' evolution assumed the existence of several so-far-unseen phenomena: ancient black holes, "cosmic strings," "dark matter" and pregalactic explosions. But these phenomena require some lumpiness in the earliest radiation, which COBE failed to detect. "We're careering toward an absolutely contradictory situation," says Harvard cosmologists. Observations show that the universe is more lumpy than believed before, but the surprising smoothness of the early radiation does not lead logically to such observations. Five years ago, theoretical cosmologists had a lot of theories and no way to prove them right or wrong. Now, there are lots and lots of data and no viable theories.

5. Significantly, however, COBE did not knock out the big-bang theory itself; indeed, it confirmed it in its simplest formulation. The big-bang theory holds that the universe began 10 to 20 billion years ago as a superhot, dense fireball that rapidly expanded and then cooled to form the complex heavenly structures now seen. In 1965, this idea advanced by detecting the first direct evidence. They found weak background radiation that pervades the universe in all directions – radiation, that must have come from the original explosion has since cooled to about 3 degrees above absolute zero, and, like a fossil, it can reveal processes that shaped the explosion and its after math. Since the radiation is disturbed by the Earth's atmosphere, COBE was designed to fly above the atmosphere and measure the cosmic background radiation far more precisely than ever before.

6. The experiment is straightforward. A major instrument aboard COBE, called the Far Infrared Absolute Spectrophotometer, looks to see how the cosmic background radiation compares with that of a "black

body", a hypothetically perfect radiator that emits a completely smooth spectrum of energy. Before the satellite flew, Space Flight Center said that if deviations from a perfect black-body spectrum were found, that would indicate explosions or other phenomena took place in the early universe. Last year, in fact, a team of scientists from the University of California at Berkeley and Japan reported that they had seen substantial deviations using another instrument, touching off a flurry of scientific papers that attempted to account for it.

7. *No Missing Link.* Surprisingly, the data received so far from COBE "tell you the universe didn't even burp after it exploded", says John Bachall, a theoretical astrophysicist at the Institute for Advanced Study in Princeton, who found the results so "clear and beautiful that I had chills going up and down the back of my neck".

8. A second COBE experiment, mapping minute differences in the brightness of the background radiation across the sky, failed to detect any hint of galactic progenitors or other stellar objects even 300,000 years further on in the universe's evolution. The scientists were looking for "the missing link" that might explain what we know appeared later. But again nothing. Project scientists concede now that even if COBE reveals some cosmic ripple in the next year and a half, it will probably not be significant enough to explain the existing universe.

9. *More Mysteries.* COBE's remarkable new findings are not the only ones causing cosmologists theoretical difficulty. They have to contend also with recent discoveries of bigger, more massive structure than any previously known. These, too, are important to the understanding of the evolution of the universe. Most galaxies, it now appears, are on the walls of enormous bubble-like voids. Scientists have identified a sheet of galaxies 500-million-light years long, dubbed the "Great Wall", which is too big to fit into some theories of the universe's evolution. Astronomers confirmed the existence of an enormous gravitation source only 150 million light years from the Earth, called the "Great Attractor". With a mass equivalent to tens of thousands of galaxies, it appears to be pulling other galaxies, including the Milky Way, toward it. They suggest that the existence of such large structures – others are likely to be found – could be fatal to the notions of how matter clustered during the universe's development.

10. Ironically, the spectacular COBE's mission that promises to keep cosmologists busy for years to come almost didn't take place. It was

conceived in 1974 as NASA's first probe of the dawn of the universe and designed to fly into orbit aboard the space shuttle. But the Challenger tragedy scratched COBE from the shuttle schedule, even though the satellite had already been constructed. Scientists and engineers at Goddard persuaded NASA headquarters that they could change its design so it could fly on an expendable rocket. They managed the neat technical trick of preserving COBE's scientific capabilities while sweating the satellite's weight from 10,000 pounds to half of that. Then a series of nagging technical glitches delayed the launch. Now COBE is safely in orbit 560 miles above the Earth. But the data all may be sucked into a terrestrial black hole.

6.

1. The Theory of Equations.
2. The Early Algebra.
3. Solution of Polynomial Equations of Third and Higher Degree.
4. The Infinitive. The Infinitive Constructions[1].

Grammar Revision

The Infinitive /інфінітив/

Інфінітив = неозначена форма дієслова в українській мові:

to read	—	читати, прочитати;
to write	—	писати, написати;
to help	—	допомагати, допомогти.

Інфінітив – це неозначена форма дієслова, яка називає дію безвідносно до часу, особи і числа. Має властивості як іменника, так і дієслова.

1) Як іменник інфінітив може бути:

1. підметом –

To read a lot is very useful. Багато читати корисно.

2. додатком –

I want **to read** this book. Я хочу прочитати цю книгу.

[1] Навчальні завдання з розвитку граматичних навичок з англійської мови (теорія, тренувальні вправи, міні та рейтингові тести) для студентів ІІ-х курсів усіх спеціальностей РДТУ (Частина IV). Рівне: РДТУ, 1999. – с. 5-18.

3. частиною присудка –

His task is **to read** this book. — Його завдання – прочитати цю книгу.

2) Як дієслово інфінітив може:

1. мати при собі додаток –

I told him **to post the letter**. — Я сказав йому відправити листа.

2. визначатися прислівником –

I asked him **to speak slowly**. — Я попросив його говорити повільно.

В науково-технічній літературі широко використовується розщеплений інфінітив /split infinitive/ типу **to + adv. +v.**, наприклад:

to clealy understand — чітко розуміти;
to fully realize — повністю усвідомлювати.

3. мати форму часу, активного та пасивного стану.

Відсутність частки ***to*** *перед інфінітивом:*

1. Якщо в реченні є два інфінітиви, з'єднані сполучником **and, or, except, but, than.**

Eg.: I'd like ***to lie down*** *and* ***go*** *to sleep.*
I'll ***do*** *anything but* ***work*** *on a farm.*

2. Після модальних дієслів **can, may, must, shall, should, will, would.**

Eg.: I ***must go*** *on.*
Can *you* ***help*** *me?*

3. Після виразів **had better, would sooner, would rather.**

Eg.: You ***had better go*** *back to your sisters.*
I'd rather not talk *about these things.*

4. Після дієслів **let, make, see, hear, feel, watch, notice, help.**

Eg.: I didn't ***see*** *you* ***come*** *in.*
She ***lets*** *her children* ***stay up*** *very late.*

5. **Why (not) –** для висловлення поради чи пропозиції**.**

Eg.: ***Why not take*** *a holiday.*
Why not let *me* ***lend*** *you some money?*

6. **Do –** у підрядному реченні, яке пояснює точне значення **do** головного речення.

Eg.: All I ***did*** *was* ***(to) give*** *him a little push.*
What a fire-door ***does*** *is* ***(to) delay*** *the spread of a fire long enough for people to get out.*

Форми інфінітива та їх комунікативні значення

	Indefinite		Continuous	Perfect		Perfect- continuous
Форми	Active	Passive	Active	Active	Passive	Active
	to help	**to be helped**	**to be helping**	**to have helped**	**to have been helped**	**to have been helping**
Приклади	I am glad **to help** you. Я радий **допомогти** вам.	I am glad **to be helped**. Я радий, що мені **допомагають**.	I am glad **to be helping** you. Я радий, що **допомагаю** вам (зараз).	I am glad **to have helped** you. Я радий, що **допоміг** вам.	I am glad **to have been helped**. Я радий, що мені **допомогли**.	I am glad **to have been helping** you for many years. Я радий, що **допомагаю** вам багато років.
	I was glad **to help** you. Я був радий **допомогти** вам.	I was glad **to be helped**. Я був радий, що мені **допомагають**.	I was glad **to be helping** you. Я був радий, що **допомагав** вам (тоді).	I was glad **to have helped** you. Я радий, що **допоміг** вам.	I was glad **to have been helped**. Я радий, що мені **допомогли**.	I was glad **to have been helping** you for many years. Я був радий, що **допомагаю** вам багато років.
	I must **help** you. Я повинен **допомогти** вам.	I must **be helped**. Мені треба **допомогти**.	Father: Where is Pete? Mary: He must **be helping** mother in the garden. Напевно, він **допомагає** матері в садку (зараз).	Father: Has anybody helped mother? Mary: Pete must **have helped** her.. Напевно, Піт **допоміг** їй.	Father: Has anybody helped mother? Mary: She must **have been helped**. Напевно, їй **допомогли**.	He must **have been helping** her for many years. Напевно, він **допомагає** їй багато років.
Значення	Називає дію **безвідносну** до часу її виконання, або дію **одночасну** чи **майбутню** по відношенню до дії, вираженої дієсловом в особовій формі.		Називає **тривалу** дію, що відбувається **одночасно** з дією, вираженою дієсловом в особовій формі.	Називає дію, що **передує** дії, вираженій дієсловом в особовій формі.		Називає тривалу дію, що почалась раніше дії, вираженої дієсловом в особовій формі і продовжується й зараз.

Функції інфінітива в реченні

	Функція	Приклад	Спосіб передачі значення інфінітива українською мовою
1.	Підмет	**To read** a lot is useful. **Читати** багато – корисно.	Неозначеною формою дієслова або (рідше) іменником.
2.	Частина складного присудка	To read a lot is **to know** a lot. Читати багато означає **знати** багато.	Неозначеною формою дієслова.
		We must **win** the game. Ми повинні **виграти** гру.	
		I am going **to enter** the university. Я збираюся **поступати** до університету.	
3.	Додаток	I want **to attend** this lecture. Я хочу **відвідати** цю лекцію.	Неозначеною формою дієслова.
4.	Означення	Who was the first **to come**? Хто **прийшов** першим?	Підрядним означальним реченням або дієсловом в особовій формі (після слів the first, the second, the last, the only, the next…).
		The text **to be translated** is difficult. Текст, **який потрібно перекладати**, важкий.	
5.	Обставина а) мети	You must work hard **to speak** English fluently. Ви повинні наполегливо працювати, **щоб говорити** англійською.	Неозначеною формою дієслова.
		(In order) **to speak** English fluently you must work hard. **Для того, щоб говорити** англійською, ви повинні наполегливо працювати.	
	б) наслідку	I was too young **to think** of such things. Я був занадто молодий, **щоб думати** про такі речі.	

The Infinitive Constructions
Інфінітивні звороти та їх функції у реченні.
Складний додаток /Complex Object/

Складнопідрядне додаткове речення за своїм значенням адекватне звороту “складний додаток з інфінітивом”.

I expect **that he will** come here.	I expect **him to come** here.	Я сподіваюсь, що він прийде сюди.

Зворот “складний додаток” вживається після наступних дієслів і має таку структуру:

<table>
<tr><td rowspan="3">S</td><td>see,
feel,
hear,
watch,
notice,
let,
make</td><td rowspan="3">me
you
him
her
it
us
them
student
Mary
mother</td><td>do</td></tr>
<tr><td>want,
expect,
believe,
know,
advise,
consider,
think,
like,
hate</td><td>to do</td></tr>
<tr><td>order,
command,
ask (for),
allow</td><td>to be done</td></tr>
</table>

Наприклад:

I	saw	him	cross the street
Я	*бачив,*	*як він*	*переходив вулицю.*
Mother	wants	Mary	to come in time.
Мама	*хоче,*	*щоб Мері*	*прийшла вчасно.*
We	believe	them	to be honest people.
Ми	*віримо,*	*що вони*	*чесні люди.*
The manager	ordered	the cargo	to be ensured.
Менеджер	*наказав,*	*щоб багаж*	*був застрахований.*

Національний університет
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та природокористування

Складний підмет /Complex Subject/

Складно-підрядне речення з головним реченням, вираженим безособовим зворотом типу:

it is said	(кажуть);
it is reported	(повідомляють);
it seems	(здається);
it is likely	(схоже);

можна замінити простим реченням із **“складним підметом”.**

It is said that they know English very well.	They are said to know English very well.	Кажуть, що вони добре знають англійську мову.

Інфінітив в реченнях із “**складним підметом**” може вживатись в різних формах.

He is said to live in Kyiv.	Кажуть, що він живе у Києві.
The water seems to be boiling	Вода, здається, кипить.
He was known to have lived in Kyiv.	Відомо, що він жив у Києві.

“**Складний підмет**” вживається, коли:

1. присудок виражений наступними дієсловами в Passive Voice:

S+be+	said, believed, stated, supposed, reported, thought, announced, expected, known, understood, considered, seen, heard.	**+to do**

This plant is known to produce tractors.	Відомо, що цей завод виробляє трактори.
The delegation is reported to have left Kyiv.	Повідомляють, що делегація поїхала з Києва.
He was said to have been travelling about the country a good deal.	Говорили, що він багато подорожував по країні.

2. присудок виражений наступними дієсловами в Active Voice:

S +	seem, appear, prove, happen, chance	**+ to do**

He seems to know English well.	Здається, він добре знає англійську
The weather appears to be improving.	Погода, напевно, покращується.

3. присудок виражений наступними прикметниками:

S + be +	likely, unlikely, certain, sure	**+ to do**

They are likely to come soon.	Схоже, що вони скоро прийдуть.
The delegation is certain to arrive in Kyiv.	Без сумніву, делегація приїде до Києва.

Прийменниковий інфінітивний комплекс (The for-to-Infinitive – Construction)

Інфінітивний комплекс може вводитися прийменником **for**, і називається **прийменниковим інфінітивним комплексом**.

… for +	noun me you her him us them	**+ to do …**

It's time **for us to go**. Нам пора йти.

Функції прийменникового інфінітивного комплексу

Функція	Приклади	Спосіб передачі значення інфінітива укр. мовою.
1. Складний підмет.	For me to help you is the greatest pleasure. Допомогти тобі – найбільше задоволення для мене.	Інфінітивом.
2. Предикатив	It's for you to decide. Вирішувати це - тобі.	Інфінітивом (з нього і починати переклад)
3. Складний додаток	We waited for the rain to stop. Ми чекали, поки припиниться дощ.	Іменником, складнопідрядним реченням, інфінітивом.

Функція	Приклади	Спосіб передачі значення інфінітива укр. мовою.
4. Складне означення	Here are some books for you to read. Ось декілька книжок, які ти можеш прочитати.	Складнопідрядним реченням; іменниковим сполученням; у деяких випадках інфінітив зовсім не перекладається.
5. Складна обставина: а) мети	I've closed the window for you not to catch cold. Я зачинив вікно, щоб ти не застудилась.	Складнопідрядним реченням з підрядним реченням мети або наслідку.
б) наслідку	You speak English too fast for me to understand. Ти говориш занадто швидко, щоб я міг зрозуміти.	

Text A. The Theory of Equations

Pre-text Exercises

1. Before reading the text, read the following questions. Do you know the answers already? Discuss them briefly with other students to see if they know the answers. The questions will help to give a purpose to your reading:

– Can you name all the existent number systems in English?

– Can you word mathematical formulae?

– Do you know the names of the distinguished mathematicians who contributed to the theory of equations?

2. Learn to recognize international words:

theory, history, progress, civilization, maths, evolution, review, system, complex, natural, negative, quadratic, positive, rational, irrational, real, prevail, cubic, fictitious, problem, product, symbol, term, theorem, coefficient, fundamental, algebra.

Read and translate the text:

The Theory of Equations

History shows the necessity for the invention of new numbers in the orderly progress of civilization and in the evolution of maths. We must review briefly the growth of the number system in the light of the theory of equations and see why *the complex number system* need not be enlarged further. Suppose we decide that we want all polynomial equations to have roots. Now let us imagine that we have no numbers in our possession except *the natural numbers.* Then a simple linear equation like $2x=3$ has no root. In order to remedy this condition, we invent fractions. But a simple linear equation, like $x+5=2$ has no root even among the fractions. Hence we invent *negative numbers.* A simple quadratic equation like $x^2=2$ has no root among all the (positive and negative) *rational numbers,* therefore we invent the *irrational numbers* which together with the rational numbers complete the system *of real numbers.*

However, a simple quadratic equation like $x^2=-1$ has no root among all the real numbers, hence, we invent *the pure imaginary numbers.* But a simple quadratic equation like $x^2+2x+4=0$ has no roots among either the real or pure imaginary numbers; therefore we invent *the complex numbers.* The story of $\sqrt{-1}$, the imaginary unit, and of $x+yi$, the complex number, originated in the logical development of algebraic theory. The word "imaginary" reflects the elusive nature of the concept for distinguished mathematicians who lived centuries ago. Early consideration of the square root of a negative number brought unvarying rejection. It seemed obvious that a negative number is not a square, and hence it was concluded that such square roots had no meaning. This attitude prevailed for a long time.

G. Cardano (1545) is credited with some progress in introducing complex numbers in his solution of the cubic equation, even though he regarded them as "fictitious". He is credited also with the first use of the square root of a negative number in solving the now-famous problem, "Divide 10 into two parts such that the product... is 40", which Cardano first says is "manifestly impossible"; but then he goes on to say, in a properly adventurous spirit, "Nevertheless, we will operate." Thus he found $5+\sqrt{15}$ and $5-\sqrt{15}$ and showed that they did, indeed, have the sum of 10 and a product of 40. Cardano concludes by saying that these quantities are "truly sophisticated" and that to continue working with them is "as subtle as it is useless". Cardano did not use the symbol $\sqrt{-15}$, his designation was "$R_x \cdot m$", that is, "radix minus", for the square root of a negative number. R. Descartes (1637) contributed the terms "real" and "imaginary". L. Euler (1748) used "i" for $\sqrt{-1}$ and K. F. Gauss (1832) introduced the term "complex number". He made significant contributions to the understanding of complex numbers through graphical representation and defined complex numbers as ordered pairs of real numbers for which

$$(a, b)\cdot(c, d) = (ac - bd, ad + bc),$$

and so forth.

Now, we may well expect that there may be some equation of degree 3 or higher which has no roots even in the entire system of complex numbers. That this is not the case was known to K. F. *Gauss,* who proved in 1799 the following theorem, the truth of which had long been expected: *Every algebraic equation of degree n with coefficient in the complex number system has a root (and hence n roots) among the complex numbers,* later Gauss published three more proofs of the theorem. It was he who called it *"fundamental theorem of algebra".* Much of the work on complex number theory is Gauss'. He was one of the first to represent complex numbers as points in a plane. Actually, Gauss gave four proofs for the theorem, the last when he was seventy; in the first three proofs, he assumes, the coefficients of the polynomial equation are real, but in the fourth proof the coefficients are any complex numbers. We can be sure now that for the purpose of solving polynomial equations we do not need to extend the number system any further.

Active Vocabulary

orderly	регулярний, методичний
review	оглядати, переглядати, передивлятися
briefly	коротко, стисло
equation	рівняння
number	математична сума, число, цифра
enlarge	збільшувати
further	подальший, додатковий

suppose	припускати, допускати
imagine	уявляти
possession	володіння
linear	лінійний
linear equation	рівняння першого розряду
root	корінь
square (second) root	квадратний корінь
cube (third) root	кубічний корінь
in order to...	для того, щоб...
remedy	виправляти; виліковувати
fraction	дріб
common fraction	простий дріб; звичайний дріб
hence	звідси, отже
the negative sign	знак мінус
quadratic equation	квадратне рівняння
positive sign	знак плюс
real number	дійсне число
therefore	тому, отже
pure	абсолютний; чистий
imaginary numbers	комплексні числа
pure imaginary numbers	абсолютні комплексні числа
originate	давати початок; брати начало, виникати
distinguished	видатний, відомий
elusive	невловимий, ухильний
consideration	розгляд, обговорення
vary	змінювати(ся), міняти(ся)
rejection	відмова; відхилення, неприйняття
obvious	очевидний, явний
prevail	мати перевагу
credit	вірити, довіряти; приписувати
solution	рішення, розв’язання; пояснення
though	хоча, незважаючи на
fictitious	вигаданий, уявний
product	добуток, результат
manifestly	очевидно, явно
properly	належно, належним чином

adventurous	нерозсудливо сміливий, заповзятливий, небезпечний, ризикований
nevertheless	незважаючи на, однак, проте
thus	так, у такий спосіб
subtle	тонкий, невловимий
designation	позначення, вказівка, призначення, мета
radix (pl. radices)	корінь; мат. основа системи числення
contribute	сприяти, робити внесок
define	визначати
and so forth	і так далі
degree	ступінь, рівень
entire	повний, цілий
it is not the case	це не так
prove	доводити
proof	доказ
radical	знак кореня, корінь
assume	приймати на себе, привласнити
polynomial	многочленний
polynomial equations	багаточленні рівняння

Grammar and Vocabulary Exercises

1. Look through the text and find sentences with the Infinitive and the Infinitive Constructions. Translate them into Ukrainian.

2. Translate the following sentences into Ukrainian:

1. This theory will be adequate for practical applications through centuries to come.
2. The first scientist to discover this law was N .
3. The effect is too small to be detected.
4. In order to understand the procedure, consider the following analogy.
5. I want him to understand the meaning of the word.
6. I tried to make him understand my point, but failed.
7. The expedition is reported to have landed safely.
8. She seems to know the subject well.

9. They happened to be in the lab.
10. He is sure to come tonight.
11. It is sure he will come tonight.
12. This method is unlikely to yield good results.
13. This law is certain to hold in all cases.

3. Paraphrase the sentences using the complex subject and the complex object:

1. It is said that form is an exact differential.
2. It is expected that two distinct points are symmetric.
3. It proves that permutation is even when the number of inversions in it is even.
4. The ancients thought that the Earth was flat.
5. Some scientists consider that Mars is covered with vegetation.
6. We watched. They were conducting the experiment.

4. Define meanings of the following words by their affixes, state what part of speech they indicate. Translate them into Ukrainian:

invention, evolution, enlarge, possession, rational, imaginary, distinguished, unvarying, solving, graphical.

5. Look through the text and give Ukrainian equivalents for the following words and word-combinations:

equation; suppose; linear; linear equation; root; square root; in order to…; fraction; complex number; real number; pure imaginary numbers; solution; product; degree; prove; designation; define; proof.

6. Fill in the gaps with the given words:

linear equation; complex numbers; quadratic equation; root; roots; proofs; fractions; degree; rational numbers.

1. A simple … … like $x^2 = 2$ has no … among all the (positive and negative) … … .
2. We may expect that there may be some equation of … 3 or higher which has no … in the entire system of … … .
3. Gauss gave four … for the theorem.
4. A simple … …, like $x + 5 = 2$ has no … even among the … .

7. Look through the text and give English equivalents for the following words and word-combinations:

рівняння; простий дріб; виправляти; квадратний корінь; рівняння першого ступеня; збільшувати; припускати; розгляд; мати перевагу; рішення; приписувати; знак плюс; добуток.

8. Combine the words from the left-and right-hand columns to make word-combinations. Translate them into Ukrainian:

number	mathematicians
complex	system
linear	rejections
square	pairs
imaginary	numbers
cubic	equation
distinguished	representation
graphical	root
ordered	theorem
entire	system
adventurous	spirit
unvarying	equation
now-famous	problem
fundamental	numbers

9. Compose sentences in English using the word-combinations from Ex. 8.

Reading Comprehension

1. Review the whole text again. Outline the subject matter of the text, its components structure, topic sentences and main ideas. Use the following phrases:

– The text deals with … (speaks about, presents, shows, points out, discusses, reviews, throws light on, traces the history of, etc)

– The subject matter of the text is …

– The text can be segmented into … paragraphs.

– The first (second, third, fourth, etc.) paragraph considers … (deals with, informs of, describes, etc.)

– The topic sentence of the first (second, third, fourth, etc.) paragraph is …

– The main idea of the first (second, third, fourth, etc.) paragraph is …

– The main idea of the text is …

– The conclusion the author came to is …

– The reasons for this conclusion are …

2. Say whether the following statements are true or false. Justify your choice. Use the given phrases:

That's right…
Exactly. Quite so…
I fully agree to it…
I don't think this is the case…
Quite the contrary…
Not quite. It's unlikely…
Just the reverse…

1. The rational numbers complete the system of real numbers.

2. A simple quadratic equation like $x^2 + 2x + 4 = 0$ has no roots among either the real or pure imaginary numbers.

3. Early consideration of the square root of a negative number was crowned with success.

4. An equation has as many roots as its degree.

5. No general algebraic solution is possible for the polynomial equation of degree greater than four.

6. In algebra x always stands for number.

7. A complex number $a + b\sqrt{-1}$ is essentially a pair of real numbers $(a; b)$.

8. L.Euler introduced the term "complex number".

9. Gauss gave the last proof for the theorem when he was seventy.

10. For the purpose of solving polynomial equations we need to extend the number system further.

3. Answer the following questions:

1. Is there any necessity for the invention of new numbers in the evolution of math?

2. Why were fractions invented?

3. Why were negative numbers, rational numbers and irrational numbers invented?

4. What numbers complete the system of real numbers?

5. Does a simple quadratic equation like $x^2 = -1$ have no root among all real numbers?

6. What caused the invention of the pure imaginary numbers and the complex numbers?

7. What does the word “imaginary” reflect?

8. Why did early consideration of the square root of a negative number bring unvarying rejection?

9. What is G.Cardano credited with?

10. Who contributed the terms “real” and “imaginary”?

11. Who introduced the term “complex number”?

12. What theorem did K.F.Gauss prove in 1799?

13. How many proofs of this theorem are there?

14. What theorem is called “fundamental theorem of algebra”?

15. Do they need to extend the number system further?

4. For each definition choose a term from the left column:

the complex number	is any real number that cannot be expressed as a ratio p/q, where p and q are integers, with q non-zero, and is therefore not a rational number.
the natural number	a statement of the equality between mathematical expressions.
fraction	a number which can be put in the form $a+bi$, where a and b are real numbers and i is called the imaginary unit, where $i^2 = -1$.
the rational numbers	a noninteger quantity expressed in terms of a numerator and a denomerator or in decimal form.
the irrational numbers	the limit of a convergent sequence of rational numbers.
the system of real number	a number that can be expressed as a fraction p/q where p and q are integers and $q \neq 0$.
equation	a positive integer.

Conversational Practice

1. Choose one of the words given below and illustrate the concept:

equation;
the pure imaginary numbers;
the real numbers.

2. Discuss the statements given below. Summarize the discussion. Use the following phrases:

There is no point is denying that…
I will start by saying that…
All I mean to say is that…
To begin with, my point is that…
I am all for … but …
That doesn't sound convincing enough…
I doubt it…
Summarizing the discussion…

1. Algebra is changing constantly and rapidly.
2. Anyone is now free to invent his own algebra.
3. The major stumbling block in the extension of complex number system and its effect on the theory of equations.

3. Give a short summary of the text.

Text B. The Early Algebra

1. Read and translate the text:

The Early Algebra
Babylonian Algebra – Rhetorical Style

Since algebra might have probably originated in Babylonia, it seems appropriate to credit the country with the origin of the rhetorical style of algebra, illustrated by the problems found in clay tablets dating back to c. 1700 B.C. The problems show the relatively sophisticated level of their algebra. Nowadays, such problems are solved by *the method of elimination.* The Babylonians also knew how to solve systems by elimination but preferred often to use their *parametric method.* The Babylonians were able to solve a rather surprising variety of equations, including certain special types of cubics and quartics – all with numerical coefficients, of course.

Algebra in Egypt

Algebra in Egypt must have appeared almost as soon as in Babylonia; but Egyptian algebra lacked the sophistication in method shown by Babylonian algebra, as well as its variety in types of equations solved. For linear equations the Egyptians used a method of solution consisting of an initial estimate followed by a final correction, a method now known as the *"rule of false position"*. The algebra of Egypt, like that of Babylonia, was rhetorical.

The numeration system of the Egyptians, relatively primitive in comparison with that of the Babylonians, helps to explain the lack of sophistication in Egyptian algebra. European mathematicians of the sixteenth century had to extend the Hindu-Arabic notion of number before they could progress significantly beyond the Babylonian results in solving equations.

Early Greek Algebra

The algebra of the early Greeks (of the Pythagoreans and Euclid, Archimedes, and Apollonius, 500-200 B.C.) was geometric because of their *logical* difficulties with irrational and even fractional numbers and their *practical* difficulties with Greek numerals, which were somewhat similar to Roman numerals and just as clumsy. It was natural for the Greek mathematicians of this period to use a geometric style for which they had both taste and skill.

The Greeks of Euclid's day thought of the product *ab* (as we write it nowadays) as a rectangle of base *b* and height *a* and they referred to it as "a rectangle contained by *CD* and *DE"*. Some centuries later, another Greek, Diophantus, made a start toward modern symbolism in his work *Diophantine Equations* by introducing abbreviated words and avoiding the rather cumbersome style of geometric algebra, Diophantus introduced the *syncopated* style of writing equations.

Hindu and Arabic Algebra

Little is known about Hindu maths before the fourth or fifth century A.D. because few records of the ancient period have been found. India was subjected to numerous invasions, which facilitated the exchange of ideas. Babylonian and Greek accomplishments, in particular, were apparently known to Hindu mathematicians. The Hindus solved quadratic equations by *"completing the square"* and they accepted negative and irrational roots; they also realized that a quadratic equation (with real roots) has two roots. Hindu work on indeterminate equations was superior to that of Diophantus; the Hindus attempted to find *all possible integral solutions* and were perhaps the first to give general methods of solution. One of their most outstanding achievements was the system of Hindu (often called Arabic) numerals.

Algebra in Europe

In the eleventh century many Greek and Arabic texts on maths were translated into Latin and became available in Europe. However, even more important for Europe, especially Italy, was the *Liber Abaci* (1202) of *Fibonacci* (Leonardo of Pisa) in which he solved equations in the rhetorical and general style and strongly advocated the use of Hindu-Arabic numerals, which he discovered on his journeys to many lands as a merchant and tradesman. It is not surprising that at first the local chambers of commerce (in Pisa and neighbouring city-states of Italy) resisted the adoption of the "new" Hindu-Arabic numerals and, in fact, viewed them with suspicion; but they were gradually adopted, and the old abacus was stored in the attic.

The algebra that entered Europe (via Fibonacci's "Liber abaci" and translations) had retrogressed both in style and in content. The semisymbolism of Diophantus and relatively advanced accomplishments of the Hindus were not destined to contribute to the eventual breakthrough in European algebra.

Active Vocabulary

abacus
accomplishment
advanced
appropriate
attempt
attic
avoid
breakthrough
chamber of commerce
clay
clumsy
content
cumbersome
destine
eventual
invasion
merchant
rectangle
sophistication
suspicion
tablet
facilitate
lack
subject

2. Answer the following questions:

1. Where did algebra probably originate?
2. What is Babylonia credited with?
3. What equations were the Babylonians able to solve?
4. When did algebra appear in Egypt?
5. What did Egyptian algebra lack?
6. What explains the lack of sophistication in Egyptian algebra?
7. What was the algebra of the early Greeks?
8. What were the difficulties the Greeks experienced?
9. What style did the Greek mathematicians use?
10. What caused the Greeks to give their algebra geometrical formulation?
11. Why is it known little about Hindu maths before the fourth and fifth century A.D.?
12. What equations did the Hindus solve?
13. What did the Hindus attempt to find?
14. What are the most outstanding achievements of the Hindus?
15. When did Greek and Arabic texts on maths become available in Europe?

3. Reconstruct the text "The early Algebra" into a dialogue.
The main rules governing a conversation in English:

The person who asks questions in a conversation usually controls it. Personal questions should be expressed tactfully.

Add new phrases to the previous ones:

Let's look at the whole problem/plan, etc. from a realistic point of view.

Don't forget about the other side of this problem.

I think I've missed some details concerning ...

Could you be a little more precise/specific?

I'd like to hear more about ...

I can't give you a definite answer yet.

4. Agree with the statements given below and develop the idea further. Use the introductory phrases:

That's right.

This is the case.

I hold a similar view.

There is no point in denying that …
I see no point at all to disagree that …

1. It was the Arabs who preserved the Greek and Hindu scientific writings through the Dark Ages of Europe.
2. Our main interest during the Arabic period centres on Al-Khowaresmi and Omar Khayyám.

5. Annotate the text in English. Use the phrases:

I.

a) The title of the article is...
It is written by prof... and published in London in the

journal..., No.3, vol.4, 2011 *magazine..., No.3, vol.4, 2011* *collection of articles ... by... editorial house in 2011* *book ... by... editorial house in 2011*	on pp.3-10

b) The article... by prof... is published in the journal..., in N.Y., pp.5-10.

II.

a) The article	*deals with* *discusses* *touches* *discloses* *is devoted to*	the problem of ...

The text tells us about ...

b) Disclosing the problem the author dwells on (upon) such matters as...

The major	*points* *matters* *problems* *issues*	of the text are the following: ...

c) The author	*pays special attention to …* *draws readers' attention to …*

Much *Great* *Special*	attention is paid to...

The author	*concentrates on, focuses on* *stresses, underlines, emphasises* *points out* *dwells on (upon)*

distinguishes between *speaks in details* *gives the classification*	

III.

a) As far as I am an expert in ... I

consider *believe* *suppose* *think* *guess*	the article to be of some (great) interest for …

b)

In my opinion *From my point of view* *To my mind*	the article is of	*great* *some*	interest for

the students in applied science *the specialists in...* *a wide range of readers*

6. Discuss the statements given below. Use the following phrases:

I will start by saying that…
My own viewpoint is that…
It's worth considering (appreciating)…
I should like to make it clear that…
One cannot say that…
One must admit that…

1. In both the Babylonian and the Egyptian civilizations computations were handled by a small and exclusive group of experts, frequently the priests. Their special and carefully guarded skills and knowledge gave them influence and power. The Pythagoreans may simply have followed their example. Your viewpoint.

2. Stories about the innovators in algebra – such as Cardano's exploration of imaginary numbers, Abel's search for the general solution, Galois' genius, Cayley's invention of matrices by noticing coefficient patterns in equations – may well serve to excite the modern mind. Your viewpoint.

Writing

Write a composition on "The greatest mathematicians of antiquity".

Extended reading

Text C. Solution of Polynomial Equations of Third and Higher Degree

Read and translate the text into Ukrainian at home. Give some more details and your own comments concerning all the algebraists mentioned in the text. Write a summary and express the main ideas of the text. Reproduce it in class.

The first records of man's interest in *cubic equations* date from the time of the old Babylonian civilization, about 1800-1600 B.C. Among the math materials that survive, are tables of cubes and cube roots, as well as tables of values of $n^2 + n^3$. Such tables could have been used to solve cubics of special types. For example, to solve the equation $2x^3 + 3x^2 = 540$, the Babylonians might have first multiplied by 4 and made the substitution $y = 2x$, giving $y^3 + 3y^2 = 2{,}160$. Letting $y = 3z$, this becomes $z^3 + z^2 = 80$. From the tables, one solution is $z = 4$, and hence 6 is a root of the original equation.

In the Greek period concern with volumes of geometrical solids led easily to problems that in modern form involve cubic equations. The well-known problem of duplicating the cube is essentially one of solving the equation $x^3 = 2$. This problem, impossible of solution by ruler and compasses alone, was solved in an ingenious manner by *Archytas of Tarentum* (c. 400 B.C.), using the intersections of a cone, a cylinder, and a degenerate torus (obtained by revolving a circle about its tangent).

The well-known Persian poet and mathematician *Omar Khayyám* (1100 A.D.) advanced the study of the cubic by essentially Greek methods. He found solutions through the use of conies. It is typical of the state of algebra in his day that he distinguished thirteen special types of cubics that have positive roots. For example, he solved equations of the type $x^3 + b^2x = b^2c$ (where b and c are positive numbers) by finding intersections of the parabola $x^2 = by$ and the circle $y^2 = x(x - c)$, where the circle is tangent to the axis of the parabola at its vertex. The positive root of Omar Khayyám's equation is represented by the distance from the axis of the parabola to a point of intersection of the curves.

The next major advance was the algebraic solution of the cubic. This discovery, a product of the Italian Renaissance, is surrounded by an atmosphere of mystery; the story is still not entirely clear. The method appeared in print in 1545 in the *Ars Magna* of *Girolamo Cardano* of Milan, a physician, astrologer, mathematician, prolific writer, and suspected heretic, altogether one of the most colourful figures of his time. The method gained currency as "Cardan's formula" (Cardan is the English form of his name). According to Cardano himself, however, the credit is due to *Scipione del Ferro,* a professor of maths at the University of Bologna, who in 1515 discovered how to solve cubics of the type $x^3 + bx = c$. As was customary among mathematicians of that time, he kept his methods secret in order to use them for personal advantage in math duels and tournaments. When he died in 1526, the only persons familiar with his work were a son-in-law and one of his students, *Antonio Maria Fior* of Venice.

In 1535 Fior challenged the prominent mathematician *Niccolo Tartaglia* of Brescia (then teaching in Venice) to a contest because Fior did not believe Tartaglia's claim of having found a solution for cubics of the type $x^3 + bx^2 = c$. A few days before the contest Tartaglia managed to discover also how to solve cubics of the type $x^3 + ax = c$, a discovery (so he relates) that came to him in a flash during the night of February 12/13, 1535. Needless to say, since Tartaglia could solve two types of cubics whereas Fior could solve only one type, Tartaglia won the contest. Cardano, hearing of Tartaglia's victory, was eager to learn his method. Tartaglia kept putting him off, however, and it was not until four years later that a meeting was arranged between them. At this meeting Tartaglia divulged his methods, swearing Cardano to secrecy and particularly forbidding him to publish it. This oath must have been galling to Cardano. On a visit to Bologna several years later he met Ferro's son-in-law and learned of Ferro's prior solution. Feeling, perhaps, that this knowledge released him from his oath to Tartaglia, Cardano published a version of the method in *Ars Magna.* This action evoked bitter attack from Tartaglia, who claimed that he had been betrayed.

Although couched in geometrical language the method itself is algebraic and the style syncopated. Cardano gives as an example the equation $x^3 + 6x = 20$ and seeks two unknown quantities, *p* and *q,* whose difference is the constant term 20 and whose product is the cube of 1/3 the coefficient of x, 8. A solution is then furnished by the difference of the cube roots of p and q. For this example the solution is

$$\sqrt[3]{\sqrt{108}+10} - \sqrt[3]{\sqrt{108}-10}\ .$$

The procedure easily applies to the general cubic after being transformed to remove the term in x^2. This discovery left unanswered such questions as these: What should be done with negative and imaginary roots, and (a related question) do three roots always exist? What should be done (in the so-called irreducible case) when Cardano's method produced apparently imaginary expression like

$$\sqrt[3]{81+30\sqrt{-3}} - \sqrt[3]{81-30\sqrt{-3}}$$

for the real root, -6, of the cubic $x^3 - 63x - 162 = 0$? These questions were not fully settled until 1732, when *Leonard Euler* found a solution.

The general *quartic equation* yielded to methods of similar character; and its solution, also, appeared in *Ars Magna.* Cardano's pupil *Ludovico Ferrari* was responsible for this result. Ferrari, while still in his teens (1540), solved a challenging problem that his teacher could not solve. His solution can be described as follows: First reduce the general quartic to one in which the x^3 term is missing, then rearrange the terms and add a suitable quantity (with undetermined coefficient) to both sides so that the left-hand member is a perfect square. The undetermined coefficients are then determined so that the right-hand member is also a square, by requiring that its determinant be zero. This condition leads to a cubic, which can now be solved – the quartic can then be easily handled.

Later efforts to solve the *quintic* and other equations were foredoomed to failure, but not until the nineteenth century was this finally recognized. *Karl Friedrich Gauss* proved in 1799 that every algebraic equation of degree n over the real field has a root (and hence n roots) in the complex field. The problem was to express these roots in terms of the coefficients by radicals. *Paolo Ruffini,* an Italian teacher of maths and medicine at Modena, gave (in 1813) an essentially satisfactory proof of the impossibility of doing this for equations of degree higher than four, but this proof was not well-known at the time and produced practically no effect.

7. 1. Informatics. 2. Cybernetics. 3. Algorithms. 4. The Participle. The Participial Constructions[1].

Grammar Revision

The Participle /дієприкметник/

Дієприкметник – це неособова форма дієслова, що має властивості дієслова, прикметника та прислівника.

В англійській мові є два дієприкметники:

1. **дієприкметник теперішнього часу (Present Participle або Participle I)**,
2. **дієприкметник минулого часу (Past Participle або Participle II).**

Утворення дієприкметників.

I. Present Participle утворюється за допомогою закінчення -**ing,** яке додається до інфінітива дієслова без частки **to:**

to read reading

1. Якщо інфінітив закінчується німим **-е**, то перед значенням -**ing** воно опускається:

to write writing

2. Якщо інфінітив закінчується однією приголосною буквою, якій передує короткий наголошений голосний звук, то перед закінченням -**ing** кінцева приголосна подвоюється:

to sit sitting

3. Кінцева буква **r** подвоюється, якщо останній склад наголошений і не містить дифтонга:

to prefer preferring

4. Кінцева буква **l** подвоюється, якщо їй передує короткий голосний звук:

to travel travelling

Participle I відповідає українському дієприкметнику активного

---

[1] Навчальні завдання з розвитку граматичних навичок з англійської мови (теорія, тренувальні вправи, міні та рейтингові тести) для студентів ІІ-х курсів усіх спеціальностей РДТУ (Частина IV). Рівне: РДТУ, 1999. – с. 35-45.

стану теперішнього часу та дієприслівнику недоконаного виду:

resting — відпочиваючий, відпочиваючи

II. Past Participle правильних дієслів утворюється за допомогою закінчення **-ed,** що додається до інфінітива дієслова без частки **to**, тобто так само, як і стверджувальна форма Past Indefinite цих дієслів:

to ask asked

Past Participle неправильних дієслів утворюється по-різному, і ці форми треба запам'ятати (*III колонка неправильних дієслів*):

to do done
to build built
to write written

Participle II перехідних дієслів відповідає українському пасивному дієприкметнику минулого часу:

dressed — одягнутий
made — зроблений

Participle II деяких неперехідних дієслів відповідає українському дієприкметнику активного стану минулого часу:

to fade — в'янути faded — зів'ялий

Як прикметник **Participle** може бути **означенням** до іменника:

A **broken** cup lay on the table. **Розбита** чашка лежала на столі.

Як прислівник **Participle** служить обставиною, що визначає дію присудка:

He sat at the table **thinking.** Він сидів біля стола **задумавшись.**

Як дієслово **Participle** може:

1. мати **додаток**:

He sat at his desk **writing something**.	Він сидів за столом і щось писав.

2. визначатися **прислівником**:

Supported unanimously, the project was approved.	Отримавши одноголосну підтримку, проект було схвалено.

3. мати форми **активного або пасивного** (для перехідних дієслів) стану;

4. мати форми **відносного часу.**

Participles: *interested and interesting, etc.*

To say how we feel about something, we can use the past participles *interested, bored, excited,* etc.

*Eg.: I was very **interested** in the lesson.*

*I didn't enjoy the party because I was **bored**.*

To talk about the person or thing that makes us feel interested, bored, etc, we use present participles (*interesting, boring, exciting,* etc.).

*Eg.: I thought the **lesson** was quite **interesting**.*

*Sheila's **party** was pretty **boring**.*

Форми Participle II та їх комунікативні значення.

Форми	Перехідні дієслова	Неперехідні дієслова
	Past Participle	Past Participle
	passive	active
	asked	**gone**
Приклади	We looked at the **destroyed** bridge. Ми дивилися на **зруйнований** міст. Her father is a doctor **loved** and **respected** by everybody. Її батько-лікар, якого всі **люблять** і **поважають**.	He has already **gone** for a walk. Він уже **пішов** на прогулянку.
Значення	Здебільшого Past Participle виражає дію, що **передує** дії, вираженій присудком речення, але також може виражати дію **одночасну** з дією, вираженою дієсловом присудком, або дію, **безвідносну** до часу.	

Форми Participle I та їх комунікативні значення

Форми	Перехідні дієслова				Неперехідні дієслова	
	Present Participle		**Perfect Participle**		Present Participle	Perfect Participle
	Active	Passive	Active	Passive	Active	Active
	asking	**being asked**	**having asked**	**having been asked**	**going**	**having gone**
Приклади	**Reading** English books I wrote out new words. **Читаючи** англійські книжки, я виписував нові слова. The students working here came from Kyiv. Студенти, які працюють тут, прибули з Києва.	**Being invited** to the party she couldn’t do this work. Оскільки її **запросили** на вечірку, вона не могла зробити цю роботу.	**Having read** the book, he gave it to his friend. **Прочитавши** книжку, він віддав її другові.	**Having been packed**, the parcel was taken to the post-office. Після того, як посилку **запакували**, її віднесли на пошту.	She is looking at the woman **going** along the street. Вона дивиться на жінку, яка **йде** вздовж вулиці.	**Having lived** in Kyiv for many years he knew the city very well. Проживши в Києві багато років, він **знав** місто дуже добре.
Значення	Називає дію, що 1) відбувається **одночасно** з дією, вираженою дієсловом присудком; 2) відноситься до **теперішнього часу**, незалежно від часу дії, вираженої дієсловом-присудком речення; 3) відбувається **безвідносно** до якогось часу; 4) **передує** дії, вираженій присудком.		Називає дію, що **передує** дії, вираженій дієсловом-присудком і перекладається дієприслівником доконаного виду.		Див. комунікативне значення перехідних дієслів.	

Функції Participle I, II в реченні

		Participle I	Participle II
Означення	**ліве**	The **rising** sun was hidden by the clouds. Сонце, що сходило, закрили хмари.	A **broken** cup lay on the table. Розбита чашка лежала на столі
Означення	**праве**	She saw a women **sitting** in the corner of the room. Вона побачила жінку, яка сиділа в кутку кімнати.	They showed us the list of the goods **sold** at the auction. Вони показали нам список товарів, які були продані на аукціоні.
Обставина	**часу**	**Entering** the room, she saw her sister there. Увійшовши до кімнати, вона побачила там свою сестру.	**When praised**, he was ill at ease. Коли його хвалили, він почував себе ніяково.
Обставина	**причини**	**Having been made** 20 years ago, the machine is out of date. Виготовлена 20 років тому, машина зараз застаріла.	**Frightened** by the dog, the child began to cry. Злякавшись собаки, дитина почала плакати.
Обставина	**способу дії**	He sat in the armchair **reading** a newspaper. Він сидів у кріслі, читаючи газету.	**Though wounded**, the soldier did not leave the battle-field. Хоч і поранений, солдат не залишив поля боя.
Частина присудка		*Continuous Tenses* Don't make noise. He's **sleeping**. Не шуміть, він спить.	*Perfect Tenses* I have just **met** him. Я тільки що зустрів його.
Частина присудка			*Passive voice* This house was **built** last year. Цей будиник був збудований минулого року.

Дієприкметникові звороти

В англійській мові дієприкметник, як і інфінітив, утворює синтаксичні звороти з іменниками та займенниками. Дієприкметник входить до складу трьох комплексів: **Складний додаток, Складний підмет та Незалежний дієприкметниковий комплекс**.

Складний додаток /Complex Object/

Зворот "Складний додаток" вживається після наступних дієслів і має таку структуру:

<table>
<tr><td rowspan="2">S</td><td rowspan="2">see
hear
watch
notice
observe
feel
find
consider
understand
want
wish
desire
have
get</td><td>me
you
him
her
it</td><td>P.I
P.II</td></tr>
<tr><td>us
them
student
mary
my coat</td><td>P.II</td></tr>
</table>

Наприклад:

I saw **him crossing** the street[9]. — Я бачив, як він переходив вулицю.
I saw **the window broken**. — Я бачив, що вікно розбите.
She considered **Mary deceived**. — Вона вважала Мері обманутою.
She had **her hair done**. — Їй зробили зачіску.

[9] "Складний додаток" з Participle дуже близький за значенням до "Складного додатка" з Infinitive (після дієслів, що означають сприйняття за допомогою органів чуттів). У першому випадку дія виражається як процес, а в другому – констатується факт.

Складний підмет /Complex Subject/

Зворот "Складний підмет" вживається переважно з наступними дієсловами і має таку структуру:

S + be +	seen, heard, felt, watched noticed, observed	**+ P.I**

A plane was heard **flying** high in the sky. Було чути, як високо в небі летів літак.

S + be +	considered believed found	**+P.II**

The work was considered **finished**. Роботу вважали закінченою.

Незалежний дієприкметниковий зворот
(The Absolute Participial Construction)

Якщо іменник у загальному відмінку (або особовий займенник у називному відмінку) виконує роль підмета по відношенню до дієприкметника і не є підметом усього речення, то це – **незалежний дієприкметниковий зворот**.

Peter coming home from Kyiv, we asked him to tell us about the conference. Коли Петро повернувся із Києва, ми розпитали його про конференцію.

У незалежному дієприкметниковому звороті можуть вживатися всі форми Participle.

В реченні зворот виконує функції обставини:

а) часу:

The rain having stopped we went home. Коли дощ припинився, ми пішли додому.

б) причини:

It being now pretty late, we went to bed. Оскільки було вже пізно,ми пішли спати.

в) умови:

Weather permitting, we shall start tomorrow. Якщо погода дозволить, ми поїдемо завтра.

г) способу дії: (вводиться прийменником **with**)

He was standing, **with his arms crossed.** Він стояв, схрестивши руки.

Способи перекладу “незалежного дієприкметникового звороту” на українську мову

“Незалежний дієприкметниковий зворот” перекладається на українську мову:

а) підрядним обставинним реченням:

The weather being fine, they went for a walk.	Оскільки погода була хорошою, вони пішли на прогулянку.

б) простим реченням, що входить до складносурядного:

We had three lectures, **the last being in physics.**	Ми мали три лекції, остання була з фізики.

в) дієприслівниковим зворотом:

Her face smiling, she came into the room.	Усміхаючись, вона увійшла в кімнату.

г) головним реченням в складнопідрядному:

She sat down at the table, **her hands beginning to tremble**.	Коли вона сідала за стіл, її руки починали тремтіти.

Text A. Informatics

Pre-text Exercises

1. Before reading the text, read the following questions. Do you know the answers already? Discuss them briefly with other students to see if they know the answers. The questions will help to give a purpose to your reading:

– Does there exist a unique, universally acceptable definition of “informatics”?

– Is informatics a young science or an old one?

– Has informatics penetrated into the most widely different spheres of human activity?

2. Learn to recognize international words:

informatics, information, definition, automatic, electronic, computer, manipulate, electrical, pulse, position, basic, code, collection, theory, technology, sphere, activity, sputnik, rocket, machine, nature, metal, technical, progress, reflect, assist, process, communicate, operation, problem, analysis, structural, functional, organism, method, aspect, mathematician, theory, design, construction, selection, nervous, system, range, regulation, industry, function, business, control, major, utilize.

Read and translate the text:

Informatics

We may ask a question what *information is.* In the discussions of computers, the word *information* has a rather special definition. *Information (data) is a set of marks that have meaning.* In a large automatic electronic computer, information may be recorded and manipulated as sequence of minute electrical pulses which are about a millionth of a second apart; and the presence or absence of a pulse in a position where either may occur is the basic code which represents information. *Informatics* is a collection of computer theories and novel information technologies.

It is difficult to say what the future holds in store for informatics. Every day we learn more and more about the penetration of informatics into the most widely differing spheres of human activity. The launching of sputniks and the delivery of our space rockets to their orbits with such high accuracy could have been hardly possible without computers. This, however, does not mean, that the machine can ever become "cleverer" than its creator. The point is that the machine does not replace man, it only increases his work output and multiplies his power over the forces of nature. It should be always remembered that the machine serves man, and not the other way round. Without man, even the most perfect machine would be only a useless heap of metal.

Man's technical progress is reflected in the tools he has invented. From early times he has been ceaselessly creating and improving devices to assist his brain in completing tasks difficult or otherwise impossible. Throughout the centuries man has developed and refined the ability to record, process, and communicate information. With the advent of automatic digital computers, man has created devices that can solve complete problems without the need for human intervention during the course of solution. Although operations performed by computers are the very basic ones (addition, subtraction, multiplication and division), great speed of operation is more than compensation. The principal use of computers has been in the area of applied mathematics. The application of computers to scientific problems has become later than the original business applications. Nowadays computers have become increasingly important as basic tools for analysis. This operation requires highly refined and flexible techniques.

The contributions of the scientists to the progress of informatics consists of the evaluation, measurement and description of the capabilities and of structural and functional attributes of living organisms. Such studies involve the methods of communication, feedback and control in the living entity. Hence, an important aspect of the work in informatics for mathematicians deals with the math theory of communication.

In terms of computer development informatics is concerned with the design and construction of electrical or electronic analogs capable of performing processes carried out within a living entity, including the selection and evaluation, as well as the storage of information. In terms of understanding the operation of the human nervous system, informatics contributes new insight into a wide range of processes such as learning, regulation and the emotional behaviour of individual human beings as well as societies. Specifically, the problems of decision-making, thinking and synthesis, imagination and creative endeavour of people, come under the scrutiny of informatics.

It is anticipated that the future developments of automated industries and societal functions will be based on the theorems developed from informatics, which thus far has made significant contribution to the technology of guided missiles, business and scientific computer applications, communications and automatic control. Informatics is a young science and yet it is increasingly applied in various branches of industry and research, invading a wide range of fields in human activity. Informatics endeavours to find the answer to two major questions: the best way of controlling this or that process, and the best way of utilizing a machine (if possible) for controlling this process.

Active Vocabulary

datum (pl. data)	дана величина
sequence	послідовність, проходження
apart	порізно, окремо
occur	зустрічатися, траплятися
minute	дрібний, найдрібніший
store	запас, достаток
in store	напоготові, про запас
novel	новий, незнаний
penetration	проникнення

launch	запускати
delivery	поставка, доставка
accuracy	точність, правильність
increase	зростати, збільшуватися
output	продукція; продукт; випуск, (мат.) результат обчислення
heap	купа
ceaselessly	безперервно, безупинно
otherwise	інакше, в інший спосіб, іншим чином
throughout	в усіх відношеннях; усюди; упродовж
refine	очищати, удосконалювати, поліпшувати
although	хоча; незважаючи на…
flexible	гнучкий
evaluation	оцінка
attribute	властивість, характерна ознака
feedback	зворотній зв'язок
entity	суть, істота, існування
in terms of	з погляду; з точки зору
to be concerned with	бути зацікавленим
carry out	виконувати, провести
insight	проникливість, інтуїція, інтуїтивне розуміння
specifically	характерно, особливо
endeavour	спроба, старання, прагнення
scrutiny	дослідження, уважний огляд
anticipate	чекати, передбачати
thus	так; у такий спосіб; тому
guide	вести, бути чиїм-небудь провідником, керувати, направляти
missile	метальний снаряд; ракета
guided missile	керований снаряд
invade	вторгатися, захоплювати
utilize	використовувати, утилізувати

Grammar and Vocabulary Exercises

1. Study the text and find sentences with the Participle. Translate them into Ukrainian.

2. Translate the following sentences into Ukrainian:

1. A symbol is a mark, or a sign, or a word representing (or symbolizing) an object or an idea.
2. The mathematicians being invited to our University from abroad are well-known scientists.
3. The methods followed by the lecturer was not accurate.
4. Considered from this point of view the question will be of great interest.
5. Having picked out the products corresponding to these tables, we obtained a coordinate system for the place.
6. The value of X being given, the velocity of a body can easily be computed.
7. Given two points A and B, we can draw a line connecting them.
8. Unless otherwise specified, the word "set" in this book will refer to a set of real numbers.
9. The notion of the limit of the function having so far been discussed rather informally, let us now give a precise definition.

3. Observe the time of occurrence, expressed by a Participle:

1. (When) solving the problem, we came across certain difficulties.
2. Having solved the problem, we verified our results.
3. Being solved in a hurry, the problem was difficult to comprehend.
4. The student solving the problem on the black-board made many mistakes.
5. The problem solved by comrade X will soon be discussed.
6. Having been solved, the problem was analyzed.
7. The problem being solved sums to be very difficult.
8. The problem having been solved, we had a break.
9. The students solving the problem were first-year students.
10. Solved, the problem helped the students to master the theory.

4. Define the meanings of the following words by their affixes:

manage – management; compute – computer; inform – information – informatics; active – activity; perfect – perfectly; wide – widely; deliver

– delivery; use – useless; cease – ceaseless – ceaselessly; add – addition; divide – division; produce – production – productive – productivity – reproduce.

5. Look through the text and give Ukrainian equivalents for the following words and word-combinations:

sequence of minute electrical pulses; occur; basic code; penetration; launch; multiply; assist; human intervention; subtraction; division; addition; application; refined and flexible techniques; evaluation; feedback; in terms of; living entity; endeavour; scrutiny.

6. Look through the text and give English equivalents for the following words and word-combinations:

дані; послідовність; порізно; траплятися; дрібний; незнаний; удосконалювати; точність; зворотний зв’язок; бути зацікавленим; передбачати; керований снаряд; захоплювати; використовувати.

7. Study the text and find antonyms to the following words:

absence; old; easy; past; narrow; low; stupid; artificial; rigid; subtraction; animal; regress; common.

8. Study the text and give synonyms to the following words:

information; manipulate; general; area; enhance; benefit; finish; main; research; invasion.

9. Combine the words from the left-and right-hand columns to make word-combinations. Translate them into Ukrainian:

information	contribution
human	behaviour
technical	making
communicative	applications
flexible	endeavour
structural	system
automated	being
societal	functions
significant	information
nervous	attributes
emotional	activity
human	techniques

decision	industries
creative	technologies
computer	progress

10. Compose sentences with the words and word-combinations from Ex. 9.

Reading Comprehension

1. Review the whole text again. Outline the subject matter of the text, its components structure, topic sentences and main ideas. Use the following phrases:

– The text deals with … (speaks about, presents, shows, points out, discusses, reviews, throws light on, traces the history of, etc)

– The subject matter of the text is …

– The text can be segmented into … paragraphs.

– The first (second, third, fourth, etc.) paragraph considers … (deals with, informs of, describes, etc.)

– The topic sentence of the first (second, third, fourth, etc.) paragraph is …

– The main idea of the first (second, third, fourth, etc.) paragraph is …

– The main idea of the text is …

– The conclusion the author came to is …

– The reasons for this conclusion are …

2. Say whether the following statements are true or false. Justify your choice. Use the given phrases:

It's right. Quite so.
I quite (fully) agree to it.
Certainly. Exactly.
I doubt that …
I don't think so.
This is not the case.
It's wrong, I am afraid.
Quite the reverse.
The definition is inappropriate.

1. It is easy to say what the future holds in store for information.
2. The machine can become cleverer than its creator.
3. The machine serves man, and not the other way round.
4. The principal use of computers has been in the area of applied

mathematics.

5. Man’s technical progress is not reflected in the tools he has invented.

6. Informatics is a young science therefore it is not increasingly applied in various branches of industry and research.

3. Answer the following questions:

1. What is information?
2. Does the word “information” have a rather special definition in the discussions of computers?
3. In what way may information be recorded and manipulated in a large automatic electronic computer?
4. What does the term “informatics” designate?
5. How does informatics penetrate into the most widely different spheres of human activity?
6. Can the machine become “cleverer” than its creator?
7. Does machine replace man or serve him?
8. What is man’s technical progress reflected in?
9. What devices has man created from early times?
10. What devices has man developed with the advent of automatic digital computers?
11. What are the operations performed by computers?
12. Has the applications of computers to scientific problems become increasingly important? And why?
13. What do the scientists’ contributions to the progress of informatics consist of?
14. What theory does an important aspect of the work in informatics deal with?
15. What is informatics concerned with?
16. Can you name the problems which are under the scrutiny of informatics?
17. What branches of industry and research is informatics applied in?
18. What answer to two major questions does informatics endeavour to find?

4. Give the definitions of the terms “information” and “informatics”:

Information (data) is … *Informatics is …*

Conversational Practice

1. Agree or disagree with the statement given below. Use the introductory phrases and develop the idea further. Use the following phrases:

I hold a similar view …
I share this viewpoint …
It's correct to say …
This is a convincing argument …
I see no point at all to disagree that …
There is no point in denying that …
That doesn't sound convincing enough …
Not quite so, I am afraid.
I don't think this is just the case.
I doubt it. Far from that.
Just the other way round.
Not at all. Quite the reverse.
The definition is inappropriate.

1. For the time being, there is no unique, universally acceptable definitions of "information" and "informatics". The formal informatics definition is: "Інформатика – наука про опис, осмислення, інтерпретацію, представлення, формалізацію і застосування знань за допомогою засобів обчислювальної техніки з метою пошуку нових знань у всіх сферах людської діяльності". If you agree – translate the given definition into English, if you disagree – give your own version.

2. Discuss the following statement. Use the given phrases:

My point is that …
It seems reasonable to say …
I can start by saying …
I have to admit that …
I have reason to believe that …
Summarizing the discussion …
On the whole …
In the long run …
In conclusion I must say …

Information has become a profitable commodity, an effective means of management, a crucial factor of science, education, culture, business, economy.

3. Give a short summary of the text.

Text B. Cybernetics

1. Read and translate the text:

The word "cybernetics" originated from the Greek "Kibernetike", the Latin "gubernator" and the English "governor" all meaning, in one sense or another, "control", "management" and "supervision". More recently *Norbert Wiener* has used the word to name his book, which deals with the activity of a group of scientists engaged in the solution of a wartime problem and some of the math concepts involved. Nowadays the word has become associated with the solution of problems dealing with activities for computers. As such, the discipline must rely on the exact sciences as well as sciences such as biology, psychology, biochemistry and biophysics, neurophysiology and anatomy.

Before studying computer systems it is necessary to distinguish between computers and calculators. These terms have, by connotation, two distinctly different meanings. The term *calculator* will refer to a machine which (1) can perform arithmetic operations, (2) which is mechanical, (3) which has a key-board input, (4) which has manually-operated controls (examples: adding machines, desk calculators). The term *computer* will refer to automatic digital computers which can (1) solve complete problems, (2) are generally electronic, (3) have various rapid input-output devices, (4) have internally-stored control programs (routines). Speed and general usefulness make a computer equivalent to thousands of calculators and their operators. The ability of electronic computers to solve math and logical problems, thereby augmenting the efficiency and productivity of the human brain, has made the sphere of their application practically boundless.

Active Vocabulary

augment
boundless
by connotation
complete
distinctly
governor
internally
rapid
supervision
thereby
to refer to
to rely on
wartime

2. Answer the following questions:

1. What is the origin of the word “cybernetics”?
2. Who was the first to use the word “cybernetics”?
3. What does Norbert Wiener’s book deal with?
4. What sciences must the discipline “cybernetics” rely on?
5. Should we distinguish between computers and calculators before studying computer system?
6. What does the term “calculator” refer to?
7. What operations can a calculator perform?
8. Are the operations performed by a computer very complicated?

3. Reconstruct the text “Cybernetics” into a dialogue.

The main rules governing a conversation in English:

The person who asks questions in a conversation usually controls it. Personal questions should be expressed tactfully.

Add new phrases to the previous ones:

Let’s be realistic about this plan/suggestion, etc.

I / we / you have got to think of other sides of this problem as well.

I think it would be reasonable / well-grounded / good, etc. if we discussed your suggestion in detail.

That’s completely irrelevant/off the point. We’re talking about another problem.

Perhaps we could go back to the main point.

Could you stick to the subject/point, please?

That’s very interesting, but I don’t think it’s really to the point.

4. Annotate the text in English. Use the phrases:

I.

a) The title of the article is...

It is written by prof... and published in London in the

journal..., No.3, vol.4, 2011 *magazine..., No.3, vol.4, 2011* *collection of articles ... by... editorial house in 2011* *book ... by... editorial house in 2011*	on pp.3-10

b) The article... by prof... is published in the journal..., in N.Y., pp.5-10.

II.

a) The article	*deals with* *discusses* *touches* *discloses* *is devoted to*	the problem of ...

The text tells us about ...

b) Disclosing the problem the author dwells on (upon) such matters as...

The major	*points* *matters* *problems* *issues*	of the text are the following: ...

c) The author	*pays special attention to …* *draws readers' attention to …*

Much *Great* *Special*	attention is paid to...

The author	*concentrates on, focuses on* *stresses, underlines, emphasises* *points out* *dwells on (upon)* *distinguishes between* *speaks in details* *gives the classification*

III.

a) As far as I am an expert in ... I

consider *believe* *suppose* *think* *guess*	the article to be of some (great) interest for …

b)	*In my opinion*	the article is of	*great some*	interest for

the specialists in... *a wide range of readers*

5. Discuss the statements given below:

That's right.

Exactly. Certainly.

I fully agree to it.

I don't think so. This is not the case.

It's wrong, I am afraid. Quite the reverse.

The definition is inappropriate.

1. Cybernetics is the means of studying the analogues existing between machines and living creatures.
2. Cybernetics is the fantastic world of the future peopled by robots and electronic brains.
3. Cybernetics is the Queen of sciences.
4. The cyberneticians today turned their attention to the study of the higher cerebral functions and intricacies of intelligence.

Writing

Write a composition on "The contribution of cybernetics to a wide range of fields in human activity".

Use the plan:

a) modification of human mentality and scientific thinking;
b) acceleration of scientific and technological progress;
c) modernization and updating of industry;
d) restructure of the management system;
e) crash changes in economy to double productive output;
f) implementation of large-scale integrated program in the strategic areas;
g) application of intensive technologies in agriculture;
h) advance in socio-economic development of the society;
i) all-embracing international security system building.

Extended reading

Text C. Algorithms

Read and translate the text into Ukrainian at home. Write an abstract (précis) of the text taking into account the following outlines:

1. An algorithm is a set of rules or directions (instructions) for getting a specific output from a specific input.

2. A computer program is the statement of an algorithm in some well-defined language.

3. Babylonian mathematicians gave rules for solving many types of equations (1800 B.C.).

4. The word "algorithm" itself originated in the Middle East.

5. Euclid's algorithm is a basic tool in modern algebra and number theory.

6. Algorithm-designing is pure and applied branches of cybernetics.

Reproduce it in class.

Twenty or more years ago the word "algorithm" was unknown to most educated people; indeed, it was scarcely necessary. The rapid rise of computer science, which has the study of algorithms as its focal point has changed all that; the word is now essential. There are some other words that almost, but not quite, capture the concept that is needed: procedure, recipe, process, routine, method. Like these things *an algorithm is a set of rules or directions (instructions) for getting a specific output from a specific input.* The distinguishing feature of an algorithm is that all vagueness must be eliminated; the rules must describe operations that are so simple and well-defined that they can be executed by a machine. Furthermore, an algorithm must always terminate after a finite number of steps.

A computer program is the statement of an algorithm in some well-defined language, although the algorithm itself is a mental concept that exists independently of any representation. Anyone who has prepared a computer program will appreciate the fact that an algorithm must be very precisely defined, with attention to detail that is unusual in comparison with other things people do. Programs for numerical problems were written as early as 1800 B.C. when Babylonian mathematicians gave rules for solving many types of equations. The rules were as step-by-step procedures applied systematically to particular numerical examples. The word "algorithm" itself originated in the Middle East, although at a much later time. Curiously enough it comes from the Latin version of the last name of the Persian scholar Abu Jafar Mohammed ibn Musa *al-Khowaresmi* (Algorithmi) whose textbook on arithmetic (c. 825 A.D.) employed for the first time Hindu positional decimal notation and gave birth to algebra as an independent branch of maths. It was translated into Latin in the 12th century and had a great influence for many centuries on the development of computing procedures. The name of the textbook's author became associated with computations in general and used as a term "algorithm".

Originally algorithms were concerned solely with numerical calculations; Euclid's algorithm for finding the greatest common divisor of two numbers – is the best illustration. There are many properties of Euclid's powerful algorithm which has become a basic tool in modem algebra and number theory. Nowadays the concept of an algorithm is *one of the most fundamental notions* not only in maths but in science and engineering. Experience with computers has shown that the data manipulated by programs can represent virtually anything. In all branches of maths the task to prove the solvability or unsolvability of any problem requires a precise algorithm. In computer science the emphasis has now shifted to the study of various structures by which information can be represented and to the branching or decision-making aspects of algorithms, which allow them to fall on one or another sequence of operations depending on the state of affairs at the time. It is precisely these features of algorithms that sometimes make algorithmic models more suitable than traditional math models for the representation and organization of knowledge.

Although numerical algorithms certainly have many interesting features, there are non-numerical ones and, in fact, algorithms in cybernetics deal primarily with manipulation of symbols that need not represent numbers. Algorithm-designing is both pure and applied branches of cybernetics. Current algorithms are becoming more and more refined and sophisticated. Algorithms for searching information stored in a computer's memory, such as sequential search, binary search, Tree search, etc., may illustrate several important points about algorithms in general: an algorithm must be stated precisely and it is not an easy task to do that as one may think. When one tries to solve a problem by computer, the first algorithm that comes to mind can usually be greatly improved. Data structures such as optimum-binary-search tree are important tools for the construction of efficient algorithms. When one starts to investigate how fast an algorithm is or when one attempts to find the best possible algorithm for a specific application, interesting issues arise and one often finds that such questions have subtle answers. Even the "best possible" algorithm can sometimes be improved if we change the ground rules. Since computers "think" differently from people, methods that work well for the human mind are not necessarily the most efficient when they are transferred to a machine.

8.

1. The Mystery of Memory.
2. The Memory of the Modern Supercomputers.
3. The Brain.
4. The Gerund. Gerundial Construction[10].

Grammar Revision.
The Gerund /герундій/

Герундій – це неособова форма дієслова із закінченням -ing, що має властивості іменника та дієслова (reading, writing, going).

1) Як іменник герундій може:

1. бути підметом:

Reading is useful.	Читати – корисно.

2. бути додатком:

He likes **reading**.	Він любить читати.

3. бути частиною присудка:

His hobby is **reading.**	Його хоббі – читання.

4. мати перед собою прийменник:

He is fond of **reading**.	Він захоплюється читанням.

5. мати перед собою присвійний займенник або іменник в присвійному відмінку.

Would you mind **my reading** the poem.	Ви не заперечуєте, якщо я прочитаю вірша.

2) Як дієслово герундій (перехідного дієслова)[11] може:

1. мати при собі прямий додаток –

I'm found of **translating articles** of this kind.	Мені подобається перекладати такі статті.

2. визначатися прислівником –

They continued **listening attentively.**	Вони продовжували уважно слухати.

[10] Навчальні завдання з розвитку граматичних навичок з англійської мови (теорія, тренувальні вправи, міні та рейтингові тести) для студентів II-х курсів усіх спеціальностей РДТУ (Частина IV). Рівне: РДТУ, 1999. – с. 24-27.

[11] Перехідні дієслова мають прямий додаток (to write a letter), а неперехідні не мають (to go).

3. мати неозначену (Indefinite) і перфектну (Perfect) форму; вживатися в активному стані (неперехідні дієслова), в активному і пасивному стані (перехідні дієслова).

Форми герундія та їх комунікативні значення.

Форми герундія неперехідного дієслова

Voice Tense	Active
Indefinite	going
Perfect	having gone

Форми герундія перехідного дієслова

Voice Tense	Active	Passive
Indefinite	**writing**	**Being written**
Perfect	**having written**	**having been written**

Порівняйте:

I am looking forward **to sending** him on a business trip.	Я з нетерпінням чекаю, коли **відправлю** його у відрядження.
I am looking forward to **being sent** on a business trip.	Я з нетерпінням чекаю, коли **мене відправлять** у відрядження.

Порівняйте:

I am surprised at his **missing** lessons.	Мене дивує, що він **пропускає** уроки.
I am surprised at his **having missed** lessons.	Мене дивує, що він **пропустив** уроки.

Indefinite Gerund – називає дію, одночасну по відношенню до дії, вираженої дієсловом в особовій формі.

Perfect Gerund – називає дію, що передує дії, вираженій дієсловом в особовій формі.

Функція герундія в реченні

Функція	Приклад	Способи перекладу
1. Підмет. Після виразів: It is no use … It is no good … It is a surprise … It is a fun … **Складний підмет** N'S +V ing Pos. Pr. + V ing	**Reading** is her favourite occupation. **Читати (читання)** – її улюблене заняття. It is no use **ringing** him up. It was a surprise **seeing** him here. Peter's **reading** *was good.* **My going** there is necessary.	Іменником, неозначною формою дієслова.
2. Частина складного присудка. Після дієслів: can't help, to begin, to continue, to finish, to go on, to keep on, to stop, to give up.	Her greatest pleasure is **reading.** Її найбільше задоволення – **читати (читання).** I **can't help smiling.** You must **give up smoking**.	
3. Прямий додаток Після дієслів: to like, to need, to prefer, to remember, to enjoy, to mind, to be busy, to excuse, to be worth, to forget	Do you like **dancing**? Вам подобається **танцювати**? Excuse my **leaving** you. Пробачте, що я **залишив** вас.	Присудком підрядного речення.
4. Прийменниковий додаток: to depend on, to rely on, to dream of, to object to, to blame for, to thank for, to praise for, to be responsible for, to be interested in, to be engaged in, to be found of, to look forward to, to feel like …	I don't feel like **going** there. Мені не хочеться туди **йти**.	
5. Означення. opportunity of, idea of, chance of, importance of, hope of, way of, experience in, interest in, reason for …	The idea of **going** there was brilliant. Ідея **піти** туди була чудовою.	

6. Обставина: а) часу з прийменниками: after, before, on. б) способу дії з прийменниками: by, without, instead of, besides.	**On seeing** his farther, the boy ran up to him. **Побачивши** батька, хлопчик побіг до нього.	Дієприслівником.
	We gain much **by reading**. **Читаючи,** ми багато пізнаємо.	
	You can’t leave **without saying** good-bye. Ви не можете поїхати, **не попрощавшись**.	

Після дієслів **to like, to begin, to continue, to finish** можна вживати як інфінітив, так і герундій, значення при цьому не змінюється.

He likes reading books.
He likes to read books.
Він любить читати книжки.

Після дієслів **to stop, to remember, to forget** можна вживати як інфінітив, так і герундій, але значення при цьому змінюється.

John **stopped** studying.	Джон припинив навчання.
John **stopped** to have a rest.	Джон зупинився, щоб перепочити.
I **remember** meeting him ten years ago.	Я пам’ятаю, що зустрічав його 10 років тому.
I must **remember** to meet him.	Я пам’ятаю, що повинен зустріти його.
She **forgot** answering the letter.	Вона забула, що відповідала на лист.
She **forgot** to answer the letter.	Вона забула відповісти на лист.

Text A. The Mystery of Memory

Pre-text Exercises

1. Before reading the text, read the following questions. Do you know the answers already? Discuss them briefly with other students to see if they know the answers. The questions will help to give a purpose to your reading:

– Are you sure you know how memory works?

–Why is information sometimes stored forever and sometimes quickly forgotten?

– Do you know what goes in the brain when we process a thought?

2. Learn to recognize international words:

mystery, caprice, indicate, information, limit, complexity, consolidate, memorize, civil, compress, association, license, police, function, observe, physiology, process, structure, nerve, preserve, neural, holographical, analogy, rudimentary.

Read and translate the text:

Mystery of Memory

How does memory work? No one – but no one – is sure. It's that simple. What makes memory so hard to understand is the seeming caprice with which it operates. Sometimes our recollections are vivid and sharp, sometimes they're blurred and murky. Sometimes we recall things in great sweeping overviews; sometimes we remember only minutiae. Research now indicates that the way information is stored depends upon the way it was learned in the first place. *Short-term memory (STM),* our simplest memory-storage receptacle, serves as a kind of holding pen for data we may or may not want to retain.

Generally, the capacity of STM is limited to seven or eight chunks of information. These can range in complexity from a single digit to an elaborate sentence of thought. STM capacity can thus be enhanced by consolidating many individual bits of information into fewer, meaningful units. For example, it is difficult to memorize at first glance a string of 12 digits such as 1, 8, 6, 5, 1, 4, 9, 2, 1, 9, 6, 9. But the task becomes far easier if we recognize that the first four digits represent the year the Civil War ended, its next four the year Columbus discovered America and the last four the year men first landed on the Moon. Twelve bits of data are thus compressed into three.

Unlike STM, *long-term memory (LTM)* has a comparatively limitless capacity and duration. In order for information to make the leap from STM to LTM, it must have some significance or association. Hence, a random license plate on a random car might be observed and quickly forgotten. But if the same car is screeching away from a robbery and the observer jots down the number to give to the police, chances are that those six or seven digits will be recollected and remembered for a lifetime.

Although observing the function of memory is easy enough, explaining its physiology is not. Just what goes on in the brain when we process a thought? Here opinions diverge. Some suggest that the structure of a nerve pathway changes when data are preserved, forming a neural road map of a thought. Others think the brain works holographically, each new piece of information being stored in all areas of the brain. The study of the physiology of memory is in its infancy, and researchers must thus still rely on analogy, on terms like *storage* and *retrieval,* to explain how we remember. But even a rudimentary understanding is better than none at all, and science is now providing at least that much insight – a significant stride in a field of study that has mystified so many for so long.

Active Vocabulary

mystery	таємниця
recollection	спогад, пам’ять
vivid	яскравий, чіткий, ясний
sharp	гострий, виразний
blur	пляма, розпливчаста пляма, нечіткі контури
murky	темний, похмурий
recall	згадувати, нагадувати, воскрешати (у пам’яті)
sweep	мчатися, проноситися
overview	огляд
minutiae	дрібниці, деталі
receptacle	вмістилище, сховище, резервуар
depend upon	залежати
retain	утримувати, зберігати
hold	тримати, утримувати
capacity	місткість, ємкість
chunk	шматок
elaborate	складний, вироблений
sentence	речення, вислів
string	низка, ряд
consolidate	об’єднувати(ся)
recognize	дізнаватися
unlike	на відміну від
comparatively	порівняно
duration	тривалість
leap	стрибок

random	вибраний навмання, випадковий
screech	пронизливо або зловісно кричати
robbery	крадіжка, грабіж
jot	стисло записати
although	хоча
diverge	розходитися, відхилятися
pathway	стежина, доріжка
infancy	дитинство (раннє)
retrieval	повернення, виправлення
rudimentary	елементарний, недорозвинений
stride	крок
mystify	містифікувати, вводити в оману

Grammar and Vocabulary Exercises

1. Study the text, and find sentences with the Gerund. Translate them into Ukrainian.

Національний університет
водного господарства
та природокористування

2. Translate the following sentences into Ukrainian:

1. Asking him about it was useless.
2. Newton's having discovered the law of gravitation contributed much to world science.
3. The trouble was his not coming in time.
4. Avoid making such bad mistakes.
5. We succeeded in accomplishing our task.
6. This is the method of solving such problems.
7. After discussing the point, we went on working.
8. The good results are due to his hard working.
9. It's worth while discussing the phenomenon.
10. It's no good arguing about it.

3. Observe the identical form of the Ukrainian translation of both the Participle and the Gerund as an adverbial modifier of time and manner:

a)	On arriving home Arriving home Having arrived home	I was told that news.
b)	Listening to tapes every day By listening to tapes every day	You will improve your pronunciation

c)	After discussing the problem in detail Having discussed the problem in detail	they found the best solution

4. Underline the affixes, state what part of speech they indicate and translate them into Ukrainian:

seem – seeming; blur – blurred; sweep – sweeping; hold – holding; consolidate – consolidating; compare – comparatively.

5. Look through the text and give Ukrainian equivalents for the following words and word-combinations:

recollection; blur; depend upon; receptacle; hold; chunk; consolidate; random; diverge; at first glance; in order for; although; rudimentary; pathway; stride.

6. Look through the text and give English equivalents for the following words and word-combinations:

тримати; складний; тривалість; стрибок; вибраний навмання; крадіжка; дитинство; на відміну від; зберігати; порівняння; низка; нечіткі контури; резервуар; залежати; порівняно.

7. Complete these sentences:

1. What makes memory so hard to understand is … .
2. Sometimes we recall things in … .
3. Short-term memory serves as a kind of holding pen for … .
4. The capacity of STM is limited to … .
5. STM capacity can thus be enhanced by … .
6. Long-term memory has a comparatively … .
7. A random license plate on a random car might be … .
8. Some suggest that the structure of a nerve pathway changes when data are preserved, forming … .

8. Combine the words from the left-and right-hand columns to make word-combinations. Translate them into Ukrainian:

seeming	understanding
vivid	road map
sweeping	caprice
limitless	bit of information
individual	stride
meaningful	pathway

long-term	units
random	capacity
neural	car
nerve	overviews
rudimentary	memory
significant	recollections

9. Compose sentences in English using the word-combinations from Ex. 8.

Reading Comprehension

1. Review the whole text again. Outline the subject matter of the text, its components structure, topic sentences and main ideas. Use the following phrases:

– The text deals with … (speaks about, presents, shows, points out, discusses, reviews, throws light on, traces the history of, etc)

– The subject matter of the text is …

– The text can be segmented into … paragraphs.

– The first (second, third, fourth, etc.) paragraph considers … (deals with, informs of, describes, etc.)

– The topic sentence of the first (second, third, fourth, etc.) paragraph is …

– The main idea of the first (second, third, fourth, etc.) paragraph is …

– The main idea of the text is …

– The conclusion the author came to is …

– The reasons for this conclusion are …

2. Say whether the following statements are true or false. Justify your choice. Use the given phrases:

It's right. Quite so.
I quite (fully) agree to it.
Certainly. Exactly.
I doubt that …
I don't think so.
This is not the case.
It's wrong, I am afraid.
Quite the reverse.
The definition is inappropriate.

1. Research now does not indicate the way information is stored.

2. Short-term memory serves as a kind of holding pen for data we may or may not want to retain.

3. The capacity of STM is unlimited.

4. STM capacity can not be enhanced.

5. LTM has a comparatively limitless capacity and duration.

6. It is easy enough to explain the physiology of memory.

7. The study of the physiology of memory is in it's infancy.

8. Researchers must not rely on analogy, on terms like *storage* or *retrieval*, to explain how we remember.

3. Answer the following questions:

1. What makes memory so hard to understand?
2. How do we recall things? What recollections are there?
3. What does the way information is stored depend upon?
4. How does short-term memory serve?
5. What is the limit of the capacity of STM?
6. How can chunks of information range in complexity?
7. What way can STM capacity be enhanced?
8. What makes it easier to memorize 12 digits?
9. What are the limits of LTM?
10. What causes the leap from STM to LTM?
11. Is it easy to observe the function of memory?
12. Is it difficult to observe the function of physiology?
13. What goes on in the brain when we process a thought?
14. What happens to the structure of a nerve pathway when data are preserved?
15. What are the two points of view on the way the brain works?
16. Is the study of physiology rather young?
17. What must researcher rely on to explain how we remember?
18. What is science providing now?

Conversational Practice

1. Speak about:

a) the way the information is stored;
b) the way the information is recollected;
c) the technique short-term memory serves;
d) the technique long-term memory serves;
e) two ideas the brain works.

2. Clarify what we mean by the phrases:

1. Short-term memory serves as a kind of holding pen for data we may or may not want to retain.

2. In order for information to make the leap from STM to LTM, it must have some significance or association.

3. Expand the given statements and develop each of them into a paragraph.

1. Short-term memory is our simplest memory-storage.

2. Long-term memory has a comparatively limitless capacity and duration.

3. The way information is stored depends upon the way it was learned in the first place.

4. Debate the given problem. It is advisable that the group be divided into two parties, each party advocating their viewpoint. Use the following introductory phases:

I will start by saying (claiming) that ...
What I mean to say is ...
You are free to disagree with me but ...
My point is that…
Much depends on who (when, what, how) ...
I'd like to make it clear…

What goes in the brain when we process a thought? Here opinions diverge. Some suggest that the structure of a nerve pathway changes when data are preserved, forming a neural road map of a thought. Others think brain works holographically, each new piece of information being stored in all areas of the brain.

5. Give a short summary of the text.

Text B. The Memory of the Modern Supercomputers

1. Read and translate the text:

The Memory of the Modern Supercomputers

The organization of computer memory has received much attention over the years. There are two general ways of partitioning memory, which can be called *vertical* and *horizontal.* The incentive for structuring memory in a vertical or hierarchical manner is that fast memories cost more per bit than slower ones. Moreover, the larger the memory is, the longer it takes to access items that have been stored randomly. The processing units in most large computers communicate directly with a small, very fast memory of perhaps several hundred words. Data can be transferred to or from one of these disk units at a maximum rate of half a million words per second, and in practice it is possible to maintain data flow between central memory and several disk units simultaneously.

The maximum rate of transfer of information to or from a memory device is known as a *bandwidth.* In order for the average computing speed not to be dominated by the smaller bandwidth of the lower memory levels, programs must be arranged so that as much computation as possible is done with instruction and data at the higher levels before the need arises to reload the higher level from the one below. This is an important consideration in programming vector operations for supercomputers, whose central-memory bandwidth is small in relation to the megaflop rate that can be sustained for data held in the register set.

Several multiprocessing supercomputers currently under development incorporate a number of independent parallel memory modules that linked to an equal number of independent processors through a high-speed program-controlled switch so that all the memories are equally accessible to all the processors. For pipelines processors still another kind of horizontal partitioning of central memory has been devised: the memory is divided into a number of "phased" memory *banks,* so described because they operate with their access cycles out of phase with one another. The rationale for the scheme is that random-access central memories are relatively slow, requiring the passage of a certain minimum number of clock periods between successive memory references. In order to keep vector operands streaming at a rate of one word per clock period to feed a pipeline, vectors are stored with consecutive operands in different banks. The phase shift that "opens" successively referenced banks is equal to one processor clock period.

The memory of the modern supercomputers – is *organized hierarchically.* The two register memories are the smallest, followed in capacity by central memory, extended semiconductor memory and disk memory. The extended semiconductor memory has just begun to appear in supercomputer installations because rotating-disc technology has not kept pace with the increasing speed of processors.

All the functional units can run concurrently, but not all can run at top speed concurrently because they share common resources, such as data paths 01 memory access cycles. Moreover, conditional branches in the program interrupt the smooth flow of instructions through the instruction processor. Before the processor issues an instruction, it must wait until it is clear that all the resources needed for the execution of the instruction will be available when they are needed.

Active Vocabulary

accessible
arrange
average
bandwidth
concurrently
consideration
execution
extend
flow
in relation to
incentive
issue
item

maintain
manner
partition
pipeline
references
relational
reload
simultaneously
smooth
structure
to access
to sustain

2. Answer the following questions:

1. How many ways of partitioning memory are there?
2. How can they be called?
3. What is the incentive for structuring memory?
4. Does there exist an interconnection of memory capacity and access time to items that have been stored randomly?
5. How do the processing units in the most large computers communicate?
6. How can data be transferred?
7. What is known as a bandwidth?
8. How must be programs arranged?
9. How is the memory of the modern supercomputers organized?
10. Why cannot all the functional units run concurrently?
11. What interrupts the smooth flow of the instructions through the instruction processor?

3. Reconstruct the text "The Memory of the Modern Supercomputers" into a dialogue.

The main rules governing a conversation in English:

The person who asks questions in a conversation usually controls it. Personal questions should be expressed tactfully.

Add new phrases to the previous ones:

Let's be realistic about this plan/suggestion, etc.

I / we / you have got to think of other sides of this problem as well.

I think it would be reasonable / well-grounded/good, etc. if we discussed your suggestion in detail.

That's completely irrelevant/off the point. We're talking about another problem.

Perhaps we could go back to the main point.

Could you stick to the subject/point, please?

That's very interesting, but I don't think it's really to the point.

4. Annotate the text in English. Use the phrases:

I.

a) The title of the article is...

It is written by prof... and published in London in the

journal..., No.3, vol.4, 2011	on pp.3-10
magazine..., No.3, vol.4, 2011	
collection of articles ... by... editorial house in 2011	
book ... by... editorial house in 2011	

b) The article... by prof... is published in the journal..., in N.Y., pp.5-10.

II.

a) The article	*deals with*	the problem of ...
	discusses	
	touches	
	discloses	
	is devoted to	

The text tells us about ...

b) Disclosing the problem the author dwells on (upon) such matters as...

The major	*points*	of the text are the following: ...
	matters	
	problems	
	issues	

c) The author	*pays special attention to …* *draws readers' attention to …*

Much *Great* *Special*	attention is paid to...

The author	*concentrates on, focuses on* *stresses, underlines, emphasises* *points out* *dwells on (upon)* *distinguishes between* *speaks in details* *gives the classification*

III.

a) As far as I am an expert in ... I

consider *believe* *suppose* *think* *guess*	the article to be of some (great) interest for …

b)

In my opinion *From my point of view* *To my mind*	the article is of	*great* *some*	interest for

the students in applied science *the specialists in...* *a wide range of readers*

5. Discuss the problems trying to prove your point of view. Use the following phrases:

My point is that …
It seems reasonable to say …
I can start by saying …
I have to admit that …
I have reason to believe that …
Summarizing the discussion …
On the whole …

In the long run …
In conclusion I must say …

1. Why does man seek to create smarter computers?
2. What algorithms must be developed to exploit supercomputers?
3. What computers can be exploited to design better computers?
4. Why does man building more and more powerful machines remain their slave as he has to control them?
5. Will coordination be left to the machines itself in the future?
6. Do such predictions belong to the realm of science fiction, or are these claims possible and realizable in practice?

Writing

Write a presentation about the human brain and electronic brains.

Extended reading

Text C. The Brain

Read and translate the text into Ukrainian at home. Write an abstract (précis) of the text. Express your personal view on the idea "The more scientists find out, the more questions they are unable to answer". Reproduce it in class.

The Brain

This century man has made many discoveries about the universe – the world outside himself. But he has also started to look into the workings of that other universe which is inside himself – the human brain. Man still has a lot to learn about the most powerful and complex part of his body – the brain.

In ancient times men did not think that the brain was the centre of mental activity. Aristotle, the philosopher of ancient Greece, thought that the mind was based in the heart. It was not until the 18th century that man realized that the whole of the brain was involved in the workings of the mind. During the 19th century scientists found that when certain parts of the brain were damaged, men lost the ability to do certain things. And so people thought that each part of the brain controlled a different activity. But modern research has found that this is not so. It is not easy to say exactly what each part of the brain does.

In the past 50 years there has been a great increase in the amount of research being done on the brain. Chemists and biologists have found that the way the brain works is far more complicated than they had thought. In fact, many people believe that we are only now really starting to learn the truth about how the human brain works. The more scientists find out, the more questions they are unable to answer. For instance, chemists have found that over 100,000 chemical reactions take place in the brain every second!

Scientists hope that if we can discover how the brain works, the better use we will be able to put it to. For example, how do we learn language? Man differs most from all the other animals in his ability to learn and use language, but we still do not know exactly how this is done. Earlier scientists thought that during a men's lifetime the power of his brain decreases. But it is now thought that this is not so. As long as the brain is given plenty of exercises, it keeps its power. It has been found that an old person who has always been mentally active has a quicker mind than a young person who has done only physical work. It is now thought that the more work we give our brains, the more work they are able to do.

Other people believe that we use only 1% of our brain's full potential. They say that the only limit on the power of the brain is the limit of what we think is possible. This is probably because of the way we are taught as children. When we first start learning to use our minds, we are told what to do, for example, to remember certain facts, but we are not taught how our memory works and how to make the best use of it.

9. 1. Math Concepts.
2. Programming. Multiprogramming.
3. The Internet Programming Languages.
4.Grammar Revision.

Text A. Math Concepts

Pre-text Exercises

1. Before reading the text, read the following questions. Do you know the answers already? Discuss them briefly with other students to see if they know the answers. The questions will help to give a purpose to your reading:

– Do you know the etymology of the term “mathematics”?

– Is it possible to give a concise and readily acceptable definition of maths as a multifield subject?

– Is it necessary to have strong brains (flexible/abstract /clear thinking) to know mathematics perfectly well?

– Could you state the difference between pure maths and applied maths?

2. Learn to recognize international words:

mathematics, etymological, regular, auditor, mental, discipline, connotation, unigue, collection, fraction, irrational, arithmetic, algebra, function, calculus, differential, logical, real, system, geometry, division, structure, concept, axiom, associative, distributive, determine, theorem, deduce, separate, compensate, organic, isolate, province, basic, abstraction, physical, creation, human, negative, operation, multiplication, phenomenon, temperature, observation, total, conception, parallel, specific, progressive, idea, illustrate, constitute, constantly, applications, defect, exist, aspect, fundamental.

Read and translate the text:

Math Concepts

The students of maths may wonder where the word "mathematics" comes from. "Mathematics" is a Greek word, and, by origin or etymologically, it means "something that must be learnt or understood", perhaps "acquired knowledge" or "knowledge acquirable by learning" or "general knowledge". The word "maths" is a contraction of all these phrases. The celebrated Pythagorean school in ancient Greece had both regular and incidental members. The incidental members were called "auditors"; the regular members were named *"mathematicians"* as a general class and not because they specialized in maths; for them maths was a mental discipline of science learning. What is maths in the modern sense of the term, its implications and connotations? There is no neat, simple, general and unique answer to this question.

Maths as a science, viewed as a whole, is a collection of branches. The largest branch is that which builds on the ordinary whole numbers, fractions, and irrational numbers, or what collectively, is called *the real number system.* Arithmetic, algebra, the study of functions, the calculus, differential equations, and various other subjects which follow the calculus in logical order are all developments of the real number system. This part of maths is termed *the maths of number.* A second branch is *geometry* consisting of several geometries. Maths contains many more divisions. Each branch has the same logical structure: it begins with certain *concepts,* such as the whole numbers or integers in the maths of number, and such as point, line and triangle in geometry. These concepts must verify explicitly stated *axioms.* Some of the axioms of the maths of number are the *associative, commutative*, and *distributive properties* and the axioms about *equalities.* Some of the axioms of geometry are that two points determine a line, all right angles are equal, etc. From the concepts and axioms *theorems* are *deduced.* Hence, from the standpoint of structure, *the concepts, axioms and theorems are the essential components of any compartment of maths.* We must break down maths into separately taught subjects, but this compartmentalization taken as a necessity, must be compensated for as much as possible. Students must see the interrelationships of the various areas and the importance of maths for other domains. Knowledge is not additive but an organic whole, and maths is an inseparable part of that whole. The full significance of maths can be seen and taught only in terms of its intimate relationships to other fields of knowledge. If maths is isolated from other provinces, it loses importance.

The basic concepts of the main branches of maths are *abstractions from experience,* implied by their obvious physical counterparts. But it is noteworthy, that many more concepts are introduced which are, in essence, creations of the human mind with or without any help of experience. Irrational numbers, negative numbers and so forth are not wholly abstracted from the physical practice, for the man's mind must create the notion of entirely new types of numbers to which operations such as addition, multiplication, and the like can be applied. The notion of a *variable* that represents the quantitative values of some changing physical phenomena, such as temperature and time, is also at least one mental step beyond the mere observation of change. The concept of *a function,* or a relationship between variables, is almost totally a mental creation. The more we study maths, the more we see that the ideas and conceptions involved become more divorced and remote from experience, and the role played by the mind of the mathematician becomes larger and larger. The gradual introduction of new concepts which more and more depart from forms of experience finds its parallel in geometry and many of the specific geometrical terms are mental creations.

As mathematicians nowadays working in any given branch discover new concepts which are less and less drawn from experience and more and more from human mind, the development of concepts is progressive and later concepts are built on earlier notions. These facts have unpleasant consequences. Because the more advanced ideas are purely mental creations rather than abstractions from physical experience and because they are defined in terms of prior concepts, it is more difficult to understand them and illustrate their meanings even for a specialist in some other province of maths. Nevertheless, the current introduction of new concepts in any field enables maths to grow rapidly. Indeed, the growth of modern maths is, in part, due to the introduction of new concepts and new systems of axioms.

Axioms constitute the second major component of any branch of maths. Up to the 19th century axioms were considered as basic self-evident truths about the concepts involved. We know now that this view ought to be given up. The objective of math activity consists of *the theorems* deduced from a set of axioms. The amount of information that can be deduced from some sets of axioms is almost incredible. The axioms of number give rise to the results of algebra, properties of functions, the theorems of the calculus, the solution of various types of differential equations. Math theorems *must be deductively established and proved.* Much of the scientific knowledge is produced by deductive reasoning; new theorems are proved constantly, even in such old subjects as algebra and geometry and the current developments are as important as the older results.

Growth of maths is possible in still another way. Mathematicians are sure now that sets of axioms which have no bearing on the physical world should be explored. Accordingly, mathematicians nowadays investigate algebras and geometries with no immediate applications. There is, however, some disagreement among mathematicians as to the way they answer the question: Do the concepts, axioms, and theorems exist in some objective world and are they merely detected by man or are they entirely human creations? In ancient times the axioms and theorems were regarded as necessary truths about the universe already incorporated in the design of the world. Hence each new theorem was a discovery, a disclosure of what already existed. The contrary view holds that maths, its concepts, and theorems are created by man. Man distinguishes objects in the physical world and invents numbers and numbers names to represent one aspect of experience. Axioms are man's generalizations of certain fundamental facts and theorems may very logically follow from the axioms. Maths, according to this viewpoint, is a human creation in every respect. Some mathematicians claim that pure maths is the most original creation of the human mind.

ActiveVocabulary

come from	походити від чогось
origin	походження
acquired knowledge	набуті знання
contraction	скорочення
implication	(прихований) сенс, значення
connotation	(супутнє) значення
explicitly	докладно, детально
commute	замінювати
distributive	який (що) розподіляє
property	властивість, якість
deduce	виводити (формулу, висновок)
standpoint	точка зору
compartment	відділення, осередок
experience	досвід
imply	містити в собі, означати
counterpart	копія, дублікат; що-небудь,

	доповнююче інше
notion	поняття, уявлення
divorce	відділення, роз’єднання, розрив
remote	віддалений, відокремлений
consequence	наслідок, результат
constitute	складати, засновувати
objective	мета
incredible	неправдоподібний, неймовірний
bear on	торкатися, мати відношення до чогось
disclosure	відкриття, виявлення

Grammar and Vocabulary Exercises

1. Grammar revision.

Summarize all the grammar rules and the verb *to do* functions so far studied.

1. Imperative Sentences.

E.g. **Suppose (Let** us **suppose)** we have a theorem. **Prove** it deductively. **Let** her (him, them) **do** it.

2. Indefinite Tense-Aspect Forms.

Present	**E. g.** ***Mathematicians*** *prove (must prove)* ***theorems deductively and rigorously. Theorems*** *are proved (must be proved)* ***deductively and rigorously.***
Past	E. g. *Mathematicians* ***proved (were to prove, had to prove) the****orems deductively. Theorems* ***were proved (were to be proved, had to be proved)*** *deductively. A deductive proof* ***is (was) much spoken and written*** *about. A rigorous and elegant* ***deductive*** *proof* ***is (was) looked*** *at with admiration.*

3. Questions.

E.g. **Who proves (must prove)** theorems? **Who proved (was to prove, had to prove)** theorems? **What do (did)** mathematicians **do? How do (did)** mathematicians **prove** theorems? Mathematicians **prove(d)** theorems, **don't (didn't)** they? **Do (Did)** mathematicians **prove** theorems deductively or inductively? **What** is a deductive proof? **Is it difficult to prove** theorems deductively?

4. Negations.

E.g. **Don't prove** theorems that way. **Don't let** him (her, them) **prove** theorems that way. **Let** us **not prove** theorems that way. Mathematicians **do not (did not) prove** theorems that way. **No** mathematician **proves** theorems **that** way. **Don't (Didn't)** mathematicians **prove** theorems deductively. Mathematicians prove(d) **no** theorem that way. Mathematicians **prove(d) nothing** that way. Mathematicians **prove(d)** theorems that way **nowhere.**

There is much thinking, reasoning, proving and justifying in **maths. Is** there? There is **no** arguing **(not any** argument) in this theory. **There exists (emerged)** a new proof of this theorem. **Does there exist...?** There **does not exist... Did there emerge...?** There **did not emerge** a new proof of this theorem.

5. Impersonal Sentences.

E.g. **It is (pre)supposed** that mathematicians prove(d) theorems that way. **One** (does not) **suppose(s) (can hardly suppose)... We** (you, they) **must (not) suppose... People should (not) suppose...**

6. Emphatic Sentences.

E.g. **It is (was)** mathematicians **who prove(d)** theorems. **It is (was)** deductively **that** mathematicians **prove(d)** theorems. **Do prove** theorems deductively! Mathematicians **do (did) prove** theorems deductively. **Whatever (Whichever)** Euclid's proof you take, it is deductive. **The earlier** you master the procedure of a deductive proof, **the sooner** you appreciate math rigour.

7. Noun Substitution.

E.g. The proof(s) by deduction is (are) much more rigorous than **that of (those of)** by induction. **Deduction** and **rigour** are essentials of a math proof. The **former** and **the latter** are essentials of a math proof. These proofs are valid but try to establish more rigorous **ones.**

8. Verb Substitution.

E.g. Mathematicians **prove** theorems inductively rather rarely but physicists **do** it regularly. Mathematicians **prove** what they **do (= prove)** deductively and rigorously.

9. The Verb To Do Functions.

E.g. **1**. These students **do maths. 2.** What **do** these students **do? 3.** They **do** prove theorems. **Do prove** this theorem deductively! 4. They **do not prove** theorems but we **do.** They prove what they **do** deductively.

2. Study the text, find the verb *to do* and state its functions.

3. Underline the affixes, state what part of speech they indicate and translate them into Ukrainian:

incident – incidental; rational – rationale – rationalism – rationalist – rationalistic – rationality – rationalize – rationally; compartment – compartmentalization; add – addition – additive; concept – conception – conceptual.

4. Look through the text and give Ukrainian equivalents for the following words and word-combinations:

regular members; incidental members; mental discipline; science learning; associative, commutative and distributive properties; abstractions from experience; deductive reasoning; implication; connotation; compartmentalization; province.

5. Look through the text and find English equivalents for the following words and word-combinations:

детально; мати відношення до чогось; відкриття; набуті знання; значення; виводити (формулу); замінювати; точка зору; походження; галузь.

6. Write an appropriate word or word-combination in the following spaces:

1. The incidental members were called … .
2. The regular members were named … .
3. … , viewed as a whole, is a collection of branches.
4. The largest branch is that which builds on the ordinary whole numbers, fractions and irrational numbers, or what collectively is called … .
5. From the concepts and axioms … are … .
6. The basic … of the main branches of maths are … .
7. The concepts of a … relationship between variables, is almost totally a … .

concept; mental creation; function; the real number system; theorems; maths as a science; auditors; deduced; abstractions from experience; mathematicians.

7. Combine the words from the left- and right-hand columns to make word-combinations. Translate them into Ukrainian:

general	discipline
science	properties
mental	values
differential	terms
associative	creation
physical	maths
quantative	whole
geometrical	knowledge
human	world
objective	knowledge
pure	learning
scientific	equations
organic	counterparts

8. Compose sentences with the words and word-combinations from Ex.7.

Reading Comprehension

1. Review the whole text again. Outline the subject matter of the text, its components structure, topic sentences and main ideas. Use the following phrases:

– The text deals with … (speaks about, presents, shows, points out, discusses, reviews, throws light on, traces the history of, etc)

– The subject matter of the text is …

– The text can be segmented into … paragraphs.

– The first (second, third, fourth, etc.) paragraph considers … (deals with, informs of, describes, etc.)

– The topic sentence of the first (second, third, fourth, etc.) paragraph is …

– The main idea of the first (second, third, fourth, etc.) paragraph is …

– The main idea of the text is …

– The conclusion the author came to is …

– The reasons for this conclusion are …

2. Say whether the following statements are true or false. Justify your choice. Use the given phrases:

It's right. Quite so.
I quite (fully) agree to it.
Certainly. Exactly.
I doubt that …
I don't think so.
This is not the case.
It's wrong, I am afraid.
Quite the reverse.
The definition is inappropriate.

1. Maths as a science, viewed as a whole, is a collection of branches.
2. Each branch has a different logical structure.
3. The largest branch is that which builds on the ordinary whole numbers, fractions and irrational numbers, or what collectively, is called the real number system.
4. Each branch begins with axioms.
5. There do not exist the interrelationships of the various areas.
6. The basic concepts of the main branches of maths are abstractions from experience.
7. There are no concepts introduced with the help of experience.
8. The concept of a function is not a mental creation.
9. The mathematicians nowadays discover new concepts which are more and more drawn from experience.
10. The more advanced ideas are purely mental creations rather than abstractions from physical experience.
11. Theorems constitute the second major component of any branch of maths.
12. Math theorems must be deductively established and proved.
13. Maths ia a human creation.

3. Answer the following question:

1. Where does the word "mathematics" come from?
2. Does math knowledge come as a consequence (result) of studying and learning alone?
3. How many subject-fields (branches, domains, divisions, compartments) of maths do there exist nowadays?

4. What are the fundamental components of any branch of maths?
5. Can you name some new branches of modern maths?
6. What field of maths is the most interesting (important, essential, significant), to your mind?
7. Why are axioms necessary in a deductive system?
8. Why ought the mathematician to reason deductively?
9. Can we distinguish between whole numbers and irrational numbers from the viewpoint of their origin?
10. What are the factors that make possible the growth of maths?
11. What can research in maths mean?
12. Is the use of abstractions peculiar to maths alone?
13. Are the concepts of force, mass, energy, wealth, liberty, justice, democracy etc., mental creations?
14. Where do math concepts come from?
15. Most abstract math concepts have their physical counterparts, haven't they?
16. Are math concepts discovered or invented?
17. What is a math postulate (axiom, theorem, proof, theory)?
18. What is meant by the phrases "pure maths", "applied maths"?
19. What is more important: a math theory or practical applications?
20. Can a single person be a specialist in many if not all the branches of present day maths?
21. Where is progress more rapid: in pure or applied maths?

4. Give the definitions of the terms "the real number system" and "the maths of number":

The real number system is …

The maths of number is …

Conversational Practice

1. Disagree with the following negative statements and keep the conversation going where possible. Begin your answer with the opening phrases:

It's not correct…
It's not right, I am afraid…
It's wrong,…
On the contrary…
Quite the reverse…

1. Scientists do not think and reason in terms of abstractions.
2. Maths is not a free creation of the human mind and reasoning.
3. Pure maths cannot be applied to the physical world.
4. Mathematicians do not seek useful applications of their theories.
5. Pure maths theories do not find any practical applications.
6. Pure maths theories are often not significant and they are entirely forgotten in say, 50 years.

2. Agree or disagree with the statements. Use the introductory phrases:

That's right…
Exactly. Certainly…
I fully agree to it…
I don't think so. This is not the case…
It's wrong, I am afraid. Quite the reverse…
The definition is inappropriate…

1. A math formula has a direct real physical counterpart.
2. Mathematicians do not rely on their intuitive judgement – they seek to give a rigorous proof.
3. If you want to know what a math theorem states, see what its proofs prove.
4. Maths is both intelligible and enjoyable.
5. Mathematicians do not deal with applications of maths.
6. An idea expressed in symbols is more scientific than the same thought presented in words.
7. Most mathematicians are not incentive to art and beauty.

3. Compose questions and a) answer them in writing at home according to the model; b) practice them orally in class:

Model	If you **asked**	me			**should**	
	Should you **ask**				**would**	
	If I **were asked**		що таке «множина»	**I**	**could**	**say** that …
	Were I **asked**				**might**	
	If I **were to be asked**				**ought to**	
	Were I **to be asked**					

Should you ask me what a "set" is, I'd say that unless otherwise specified "set" is an undefined concept in modern maths.

1. … що таке «математика», …

2. … що таке «постулат», …

3. … що таке «прикладна математика», …

4. … яка різниця між «чистою математикою» і «прикладною математикою», …

5. … де і коли виникла перша математична школа, …

6. … що означає поняття «a variable», …

7. … які найбільш фундаментальні поняття сучасної математики, …

4. Practise problem questions and answers. Work in pairs. Change over!

1. What do you feel looking at a book page sprinkled with x’s and y’s, = ‘s and other math symbols and signs?

2. Does the mathematician write in the language of maths to hide his knowledge from the world at large?

3. Do new symbols often appear in maths?

4. When do mathematicians introduce new symbols and signs into the language of maths?

5. To whom is language of maths “foreign”?

5. What is implied in the following assertion?

There is no national prejudice in maths.

6. Discuss the statements given below. Use the following phrases:

Mathematicians reject…
The statement does not imply…
Scientists do not claim…
That’s right...
Exactly. Certainly…
I fully agree to it…
I don’t think so. This is not the case…
It’s wrong, I am afraid. Quite the reverse…
The definition is inappropriate…

1. Most mathematicians object to the separation of pure and applied aspects of maths. Why? Do pure and applied maths have common language, methods, applications?

2. Mathematicians – what are they? When (why) does a person make up his mind to become a mathematician? What motivates and directs the activities of mathematicians? What mathematician(s) to your mind, is (are) the most distinguished and why?

3. Wherein is the beauty of maths? Beautiful maths is the greatest contribution of the man's mind to all the civilization. Prove it.

7. Give a short summary of the text.

Text B. Programming. Multiprogramming

1. Read and translate the text:

Programming. Multiprogramming

The following items are included in the programming: a) *Consideration of the problem.* Is the problem completely defined? Can we find a method of solution? Will the method fit the computer we use? Will we have enough time, both to prepare the solution on the computer and to run out the answers? b) *Analysis of the problem.* Does the algorithm that we can use exist? Are there "canned" routines that we can apply? That is, are there parts of this problem for which we may already have the computer solution? How much accuracy do we want? How well we assure ourselves that the solutions are correct? Can we construct test data to check the computer solution? Thus, programming covers all activities from the start of the job up to the end and including flowcharting.

Even in scientific computations, the most difficult part of programming is not *the coding,* or actual writing of the instructions for the computer, but the technical analysis of exactly *what to be computed* and *how it is to be computed.* To illustrate it, consider the case where a large problem involves, at some state, the solution of a quadratic equation. There are several methods of solving such an equation with the pencil and paper, but what method is preferable on the computer? Preferable in what sense – in the sense of fastest execution time for the calculation, in the sense of fitting into the least possible amount of core storage; or perhaps in the sense of being easiest to code. The programmer must take these decisions. The programmer does not make all his decisions at once. He usually begins with an overall view of the entire system and the computer is considered as just another unit in the system. As he plans the system, he draws *a system flowchart,* a graphic and easily understood picture of what happens in the system. He then breaks each part of the system flowchart down into as much detail as needed, producing *detailed flowcharts.* For the computer processing he draws a special *program flowchart, outlining,* in general, the essential steps in the computer program. This is refined to produce detailed program flowcharts from which the coding begins. The coder, who may or may not be the same person who did the system analysis, translates each block of the flowchart into one or more instructions for the computer.

One reason for using an operating system is to increase *throughout* the amount of useful work the computer performs in a given time period. In many jobs, the computer spends most of its time waiting for the completion of input-output operations, particularly printing. If the computer has enough core storage and sufficient input-output devices, it allows for *multiprogramming.* Multiprogramming means that two or three different and unrelated programs are placed in storage, with each program having its own set of input-output files. The supervisor gives control to the highest priority program and it continues to be executed until it reaches a point where it can go no further until some pending input-output is completed. At this point, the supervisor saves the status of the program and transfers control to the next highest priority program. When input-output operation is completed, the supervisor halts program which was running and returns control to the first program. Processing continues in this way with the computer entering to wait state only when all programs are waiting. Although the amount of time taken for the computer to complete any one program is increased, the total time for all programs will usually be reduced substantially.

Active Vocabulary

instruction	storage
consider	overall
involve	view
solution	entire
solve	pending
equation	flowchart
preferable	system flowchart
execution	detailed flowchart

amount	program flowchart
core	essential
increase	completion
particularly	halt

2. Answer the following questions:

1. What items are included in the programming?
2. What decisions must the programmer take choosing a preferable method of solving a large problem on the computer?
3. Does the programmer make all his decisions at once?
4. What does the programmer begin with?
5. What does the term "a system flowchart" mean?
6. What are the essential steps in the computer program?
7. Who translates each block of the flowchart into one or more instructions for the computer?
8. What is the reason for using an operating system?
9. What characteristics of core-storage and input-output devices allow for multiprogramming?
10. What does "multiprogramming" mean?
11. What are the procedures of multiprogramming the supervisor provides?
12. What is the most difficult part of programming?

3. Reconstruct the text into a dialogue. The main rules governing a conversation in English:

The person who asks questions in a conversation usually controls it. Personal questions should be expressed tactfully.

Add new phrases to the previous ones:

Let's be realistic about this plan/suggestion, etc.

I / we / you have got to think of other sides of this problem as well.

I think it would be reasonable/well-grounded/good etc. if we discussed your suggestion in detail.

That's completely irrelevant/off the point. We're talking about another problem.

Perhaps we could go back to the main point.

Could you stick to the subject/point, please?

That's very interesting, but I don't think it's really to the point.

4. Annotate the text in English. Use the phrases:

I.

a) The title of the article is...

It is written by prof... and published in London in the

journal..., No.3, vol.4, 2011 *magazine..., No.3, vol.4, 2011* *collection of articles ... by... editorial house in 2011* *book ... by... editorial house in 2011*	on pp.3-10

b) The article... by prof... is published in the journal..., in N.Y., pp.5-10.

II.

a) The article	*deals with* *discusses* *touches* *discloses* *is devoted to*	the problem of ...

The text tells us about ...

b) Disclosing the problem the author dwells on (upon) such matters as...

The major	*points* *matters* *problems* *issues*	of the text are the following: ...

c) The author	*pays special attention to …* *draws readers' attention to …*

Much *Great* *Special*	attention is paid to...

The author	*concentrates on, focuses on* *stresses, underlines, emphasises* *points out* *dwells on (upon)* *distinguishes between* *speaks in details* *gives the classification*

III.

a) As far as I am an expert in ... I

consider *believe* *suppose* *think* *guess*	the article to be of some (great) interest for …

b)	*In my opinion* *From my point of view* *To my mind*	the article is of	*great* *some*	interest for

the students in applied science *the specialists in...* *a wide range of readers*

5. Read the statements and develop the idea further. Use the given phrases:

There is one more point to be noted…
Moreover…
I might as well add that…
More than that…
Bearing in mind…
In this connection one more aspect is interesting to mention…

– A single error in one instruction invalidates the entire code.

– Programming is an exacting technique, requiring attention to details without loosing sight of the overall plan.

– Programming covers all activities from the start of the job up to the end and including flowcharting.

Writing

Using texts A and B of Unit 9 write a composition on "My future profession". Take into account the following outlines or give your own version.

1. Why have you made up your mind to study maths?
2. What subjects do you study at the University?
3. What is your favourite maths subject?

4. Have you made up your mind to choose a field of maths to specialize in?

5. When are you going to make your final decision?

6. Does the University aim to give the students the top level of education and to enable them to carry on scientific research work?

7. What scientific research work does the fifth-year student write? (Research diploma project.)

8. What scientific writings are defended by the Department graduates to get a scientific degree in both pure and applied fields of modern maths? (Thesis/dissertation.)

9. Are the Department graduates sure to get jobs they are willing to have?

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computer programmer, computer analyst, internet system administrator, CAD-CAM technician, computer manager, computer engineer, graphic arts specialist, computer graphic specialist, computer software engineer, etc.

Extended reading

Text C. The Internet Programming Languages

Read and translate the text into Ukrainian at home. Write an abstract (précis) characterizing the Internet languages in detail. Which of them is more familiar to you? Add your own comments. Reproduce it in class.

The Internet Programming Languages

A computer carries out the instructions given in "absolute" machine languages. But people-programmers don't write programs in machine languages, but in programming languages – i.e., the tools, programmers use to create programs, just as English and other spoken languages are the tools writers use to create books. Perhaps the first thing we need to know is the distinction between *assembly languages* and all other programming languages, collectively called *high-level languages.*

Writing a program in *the assembly language* is an exceedingly long and tedious process – a medium-sized program has about 20,000 machine-language instructions in it. A large and complex program can consist of hundreds of thousands of separate machine-language instructions, *high-level languages* are designed to eliminate the tedium and error-prone nature of assembly language by letting the computer do itself much of the work of generating the detailed machine-language instructions. Assembly languages and high-level languages have their own benefits and drawbacks. There are literally hundreds of programming languages and easily dozens that are used on the PC - the most important are *BASIC, Pascal, C* and *d BASE.*

BASIC is the closest thing we have so far to a universal language for personal computers. Its strength is that it is easy to fiddle with and includes features that give us easy access to most of the PC family's special features, such as the capability to play music on the computer's speaker. Two other well-known languages that are well-suited for professional programming are *Pascal* and *C.* Both have the features that are considered most useful in helping programmers create well-crafted programs that are reliable and easy to update. *Pascal* and C have many similarities, including structural features that promote good programming practices. *Pascal* finds its champions among those who have studied it in school. It is the language most favored for teaching computer science, and it was originally created as a language for teaching, rather than for professional use. C is favored by the programmers who are looking for the utmost efficiency in this language, for writing programs that need to be tight and efficient.

Usually a programming language is chosen on very pragmatic ground: which languages the programmer already knows (or can easily learn) and how well suited the programming language into the work that the program has to accomplish. *Personal taste* and *convenience* also play a major part in the selection of a programming language and why shouldn't they?

The last group of programming languages are *application languages* – the integral part of major application programs. Individually each of the application languages is a whole world “into” itself. Probably, the most widely known and used kind of application languages is the *spreadsheet,* which allows to set up and stove commands that can be used over and over again, which is the essence of what a programming language is. A spreadsheet is much more specialized programming language than other languages, because it has to work within its own spreadsheet context.

As *artificial intelligence (AI)* evolved, it has produced specific programs that solve specific kinds of programs and a set of tools that help one construct other program-solving programs. By the end of 1950 it was recognized that the standard programming languages of the time, which had been designed to support a primarily numeric processing, were not very effective in supporting the nonnumeric symbolic computing that *AI* programs do. *LISP* – a language designed for symbolic computing, particularly list processing, had appeared by 1960. *LISP* still serves (although in several greatly extended forms) as the basis for most *AI* program development. *LISP* is an interpreted language, although *compilers* for it are available as well. But when it is run *interpretively,* it supports significant interactive *symboling debugging.*

In recent years other kinds of *AI* languages have emerged. *Prolog* – is a language whose main control structure is not the sequential execution of a set of statements, but rather the application of a specific *inference mechanism* to the program, which is actually a set *of logical assertions. Prolog* has been designed to exploit the communicational possibilities associated with the sequential execution of programs.

10.

1. Automated Factory Update.
2. Planning and Justifying Factory Automation.
3. Control Engineering.
4. Modern Control Systems.

Text A. Automated Factory Update

Pre-text Exercises

1. Before you read the text, read the following questions. Do you know the answers already. Discuss them briefly with other students to see if they know the answers. The questions will help to give a purpose to your reading:

– Can we use the term “factory automation” and “computer-aided manufacturing” interchangeably?

– What does the factory automation include?

– How can you characterize the factory of the past?

2. Learn to recognize international words:

automation, complex, concept, definition, function, systems integration, technology, industrial process, product, design, materials, synergistic, productivity, electronical, organizational, variation, programmable, controllable, manager, instruction, parallel, classical, potential, conflict, structure, problem.

Read and translate the text:

Automated Factory Update

Factory automation and computer-integrated manufacturing are extremely popular terms and are often used interhangeably. But they are fairly complex concepts that require careful definition in order to avoid confusion and to understand where the real opportunities are.

Factory automation is composed of three key functions: engineering automation, manufacturing automation and systems integration.

Engineering automation includes all of the hardware and software technologies that support the automation of the engineering activities. Engineering is a very critical and important part of the overall industrial process because it is the up-front product and/or process design that leads eventually to manufacturing, and it is the area where much of the data that is necessary to drive the manufacturing process are created.

Manufacturing automation is all of the automation that supports the production of finished goods from raw materials. This automation has taken many forms and has been evolving for several years, generally in the form of increasingly more powerful and accurate fixed automation. Recently, however, the trend has been to more flexibility and more programmability.

Systems integration is the technology and activity that supports the integration of the engineering automation products into synergistic systems where the whole is more productive than the sum of the parts. This is the area where the quantum increases in productivity will ultimately be available, and it is this area to which the term computer-integrated manufacturing applies. And there are actually three types of integration involved: electronic, physical and organizational.

Electronic systems integration is necessary to exploit the opportunity available from using electronic data bases. As more computer-aided design (CAD) systems are used to design a high percentage of the products and processes, more of the engineering data will be in electronic form. And as more of the manufacturing automation devices become computer-controlled, they will have to be driven by electronic data bases. The factory of the past was integrated via paper data, but the factory with a future must be integrated via electronic data.

Physical systems integration will be a growing necessity as the factory becomes more flexible and programmable. And as a factory which is oriented toward batch manufacturing becomes more controllable in real time – and therefore more flexible-batch sizes can become smaller and the variation in types of batches can become greater. This implies that a batch factory will become more like a continuous process factory in terms of managing the flow of material through the factory and the flow of instructions to the various machines. The physically integrated factory will have to depend on the electronically integrated factory for its control, coordination, sequencing, and scheduling. And as a result, the implementation of a physically integrated system has to depend on either the prior or parallel implementation of electronic systems that support the physical integration.

Organizational systems integration is much less tangible and yet just as important. The classical example of what has surfaced because of the advent of CAD/CAM systems is the potential conflict between the engineering and manufacturing organizations.

While an engineering manager may have just as much reason to differ in opinion in the future as they have in the past, they should not be permitted to perpetuate organizational structures that impede the opportunities for productivity improvement through electronic and physical systems integration.

It is the integration of CIM that will provide much of the additional benefit that factory automation has to offer. And it is from factory systems integration that automation solutions to manufacturing problems are derived.

Active Vocabulary

factory automation	автоматизоване виробництво
computer-integrated manufacturing (CIM)	виробництво, яке інтегрується на базі ЕОМ
computer-aided manufacturing (CAM)	автоматизація виробництва; автоматизована система керування виробництвом
computer-aided design (CAD)	автоматизоване проектування
interchangeably	поперемінно, по черзі
to avoid confusion	уникати плутанини
opportunity	зручний випадок, сприятлива нагода
engineering automation	автоматизація виробництва

to support	підтримувати, сприяти
manufacturing automation	автоматизація виробничого процесу
systems integration	об'єднання (інтеграція) систем
engineering activities	проектування
critical	вирішальний
overall	повний, загальний
up-front product	попередній продукт
process design	проектування виробничого процесу
eventually	кінець кінцем
accurate	точний
to drive	керувати
to create	створювати
finished goods	готова продукція
raw materials	сировина
evolve	розвивати(ся)
powerful	потужний, могутній
however	однак, проте
trend	напрямок, тенденція
synergism	синергізм (взаємне підсилення дії факторів)
quantum	кількість, сума, частка, частина
ultimately	остаточно
to be available	1) бути доступним; 2) наявний (в розпорядженні); 3) придатний, дійсний
involve	включати в себе
physical	виробничий
to exploit	експлуатувати, використовувати
physical systems integration	об'єднання виробничих систем
flexible	гнучкий
programmable	з програмним управлінням
batch manufacturing	серійне виробництво
controllable	керований
therefore	тому, отже
size	партія
variation	різновид
imply	означати
continuous	безперервний

in terms of	із погляду; з точки зору
flow	потік
through	через
to depend on	залежати
sequencing	послідовність; порядок (проходження)
scheduling	планування
implementation	впровадження
either … or	чи … чи
prior	попередній
tangible	відчутний, реальний
to surface	спливати на поверхню
advent	прихід
to permit	дозволяти
to perpetuate	зберігати назавжди; увічнювати
to impede	перешкоджати; заважати; затримувати
to provide	надавати, забезпечувати
benefit	вигода, користь
to offer	пропонувати
to derive	отримувати; одержати; діставати; походити

Vocabulary Exercises

1. Look through the text and give Ukrainian equivalents of the following words and word-combinations:

computer-integrated manufacturing, engineering automation, manufacturing automation, systems integration, hardware and software technologies, engineering activities, manufacturing problem, finished goods, fixed automation, flexibility and programmability, engineering, automation products, engineering data, batch manufacturing, sequencing and scheduling, implementation, productivity improvement, physically integrated system.

2. Look through the text and give Ukrainian equivalents of the following words and word-combination:

автоматизація виробництва; виробництво, яке інтегрується на базі ЕОМ; автоматизоване керування; серійне виробництво; установлення та складання; впровадження; електронна база даних; управління; вдосконалення виробництва; додаткова перевага; розвивати(ся); гнучкий; готова продукція; гнучкі виробничі системи; проблеми виробництва; менеджер у виробничій сфері.

3. Look through the text and find words with the same meaning:

to apply, production, to involve, significant, complicated, possibility, really, viewpoint, to harm; to increase, different, a lot of, to allow.

4. Look through the text and find words with opposite meaning:

seldom, to misunderstand, unimportant, to ruin, raw materials, to decrease, to increase, intangible, deterioration, to forbid.

5. Combine the words from the left- and right-hand columns to make word-combinations. Translate them into Ukrainian:

factory	system
engineering	manager
computer-integrated	automation
complex	manufacturing
to avoid	engineering
manufacturing	concepts
systems	confusion
hardware	integration
software	technology
up-front	activities
finished	product
fixed	process
synergistic	problem
electronic	goods
computer-aided	data base
batch	design
flexible-batch	automation devices
physical	sizes
organizational	structures
productivity	improvement
additional	benefit
automation	solutions

6. Compose sentences in English using the word combinations from Ex. 5.

Reading Comprehension

1. Review the whole text again. Outline the subject matter of the text, its components structure, topic sentences and main ideas. Use the following phrases:

– The text deals with … (speaks about, presents, shows, points out, discusses, reviews, throws light on, traces the history of, etc)

– The subject matter of the text is …

– The text can be segmented into … paragraphs.

– The first (second, third, fourth, etc.) paragraph considers … (deals with, informs of, describes, etc.)

– The topic sentence of the first (second, third, fourth, etc.) paragraph is …

– The main idea of the first (second, third, fourth, etc.) paragraph is …

– The main idea of the text is …

– The conclusion the author came to is …

– The reasons for this conclusion are …

2. Say whether the following statements are true or false. Justify your choice. Use the given phrases:

It's right. Quite so.

I quite (fully) agree to it.

Certainly. Exactly.

I doubt that …

I don't think so.

This is not the case.

It's wrong, I am afraid.

Quite the reverse.

The definition is inappropriate.

1. Engineering automation does not include the hardware and software technologies.

2. Manufacturing automation is all of the automation that supports the production of finished goods from raw materials.

3. Systems integration is the technology and activity that support only the hardware technology.

4. Organizational systems integration is much more tangible and yet just as important.

5. With the advent of CAD/CAM systems there will be no conflicts between the engineering and manufacturing organizations.

3. Answer the following questions:

1. What is factory automation composed of?
2. What does engineering automation include?
3. Why is engineering automation a very critical and important part of the overall industrial process?
4. What is manufacturing automation concerned with?
5. What technology supports the integration of the engineering automation products into synergistic systems?
6. What do you mean under the term “computer-integrated manufacturing”?
7. Why is electronic systems integration necessary to exploit the opportunity available from using electronic data base?
8. What form will more of the engineering data be in?
9. Was the factory of the past integrated via paper or electronic data?
10. Will physical systems integration be a growing necessity as the factory becomes more flexible and programmable?
11. What case does a factory which is oriented towards batch manufacturing become more controllable in real time?
12. What has the implementation of a physically integrated system to depend on?
13. Is organizational systems integration as just important as electronic systems integration and physical systems integration?
14. What causes the potential conflict between the engineering and manufacturing organizations?
15. What benefit will the integration of CIM provide?

4. Give the terms to the following definitions:

1. The area that includes all the hardware and software technologies that support the automation of the engineering activities.
2. Design of the products and processes with the help of computers.
3. The automation that supports the production of finished goods from raw materials.
4. The technology and activity that support the integration of the engineering automation products into synergistic system.
5. The type of integration that is based on the use of electronic data bases.

Conversational Practice

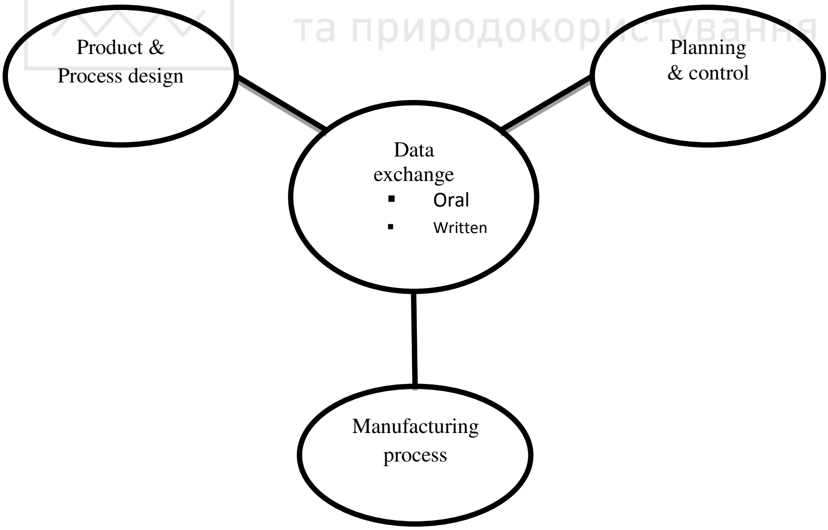
1. Clarify what we mean by the following statements:

1. Nowadays manufacturing automation tends to more flexibility and more programmability.
2. In the synergistic systems the whole is more productive than the sum of the parts.
3. A batch factory will become more like a continuous process factory.

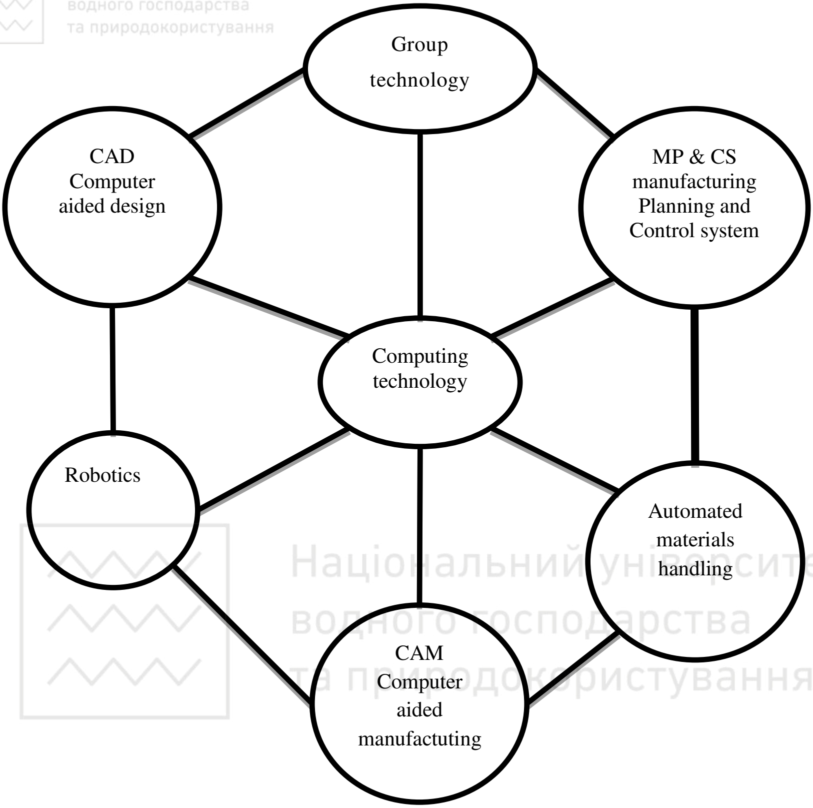
2. Discuss the advantages of CIM comparing traditional manufacturing and computer-integrated manufacturing. The schemes given below will be helpful.

Use the following phrases:

To begin with, my point is that…
CAD (CIM) technicians claim (refute)…
There is no point in denying that…
It must be admitted that…
That sounds convincing enough…
It's too much to say that…



Traditional manufacturing



Computer integrated manufacturing

3. Debate the given problem. It is advisable that the group be divided into two parties, each party advocating their viewpoint. Use the following introductory phrases:

I will start by saying (claiming) that…
What I mean to say is…
You are free to disagree with me but…
My point is that…
Much depends on who (when, what, how)…
I'd like to make it clear…

According to some scientists, till the 40's of this century, the overwhelming majority of people will be occupied in science, education, administration and the service industry, while only 15 per cent of the labour force will remain directly in production. Machines and robots will be the primary producers of material wealth.

4. Give a short summary of the text.

Text B. Planning and Justifying Factory Automation Systems

1. Read and translate the text:

The systems approach to factory automation is undoubtedly the best way to achieve quality, productivity, and financial justification goals. But technology alone is not the answer. Manufacturing managers and production engineers must avoid looking at each piece of equipment in isolation from the rest of the manufacturing process.

The key to success is the fitting the technologies together with appropriate management disciplines, inventory disciplines, and process disciplines, which leads to making the total payback greater than the sum of the parts. Thus, manufacturing problems must be looked at as integrated problems – not as isolated problems that can be solved simply by attacking them with technology. And integrated problems require integrated solutions.

It is impossible to overemphasize the fact that successful factory automation implementation begins with a well-thought out long-range manufacturing strategy. And this strategic planning must be driven from the top down. Before the strategic planning can begin top management has to first set down the performance goals which the enterprise will be expected to achieve.

Automation technology will require, in many cases, a whole new way of thinking, of planning, of operating, of allocating funds, and of managing human resources. And the need for this kind of self-examination is often not recognized in the normal interplay between top management and the people that have to do the actual implementation. A corollary to this is the need for close interpersonal communication.

The issue of closer relationships between suppliers and users is also becoming more important. For example, in the area of flexible manufacturing systems, new levels of communication and cooperation between the supplier and the user, and an unprecedented level of exposure to the user's business plan for the long term, are required to gain the greatest benefits from the substantial investments represented by the systems. In these co-destiny relationships, the supplier essentially becomes a part of the user's business plan, because one goal of the business plan is having the right parts produced in the correct quantities at exactly the times they are needed.

FMS and other factory automation investments are not tactical decisions with short-term implications. They are strategic decisions, with far-reaching competitive implications. Factory automation provides permanent long-term savings plus numerous intangible benefits including higher quality products, shorter production runs, increased worker satisfaction, and greater manufacturing flexibility.

Factory automation affects three major elements of the business: engineering, manufacturing, and information systems. In the engineering operation, quality and producibility are designed into the product. In the manufacturing process, quality is built into the product, and the efforts to simplify product design pay off in lower manufacturing costs. And information systems permit the quality of the products and the flow of production to be monitored and controlled in real time.

To fully comprehend the financial implications of investing inflexible, programmable manufacturing technologies, it is necessary to consider the three major elements of the factory engineering, manufacturing, and information systems, as an inseparable, integrated whole.

Active Vocabulary

approach	recognize
undoubtedly	interplay
justification	actual
to avoid	corollary
piece	supplier
appropriate	level
inventory	unprecedented
payback	exposure
to attack	to gain
require	substantial
overemphasize	co-destiny
to set down	essentially

allocating	exactly
fitting	far-reaching
simplify	competitive
costs	runs
to consider	affect
	effort

2. Answer the following questions:

1. What is the systems approach to factory automation?
2. Must manufacturing managers and production engineers avoid looking at each piece of equipment in isolation from the rest of manufacturing process?
3. What is the key to success which leads to making the total payback greater than the sum of the past?
4. Why is it impossible to overemphasize the fact that successful factory automation implementation begins with a well-thought out long-range manufacturing strategy?
5. What will automation technology require in many cases?
6. Why is the issue of closer relationships between suppliers and users also becoming more important?
7. Are FMS and other factory automation investments the tactical decisions?
8. How many elements of the business does factory automation affect? What are they?
9. What is the common feature of the engineering operation, manufacturing process and information systems?
10. What is necessary to consider to fully comprehend the financial implications of investing in flexible, programmable manufacturing technologies?

3. Reconstruct the text “Planning and Justifying Factory Automation Systems” into a dialogue. The main rules governing a conversation in English:

The person who asks questions in a conversation usually controls it. Personal questions should be expressed tactfully.

Add new phrases to the previous ones:

Let’s be realistic about this plan/suggestion, etc.

I /we/ you have got to think of other sides of this problem as well.

I think it would be reasonable/well-grounded/good, etc. if we discussed your suggestion in detail.

That's completely irrelevant/off the point. We're talking about another problem.

Perhaps we could go back to the main point.

Could you stick to the subject/point, please?

That's very interesting, but I don't think it's really to the point.

4. Annotate the text in English. Use the phrases:

I.

a) The title of the article is...

It is written by prof... and published in London in the

journal..., No.3, vol.4, 2011 *magazine..., No.3, vol.4, 2011* *collection of articles ... by... editorial house in 2011* *book ... by... editorial house in 2011*	on pp.3-10

b) The article... by prof... is published in the journal..., in N.Y., pp.5-10.

II.

a) The article	*deals with* *discusses* *touches* *discloses* *is devoted to*	the problem of ...

The text tells us about ...

b) Disclosing the problem the author dwells on (upon) such matters as...

The major	*points* *matters* *problems* *issues*	of the text are the following: ...

c) The author	*pays special attention to …* *draws readers' attention to …*

Much *Great* *Special*	attention is paid to...

The author	*concentrates on, focuses on* *stresses, underlines, emphasises* *points out* *dwells on (upon)*

distinguishes between
speaks in details
gives the classification

III.

a) As far as I am an expert in ... I

consider *believe* *suppose* *think* *guess*	the article to be of some (great) interest for …

b)	*In my opinion* *From my point of view* *To my mind*	the article is of	*great* *some*	interest for

the students in applied science
the specialists in...
a wide range of readers

5. Express your personal view on the statement "Integrated problems require integrated solutions". Use the following phrases:

As for me… As concerns…
As far as I am concerned…
What I mean to say is…
Summing up the discussion…
In conclusion, I may to say…
To summarize the topic…

Writing

1. Using texts A and B of Unit 10 write a composition on "My future profession". Take into account the following outlines or give your own version.

1. Why have you made up your mind to study computer integrated systems?
2. What subjects do you study at the University?
3. What is your favourite subject?
4. Have you made up your mind to choose a field of CIM or CAD to specialize in?
5. When are you going to make your final decision?

6. Does the University aim to give the students the top level of education and enable them to carry on scientific research work?

7. What scientific research work does the fifth-year student write?

8. What scientific writings are defended by the Department graduates to get a scientific degree in modern automation?

9. Are the Department graduates sure to get jobs they are willing to have?

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computer-aided design, computer-integrated manufacturing, computer-aided engineering, control engineering, robotics, artificial intelligence, information technologies, advanced programming languages.

Extended reading

Text C. Control Engineering

Read and translate the text into Ukrainian at home. Write an abstract (précis). Give your own comments on the evolution of control systems through the course of history. Reproduce it in class.

Control Engineering

Engineering is concerned with understanding and controlling the materials and forces of nature for the benefit of mankind. Control system engineers are concerned with understanding and controlling segments of their environment, often called *systems,* in order to provide useful economic products for society. The twin goals of understanding and control are complementary because, in order to be controlled more effectively, the systems under control must be understood and modeled. Furthermore, control engineering often must consider the control of poorly understood systems such as chemical process systems. The present challenge to control engineers is the modeling and control of modern, complex, interrelated systems such as traffic-control systems, chemical processes, and robotic systems. However, simultaneously, the fortunate engineer has the opportunity to control many very useful and interesting industrial automation systems. Perhaps the most characteristic quality of control engineering is the opportunity to control machines, and industrial and economic processes for the benefit of society.

Control engineering is based on the foundations of feedback theory and linear system analysis, and integrates the concepts of network theory and communication theory. Therefore control engineering is not limited to any engineering discipline but is equally applicable for aeronautical, chemical, mechanical, environmental, civil, and electrical engineering. For example, quite often a control system includes electrical, mechanical, and chemical components. Furthermore, as the understanding of the dynamics of business, social, and political systems increases, the ability to control these systems will increase also.

A *control system* is an interconnection of components forming a system configuration that will provide a desired system response. The basis for analysis of a system is the foundation provided by linear system theory, which assumes a cause-effect relationship for the components of a system. Therefore a component or *process* to be controlled can be represented by a block as shown in Fig. 1. The input-output relation represents the cause and effect relationship of the process, which in turn represents a processing of the input signal to provide an output signal variable, often with a power amplification. An *open-loop* control system utilizes a controller or control actuator in order to obtain the desired response as shown in Fig. 2.

In contrast to an open-loop control system, a closed-loop control system utilizes an additional measure of the actual output in order to compare the actual output with the desired output response. The measure of the output is called the *feedback signal.* A simple *closed-loop feedback control system* is shown in Fig. 3

Figure 1. Process to be controlled

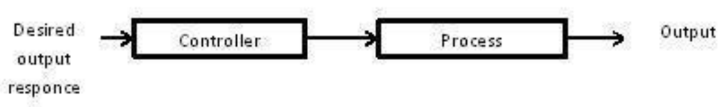

Figure 2. Open-loop control system

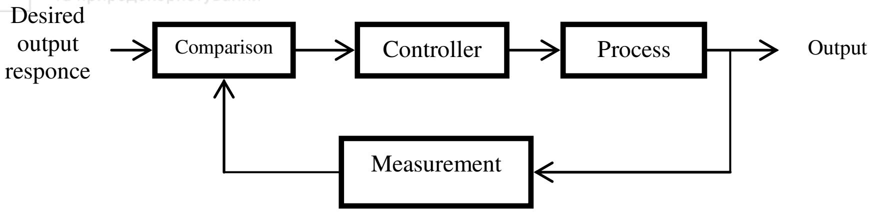

Figure 3. Closed-loop feedback control system

A standard definition of a feedback control system is as follows: A feedback control system is a control system that tends to maintain a prescribed relationship of one system variable to another by comparing functions of these variables and using the difference as a means of control.

A feedback control system often uses a function of a prescribed relationship between the output and reference input to control the process. Often the difference between the output of the process under control and the reference input is amplified and used to control the process so that the difference is continually reduced. The feedback concept has been the foundation for control system analysis and design.

Due to the increasing complexity of the system under control and the interest in achieving optimum performance, the importance of control system engineering has grown in this decade. Furthermore, as the systems become more complex, the interrelationship of many controlled variables must be considered in the control scheme. A block diagram depicting a *multivariable control system* is shown in Fig. 4.

A common example of an open-loop control system is an electric toaster in the kitchen. An example of a closed-loop control system is a person steering an automobile (assuming his or her eyes are open).

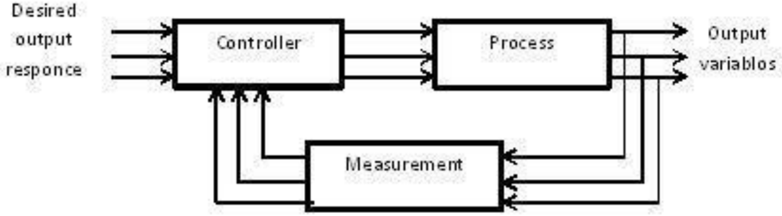

Figure 4. Multivariable control system

Text D. Control Engineering Practice

Read and translate the text into Ukrainian at home. Get additional information from the Internet. Give more details and your own comments on the analysis and design of goal-oriented systems. Consult "Modern Control Systems" by Richard C.Dorf, University of California, Davis, if necessary.
Reproduce it in class.

Control Engineering Practice

Control engineering is concerned with the analysis and design of goal-oriented systems. Therefore the mechanization of goal-oriented policies has grown into a hierarchy of goal-oriented control systems. Modern control theory is concerned with systems with the self-organizing, adaptive, robust, learning, and optimum qualities. This interest has aroused even greater excitement among control engineers.

The control of an industrial process (manufacturing, production, and so on) by automatic rather than human means is often called *automation.* Automation is prevalent in the chemical, electric power, paper, automobile, and steel industries, among others. The concept of automation is central to our industrial society. Automatic machines are used to increase the production of a plant per worker in order to offset rising wages and inflationary costs. Thus industries are concerned with the productivity per worker of their plant. *Productivity* is defined as the ratio of physical output to physical input. In this case we are referring to labor productivity, which is real output per hour of work. In a study conducted by the U.S. Commerce Department it was determined that labor productivity grew at an average annual rate of 2.8% from 1948 to 1984. In order to continue these productivity gains, expenditures for factory automation in the United States are expected to double from 5.0 billion dollars in 1988 to 8.0 billion dollars in 1992. World-wide, expenditures for process control and manufacturing plant control are expected to grow from 12.0 billion dollars in 1988 to 22.0 billion dollars in 1992. The U.S. manufacturers currently supply approximately one-half of worldwide control equipment.

The transformation of the U.S. labor force in the country's brief history follows the progressive mechanization of work that attended the evolution of the agrarian republic into an industrial world power. In 1820 more than 70% of the labor force worked on the farm. By 1900 fewer than 40% were engaged in agriculture. Today, less than 5% work in agriculture.

In 1925 some 588,000 people, about 1.3% of the nation's labor force, were needed to mine 520 million tons of bituminous coal and lignite, almost all of it from underground. By 1980 production was up to 774 million tons, but the work force had been reduced to 208,000. Furthermore, only 136,000 of that number were employed in underground mining operations. The highly mechanized and highly productive surface mines, with just 72,000 workers, produced 482 million tons, or 62% of the total.

The easing of human labor by technology, a process that began in prehistory, is entering a new stage. The acceleration in the pace of technological innovation inaugurated by the Industrial Revolution has until recently resulted mainly in the displacement of human muscle power from the tasks of production. The current revolution in computer technology is causing an equally momentous social change: the expansion of information gathering and information processing as computers extend the reach of the human brain.

The work week in U.S. manufacturing industries shortened from 67 hours in 1860 to about 39 hours in 1984.

Control systems are used to achieve (1) increased productivity and (2) improved performance of a device or system. Automation is used to improve productivity and obtain high quality products. Automation is the automatic operation or control of a process, device, or system. We utilize automatic control of machines and processes in order to produce a product within specified tolerances.

The term *automation* first became popular in the automobile industry. Transfer lines were coupled with automatic machine tools to create long machinery lines that could produce engine parts, such as the cylinder block, virtually without operator intervention. In body-parts manufacturing, automatic-feed mechanisms were coupled with high-speed stamping presses to increase productivity in sheet-metal forming. In many other areas where designs were relatively stable, such as radiator production, entire automated lines replaced manual operations.

With the demand for flexible, custom production emerging in the 1980s, a need for flexible automation and robots is growing.

There are about 150,000 control engineers in the United States and also in Japan, and over 100,000 control engineers in the Soviet Union. In the United States alone, the control industry does a business of over thirty billion dollars per year! The theory, practice, and application of automatic control is a large, exciting, and extremely useful engineering discipline. One can readily understand the motivation for a study of modern control systems.

Professionally oriented texts for individual studying and the development of communicative language competences

APPENDIX I

Text 1. Strong AI and Searle's Chinese Room

Internet Assignment:

1. Use the Internet search engine and find additional information about the supporters and opponents of strong AI. Start your search with such key-words as: Chinese room, Turing test, Searle's program, Schank's algorithm, Holstadter's argument.

2. "Can a computer have a mind?" Provide answers to this question, discussing it with Internet community. Consult Roger Penrose's Penguin book "The Emperor's New Mind", if necessary.

There is a point of view, referred to as strong AI which adopts a rather extreme position on these issues. According to strong AI, not only would the devices just referred to indeed be intelligent and have minds, etc., but mental qualities of a sort can be attributed to the logical functioning of any computational device, even the very simplest mechanical ones, such as a thermostat. The idea is that mental activity is simply the carrying out of some well-defined sequence of operations, frequently referred to as an algorithm. I shall be more precise later on, as to what an algorithm actually is. For the moment, it will be adequate to define an algorithm simply as a calculational procedure of some kind. In the case of a thermostat, the algorithm is extremely simple: the device registers whether the temperature is greater or smaller than the setting, and then it arranges that the circuit be disconnected in the former case and connected in the latter. For any significant kind of mental activity of a human brain, the algorithm would have to be something vastly more complicated but, according to the strong-AI view, an algorithm nevertheless. It would differ very greatly in degree from the simple algorithm of the thermostat, but need not differ in principle. Thus, according to strong AI, the difference between the essential functioning of a human brain (including all its conscious manifestations) and that of a thermostat lies only in this much greater complication (or perhaps 'higher-order structure' or 'self-referential properties', or some other attribute that one might assign to an algorithm) in the case of a brain. Most importantly, all mental qualities – thinking, feeling, intelligence, understanding, consciousness – are to be regarded, according to this view, merely as aspects of this complicated functioning; that is to say, they are features merely of the algorithm being carried out by the brain.

The virtue of any specific algorithm would lie in its performance, namely in the accuracy of its results, its scope, its economy, and the speed with which it can be operated. An algorithm purporting to match what is presumed to be operating in a human brain would need to be a stupendous thing. But if an algorithm of this kind exists for the brain and the supporters of strong AI would certainly claim that it does – then it could in principle be run on a computer. Indeed it could be run on any modern general purpose electronic computer, were it not for limitations of storage space and speed of operation. (The justification of this remark will come later, when we come to consider the universal Turing machine.) It is anticipated that any such limitations would be overcome for the large fast computers of the not-too-distant future. In that eventuality, such an algorithm, if it could be found, would presumably pass the Turing test. The supporters of strong AI would claim that whenever the algorithm were run it would, in itself: experience feelings; have a consciousness; be a mind.

By no means everyone would be in agreement that mental states and algorithms can be identified with one another in this kind of way. In particular, the American philosopher John Searle (1980, 1987) has strongly disputed that view. He has cited examples where simplified versions of the Turing test have actually already been passed by an appropriately programmed computer, but he gives strong arguments to support the view that the relevant mental attribute of 'understanding' is, nevertheless, entirely absent. One such example is based on a computer program designed by Roger Schank (Schank and Abelson 1977). The aim of the program is to provide a simulation of the understanding of simple stories like: 'A man went into a restaurant and ordered a hamburger. When the hamburger arrived it was burned to a crisp, and the man stormed out of the restaurant angrily, without paying the bill or leaving a tip.' For a second example: 'A man went into a restaurant and ordered a hamburger; when the hamburger came he was very pleased with it; and as he left the restaurant he gave the waitress a large tip before paying his bill.' As a test of 'understanding' of the stories, the computer is asked whether the man ate the hamburger in each case (a fact which had not been explicitly mentioned in either story). To this kind of simple story and simple question the computer can give answers which are essentially indistinguishable from the answers an English-speaking human being would give, namely, for these particular examples, 'no' in the first case and 'yes' in the second. So in this very limited sense a machine has already passed a Turing test!

The question that we must consider is whether this kind of success actually indicates any genuine understanding on the part of the computer – or, perhaps, on the part of the program itself. Searle's argument that it does not is to invoke his concept of a "Chinese room". He envisages first of all, that the stories are to be told in Chinese rather than English surely an inessential change – and that all the operations of the computer's algorithm for this particular exercise are supplied (in English) as a set of instructions for manipulating counters with Chinese symbols on them. Searle imagines himself doing all the manipulations inside a locked room. The sequences of symbols representing the stories, and then the questions, are fed into the room through some small slot. No other information whatever is allowed in from the outside. Finally, when all the manipulations are complete, the resulting sequence is fed out again through the slot. Since all these manipulations are simply carrying out the algorithm of Schank's program, it must turn out that this final resulting sequence is simply the Chinese for 'yes' or 'no', as the case may be, giving the correct answer to the original question in Chinese about a story in Chinese. Now Searle makes it quite clear that he doesn't understand a word of Chinese, so he would not have the faintest idea what the stories are about. Nevertheless, by correctly carrying out the series of operations which constitute Schank's algorithm (the instructions for this algorithm having been given to him in English) he would be able to do as well as a Chinese person who would indeed understand the stories. Searle's point – and I think it is quite a powerful one – is that the mere carrying out of a successful algorithm does not in itself imply that any understanding has taken place. The (imagined) Searle, locked in his Chinese room, would not understand a single word of any of the stories!

A number of objections have been raised against Searle's argument. I shall mention only those that 1 regard as being of serious significance. In the first place, there is perhaps something rather misleading in the phrase 'not understand a single word', as used above. Understanding has as much to do with patterns as with individual words. While carrying out algorithms of this kind, one might well begin to perceive something of the patterns that the symbols make without understanding the actual meanings of many of the individual symbols. For example, the Chinese character for 'hamburger' (if. indeed, there is such a thing) could be replaced by that for some other dish, say 'chow mein', and the stories would not be significantly affected. Nevertheless, it seems to me to be reasonable to suppose that in fact very little of the stories' actual meanings (even regarding such replacements as being unimportant) would come through if one merely kept following through the details of such an algorithm.

In the second place, one must take into account the fact that the execution of even a rather simple computer program would normally be something extraordinarily lengthy and tedious if carried out by human beings manipulating symbols. (This is, after all, why we have computers to do such things for us!) If Searle were actually to perform Schank's algorithm in the way suggested, he would be likely to be involved with many days, months, or years of extremely boring work in order to answer just a single question – not an altogether plausible activity for a philosopher! However, this does not seem to me to be a serious objection since we are here concerned with matters of principle and not with practicalities. The difficulty arises more with a putative computer program which is supposed to have sufficient complication to match a human brain and thus to pass the Turing test proper. Any such program would have to be horrendously complicated. One can imagine that the operation of this program, in order to effect the reply to even some rather simple Turing-test question, might involve so many steps that there would be no possibility of any single human being carrying out the algorithm by hand within a normal human lifetime. Whether this would indeed be the case is hard to say, in the absence of such a program. But, in any case, this question of extreme complication cannot, in my opinion, simply be ignored. It is true that we are concerned with matters of principle here, but it is not inconceivable to me that there might be some 'critical' amount of complication in an algorithm which it is necessary to achieve in order that the algorithm exhibit mental qualities. Perhaps this critical value is so large that no algorithm, complicated to that degree, could conceivably be carried out by hand by any human being, in the manner envisaged by Searle.

Searle himself has countered this last objection by allowing a whole team of human non-Chinese- speaking symbol manipulators to replace the previous single inhabitant ('himself') of his Chinese room. To get the numbers large enough, he even imagines replacing his room by the whole of India, its entire population (excluding those who understand Chinese!) being now engaged in symbol manipulation. Though this would be in practice absurd, it is not in principle absurd, and the argument is essentially the same as before: the symbol manipulators do not understand the story, despite the strong-AI claim that the mere carrying out of the appropriate algorithm would elicit the mental quality of "understanding". However, now another objection begins to loom large. Are not these individual Indians more like the individual neurons in a person's brain than like the whole brain itself? No-one would suggest that neurons, whose firings apparently constitute the physical activity of a brain in the act of thinking, would themselves individually understand what that person is thinking, so why expect the individual Indians to understand the Chinese stories? Searle replies to this suggestion by pointing out the apparent absurdity of India, the actual country, understanding a story that none of its individual inhabitants understands. A country, he argues, like a thermostat or an automobile, is not in the 'business of understanding', whereas an individual person is.

This argument has a good deal less force to it than the earlier one. I think that Searle's argument is at its strongest when there is just a single person carrying out the algorithm, where we restrict attention to the case of an algorithm which is sufficiently uncomplicated for a person actually to carry it out in less than a lifetime. I do not regard his argument as rigorously establishing that there is not some kind of disembodied 'understanding' associated with the person's carrying out of that algorithm, and whose presence does not impinge in any way upon his own consciousness. However, I would agree with Searle that this possibility has been rendered rather implausible, to say the least. I think that Searle's argument has a considerable force to it, even if it is not altogether conclusive. It is rather convincing in demonstrating that algorithms with the kind of complication that Schank's computer program possesses cannot have any genuine understanding whatsoever of the tasks that they perform; also, it suggests (but no more) that no algorithm, no matter how complicated, can ever, of itself alone, embody genuine understanding – in contradistinction to the claims of strong AI.

There are, as far as I can see, other very serious difficulties with the strong-AI point of view. According to strong AI, it is simply the algorithm that counts. It makes no difference whether that algorithm is being effected by a brain, an electronic computer, an entire country of Indians, a mechanical device of wheels and cogs, or a system of water pipes. The viewpoint is that it is simply the logical structure of the algorithm that is significant for the 'mental state' it is supposed to represent, the particular physical embodiment of that algorithm being entirely irrelevant. As Searle points out, this actually entails a form of 'dualism'. Dualism is a philosophical viewpoint espoused by the highly influential seventeenth century philosopher and mathematician Rene Descartes, and it asserts that there are two separate kinds of substance: 'mind-stuff and ordinary matter. Whether, or how, one of these kinds of substance might or might not be able to affect the other is an additional question. The point is that the mind-stuff is not supposed to be composed of matter, and is able to exist independently of it. The mind-stuff of strong AI is the logical structure of an algorithm. As I have just remarked, the particular physical embodiment of an algorithm is something totally irrelevant. The algorithm has some kind of disembodied 'existence' which is quite apart from any realization of that algorithm in physical terms. How seriously we must take this kind of existence is a question I shall need to return to in the next chapter. It is part of the general question of the Platonic reality of abstract mathematical objects. For the moment I shall sidestep this general issue and merely remark that the supporters of strong AI do indeed seem to be taking the reality at least of algorithms seriously, since they believe that algorithms form the 'substance' of their thoughts, their feelings, their understanding, their conscious perceptions. There is a remarkable irony in this fact that, as Searle has pointed out, the standpoint of strong AI seems to drive one into an extreme form of dualism, the very viewpoint with which the supporters of strong AI would least wish to be associated!

This dilemma lies behind the scenes of an argument put forward by Douglas Hofstadter (1981) – himself a major proponent of the strong-AI view – in a dialogue entitled 'A Conversation with Einstein's Brain'. Hofstadter envisages a book, of absurdly monstrous proportions, which is supposed to contain a complete description of the brain of Albert Einstein. Any question that one might care to put to Einstein can be answered, just as the living Einstein would have, simply by leafing through the book and carefully following all the detailed instructions it provides. Of course 'simply' is an utter misnomer, as Hofstadter is careful to point out. But his claim is that in principle the book is completely equivalent, in the operational sense of a Turing test, to a ridiculously slowed-down version of the actual Einstein. Thus, according to the contentions of strong AI, the book would think, feel understand, be aware, just as though it were Einstein himself, but perhaps living at a monstrously slowed-down rate (so that lo the book-Einstein the world outside would seem to flash by at a ridiculously speeded-up rate). Indeed, since the book is supposed to be merely a particular embodiment of the algorithm which constitutes Einstein's 'self, it would actually be Einstein.

But now a new difficulty presents itself. The book might never be opened, or it might be continually pored over by innumerable students and searchers after truth. How would the book 'know' the difference? Perhaps the book would not need to be opened, its information being retrieved by means of X -ray tomography, or some other technological wizardry. Would Einstein's awareness be enacted only when the book is being so examined? Would he be aware twice over if two people chose to ask the book the same question at two completely different times? Or would that entail two separate and temporally distinct instances of the same state of Einstein's awareness? Perhaps his awareness would be enacted only if the book is changed? After all, normally when we are aware of something we receive information from the outside world which affects our memories, and the states of our minds are indeed slightly changed. If so, does this mean that it is (suitable) changes in algorithms (and here I am including the memory store as part of the algorithm) which are to be associated with mental events rather than (or perhaps in addition to) the activation of algorithms? Or would the book-Einstein remain completely self-aware even if it were never examined or disturbed by anyone or anything? Hofstadter touches on some of these questions, but he does not really attempt to answer or to come to terms with most of them.

What does it mean to activate an algorithm, or to embody it in physical form? Would changing an algorithm be different in any sense from merely discarding one algorithm and replacing it with another? What on earth does any of this have to do with our feelings of conscious awareness? The reader (unless himself or herself a supporter of strong AI) may be wondering why I have devoted so much space to such a patently absurd idea. In fact, I do not regard the idea as intrinsically an absurd one – mainly just wrong! There is, indeed some force in the reasoning behind strong AI which must be reckoned with, and this I shall try to explain. There is, also, in my opinion, a certain appeal in some of the ideas – if modified appropriately – as I shall also try to convey. Moreover, in my opinion, the particular contrary view expressed by Searle also contains some serious puzzles and seeming absurdities, even though, to a partial extent, I agree with him!

Searle, in his discussion, seems to be implicitly accepting that electronic computers of the present-day type, but with considerably enhanced speed of action and size of rapid-access store (and possibly parallel action) may well be able to pass the Turing test proper, in the not-too-distant future. He is prepared to accept the contention of strong AI (and of most other 'scientific' viewpoints) that 'we are the instantiations of any number of computer programs'. Moreover, he succumbs to: 'Of course the brain is a digital computer. Since everything is a digital computer, brains are too. Searle maintains that the distinction between the function of human brains (which can have minds) and of electronic computers (which, he has argued, cannot) both of which might be executing the same algorithm, lies solely in the material construction of each. He claims, but for reasons he is not able to explain, that the biological objects (brains) can have 'intentionality' and 'semantics', which he regards as defining characteristics of mental activity, whereas the electronic ones cannot. In itself this does not seem to me to point the way towards any helpful scientific theory of mind. What is so special about biological systems, apart perhaps from the 'historical' way in which they have evolved (and the fact that we happen to be such systems), which sets them apart as the objects allowed to achieve intentionality or semantics? The claim looks to me suspiciously like a dogmatic assertion, perhaps no less dogmatic, even, than those assertions of strong AI which maintain that the mere enacting of an algorithm can conjure up a state of conscious awareness!

In my opinion Searle, and a great many other people, have been led astray by the computer people. And they, in turn, have been led astray by the physicists. (It is not the physicists' fault. Even they don't know everything!) The belief seems to be widespread that, indeed, 'everything is a digital computer'. It is my intention, in this book, to try to show why, and perhaps how, this need not be the case.

Text 2. The Insolubility of Hilbert's Problem

Internet Assignment:

Use the Internet and provide answers to these questions:

1. What directions and tendencies in the 19th century maths gave implications and led D.Hilbert to formulating those particular problems?
2. How do the 20th century mathematicians estimate the solution of any problem in D.Hilbert’s list?
3. Who solved D.Hilbert’s 10th problem? When?
4. What is the contribution of the Ukrainian mathematicians to the solution of the problems under study?
5. Are the unsolved problems the very essence of maths?

We now come to the purpose for which Turing originally put forward his ideas, the resolution of Hilbert's broad-ranging *Entscheidungsproblem:* is there some mechanical procedure for answering all mathematical problems, belonging to some broad, but well-defined class? Turing found that he could phrase his version of the question in terms of the problem of deciding whether or not the n^{th} Turing machine would actually ever *stop* when acting on the number m. This problem was referred to as the *halting problem.* It is an easy matter to construct an instruction list for which the machine will not stop for *any* number m (for example, $n=1$ or 2, as given above, or any other case where there are no stop instructions whatever). Also there are many instruction lists for which the machine would always stop, whatever number it is given (e.g. $n=11$); and some machines would stop for some numbers but not for others. One could fairly say that a putative algorithm is not much use when it runs forever without stopping. That is no algorithm at all. So an important question is to be able to decide whether or not T_n applied to m actually ever gives any answer! If it does *not* (i.e. if the calculation does *not* stop), then I shall write

$$T_n(m) = \square.$$

(Included in this notation would be those situations where the Turing machine runs into a problem at some stage because it finds no appropriate instruction to tell it what to do – as with the dud machines such as T_4 and T_7 considered above. Also, unfortunately, our seemingly successful machine T_3, must now also be considered a dud: $T_3(m) =$, because the result of the action of T_3 is always just blank tape, whereas we need at least one 1 in the output in order that the result of the calculation be assigned a number! The machine T_{11} is, however, legitimate since it produces a single 1. This output is the tape numbered 0, so we have $T_{11}(m) = 0$ for all *m*.)

It would be an important issue in mathematics to be able to decide when Turing machines stop. For example, consider the equation:

$$(x+1)^{w+3} + (y+1)^{w+3} = (z+1)^{w+3}.$$

(If technical mathematical equations are things that worry you, don't be put off! This equation is being used only as an example, and there is no need to understand it in detail.) This particular equation relates to a famous unsolved problem in mathematics – perhaps the most famous of all. The problem is this: is there *any* set of natural numbers *w, x, y, z* for which this equation is satisfied? The famous statement known as 'Fermat's last theorem', made in the margin of Diophantus's *Arithmetica,* by the great seventeenth century French mathematician Pierre de Fermat (1601-1665), is the assertion that the equation is *never* satisfied.[12] Though a lawyer by profession (and a contemporary of Descartes), Fermat was the finest mathematician of his time. He claimed to have a truly wonderful proof of his assertion, which the margin was too small to contain; but to this day no-one has been able to reconstruct such a proof

[12] Recall that by the *natural* numbers we mean 0,1, 2, 3,4, 5, 6,. . . The reason for the '$x+1$' and '$w+3$', etc., rather than the more familiar form ($x^w + y^w = z^w$; $x, y, z > 0$, $w > 2$) of the Fermat assertion, is that we are allowing *all* natural numbers for x, w, etc., starting with zero.

nor, on the other hand, to find any counter-example to Fermat's assertion!

It is clear that *given* the quadruple of numbers (w, x, y, z), it is a mere matter of computation to decide whether or not the equation holds. Thus we could imagine a computer algorithm which runs through all the quadruples of numbers one after the other, and stops only when the equation is satisfied. (We have seen that there are ways of coding finite sets of numbers, in a computable way, on a single tape, i.e. simply as single numbers, so we can 'run through' all the quadruples by just following the natural ordering of these single numbers.) If we could establish that this algorithm does *not* stop, then we would have a proof of the Fermat assertion.

In a similar way it is possible to phrase many other unsolved mathematical problems in terms of the Turing machine halting problem. Such an example is the 'Goldbach conjecture', which asserts that every even number greater than 2 is the sum of two prime numbers.[13] It is an algorithmic process to decide whether or not a given natural number is prime since one needs only to test its divisibility by numbers *less* than itself, a matter of only *finite* calculation. We could devise a Turing machine which runs through the even numbers 6, 8,10, 12, 14, ... trying all the different ways of splitting them into pairs of odd numbers

$$6 = 3+3, \qquad 8 = 3+5, \qquad 10 = 3+7 = 5+5,$$
$$12 = 5+7, \qquad 14 = 3+11 = 7+7, \ldots$$

and testing to make sure that, for *each* such even number, it splits to *some* pair for which *both* members are prime. (Clearly we need not test pairs of *even* summands, except 2 + 2, since all primes except 2 are odd.) Our machine is to stop only when it reaches an even number for which *none* of the pairs into which that number splits consists of two primes. In that case we should have a counter-example to the Goldbach conjecture, namely an even number (greater than 2) which is *not* the sum of two primes. Thus if we could decide whether or not this Turing machine ever stops, we should have a way of deciding the truth of the Goldbach conjecture also.

[13] Recall that the *prime* numbers 2, 3, 5, 7, 11, 13, 17, . . are those natural numbers divisible, separately, only by themselves and by unity. Neither 0 nor 1 is considered to be a prime.

A natural question arises: how are we to decide whether or not any particular Turing machine (when fed with some specific input) will ever stop? For many Turing machines this might not be hard to answer; but occasionally, as we have seen above, the answer could involve the solution of an outstanding mathematical problem. So, is there some *algorithmic* procedure for answering the general question – the halting problem – completely automatically? Turing showed that indeed there is not.

His argument was essentially the following. We first suppose that, on the contrary, there *is* such an algorithm.[14] Then there must be some Turing machine H which 'decides' whether or not the n^{th} Turing machine, when acting on the number m, eventually stops. Let us say that it outputs the tape numbered 0 if it does not stop and 1 if it does:

$$H(n;m)=\begin{cases}0 & if \quad T_n(m)=\square \\ 1 & if \quad T_n(m) \quad stops\end{cases}.$$

Here, one might take the coding of the pair $(n;m)$ to follow the same rule as we adopted for the universal machine U. However this could run into the technical problem that for some number n (e.g. $n=7$), T_n is not correctly specified; and the marker 111110 would be inadequate to separate n from m on the tape. To obviate this problem, let us assume that n is coded using the *expanded* binary notation rather than just the binary notation, with m in ordinary binary, as before. Then the marker 110 will actually be sufficient to separate n from m. The use of the *semicolon* in $H(n;m)$, as distinct from the *comma* in $U(n;m)$, is to indicate this change.

Now let us imagine an infinite array, which lists all the outputs of all possible Turing machines acting on all the possible different inputs. The n^{th} row of the array displays the output of the n^{th} Turing machine, as applied to the various inputs 0,1, 2, 3,4, … :

[14] This is the familiar – and powerful – mathematical procedure known as *reductio ad absurdum,* whereby one first assumes that what one is trying to prove is false; and from that one derives a contradiction, thus establishing that the required result is actually *true.*

m →	0	1	2	3	4	5	6	7	8	…
n ↓										
0	□	□	□	□	□	□	□	□	□	…
1	0	0	0	0	0	0	0	0	0	…
2	1	1	1	1	1	1	1	1	1	…
3	0	2	0	2	0	2	0	2	0	…
4	1	1	1	1	1	1	1	1	1	…
5	0	□	0	□	0	□	0	□	0	…
6	0	□	1	□	2	□	3	□	4	…
7	0	1	2	3	4	5	6	7	8	…
8	□	1	□	□	1	□	□	□	1	…
.	.				.				.	…
.	.				.				.	
.	.				.				.	
197	2	3	5	7	11	13	17	19	23	…
.	.				.				.	
.	.				.				.	
.	.				.				.	

In the above table I have cheated a little, and not listed the Turing machines as they are *actually* numbered. To have done so would have yielded a list that looks much too boring to begin with, since all the machines for which n is less than 11 yield nothing but Ds, and for $n = 11$ itself we get nothing but 0s. In order to make the list look initially more interesting, I have assumed that some much more efficient coding has been achieved. In fact I have simply made up the entries fairly randomly, just to give some kind of impression as to what its general appearance could be like.

I am not asking that we have actually *calculated* this array, say by some algorithm. (In fact, there is no such algorithm, as we shall see in a moment.) We are just supposed to *imagine* that the *true* list has somehow been laid out before us, perhaps by God! It is the occurrence of the Ds which would cause the difficulties if we were to attempt to calculate the array, for we might not know for sure when to place a Din some position since those calculations simply run on forever!

However, we *could* provide a calculational procedure for generating the table if we were allowed to use our putative H, for H would tell us where the □s actually occur. But instead, let us use H to *eliminate* every □ by replacing each occurrence with 0. This is achieved by preceding the action of T_n on m by the calculation $H(n; m)$; then we allow T_n to act on m only if $H(n; m) = 1$ (i.e. only if the calculation $T_n(m)$ actually gives an answer), and simply write 0 if $H(n; m) = 0$ (i.e. if $T_n(m) = \square$). We can write our new procedure (i.e. that obtained by preceding $T_n(m)$ by the action of $H(n; m)$) as

$$T_n(m) \times H(n; m).$$

(Here I am using a common mathematical convention about the ordering of mathematical operations: the one on the *right* is to be performed *first*. Note that, symbolically, we have □ x 0 = 0.) The table for this now reads:

$m \rightarrow$	0	1	2	3	4	5	6	7	8	…
n										…
$\downarrow$										…
0	0	0	0	0	0	0	0	0	0	…
1	0	0	0	0	0	0	0	0	0	…
2	1	1	1	1	1	1	1	1	1	…
3	0	2	0	2	0	2	0	2	0	…
4	1	1	1	1	1	1	1	1	1	…
5	0	0	0	0	0	0	0	0	0	…
6	0	0	1	0	2	0	3	0	4	…
7	0	1	2	3	4	5	6	7	8	…
8	0	1	0	0	1	0	0	0	1	…
⋮	⋮				⋮				⋮	…

Note that, assuming H exists, the rows of this table consist of *computable sequences.* (By a computable sequence I mean an infinite sequence whose successive values can be generated by an algorithm; i.e. there is some Turing machine which, when applied to the natural numbers m = 0,1, 2, 3, 4, 5, … in turn, yields the successive members of the sequence.) Now, we take note of two facts about this table. In the first place, *every* computable sequence of natural numbers must appear somewhere (perhaps many times over) amongst its rows. This property was already true of the original table with its Ds. We have simply *added* some rows to replace the 'dud' Turing machines (i.e. the ones which produce at least one D). In the second place, the assumption having been made that the Turing machine H actually exists, the table has been *computably generated* (i.e. generated by some definite algorithm), namely by the procedure $T_n(m) \times H(n; m)$. That is to say, there is some Turing machine Q which, when acting on the pair of numbers $(n; m)$ produces the appropriate entry in the table. For this, we may code n and m on Q*'s* tape in the same way as for H, and we have

$$Q(n; m) = T_n(m) \times H(n; m).$$

We now apply a variant of an ingenious and powerful device, the 'diagonal slash' of Georg Cantor. Consider the elements of the main diagonal, marked now with bold figures:

0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
1	1	1	1	1	1	1	1	1
0	2	0	2	0	2	0	2	0
1	1	1	1	1	1	1	1	1
0	0	0	0	0	0	0	0	0
0	0	1	0	2	0	3	0	4
0	1	2	3	4	5	6	7	8
0	1	0	0	1	0	0	0	1
⋮				⋮				⋮

These elements provide some sequence 0, 0, 1, 2, 1,0, 3, 7, 1, … to each of whose terms we now add 1:

1, 1, 2, 3, 2, 1, 4, 8, 2, … .

This is clearly a computable procedure and, given that our table was computably generated, it provides us with some new computable sequence, in fact with the sequence $1 + Q(n; n)$, i.e.

$$1 + T_n(n) \times H(n; n)$$

(since the diagonal is given by making m equal to n). But our table contains *every* computable sequence, so our new sequence must be somewhere in the list. Yet this cannot be so! For our new sequence differs from the first row in the first entry, from the second row in the second entry, from the third row in the third entry, and so on. This is manifestly a contradiction. It is the contradiction which establishes what we have been trying to prove, namely that the Turing machine H does not in fact exist! *There is no universal algorithm for deciding whether or not a Turing machine is going to stop.*

Another way of phrasing this argument is to note that, on the assumption that H exists, there is some Turing machine number, say k, for the algorithm (diagonal process!) $1+Q(n;n)$, so we have

$1+T_n(n)\times H(n;n)=T_k(n)$.

But if we substitute $n=k$ in this relation we get

$1+T_k(k)\times H(k;k)=T_k(k)$.

This is a contradiction because if $T_k(k)$ stops we get the impossible relation

$1+T_k(k)=T_k(k)$

(since $H(k;k)=1$), whereas if $T_k(k)$ does not stop (so $H(k;k)=0$) we have the equally inconsistent

$1+0=\square$.

The question of whether or not a particular Turing machine stops is a perfectly well-defined piece of mathematics (and we have already seen that, conversely, various significant mathematical questions can be phrased as the stopping of Turing machines). Thus, by showing that no algorithm exists for deciding the question of the stopping of Turing machines, Turing showed (as had Church, using his own rather different type of approach) that there can be no general algorithm for deciding mathematical questions. Hilbert's *Entscheidungsproblem* has no solution!

This is not to say that in any *individual* case we may not be able to decide the truth, or otherwise, of some particular mathematical question; or decide whether or not some given Turing machine will stop. By the exercise of ingenuity, or even of just common sense, we may be able to decide such a question in a given case. (For example, if a Turing machine's instruction list contains *no* STOP order, or contains *only* STOP orders, then common sense alone is sufficient to tell us whether or not it will stop!) But there is no one algorithm that works for *all* mathematical questions, nor for *all* Turing machines and all numbers on which they might act.

It might seem that we have now established that there are at least *some* undecidable mathematical questions. However, we have done nothing of the kind! We have *not* shown that there is some especially awkward Turing machine table for which, in some absolute sense, it is impossible to decide whether or not the machine stops when it is fed with some especially awkward number – indeed, quite the reverse, as we shall see in a moment. We have said nothing whatever about the insolubility of *single* problems, but only about the *algorithmic* insolubility of *families* of problems. In any single case the answer is either 'yes' or 'no', so there certainly *is* an algorithm for deciding that particular case, namely the algorithm that simply says 'yes', when presented with the problem, or the one that simply says 'no', as the case may be! The difficulty is, of course, that we may not know *which* of these algorithms to use. That is a question of deciding the mathematical truth of a single statement, not the systematic decision problem for a family of statements. It is important to realize that algorithms do not, in themselves, decide mathematical truth. The *validity* of an algorithm must always be established by external means.

Text 3. Construction of the Mandelbrot Set

Internet Assignment:

1. Using Internet try to find out all you can about the land of Tor'Bled-Nam.

2. What is the very essence of mathematical visualization? Key-words: magnification, abstract mathematics, complex numbers, miracles of mathematics.

We are now in a position to see how the Mandelbrot set is defined. Let z be some arbitrarily chosen complex number. Whatever this complex number is, it will be represented as some point on the Argand plane. Now consider the *mapping* whereby z is replaced by a *new* complex number, given by

$$z \rightarrow z^2 + c,$$

where c is another *fixed* (i.e. given) complex number. The number z^2+c will be represented by some new point in the Argand plane. For example, if c happened to be given as the number $1.63-i\,4.2$, then z would be mapped according to

$$z \to z^2+1.63-i\,4.2$$

so that, in particular, 3 would be replaced by

$$3^2+1.63-i\,4.2=9+1.63-i\,4.2=10.63-i\,4.2$$

and $-2.7-i\,0.3$ would be replaced by

$$\begin{aligned}&(-2.7-i\,0.3)^2+1.63-i\,4.2=\\&=(-2.7)^2-(0.3)^2+1.63+i\,\{2\cdot(-2.7)\cdot(0.3)-4.2\}\\&=8.83-i\,5.82\end{aligned}$$

When such numbers get complicated, the calculations are best carried out by an electronic computer.

Now, whatever c may be, the particular number 0 is replaced, under this scheme, by the actual given number c. What about c itself? This must be replaced by the number c^2+c Suppose we continue this process and apply the replacement to the number c^2+c; then we obtain

$$(c^2+c)^2+c=c^4+2c^3+c^2+c.$$

Let us iterate the replacement again, applying it next to the above number to obtain

$$(c^4+2c^3+c^2+c)^2+c=c^8+4c^7+6c^6+6c^5+5c^4+2c^3+c^2+c$$

and then again to this number, and so on. We obtain a sequence of complex numbers, starting with 0:

$$0, c, c^2+c, c^4+2c^3+c^2+c, \dots$$

Now if we do this with *certain* choices of the given complex number c, the sequence of numbers that we get in this way never wanders very far from the origin in the Argand plane; more precisely, the sequence remains *bounded* for such choices of *c* which is to say that every member of the sequence lies within *some fixed circle* centred at the origin (see Fig. 1). A good example where this occurs is the case $c=0$, since

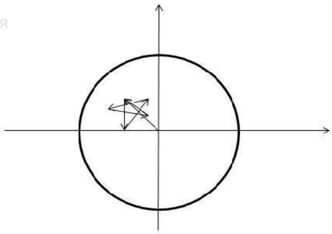

Fig. 1. A sequence of points in the Argand plane is bounded if there is some fixed circle that contains all the points. (This particular iteration starts with zero and has $c=-\frac{1}{2}+\frac{1}{2}i$*).*

in this case, every member of the sequence is in fact 0. Another example of bounded behaviour occurs with $c=-1$, for then the sequence is: $0, -1, 0, -1, 0, -1, \ldots$; and yet another example occurs with $c=i$, the sequence being $0, i, i-1, -i, i-1, -i, \ldots$. However, for various other complex numbers c the sequence wanders farther and farther from the origin to indefinite distance; i.e. the sequence is *unbounded,* and cannot be contained within any fixed circle. An example of this latter behaviour occurs when $c=1$, for then the sequence is $0, 1, 2, 5, 26, 677, 458330, \ldots$; this also happens when $c=-3$, the sequence being $0, -3, 6, 33, 1086, \ldots$; and also when $c=i-1$, the sequence being

$0, i-1, -i-1, -1+3i, -9-5i, 55+91i, 5257+10011i, \ldots$.

The *Mandelbrot set,* that is to say, the *black* region of our world of Tor'Bled-Nam, is precisely that region of the Argand plane consisting of points c for which the sequence remains bounded. The *white* region consists of thoses points c for which the sequence is unbounded. The detailed pictures that we saw earlier were all drawn from the outputs of computers. The computer would systematically run through possible choices of the complex number c, where for each choice of c it would work out the sequence $0, c, c^2+c, \ldots$ and decide, according to some appropriate criterion, whether the sequence is remaining bounded or not. If it is bounded, then the computer would arrange that a black spot appear on the screen at the point corresponding to c. If it is unbounded, then the computer would arrange for a white spot. Eventually, for every pixel in the range under consideration, the decision would be made by the computer as to whether the point would be coloured white or black.

The complexity of the Mandelbrot set is very remarkable, particularly in view of the fact that the definition of this set is, as mathematical definitions go, a strikingly simple one. It is also the case that the general structure of this set is not very sensitive to the precise algebraic form of the mapping $z \to z^2 + c$ that we have chosen. Many other iterated complex mappings (e.g. $z \to z^3 + iz^2 + c$) will give extraordinarily similar structures (provided that we choose an appropriate number to start with – perhaps not 0, but a number whose value is characterized by a clear mathematical rule for each appropriate choice of mapping). There is, indeed, a kind of universal or absolute character to these 'Mandelbrot' structures, with regard to iterated complex maps. The study of such structures is a subject on its own, within mathematics, which is referred to as *complex dynamical systems.*

Text 4. Cosmology and the Big Bang

Internet Assignment:

Get information from the Internet to confirm or refuse the following statement:

Now, it follows from the equations of Einstein's general relativity that this positively closed universe cannot continue to expand forever. After it reaches a stage of maximum expansion, it collapses back in on itself, finally to reach zero size again in a kind of big bang in reverse.

As far as we can tell from using our most powerful telescopes – both optical and radio – the universe, on a very large scale, appears to be rather uniform; but, more remarkably, it is *expanding*. The farther away that we look, the more rapidly the distant galaxies (and even more distant quasars) appear to be receding from us. It is as though the universe itself was created in one gigantic explosion – an event referred to as the *big* *bang,* which occurred some ten thousand million years ago.[15] Impressive further support for this uniformity, and for the actual existence of the big bang, comes from what is known as the *black-body background radiation.* This is thermal radiation – photons moving around randomly, without discernible source – corresponding to a temperature of about 2.7° absolute (2.7 K), i.e. -270.3° Celsius, or 454.5° below zero Farenheit. This may seem like a *very* cold temperature – as indeed it is! – but it appears to be the leftover of the flash of the big bang itself! Because the universe has expanded by such a huge factor since the time of the big bang, this initial fireball has dispersed by an absolutely enormous factor. The temperatures in the big bang far exceeded any temperatures that can occur at the present time, but owing to this expansion, that temperature has cooled to the tiny value that the black-body background has now. The presence of this background was *predicted* by the Russian-American physicist and astronomer George Gamow in 1948 on the basis of the now-standard big-bang picture. It was first observed (accidentally) by Penzias and Wilson in 1965.

I should address a question that often puzzles people. If the distant galaxies in the universe are all receding from us, does that not mean that we ourselves are occupying some very special central location? No it does not! The same recession of distant galaxies would be seen *wherever* we might be located in the universe. The expansion is uniform on a large scale, and no particular location is preferred over any other. This is often pictured in terms of a balloon being blown up (Fig. 1). Suppose that there are spots on the balloon to represent the different galaxies, and take the two-dimensional surface of the balloon itself to represent the entire three-dimensional spatial universe. It is clear that from *each* point on the balloon, *all* the other points are receding from it. No point on the balloon is to be preferred, in this respect, over any other point. Likewise, as seen from the vantage point of each galaxy in the universe, all other galaxies appear to be receding from it, equally in all directions.

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[15] At the present time there is a dispute still raging as to the value of this figure, which ranges between about 6×10^9 and 1.5×10^{10} years. These figures are considerably larger than the figure of 10^9 years that originally seemed appropriate after Edwin Hubble's initial observations in around 1930 showed that the universe is expanding.

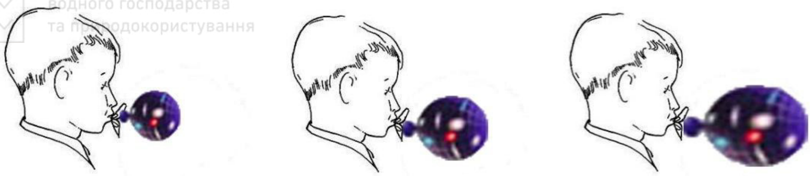

Fig. 1. The expansion of the universe can be likened to the surface of a balloon being blown up. The galaxies all recede from one another

This expanding balloon provides quite a good picture of one of the three standard so-called *Friedmann-Robertson-Walker* (FRW) models of the universe – namely the spatially closed *positively curved* FRW-model. In the other two FRW-models (zero or negative curvature), the universe expands in the same sort of way, but instead of having a spatially finite universe, as the surface of the balloon indicates, we have an *infinite* universe with an infinite number of galaxies.

In the easier to comprehend of these two infinite models, the spatial geometry is *Euclidean,* i.e. it has *zero* curvature. Think of an ordinary flat plane as representing the entire spatial universe, where there are points marked on the plane to represent galaxies. As the universe evolves with time, these galaxies recede from one another in a uniform way. Let us think of this in *space-time* terms. Accordingly, we have a different Euclidean plane for each 'moment of time', and all these planes are imagined as being stacked one above the other, so that we have a picture of the entire space-time all at once (Fig. 2). The galaxies are now represented as *curves* – the *world-lines* of the galaxies' histories – and these curves move away from each other into the future direction. Again no particular galaxy world-line is preferred.

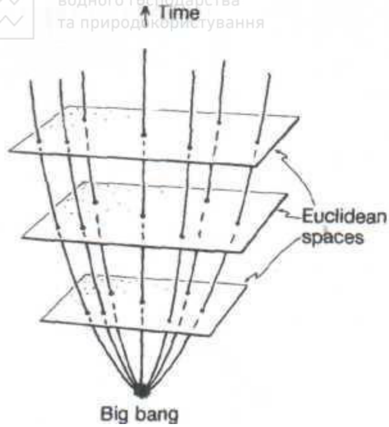

Fig. 2. Space-time picture of an expanding universe with Euclidean spatial sections (two space dimensions depicted)

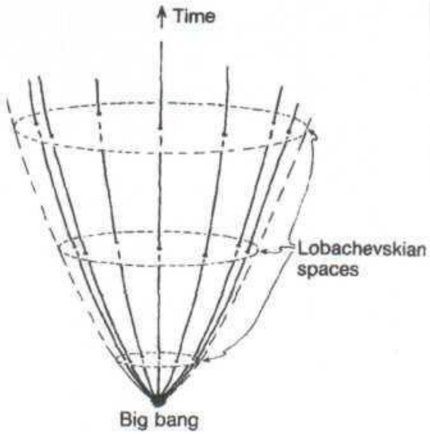

Fig. 3. Space-time picture of an expanding universe with Lobachevskian spatial sections (two space dimensions depicted)

For the one remaining FRW-model, the «negative-curvature model, the spatial geometry is the non-Euclidean *Lobachevskian*. For the space-time description, we need one of these Lobachevsky spaces for each 'instant of time', and we stack these all on top of one another to give a picture of the entire space-time (Fig. 3). Again the galaxy world-lines are curves moving away from each other in the future direction, and no galaxy is preferred.

Of course, in all these descriptions we have suppressed one of the three spatial dimensions to give a more visualizable three-dimensional space-time than would be necessary for the complete four-dimensional space-time picture. Even so, it is hard to visualize the positive-curvature space-time without discarding yet another spatial dimension! Let us do so, and represent the positively curved closed spatial universe by a *circle* (one-dimensional), rather than the sphere (two-dimensional) which had been the balloon's surface. As the universe expands, this circle grows in size, and we can represent the space-time by stacking these circles (one circle for each 'moment of time') above one another to obtain a kind of curved cone (Fig. 4). Now, it follows from the equations of Einstein's general relativity that this positively closed universe cannot continue to expand forever. After it reaches a stage of maximum expansion, it collapses back in on itself, finally to reach zero size again in a kind of big bang in reverse (Fig. 4). This time-reversed big bang is sometimes referred to as the *big crunch.* The negatively curved and zero-curved (infinite) universe FRW-models do not recollapse in this way. Instead of reaching a big crunch, they continue to expand forever.

At least this is true for *standard* general relativity in which the so-called *cosmological constant* is taken to be zero. With suitable non-zero values of this cosmological constant, it is possible to have spatially infinite universe models which recollapse to a big crunch, or finite positively curved models which expand indefinitely. The presence of a non-zero cosmological constant would complicate the discussion slightly, but not in any significant way for our purposes. For simplicity, I shall take the cosmological constant to be zero.[16] At the time of writing, the cosmological constant is known observationally to be very small, and the data are consistent with its being zero. (For further information on cosmological models, see Rindler 1977.)

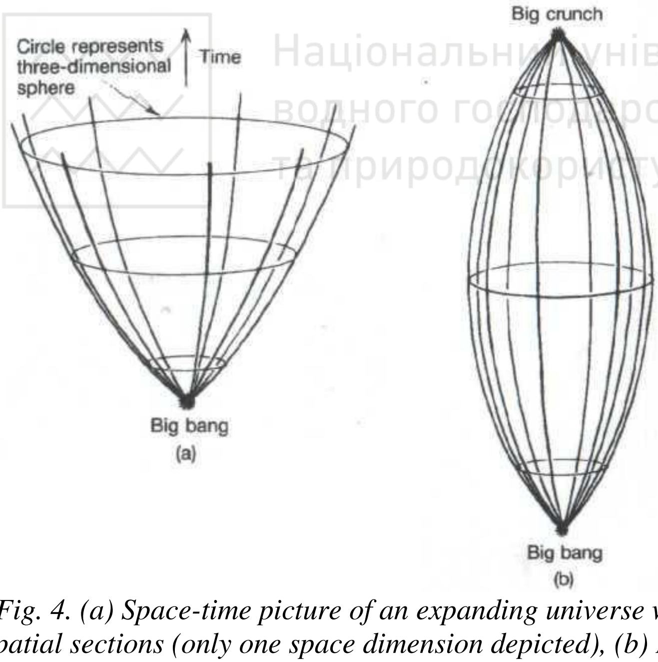

Fig. 4. (a) Space-time picture of an expanding universe with spherical spatial sections (only one space dimension depicted), (b) Eventually this universe re-collapses to a final big crunch

[16] Einstein introduced the cosmological constant in 1917, but had retracted it again by 1931, referring to its earlier introduction as his ‘greatest mistake’.

Unfortunately the data are not yet good enough to point clearly to one or other of the proposed cosmological models (nor to determine whether or not the presence of a tiny cosmological constant might have a significant overall effect). On the face of it, it would appear that the data indicate that the universe is spatially negatively curved (with Lobachevsky geometry on the large scale) and that it will continue to expand indefinitely. This is largely based on observations of the amount of actual matter that seems to be present in visible form. However, there may be huge amounts of invisible matter spread throughout space, in which case the universe could be positively curved, and it could finally recollapse to a big crunch – though only on a time-scale far larger than the 10^{10} years, or so, for which the universe has been in existence. For this recollapse to be possible there would have to be some thirty times as much matter permeating space in this invisible form – the postulated so-called 'dark matter' – than can be directly discerned through telescopes. There is some good indirect evidence that a substantial amount of dark matter is indeed present, but whether there is *enough* of it 'to close the universe' (or make it spatially flat) – and recollapse it – is very much an open question.

Text 5. Black Holes

Internet Assignment:

1. Try to find additional information about black and white holes.

2. Find out the names dealt with these problems/ approaches/ theories/ hypotheses.

3. Present your ideas on the given subject for the students' research society.

Let us first consider what theory tells us will be the ultimate fate of our sun. The sun has been in existence for some five thousand million years. In another 5-6 thousand million years it will begin to expand in size, swelling inexorably outwards until its surface reaches to about the orbit of the earth. It will then have become a type of star known as a *red giant.* Many red giants are observed elsewhere in the heavens, two of the best known being Aldebaran in Taurus and Betelgeuse in Orion. All the time that its surface is expanding, there will be, at its very core, an exceptionally dense small concentration of matter, which steadily grows. This dense core will have the nature of a *white dwarf star* (Fig. 1).

White dwarf stars, when on their own, are actual stars whose material is concentrated to extremely high density, such that a ping-pong ball filled with their material would weigh several hundred tonnes! Such stars are observed in the heavens, in quite considerable numbers: perhaps some ten per cent of the luminous stars in our Milky Way galaxy are white dwarfs. The most famous white dwarf is the companion of Sirius, whose alarmingly high density had provided a great observational puzzle to astronomers in the early part of this century. Later, however, this same star provided a marvellous confirmation of physical theory (originally by R. H. Fowler, in around 1926) – according to which, some stars could indeed have such a large density, and would be held apart by 'electron degeneracy pressure', meaning that it is Pauli's quantum-mechanical exclusion principle, as applied to electrons, that is preventing the star from collapsing gravitationally inwards.

Any red giant star will have a white dwarf at its core, and this core will be continually gathering material from the main body of the star. Eventually, the red giant will be completely consumed by this parasitic core, and an actual white dwarf – about the the size of the earth – is all that remains. Our sun will be expected to exist as a red giant for 'only' a few thousand million years. Afterwards, in its last 'visible' incarnation – as a slowly cooling dying ember[1] of a white dwarf – the sun will persist for a few more thousands of millions of years, finally obtaining total obscurity as an invisible *black dwarf.*

Not all stars would share the sun's fate. For some, their destiny is a considerably more violent one, and their fate is sealed by what is known as the *Chandrasekhar limit:* the maximum possible value for the mass of a white dwarf star. According to a calculation performed in 1929 by Subrahmanyan Chandrasekhar, white dwarfs cannot exist if their masses are more than about one and one-fifth times the mass of the sun. (He was a young Indian research student-to-be, who was travelling on the boat from India to England when he made his calculation.) The calculation was also repeated independently in about 1930 by the Russian Lev Landau. The modern somewhat refined value for Chandrasekhar's limit is

[1] In fact, in its final stages, the dwarf will glow dimly as a red star – but what is referred to as a 'red dwarf is a star of quite a different character!

about $1.4\,M_{\Theta}$ where M_{Θ} is the mass of the sun, i.e. M_{Θ} = one *solar mass*.

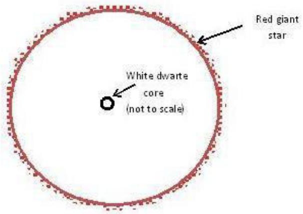

Fig. 1. A red giant star with a white dwarf core

Note that the Chandrasekhar limit is not much greater than the sun's mass, whereas many ordinary stars are known whose mass is considerably greater than this value. What would be the ultimate fate of a star of mass $2\,M_{\Theta}$, for example? Again, according to established theory, the star should swell to become a red giant, and its white-dwarf core would slowly acquire mass, just as before. However, at some critical stage the core will reach Chandrasekhar's limit, and Pauli's exclusion principle will be insufficient to hold it apart against the enormous gravitationally induced pressures. At this point, or thereabouts, the core will collapse catastrophically inwards, and hugely increased temperatures and pressures will be encountered. Violent nuclear reactions take place, and an enormous amount of energy is released from the core in the form of neutrinos. These heat up the outer regions of the star, which have been collapsing inwards, and a stupendous explosion ensues. The star has become a supernova!

What then happens to the still-collapsing core? Theory tells us that it reaches enormously greater densities even than those alarming ones already achieved inside a white dwarf. The core can stabilize as a *neutron star*, where now it is *neutron degeneracy pressure* – i.e. the Pauli principle applied to neutrons – that is holding it apart. The density would be such that our ping-pong ball containing neutron star material would weigh as much a the asteroid Hermes (or perhaps Mars's moon Deimos). This is the kind of density found inside the very nucleus itself! (A neutron star is like a huge atomic nucleus, perhaps some ten kilometres in radius, which is, however, extremely tiny by stellar standards!) But there is now a *new* limit, analogous to Chandrasekhar's (referred to as the Landau-Oppenheimer-Volkov limit) whose modern (revised) value is very roughly $2.5\,M_{\Theta}$, above which a neutron star cannot hold itself apart.

What happens to this collapsing core if the mass of the original star is great enough that even *this* limit will be exceeded? Many stars are known, of masses ranging between $10\,M_{\Theta}$ and $100M_{\Theta}$, for example. It would seem highly unlikely that they would invariably throw off so much mass that the resulting core necessarily lies below this neutron star limit. The expectation is that, instead, a *black hole* will result.

What is a black hole? It is a region of space – or of space-time – within which the gravitational field has become so strong that even light cannot escape from it. Recall that it is an implication of the principles of relativity that the velocity of light is the limiting velocity: no material object or signal can exceed the local light speed. Hence, if light cannot escape from a black hole, *nothing* can escape.

Perhaps the reader is familiar with the concept of *escape velocity*. This is the speed which an object must attain in order to escape from some massive body. Suppose that body were the earth; then the escape velocity from it would be approximately 40000 kilometres per hour, which is about 25000 miles per hour. A stone which is hurled from the earth's surface (in any direction away from the ground), with a speed exceeding this value, will escape from the earth completely (assuming that we may ignore the effects of air resistance). If thrown with less than this speed, then it will fall back to the earth. (Thus, it is *not* true that 'everything that goes up must come down'; an object returns only if it is thrown with *less* than the escape velocity!) For Jupiter, the escape velocity is 220000 kilometres per hour i.e. about 140000 miles per hour; and for the sun it is 2200000 kilometres per hour, or about 1400000 miles per hour. Now suppose we imagine that the sun's mass were concentrated in a sphere of just *one quarter* of its present radius, then we should obtain an escape velocity which is *twice* as great as its present value; if the sun were even more concentrated, say in a sphere of *one-hundredth* of its present radius, then the velocity would be *ten times* as great. We can imagine that for a sufficiently massive and concentrated body, the escape velocity could exceed even the velocity of light! When this happens, we have a black hole.

In Fig. 2, I have drawn a space-time diagram depicting the collapse of a body to form a black hole (where I am assuming that the collapse proceeds in a way that maintains spherical symmetry reasonably closely, and where I have suppressed one of the spatial dimensions). The light cones have been depicted, and, as we recall from the discussion of general relativity, these indicate the absolute limitations on the motion of a material object or signal. Note that the cones begin to tip inwards towards the centre, and the tipping gets more and more extreme the more central they are.

There is a critical distance from the centre, referred to as the *Schwarzschild radius,* at which the outer limits of the cones become *vertical* in the diagram. At this distance, light (which must follow the light cones) can simply hover above the collapsed body, aid all the outward velocity that the light can muster is just barely enough to counteract the enormous gravitational pull. The (3-)surface in space-time traced out, at the Schwarzschild radius, by this hovering light (i.e. the light's entire history) is referred to as the *(absolute) event horizon* of the black hole. Anything that finds itself within the event horizon is unable to escape or even to communicate with the outside world. This can be seen from the tipping of the cones, and from the fundamental fact that all motions and signals are constrained to propagate within (or on) these cones. For a black hole formed by the collapse of a star of a few solar masses, the radius of the horizon would be a few kilometres. Much larger black holes are expected to reside at galactic centres. Our own Milky Way galaxy may well contain a black hole of about a million solar masses, and the radius of the hole would then be a few million kilometres.

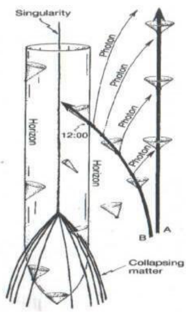

Fig. 2. A space-time diagram depicting collapse to a black hole. The Schwarzschild radius is marked 'Horizon'

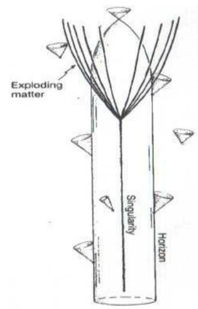

Fig. 3. A hypothetical space-time configuration: a white hole, ultimately exploding into matter (the time reverse of the space-time of Fig. 2)

The actual material body which collapses to form the black hole will end up totally within the horizon, and so it is then unable to communicate with the outside. We shall be considering the probable fate of the body shortly. For the moment, it is just the space-time geometry created by its collapse that concerns us – a space-time geometry with profoundly curious implications.

Let us imagine a brave (or foolhardy?) astronaut **B**, who resolves to travel into a large black hole, while his more timid (or cautious?) companion **A** remains safely outside the event horizon. Let us suppose that **A** endeavours to keep **B** in view for as long as possible. What does A see? It may be ascertained from Fig. 2 that the portion of **B**'s history (i.e. **B**'s world-line) which lies *inside* the horizon will never be seen by **A**, whereas the portion *outside* the horizon will all eventually have become visible to **A** – though **B**'s moments immediately preceding his plunge across the horizon will be seen by **A** only after longer and longer periods of waiting. Suppose that **B** crosses the horizon when his own watch registers 12 o'clock. That occurrence will never actually be witnessed by A, but the watch-readings $11:30$, $11:45$, $11:52$, $11:56$, $11:58$, $11:59$, $11:59\tfrac{1}{2}$, $11:59\tfrac{3}{4}$, $11:59\tfrac{7}{8}$, etc. will be successively seen by **A** (at roughly equal intervals, from **A**'s point of view). In principle, **B** will always remain visible to **A** and would appear to be forever hovering just above the horizon, his watch edging ever more slowly towards the fateful hour of 12:00, but never quite reaching it. But, in fact the image of **B** that is perceived by **A** would very rapidly become too dim to be discernible. This is because the light from the tiny portion of **B**'s world-line just outside the horizon has to make do for the whole of the remainder of **A**'s experienced time. In effect, **B** will have vanished from **A**'s view – and the same would be true of the entire original collapsing body. All that **A** can see will indeed be just a 'black hole'!

What about poor **B**? What will be *his* experience? It should first be pointed out that there will be nothing whatever noticeable by **B** at the moment of his crossing the horizon. He glances at his watch as it registers around 12 o'clock and he sees the minutes pass regularly by: $11:57$, $11:58$, $11:59$, $12:00$, $12:01$, $12:02$, $12:03$, … . Nothing seems particularly odd about the time $12:00$. He can look back at **A**, and will find that **A** remains continuously in view the whole time. He can look at **A**'s own watch, which appears to **B** to be proceeding forwards in an orderly and regular fashion. Unless **B** has *calculated* that he must have crossed the horizon, he will have no means of knowing it. The horizon has been insidious in the extreme. Once crossed, there is no escape for **B**. His local universe will eventually be found to be collapsing about him, and he will be destined shortly to encounter his own private' big crunch'!

Or perhaps it is not so private. All the matter of the collapsed body that formed the black hole in the first place will, in a sense, be sharing the 'same' crunch with him. In fact, if the universe *outside* the hole is spatially closed, so that the outside matter is also ultimately engulfed in an all-embracing big crunch, then that crunch, also, would be expected to be the 'same' as **B**'s 'private' one.

Despite **B**'s unpleasant fate, we do not expect that the local physics that he experiences up to that point should be at odds with the physics that we have come to know and understand. In particular, we do not expect that he will experience local violations of the second law of thermodynamics, let alone a complete reversal of the increasing behaviour of entropy. The second law will hold sway just as much inside a black hole as it does elsewhere. The entropy in **B**'s vicinity is still increasing, right up until the time of his final crunch.

To understand how the entropy in a 'big crunch' (either 'private' or 'all-embracing') can indeed be enormously high, whereas the entropy in the big bang had to have been much lower, we shall need to delve a little more deeply into the space-time geometry of a black hole. But before we do so, the reader should catch a glimpse also of Fig. 3 which depicts the hypothetical time-reverse of a black hole, namely a *white* hole. White holes probably do *not* exist in nature, but their theoretical possibility will have considerable significance for us.

Text 6. Hawking's box: a link with the Weyl curvature hypothesis?

Internet Assignment:

1. Find the film "Time Travel".

2. Discuss it at the students' on line conference.

That is as may be, the reader is no doubt thinking, but what has ali this to do with WCH or CQG? True, the *second law,* as it operates today, may well be part of the operation of **R**, but where is there any noticeable role for space-time singularities or quantum gravity in these continuing 'everyday' occurrences state-vector reduction? In order to address this question, I wish to describe an outlandish 'thought experiment', originally proposed by Stephen Hawking, though the purpose to which it will be put is not part of what Hawking had originally intended.

Imagine a sealed box of monstrous proportions. Its walls are taken to be totally reflecting and impervious to any influence. No material object may pass through, nor may any electromagnetic signal, or neutrino, or anything. All must be reflected back, whether they impinge from without or from within. Even the effects of gravity are fobidden to pass through. There is no actual substance out of which such walls could be built. No-one could actually *perform* the 'experiment' that I shall describe. (Nor would anyone want to, as we shall see!) That is not the point. In a thought experiment one strives to uncover general principles from the mere mental consideration of experiments that one *might* perform. Technological difficulties are ignored, provided they have no bearing on the general principles under consideration. In our case, the difficulties in constructing the walls for our box are to be regarded as purely 'technological' for this purpose, so these difficulties will be ignored.

Inside the box is a large amount of material substance, of some kind. It does not matter much what this substance is. We are concerned only with its total mass *M,* which should be very large, and with the large volume *V* of the box which contains it. What are we to do with our expensively constructed box and its totally uninteresting contents? The experiment is to be the most boring imaginable. We are to leave it untouched – forever!

The question that concerns us is the ultimate fate of the contents of the box. According to the second law of thermodynamics, its entropy should be increasing. The entropy should increase until the maximum value is attained, the material having now reached 'thermal equilibrium'. Nothing much would happen from then on, were it not for 'fluctuations' where (relatively) brief departures from thermal equilibrium are temporarily attained. In our situation, we assume that M is large enough, and V is something appropriate (*very* large, but not too large), so that when 'thermal equilibrium' is attained most of the material has collapsed into a *black hole,* with just a little matter and radiation running round it – constituting a (very cold!) so-called 'thermal bath', in which the black hole is immersed. To be definite, we could choose M to be the mass of the solar system and V to be the size of the Milky Way galaxy! Then the temperature of the 'bath' would be only about 10^{-7} of a degree above absolute zero!

To understand more clearly the nature of this equilibrium and these fluctuations, let us recall the concept of *phase space*, particularly in connection with the definition of entropy. Figure 1 gives a schematic description of the whole phase space $\mathbb{P}$ of the contents of Hawking's box. As we recall, a phase space is a large-dimensional space, each single point of which represents an entire possible state of the system under consideration – here the contents of the box. Thus, each point of $\mathbb{P}$ codifies the positions and momenta of all the particles that are present in the box, in addition to all the necessary information about the *space-time geometry* within the box. The subregion $\mathbb{B}$ (of $\mathbb{P}$) on the right of Fig. 1 represents the totality of all states in which there is a *black hole* within the box (including all cases in which there is more than one black hole), whilst the subregion $\mathbb{A}$ on the left represents the totality of all states free of black holes. We must suppose that each of the regions $\mathbb{A}$ and $\mathbb{B}$ is further subdivided into smaller compartments according to the 'coarse graining' that is necessary for the precise definition of entropy, but the details of this will not concern us here. All we need to note at this stage is that the largest of these compartments – representing thermal equilibrium, with a black hole present – is the major portion of $\mathbb{B}$, whereas the (somewhat smaller) major portion of $\mathbb{A}$ is the compartment representing what *appears* to be thermal equilibrium, except that no black hole is present.

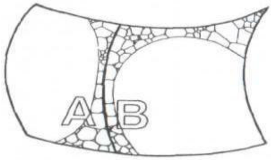

Fig. 1. The phase space $\mathbb{P}$ of Hawking's box. The region $\mathbb{A}$ corresponds to the situations where there is no black hole in the box and $\mathbb{B}$, to where there is a black hole (or more than one) in the box

Recall that there is a field of arrows (vector field) on any phase space, representing the temporal evolution the physical system. Thus, to see what will happen next in our system, we simply follow along arrows in $\mathbb{P}$. Some of these arrows will cross over from the region $\mathbb{A}$ into the region $\mathbb{B}$. This occurs when a black hole first forms by the gravitational collapse of matter. Are there arrows crossing back again from region $\mathbb{B}$ into region $\mathbb{A}$? Yes there are, but only if we take into account the phenomenon of *Hawking evaporation.* According to the strict *classical* theory of general relativity, black holes can only swallow things; they cannot emit things. But by taking quantum-mechanical effects into account, Hawking (1975) was able to show that black holes ought, at the quantum level, to be able to emit things after all, according to the process of *Hawking radiation.* (This occurs via the quantum process of 'virtual pair creation', whereby particles and anti-particles are continually being created out of the vacuum – momentarily – normally only to annihilate one another immediately afterwards, leaving no trace. When a black hole is present, however, it can 'swallow' one of the particles of such a pair before this annihilation has time to occur, and its partner may escape the hole. These escaping particles constitute Hawking's radiation.) In the normal way of things, this Hawking radiation is very tiny indeed. But in the thermal equilibrium state, the amount of energy that the black hole loses in Hawking radiation exactly balances the energy that it gains in swallowing other 'thermal particles' that happen to be running around in the 'thermal bath' in which the black hole finds itself. Occasionally, by a 'fluctuation', the hole might emit a little too much or swallow too little and thereby lose energy. In losing energy, it loses mass (by Einstein's $E = mc^2$) and, according to the rules governing Hawking radiation, it gets a tiny bit hotter. Very *very* occasionally, when the fluctuation is large enough, it is even possible for the black hole to get into a runaway situation whereby it grows hotter and hotter, losing more and more energy as it goes, getting smaller and smaller until finally it (presumably) disappears completely in a violent explosion! When this happens (and assuming there are no other holes in the box), we have the situation where, in our phase space $\mathbb{P}$, we pass from region $\mathbb{B}$ to region $\mathbb{A}$, so indeed there *are* arrows from $\mathbb{B}$ to $\mathbb{A}$!

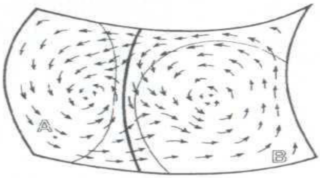

Fig. 2. The 'Hamiltonian flow' of the contents of Hawking's box. Flow lines crossing from $\mathbb{A}$ to $\mathbb{B}$ represent collapse to a black hole; and those from $\mathbb{B}$ to $\mathbb{A}$, disappearance of a black hole by Hawking evaporation

At this point, I should make a remark about what is meant by a 'fluctuation'. The phase-space points that belong to a single compartment are to be regarded as (macroscopically) 'indistinguishable' from one another. Entropy increases because by following the arrows we tend to get into huger and huger compartments as time progresses. Ultimately, the phase-space point loses itself in the hugest compartment of all, namely that corresponding to thermal equilibrium (maximum entropy). However, this will be true only up to a point. If one waits for long enough, the phase-space point will *eventually* find a smaller compartment, and the entropy will accordingly go down. This would normally not be for long (comparatively speaking) and the entropy would soon go back up again as the phase-space point re-enters the largest compartment. This is *a fluctuation,* with its momentary lowering of entropy. Usually, the entropy does not fall very much, but very, very occasionally a *huge* fluctuation will occur, and the entropy could be lowered substantially – and perhaps remain lowered for some considerable length of time.

This is the kind of thing that we need in order to get from region $\mathbb{B}$ to region $\mathbb{A}$ via the Hawking evaporation process. A very large fluctuation is needed because a tiny compartment has to be passed through just where the arrows cross over between $\mathbb{B}$ and $\mathbb{A}$. Likewise, when our phase-space point lies inside the major compartment within $\mathbb{A}$ (representing a thermal equilibrium state without black holes), it will actually be a very long while before a gravitational collapse takes place and the point moves into $\mathbb{B}$. Again a large fluctuation is needed. (Thermal radiation does not readily undergo gravitational collapse!)

Are there *more* arrows leading from $\mathbb{A}$ to $\mathbb{B}$, or from $\mathbb{B}$ to $\mathbb{A}$, or is the number of arrows the *same* in each case? This will be an important issue for us. To put the question another way, is it 'easier' for Nature to produce a black hole by gravitationally collapsing thermal particles, or to get rid of a black hole by Hawking radiation, or is each as 'difficult' as the other? Strictly speaking it is not the 'number' of arrows that concerns us, but the rate of flow of phase-space volume. Think of the phase space as being filled with some kind of (high-dimensional!) incompressible fluid. The arrows represent the flow of this fluid. Recall *Liouville's theorem*. Liouville's theorem asserts that the phase-space volume is preserved by the flow, which is to say that our phase-space fluid is indeed incompressible! Liouville's theorem seems to be telling us that the flow from $\mathbb{A}$ to $\mathbb{B}$ must be *equal* to the flow from $\mathbb{B}$ to $\mathbb{A}$ because the phase-space 'fluid', being incompressible, cannot accumulate either on one side or the other. Thus it would appear that it must be exactly equally 'difficult' to build a black hole from thermal radiation as it is to destroy one!

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This, indeed, was Hawking's own conclusion, though he came to this view on the basis of somewhat different considerations. Hawking's main argument was that all the basic physics that is involved in the problem is *time-symmetrical* (general relativity, thermodynamics, the standard unitary procedures of quantum theory), so if we run the clock backwards, we should get the same answer as if we run it forwards. This amounts simply to reversing the directions of all the arrows in $\mathbb{P}$. It would then indeed follow also from *this* argument that there must be exactly as many arrows from $\mathbb{A}$ to $\mathbb{B}$ as from $\mathbb{B}$ to $\mathbb{A}$ *provided* that it is the case that the time-reverse of the region $\mathbb{B}$ is the region $\mathbb{B}$ again (and, equivalently, that the time-reverse of $\mathbb{A}$ is $\mathbb{A}$ again). This proviso amounts to Hawking's remarkable suggestion that black holes and their time-reverses, namely white holes, are actually physically identical! His reasoning was that with time-symmetric physics, the thermal equilibrium state ought to be time-symmetric also. I do not wish to enter into a detailed discussion of this striking possibility here. Hawking's idea was that somehow the quantum-mechanical Hawking radiation could be regarded as the time-reverse of the classical 'swallowing' of material by the black hole.

Though ingenious, his suggestion involves severe theoretical difficulties, and I do not myself believe that it can be made to work.

In any case, the suggestion is not really compatible with the ideas that I am putting forward here. I have argued that whereas black holes ought to exist, white holes are *forbidden* because of the *Weyl curvature hypothesis!* WCH introduces a *time-asymmetry* into the discussion which was not considered by Hawking. It should be pointed out that since black holes and their space-time singularities are indeed very much part of the discussion of what happens inside Hawking's box, the unknown physics that must govern the behaviour of such singularities is certainly involved. Hawking takes the view that this unknown physics should be a *time-symmetric* quantum gravity theory, whereas I am claiming that it is the time-flasymmetric CQG! I am claiming that one of the major implications of COG should be WCH (and, consequently, the second law of thermodynamics in the form that we know it), so we should try to ascertain the implications of WCH for our present problem.

Let us see how the inclusion of WCH affects the discussion of the flow of our 'incompressible fluid' in $\mathbb{P}$. In space-time, the effect of a black-hole singularity is to absorb and destroy all the matter that impinges upon it. More importantly for our present purposes, *it destroys information.* The effect of this, in $\mathbb{P}$, is that some flow lines will now merge together (see Fig. 3). Two states which were previously different can become the same as soon as the information that distinguishes between them is destroyed. When flow lines in $\mathbb{P}$ merge together we have an effective *violation* of Liouville's theorem. Our 'fluid' is no longer incompressible, but it is being *continually annihilated* within region $\mathbb{B}$!

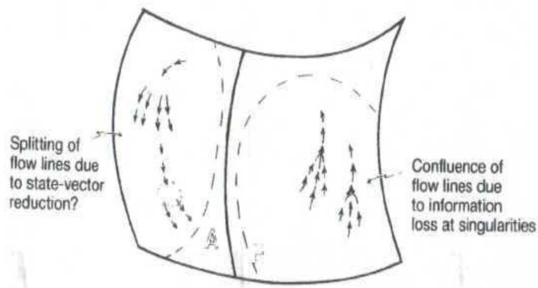

*Fig. 3. In region $\mathbb{B}$ flow lines must come together because of information loss at black-hole singularities. Is this balanced by a creation of flow lines due to the quantum procedure **R** (primarily in region $\mathbb{A}$)?*

Now we seem to be in trouble. If our 'fluid' is being continually destroyed in region $\mathbb{B}$, then there must be *more* flow lines from $\mathbb{A}$ to $\mathbb{B}$ than there are from $\mathbb{B}$ to $\mathbb{A}$ – so it is 'easier' to create a black hole than to destroy one after all! This could indeed make sense were it not for the fact that now more 'fluid' flows out of region $\mathbb{A}$ than re-enters it. There are no black holes in region $\mathbb{A}$ – and white holes have been excluded by WCH – so surely Liouville's theorem ought to hold perfectly well in region $\mathbb{A}$! However, we now seem to need some means of 'creating fluid' in region $\mathbb{A}$ to make up the loss in region $\mathbb{B}$. What mechanism can there be for increasing the number of flow lines? What we appear to require is that sometimes one and the same state can have more than one possible outcome (i.e. bifurcating flow lines). This kind of uncertainty in the future evolution of a physical system has the 'smell' of quantum theory about it – the **R** part. Can it be that **R** is, in some sense, 'the other side of the coin' to WCH? Whereas WCH serves to cause flow lines to merge within $\mathbb{B}$, the quantum-mechanical procedure **R** causes flow lines to bifurcate. I am indeed claiming that it is an *objective* quantum-mechanical process of state-vector reduction (**R**) which causes flow lines to bifurcate, and so compensate exactly for the merging of flow lines due to WCH (Fig. 3)!

In order for such bifurcation to occur, we need R to be time-asymmetric, as we have already seen: recall our experiment above, with the lamp, photo-cell, and half-silvered mirror. When a photon is emitted by the lamp, there are two (equally probable) alternatives for the final outcome: either the photon reaches the photo-cell and the photo-cell registers, or the photon reaches the wall at A and the photo-cell does not register. In the phase space for this experiment, we have a flow line representing the emission of the photon and this bifurcates into two: one describing the situation in which the photo-cell fires and the other, the situation in which it does not. This appears to be a genuine bifurcation, because there is only one allowed input and there are two possible outputs. The other input that one might have had to consider was the possibility that the photon could be ejected from the laboratory wall at B, in which case there would be two inputs and two outputs. But this alternative input has been excluded on the grounds of inconsistency with the second law of thermodynamics – i.e. from the point of view expressed here, finally with WCH, when the evolution is traced into the past.

I should re-iterate that the viewpoint that I am expressing is not really a 'conventional' one – though it is not altogether clear to me what a 'conventional' physicist would say in order to resolve all the issues raised. (I suspect that not many of them have given these problems much thought!) I have certainly heard a number of differing points of view. For example, it has from time to time been suggested, by some physicists, that Hawking radiation would never *completely* cause a black hole to disappear, but some small 'nugget' would always remain. (Hence, on this view, there are *no* arrows from $\mathbb{B}$ to $\mathbb{A}$)! This really makes little difference to my argument (and would actually strengthen it). One could evade my conclusions, however, by postulating that the total volume of the phase-space $\mathbb{P}$ is actually *infinite,* but this is at variance with certain rather basic ideas about black-hole entropy and about the nature of the phase space of a bounded (quantum) system; and other ways of technically evading my conclusions that I have heard of seem to me to be no more satisfactory. A considerably more serious objection is that the idealizations involved in the actual construction of Hawking's box are too great, and certain issues of principle are transgressed in assuming that it can be built. I am uncertain about this myself, but I am inclined to believe that the necessary idealizations can indeed be swallowed!

Finally, there is a serious point that I have glossed over. I started the discussion by assuming that we had a *classical* phase space – and Liouville's theorem applies to classical physics. But then the quantum phenomenon of Hawking radiation needed to be considered. (And quantum theory is actually also needed for *the finite-dimensionality* as well as finite volume of $\mathbb{P}$). As we saw, the quantum version of phase space is *Hilbert space,* so we should presumably have used Hilbert space rather than phase space for our discussion throughout. In Hilbert space there *is* an analogue of Liouville's theorem. It arises from what is called the *'unitary'* nature of the time-evolution U. Perhaps my entire argument could be phrased entirely in terms of Hilbert space, instead of classical phase space, but it is difficult to see how to discuss the classical phenomena involved in the space-time geometry of black holes in this way. My own opinion is that for the *correct* theory neither Hilbert space nor classical phase space would be appropriate, but one would have to use some hitherto undiscovered type of mathematical space which is intermediate between the two. Accordingly, my argument should be taken only at the heuristic level, and it is merely *suggestive* rather than conclusive. Nevertheless, I do believe that it provides a strong case for thinking that WCH and **R** are profoundly linked and that, consequently, **R** *must indeed be a quantum gravity effect.*

To re-iterate my conclusions: I am putting forward the suggestion that quantum-mechanical state-vector reduction is indeed the other side of the coin to WCH. According to this view, the two major implications of our sought-for 'correct quantum gravity' theory (CQG) will be WCH and **R**. The effect of WCH is *confluence* of flow lines in phase space, while the effect of **R** is an exactly compensating *spreading* of flow lines. Both processes are intimately associated with the second law of thermodynamics.

Note that the confluence of flow lines takes place entirely within the region $\mathbb{B}$, whereas flow-line spreading can take place either within $\mathbb{A}$ *or* within $\mathbb{B}$. Recall that $\mathbb{A}$ represents the *absence* of black holes, so that state-vector reduction can indeed take place when black holes are absent. Clearly it is not necessary to have a black hole in the laboratory in order that **R** be effected (as with our experiment with the photon, just considered). We are concerned here only with a general overall balance between possible things which *might* happen in a situation. On the view that I am expressing, it is merely the *possibility* that black holes might form at some stage (and consequently then destroy information) which must be balanced by the lack of determinism in quantum theory!

APPENDIX II

1. Study all the texts, collect information and write two-pages-long compositions on each of the following topics:

1. The Founders of Number Theory.
2. Number Theory.
3. Modern Number Systems and Concepts.
4. Natural Numbers.
5. Real Numbers.
6. Structures.

2. The following questions may direct you:

1. What are the stages of Number Theory evolution during the past 2300 years?
2. What new methods are basic nowadays for the Number Theory?
3. What are your critical comments on Modern Number Systems and Concepts?
4. Why are Natural Numbers one of the basic and most essential Concept of Maths?
5. What was the evolution of Real Numbers from the Babylonians till nowadays?
6. Are there any theories with their Structures entirely indeterminate?

Number Theory and its Founders

Mathematics is the Queen of Science and
Arithmetic is the Queen of Mathematics.
Gauss.

The theory of numbers, one of the oldest branches of maths, has engaged the attention of many gifted mathematicians during the past 2300 years. The Greeks, Indians and Chinese had made significant contributions prior to 1000 A.D. and in more modern times the subject has been developed steadily since Fermat, one of the fathers of maths.

In view of the diversity of problems and methods grouped together under the name of number theory, it is impossible to write even an introductory treatment which in any sense covers the field completely. The properties of the series of natural numbers, one of the basic and most essential concepts of maths, are the object of the theory of numbers. One finds that there exist many simple rules regarding numbers that are quite easy to discover and not too difficult to prove.

However, number theory also includes an abundance of problems whose content can be comprehended and expressed in simple terms, yet whose solution has for centuries defied all math investigation. Other problems whose solutions have been successfully obtained have yielded only to attacks by some of the most ingenious and advanced methods of modern maths.

The simplicity in form of its problems and the great variation in the methods and tools for their solution explain the attraction that number theory has had for mathematicians and laymen. The innumerable individual contributions, calculations, speculations, and conjectures bear witness to the continued interest in this field of maths throughout the centuries.

The origins of the study of number properties go back probably almost as far as counting and the arithmetic operations. It does not take long before it is discovered that some numbers behave differently from the others; for instance, some numbers can be divided into smaller equal parts and others not. The operations with fractions lead immediately to the study of divisibility of numbers, the least common multiple, and the greatest common divisor. Other approaches have led to early number-theory questions.

In number theory we are concerned with properties of certain of the integers ..., -3, -2, -1, 0, 1, 2, 3, ..., or sometimes with those properties of the real and complex numbers which depend rather directly on the integers. As in most branches of abstract thought, it is easier to characterize the theory of numbers extensively, by giving a large number of examples of problems which are usually considered as parts of number theory, than to define it intensively, by saying that exactly those problems having certain characteristics will be included in the subject.

The problems treated in classical number theory can be divided into groups according to a more or less rough classification. First, there are *multiplicative problems,* concerning with divisibility properties of the integers. It will be proved later that any positive integer n greater than 1 can be represented uniquely except for the order of the factors, as a product of primes, i.e., integers greater than 1 having no exact divisors except itself and 1. This may also be termed *the fundamental theorem of number theory* so manifold and varied are its applications. From the decomposition of n into primes, it is easy to determine the number of divisors of n.

In another direction, we have the problems *of additive number theory:* questions concerning the representability, and the number of representations of a positive integer as a sum of integers of a specified kind. For instance, upon examination it appears that some integers, like $5 = 1^2 + 3^2$ and $13 = 2^2 + 3^2$, are representable as a sum of two squares; while others, like 3 or 12, are not. Which integers are so representable and how many such representations are there?

A third category may include what are known as *Diophantine equations* named after the Greek mathematician Diophantus, who first studied them. These are equations in one or more variables whose solutions must be integers, or at any rate rational numbers. For example, it is a familiar fact that $3^2 + 4^2 = 5^2$ which gives us a solution of the Diophantine equation $x^2 + y^2 = z^2$. Giving a particular solution is hardly of interest; what is desired is an explicit formula for absolutions. A very famous Diophantine equation is that known as Fermat's equation: $x^n + y^n = z^n$. Fermat asserted that this equation has no solution (in nonzero integers, of course) if $n \geq 3$; the assertion has never been proved or disproved for general n. There is at present practically no general theory of Diophantine equations, although there are many special methods, most of which were devised for the solution of particular equations.

Finally, there are problems in *Diophantine approximations.* For example, given a real number x and a positive integer N, find that rational number p/q for which $q \leq N$ *and* $\left|x - (p/q)\right|$ is minimal. The proofs that e and π are transcendental also fall in this category. This branch of number theory probably borrows the most from, and contributes the most to, other branches of maths.

The theorems of number theory can also be subdivided along entirely different lines – for example, according to the methods used in their proofs. Thus, the dichotomies of elementary and nonelementary, analytic and synthetic. A proof is *elementary* (although not necessarily simple!) if it makes no use of the theory of functions of a complex variable, and *synthetic* if it does not involve the usual concepts of analysis – limits, continuity, etc. Sometimes, but not always, the nature of the theorem shows that the proof will be in one or another of these categories.

Pierre de Fermat

P. Fermat (1601-1665) must be awarded the honour of being the founding father of number theory as a systematic science. His life was quiet and uneventful and entirely centred around the town of Toulouse, where he first studied jurisprudence, practised law, and later became prominent as councillor of the local parliament.

His leisure time was devoted to scholary pursuits and to a voluminous correspondence with contemporary mathematicians, many of whom, like himself, were gentlemen-scholars, the ferment of intellectual life in the seventeenth and eighteenth centuries. Fermat possessed a broad knowledge of the classics, enjoyed literary studies, and wrote verse, but *maths was his real love!*

He published practically nothing personally, so that his works have been gleaned from notes that were preserved after his death by his family, and from letters and treatises that he had sent to his correspondents. In spite of his modesty, Fermat gained an outstanding reputation for his math achievements. He made considerable contributions to the foundation of the theory of probability in his correspondence with Pascal and introduced coordinates independently of Descartes. The French often interject the name of Fermat as a cofounder of the calculus, and there is considerable justification for this point of view.

In spite of all these achievements, Fermat's real passion in maths was undoubtebly number theory. He returned to such problems in almost all his letters; he delighted to propose new and difficult problems, and to give solutions in large figures that require elaborate computations; and most important of all, he announced new principles and methods that have inspired all work in number theory after him. Fermat's factorization method (which is the point interesting us particularly) is based upon the following facts. If a number n can be written as the difference between two square numbers, one has the obvious factorization

$$n = x^2 - y^2 = (x - y)(x + y) \tag{1}$$

On the other hand, if $n = ab$, $b \geq a$ is composite, one can obtain a representation (1) of n as the difference of two squares by putting $x - y = a$, $x + y = b$ so that

$$x = \frac{b+a}{2}, \quad y = \frac{b-a}{2} \tag{2}$$

Since we deal with the question of factoring n, we can assume that n is odd, hence a and b are odd and the values of x and y are integral. Corresponding to each factorization of n there exists, therefore, a representation (1). To determine the possible x and y in (1) we write $x^2 = n + y^2$.

Since $x^2 \geq n$, one has $x \geq \sqrt{n}$. The procedure consists in substituting successively for x the values above $\sqrt{n}$ and examining whether the corresponding, $\Delta(x) = x^2 - n$ is a square y^2.

Fermat's method is particularly helpful when the number n has two factors whose difference $2y = b - a$ is relatively small, because a suitable y will then quickly appear. By means of certain other improvements that can be introduced in the procedure, it becomes one of the most effective factorization methods available.

Of particular interest is Fermat's last theorem. Greek maths, as is known, was geometric in character. However, during the later Alexandrian period, the algebraic methods came more into the foreground. During this period, Diophantus (A.D. 250), the most renowned proponent of Greek algebra, lived in Alexandria. Nothing is known about his life. All his books deal with the properties of rational and integral numbers, topics on algebraic equations and more particularly with the solution of certain problems in which it is required to find rational numbers satisfying prescribed conditions. More than 130 problems of this latter type are discussed, and Diophantus shows great ingenuity in devising elegant methods for their solution.

The path from Diophantus to Fermat although long in time, is quite direct. Fermat represents a focal point in the history of number theory; in his work the radiating branches of earlier periods were united and their content recreated in a richer and more systematic form. Fermat possessed a well-known copy of Diophantus, which he also used as a notebook. In the margins he jotted down several of his most important remarks as they occurred to him in connection with the related problems in Diophantus.

We now come to the most famous of Fermat's remarks in his copy of Diophantus. In problem 8 in Book II Diophantus propounds: *"To decompose a given square number into the sum of two squares."* To use a general notation, let a^2 be the given square for which one wants to find x and y such that $a^2 = x^2 + y^2$. As usual, Diophantus asks for rational solutions.

This problem to us is quite straightforward, but it was not always so. In the oldest preserved Diophantus' manuscript, copied in the thirteenth century we find at this point the following heartfelt remark by the writer: "Thy soul, Diophantus, to Satanas, for the difficulty of thy problems and this one in particular." Fermat's comments in connection with this problem are as one should expect considerably more constructive and of much greater consequence: "However, it is impossible to write a cube as the sum of two cubes, a fourth power as the sum of two fourth powers and in general any power beyond the second as the sum of two similar powers. For this I have discovered a truly wonderful proof, but the margin is too small to contain it."

This is the famous Fermat's theorem, sometimes called Fermat's last theorem, on which the most prominent mathematicians have tried their skill ever since its announcement three hundred years ago. In algebraic language, it requires that it shall be shown that the Diophantine equation $x^n + y^n = z^n$ has no solution in integers, x, y and z, all different from zero, when $n \geq 3$. The question whether Fermat possessed a demonstration of his last problem will in all likelihood forever remain an enigma. Fermat, undoubtedly, had one of the most powerful minds ever applied to investigate the laws of numbers, and from his indications there is every reason to believe that he was able to prove the various other assertions that he included in the Diophantus notes. The remark that the margin was too small may, perhaps, sound a bit like an excuse, but it was an observation he had to make also in other instances.

Fermat's problem has remained remarkably active throughout its history, and results and research on it still appear frequently in the math journals. It must be admitted frankly that if the specific result implied in the theorem were obtained, it would, probably, have little systematic significance for the general progress of maths. However, the theorem has been extremely important as a goal and a constant source of new efforts. Some of the new methods it has inspired are basic nowadays not only for number theory but also for many other branches of maths.

Leonhard Euler

Leonhard Euler (1707-1783) was a remarkable scientist whose contributions have left their imprint on almost all branches of maths. His papers were rewarded ten times by prizes of the French Academy. His productivity was immense; it has been estimated that his collected works fill upward of 100 large volumes. One of his best known works *Complete Introduction to Algebra* (1770) contains much material on elementary number theory. Euler's *factorization method* applies only to numbers which in some way can be represented as a sum of two squares $N = a^2 + b^2$ as, for instance, $41 = 5^2 + 4^2$. It is possible to show that if a number can be represented as the sum of two squares, one can find all factorizations by Euler's method. Euler's method is capable of wide extensions. It leads to the theory of representations of numbers by means of a quadratic forms, i.e., $N = ax^2 + bxy + cy^2$.

Such representations can under certain conditions be used for factoring in the same manner as the special form $N = x^2 + y^2$.

It will carry us too far to discuss the great number of other aids and methods for factoring, some of them very ingenious. Considerable effort has been centred on the factorization of numbers of particular types. Some of them are numbers resulting from math problems of interest. Others have been selected because it is known for theoretical reasons that the factors must have a special form. Among the numbers that have been examined in great detail one should mention the so-called binomial numbers $N = a^n \pm b^n$ where a and b are integers.

Georg Friedrich Bernhard Riemann

Although Euler had begun applying the methods of the calculus to number-theory problems, however, the German mathematician G. F. B. Riemann (1826-1866) is generally regarded as the real founder of analytic number theory. His personal life was modest and uneventful until his premature death from tuberculosis. According to the wish of his father he was originally destined to become a minister, but his shyness and lack of ability as a speaker made him abandon this plan in favour of math scholarship. At present he is recognized as one of the most penetrating and original math minds of the nineteenth century. In analytic number theory, as well as in many other fields of maths, his ideas still have a profound influence.

His starting point was a function now called Riemann's zeta function

$$\zeta(s) = 1 + \frac{1}{2^s} + \frac{1}{3^s} + \frac{1}{4^s} + \dots$$

This function he investigated in great detail and showed that its properties are closely connected with the prime-number distribution. On the basis of Riemann's ideas, the prime-number theorems were proved by other mathematicians. Much progress has been made in analytic number theory since that time, but it remains a peculiar fact that the key to some of the most essential problems lies in the so-called Riemann's hypothesis, the last of his conjectures about the zeta function, which has not been demonstrated. It states that the complex roots of the function all have the real component $\frac{1}{2}$.

Active Vocabulary

number	prime	sum		
numeral	odd	difference	common	
integer	even	product	decimal	fraction
fraction	factor	quotion	repeating	
digit	divisor	ratio	non-repeating	
series				

whole		ring
counting		group
natural		field
rational		matrix
directed	numbers	numbers
complex		structures
imaginary		quaternions
transfinite		manifold
positive		isomorphism
negative		

hierarchy of algebraic topological order mother multiple isomorphic	structures	decimal duodecimal binary	scale

measurable immeasurable commensurable incommensurable	existence uniqueness commutative associative distributive	principle

the least common multiple
the greatest common divisor

The Greek Genius

"The Greek genius" did not happen spontaneously. Once the Greeks were settled in the Peloponesus and on the western shores of Asia Minor, they began to travel. Soon they were off the faraway places. On these travels they made contact with many more ancient cultures – in India, in Mesopotamia, and in Egypt. They learned and partially absorbed ways of life that had taken thousands of years to develop. Knowledge, wisdom and religion often were indistinguishable in these ancient cultures. What the early Greek travellers brought home from their trips abroad was a curious and intricate mixture of various religious cults and philosophies of life grown under conditions very different from those familiar to the Greeks. They accumulated also a tremendous wealth of knowledge pertaining to practically all aspects of life. Deeply woven into it all was knowledge of numeration and number, astronomy and (as we would call it now) astrology, and an abundance of geometric patterns and designs.

It may be supported that the early Greeks were not very much interested in numeration – if, indeed, they were interested in it at all. This was true in spite of the infinite contact with positional numeration systems, like those of Babylonians, which were vastly superior in design and manageability to their own nonpositional numeration system. Their minds apparently were not inclined toward the mechanical and rote aspects of elementary maths but rather were fascinated by suspected underlying reasons and possible justifications.

The Pythagoreans did not refine and propagandize numeration but concentrated – aside from their magnificent work in geometry – on studying the properties of numbers, in particular, the positive integers. They, thereby, missed or knowingly passed by the much more significant study of the properties of operations on numbers, which might have led them to create a structure of number systems similar to that which they created for geometry.

To appreciate the preoccupation of the Pythagoreans with properties of numbers, we must keep two things in mind: 1) The Greeks had inherited from the earlier Eastern cultures an almost inextricable mixture of genuine number knowledge, myths, religious beliefs; 2) The prevailing numeration system of this period made use of the standard Greek alphabet supplemented by special symbols so as to make a set of twenty-seven characters. Although there was no difficulty in determining when the symbols represented a number instead of a word, it was possible to use the numerical value of each letter to assign a unique number to any given word.

Regardless of what mystical reasons may have motivated the early Pythagorean investigators, they discovered many curious and fascinating number properties. Since the general Greek outlook toward maths was more geometric than in arithmetical, and since in their earlier work the Greeks considered only whole numbers, it is no wonder that they attempted to represent numbers as geometric patterns.

The Greeks' concern with prime numbers was considerably deeper and more serious. It was known that, with the exception of one and two, any whole number that is not prime can be expressed as a product of primes. The Greeks not only formalized these findings but established what later became known as "the fundamental theorem of arithmetic" – namely, that a composite number can be expressed as a product of primes in one and only one way. This theorem is known as the "unique factorization theorem". Euclid presented a proof in his *Elements* to show that the set of prime numbers is infinite – that is, that there is no greatest prime. In spite of many attempts so far, no one has been able to devise a practical test for checking the primality of large numbers, nor has a truly general prime generator been discovered.

With due respect to a very few isolated Greek mathematicians, it must be pointed out that the only numbers accepted by Greeks were the natural numbers. The foremost of these few mathematicians was

Eudoxus (408-355 B.C.). He showed that the measure of the diagonal of the unit square could not be expressed as the ratio of two natural numbers, that is, that the symbol $\sqrt{2}$ does not represent a rational number. He developed an ingenious theory of "equal ratios" which with just a few minor refinements could have become the basis for the real number system. Probably, Eudoxus was not understood by more than a very few contemporaries; it is doubtful whether any of them (and this may well include Euclid himself) could have foreseen the tremendous implications of this discovery.

To most of the Greek mathematicians the very idea of incommensurable quantities was disagreeable and fearful. Eudoxus' theory of equal ratios was soon discarded and forgotten. More than two thousand years elapsed before the German mathematicians Dedekind and Cantor took up the work where Eudoxus had left off and brought it to completion creating the real number system and thereby, a legitimate "place" for imaginary and complex numbers.

Thus, the "Greek genius" was no more concerned with number systems than with numerational systems. While the math contributions of many ancient cultures were numeration, a principal Greek contribution was arithmetic, knowledge of the properties of numbers. The modern approach is definitely oriented toward the structural properties of number systems (not of numeration systems) – that is, toward the patterns and properties of operations on numbers which provide unity, simplicity, and continuity from the system of the whole numbers through the system of the complex numbers.

Natural Numbers

What are natural numbers? The question has been a topic of debate among philosophers and mathematicians at least since the time of Pythagoras in the sixth century B.C. Pythagoras believed that what we call the positive integers or natural numbers (1,2,3 and so on) were *God-given entities* that formed the ultimate foundation both of maths and of the Universe. The Pythagoreans' own discovery of such "incommensurable" quantities as the ratio between the diameter of a circle and its circumference ultimately dispelled the belief that the Universe was built on natural numbers. That the natural numbers provided the foundation of maths, however, persisted as an article of faith among mathematicians until well into the 19th century.

But then the attitude toward the natural numbers had begun to change. The centrality of natural numbers was no longer considered an accepted fact but was viewed as a conjecture that required rigorous proof. The proofs usually took the form of a stepwise derivation of such well-known number systems as rational, real and complex numbers from the natural numbers themselves. Two examples are the attempts of K.Weierstrass and R. Dedekind to "arithmetize" math analysis. Both scholars derived real numbers – the combined set of all rational and irrational numbers that is employed in most classical maths – from the rational numbers. A third example is the proposal of L.Kronecker to found all maths on the natural numbers. This Kronecker attempted to accomplish solely with "finitary" methods, that is, methods invoking neither nonfinite entities nor proofs involving more than a finite number of steps.

Still other mathematicians, in particular those who were conversant with contemporary advances in symbolic logic, put forward the suggestion that, far from being God-given, natural numbers were constructions of the human mind. The three most famous propagators of this suggestion were *G.Frege*, *G.Peano* and *B.Russell*. Obviously a theory was needed that would trace the rise of the natural numbers from some more basic notion or notions, but how was such a theory to be constructed? If most or all of classical maths had evolved from the natural numbers, it was improbable that the required theory could be devised entirely within the bounds of classical maths.

First Frege, then Peano and finally Russell turned to symbolic logic as a potential source of the fundamental notions necessary for a theory of natural numbers. *Frege* was the first of the three to publish specific theory (1884) in which he proposed that the natural numbers could be reduced to the notion of "class" and the operation of "correspondence", by virtue of which classes are quantified. According to Frege, each natural number n was to be regarded as a "superordinate class" whose members, "subordinate classes", each contain precisely n elements. Given two subordinate classes, A and B, the two are said to be members of the same superordinate class, that is, instances of the same number, if and only if a one-to-one correspondence can be established between their respective elements. If instead the correspondence is many to one, then A and B are said to be instances of different numbers.

In essence, Frege's theory states that the series of natural numbers presents a general problem of quantification, but that the general problem can be reduced to the more restricted notion of "cardination" or quantifying classes. The commonest example of cardination is the matching of things. Frege's cardinal theory remained unknown until *Russell* rediscovered it in 1901. Russell subsequently published the cardinal theory, with full acknowledgement to Frege, in his own works and in his joint work with A.N. Whitehead: *Principia Mathematica* (1910-1913).

Between the time Frege first published the cardinal theory and the time Russell rediscovered it, *Peano* developed a second theory about the natural numbers. This theory first appeared in 1894 in the form of five axioms, that we shall slightly reword here. First, 1 is a natural number. Second, any number that is the successor of a natural number is itself a natural number. Third, no two natural numbers have the same successor. Fourth, the natural number 1 is not the successor of any natural number. Fifth, if a series of natural numbers include both the number 1 and the successor of every natural number, then the series contains all natural numbers.

In essence, Peano's theory places the natural numbers in *an ordinal relation* or in the language of symbolic logic, a "transitive, asymmetrical relation". If we are willing to stipulate that the relation *R* that obtains between every nonidentical pair of natural numbers be an ordinal relation, then the complete series of natural numbers can be constructed stepwise with the aid of the rule of math induction. Like Frege's cardinal theory, Peano's states that the series of natural numbers presents a general problem of quantification. Unlike Frege's theory, however, Peano's ordinal theory reduces the general problem to the more restricted notion of quantifying transitive, asymmetrical relations, or ordination. The commonest example of ordination is the counting of things.

Just which of the two theories, the cardinal or the ordinal, is mathematically preferable is a question that has never been answered to everyone's satisfaction. Reasonable objections can be lodged against both. For example, the cardinal theory is subject to the celebrated paradox, discovered by Russell in 1901, concerning the class composed of all those classes that are not members of themselves. With respect to the ordinal theory, as Russell pointed out, whereas Peano's five axioms obviously are satisfied by the series of natural numbers, they are equally satisfied by other number systems. For example, the rational fractions (1, $\frac{1}{2}$, $\frac{1}{3}$, $\frac{1}{4}$ and so on) satisfy the axioms, as will any series of math or empirical entities that has a beginning, no repetitions and no end and is such that every entity can be reached in a finite number of steps. In short,, the domain of application of the ordinal theory is much wider than the series of natural numbers.

Because there is no universally accepted math basis for choosing between the cardinal and the ordinal theories, the choice becomes a subjective matter. Typically, the choice is determined by one's degree of sympathy with one or another of three modern schools of math thought: logicism, formalism and intuitionism. Those who lean toward logicism, favour the cardinal theory, a choice that is natural enough when one considers that the codiscoverers of the theory, Frege and Russell, were the principal founders of logicism. Those whose sympathies are with formalism, lean toward the ordinal theory; the fact that Peano's axioms seem to denude the number concept of innate "meaning" probably explains this preference. As for the intuitionists, they have, in effect, returned to the Pythagorean position that the natural numbers must be accepted without further analysis as the foundation of maths. They deny that the natural numbers are the invention of math minds and offer a "psychological" thesis: The series of natural numbers is an innate intuition, present at birth in all normal members of the human species.

Nonmath scholars tend to view with profound indifference the tortures that mathematicians suffer over such basic issues as the nature of number. They have learned from centuries of hard experience that the mere fact that the foundations of some math system or concept are not secure need not deter them from employing the system in their work. On the contrary, math notions whose foundations have been matters of continuous debate have often yielded the most mileage; the notion of an infinitesimal is perhaps the best-known example. Unlike the infinitesimal, number is not the exclusive property, or even, largely, the personal property, of the mathematician. Number has been a concept of social importance since the dawn of recorded history. The significance to society of number and number-related skills has increased tremendously with the rise of industrial civilization.

Real Numbers

Every measurement of quantities implies a vague notion of real numbers. From (the math point of view, the origins of the theory of real numbers can be traced back to the progressive formation by the Babylonians of a system of numeration which was (in principle) capable of representing arbitrarily close approximations to any real number. The possession of such a system, and the confidence in numerical calculation which naturally resulted from it, inevitably led to a "naive" notion of real number which differs hardly at all from that which is current today (linked with the decimal system of numeration) in elementary education and among physicists and engineers.

This notion cannot be precisely defined, but can be expressed by saying that a number is regarded as defined by the possibility of finding approximations to it and using these approximations in calculation; this necessarily implies a certain amount of confusion between measures of physical quantities, which, of course, are not susceptible to an infinite series of successively closer and closer approximation, and "numbers" such as $\sqrt{2}$ (assuming that one in possession of an algorithm which would make possible an infinite series of successively closer and closer approximation of such numbers).

A similar "pragmatic" attitude appears in all math schools in which experience in calculation is more important than rigour and theory. The latter, however, were predominant in Greek maths and it is to the Greeks that we owe the first rigorous and coherent theory of ratios of magnitudes, that is, essentially, of real numbers. This theory was the culmination of a series of discoveries about proportions and, in particular, incommensurable ratios, whose importance in the history of Greek thought can hardly be exaggerated, but which in the absence of accurate texts can be discerned only in outline.

Greek maths in its early stages was inextricably bounded up with speculations, part scientific and part philosophical and mystical, about proportion, similitude and ratios, especially "simple ratios" (expressible by fractions with small numerators and denominators) and one of the characteristic tendencies of the Pythagorean school was to attempt to explain all in terms of integers and ratios of integers.

But it was the Pythagorean school, in fact, which discovered that $\sqrt{2}$ is irrational. This is without doubt the first example of a proof of impossibility in maths and the mere fact of posing such a question implies a clear distinction between a ratio and approximations to it, and indicates the immense gap which separates the Greek maths from their predecessors.

We know little about the movement of ideas which accompanied and followed) this important discovery. *We* shall give only a brief summary of the main ideas 'which lie at the base of the theory' of ratios of magnitudes which was constructed by the great mathematician Eudoxus (a contemporary and friend of Plato), definitely adopted by classical Greek maths and is known to us through Euclid's *Elements.*

1) The word and the idea of *number* are strictly reserved to natural integers >1 (1 is the monad and not, strictly speaking, a number), to the exclusion not only of our irrational numbers but also of what we call rational numbers: to the Greek mathematicians of the classical period the latter are ratios of numbers. There is much more here than a simple question of terminology: the word "number" was for the Greeks (and for the moderns up to a recent time) linked with the idea of *a system with two laws of composition* (addition and multiplication); ratios of integers were regarded by the classical Greek mathematicians as operators, defined on the set of integers or on some subset of this set [the ratio of p to q is the operator, which, applied to N, if N is *a multiple of* q, gives the integer $p\left(N/q\right)$ forming a multiplicative group but not a system with two laws of composition].

In this the Greek mathematicians separated themselves voluntarily from the "logisticians" or professional calculators who, like their Egyptian and Babylonian predecessors, had no scruples about treating fractions as if they were numbers, or adding a fraction to an integer. It seems moreover that this self-imposed restriction on the concept of number came from philosophical rather than math motives and followed the reflections of the first Greek thinkers on the unit and the multiple, the unit (in this system of thought) being incapable of subdivision without thereby losing its character of unit.

2) The theory of magnitudes is based on axioms, which applied simultaneously to all types of magnitudes (there are allusions to earlier theories which apparently treated lengths, areas, volumes, times, etc., all separately). Magnitudes of the same type are characterized by the facts that they can be compared (that is to say, it is assumed that equality,

which is an equivalence relation, and the relations $>$ and $<$ are defined), that they can be added and subtracted *(* $A+B$ is defined, and also *is* $A-B$ *if* $A>B$ *)* and that they satisfy "Archimedes' axiom". It is clearly realized from the beginning that this latter fact is the key stone of the whole edifice (it is, in fact, indispensable in any axiomatic characterization of real numbers).

For Eudoxus, the magnitudes of a given type form a system with *one* internal law of composition (addition), but that this system has an external law of composition whose operators are *ratios of magnitudes,* conceived of as forming *an Abelian multiplicative group.* The universal domain of operators thus constructed was the equivalent, for the Greek mathematicians, of what the set of real numbers is for us; moreover, it is clear that, with *addition* of magnitudes and *multiplication* of ratios of magnitudes they possessed the equivalent of what *the field* of real numbers is for us, although in a much less manageable form.

Such was the state of the theory of real numbers in the classical period of Greek maths. Admirable though Eudoxus' construction was, and leaving nothing to the desired in rigour or coherence, nevertheless, it must be admitted that it lacked flexibility and did not encourage the development of numerical calculation, still less the development of algebraic calculation. Moreover, its logical necessity could not be apparent except to those in love with rigour and familiar with abstraction; thus, it is natural that, with the decline of Greek maths, the "naive" point of view, which had been preserved through the tradition of the logisticians, should gradually re-emerge.

This point of view is dominant, for example, in Diophantus who in truth was an upholder of this tradition rather than of official Greek science. He reproduces the Euclidean definition of number, but in reality he used the word "number" to mean the unknown in algebraic problems whose solution may be either an integer, or a fraction, or an irrational number. Although this change of attitude on the subject of number is connected with the development of algebra, it does not, of course, constitute an advance in itself, but rather a retreat.

We cannot trace the vicissitudes of the concept of number through Hindu, Arab, and western maths up to the end of the Middle Ages. The "naive" notion of number predominated, and although Euclid's *Elements* served as a basis for the teaching of maths during this period, it is most likely that the doctrine of Eudoxus remained generally uncomprehended because the need for it was no longer appreciated. The "ratios" of Euclid were customarily described as "numbers", and the rules for calculating with integers were applied to them without any attempt to analyse the reasons for the success of these methods.

Nevertheless, we see *R. Bombelli,* as early as the middle of the 16th century, expounding a point of view on this subject in his *Algebra* which is essentially correct; having realized that once the unit of length has been chosen, there is a one-to-one correspondence between lengths and ratios of magnitudes, he defines the various algebraic operations on lengths (assuming, of course, that the unit has been fixed) and, representing numbers by lengths, obtains the geometrical definition of the field of real numbers and thus gives his algebra a solid geometrical foundation.

In the following two centuries the definitive establishment of correct methods was twice retarded by the development of two theories: the infinitesimal calculus and the theory of series. In the seventeenth century the main subject of debate was the notion of "infinitely" small, which though justified *a posteriori* by the results which were obtained with its help, seemed to be in open opposition to the axiom of Archimedes; and we see the most enlightened minds of this period finally adopting a point of view which differed little from that of Bombelli, and which is distinguished above all by the greater attention it paid to the rigorous methods of the ancients.

Isaac Barrow (Newton's teacher, who himself played an important part in the creation of the infinitesimal calculus) recognized the need to return to the theory of Eudoxus in order to regain the proverbial "geometrical certainty" in the subject of number. On the other hand, defining numbers to be symbols which denote ratios of magnitudes and to be capable of being combined by the operations of arithmetic, Barrow obtains the field of real numbers in terms which Newton took up again in his *Arithmetic* and which his successors up to Dedekind and Cantor did not change.

But it was in this period that the method of expansion in series was introduced; this rapidly took on an extremely formal character in the hands of impenitent algebraists and deflected the attention of mathematicians from the questions of convergence which are essential to any sound use of series in the domain of real numbers. At the same time began the movement of ideas which led to the definition of continuous functions and the general definition of compact spaces. *Weierstrass* had perceived the logical importance in making the idea of real numbers entirely independent of the theory of magnitudes; the latter is effectively equivalent to an axiomatic definition of the points of the line (and thus of the set of real numbers) and the assumption of the existence of such a set. Although this method is essentially correct, it is evidently preferable to start only from the rational numbers, and to construct the real numbers from them by completion. This was achieved, by diverse methods and independently of each other, by Weierstrass, Dedekind, Meray and Cantor; while the method of "cuts", proposed by Dedekind came very near to the definitions of Eudoxus.

Simultaneously, Cantor began to develop the theory of sets of real numbers, the idea of which was first conceived by Dedekind, and thus obtained the principal elementary results on the topology of the real line, the structure of its open and closed sets, the notion of derived set and of totally disconnected perfect set. Cantor also obtained Theorem I on the power of the continuum and deduced from it that the continuum is uncountable, that the set of transcendental numbers has the power of the continuum, and also (a paradoxical result for its time) that the set of points of a plane (or of space) has the same power as the set of points of a line. With Cantor these questions assumed practically their definitive form.

Apart from leading to work on general topology and applications to integration Cantor's work has led to investigations of the structure and classification of sets of points on a line, and a realvalued functions of a real variable. These have their origin in the work of Borel which was directed mainly towards measure theory and "Borel sets".

Toward Mathematical Structure

Three new approaches to numbers, in 1801 and in the 1830s, were to the hint at the general concept of math structure and reveal unsuspected horizons in the whole of maths. That of 1801 was the concept of congruence, introduced by Gauss. To this and the revolutionary work (1830) of E. Galois in the theory of algebraic equations can be traced the partial execution of L. Kronecker's (1823-1891) programme in the 1880s for basing all maths on the natural numbers.

The same sources are one origin of the modern abstract development of algebraic and geometric theories, in which the structure of math systems is the subject of investigation, and it is sought to obtain the interrelations of the math objects concerned with a minimum of calculation. "Structure" may be thought of at present in any of its intuitive meanings; it was precisely defined in 1910 by the math logicians. We shall approach math structure through the union effected In the nineteenth century between algebra and arithmetic.

From the standpoint of maths as a whole, the methodology of deliberate generalization and abstraction, culminating in the twentieth century in a rapidly growing maths of structure, is doubtless the most significant contribution of all the successive attempts to extend the number concept. But at every stage of the progression from the natural numbers 1, 2, 3, ... to other types of numbers, each of several fields of maths adjacent to arithmetic was broadened and enriched.

New acquisitions in other fields reacted reciprocally on arithmetic. For example, the first satisfactory theory of ordinary complex numbers to become widely known was that of Gauss (1831) devised to provide a concise solution for a special problem in Diophantine analysis.

The theory of complex numbers necessitated a radical revision and generalization of the concept of arithmetical divisibility, which in turn suggested a reformulation of certain parts of algebraic geometry. The latter, in its turn, was partly responsible for further generalizations (modular systems) in the algebraic arithmetic – or arithmetical algebra – of the twentieth century. The forward movement was universal and each major advance in one department induced progress in others.

The passage to final abstractness took about a quarter of a century. The turning point was Hilbert's work on the foundation of geometry in 1899. Although this did not concern algebra or arithmetic directly, it set a new and high standard of definiteness and completeness in the statement of all math definitions or, what is equivalent, in the construction of postulate systems. A general theory of structure was developed by A. N. Whitehead and B. Russell in 1910.

It will suffice here to recall a cardinal definition: A relation $ð$ between the members of a set X_p has the same structure as a relation q between the members of a set Y_q if there is a one-to-one correspondence between the elements of X_q and Y_p such that, whenever two elements of X_p are in the relation p to each other, their correlates (by the correspondence) in Y_q are in the relation q to each other, and vice versa. Modern developments of numbers and their influence on the emergence of structure, the greatly generalized concept of whole number, or integer, distinguished the higher arithmetic of the late nineteenth century from all that had preceded it.

There are six major developments in maths that greatly influenced the modern theory of numbers. They are: 1) the definition by Gauss, Kummer and Dedekind of algebraic integers; 2) the restoration of the fundamental theorem of arithmetic in algebraic number fields by Dedekind's introduction of ideals; 3) the definitive work of Galois on the solution of algebraic equations by radicals; 4) the theory of finite groups; 5) the modern theory of fields that followed; 6) the partial application of arithmetical concepts to certain linear algebras.

All of these developments are closely interrelated. The last marks the farthest extension of classical arithmetic up to 1945, and it is either the climax or the beginning of a structural arithmetization of algebra, foreseen as early as 1860 by Kronecker. As if in preparation for the climax, the algebra of hypercomplex numbers rapidly outgrew its classificatory adolescence of the 1870s and became progressively more concerned with general methods reaching a certain maturity early in the twentieth century.

The fifth major development, which logically would seem to be a necessary prelude to the others, strangely enough came last. Not until the closing years of the nineteenth century was anyone greatly perturbed about the natural numbers 1, 2, 3,.... All maths, from the classical arithmetic to Fermat, Euler, Lagrange, Legendre, Gauss and their numerous imitators, to geometry and analysis, had accepted these speciously simple numbers as "given". Without them, none of the major advances of modern arithmetic would ever have happened.

Yet no arithmetician asked, "By whom are the natural numbers 'given'? Kronecker ascribed them to God, but this was hardly a math solution. The question arose, not in arithmetic, but in analysis. It was answered by the modern definition of cardinal and ordinal numbers. This finally united arithmetic and analysis at their common source.

The sixth and last major development in the evolution of the number concept was the application of arithmetic to the differential and integral calculus. It is a point of great interest that one of the strongest initial impulses for the final application of arithmetic to analysis came from math physics. It was gradually perceived that the cardinals and ordinals 1, 2, 3, ... demanded clarification. The arithmetic of 1,2,3,..., and with it math analysis, resigned its soul to the searching mercies of math logic.

About twenty-five centuries of struggle to understand numbers thus ended where it had begun with Pythagoras. The modern programme is his, but with a difference. Pythagoras trusted 1,2,3, ... to "explain" the Universe including maths, and the spirit animating his "explanation" was strict deductive reasoning. The natural numbers are still trusted by mathematicians and scientists in their technical maths and its applications. But math reasoning itself, vastly broadened and deepened in the twentieth century beyond the utmost ever imagined by any Greek, supplanted the natural numbers in math interest.

When, if ever, math logic shall have surmounted its obscurities, the natural numbers may be clearly seen for what they "are". But there will always remain the possibility that any unsealed range may conceal a higher just beyond, and arithmeticians will come upon many things to keep them busy and incompletely satisfied for the next five thousand years. After that, perhaps, it will not matter to anyone that 1,2,3, ... "are".

From the great mass of work that has been done since 1900 on the arithmetization of algebra – or vice versa – one should mention the study of all possible types of fields and the relations between them.

The final outcome may be roughly described as an analysis of the structure of fields with respect to their possible subfields and superfields. The next item, dating from about 1920 marks a distinct advance. It is represented by a host of mathematicians who undertook to do for an abstract ring what Dedekind has done for any ring of algebraic numbers, and to extend the Galois theory to abstract fields.

Thus, the Dedekind theory of ideals was abstracted and generalized, as was also the Galois theory. The first of these may properly be assigned to arithmetic, as one of the chief objectives is the discovery, for any ring, of unique decomposition theorems analogous to the fundamental theorem of arithmetic, or to the unique representation of a Dedekind ideal as a product of prime ideals.

Two basic but rather inconspicuous-looking items of the classical theory of algebraic number ideals passed unchanged into the abstract theory, "the greatest common divisor (the GCD)" and "least common multiple (LCM)". Although at the first glance these are mere details, experience has shown that they are the framework of much algebraic structure and that, when their simplest properties are restated abstractly as postulates, the resulting system unifies widely separated and apparently distinct theories of algebra and arithmetic. They lead, in fact, to what seemed the most important theory of algebraic-arithmetic structures.

The rapid expansion of the theory of structures or *lattices* following Dedekind's introduction of dual groups is typical of much in the recent development of maths.

Structures

The generic concept of structure may be quite simply explained, as J. Diendonne did, namely: "If the temperature is 80^0 F and a 20-degree rise is predicted, we expect without counting, an eventual temperature of 100^0. If we have a book open at page 80 and we are told to look 20 pages further on, we turn without hesitation to page 100 without counting the intervening pages. We are using the fact that the structure of addition applies to both cases, adding the numbers gives the correct result when interpreted either for temperatures or for pages. We do not (fortunately!) have to learn a special arithmetic for thermometers and another for books...".

This is, of course, one of the simplest examples of structures, but it shows at once that the most striking feature of structures has something to do with *the economy of thought* and this aspect is naturally of paramount importance in maths. The structures are almost custom-made tools for mathematicians. Whenever a mathematician has been able to prove that the objects he is studying verify the axioms of a certain type of structure, he has *ipso facto* (by the fact itself) proved all the theorems from the theory of that type of structure for these particular objects (theorems which he would otherwise probably either miss altogether or for which he would have to devise special proofs).

Simularly, whenever two given structures are proved to be *isomorphic,* the number of theorems is immediately doubled, each theorem proved for one of the structures giving at once a corresponding theorem for the other (and sometimes I it is much easier to prove one than the other). No wonder, therefore, that there exist whole theories of a highly complex and difficult nature, such as the so-called "class-field theory" in the theory of numbers, whose major aim is to prove that the two structures are isomorphic.

Anyone who is familiar with the theory of groups however elementary, already knows something about the working mechanism of such structures in concrete, although he may not be explicitly aware of it. Namely, the nature of the objects or elements forming a group may vary, indeed, tremendously, but they share the same structure of group, defined by the groups themselves. If he knows, in addition, something about isomorphisms among groups, he is then even better off, since the concept of "isomorphism" is, evidently, one of those abstract notions which are closely and naturally linked to that of structure.

Generally, a structure of a certain type is defined for a set S if a relation between the elements of S is specifically defined such that a fixed set of axioms characteristic of the type of structure at issue can be verified. For example, the structure of the group (or ring, or field, etc.) belongs to a specific type, called *algebraic structures,* which in turn are characterized by the prescription for *composition,* namely, the unique relation $a \cdot b = c$ for any three elements a b c. For example, addition of numbers is a prescription in virtue of which a third number is uniquely assigned to the sum of the first two; similarly, multiplication of numbers, addition of vectors, composition of rotations, etc., exemplify algebraic structures. Some algebraic structures belong to the second type, called *structures of order;* for example, the set of real numbers is ordered, since one of any two distinct real numbers is greater than the other.

Then again, there is the third type, called *topological structures* (or *topologies).* A topology is given on a set if a concept of neighbourhood or limit which satisfied certain conditions (also called axioms) is adopted for the set in a suitable manner. It yields, therefore, an abstract formulation of the more or less intuitive notion of neighbourhood (or limit of continuity) to which we were originally led by our physical sense of space.

The degree of abstraction necessary for the formulation of the axioms of a topology is evidently greater than that for algebraic or order structures; but this may be considered still simple or less sophisticated in comparison with certain structures which are found strung-together, namely, *mixed* (or *multiple)* structures. For example, a structure may be both algebraic and topological, linked together by new axioms, topological algebra and algebraic topology are two specific examples of such a mixed structure (although homological algebra is still unmixed, exemplifying a pure type of structure).

The mixed structure may appear also in elementary cases; for instance, the set of real numbers reveals three kinds of structures at the same time: an algebraic structure defined by computative operations (addition and multiplication), a structure of order by which inequalities between real numbers can be treated, and, finally, a topological structure where a concept of limit is explicated. These structures are obviously associated with each other so that topology may be defined by order or relations (two inequalities added term by term, etc. may exist between order and algebra). Several other structures appear strung-together, more likely at the level of advanced examples such as topological groups, differential manifolds, analytic fibre spaces, discontinuous groups of transformations, etc.

These structures, pure or mixed, are now found everywhere at the concentric centre of the math universe. A considerable diversity can be observed among the great types of structures, some of which may be called *mother structures,* namely, the most general structures with the smallest number of axioms, while there are also those which are obtainable by adding more axioms such that they will yield the harvest of new consequences. Here appear, thus, *a hierarchy of structures,* descending from the simple and general at the top to the complex and particular at the bottom.

Farther along, at the lowest of the structural totem pole, one finally descends upon the ground of the particular and individual where certain areas have long remained or will for some time remain indeterminate, structure-wise, such that the "classical" maths begins to emerge. For example, certain fragments from the theory of numbers, of functions of a real or complex variable, of differential equations, of differential geometry, etc.

Nevertheless, after the extensive reconstructions even the hard-core areas cannot but fail to retain their former autonomy; they have become crossroads, where several more general structures meet and react upon each other. For example, the redoubtable theory of primes is now a close neighbour of the theory of algebraic curves, and the most ancient Euclidean geometry borders on a brand-new theory of integral equations. One cannot hope to have a complete and final list of such types of structures on hand; several new ones have been discovered, and we have every reason to expect new discoveries of that kind.

Still, there are many large chunks of classical material, where the structural reconstruction by the axiomatic method has rather very slowly progressed. This means only a greater challenge, or a new area to bulldoze through, revealing new types of structures which will introduce new fusions among theories. And these breakthroughs will, in turn, mean another substantial progress in the direction of pregnant abstraction, simplification and unification, the process of which will be adapted time and again as long as maths will go on growing.

APPENDIX III

GREEK ALPHABET

A	α	*alpha*	*альфа*	N	ν	*nu*	*ні (ню)*
B	β	*beta*	*бета*	Ξ	ξ	*xi*	*ксі*
Γ	γ	*gamma*	*гама*	O	o	*omikron*	*омікрон*
Δ	δ	*delta*	*дельта*	Π	π	*pi*	*пі*
E	ε	*epsilon*	*іпсилон*	P	ρ	*rho*	*ро*
Z	ς	*(d)zeta*	*дзета*	Σ	σ	*sigma*	*сигма*
H	η	*eta*	*ета*	T	τ	*tau*	*тау*
Θ	θ	*theta*	*тета*	Z	υ	*upsilon*	*іпсилон*
I	ι	*iota*	*йота*	Φ	φ	*phi*	*фі*
K	κ	*kappa*	*капа*	X	χ	*chi*	*хі*
Λ	λ	*lambda*	*лямбда*	Ψ	ψ	*psi*	*псі*
M	μ	*mu*	*мі (мю)*	Ω	ω	*omega*	*омега*

Nouns of Latin and Greek Origin

Singular	*Plural*	*Singular*	*Plural*
	a) -on (-um) → -a [ə]		
continuum *континуум*	continua	maximum *максимум*	maxima
criterion *критерій*	criteria	medium *середовище*	media
curriculum *навчальний план*	curricula	minimum *мінімум*	minima
datum *задана величина*	data	momentum *кількість руху*	momenta
equilibrium *рівновага*	equilibria	phenomenon *явище*	phenomena
infinitum *нескінченність*	infinita	polyhedron *багатогранник*	polyhedra
latus rectum *фокальний параметр*	latera recta	quantum *квант*	quanta
symposium *симпозіум*	symposia	vacuum *вакуум*	vacua

spectrum	spectra	stratum	strata
спектр		*шар*	

b) -is [is], -ix [iks] → -es [i:z]

analysis	analyses	emphasis	emphases
аналіз		*емфаза*	
axis	axes	hypothesis	hypotheses
вісь		*гіпотеза*	
basis	bases	index	indices
базис		*покажчик*	
crisis	crises	matrix	matrices
криза		*матриця*	
directrix	directrices	parenthesis	parentheses
директриса		*дужка*	
vertex	vertices	phasis	phases
вершина		*фаза*	
thesis	theses	synthesis	syntheses
тезис, дисертація		*синтез*	

c) -us [əs] → -i [ai]

calculus	calculi	modulus	moduli
числення, математичний аналіз		*модуль*	
focus	foci	nucleus	nuclei
фокус		*ядро*	
genius	genii	radius	radii
геній		*радіус*	
locus	loci	rhombus	rhombi
геометричне місце точок		*ромб*	

d) Similar Forms

an apparatus	apparatus	a means	means
апарат, прилад		*засіб*	
a headquarters	headquarters	a series	series
штаб		*ряд*	
news	news	a species	species
новина		*вид*	

e) -a [ə] → -ae [i:]

abscissa *абсциса*	abscissae
hyperbola *гіпербола*	hyperbolae
formula *формула*	formulae
corona *корона*	coronae
lacuna *пустота*	lacunae
nebula *туманність*	nebulae

Modern Forms

abscissas	crilerions
formulas	hyperbolas
geniuses	indices
radiuses	terminuses
mediums	nucleuses
indexes	spectrums
rhombuses	vacuums
lacunas	maximums

Mathematical Symbols and Signs

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та природокористування

$+$	plus
$-$	minus
$\pm$	plus or minus
$\times$	multiplication sign
$\bullet$	point (1.5 – one point five)
$:$	division sign; ratio sign
$=$	sign of equality (equals, (is) equal to)
$\neq$	(is) not equal to
$\sim$	difference
$\approx$	approximately equal; approaches
$>$	greater than
$<$	less than
$\geq$	equal or greater than
$\leq$	equal or less than
∞	infinity
$\sqrt{\ }$	the square root (out) of
$\sqrt[3]{\ }$	the cube root (out) of
$\sqrt[n]{\ }$	the n-th root (out) of

$[\ ]$	brackets, square brackets *(pl)*
$(\ )$	parentheses, round brackets *(pl)*
$\{\ \}$	braces *(pl)*
$\varnothing$	empty set
$\rightarrow$	tends to, corresponds to
$\in \quad \subseteq$	belongs to
$\subset$	is contained in
$\not\subset$	is not contained in
$\int$	integral of
$\int_b^a$	integral between limits a and b
$\int_m^n$	integral from n to m
$\overline{A}$	A barred
$\overline{a}$	a vector; the mean value of a
$\tilde{a}$	a tilded
a^*	a star
a'	a prime
a''	a double prime
b_1	b sub, b first
x_m	x sub m, x m-th
x^n	x to the power n
N_v'	N sub v prime
lim	limit (of)
$\lim\limits_{v \to \infty}$	the limit as v becomes infinite
max	maximum
$\max\limits_{x \in k}$	maximum over x belongs to k
min	minimum

$\min\limits_{y \in Lf}$	minimum over y belongs to L of f
Z	the first derivative of Z
f	function
$f(x)$, $\varphi(x)$	function of x
Δx	increment of x
$\sum$	summation
$\sum\limits_{X \in S}$	the sum from x belongs to S
$\sum\limits_{i=0}^{r}$	the sum from i equals 0 to i equals r
dx	differential of x
dy/dx	the first derivative of y with respect to x, dy over dx
d^2y/dx^2	the second derivative of y with respect to x
y/x	the first derivative of y with respect to x
$R(s)$	R of s
$V = 1, 2, \ldots$	(where) V is equal to 1, 2 and so on
$i = 0, 1, \ldots, r$	(where) i runs from zero to r
Δ	Laplacian
$C \cup D$	union of sets C and D
$C \cap D$	intersection of sets C and D
$B \subset A$	B is a subset of A
$\nabla f(x)$	gradient of the function $f(x)$
$\lvert a \rvert$	modulus of a

$$K = \max_{i} \sum_{j=1}^{n} \left| a_{ij}(s) \right| \quad (s \in [a, b]; \; i = 1, 2, \ldots, n)$$

K is equal to the maximum over i of the sum from j equals one to j equals n of the modulus of a_{ij} of s, where s lies in the closed interval ab and where i runs from one to n.

Wording Mathematical Formulae

$$\frac{a+b}{a-b} = \frac{c+d}{c-d},$$

a plus b over a minus b is equal to c plus d over c minus d.

$$a^3 = \log_c d,$$

a cubed is equal to the logarithm of d to the base c.

$$\varphi(z) = b\left[\left(+ \frac{z}{c_m}\right)^{m/(m-1)} - 1\right],$$

a) φ of z is equal to b, square brackets, parenthesis, z divided by c sub m plus 2, close parenthesis, to the power m over m minus 1, minus 1, close square brackets;
b) φ of z is equal to b multiplied by the whole quantity: the quantity two plus z over c sub m, to the power m over m minus 1, minus 1.

$$\left|\varphi_j(t_1) - \varphi_j(t_2)\right| \leq \left| M\left(t_1 - \frac{\beta}{t}\right) - M\left(t_2 - \frac{\beta}{t}\right)\right|,$$

the absolute value of the quantity φ sub j of t one, minus φ sub j of t two, is less than or equal to the absolute value of the quantity M of t_1 minus β over j, minus M of t_2 minus β over j.

$$k = \max_{j} \sum_{i=}^{n} \left| a_{ji}(t) \right| \quad (t \in [a, b]; \; j = 1, 2, \ldots, n),$$

k is equal to the maximum over j of the sum from i equals one to i equals n of the modulus of a_{ji} of t, where t lies in the closed interval ab and where j runs from one to n.

$$\lim_{n\to\infty}\int_{\tau}^{t} f[s,\varphi_n(s)+\Delta_n(s)]\,ds=\int_{\tau}^{t} f[s,\varphi(s)]\,ds,$$

the limit as n becomes infinite of the integral of f of s and φ_n of s plus delta n of s, with respect to s, from τ to t, is equal to the integral of f of s and φ of s with respect to s, from τ to t.

$$\Psi_{n-r_s+1}(t)=e^{t\lambda_{q+s}}p_{n-r_s+1}$$

Ψ sub n minus r sub s plus 1 of t is equal to p sub n minus r sub s plus 1, times e to the power t times λ sub q plus s.

$$L_n^+g=(-1)^n(\overline{a_0}g)^{(n)}+(-1)^{n-1}(\overline{a_1}g)^{(n-1)}+\ldots+\overline{a_n}g,$$

L sub n adjoint of g is equal to minus 1 to the n, times the nth derivative of a sub zero conjugate times g, plus, minus one to the n minus 1, times the n minus first derivative of a sub one conjugate times g, plus … plus a sub n conjugate times g.

$$\frac{\partial F[\lambda_i(t),t]}{\partial\lambda}\lambda_i'(t)+\frac{\partial F[\lambda_i(t),t]}{\partial t}=0,$$

the partial derivative of F of lambda sub i of t and t, with respect to lambda, multiplied by lambda sub i prime of t, plus the partial derivative of F with arguments lambda sub i of t and t, with respect to t, is equal to 0.

$$\frac{d^2y}{ds^2}+[1+b(s)]y=0,$$

the second derivative of y with respect to s, plus y, times the quantity 1 plus b of s, is equal to zero.

$$f(z)=\hat{\varphi}_{mk}+O(|z|^{-1})\quad(|z|\to\infty;\quad \arg z=\gamma),$$

f of z is equal to φ sub mk hut, plus big O of one over the absolute value of z, as absolute z becomes infinite, with the argument of z equal to gamma.

$$D_{n-1}'(x)=\prod_{s=0}^{n}(1-x_s^2)^{\varepsilon-1},$$

D sub n minus 1 prime of x is equal to the product from s equal to zero to n of, parenthesis, 1 minus x sub s squared, close parenthesis, to the power … epsilon minus 1.

$$K(t, x) = \frac{1}{2\pi i} \int_{\left|\omega - \frac{1}{2}\right| = \rho} \frac{K(t, z)}{\omega - \omega(x)} d\omega ,$$

K of t and x is equal to one over two πi, times the integral of K of t and z, over ω minus ω of x, with respect to ω along curve of the modulus of ω minus one half, is equal to rho.

$$\frac{d^2 u}{dt^2} + a^4 \Delta\Delta u = 0 \quad (a > 0),$$

the second partial (derivative) of u with respect to t, plus a to the fourth power, times the Laplacian of the Laplacian of u, is equal to zero, where a is positive.

$$D_k(x) = \frac{1}{2\pi i} \int_{c-i\infty}^{c+i\infty} \xi^k(\omega) \frac{x^\omega}{\omega} d\omega \quad (c > 1),$$

D sub k of x is equal to one over two πi, times integral from c minus i infinity to c plus πi infinity of dzeta to the k of ω, x to the ω divided by ω, with respect to ω, where c is greater than 1.

Giving an Oral Presentation

Sub-skills	Functions	Recommended exponents
Introducing a presentation	Creating and introducing oneself	Good morning/afternoon. My name 's .../I am ... Let me introduce myself. Let me start by saying a few words about ...
General professional environment and routine	Presenting the title/subject	The subject of my presentation is ... The focus of my paper (academic) is ... Today I'd like to talk about... I'm going to tell you something about...
	Specifying the purpose/objective	We are here today to decide/ agree/learn about ... The purpose of the talk/ presentation is ... The talk /presentation is designed to ...
	Signposting the presentation	My presentation will be in ... parts. First/ Firstly/ First of all, I'll give you .... Second/secondly/Next/Then, ... Lastly/finally last of all.... I've divided my presentation into ... parts/sections. They are ... . I'll be developing ... main points. The first point will .... Second . … Lastly ... .
Sequencing and linking ideas	Sequencing / ordering	Firstly ... , secondly ... , thirdly ... . Then ... next... finally/lastly ... Let's start with ... Let's move /go onto ... Now we come to ... That brings us to ... Let's leave that... That covers ... Let's go back to ... Let me turn now to ...
	Giving reasons/causes	Therefore So, As a result, Consequently. That's why ... This is because of ... This is largely due to … It could lead to ... It may result in ...

Sub-skills	Functions	Recommended exponents
	Contrasting	But On the other hand. … Although ... . In spite of this, ... However, ...
	Comparing	Similarly, In the same way,
	Contradicting	In fact, Actually,
	Highlighting	… in particular, … especially
	Digressing	By the way, In passing,
	Giving examples	For example, For instance, Such as A good example of this is … To illustrate this point, ...
	Generalising	Usually Generally As a rule
Involving the audience	Asking rhetorical questions	What's the explanation for this? How can we explain this? How can we do about it? How will this affect ... ? What are the implications for … ?
	Referring to the audience	As I'm sure you Know /we'd all agree … We have all experienced ... You may remember ...
Describing and analysing performance[17]	Describing performance to date	The ... performed well/poorly. The .. has/have shown considerable/slight growth/improvement/decrease...
	Analysing performance	The main explanation for this is ... A particular/one/another reason is … A key problem is ...

[17] This is a sample specification for one type of presentation. Other types, e.g. product presentation, marketing presentation, etc., would need a different specification.

Sub-skills	Functions	Recommended exponents
	Describing trends, charts and graphs	There is/has been a slight/dramatic/considerable/significant/ moderate decrease/fall/drop/collapse/rise/increase in … … . remain(s)/has remained constant/stable … … has/have decreased/increased/fallen/risen dramatically/considerably/slightly/moderately
Using visual aids	Preparing the audience for a visual	Now, let's look at the position of... Now, I'll show you the ... For … the situation is very different. Let's move on now and took at ... The next slide shows ... If we now turn to the ... This chart compares ... and ... The (upper) part of the slide gives information about … You can see here the ... I'd like to draw your attention to ...
	Focusing the audience's attention	You can see the ... As you can see ... What is interesting/important is ... I'd like to draw your attention to ... Notice/Observe the ... It is important/interesting to notice that …
Ending a presentation	Summarising	To sum up... In brief... In short.... I'd like to sum up now … … I'll briefly summarise the main issues. Let me summarise briefly what I've said. if I can just sum up the main points. At this stage I'd /like to run through /to go over. Let's recap, shall we?
	Concluding	In conclusion, ... To conclude, ... As you can see, there are some very good reasons ... I'd like to leave you with the following thought/idea.

Sub-skills	Functions	Recommended exponents
	Recommendin g	My/our suggestion/proposal/recommendation would be/is to ... We recommend/I'd like to suggest/I propose setting up....
	Closing formalities	I'd be happy to answer any questions. If you have any questions, I'd be pleased to answer them. I would welcome any comments/suggestions. Thank you for your attention.
Handling questions	Clarifying questions	So, what you are asking is ... If I understand the question correctly, you would like to know … When you say ... do you mean ...? I'm sorry, I didn't hear. Which slide was it? Sorry, could you repeat that? I'm not sure what you're getting at.
	Avoiding giving an answer	Perhaps we could deal with that later. Can we talk about that another time? I'm afraid that's not my field. I don't have the figures with me. I'm sure Mr X could answer that question. That's interesting, but I'd prefer not to answer that today. I'm afraid I'm not the right person to answer that. Could we leave that till later? I'm not sure this is the right place/time to discuss this particular question.
	Checking the questioner is satisfied	May we go on? Does that answer your question? Is that clear?

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CONTENTS

Навчальне видання

Воловик Лариса Олександрівна
Махаринець Світлана Степанівна
Красовська Антоніна Миколаївна

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