МИНИСТЕРСТВО ОБРАЗОВАНИЯ И НАУКИ РОССИЙСКОЙ ФЕДЕРАЦИИ
ФЕДЕРАЛЬНОЕ АГЕНТСТВО ПО ОБРАЗОВАНИЮ
Государственное образовательное учреждение
высшего профессионального образования
«Оренбургский государственный университет»

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ПРОФЕССИОНАЛЬНО-ОРИЕНТИРОВАННОЕ ОБУЧЕНИЕ АНГЛИЙСКОМУ ЯЗЫКУ БУДУЩИХ ИНЖЕНЕРОВ-ЭЛЕКТРИКОВ

Рекомендовано Ученым советом государственного образовательного учреждения высшего профессионального образования «Оренбургский государственный университет» в качестве учебного пособия для студентов, обучающихся по программам высшего профессионального образования по естественнонаучным и инженерно-техническим специальностям

Оренбург 2008

УДК 802. 0 (075.8)
ББК 81.2 Англ-973
М 69

Рецензент
доктор педагогических наук, профессор Н.С. Сахарова

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М 69 **Профессионально-ориентированное обучение английскому языку будущих инженеров: учебное пособие / Н.В.Михайлова. - Оренбург: ГОУ ОГУ, 2008. -119 с.**

ISBN

Данное пособие предназначено для студентов I-II курсов всех специальностей электроэнергетического факультета. Цель пособия – профессионально направленное обучение иностранному языку на основе использования современных методов и средств обучения.

М $\frac{4602020}{6Л8-08}$ ББК 81.2 Англ-923

ISBN

Содержание

Введение

В современных условиях иноязычное общение становится существенным компонентом будущей профессиональной деятельности специалиста, в связи с этим значительно возрастает роль дисциплины «Иностранный язык» на неязыковых факультетах вузов. Государственный образовательный стандарт высшего профессионального образования требует учета профессиональной специфики при изучении иностранного языка, его нацеленности на реализацию задач будущей профессиональной деятельности выпускников. Кроме того, сегодня свободное владение иностранным языком является одной из составляющих инженерной компетентности специалиста. Об этом свидетельствуют требования, обозначенные в документах Ассоциаций и Федераций инженеров и инженерных обществ, в стандартах национальных инженерных советов. Среди требований к компетенциям профессиональных инженеров можно выделить следующие, наиболее существенные и общие для различных моделей (американская, болонская и т.д.) инженеров:

- анализ инженерных задач;
- организация и оценка инженерной деятельности;
- коммуникация;
- индивидуальная и командная работа;
- свободное владение европейскими языками;
- обучение в течение всей жизни.

В связи с этим, особую актуальность приобретает профессионально-ориентированный подход к обучению иностранного языка на неязыковых факультетах вузов, который предусматривает формирование у студентов способности иноязычного общения в конкретных профессиональных, деловых, научных сферах и ситуациях с учетом особенностей профессионального мышления.

В условиях современных общественно-экономических отношений, профессиональной мобильности мы не можем не учитывать вышеизложенное при обучение профессионально-ориентированному иностранному языку в рамках высшего профессионального образования. Обучение иностранному языку не должно сводиться лишь к изучению специальной лексики, к чтению и переводу научно-технической литературы. Такое традиционное понимание, к сожалению, сохранялось долгие годы.

В настоящее время будущему инженеру в ситуациях международного общения необходимо быть готовым к решению профессиональных задач, уметь работать индивидуально и как член команды, знать и использовать методы эффективной коммуникации, т.е. обладать тем набором личностно-профессиональных качеств, которые необходимы ему для дальнейшей работы.

Перед преподавателем иностранного языка, готовящим будущего профессионала, должны стоять такие задачи как:

-формирование навыков критического мышления;

-развитие способностей к оценочным суждениям;

-подготовка к успешной работе в команде;

-развитие способности анализировать предстоящие ситуации общения и выбирать оптимальные средства, стиль и форму общения;

-развитие умения ставить, исследовать и анализировать инженерные задачи;

-обеспечения творческого подхода к деятельности.

Прекрасным средством для решения вышеуказанных задач, на наш взгляд, является использование современных ИКТ. Интернет, например, является не только источником современных аутентичных материалов, учебных сайтов, что само по себе уже ценно. На основе широкого применения новых информационных технологий, компьютерных, в первую очередь, становится возможным реализация таких новых методов обучения как:

- обучение в сотрудничестве;
- метод проектов;
- разноуровневое обучение;
- «Портфель ученика»;
- смешанное обучение.

Именно новые информационные технологии позволяют в полной мере раскрыть педагогические, дидактические функции этих методов, реализовать заложенные в них потенциальные возможности.

В данном пособии предлагается ряд современных научно-технических текстов как узкопрофильного, так и общетехнического характера. На основе таких текстов студенты могут ознакомиться с последними достижениями науки и техники, изучить исторические аспекты явлений и реалии профессии инженера-электрика. Для развития коммуникативных навыков в сфере профессионального общения в пособии даны разнообразные языковые и речевые упражнения, направленные на активизацию общеупотребительной и специальной лексики.

Особенностью данного пособия является то, что в нем делается акцент на:

1) использовании ИТ в процессе выполнения предложенных заданий во время аудиторной и внеаудиторной работы;

2) использовании новых методов обучения на основе ИТ;

3) развитие как личностных, так и профессионально значимых качеств будущих инженеров, необходимых им для осуществления профессиональной деятельности в условиях международного общения, а так же для реализации себя как успешного профессионала соответствующего международным требованиям.

1 Part 1. Topic "Choosing a Profession"

1.1 Jobs

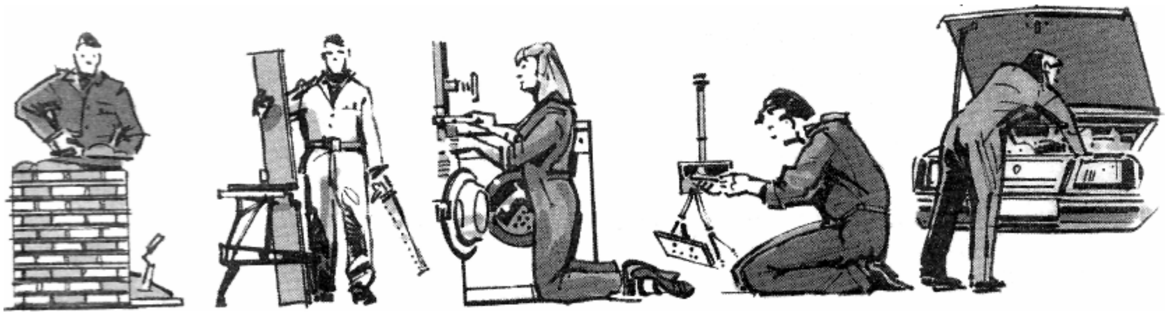
The medical profession

These people treat (= give medical treatment and try to solve a medical problem) and look after (= care for / take care of) others: doctor, nurse, surgeon (= a specialist doctor who works in a hospital and operates on people), dentist, and vet (= animal doctor). The word 'vet' is a short form for 'veterinary surgeon'.

Manual jobs

These are jobs where you work with your hands, and all the examples below are skilledjobs (= they need a lot of training).

1.1.1 Do you know how to pronounce these professions in English?



1.1.2 Find the pronunciation of the following words in the dictionary

bricklayer carpenter plumber electrician mechanic

1.1.3 What do we call someone who

1) builds walls
2) makes things using wood
3) fits and repairs water pipes, bathrooms, etc
4) fits and repairs electrical things
5) repairs cars

1.1.4 Professional people

Job	*Definition*
architect	designs buildings
lawyer	represents people with legal problems
engineer	plans the building of roads, bridges, machines, etc.
accountant	controls the financial situation of people and companies
university lecturer	teaches in a university
broker (stock market)	buys and sells stocks and shares

1.1.5 The armed forces and the emergency services
soldier (in the army)
sailor (in the navy)
pilot (in the air force)
police officer (in the police force)
firefighter (in the fire brigade)

1.1.6 Exercises

1.1.6.1 Write down at least one job from the opposite page that would probably be impossible for these people

1 Someone who didn't go to university.
2 Someone with very bad eyesight (= cannot see very well).
3 Someone who is always seasick on a boat.
4 Someone who understands nothing about cars.
5 Someone who will not work in the evening or at weekends.
6 Someone who is afraid of dogs.
7 Someone who is afraid of heights and high places.
8 Someone who is terrible at numbers and figures.
9 Someone who can't stand the sight of blood.
10 Someone who is a pacifist, who is anti-war.

1.1.6.2 Complete these definitions

An architect…………………………………………………...
A university lecturer ....
An accountant ....
A vet.. ....
A lawyer ....
An engineer ....
A bricklayer...
A stock broker ....
A mechanic..
A surgeon ....

1.1.6.3 Respond to the statements below, as in the example.

Example: A: He's a policeman.
B: **Really? When did he join the police force?**

1 A: He's a soldier.
B: ....?
2 A: He's a sailor.
B: ....?
3 A: He's a fighter pilot.

B: ....?
4 A: He's a firefighter.
B:……………………………………?

1.1.6.4 You have just bought a piece of land and you are planning to build a house on it. Write down at least six people from the opposite page that you may need to help you. What would you need their help for?

Example: a bricklayer to build the walls

1.1.6.5 Write a list of friends, relatives and neighbours (just choose people who have jobs). Can you write down what each person does? Use a bilingual dictionary to help you if necessary

Example: My uncle Jim is an engineer. His wife is an accountant.

1.2 The Career Ladder

A Getting a job

When Paul left school he applied for (= wrote an official request for) a job in the accounts department of a local engineering company. They gave him a job as a trainee (= a very junior person in a company). He didn't earn very much but they gave him a lot of training (= organized help and advice with learning the job), and sent him on training courses.

Note: Training is an uncountable noun, so you cannot say 'a training'. You can only talk about training (in general), or a training course (if you want to refer to just one). Here you can use the verbs do or go on: I did / went on several training courses last year.

B Moving up

Paul worked hard at the company and his prospects (= future possibilities in the job) looked good. After his first year he got a good pay rise (= more money), and after two years he was promoted (= given a higher position with more money and responsibility). After six years he was in charge of (= responsible for / the boss of) the accounts department with five other employees (= workers in the company) under him (= under his responsibility/authority).

C Leaving the company

By the time Paul was 30, however, he decided he wanted a fresh challenge (= a new exciting situation). He was keen to work abroad, so he resigned from his company (= officially told the company he was leaving his job; you can also say 'he quit the company') and started looking for a new job with a bigger company. After a couple of months he managed to find a job with an international company which involved (= included) a lot of foreign travel. He was very excited about the new job and at first he really enjoyed the travelling, but ...

D Hard times

After about six months, Paul started to dislike the constant moving around, and after a year he hated it; he hated living in hotels, and he never really made any friends in the new company. Unfortunately his work was not satisfactory either and finally he was sacked (= told to leave the company / dismissed / given the sack) a year later.

After that, Paul found things much more difficult. He was unemployed (= out of work / without a job) for over a year. He had to sell his car and move out of his new house. Things were looking bad and in the end Paul had to accept a part-time job (= working only some of the day or some of the week) on a fruit and vegetable stall in a market.

1.2.1 Exercises

1.2.1.1 Write a single word synonym for each of these words/phrases

given the sack =.....................
out of work = ...
left the company = ...
was given a better position in the company =..........
future possibilities in a job = ...
stopped working for ever =................
workers in a company = ...

1.2.1.2 Find the logical answer on the right for each of the questions on the left

1Why did they sack him?	a Because he was nearly 65.
2Why did they promote him?	b Because he was late for work every day.
3Why did he apply for the job?	c Because he needed more training.
4Why did he retire?	d Because he was out of work.
5Why did he resign?	e Because he was the best person in the department.
6Why did he go on the course?	f Because he didn't like his boss.

1.2.1.3 Complete these sentences with a suitable word or phrase

1 I don't want a full-time job. I'd prefer to work …………..
2 She'd like to go on another training ……………
3 I'm bored in my job. I need a fresh
4 He works on a stall in the ……………
5 At the end of this year we should get a good pay ……………..

6 She's got more than a hundred workers under ……………..
7 I didn't know he was the new manager. When did he take ……………?
8 It's a boring job and the pay is awful. Why did he ………………...?

1.2.1.4 Complete this word-building table. Use a dictionary to help you

Verb	*General noun*	*Personal noun(s)*
promote	…………….	-
employ	…………….	……………
resign	... …………….	-
retire	…………….	-
train	…………….	……………

1.2.1.5 Have you got a job in a company? If so, answer these questions as quickly as you can

1 What does your job involve?
2 Are you responsible for anything or anyone?
3 Have you had much training from the company?
4 Have the company sent you on any training courses?
5 Have you been promoted since you started in the company?
6 Do you normally get a good pay rise at the end of each year?
7 How do you feel about your future prospects in the company?
8 Are you happy in the job or do you feel it is time for a fresh challenge in another company?

If possible, ask another person the same questions

1.2.1.6 Check up your knowledge

1. We can't ... with their low prices; we'll have to sell the shop.
a) compete c) concur
b) fight d) conflict

2. His company has given Fred the ...! They say he doesn't work hard enough.
a) dismissal c) bag
b) unemployment d) sack

3. I don't have the ... to be a salesperson.
a) skills c) courses
b) qualified d) study

4. I don't particulary like working ... but I need the money.
a) overtime c) extra time
b) supplementary time d) double time

5. I know I'm not a computer expert, but I did take a ... in working with various types of software.

a) course c) lesson
b) study d) curriculum

6. I'd like a job with plenty of ... .

a) chances c) chance
b) opportunities d) possibility

7. In order to promote our products we've hired a ... advertising firm.

a) main c) top-rate
b) leading d) forefront

8. It was hard ... , but it was worth it.

a) work c) industry
b) effort d) labour

9. You've been drifting from one job to another for years now. What you need is a ... job.

a) firm c) regular
b) steady d) continuous

10. Working with handicapped children is not a job, it's a ... .

a) inspiration c) post
b) vocation d) career

1.3 Work: duties, conditions and pay

What do you do?

People may ask you about your job. They can ask and you can answer in different ways:

What do you do? I'm (+ job) e.g. a banker / an engineer / a teacher / a builder
What's your job? I work in (+ place or general area) e.g. a bank / marketing
What do you do for a living? I work for (+ name of company) e.g. Union Bank

Note: 'Work' is usually an uncountable noun, so you cannot say 'a work'. If you want to use the indefinite article you must say 'a job', e.g. She hasn't got a job at the moment.

What does that involve? (= What do you do in your job?)

When people ask you to explain your work/job, they may want to know your main **responsibilities** (= your duties / what you have to do), or something about your daily **routine** (= what you do every day/week). They can ask like this: **What does that** (i.e. your job) **involve?**

Main responsibilities

I'm **in charge of** (= **responsible for**) all deliveries out of the factory.

I have to **deal with** any complaints (= take all necessary action if there are complaints).

I **run** the coffee bar and restaurant in the museum (= I am in control of it /1 manage it).

Note: We often use **responsible for / in charge of** for part of something, e.g. a department or some of the workers; and **run** for control of all of something, e.g. a company or a shop.

Daily duties/routines

I have to **go to / attend** *(fml)* a lot of **meetings**.

I visit/see/meet **clients** (= people I do business with or for).

I **advise** clients (= give them help and my opinion).

It involves **doing** quite a lot of **paperwork** (a general word we use for routine work that involves paper e.g. writing letters, filling in forms, etc.). Note the **-ing** form after **involve**.

Pay

Most workers are **paid** (= receive money) every month and this pay goes directly into their bank account. It is called a **salary**. We can express the same idea using the verb **to earn**:

My **salary** is $60,000 a year. (= I **earn** $60,000 a year.)

With many jobs you get (= receive) **holiday pay** and **sick pay** (when you are ill). If you want to ask about holidays, you can say:

How **much holiday** do you get? *or* How **many weeks' holiday** do you get?

The total amount of money you receive in a year is called your **income**. This could be your salary from one job, or the salary from two different jobs you have. And on this income you have to **pay** part to the government - called **income tax**.

Working hours

For many people in Britain, these are 8.30-9.00 a.m. to 5.00-5.30 p.m. Consequently people often talk about a **nine-to-five job** (= regular working hours). Some people have **flexi-time** (= they can start an hour or so earlier or finish later); and some have to **do shiftwork** (= working at different times, e.g. days one week and nights the next week). Some people also **work overtime** (= work extra hours). Some people are paid to **do/work overtime**, others are not paid.

1.3.1 Exercises

1.3.1.1 Match the verbs on the left with the nouns or phrases on the right. Use each word once only

earn	overtime

work	meetings
pay	a shop
go to	clients
deal with	£500
run	income tax

1.3.1.2 Starting with the words you are given, rewrite each of these sentences using vocabulary of the topic. The basic meaning must stay the same

Example: I'm a banker.

I work *...in banking*.................

1. What do you do?

What's……………………………..

2. I earn $50,000 dollars.

My ....

3. I get £20,000 from my teaching job and another £10,000 from writing. My total ……………………………………..

4. I am a chemist.

I work for...

5. In my job I have to look after and maintain all the computers in the building.

My job involves ………………………

6. I'm responsible for one of the smaller departments.

I'm in ………………………………

1.3.1.3 This is part of a conversation with a teacher about her job. Can you supply the missing questions?

A: ....?

B: I usually start at nine and finish at four.

A: .... ………?

B: Yes a bit. On certain courses I work until five o'clock, and then I get paid extra.

A: ....?

B: Twelve weeks. That's one of the good things about being a teacher.

A: ....?

B: No we don't, I'm afraid. That's one of the disadvantages of being a teacher. But I suppose money isn't everything.

1.3.1.4 Can you answer these general knowledge questions about work?

1) What are normal working hours for most office jobs in your country?

2) Can you name three jobs that get very high salaries in your country?

3) When you start paying income tax in your country, what is the minimum amount you have to pay?

4) What jobs often involve shiftwork? (Give at least two examples.)

5) Is flexi-time common in your company or your country?

1.3.1.5 Think about your own job. How many of the things on the opposite page do you do? How is your work different? Can you explain your responsibilities and daily duties in English?

1.3.1.6 Check up your knowledge. Translate from Russian into English

1) Чем вы занимаетесь?- Я работаю в области маркетинга.

2) В чем заключается твоя работа?- Я отвечаю за поставку продуктов нашей компании заказчикам.

3) Кто занимается жалобами наших клиентов? Пожалуйста, примите все необходимые меры, чтобы решить проблемы.

4) Я рад за Боба. Слышал, что его повысили, и он теперь управляет крупным рестораном в Бостоне.

5) Моя работа предполагает регулярное посещение собраний и встречи с клиентами.

6) Ты работаешь секретарем? Наверное, тебе приходиться выполнять много бумажной работы.

7) Многим рабочим платят ежемесячно, и эти выплаты поступают прямо на их счет.

8) - Сколько вы платите своим служащим?

- В нашей компании самые высокие заработные платы.
- Вы оплачиваете отпуск и больничные?
- Да, конечно.
- Сколько дней в отпуске?
- 28 рабочих дней.

9) Я считаю разумным, что люди с большим доходом должны выплачивать больший подоходный налог.

10) Обычно я начинаю работать в 9 и заканчиваю в 5. Но иногда мне приходиться работать сверх нормы. Эти часы оплачиваются.

1.4 Naturally Speaking “Job Interview”

1.4.1 These are the most common questions asked in a normal interview with some ideas of how to prepare an answer. Study the table

Tell me about yourself.	This does not mean "Give me your life story". It's your chance to give an overall impression of who you are. Research the company to get an idea of the skills and experience they're looking for, work those into your response. Make sure you concentrate on who you are, your work experience, and relate everything to show that you would be a great candidate for the position.
What were your main responsibilities in your last job?	Be specific and positive about what you did in your current / previous job. Try to relate them to the job you are being interviewed for.
What is your biggest accomplishment?	Give an example that relates to the job you are interviewing for.
What are your greatest strengths / weaknesses?	Your ability to work well under pressure, prioritizing skills, problem-solving skills, professional expertise, leadership skills, team spirit. Be prepared to give real life examples. Be honest about a specific weakness, but show what you are doing to overcome it.
Why do you want to work for this company?	Be positive. Research the organisation and relate what they offer to your long-term ambitions.
Why do you want to leavel your current job? **Or** **Why did you leave your last job?**	***Never*** say anything bad about your previous employers. Think about leaving for a positive reason.
When can you start?	Straight away. I need to give *x* weeks notice.
Do you have any questions.	Yes. Prepare several questions before the interview. You could ask about career / development / training opportunities. Be sure to ask when they'll make their decision.

1.4.2 Dramatize the dialogue “John has a job interview for a Saturday job”

Interviewer: So, you've applied for the Saturday position, right?

John: Yes, I have.

Interviewer: Can you tell me what made you reply to our advertisement?

John: Well, I was looking for a part-time job to help me through college. And I think that I'd be really good at this kind of work.

Interviewer: Do you know exactly what you would be doing as a shop assistant?

John: Well I imagine I would be helping customers, keeping a check on the supplies in the store, and preparing the shop for business.

Interviewer: That about covers it, you would also be responsible for keeping the front of the store tidy. What sort of student do you regard yourself as . . . did you enjoy studying while you were at school?

John: I suppose I'm a reasonable student. I passed all my exams and I enjoy studying subjects that interest me.

Interviewer: Have you any previous work experience?

John: Yes. I worked part-time at a take-away in the summer holidays.

Interviewer: Now, do you have any questions you'd like to ask me about the position?

John: Yes. Could you tell me what hours I'd have to work?

Interviewer: We open at 9.00, but you would be expected to arrive at 8.30 and we close at 6.00 pm. You would be able to leave then. I think I have asked you everything I wanted to. Thank you for coming along to the interview.

John: Thank you. When will I know if I have been successful?

Interviewer: We'll be making our decision next Monday, we'll give you a call.

1.4.3 Make up your own dialogue using all the words and expressions you have learnt

1.5 Topic "Men motivated by co-worker salaries" (Listening)

1.5.1 Warm-ups

1.5.1.1 Walk around the class and talk to other students about salaries and wages. Change partners often. After you finish, sit with your original partner(s) and share what you found out

1.5.1.2 In pairs / groups, decide which of these topics or words from the article are most interesting and which are most boring

motivation / colleagues / pay packets / peers / rewards / brains / rivals / individual success / the workplace / productivity / jealousy / harmony

Have a chat about the topics you liked. Change topics and partners frequently

1.5.1.3 Have the following fun 2-minute debates. Students A strongly believe in the first argument, students B the second. Change pairs often

a) Workers should get rises every year. **Vs.** Only if they work very well.
b) Millionaire CEOs get paid too much. **Vs.** Worth every penny.
c) A country's leader should get millions. **Vs.** Public duty is sufficient reward.
d) A 15% pay rise is way too much. **Vs.** A 50% pay rise is much better.
e) Teachers and nurses get paid too little. **Vs.** But they don't make anything.
f) Merit-based rises are better than length of service rises. **Vs.** No way.

1.5.1.4 With your partner(s), talk about whether you would be motivated by these things in your workplace. Rate them from 10 (= major motivation) to 1 (= couldn't care less)

money
being better than your colleagues
pleasing your boss
impressing someone you want to date
reaching company targets
breaking departmental records
promotion
making a name for yourself in the company

1.5.1.5 Spend one minute writing down all of the different words you associate with the word 'rewards'. Share your words with your partner(s) and talk about them. Together, put the words into different categories

1.5.1.6 Student A is the leader of a country. His/her salary is $100,000 a year; Student B is a company CEO. His/her salary is $1,000,000 a year. Is this fair? Role play their conversation. Change partners often. Change partners again and talk about your roles and conversations

1.5.2 Before reading/listening

1.5.2.1 Look at the article's headline and guess whether these sentences are true (T) or false (F)

a) A new survey found men want to help their colleagues earn more. T / F
b) Traditionally, men have never really been interested in pay. T / F
c) The survey was conducted on 38,000 male workers worldwide. T / F
d) Scientific tests focused on the "reward centre" in the men's brain. T / F
e) The scientists now want to do the same tests on women. T / F
f) The survey findings point to clear, new methods to motivate staff. T / F
g) Adopting this research into the workplace may not be so good. T / F
h) A CEO said trying to keep balanced was a real harmony act. T / F

1.5.2.2 Match the following synonyms from the article

motivated	assess
colleagues	productive
peers	effect
perform	income
rivals	equals
gauge	driven
earnings	nasty
impact	carry out
sour	coworkers
efficient	competitors

1.5.2.3 Match the following phrases from the article (sometimes more than one combination is possible)

1) New research shows that men are not	a) under the microscope
2) men were only interested in the size	b) peers are getting
3) concerned about how much their	c) on how well they did
4) Researchers put 38 male volunteers	d) if rivalries turn sour
5) they received payments depending	e) of their pay packets
6) gauge whether they too are motivated	f) competitiveness to offices
7) Sales staff have long	g) by their peers' earnings
8) find ways of bringing a sense of	h) just motivated by money
9) a negative impact in the workplace	i) act
10) It's a balancing	j) been in competition

1.5.3 While reading/listening

1.5.3.1 Put the words into the gaps in the text

New research shows that men are not __________ motivated by money, but also by how much more or less they __________ than their colleagues. Traditional thinking was that men were only interested in the size of their pay packets. New __________ from a study at the University of Bonn reveal that men are also concerned about how much their peers are __________. The research is published in this month's edition of the journal Science. Researchers put 38 male volunteers __________ the microscope. The men had to perform simple tasks so that scientists could analyze the __________ in the "reward centre" in their brain. They played a game in which they received payments __________ on how well they did. They were also told how much money the other men were getting. The researchers discovered a lot more brain activity with the men who knew they were __________ their rivals.

activity
earn
getting
depending
just
beating
under
findings

Lead scientist Dr Bernd Weber said he now wants to __________ a similar study on women. He wants to __________ whether they too are motivated by their peers' earnings and not just individual success. It is not yet clear how the new findings will __________ the workplace. There is a possibility that worker productivity could increase with the introduction of a system that __________ competition. Sales staff have __________ been in competition with each other to win bonuses. Human resource officers may now look at this research to find ways of bringing a __________ of competitiveness to offices and perhaps schools. However, this may have a negative impact in the workplace if rivalries __________ sour with jealousy. One company CEO, Jackie Baxter said: "It's a balancing __________ between keeping harmony in the office and encouraging workers to be more efficient."

sense
created
gauge
act
turn
conduct
affect
long

1.5.3.2 Listen and fill in the spaces

New research shows that men ______________________ money, but also by how much more or less they earn than their colleagues. Traditional thinking ______________________ interested in the size of their pay packets. New findings from a study at the University of Bonn reveal that men are also concerned ______________________ peers are getting. The research is published in this month's edition of the journal Science. Researchers put 38 male ______________________. The men had to perform simple tasks so that scientists could analyze the activity in the "reward centre" in their brain. They played a game in which they received payments ______________________ they did. They were also told how much money the other men were getting. The researchers discovered a lot more brain activity ______________________ were beating their rivals.

Lead scientist Dr Bernd Weber said ______________________ similar study on women. He wants ______________________ motivated by their peers' earnings and not just individual success. It is not yet clear how the new findings will affect the workplace. There is a possibility that worker productivity could increase ______________________ system that created competition. Sales staff have long been in competition with each other to win bonuses. Human resource officers ______________________ to find ways of bringing a sense of competitiveness to offices and perhaps schools. However, ____________________________ in the workplace if rivalries turn sour with jealousy. One company CEO, Jackie Baxter said: "It's a ______________________________ harmony in the office and encouraging workers to be more efficient."

1.5.4 After reading/listening

1.5.4.1 Look in your dictionaries / computer to find collocates, other meanings, information, synonyms … for the words 'pay' and 'packet'

pay	packet

a) Share your findings with your partners

b) Make questions using the words you found

c) Ask your partner / group your questions

1.5.4.2 Look back at the article and write down some questions you would like to ask the class about the text

1.5.4.3 Share your questions with other classmates / groups. Ask your partner / group your questions

1.5.4.4 In pairs / groups, compare your answers to this exercise. Check your answers. Talk about the words from the activity. Were they new, interesting, worth learning…?

1.5.4.5 Circle any words you do not understand. In groups, pool unknown words and use dictionaries to find their meanings

1.5.4.6 Look at the words below. With your partner, try to recall exactly how these were used in the text

not just	conduct
size	individual
peers	sales
microscope	impact
depending	sour
rivals	act

1.5.5 Student salary survey

1.5.5.1 Write five GOOD questions about salaries in the table. Do this in pairs. Each student must write the questions on his / her own paper

1.5.5.2 When you have finished, interview other students. Write down their answers

	STUDENT 1 _______________	STUDENT 2 _______________	STUDENT 3 _______________
Q.1.			
Q.2.			
Q.3.			
Q.4.			
Q.5.			

1.5.5.3 Now return to your original partner and share and talk about what you found out. Change partners often

1.5.5.4 Make mini-presentations to other groups on your findings

1.5.6 Discussion

Student A's questions (Do not show these to student B)

a) What did you think when you read the headline?
b) What motivates you in the workplace?
c) How much of a motivating factor is money for you?
d) Do you care about how much your colleagues are getting?
e) How often do you think about the size of your pay packet and wish it was bigger?
f) What other things concern you about your peers or colleagues?
g) What does the reward centre in your brain like?
h) How important is it for you to beat your rivals?
i) What things are much more important in life than money?

Student B's questions (Do not show these to student A)

a) Did you like reading this article?
b) Do you think men and women look at money differently?
c) Which sex is more competitive, men or women?
d) Do you think knowledge of colleagues' salaries would increase productivity in the workplace?
e) What would the introduction of competition in offices, hospitals and

schools do to working relationships?

f) Would rivalries and jealousies increase efficiency?

g) How do managers balance keeping workers happy with their salaries and working conditions while increasing productivity?

h) What questions would you like to ask Dr Bernd Weber?

i) Did you like this discussion?

1.5.7 Put the correct words from a–d below in the article

New research shows that men are not (1) ____ motivated by money, but also by how much more or less they (2) ____ than their colleagues. Traditional thinking was that men were only interested in the size of their pay packets. New findings from a study at the University of Bonn reveal (3) ____ men are also concerned about how much their (4) ____ are getting. The research is published in this month's edition of the journal Science. Researchers put 38 male volunteers (5) ____ the microscope. The men had to perform simple tasks so that scientists could analyze the activity in the "reward centre" in their brain. They played a game in which they received payments depending on how well they did. They were also told how much money the other men were getting. The researchers discovered a lot more brain activity with the men who knew they were (6) ____ their rivals.

Lead scientist Dr Bernd Weber said he now wants to conduct a similar study (7) ____ women. He wants to gauge whether they too are motivated (8) ____ their peers' earnings and not just individual success. It is not yet clear how the new findings will affect the workplace. There is a possibility that worker productivity could increase with the introduction of a system that created competition. Sales staff have (9) ____ been in competition with each other to win bonuses. Human resource officers may now look at this research to find ways of bringing a (10) ____ of competitiveness to offices and perhaps schools. However, this may have a negative impact in the workplace if rivalries (11) ____ sour with jealousy. One company CEO, Jackie Baxter said: "It's a balancing (12) ____ between keeping harmony in the office and encouraging workers to be more efficient."

1)	(a)	gist	(b)	justice	(c)	just	(d)	jest
2)	(a)	earn	(b)	earnings	(c)	earning	(d)	earns
3)	(a)	much	(b)	though	(c)	what	(d)	that
4)	(a)	peers	(b)	pears	(c)	pairs	(d)	pores
5)	(a)	under	(b)	in	(c)	through	(d)	as
6)	(a)	beaten	(b)	beat	(c)	beating	(d)	beatings
7)	(a)	to	(b)	on	(c)	of	(d)	in
8)	(a)	with	(b)	for	(c)	of	(d)	by
9)	(a)	long	(b)	wide	(c)	high	(d)	deep
10)	(a)	sensory	(b)	sensation	(c)	sense	(d)	sensational
11)	(a)	come	(b)	mix	(c)	flow	(d)	turn

12) (a) action (b) act (c) actor (d) acting

1.5.8 Write about salaries for 10 minutes. Correct your partner's paper

1.5.9 Homework

1.5.9.1 Choose several of the words from the text. Use a dictionary or Google's search field (or another search engine) to build up more associations / collocations of each word

1.5.9.2 Search the Internet and find more information about the "reward centre" in the brain. Talk about what you discover with your partner(s) in the next lesson

1.5.9.3 Make a poster about average pay in different countries for different jobs and professions. Show your poster to your classmates in the next lesson. Did you all include similar things?

1.5.9.4 a) Write a magazine article about how people's pay should be worked out according to the jobs they do – how much should a nurse or a president get? Include imaginary interviews with a nurse and a president

b) Read what you wrote to your classmates in the next lesson. Write down new words and expressions

1.5.9.5 Write a letter to the boss of your company. Give him/her three reasons why you should get a pay rise. Make three promises on what you'll do from now to deserve your pay rise. Read your letter to your partner(s) in your next lesson. Your partner(s) will answer your questions

2 Part 2. Topic «A Century of Plastics»

2.1 Warm-ups

2.1.1 Answer the following questions

1) What do we call the "Plastic Age"?
2) Name the products made of plastics. What advantages do they have?

2.1.2 Pronounce the following words

polymer synthetic polymerization organic fiber plasticity bakelite cellophane cellulose acetate acrylics polystyrene Celsius

2.1.3 Vocabulary box

to bond   to mold   malleable   repetitive motion   recycling

2.2 Read for information

Text «A Century of Plastics»

The 19th Century saw enormous advances in polymer chemistry. However, it required the insights of chemical engineers during the 20th Century to make mass produced polymers a viable economic reality. When a plastic called Bakelite was introduced in 1908 it launched the "Plastic Age." Bakelite was engineered into many products from electric plugs, to hairbrushes, to radios, clocks, and even jewelry. The bakelite products from this era are now highly collectible! Today, plastics are found in almost every product. It's difficult to find many machines that do not incorporate several types of plastic.

What Are Plastics?

Plastics are polymers: long chains of atoms bonded to one another. Plastic is a term that actually covers a very broad range of synthetic or semi-synthetic polymerization products. They are composed of organic condensation or addition polymers and may contain other substances to make them better suited for an application with variances in heat tolerance, how hard it is, color, and flexibility. Plastics can be molded or formed into particular hard shapes, or be developed as a films or fibers. At some stage in its manufacture, every plastic is capable of flowing. The word plastic is derived from the fact that many forms are malleable, having the property of plasticity. Engineers often turn to a plastic as component parts in many products because it is lightweight, relatively inexpensive, and durable. It has reduced the cost of many products, and many products would not exist today without plastic.

Plastics Engineers

The development of plastics launched a new field of work: Plastics Engineers! They study the properties of polymer materials, and develop machines that can shape plastic parts. They explore ways to mold plastics to meet the needs of other engineers who need parts, such as cell phone covers, soles of shoes, and backpack wheels. They also work to improve the performance of plastics, looking for new materials that react better to high or low temperature or repetitive motion.

Short Timeline

1907: the first plastic based on a synthetic polymer -- Bakelite -- was created by Leo Hendrik Baekeland. Bakelite was the first plastic invented that held its shape after being heated.

1908: Cellophane was discovered by Swiss chemist Jacques Brandenberger.

1920's: Cellulose acetate, acrylics (Lucite & Plexiglas), and polystyrene are produced.

1957: General Electric develops polycarbonate plastics.

1968: Consumption of man-made fibers tops natural fibers in U.S.

1987: Nipon Zeon develops plastic with "memory" so that it can be bent and twisted at low temperatures, but when heated above 37 Celsius it bounces right back to its original shape!

1990's: Plastics recycling programs are common, offering new use for old plastics.

2.2.1 Discuss the following questions in small groups

1) What are plastics?
2) What do plastics engineers do?
3) Why do engineers often use plastics?

2.3 Text «Pre-Plastic History of Everyday Objects»

Toothbrush

The earliest known toothbrush was a "chew stick" made of chewed or mashed twigs. This style of dental hygiene dates back thousands of years. More recently, toothbrushes were manufactured with bone handles with the bristles or hair of pigs wound together using wire. This style was popular from as early as the 1600's well into the mid 1800's, though the handle was sometimes made of wood. The next major design change was prompted by the introduction of Nylon. This synthetic material was first applied to the toothbrush around 1938. By 1939 engineers began to develop electric toothbrushes to improve the effectiveness of brushing. The first real electric toothbrush was developed in Switzerland in 1939. In the United States, Squibb introduced an electric toothbrush in 1960, followed by General Electric introducing a rechargeable cordless toothbrush in 1961. A rotary action electric toothbrush was introduced by Interplak in 1987. Even dental floss, which originally was made of silk threads wasn't popularized until the advent of plastics and synthetic materials.

Pen

For the first three thousand years since paper was invention of paper, the writing instrument most people used was a quill of a bird -- usually a goose -- which was dipped in a well of ink. Mass-produced steel pen points began to appear in the early 1800s, which provided more control over the line. During World War I, pens began to be made of a hard, usually black, rubber substance knows as vulcanite. Early colored plastics were introduced in the 1920's. Sheaffer introduced pens made from celluloid in different colors. These were very expensive, but proved so popular that within a few years most fountain pen manufacturers were offering pens in the new synthetic material, replacing some metal and wood designs. However, it was the widespread use of plastics and the engineering of the non-leaky ball point pen that brought the cost of fine writing instruments down and within reach of most people. By the 1960s, disposable, ball point pens took over, and while fountain pens remain available, they have only a very small share of the market today.

Eyeglasses

Eyeglasses were originally crafted of metal and glass. If someone required a particularly strong prescription, however, the glass would be very heavy resting on the nose. Plastics revolutionized glasses, by replacing the glass lens with lighter weight material, and replacing most of the metal in the frames with lighter, colorful, plastics. There is still metal in the frame however, as most hinges are still made of metal. And, of course, there would be no contact lenses without the development of synthetic materials.

2.3.1 Exercises

2.3.1.1 Plastic Hunt!

As a team think about items you can find in your home, classroom, or on the playground. Can you identify any items that have no component parts made of plastic?

Kitchen Items	**Bathroom Items**	**Classroom Items**	**Sports Equipment**

2.3.1.2 Questions

1. Was it harder than you thought to find products that contained no plastic?
2. Of the products you found with no plastic, what did they have in common?
3. If you were reengineering one of the products you found, would you change any of the component parts to plastic? Why? Why not?
4. Do you think CDs would be possible without plastics? Why? Why not?
5. Why is recycling important?

2.3.1.4 You Be the Engineer

Step One: As a team, come up with a list of four machines or products that you think would be impossible without the invention of plastics. For each, answer the questions below

	What % of product is plastic?	**Why would this be impossible without plastic?**	**How has this machine or product impacted the world?**

1-			
2-			
3-			
4-			

Step Two: Your challenge is to work as a team of "engineers" to replace some of the plastic in any of the four products or machines you identified in the first part of this worksheet to make them easier to recycle. Discuss what materials you will use instead, how it will impact performance, price, or aesthetics. Then present your ideas to the class including the following:

• describe what your product does, and the percentage of it you think is plastic.

• explain which components you will replace with other materials, describe how you selected the replacement materials and how the new materials will impact weight, cost, and functionality of the product.

• predict whether this product will be as effective as the current design, whether it might cost more to manufacture, and how it would be easier to recycle.

• describe how your team believes that the engineering of plastics into common products has impacted the world.

2.4 Topic “Recycling” (Reading)

2.4.1 Science Corner

Recycling is the reprocessing of old materials into new products, with the aims of preventing the waste of potentially useful materials, reducing the consumption of fresh raw materials, reducing energy usage, reducing air (from **incineration**) and water (from **landfilling**) pollution by reducing the need for "conventional" waste disposal, and lowering greenhouse gas emissions as compared to **virgin production**. Recycling is a key concept of modern waste management and is the third component of the "Reduce, Reuse, Recycle" waste hierarchy, though colloquial usage of "recycling" can also include "reuse".

"Recyclable materials" or **"recyclables",** may originate from home, business or industry. They include glass, paper, metal, textiles and plastics. Though analogus, the composting of **biodegradable** waste—such as food or garden waste—is not typically considered recycling. These materials are either brought to a collection centre or picked-

up from the curbside; and sorted , cleaned and reprocessed into new products bound for manufacturing.
To judge the environmental benefits of recycling, the cost of this entire process must be compared to the cost of virgin extraction. In order for recycling to be economically viable, there usually must be a steady supply of recyclates and constant demand for the reprocessed goods; both of which can be stimulated through government legislation.
Meanwhile, critics claim that government mandated recycling wastes more resources than it saves. These critics claim that free market prices, and not politicians, are the most accurate way to determine whether or not any particular type of garbage should be recycled. According to these critics, whenever recycling truly does save resources, the private sector will voluntarily offer people money for their garbage.

2.4.2 Newspaper article *(from "International Herald Tribune")*

Recycling: A global work in progress

PARIS: Why recycle? It is costly, time-consuming and takes more effort than simply chucking all the waste into a single bin.
Nonetheless, over the last two decades, recycling has become the norm in the Western world. Citizens pay higher taxes to cover the costs; municipalities enforce recycling regulations and refuse to pick up the garbage of households that do not comply.
Some people complain, but others get angry when they cannot apply what they see as eco- friendly solutions to problems like an overabundance of trash. In Britain, the 211,000 members of the Women's Institute, a respected civic group, staged a revolt last June, saving up food packaging for a week and taking it back to supermarkets around the country.
Even in France, where recycling got off to a slower start than in pioneering places like Germany and California, people have now come to accept it.
"A few years ago we had a hard time making people understand the need for recycling," said Reynald Gilleron, chief of sanitation for Paris's wealthy 16th district. "Now, given the importance that ecology and sustainable development have taken on in political life, it's become a no-brainer. There has been a collective wake-up call."
Still, there are issues.
For one thing, various cities in Europe and the United States send their sorted waste to Asia for recycling, and one major buyer ? China ? may be having second thoughts. Last month the Chinese authorities ordered an investigation into reports that Britain, which ships paper and plastic to China, had sent harmful waste to Guangdong Province.
Some Westerners, too, are troubled by the notion of sending their garbage abroad and wonder whether Asia has sufficient safeguards to recycle used materials without creating risks to health or the environment. There is also the question of what will happen when Asian manufacturing powerhouses like India and China begin to produce even a fraction of the trash produced in the West.

Skeptics question recycling's cost-benefit relationship. If it costs less to bury trash in a landfill, they say, why sort and reprocess it? Wouldn't it be better to use the savings on other environment-friendly projects?
Proponents answer that recycling helps conserve natural resources and also reduces the greenhouse gas emissions held responsible for climate change because less energy is needed to transform goods than to obtain raw materials and manufacture new products.
A deeper issue is how to create less waste. According to Gilleron, a new collective wake- up call is in order. "We need to reduce the amount of trash we make," he said. This, in turn, would cut back on the need for recycling.
As for the actual process, the International Herald Tribune decided to board garbage trucks in seven cities to see firsthand what happens once people stash their trash in a recycling bin.
What emerges is a global work in progress.

2.4.2.1 Team Work. What happens at the other end when you throw your trash into a recycling bin? IHT reporters boarded garbage trucks in seven cities to find out. Compare what happens in the other cities. Use
http://www.iht.com/indexes/special/trash/index.php

2.5 Topic «London set to ban plastic bags» (Listening)

2.5.1 Warm-ups

2.5.1.1 Walk around the class and talk to other students about plastic bags. Change partners often. After you finish, sit with your original partner(s) and share what you found out

2.5.1.2 In pairs / groups, decide which of these topics or words from the article are most interesting and which are most boring
habits / environment / shopping bags / landfill sites / environmental projects / being up in arms / bans / inconvenience / sales / convenience stores / surveys
Have a chat about the topics you liked. Change topics and partners frequently

2.5.1.3 Are there everyday things in society we should ban? Rank these things on a scale of 1 (= doesn't need banning) to 10 (= definitely needs banning). Explain your choices to your partner(s)

plastic bags	Disney goods
cars that can exceed the speed limit	cigarettes
fast food	alcohol
guns	other _______________

2.5.1.4 With your partner(s), discuss which of the things below you would miss most when shopping

plastic bags
trolleys / carts
itemized receipts
two-for-the-price-of-one special offers
cash
sales assistants

2.5.1.5 Spend one minute writing down all of the different words you associate with the word 'plastic'. Share your words with your partner(s) and talk about them. Together, put the words into different categories

2.5.1.6 Students A think plastic bags should be banned; Students B think the opposite. Change partners often

2.5.2 Before reading/listening

2.5.2.1 Look at the article's headline and guess whether these sentences are true (T) or false (F)

a) London has banned all stores from giving plastic bags to shoppers.	T / F
b) People use around 1.6 billion plastic bags in London every year.	T / F
c) It takes around 4,000 years for a plastic bag to decompose.	T / F
d) London has no ambitions to set an example with a plastic bag ban.	T / F
e) London stores are totally behind the idea of banning plastic bags.	T / F
f) Retailers do not yet have a target to reduce the number of bags.	T / F
g) Stores are worried people would buy fewer products with no bags.	T / F
h) 19.2 percent of Londoners agreed with the plastic bag ban.	T / F

2.5.2.2 Match the following synonyms from the article

habits	effect
ubiquitous	furious
estimates	serious
strain	questionnaire
determined	guesses
up in arms	annoyance
inconvenience	routines
excessive	pressure
impact	ever-present
survey	extreme

2.5.2.3 Match the following phrases from the article (sometimes more than one combination is possible)

1) banning the use of the ubiquitous	a) total ban on plastic bags
2) many of which are thrown	b) to break down
3) bags take 400 years	c) lead on this issue
4) pass the money raised	d) arms at the idea
5) determined to take an ambitious	e) away after just one use
6) Retailers are up in	f) of bags by 25 per cent
7) it would simply cause inconvenience	g) practical terms
8) reducing the environmental impact	h) plastic shopping bag
9) it's hard to see in	i) on to environmental projects
10) Londoners supported a	j) to shoppers

2.5.3 While reading/listening

2.5.3.1 Gap fill. Put the words into the gaps in the text

London may soon be changing the __________ of shoppers in the city and helping the environment by banning the __________ of the ubiquitous plastic shopping bag. Estimates are that Londoners and tourists use 1.6 billion plastic bags each year, many of which are __________ away after just one use. Shoppers may soon have to buy __________ bags in an attempt to reduce the strain on landfill sites, where the bags take 400 years to __________ down. Local authorities have asked the British government to ban __________ from giving away free plastic bags. A spokesman said stores should sell reusable bags and pass the money raised on to environmental projects.

"As a __________, we need to do far more to reduce the amount of waste we are sending to landfill and London as a city is determined to take an ambitious lead on this __________," he said.

Retailers are up in __________ at the idea and have promised to fight the government to stop the ban from going __________. The British Retail Consortium said there was no need for the ban as it would simply __________ inconvenience to shoppers. A spokesman told reporters: "We think it's __________ and misguided [because] retailers are already committed to reducing the environmental impact of bags by 25 per cent by the __________ of next year." He was worried the ban would affect sales, saying: "If somebody is going to go into a supermarket or convenience store, it's hard to __________ in practical terms, unless they have brought a bag with them, how they will be able to buy more than a few __________." A recent survey found 92 percent of Londoners supported a __________ ban on plastic bags or a tax on

break
society
use
issue
reusable
habits
retailers
thrown
see
cause
end
total
arms
items
ahead
excessive

them.

2.5.3.2 Listen and fill in the spaces

London may soon ____________________ shoppers in the city and helping the environment by banning the use of the ubiquitous plastic shopping bag. ____________________ Londoners and tourists use 1.6 billion plastic bags each year, many of which are thrown ____________________. Shoppers may soon have to buy reusable bags in an attempt to reduce the strain on landfill sites, where the bags take 400 ____________________. Local authorities have asked the British government to ban retailers from giving away free plastic bags. A spokesman said ____________________ bags and pass the money raised on to environmental projects. "As a society, we need to do far more to ____________________ waste we are sending to landfill and London as a city is determined to take an ambitious lead on this issue," he said.

Retailers ____________________ idea and have promised to fight the government to stop the ban from going ahead. The British Retail Consortium said there was ____________________ would simply cause inconvenience to shoppers. A spokesman told reporters: "We think it's excessive and misguided [because] ____________________ committed to reducing the environmental impact of bags by 25 per cent by the end of next year." He ____________________ affect sales, saying: "If somebody is going to go into a supermarket or convenience store, ____________________ practical terms, unless they have brought a bag with them, how they will be able to buy more than a few items." ____________________ 92 percent of Londoners supported a total ban on plastic bags or a tax on them.

2.5.4 After reading/listening

2.5.4.1 Word search. Look in your dictionaries / computer to find collocates, other meanings, information, synonyms … for the words 'plastic' and 'bag'

plastic	bag

b) Share your findings with your partners
c) Make questions using the words you found
d) Ask your partner / group your questions

2.5.4.2 Article questions

a) Look back at the article and write down some questions you would like to ask the class about the text
b) Share your questions with other classmates / groups

c) Ask your partner / group your questions

2.5.4.3 In pairs / groups, compare your answers to this exercise. Check your answers. Talk about the words from the activity. Were they new, interesting, worth learning…?

2.5.4.4 Vocabulary. Circle any words you do not understand. In groups, pool unknown words and use dictionaries to find their meanings

2.5.4.5 Test each other. Look at the words below. With your partner, try to recall exactly how these were used in the text

changing estimates strain pass society lead	arms cause impact worried practical tax

2.5.4.6 Student plastic bag survey

a) Write five GOOD questions about plastic bags in the table. Do this in pairs. Each student must write the questions on his / her own paper

b) When you have finished, interview other students. Write down their answers

	STUDENT 1 ______________	STUDENT 2 ______________	STUDENT 3 ______________
Q.1.			
Q.2.			
Q.3.			
Q.4.			
Q.5.			

Now return to your original partner and share and talk about what you found out. Change partners often

Make mini-presentations to other groups on your findings

2.5.5 Discussion

STUDENT A's QUESTIONS (Do not show these to student B)

a) What did you think when you read the headline?
b) What are your feelings after reading the article?
c) What do you think about plastic bags?
d) Are there too many plastic bags in your country?
e) Does your country have any campaigns to recycle plastic?
f) Do you think shops need to give plastic (or any) bags to customers?
g) Do you think our throwaway society has gone too far?
h) What do you think of the idea of selling reusable bags and giving the money to environmental projects?
i) Could you easily live without bags?

STUDENT B's QUESTIONS (Do not show these to student A)

a) Did you like reading this article?
b) Do you think retailers are right to be up in arms over this issue?
c) When was the last time you were up in arms about something?
d) Do you think no free plastic bags would inconvenience shoppers?
e) What other everyday things do you think should be banned to help protect the environment?
f) Do you think people really would buy less if there were no free plastic bags?
g) What questions would you like to ask the head of the retail organization?
h) What do you think his answers would be?
j) Did you like this discussion?

2.5.6 Language

2.5.6.1 Put the correct words from a–d below in the article

London may soon be changing the (1) ____ of shoppers in the city and helping the environment by banning the (2) ____ of the ubiquitous plastic shopping bag. Estimates are that Londoners and tourists use 1.6 billion plastic bags each year, many of (3) ____ are thrown away after just one use. Shoppers may soon have to buy reusable bags in an attempt to reduce the strain on landfill sites, where the bags take 400 years to break (4) ____. Local authorities have asked the British government to ban retailers from giving away free plastic bags. A spokesman said stores should sell reusable bags and pass the money (5) ____ on to environmental projects. "As a society, we need to do far more to reduce the amount of waste we are sending to landfill and London as a city is determined to take an ambitious (6) ____ on this issue," he said.

Retailers are up in (7) ____ at the idea and have promised to fight the government to stop the ban from going ahead. The British Retail Consortium said there was no need for the ban as it would (8) ____ cause inconvenience to shoppers. A spokesman told reporters: "We think it's excessive and misguided [because] retailers are (9) ____ committed to reducing the environmental impact of bags (10) ____ 25 per cent by the end of next year." He was worried the ban would affect sales, saying: "If somebody is going to go into a supermarket or convenience store, it's (11) ____ to see in practical terms, unless they have brought a bag with them, how they will be able to buy more than a few items." A recent survey (12) ____ 92 percent of Londoners supported a total ban on plastic bags or a tax on them.

1)	(a)	habitation	(b)	habit	(c)	habits	(d)	habitat
2)	(a)	useful	(b)	use	(c)	using	(d)	user
3)	(a)	which	(b)	whom	(c)	that	(d)	who
4)	(a)	away	(b)	out	(c)	in	(d)	down
5)	(a)	heightened	(b)	upped	(c)	increased	(d)	raised
6)	(a)	leading	(b)	leader	(c)	lead	(d)	leads
7)	(a)	legs	(b)	arms	(c)	head	(d)	feet
8)	(a)	simply	(b)	simple	(c)	simpler	(d)	simplest
9)	(a)	yet	(b)	already	(c)	as	(d)	by
10)	(a)	at	(b)	with	(c)	for	(d)	by
11)	(a)	hard	(b)	hardly	(c)	harden	(d)	hardness
12)	(a)	findings	(b)	finding	(c)	found	(d)	find

2.5.6.2 Write about plastic bags for 10 minutes. Correct your partner's paper

2.5.7 Homework

2.5.7.1 Choose several of the words from the text. Use a dictionary or Google's search field (or another search engine) to build up more associations / collocations of each word

2.5.7.2 Search the Internet and find more information about countries that have had campaigns regarding plastic bags and the environment. Talk about what you discover with your partner(s) in the next lesson

2.5.7.3 Make a poster about how plastic bags can affect the environment. Show your poster to your classmates in the next lesson. Did you all include similar things?

2.5.7.4 Write a magazine article about how plastic bags can affect the environment. Include imaginary interviews with a plastic bag manufacturer and an environmentalist
Read what you wrote to your classmates in the next lesson. Write down new words and expressions

2.5.7.5 Write a letter to the head of the British Retail Consortium. Ask him/her three questions about the plastic bag ban. Give him/her three pieces of advice on how to keep shoppers happy and keep the environment clean. Read your letter to your partner(s) in your next lesson. Your partner(s) will answer your questions

3 Part 3. Topic «Simple Machines»

3. 1 Warm-ups

3.1.1 Answer the following questions

a) What do you know about simple machines? What are their principles and uses?

b) Can you give any examples of simple machines?

3.1.2 Read the definition

“A simple machine is a device for altering the magnitude or direction of a force. The six basic types are the lever, screw, wheel and axle, pulley, wedge, inclined plane.”

lever - рычаг
wheel and axle – колесо и ось
pulley - блок
wedge - клин
inclined plane – наклонная плоскость
screw - винт

3.1.3 Do you know what these words mean? If you are not sure look them up in a dictionary

nail clipper, shovel, nutcracker, seesaw, crow-bar, elbow, tweezers, bottle opener, slide, stairs, ramp, escalator, slope, doorknob, pencil sharpener, bike, curtain rod, tow truck, mini-blind, flag pole, crane

3.1.4 Say what you think about the following statements

Simple machines are "simple" because most have only one moving part.
Machines do not reduce the amount of work for us, but they can make it easier.
"Work" is only done when something is moved.

"Work" is the product of effort and distance.

3.1.5 Optional writing activity. Write an essay or a paragraph describing three simple machines you can find in an office or classroom

3.1.6 Read for information

Vocabulary box

What is a Simple Machine?

Work is performed by applying a force over a distance. These simple machines create a greater output force than the input force; the ratio of these forces is the mechanical advantage of the machine. All six of the simple machines have been used for thousands of years, and the physics behind several of them were quantified by Archimedes. These machines can be used together to create even greater mechanical advantage, as in the case of a bicycle.

Background of inventions

Before engines and motors were invented, people had to do things like lifting heavy loads by hand. Using an animal could help, but what they really needed is some clever ways to either make work easier or faster. Ancient people invented, simple machines that would help them overcome resistive forces and allow them to do the desired work against those forces.

Ancient Egyptians

The ancient Egyptians, for example, used such inventions to help them build the pyramids. They used levers to pick up large blocks of stone. They put those blocks on rollers to move from one area to another. Then they used ramps to move the blocks up to the top of the pyramid they were building.

Ancient Romans

The ancient Romans used catapults to throw stones at their enemies. The catapult was a large lever. They used a pulley to pull down the arm of the catapult. The device was set on wheels--an advanced version of rollers--to move it from place to place.

Today

We still use those simple machines today, by themselves and as part of more complex machines.

3.2 Read the text quickly

Text «Simple Machines»

Introduction

Simple machines are "simple" because most have only one moving part. When you put simple machines together, you get a complex machine, like a **lawn mower**, a car, even an electric nose hair trimmer! Remember, a machine is any device that makes work easier. In science, "work" means making something move. It's important to know that when you use a simple machine, you're actually doing the same amount of work — it just seems easier. A simple machine reduces the amount of effort needed to move something, but you wind up moving it a greater distance to accomplish the same amount of work. So remember, there's a **trade–off** of energy when using simple machines.

What does "work" mean in science?

Simple machines all require human energy in order to function. "Work" has a special meaning in science. "Work" is only done when something is moved. For example, when you push on a wall, you actually are not doing work, because you cannot move it. Work consists of two parts. One is the amount of force (push or pull) needed to do the work. The other is the distance over which the force is applied. The formula for work is:

Work = Force X Distance

Force is the pull or the push on an object, resulting in its movement. Distance is the space the object moves. Thus, the work done is the force **exerted multiplied** by the distance moved.

When we say a machine makes it easier for us to do work, we mean that it requires less force to accomplish the same amount of work. Apart from allowing us to increase the distance over which we apply the smaller force, machines may also allow us to change the direction of an applied force. Machines do not reduce the amount of work for us, but they can make it easier.

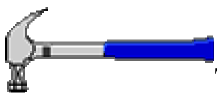
Words and expressions

lawn mower -газонокосилка
trade–off – оптимальное соотношение, обмен
exert –приводить в действие
multiply – умножать

3.3 Text «Types of Simple Machines»

There are four types of simple machines which form the basis for all mechanical machines:

- **Lever**



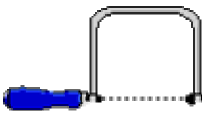
Try pulling a really stubborn weed out of the ground. Using just your bare hands, it might be difficult or even painful. With a tool, like a hand shovel, however, you should win the battle. Any tool that pries something loose is a lever. A lever is an arm that "pivots" (or turns) against a "fulcrum" (or point). Think of the claw

end of a hammer that you use to pry nails loose. It's a lever. It's a curved arm that rests against a point on a surface. As you rotate the curved arm, it pries the nail loose from the surface. And that's hard work! There are three kinds of levers:
First Class Lever - When the fulcrum lies between the force arm and the lever arm, the lever is described as a first class lever. In fact many of us are familiar with this type of lever. It is the classic teeter-totter example.
Second Class Lever - In the second class lever, the load arm lies between the fulcrum and the force arm. A good example of this type of lever is the wheelbarrow.
Third Class Lever - In this class of levers, the force arm lies between the fulcrum and the load arm. Because of this arrangement, a relatively large force is required to move the load. This is offset by the fact that it is possible to produce movement of the load over a long distance with a relatively small movement of the force arm. Think of a fishing rod!

- **Inclined Plane**

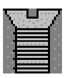
A plane is a flat surface. For example, a smooth board is a plane. Now, if the plane is lying flat on the ground, it isn't likely to help you do work. However, when that plane is inclined, or slanted, it can help you move objects across distances. And, that's work! A common inclined plane is a ramp. Lifting a heavy box onto a loading dock is much easier if you slide the box up a ramp - a simple machine.

- **Wedge**



Instead of using the smooth side of the inclined plane, you can also use the pointed edges to do other kinds of work. For example, you can use the edge to push things apart. Then, the inclined plane is a wedge. So, a wedge is actually a kind of inclined plane. An axe blade is a wedge. Think of the edge of the blade. It's the edge of a smooth slanted surface. That's a wedge!

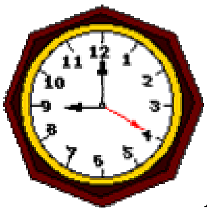
- **Screw**



Now, take an inclined plane and wrap it around a cylinder. Its sharp edge becomes another simple tool: the screw. Put a metal screw beside a ramp and it's kind of hard t o see the similarities, but the screw is actually just another kind of inclined plane.

How does the screw help you do work? Every turn of a metal screw helps you move a piece of metal through a wooden space.

- **Wheel and Axle**



A wheel is a circular disk attached to a central rod, called an axle. The steering wheel of a car is a wheel and axle. The section that we place our hands on and apply force (torque) is called the wheel, which turns the smaller axle. The screwdriver is another example of the wheel and axle. Loosening a tight screw with bare hands can be impossible. The thick handle is the wheel, and the metal shaft is the axle. The larger the handle, the less force is needed to turn the screw.

- **Pulley**

Instead of an axle, the wheel could also rotate a rope or cord. This variation of the wheel and axle is the pulley. In a pulley, a cord wraps around a wheel. As the wheel rotates, the cord moves in either direction. Now, attach a hook to the cord, and you can use the wheel's rotation to raise and lower objects. On a flagpole, for example, a rope is attached to a pulley. On the rope, there are usually two hooks. The cord rotates around the pulley and lowers the hooks where you can attach the flag. Then, rotate the cord and the flag raises high on the pole.

3.3.1 Complete the table

Simple machines	What it is	How it helps us to work	Examples
Lever			
Inclined plane			
Wheel and axle			
Pulley			

3.3.2 Match the examples of simple machine to their definitions

a teeter-totter or **seesaw**		**the nail bar**
the wheel chair ramp	**the screw**	**a fishing pole**

- is an example of a class-one lever. The balance point, or fulcrum, is somewhere between the applied force and the load. This type of lever (class one) has three parts: the balance point or fulcrum, the effort arm where the force or work is applied, and the resistance arm where the object to be moved is placed.
- is also a lever, but it is a class-two lever (if you use the right end of the nail bar shown in the picture). A class-two lever is a lever with the effort and resistance forces on the same side of the fulcrum. To pry the nail with the right end of the bar shown, the fulcrum is the tip, the nail head applies a resistive force, and at the opposite end is the effort or work. Another example of a class-two lever is a wheel barrow.
- is an inclined plane. Although the distance up the ramp is greater than the distance straight up, less force is required.
- is actually just another kind of inclined plane. It is basically an inclined plane that is wrapped around a cylinder.
- is a very good example of a third class lever. In this class of levers, the force arm lies between the fulcrum and the load arm. Because of this arrangement, a relatively large force is required to move the load. This is offset by the fact that it is possible to produce movement of the load over a long distance with a relatively small movement of the force arm. Think of a fishing rod! Because of this relationship, we often employ this class of lever when we wish to produce large movements of a small load, or to transfer relatively low speed of the force arm to high speed of the load arm. When a hockey stick or a baseball bat is swung, a third class lever is in effect. The elbow acts as a fulcrum in both cases and the hands provide the force (hence the lower arm becomes part of the lever). The load (i.e. the puck or the ball) is moved at the end of the stick or bat. Example of third class levers are: a fishing pole, a pair of tweezers, an arm lifting a weight, a pair of calipers, a person using a broom, a hockey stick, a tennis racket, a spade, or a shovel.

3.4 What is Work?

Work is the product of the force exerted on an object and the object's displacement due to that force. The formula to describe this is:

Work = Force x distance

Work is measured in joules, j (after James Prescott Joule).

Force is measured in newtons, N (after Sir Isaac Newton).

Distance is measured in meters, m.

In this equation, however, the force only counts if it is in the direction that the object is moving. As an example, consider if you lifted a heavy horse and carried the horse across a river. When you have crossed the river, the only work you have done was lifting the horse. Crossing the river while holding the horse added nothing to the amount of work you did. Keep in mind that applying force to an object doesn't always equal work being done. If you sit on your bicycle, you apply force on the seat, but no work is being done because your force on the seat is not causing displacement. But, if you applied force to the chair by lifting it up off the floor, they your force produces displacement in the direction of motion - and work has been done.

The distance an object moves is another factor to be considered when calculating work. For a ball (for example) to move a distance from its original position, requires work to be done on the ball. And, distance is directional. This means that if you move an object in a positive direction, you have done positive work. If you move it in a negative direction, you have done negative work.

3.4.1 Math in English:

Student Question A:

A 45kg girl sits on a 8 kg bench. How much work is done on the bench? Remember that work = force x distance. Hint: In this case force is 45 x 8. What is the distance? What is the work?

Student Question B:

A 40kg boy lifts a 30kg dragon 2 meters above the ground. How much work did the boy do on the dragon? Remember that work = force x distance. Hint: In this case force is 40 x 30. What is the distance? What is the work?

3.4.2 Jumping Coin Experiment

Purpose:

To find out where to push on a lever to get the best lift.

Materials:

ruler
pencil
two large coins

Procedure:

-Put the pencil under the ruler and place a coin on one end.

-Drop another coin from a height of 30 cm so it hits the ruler at about the 8 cm mark. Notice how high the coin jumps in the air.

-Repeat the coin drop but drop it at the end of the ruler from the same height.

Observe how high the coin jumps.

Questions:

What would happen if you put an object with a larger diameter than the pencil under the ruler?

Try this experiment: Move the pencil to several different locations under the ruler, then repeat the experiment. How were your results different/the same?

3.4.3 Make Your Own Inclined Plane

Objectives:
Show that a screw is an inclined plane.
Materials:
paper
pencil
tape
crayon
Procedure:
-Give each student a paper right-triangle and have the longest side colored.
-Tape one of the uncolored sides of the triangle to the pencil.
-Wrap the triangle around the pencil and tape down.
-The triangle wraps in a spiral
Lesson Details:
Explain about incline planes and show examples of several, including how they make life easier, or reduce work.

3.5 Text «Mechanical advantage» (Reading)

A common trait runs through all forms of machinery: **mechanical advantage,** or the ratio of force output to force input. In the case of the lever mechanical advantage is high. In some machines, however, mechanical advantage is actually less than 1, meaning that the resulting force is less than the applied force.

This does not necessarily mean that the machine itself has a **flaw**; on the contrary, it can mean that the machine has a different purpose than that of a lever. One example of this is the screw: a screw with a high mechanical advantage that is, one that rewarded the user input of effort by yielding an equal or greater output would be useless. In this case, mechanical advantage could only be achieved if the screw backed out from the hole in which it had been placed, and that is clearly not the purpose of a screw.

Here a machine offers an improvement in terms of direction rather than force; likewise with scissors or a fishing rod, an improvement with regard to distance or range of motion is bought at the expense of force. In these and many more cases, mechanical advantage alone does not measure the benefit. Thus, it is important to keep in mind that a machine either increases force output, or changes the force, distance or direction of operation.

Most machines, however, work best when mechanical advantage is maximized. Yet mechanical advantage, whether in theoretical terms or real-life instances, can only go so high, because there are factors that limit it. For one thing, the operator must give some kind of input to yield an output; furthermore, in most situations friction greatly diminishes output. Hence, in the operation of a car, for instance, one-quarter of the vehicle energy is expended simply on overcoming the resistance of frictional forces.

For centuries, inventors have dreamed of creating a mechanism with an almost infinite mechanical advantage. This is the much-sought-after **perpetual** motion machine, that would only require a certain amount of initial input; after that, the machine would simply run on its own forever. As output compounded over the years, its ratio to input would become so high that the figure for mechanical advantage would approach infinity.

A number of factors, most notably the existence of friction, prevent the perpetual motion machine from becoming anything other than a pipe dream. In outer space, however, the near-absence of friction makes a perpetual motion machine viable: hence, a space probe launched from Earth can travel indefinitely unless or until it enters the gravitational field of some other body in deep space.

The concept of a perpetual motion machine, at least on Earth, is only an idealization; yet idealization does have its place in physics. Physicists discuss most concepts in terms of an idealized state. For instance, when illustrating the acceleration due to gravity experienced by a body in free fall, it is customary to treat such an event as though it were taking place under conditions divorced from reality. To consider the effects of friction, air resistance, and other factors on the body fall would create an impossibly complicated problem, yet real-world situations are just that complicated.

In light of this tendency to discuss physical processes in idealized terms, it should be noted that there are two types of mechanical advantage: theoretical and actual. Efficiency, as applied to machines in its most specific scientific sense, is the ratio of actual to theoretical mechanical advantage. This in some ways resembles the formula for mechanical advantage itself: once again, what is being measured is the relationship between output (the real behavior of the machine) and input (the planned behavior of the machine).

As with other mechanical processes, the actual mechanical advantage of a machine is a much more complicated topic than the theoretical mechanical advantage. The gulf between the two, indeed, is enormous. It would be almost impossible to address the actual behavior of machines within an environment framework that includes complexities such as friction.

Each real-world framework that is, each physical event in the real world is just a bit different from every other one, due to the many varieties of factors involved. By contrast, the idealized machines of physics problems behave exactly the same way in one imaginary situation after another, assuming outside conditions are the same. Therefore, the only form of mechanical advantage that a physicist can easily discuss is theoretical. For that reason, the term “efficiency” will henceforth be used as a loose synonym for mechanical advantage, even though the technical definition is rather different.

3.5.1 Mini-quiz to check your understanding

1. How do you lift a car up to fix a flat tire?

You lift it up with pulleys
Use a car jack, which is a form of lever
You get several friends to help you

2. What did the ancient Egyptians use to build the pyramids?
They used elephants and ramps
They used levers and bulldozers
They used levers, rollers, and ramps
3. Why isn't a perpetual motion machine possible?
Friction will slow it down
There are strict laws against them
They are possible, but only in Germany

4 Part 4. Topic «Electricity»

4.1 Warm-ups

4.1.1 Discuss the following questions

a) Can you imagine our life without electricity?
b) What benefits can we get from electricity?

4.1.2 Some students are writing their course paper. Suddenly the light went off. Read their conversation to see how they will solve this problem

Olga: Alex, I need your help badly. I'd like you to have a look at my table lamp.

Alex: What is wrong with it?

Olga: I have no idea. I was writing my coursework when suddenly the light went off. Can you repair it?

Alex: I'll try. Give me the lamp.

Olga: Well?

Alex: No wonder the light doesn't work. The **bulb** has a broken **filament.**

Olga: What do you mean?

Alex: The bulb has simply **burnt out**. All we have to do is to **turn** the burnt bulb **out of the socket** and replace it with a new bulb. Do you have one?

Olga: Unfortunately not. And my roommates are all asleep - I can't ask them. You can't lend me your own lamp, can you?

Alex: Well, yes. But it is time to sleep already. Why don't you finish the coursework in the morning?

Olga: You see, my supervisor asked me to bring it to the consultation tomorrow. He expects me to finish it.

Alex: OK. Don't sit up too late anyway. I'll ask Irene to bring you a new bulb. Don't switch on the power till you have turned it into the socket.

Olga: I won't. Thanks a lot.

4.1.3 Complete the dialogues

1) - Nick, I need you to ….

-…? It was all right ten minutes ago.

2) - I'm afraid …
- Don't worry. We'll ask somebody to ….
3) -Let's…
- Well?
- You see, ...
- What shall we do?
- .... But I'd like you to ... the power first.
- …
- I'm sure you won't forget to turn on the ... again. The light will let... your report.

4.1.4 Look up the following terms in the dictionary. Practice reading them

alteration, bulb, cell, charged elements, circuit, electrical current (direct and alternating), dielectric, filament, to transmit, transmission grid, insulator, power (thermal, nuclear, underground steam, solar, kinetic, chemical power), power plant, rectifier, socket, transformer (step-up, step-down transformers), capacitor, condenser, winding (input, output or primary and secondary winding), wire, overhead conductor wire, resistance, to glow, notions, frequency, to reverse, a flow, mica

4.1.5 Cross out the odd word. All the words in the line should belong to the same part of speech

1) complete, carry out, measurement, perform
2) wire, bulb, socket, switch off
3) winding, capacitor, frame, rectify
4) current, power, electrical, flow
5) into, out of, from, careful
5) transformer, alternate, rectifier, generator
6) voltage, insulate, frequency, resistance

4.2 Look at the title and say what information the text gives. Read the text attentively for the details

Text "Electricity Basics"

Electricity is something we do not notice until we do not have it. However, few people understand what it is and still fewer can explain it. Let us try it anyway.

So, what is electricity? Electricity is simply a movement of **charged** particles through a closed **circuit.** The electrons, which flow through this wire, carry a negative charge. A lightning discharge is the same idea, just without the **wire.**

Electricity is made by converting some form of energy into flowing electrons at the power plant. The type of power plant depends on the source of energy used: **thermal power** (coal, oil, gas, nuclear, underground steam), **solar power** (photovoltaic), **kinetic power** (water, wind) and **chemical power** (fuel cell). I

After it is made, electricity is sent into a system of cables and wires called a **transmission grid.** This system enables power plants I and end users to be connected together.

The basic notions in electricity include the following.

An **Amp** (A) is a unit measure of amount of current in a circuit. An ammeter permits the current to be measured.

The pressure that forces the current to flow is measured in **Volts** (V). A **transformer** is used to change the voltage of electricity. This allows electricity to be transmitted over long distances at high voltages, but safely used at a lower voltage.

A **Watt** (W) is a unit measure of electric power that depends on amps and volts. The more watts the bulb uses the more light is produced. Watts = Volts x Amps.

An **Ohm** (O) is a unit measure of materials resistance to a flowing current. The **filament** in this light bulb glows because its high **resistance** makes it hot. Low resistance of the support wires does not let them glow. The glass has a resistance so high that it does not allow the current to move through it - this property makes glass a good **insulator.**

There are two different kinds of **electrical current.** One is called **direct current** because electrons are made to move in one direction only. It is usually abbreviated to DC. This kind of electricity is produced by a battery.

AC Stands for **alternating current**, which is generated by power station for domestic and industrial use. The wires in the centre of the generator rotate past the North and the South poles of the magnet. This movement forces the electrons in the circuit to reverse the direction of their flow. The number of these alterations (or cycles) per second is known as frequency.

As domestic supply requires alternating current it is therefore necessary to change it to direct current inside most electrical appliances. A **rectifier** allows AC to be converted into DC.

Power stations are designed to provide electrical energy to large housing developments. This causes the necessity to transmit power from its source, the generating station, to wherever it is required for use, which maybe far away, with minimal energy losses. It is cheaper and easier to carry a very high voltage but low current, over long distances. It can be done with the help of thinner overhead conductor wires, with an air gap between them to act as an insulator.

A transformer is used to increase or decrease the voltage of an electric power supply. This is a static machine since it has no moving parts. It consists of two coils of wire that are wound around a soft iron core., The coils are called **windings**, one is the **primary, or input winding**, and the other is the **secondary, or output winding.**

When current passes through the primary winding, a magnetic field is created around the iron core, which induces a voltage in the secondary winding. If the number of turns in the secondary winding is greater than that in the primary winding it is a step-up transformer and the output voltage is greater than the input voltage. And vice versa, a step-down transformer enables the input voltage to be reduced.

A device, which allows an electrical charge to be build up and stored for some time is known as a **capacitor (or a condenser).** A simple capacitor is made from two metal plates (electrodes), which are separated by an insulator such as air, paper or mica (**the dielectric**).

4.2.1 Say if the following statements are true or false. Correct the false statements

1 There are two different kinds of electricity: AD and BC.
2 Direct current is received from a battery.
3 AC is used for domestic and industrial purposes.
4 The frequency is the number of cycles per second.
5 Conversion is brought about by means of an insulator.
6 Air is a rather good insulator.
7 High voltage is supplied by a transformer.
8 To decrease voltage a step-down, transformer should be used.
9 The function of a capacitor is to transmit electricity to electrical appliances.

4.2.2 Explain why...

a) two kinds of current exist
b) electrons change the direction of the flow in AC
c) a rectifier is necessary
d) energy is lost on the way from the power plant to the end user
e) a high voltage and low current are transmitted through the wires
f) a transformer is used
g) a transformer is known as a static machine
h) a step-up transformer permits the input voltage to be increased
i) a condenser is necessary in domestic appliances

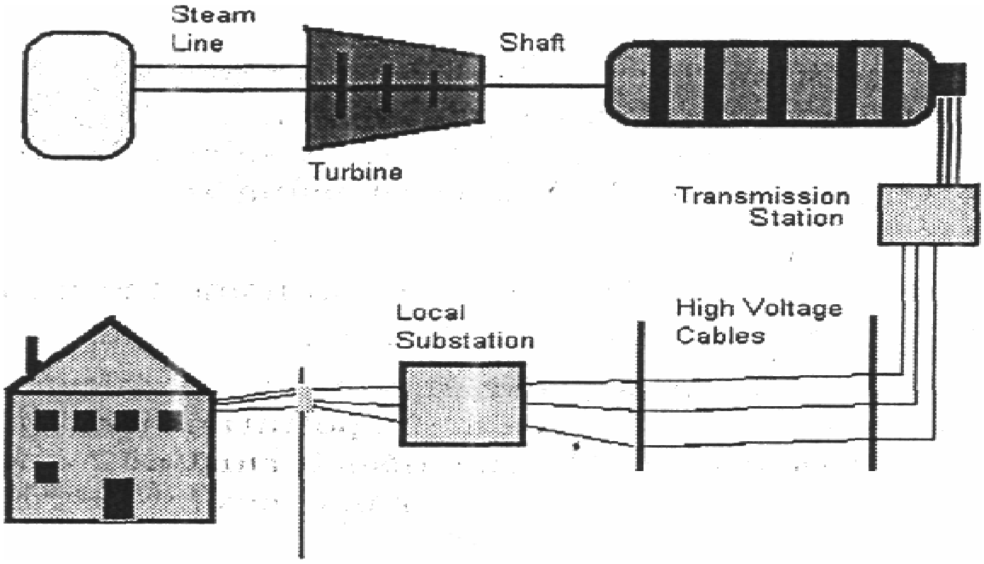
4.2.3 Give another title to the text. Render its contents in 6 simple sentences

4.3 Activity

4.3.1 Create a questionnaire on the topic 'Basic Electricity Notions' and test your classmates' knowledge

4.3.2 Describe a step-down transformer, its structure, operation and function. Use the description of a step-up transformer as a model

4.3.3 Study the picture and describe in writing how electricity is produced and then transmitted to our houses



Picture 1

4.4 You be the engineer. Read the passage and say what a simple circuit is

A simple circuit consists of three minimum elements that are required to complete a functioning electric circuit: a source of electricity (battery), a path or conductor on which electricity flows (wire) and an electrical resistor (lamp) which is any device that requires electricity to operate. The illustration below shows a simple circuit containing, one battery, two wires, and a bulb. The flow of electricity is from the high potential (+) terminal of the battery through the bulb (lighting it up), and back to the negative (-) terminal, in a continual flow.

4.4.1 The following is a schematic diagram of the simple circuit showing the electronic symbols for the battery, switch, and bulb. Ask you partner several questions on how it works

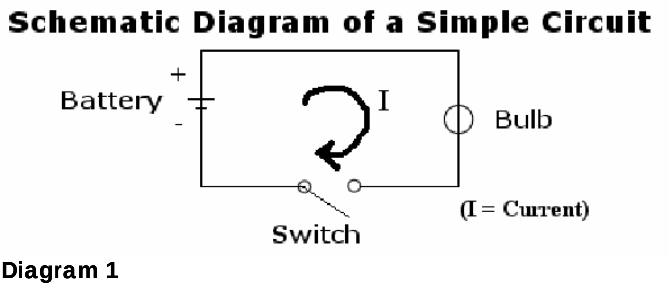
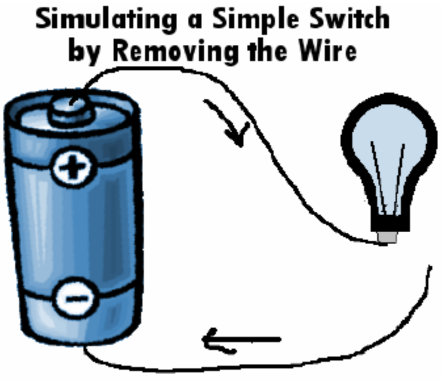
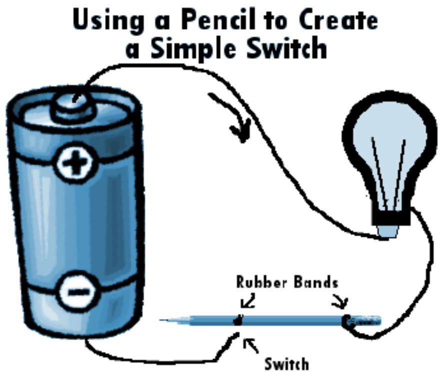


Diagram 1

4.4.2 Study the pictures, then read the passage and say how to simulate a switch in a simple circuit



Picture 1



Picture 2

There are several ways you can simulate a switch in a simple circuit. Simply removing and replacing the wire from the bulb can serve as a switch. Another simple switch can be made by attaching the end of one of the wires to the eraser end of a pencil using a rubber band. Then attach another rubber band to the other end of the pencil, and by simply laying the other end on top of - and then off of - the connecting wire, you have created a switch. Other types of conductors can also be used in switch design, such as aluminum foil, hairclips, paperclips, paper fasteners, and some metal pens.

4.5 Read the texts and match them with the following titles
1) Battery History
2) How Flashlights Work
3) The Flow of Electrons
4) How Batteries Work
5) Flashlight History

A

The first battery was demonstrated in 1800 by Count Alessandro Volta. His experiments showed that different metals in contact with each other could create electricity. He constructed a stack of discs of zinc alternating with blotting paper soaked in saltwater and silver or copper. When wires made of two different metals were attached to both the top and bottom discs, Volta was able to measure a voltage and a current. He also discovered that the higher the pile, the higher the voltage. The current is produced because of a chemical reaction arising from the different electron attracting capabilities of the two metals. This device became known as a 'voltaic pile' (the French word for 'battery' is 'pile'). Although they were large and bulky, voltaic piles provided the only practical source of electricity in the early 19th century.

B

The pile or battery remained a laboratory curiosity for years, until the newly invented telegraph and telephone created a demand for reliable electrical power. After many years of experimentation, the "dry cell" battery was invented in the 1860s for use with the telegraph. The dry cell is not completely dry, however. It holds a moist paste inside a zinc container. The interaction of the paste and the zinc creates a source of electrons. A carbon rod is inserted into the paste and conducts electrons to the outside of the cell, where wires or metal contacts carry the electrons that power the device. A single dry cell produces about 1.5 volts.

C

The carbon rod, the chemical paste, and the can react to create free electrons. The bottom terminal is called the "negative" terminal. The top terminal is called the "positive" terminal. When a circuit connects the positive and negative terminals, the free electrons at the negative terminal flow towards the positive terminal. The flow of electrons is called an electric current, but engineers define the current as moving from the positive terminal to the negative terminal, the opposite of the actual flow of electrons. This is because current was defined before scientists knew that the charge on an electron is negative. Electrons are the particles that carry the electric current. In the example to the left below, a switch connecting the battery to a bulb is in the "off" position, so the bulb is dark. On the right, the switch is in the "on" position, allowing the flow of electrons to light up the bulb.

D

In the 1890s, American Ever-Ready Company founder Conrad Hubert invented the electric hand torch. Hubert acquired the patent for the first Eveready flashlight in 1898. Hubert's first flashlights were made from paper and fiber tubes, with a bulb and a brass reflector. At the time, batteries were very weak and bulbs were still developing, so the first flashlights produced only a brief "flash" of light - which gave the invention its name.

E

There are seven main components to a flashlight:

- Case or Tube: holds all the other components of the flashlight.
- Contacts: thin spring or strip of metal usually made of copper or brass that serves as the connection between the battery, lamp, and switch.
- Switch: can be in on or off position.
- Reflector: plastic coated with a reflective aluminum layer to help brighten the light of the bulb.
- Bulb: usually very small.
- Lens: plastic cover in front of the bulb to protect the lamp which could easily be broken.

- Batteries: Provide power to the flashlight.

When the switch is in the "on" position, it connects the two contract strips which allow electrons to flow. The batteries provide power to the flashlight, and sit on top of a small spring that is connected to one of the contact strips. This contact strip runs along the length of the case and contacts the switch. Another contact strip connects the switch with the bulb. Finally, another contact connects the bulb to the top battery, completing the circuit.

4.5.1 a) Draw a schematic diagram of the circuit design for the standard flashlight in the "on" position; b) draw the schematic diagram for your improved flashlight

4.6 Read the text and get ready to discuss the main electricity concepts in detail

Electricity (from Greek ήλεκτρον (electron) "amber") is a general term for the variety of phenomena resulting from the presence and flow of electric charge. Together with magnetism, it constitutes the fundamental interaction known as electromagnetism. It includes many well-known physical phenomena such as lightning, electric fields and electric currents, and is put to use in industrial applications such as electronics and electric power.

The ancient Greeks and Parthians knew of static electricity from rubbing objects against fur.

Though Benjamin Franklin's famous "invention" of electricity by flying a kite in a thunderstorm turned out to be more fiction than fact, his theories on the relationship between lightning and static electricity sparked the interest of later scientists whose work provided the basis for modern electrical technology. Most notably these include Luigi Galvani (1737–1798), Alessandro (1745-1827), Michael Faraday (1791–1867), André-Marie Ampère (1775–1836), and Georg Simon Ohm (1789-1854). The late 19th and early 20th century produced such giants of electrical engineering as Nikola Tesla, Samuel Morse, Antonio Meucci, Thomas Edison, George Westinghouse, Werner von Siemens, Charles Steinmetz, and Alexander Graham Bell.

Electric charge is a property of certain subatomic particles (e.g., electrons and protons) which interacts with electromagnetic fields and causes attractive and repulsive forces between them. Electric charge gives rise to one of the four fundamental forces of nature, and is a conserved property of matter that can be quantified. In this sense, the phrase "quantity of electricity" is used interchangeably with the phrases "charge of electricity" and "quantity of charge." There are two types of charge: we call one kind of charge positive and the other negative. Through experimentation, we find that like-charged objects repel and opposite-charged objects attract one another. The magnitude of the force of attraction or repulsion is given by Coulomb's law.

The concept of **electric field** was introduced by Michael Faraday. The electrical field force acts between two charges, in the same way that the gravitational field force acts between two masses. However, the electric field is a little bit different. Gravitational force depends on the masses of two bodies, whereas electric force depends on the electric charges of two bodies. While gravity can only pull two masses together, the electric force can be an attractive or repulsive force. If both charges are of same sign (e.g. both positive), there will be a repulsive force between the two. If the charges are opposite, there will be an attractive force between the two bodies. The magnitude of the force varies inversely with the square of the distance between the two bodies, and is also proportional to the product of the unsigned magnitudes of the two charges.

The **electric potential** difference between two points is defined as the work done per unit charge (against electrical forces) in moving a positive point charge slowly between two points. If one of the points is taken to be a reference point with zero potential, then the electric potential at any point can be defined in terms of the work done per unit charge in moving a positive point charge from that reference point to the point at which the potential is to be determined. For isolated charges, the reference point is usually taken to be infinity. The potential is measured in volts. (1 volt = 1 joule/coulomb) The electric potential is analogous to temperature: there is a different temperature at every point in space, and the temperature gradient indicates the direction and magnitude of the driving force behind heat flow. Similarly, there is an electric potential at every point in space, and its gradient indicates the direction and magnitude of the driving force behind charge movement

An **electric current** is a flow of electric charge, and its intensity is measured in amperes. Examples of electric currents include metallic conduction, where electrons flow through a conductor or conductors such as a metal wire, and electrolysis, where ions (charged atoms) flow through liquids. The particles themselves often move quite slowly, while the electric field that drives them propagates at close to the speed of light. See electrical conduction for more information.

Devices that use charge flow principles in materials are called electronic devices.

A **direct current** (DC) is a unidirectional flow, while an **alternating current** (AC) reverses direction repeatedly. The time average of an alternating current is zero, but its energy capability (RMS value) is not zero.

Ohm's Law is an important relationship describing the behaviour of electric currents, relating them to voltage.

For historical reasons, electric current is said to flow from the most positive part of a circuit to the most negative part. The electric current thus defined is called conventional current. It is now known that, depending on the conditions, an electric current can consist of a flow of charged particles in either direction, or even in both directions at once. The positive-to-negative convention is widely used to simplify this situation. If another definition is used - for example, "electron current" - it should be explicitly stated.

Electrical energy is energy stored in an electric field or transported by an electric current. Energy is defined as the ability to do work, and electrical energy is simply one of the many types of energy. Examples of electrical energy include:

- the energy that is constantly stored in the Earth's atmosphere, and is partly released during a thunderstorm in the form of lightning
- the energy that is stored in the coils of an electrical generator in a power station, and is then transmitted by wires to the consumer; the consumer then pays for each unit of energy received
- the energy that is stored in a capacitor, and can be released to drive a current through an electrical circuit

Electric power is the rate at which electrical energy is produced or consumed, and is measured in watts (symbol is: W).

A fossil-fuel or nuclear power station converts heat to electrical energy, and the faster the station burns fuel, assuming constant efficiency of conversion, the higher its power output. The output of a power station is usually specified in megawatts (millions of watts). The electrical energy is then sent over transmission lines to reach the consumers.

Every consumer uses appliances that convert the electrical energy to other forms of energy, such as heat (in electric arc furnaces and electric heaters), light (in light bulbs and fluorescent lamps), or motion, i.e. kinetic energy (in electric motors). Like the power station, each appliance is also rated in watts, depending on the rate at which it converts electrical energy into another form. The power station must produce electrical energy at the same rate as all the connected appliances consume it.

In electrical engineering, the concepts of apparent power and reactive power are also used. Apparent power is the product of RMS voltage and RMS current, and is measured in volt-amperes (VA). Reactive power is measured in volt-amperes-reactive (VAr).

Non-nuclear electric power is categorized as either green or brown electricity.

Green power is a cleaner alternative energy source in comparison to traditional sources, and is derived from renewable energy resources that do not produce any nuclear waste; examples include energy produced from wind, water, solar, thermal, hydro, combustible renewables and waste.

Electricity from coal, oil, and natural gas is known as traditional power or "brown" electricity.

5 Part 5. Topic «Energy Problems»

5.1 Warm-ups

5.1.1 Discuss the following questions

a) What do you know about the energy crisis we are facing today?

b) What solutions can you offer?

5.1.2 Read the students' discussion and name advantages and disadvantages of alternative energy sources

Alice: Alex, I would like you to read this article. It seems to be very interesting.

Alex: Does it really? What's so special about it?

Alice: Well, you had better read it by yourself. Anyway, it appears to discuss the energy crisis **threatening** us today.

Alex: Oh, I hear something about it. We consume too much energy and **exhaust** our fossil fuel **resources** consisting of oil, coal and gas. However, technological progress cannot be stopped.

Alice: Don't worry. The solution is likely to be found anyway. Have you heard about alternative energy sources developed by the scientists all over the world?

Alex: Certainly, these **alternative sources of energy** are assumed to have many advantages, but actually they are very expensive and rather **inefficient.**

Alice: Well, the new method only needs perfection; Besides, as we are sure to **run out of** fossil fuels soon, do we have other **options**?

Alex: No, we don't. And moreover, the alternative sources of energy seem to be inexhaustible and causing no pollution.

Alice: That speaks for itself, doesn't it?

Alex: Without any doubts. OK, where is the article? I need further information.

Alice: Here it is.

5.1.3 Find the meaning and the pronunciation of the following words in the dictionary

alternative energy sources, exhaust, exhaustible, fossil fuel resources, steam, essential, available, evident, constantly, renewable, nonrenewable, to consume, consumption, shortage, polluting, pollution-free, to satisfy smb's needs, immensely, producing no waste, safe, dangerous, poisonous, dam, turbines, requirements, environment, advantage, disadvantage

5.1.4 Match the words with the opposite meaning

to accelerate	excess
adequate	pollution free
renewable	inexhaustible
polluting	to slow down
safe	unsuitable
shortage	nonrenewable
expensive	dangerous
suitable	cheap
exhaustible	inadequate

5.1.5 Find in B the derivatives from the words in A

A

- civilization, civil, sensible, unsuitable
- converter, conservation, consumption, measurement
- consumer, usable, reduction, increase
- report, comfort, ensure, shortage
- empire, powerfully, sensible, waterwheel
- consist, student, suitable, institute
- example, inexhaustible, exhibition, explanation
- plant, pursuit, production, pollution

B

to civilize
to consume
use
short
power
to suit
to exhaust
to pollute

5.1.6 Translate the following compound nouns into Russian

energy crisis prospects, steam engine, oil-equivalent, energy cost, total fuel consumption, overall energy supply

5.2 Read the text carefully for the details about the energy problems

Energy is an essential part of our civilization. A million years ago primitive man used only 6,000 (kJ) a day, which he got from the food he ate. A hundred thousand years ago people had learnt to make fire and used four times as much energy (the equivalent of 25,000 kJ). By the 15th century man using animals, windmills and waterwheels, and a little coal, was already; consuming nearly twenty times as much energy (120,000 kJ). .By 1875 the steam engine made 340,000 kJ a day available to industrial man in England. Today's technological man uses kJ a day, or one hundred and fifty times as much as primitive man, about one third in the form of electricity.

What do we need energy for? Comfort and lighter work, first of all. Energy consumed in great quantities falls into two kinds: a) energy needed every day (lighting, heating, etc.) and b) energy used to produce necessary objects (house, clothes, etc.). Take a man building a small house (10 tons of oil-equivalent), heating (3 tons of oil-equivalent) and lighting (200 kg of oil-equivalent or 700 kWh) it for a year and having a car (1.3 tons of oil-equivalent + 1.3 tons for every 12,000 km run). The energy cost of these basic things is tremendous but multiply it by 6 billion to get the real picture of man's needs. Besides, energy consumption is sure to increase since the more energy is consumed, the easier our life becomes.

The current energy problem caused by many interrelated factors must be tackled quickly. Strange as it sounds, there is no shortage of primary energy. The sun provides ten thousand times as much energy as we require today, in many forms ranging from solar radiation through wind and waves to trees and plants. The problem is to convert these resources into mechanical work or other usable forms of energy, The history of energy has been the history of converters - man's body itself converting food into warmth and mechanical work, animals doing such work more powerfully, the waterwheel, the windmill, the steam engine, the nuclear reactor and in the near future the solar cell.

5.2.1 Find answers to these questions in the text

1 Did primitive man get the energy he needed?
2 How much energy does man consume today?
3 How What does technological man do half of his life?
4 In what two ways is energy used?
5 What is the standard measurement of energy cost?
6 Does the car require much energy?
7 Why is it essential to cut energy consumption?
8 What is the primary source of energy?

5.2.2 Complete the table with the information from the article

Time	**Man**	**Years of Life**	**Energy Consumption**	**Why**

Consider food, domestic consumption, services (trade, office work, teaching, leisure), industry and agriculture, transport

5.2.3 Think over the following situations

1. What are the ways of using energy? Supply your own examples.
2. How much energy (in oil-equivalent) is necessary to build a house and light and heat it for a year?
3. What is the energy problem? Describe its causes and ways of solving it.
4. Continue the sentence: The less energy we will use, the .... Do you agree? Give reasons for your opinion.
5. What energy sources on the Earth are or have been provided by the Sun?

5.2.4 a) Does the article provide any interesting information? What is the main idea of the article? What other questions does it discuss?

b) Give a title to the article.

5.3 Read the text for detailed information about alternative sources of energy

Text "Alternative Sources of Energy"

It is not a secret that energy consumption has increased immensely in the last decades. But do we have enough fossil fuels to satisfy our needs? As fossil fuels are nonrenewable we are highly interested in developing alternative sources of energy.

Solar Power is renewable. It is used for heating houses. Solar cells and furnace make electricity from sunlight. Solar cells are expensive. Solar power isn't much use unless you live somewhere sunny. It doesn't cause pollution and doesn't need fuel.

Wind Power is renewable as well. It doesn't cause pollution, doesn't need fuel. However, a lot of generators are needed to get a sensible amount of power. It is necessary to put them where winds are reliable. And the noise can drive you nuts.

Hydroelectric Power plants are built for getting energy from flowing water. Usually we build a dam, and let the water turn turbines and generators as it goes through pipes in the dam. Renewable. No pollution, no fuel needed, no waste. Very expensive to build. Building a dam we flood a lot of land.

Waves Power. There's a lot of energy in waves on the sea. However it is not easy to get it. A wave power station needs to be able to stand really rough weather, and yet still be able to generate power from small waves. This source of energy is renewable - the waves will come whether we use them or not.

Geothermal Energy means heat from underground hot rocks. Hot water comes up and we use the heat to make steam to drive turbines, or to heat houses. It is renewable - so long as we don't take out too much, the energy keeps on coming. However, there are not many places you can do it — the rocks must be suitable. Sometimes we get poisonous gases coming up too.

"Biomass" means burning wood, dung, sugar cane or similar. It is renewable - we can always plant more trees. We burn the fuel to heat water into steam, which drives turbines, which drive generators. Burning anything we pollute the environment.

Nuclear (atomic) power stations use uranium as fuel. It is nonrenewable. Heat from the reactor turns water into steam, which drives turbines, which drive generators. It doesn't cause pollution unless something goes wrong.

5.3.1 Answer the following questions

Why do we have to develop alternative sources of energy?

What is solar energy used for?

What are the disadvantages of wind power?

What requirements should hydroelectric power stations meet?

Why can the use of geothermal energy be dangerous?

Are nuclear power plants considered safe?

5.3.2 Name the sources of energy that are ...
1) renewable
2) pollution-free
3) producing no waste
4) needing no fuel
5) safe

5.3.3 Can these sources of energy be used in your country? Give your reasons

Power Source	**Can be Used**	**Cannot be Used**
solar power		
wind power		
hydroelectric		
waves power		
geothermal		
biomass		
nuclear power		

5.4 Activity

Your country is running out of fossil fuels soon and is facing an energy crisis. Other sources of energy must be developed quickly. Divide into several groups and make presentations of some projects (consider all the factors both positive and negative), explain your choice and answer possible questions

5.5 Text "Wind Power" (Reading)

5.5.1 Search your knowledge

1. What's a wind turbine? How does it work? How is it similar to a windmill?
2. How is a wind turbine similar to an electric fan? How are they different?
3. Is wind power used widely around the world? Why or why not?
4. Can you name other sources of energy that are used by power plants to produce electricity?
5. What are the advantages and disadvantages of wind power over other sources of energy?
6. How can the disadvantages be overcome?

5.5.2 The text contains the words *blade, prototype, flexible, hinge, niche,* and *capacity.* Do you know what these words mean? If you don't, see if you can figure them out from the sentences that follow. Then, see how the words are used in the article

1. The blades of a fan, like the blades of a knife, cut through air and make the air move.

2. After the engineers successfully tested the prototype of a newly designed electric car, the managers of the company decided to go ahead with mass production of this design.

3. The Olympic gymnast was very flexible. She could bend backward so that her head touched her feet.

4. When a door squeaks, it's time to oil its hinges to make it move more smoothly.

5. a. A mouse found a niche in the side of a hill and made a nest there.

b. The little diner that serves only soup found a small but successful niche in the large restaurant market.

6. a. The gas tank in my car has a capacity of 16 gallons.

b. When the candy factory operates at full capacity, it produces 100 chocolate bars an hour.

5.5.3 Text "Wind Power for Pennies" (*Peter Fairley* from *"Technology Review")*

A Lightweight wind turbine is finally on the horizon — and it might just be the breakthrough needed to give Fuels a run for their money

The newest wind turbine standing at Rocky Flats in Colorado, the U.S. Department of Energy's **proving ground** for wind power technologies, looks much like any other apparatus for capturing energy from wind: a boxy turbine sits atop a steel tower that sprouts two propeller blades stretching a combined 40 meters — almost half the length of a football field. Wind rushes by, blades rotate, and electricity flows. But there's a key difference. This prototype has flexible, hinged blades: in strong winds, they bend back slightly while spinning. The bending is barely perceptible to a casual observer, but it's a radical departure from how existing wind turbines work — and it just may change the fate of wind power.

Indeed, the success of the prototype at Rocky Flats comes at a crucial moment in the evolution of wind power. Wind-driven generators are still a niche technology — producing less than one percent of U.S. electricity. But last year, 1,700 megawatts' worth of new wind capacity was installed in the United States — enough to power 500,000 houses — nearly doubling the nation's wind power capacity. And more is on the way. Manufacturers have reduced the cost of heavy-duty wind turbines fourfold since 1980, and these gargantuan machines are now reliable and efficient enough to be built offshore. An 80- turbine, $240 million wind farm under construction off the Danish coast will be the world's largest, and developers *are* beginning to colonize German, Dutch and British waters, too. In North America, speculators envision massive offshore wind farms near British Columbia and Nantucket, MA.

But there is still **a black cloud** hovering over this seemingly sunny scenario. Wind turbines remain expensive to build — often prohibitively so. On average, it costs about $1 million per megawatt to construct a wind turbine farm, compared to about $600,000 per megawatt for a conventional gas-fired power plant; in the economic calculations of power companies, the fact that wind is free doesn't close this gap. In short, the price of building wind power must come down if it's ever to be more than a niche technology.

And that's where the prototype at Rocky Flats comes in. The flexibility in its blades will enable the turbine to be 40 percent lighter than today's industry standard but just as capable of surviving destructive storms. And that lighter weight could mean machines that are 20 to 25 percent cheaper than today's large turbines.

Earlier efforts at lighter designs were universal failures — disabled or destroyed, some within weeks, by the wind itself. Given these failures, wind experts are understandably cautious about the latest shot at a lightweight design. But most agree that lightweight wind turbines, if they work, will change the economic equation. "The question would become, 'How do you get the transmission capacity built fast enough to keep up with growth,'" says Ward Marshall, a wind power developer at Columbus, OH-based American Electric Power who is on the board of directors of the American Wind Energy Association, a trade group. "You'd have plenty of folks willing to sign up."

And, say experts, the Rocky Flats prototype — designed by Wind Turbine of Bellevue, WA — is the best hope in years for a lightweight design that will finally succeed. "I can say pretty unequivocally that this is a dramatic step in lightweight [wind turbine] technology," says Bob Thresher, director of the National Wind Technology Center at Rocky Flats. "Nobody else has built a machine that flexible and made it work."

Steady as She Blows

Wind turbines are like giant fans run in reverse. Instead of motor-driven blades that push the air, they use airfoils that catch the wind and crank a generator that pumps out electricity. Many of today's turbines are mammoth machines with three-bladed rotors that span 80 meters — 20 meters longer than the wingspan of a Boeing 747. And therein lies the technology challenge. The enormous size is needed if commercial wind turbines are to compete economically because power production rises exponentially with blade length. But these vast structures must be **rugged** enough to endure gales and extreme turbulence.

In the 1970s and '80s, U.S. wind energy pioneers made the first serious efforts at fighting these forces with lightweight, flexible machines. Several startups installed thousands of such wind turbines; most were literally torn apart or disabled by **gusts.** Taking lightweight experimentation to the extreme, General Electric and Boeing built much larger prototypes — behemoths with 80-, 90-, and even 100-meter-long blades. These also proved prone to breakdown; in some cases their blades bent back and actually struck the towers.

All told, U.S. companies and the Department of Energy spent hundreds of millions of dollars on these failed experiments in the 1980s and early 1990s. "The American model has always gravitated toward the light and sophisticated and things that didn't work," says James Manwell, a mechanical engineer who leads the University of Massachusetts's renewable-energy research laboratory in Amherst, MA.

Into these technology doldrums sailed researchers from Denmark's Riso National Laboratory and Danish companies like Vestas Wind Systems. During the past two decades they perfected a heavy-duty version of the wind turbine — and it has become the Microsoft Windows of the wind power industry. Today, this Danish design accounts for virtually all of the electricity generated by the wind worldwide. Perhaps reflecting national inclinations, these sturdy Danish designs had tittle of the aerodynamic flash of the earlier U.S. wind turbines; they were simply braced against the wind with heavier, thicker steel and composite materials. They were tough, rugged — and they worked.

What's more, in recent years, power electronics — digital silicon switches that massage the flow of electricity from the machine — further improved the basic design. Previously, the turbine's rotor was held to a constant rate of rotation so its alternating-current output would be <u>in sync</u> with the power grid; the new devices maintain the <u>synchronization</u> white allowing the rotor to freely speed up and slow down with the wind. "If you get a gust, the rotor can accelerate instead of just sitting there and receiving the brute force of the wind," says Manwelll.

Mastering such strains enabled the Danish design to grow larger and larger. Whereas in the early 1980s a typical commercial machine had a blade span of 12.5 meters and could produce 50 kilowatts — enough for about a dozen homes — today's biggest blades stretch 80 meters and **crank out** two megawatts; a single machine can power more than 500 homes.

The newest challenge facing the Danish design is finding ways for it <u>to weather</u> the corrosive and punishing offshore environment, where months can pass before a mechanic *can* safely board and fix a turbine. Vestas, for one, is equipping its turbines with sensors on each of their components to detect **wear and tear,** and backup systems to take over in the case of, say, a failure in the power electronics. Vestas's approach goes to the test this summer, as Denmark's power supplier begins installing 80 Vestas machines in shallow water 14 to 20 kilometers off the Danish coastline. It will be the world's biggest offshore wind farm, powering as many as 150,000 Danish households.

Wind Shadows

These upgrades will make big, heavy turbines more reliable, but they don't add up to a fundamental <u>shift</u> in the economics of wind power. Nations like Denmark and Germany are prepared to pay for wind power partly because fossil fuels are so much more costly in Europe, where higher taxes cover environmental and health costs associated with burning them. (About 20 percent of Denmark's power comes from wind.) But for wind power to be truly cost competitive with fossil fuels in the United States, the technology must change.

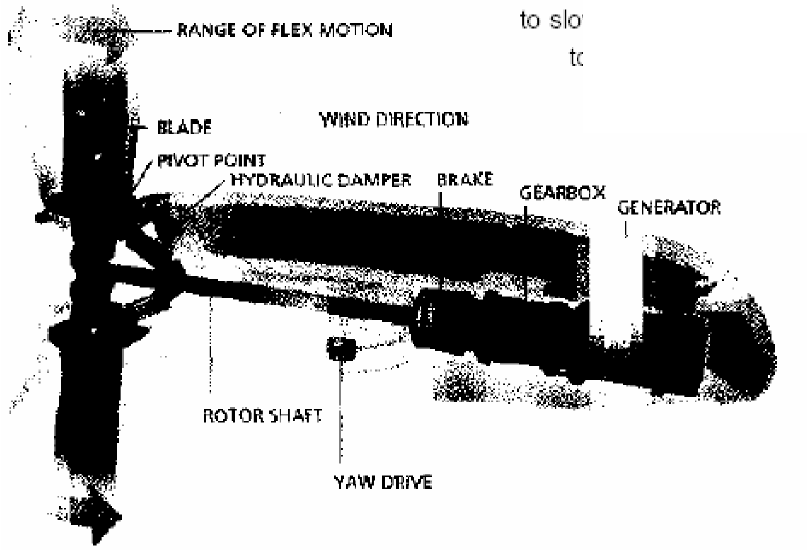
What makes Wind Turbine's Rocky Flats design such a departure is not only its hinged blades, but also their downwind orientation. The Danish design faces the blades into the wind and makes the blades heavy so they won't bend back and slam into the tower. The Wind Turbine design can't face the wind — the hinged blades would hit the tower — so the rotor is positioned downwind. Finally, it uses two blades, rather than the three in the traditional design, to further reduce weight.

A Lighter, Cheaper Turbine

Hinged blades and sophisticated control systems allow the lightweight turbine designed by Wind Turbine of Bellevue, WA, to survive storms and gusts.

In Normal Conditions: Blades spin freely, the entire turbine swivels according to wind direction, and a gearbox amplifies blade rotation speed so a generator can produce power.

In High Wind or Erratic Conditions: Hydraulic dampers allow blades to flex up to 15 degrees downwind and five degrees upwind to shed excess wind force. Control systems include a brake to slow blade spin and a yaw drive to counteract swiveling.



Advances in the computer modeling of such dangerous forces as vibration helped the design's development. Flexible blades add an extra dimension to the machine's motion; so does the fact that the whole machine can freely swivel with the wind. (Traditional designs are driven to face the wind, then locked in place.) Predicting, detecting and preventing disasters — like rapidly shifting winds that swing a rotor upwind and send its flexible blades into the tower — are control challenges even with the best design. "If you don't get that right, the machine can literally beat itself to death," says Ken Deering, Wind Turbine's vice president of engineering.

Two years ago, when Wind Turbine's prototype was erected at Rocky Flats, there were worries that this machine, too, would beat itself to death. Thresher says some of his staff feared that the machine, like its 1980s predecessors, would not long escape **the scrap heap.** Today, despite some minor setbacks, those doubts are fading.

Emboldened by its early success, Wind Turbine has installed, near Lancaster, CA, a second prototype, with a larger, 48-meter blade span. By the end of this year, the company expects to boost blade length on this machine to 60 meters — full commercial size. What's more, this new prototype has a thinner tower, aimed at reducing the noisy thump — known as a "wind shadow" — that can occur each time a blade whips through the area of turbulent air behind the tower. And with its lighter weight, the turbine can be mounted atop higher towers, reaching up to faster winds.

Becalmed

Whatever the advances in technology, however, the wind power industry still faces significant hurdles, starting with uncertain political support in the United States. In Europe, wind power is already a relatively easy sell. But in the United States, wind developers rely on federal tax credits to make a profit. These vital credits face chronic opposition from powerful oil and coat lobbies and often lapse. The wind power industry raced to plug in its turbines before these credits expired at the end of last year, then went dormant for the three months it took the U.S. Congress to renew them. Congress extended the credits through the end of next year, initiating what is likely to be yet another start-and-stop development cycle.

A second obstacle to broad adoption is the wind itself. It may be free and widely accessible, but it is also frustratingly inconsistent. Just ask any sailor. And this **fickleness** translates into intermittent power production. The more turbines get built, the more their intermittency will complicate the planning and management of large flows of power across regional and national power grids. Indeed, in west Texas, a recent boom in wind turbine construction is straining the region's transmission lines — and also producing power out of sync with local needs: wind blows during coo) nights and stalls on hot days when people most need electricity.

Texas utilities are patching the problems by expanding transmission lines. But to really capture the value of wind power on a large scale, new approaches are needed to storing wind power when it's produced and releasing it when needed. The Electric Power Research Institute, a utility-funded R&D consortium in Palo Alto, CA, is conducting research on how to make better one-day-ahead wind predictions. More important, it is exploring ways to store energy when the wind is blowing. "We need to think about operating an electrical system rather than just focusing on the wind turbines," says Chuck McGowin, manager for wind power technology at the institute. Storage facilities "would allow us to use what we have more efficiently, improve the value of it."

In the northwest United States, one storage option being developed by the Portland, OR-based Bonneville Power Administration balances wind power with hydroelectric power. The idea is simple: when the wind is blowing, don't let the water pass through the hydroelectric turbines; on calm days, open up the gates. And the Tennessee Valley Authority is even experimenting with storing energy in giant fuel cells; a pilot plant is under construction in Mississippi.

Wind power faces plenty of obstacles, but there's more reason than ever to believe these obstacles will be overcome. Worries over the environmental effects of burning fossil fuels and political concerns about an overdependence on petroleum are spurring a boom in wind turbine construction. But it is advances in technology itself, created by continued strong research efforts, that could provide the most critical impetus for increased use of wind power.

At Rocky Flats, four rows of research turbines — a total of a dozen machines ranging from 400-watt battery chargers to grid-ready 600-kilowatt machines — share a boulder-strewn 115-hectare plain. With the Rocky Mountains as a backdrop, their blades whip against the breezes blowing in from El Dorado Canyon to the west. At least, they do much of the time. "We have a lot of calm days, in the summer in particular, and for a testing site it's good to have a mix," Thresher says.

Calm days may be good for wind turbine research, but they're still among the biggest concerns haunting wind turbine commercialization. While no technology can make the wind blow, lower-cost, reliable technologies appear ready to take on its fickleness. And that could mean a wind turbine will soon sprout atop a breezy hill near you.

5.5.4 What's the Point? Show your understanding of the reading. Based on the reading, choose the best answer to complete these sentences

1. The new wind turbine being tested at Rocky Plats looks like__________.

a) a normal wind turbine
b) a football field
c) a jet airplane turbine

2. Since 1980, wind turbines have become four times__________.

a) more efficient
b) less expensive
c) smaller

3. The most important innovation of the new wind turbine is_________.

a) flexible, hinged blades that face away from the wind
b) 2 blades instead of the traditional 3
c) greater height than that of existing turbines

4. According to the article, the new turbines would cost less because of_______.

a) cheaper materials
b) lower weight
c. lower manufacturing cost

5. Early light-weight wind turbines __________.

a) were successful in Denmark
b) were used offshore
c) all failed

6. The new wind turbine prototype was designed by __________.

a) the Unites States Department of Energy
b) the National Wind Technology Center, a government agency
c) Wind Turbine, a company in Bellevue, Washington

7. Early American designs failed because they were ___________.
a) too simple
b) too high-tech
c) too expensive
8. Danish designs were successful because the wind turbines were___________.
a) supported by strong, heavy structures
b) designed using advanced aerodynamics
c) constructed from new materials
9. Two important technological advances that made modern turbine designs possible are ____________.
a) power electronics devices and computer modeling
b) computer modeling and weather forecasting
c) weather forecasting and manufacturing
10. Since the early 1980s, the power production of a single wind turbine has _____________.
a) not increased significantly
b) increased four times
c) increased 40 times
11. The new wind turbine could be installed on a higher tower than before, and could thus reach faster winds, because the tower would _____________.
a) be thicker and, therefore, stronger
b) be made of new stronger materials
c) support a lighter turbine
12. For wind power to become more widely accepted and used, it will be necessary ____________.
a) to store wind energy
b) to replace hydroelectric power plants
c) to build all wind turbines off shore

5.5.5 Complete the sentences below based on the article you just read. To complete a sentence, sometimes you may need a single word and sometimes a phrase. You may use your own words or words from the text

1. According to the chart in the article, the number of countries that are "major players" in wind power is __________.
2. An important drawback (negative side) of wind power is _____________.
3. When this article was written, the largest wind power plant was in__________.
4. Wind turbines must be very large in order to______________
5. In the United States, the most abundant and least expensive form of energy for producing electricity is ______________.
6. In Europe, fossil fuels are very costly because of ________________

7. A commercial wind-turbine machine built by Wind Turbine Company will have a combined blade length of _____________.

8. A power-plant wind turbine can produce as much power as ___________kilowatts.

5.5.6 Understanding words and phrases. Choose one of the words to fill in the blank in each sentence. You may have to change the form of the word to fit the sentence

breakthrough	intermittent	synchronization
conventional	in sync; out of sync	unequivocally
crucial	prone	universal
departure	to shift	to weather
to envision		

1. People's tastes for different kinds of food vary from culture to culture, but their pleasure in eating is _____________ .

2. Tom woke up many times during the night and felt tired the next day because of his ______________ sleep.

3. Ten years ago, a great fire destroyed most of the family's farm, but they ________________this catastrophe and are still running the farm today.

4. When Diane heard her name mentioned by her colleagues, she her attention from her work to their conversation_____________.

5. Gandhi's peaceful protest against the government of Great Britain was a ___________from the more violent rebellions against ruling regimes.

6. Katie was poor and had a difficult life, but she worked very hard and _________ a brighter future for her two children.

7. After the dog lost one of its legs in an accident, it was __________to falling down if it ran too fast.

8. Helen's office clock, wristwatch, and computer clock are all ____________, so she is never sure of the correct time.

9. For a while, the factory workers weren't sure whether or not they would lose their jobs. But, in a recent announcement, the company president stated __________ that the factory would shut down in six months and all employees would be laid off.

10. For a psychologist, the ability to listen is _____________.

11. The discovery of antibiotics was a major _______________ in treating infections.

12. For our home movie, we recorded the action on a videotape and the sound on an audiotape. When we showed the movie, we had to _____________ the two tapes to match the action with the sound.

5.5.7 The article uses several idiomatic expressions. They are defined in the text margins. Each of these phrases is used as a single unit that has a particular

meaning. Review the use of these expressions in the article. Then, select the phrase that fits best in each of the following sentences

on the horizon	a proving ground	a black cloud
wear and tear	the scrap heap	give (someone) a run for (one's) money

1. My little 40-year-old refrigerator is not ready for ___________________ yet; it still runs very well and keeps the food cold.

2. Many older people suffer from arthritis due to normal ___________________ on their joints.

3. The Olympic training camp is ________________________ for the country's best athletes. The few who succeed there will go on to compete in the Olympic Games.

4. The basketball coach said, "The other team is very strong, but we can beat them. At least, we'll ________________________________!"

5. When Laura finally began to recover from her long and dangerous illness____________________________, was lifted from her family, and they celebrated the good news.

6. Yes, their wedding is ________________________________; they'll probably be married before the end of the year.

5.6 Text "History of Electrical Engineering"

5.6.1 Read the text and get ready to speak about electrical engineering

Electrical engineering (sometimes referred to as electrical and electronic engineering) is a professional engineering discipline that deals with the study and application of electricity, electronics and electromagnetism. The field first became an **identifiable** occupation in the late nineteenth century with the commercialization of the electric telegraph and electrical **power supply**. The field now covers a range of sub-disciplines including those that deal with power, **optoelectronics**, digital electronics, **analog electronics**, artificial intelligence, control systems, electronics, signal processing and telecommunications.

The term electrical engineering may or may not **encompass** electronic engineering. Where a distinction is made, electrical engineering is considered to deal with the problems associated with **large-scale** electrical systems such as power transmission and **motor control**, whereas electronic engineering deals with the study of small-scale electronic systems including computers and **integrated circuits**. Another way of looking at the distinction is that electrical engineers are usually concerned with using electricity to transmit energy, while electronics engineers are concerned with using electricity to transmit information.

Early developments

Electricity has been a subject of scientific interest since at least the 17th century, but it was not until the 19th century that research into the subject started to intensify.

Notable developments in this century include the work of **George Ohm**, who in 1827 **quantified** the relationship between the **electric current** and potential difference in a **conductor**, **Michael Faraday**, the discoverer of **electromagnetic induction** in 1831, and **James Clerk Maxwell**, who in 1873 published a **unified** theory of electricity and magnetism in his **treatise** on *Electricity and Magnetism*.

During these years, the study of electricity was largely considered to be a subfield of physics. It was not until the late 19th century that universities started to offer degrees in electrical engineering. The Darmstadt University of Technology founded the first chair and the first faculty of electrical engineering worldwide in 1882. In 1883 Darmstadt University of Technology and Cornell University introduced the world's first courses of study in electrical engineering and in 1885 the University College in London founded the first chair of electrical engineering in the United Kingdom. The University of Missouri **subsequently** established the first department of electrical engineering in the United States in 1886.

During this period, the work concerning electrical engineering increased dramatically. In 1882, **Edison** switched on the world's first large-scale **electrical supply network** that provided 110 volts **direct current** to fifty-nine **customers** in lower Manhattan. In 1887, **Nikola Tesla** filed a number of patents related to a competing form of power **distribution** known as **alternating current**. In the following years a bitter **rivalry** between Tesla and Edison, known as the "**War of Currents**", took place over the preferred method of distribution. AC eventually replaced DC for generation and power distribution, enormously extending the range and improving the safety and **efficiency** of power distribution.

The efforts of the two did much to further electrical engineering—Tesla's work on **induction motors** and **polyphase systems** influenced the field for years to come, while Edison's work on telegraphy and his development of the **stock ticker** proved **lucrative** for his company, which ultimately became **General Electric**. However, by the end of the 19th century, other key figures in the progress of electrical engineering were beginning to emerge.

Modern developments (Emergence of radio and electronics)

During the development of radio, many scientists and inventors contributed to **radio technology** and **electronics**. In his classic UHF experiments of 1888, **Heinrich Hertz** transmitted (via a **spark-gap transmitter**) and detected radio waves using electrical equipment. In 1895, Nikola Tesla was able to detect signals from the transmissions of his New York lab at West Point (a distance of 80.4 km). In 1897, **Karl Ferdinand Braun** introduced the **cathode ray tube** as part of an **oscilloscope**, a **crucial** enabling technology for electronic television. **John Fleming** invented the first radio tube, the **diode**, in 1904. Two years later, **Robert von Lieben** and **Lee De Forest** independently developed the **amplifier tube**, called the **triode**. In 1920 **Albert Hull** developed the **magnetron** which would eventually lead to the development of the **microwave oven** in 1946 by **Percy Spencer**. In 1934 the British military began to make strides towards **radar** (which also uses the magnetron), under the direction of **Dr**

Wimperis culminating in the operation of the first radar station at Bawdsey in August 1936.

In 1941 **Konrad Zuse** presented the **Z3**, the world's first fully functional and programmable computer. In 1946 the **ENIAC (Electronic Numerical Integrator and Computer)** of **John Presper Eckert** and **John Mauchly** followed, beginning the computing era. The arithmetic performance of these machines allowed engineers to develop completely new technologies and achieve new objectives, including the Apollo missions and the NASA moon landing.

The invention of the **transistor** in 1947 by **William B. Shockley**, **John Bardeen** and **Walter Brattain** opened the door for more compact devices and led to the development of the **integrated circuit** in 1958 by **Jack Kilby** and independently in 1959 by **Robert Noyce**. In 1968 **Marcian Hoff** invented the first **microprocessor** at Intel and thus ignited the development of the personal computer. The first realization of the microprocessor was the Intel 4004, a 4-bit processor developed in 1971, but only in 1973 did the Intel 8080, an 8-bit processor, make the building of the first personal computer, the Altair 8800, possible.

5.6.2 Exercises

5.6.2.1 Expressions to be memorized

electrical equipment
microwave oven
integrated circuit
occupation
power supply
artificial
electric current
conductor
electromagnetic induction
electrical supply network
direct current
distribution
alternating current
efficiency
induction motor

5.6.2.2 Practice the pronunciation of the following words

electrical engineering, discipline, electricity, electronics, electromagnetism, commercialization, optoelectronics, processing, whereas, transmit, scientific, Missouri, subsequently, patent, enormously, telegraphy, ultimately, technology, experiments, oscilloscope, crucial, diode, triode, radar, microprocessor, via

5.6.2.3 Look up the following words and word combinations in the dictionary

spark-gap transmitter, cathode ray tube, amplifier tube, magnetron, ignite, quantify, rivalry, identifiable, analog, electronics, encompass, large-scale, distinction, notable, unify, treatise, customer, compete, range, polyphase systems, stock ticker, lucrative, emerge, culminate

5.6.2.4 Give synonyms to the following words

burn, measure, competition, include, big, difference, important, client, finish, distance, find out, job

5.6.2.5 Translate word combinations from English into Russian

to generate electricity, to conduct electricity, static electricity, electricity flows, processing industry, data processing, food processing industry, picture telegraphy, wireless telegraphy, to apply (employ) technology, state-of-the-art technology, crucial point, crucial game, to carry out an experiment, tunnel triode, early-warning radar, on a large scale, draw (make) a distinction, biggest consumer

5.6.2.6 Translate sentences

1. Scientists could not explain why the gas had suddenly **ignited**.
2. The questionnaire is intended to **quantify consumer's** requirements for shopping malls.
3. There is often **rivalry** between brothers and sisters to do better at school.
4. The Hindu religion **encompasses** many widely different forms of worship.
5. **Large-scale** development has given new life to the inner city.
6. Blood samples can provide a clear **distinction** between the two forms of the disease.
7. The creation of the UN was, perhaps, the most **notable** achievement of the 20^{th} century.
8. The barman was serving the last **customer**.
9. Ford has **launched** a big new sales campaign in an effort to bring in new consumers.
10. The phone has a built-in transmitter with a **range** of about 50 kilometers.
11. More details of the plan **emerged** at yesterday meeting.

5.6.2.7 Answer the questions

1. What is electrical engineering? Is it a discipline now?
2. What does this discipline deal with?
3. What sub-disciplines does the field cover now?
4. What is the difference between electrical and electronic engineering?

5 Name the notable developments of the 19^{th} century?

6. What is known as the "War of Currents"?
7. Which scientists and inventors contributed to radio technology and electronics at the end of the 19^{th} century?

8. What inventions were made in the 20^{th} century?

5.6.2.8 Speak about the outstanding scientists who influenced the development of electrical engineering. Make presentations about them. Use the information from *Wikipedia* (http://en.wikipedia.org/wiki/Main_Page) and *IEEE Virtual Museum* (http://www.ieee-virtual-museum.org)

1. George Ohm
2. Michael Faraday
3. James Clerk Maxwell
4. Edison.
5. Nicola Tesla
6. Heinrich Hertz

6 Part 6. Topic "My Specialty"

6.1 Read, translate and retell the following text. Add more information on the topic

I am a second year student of the Power Engineering Faculty of Orenburg State University. It is one of the largest higher educational establishments in our town. The Power Engineering Faculty was organized in November, 1999. It trains engineers-electricians. During the years of its activity the faculty has trained many highly-qualified engineers. Such specialists are in great demand nowadays.

There are the day-time, the evening-time and the extra-mural departments. Those who combine studies with their work are trained at the evening-time and the extramural departments.

The whole process of studying deals with mastering new systems of power supply and progressive technology of using these systems.

The junior students are taught mathematics, physics, a foreign language (English, German or French), chemistry, philosophy, computer processing of information. We attend lectures, do laboratory work and tests. We have quite a number of well-equipped laboratories at our disposal. Mastering one of the foreign languages enables us to read foreign literature and learn about the latest scientific and technical achievements abroad.

The senior students study special electric subjects such as: Strength of Materials, Electrical Engineering, Electrical Power Engineering, Vocational Training, Industrial Physics, Economy and Organization of Production, Technical Servicing, etc.

The fourth-year students combine their studies with their research work. We write course papers and graduation thesis on the scientific problems of our research work.

Many highly-qualified teachers work at the departments of our faculty, some of them have candidate's degrees and scientific ranks.

According to the academic plan the fifth-year students are sent to work at different plants and electric power stations, where they learn to employ in practice the knowledge they gained at the University.

During practice the students master the job of engineer-electrician and at the same time collect materials for their diploma papers.

The final and most important period in the student's life is the defense of the graduation work in the presence of the State Examining Board. All the graduates find work according to their specialty.

We shall work at electric power stations, at heat and power plants or at industrial enterprises, at power control inspections, at design and research institutions and laboratories. Besides, we are provided with everything necessary for a scientific career entering a post-graduate course. In a word we have a wide range of job opportunities.

6.2 Text "Profession of Electrical Engineer"

6.2.1 Read the text quickly and answer the questions to the each part of it

I. Education

designate – обозначать, именовать; получить
project management – проектный менеджмент
initially – в начале
pursue - продолжать
significant – значительный, важный
academia - научное сообщество, мир университетской науки
duration – длительность, продолжительность

Electrical engineers typically possess an academic degree with a major in electrical engineering. The length of study for such a degree is usually four or five years and the completed degree may be **designated** as a Bachelor of Engineering, Bachelor of Science, Bachelor of Technology or Bachelor of Applied Science depending upon the university. The degree generally includes units covering physics, mathematics, **project management** and specific topics in electrical engineering. **Initially** such topics cover most, if not all, of the sub-disciplines of electrical engineering. Students then choose to specialize in one or more sub-disciplines towards the end of the degree.

Some electrical engineers also choose to **pursue** a postgraduate degree such as a Master of Engineering/Master of Science, a Master of Engineering Management, a Doctor of Philosophy in Engineering or an Engineer's degree. The Master and Engineer's degree may consist of either research, coursework or a mixture of the two. The Doctor of Philosophy consists of a **significant** research component and is often viewed as the entry point to **academia**. In the United Kingdom and various other European countries, the Master of Engineering is often considered an undergraduate degree of slightly longer **duration** than the Bachelor of Engineering.

1) How long does it take students to get an academic degree in electrical engineering?

2) What subjects do they study at university?

3) What undergraduate and postgraduate degrees do they get? What is the difference between them?

II. Practicing engineers

a range of requirements – ряд требований
licensed - дипломированный
code of ethics – моральный кодекс
abide – следовать
comply - соблюдать
expulsion - увольнение
negligence – халатность
tort – деликт, гражданское правонарушение
pertaining – отношение, принадлежность
obsolescence - устарелость
gauge – оценивать, измерять
meticulous – тщательный, подробный

In most countries, a Bachelor's degree in engineering represents the first step towards professional certification and the degree program itself is certified by a professional body. After completing a certified degree program the engineer must satisfy **a range of requirements** (including work experience requirements) before being certified. Once certified the engineer is designated the title of Professional Engineer (in the United States, Canada and South Africa), Chartered Engineer (in the United Kingdom, Ireland, India and Zimbabwe), Chartered Professional Engineer (in Australia and New Zealand) or European Engineer (in much of the European Union).

The advantages of certification vary depending upon location. For example, in the United States and Canada "only a **licensed** engineer may seal engineering work for public and private clients". This requirement is enforced by state and provincial legislation such as Quebec's Engineers Act. In other countries, such as Australia, no such legislation exists. Practically all certifying bodies maintain a **code of ethics** that they expect all members to **abide** by or risk **expulsion**. In this way these organizations play an important role in maintaining ethical standards for the profession. Even in jurisdictions where certification has little or no legal bearing on work, engineers are **subject to** contract law. In cases where an engineer's work fails he or she may be subject to the **tort of negligence** and, in extreme cases, the charge of criminal negligence. An engineer's work must also **comply** with numerous other rules and regulations such as building codes and legislation **pertaining** to environmental law.

Professional bodies of note for electrical engineers include the Institute of Electrical and Electronics Engineers (IEEE) and the Institution of Electrical Engineers (IEE). The IEEE claims to produce 30 percent of the world's literature in electrical engineering, has over 360,000 members worldwide and holds over 300 conferences annually. The IEE publishes 14 journals, has a worldwide membership of 120,000, and claims to be the largest professional engineering society in Europe. **Obsolescence** of technical skills is a serious concern for electrical engineers. Membership and participation in technical societies, regular reviews of periodicals in the field and a habit of continued learning are therefore essential to maintaining proficiency.

In countries such as Australia, Canada and the United States electrical engineers make up around 0.25% of the labour force. Outside of these countries, it is difficult to gauge the demographics of the profession due to less **meticulous** reporting on labour statistics. However, in terms of electrical engineering graduates per-capita, electrical engineering graduates would probably be most numerous in countries such as Taiwan, Japan and South Korea.

1) What must the engineer do after completing a certified degree program?
2) What title is the certified engineer designated?
3) Is there any difference in certification of engineers in the US and Australia?
4) What are IEEE and IEE?

III. Tools and work

Global Positioning System – глобальная система позитирования
household appliances – бытовая техника
capacitor – конденсатор
circuit theory – теория схем
off-the-shelf – готовый
account for – отвечать
pristine - первоначальный

From the **Global Positioning System** to electric power generation, electrical engineers are responsible for a wide range of technologies. They design, develop, test and supervise the deployment of electrical systems and electronic devices. For example, they may work on the design of telecommunication systems, the operation of electric power stations, the lighting and wiring of buildings, the design of **household appliances** or the electrical control of industrial machinery.

Fundamental to the discipline are the sciences of physics and mathematics as these help to obtain both a qualitative and quantitative description of how such systems will work. Today most engineering work involves the use of computers and it is commonplace to use computer-aided design programs when designing electrical systems. Nevertheless, the ability to sketch ideas is still invaluable for quickly communicating with others.

Although most electrical engineers will understand basic **circuit theory** (that is the interactions of elements such as resistors, **capacitors**, diodes, transistors and inductors in a circuit), the theories employed by engineers generally depend upon the work they do. For example, quantum mechanics and solid state physics might be relevant to an engineer working on VLSI (the design of integrated circuits), but are largely irrelevant to engineers working with macroscopic electrical systems. Even circuit theory may not be relevant to a person designing telecommunication systems that use

off-the-shelf components. Perhaps the most important technical skills for electrical engineers are reflected in university programs, which emphasize strong numerical skills, computer literacy and the ability to understand the technical language and concepts that relate to electrical engineering.

For most engineers technical work **accounts for** only a fraction of the work they do. A lot of time is also spent on tasks such as discussing proposals with clients, preparing budgets and determining project schedules. Many senior engineers manage a team of technicians or other engineers and for this reason project management skills are important. Most engineering projects involve some form of documentation and strong written communication skills are therefore very important.

The workplaces of electrical engineers are just as varied as the types of work they do. Electrical engineers may be found in the **pristine** lab environment of a fabrication plant, the offices of a consulting firm or on site at a mine. During their working life, electrical engineers may find themselves supervising a wide range of individuals including scientists, electricians, computer programmers and other engineers.

1) What are electrical engineers responsible for?

2) What knowledge and skills are they supposed to have?

3) What are the workplaces of electrical engineers?

6.3 Speak about the differences of an electrical engineer's job in your country and other countries

6.4 Read the passage carefully and get ready to speak about sub-disciplines of electrical engineering. What does each discipline deal with? What field are you going to work in? Try to guess the meanings of words underlined

Electrical engineering has many sub-disciplines, the most popular of which are listed below. Although there are electrical engineers who focus <u>exclusively</u> on one of these sub-disciplines, many deal with a combination of them. Sometimes certain fields, such as electronic engineering and computer engineering, are considered separate disciplines in their own right.

Power engineering deals with the generation, transmission and distribution of electricity as well as the design of a range of related devices. These include transformers, electric generators, electric motors and power electronics. In many regions of the world, governments maintain an electrical network called a power grid that connects a variety of generators together with users of their energy. Users purchase electrical energy from the grid, avoiding the costly exercise of having to generate their own. Power engineers may work on the design and maintenance of the power grid as well as the power systems that connect to it. Such systems are called on-grid power systems and may supply the grid with additional power, draw power from the grid or do both. Power engineers may also work on systems that do not connect to the grid, called off-grid power systems, which in some cases are preferable to on-grid systems.

Electronic engineering involves the design and testing of electronic circuits that use the properties of components such as resistors, capacitors, inductors, diodes and transistors to achieve a particular functionality. The tuned circuit, which allows the user of a radio to filter out all but a single station, is just one example of such a circuit.

Prior to the Second World War, the subject was commonly known as radio engineering and basically was restricted to aspects of communications and radar, commercial radio and early television. Later, in post war years, as consumer devices began to be developed, the field grew to include modern television, audio systems, computers and microprocessors. In the mid to late 1950s, the term radio engineering gradually gave way to the name electronic engineering.

Before the invention of the integrated circuit in 1959, electronic circuits were constructed from discrete components that could be manipulated by humans. These discrete circuits consumed much space and power and were limited in speed, although they are still common in some applications. By contrast, integrated circuits packed a large number—often millions—of tiny electrical components, mainly transistors, into a small chip around the size of a coin. This allowed for the powerful computers and other electronic devices we see today.

Microelectronics engineering deals with the design of very small electronic components for use in an integrated circuit or sometimes for use on their own as a general electronic component. The most common microelectronic components are semiconductor transistors, although all main electronic components (resistors, capacitors, inductors) can be created at a microscopic level.

Most components are designed by determining processes to mix silicon with other chemical elements to create a desired electromagnetic effect. For this reason microelectronics involves a significant amount of quantum mechanics and chemistry.

6.5 Text "Engineering Achievements"

6.5.1 Search Your Knowledge

1. What was life like 100 years ago? How much of your life today is affected by engineering accomplishments?
2. What do engineers do?
3. What are some of the engineering achievements of the 20th century? List as many as you can.
4. Think about what life might be like without these developments.
Which engineering achievements are the most important? Why?
5. **Class activity:** Rank the engineering achievements in order of importance. Discuss the choices and agree or vote on the order.

6.5.2 Now, compare your class results to the list of engineering achievements that was put together by the National Academy of Engineering in the United States. Read the document from the Academy, which selected the top engineering feats of the

20th century. The document was issued as a *press release* to various news services and press clubs, including the National Press Club in Washington, DC.

6.5.3 Learn how to read

Can you understand the underlined words in the text? These words may be new to you; therefore, they are underlined so that you can find them easily later on, if you wish to refer to them again. See if you can figure out what they mean from context or from the other words and meanings around the underlined word. The words are also included in the vocabulary exercises under Key Words and Understanding Words and Phrases.

6.5.4 The boldfaced words in the text are glossed in the margin. These non-high frequency vocabulary words or phrases are helpful to understanding the reading. Read the entire text before doing the exercises

National Academy of Engineering Reveals Top Engineering Impacts of the 20th Century: Electrification Cited as Most Important

WASHINGTON — One hundred years ago, life was a constant struggle against disease, pollution, deforestation, treacherous working conditions, and enormous cultural divides unreachable with current communications technologies. By the end of the 20th century, the world had become a healthier, safer, and more productive place, primarily because of engineering achievements.

Speaking **on behalf of** the National Academy of Engineering (NAE), astronaut/engineer Neil Armstrong today announced the 20 engineering achievements that have had the greatest impact on quality of life in the 20th century. The announcement was made during National Engineers Week 20001 at a National Press Club luncheon.

The achievements — nominated by 29 professional engineering societies —were selected and ranked by a distinguished panel of the nation's top engineers. Convened by the NAE, this committee — chaired by H. Guyford Stever, former director of the National Science Foundation (1972-76) and Science Advisor to the President (1973-76) — worked in anonymity to ensure the unbiased nature of its deliberations.

"As we look at engineering breakthroughs selected by the National Academy of Engineering, we can see that if any one of them were removed, our world would be a very different — and much less hospitable — place," said Armstrong. Armstrong's announcement of the top 20 list, which includes space exploration as the 12th most important achievement, covers an incredibly broad spectrum of human endeavor — from the vast networks of electrification in the world (No. 1), to the development of high-performance materials (No. 20) such as steel alloys, polymers, synthetic fibers, composites and ceramics. In between are advancements that have revolutionized the way people live (safer water supply and treatment, No. 4, and health technologies, No. 16); work (computers, No. 8, and telephones, No. 9); play (radio and television, No. 6); and travel (automobile, No. 2, airplane, No. 3, and interstate highways, No. 11).

In his statement delivered to the National Press Club, Armstrong said that he was delighted to announce the list of the greatest achievements to underscore his commitment to advancing the understanding of the critical importance of engineering. "Almost every part of our lives underwent profound changes during the past 100 years thanks to the efforts of engineers, changes impossible to imagine a century ago. People living in the early 1900s would be amazed at the advancements wrought by engineers," he said. adding, "as someone who has experienced **firsthand** one of engineering's most incredible advancements — space exploration — I have no doubt that the next 100 years will be even more amazing."

The NAE notes that the top achievement, electrification, powers almost every pursuit and enterprise in modern society. It has literally lighted the world and impacted countless areas of daily life, including food production and processing, air conditioning and heating, refrigeration, entertainment, transportation, communication, health care, and computers.

Many of the top 20 achievements, given the immediacy of their impact on the public, seem obvious choices, such as automobiles, at No. 2, and the airplane, at No. 3. These achievements, along with space exploration, the nation's interstate highway system at No. 11, and petroleum and gas technologies at No. 17, made travel and mobility-related achievements the single largest segment of engineering to be recognized.

Other achievements are less obvious, but nonetheless introduced changes of staggering proportions- The No. 4 achievement, for example, the availability of safe and abundant water, literally changed the way Americans lived and died during the last century. In the early 1900s, waterborne diseases like typhoid fever and cholera killed tens-of-thousands of people annually, and dysentery and diarrhea, the most common waterborne disease, were the third largest cause of death. By the 1940s, however, water treatment and distribution systems devised by engineers had almost totally eliminated these diseases in America and other developed nations. They also brought water to vast tracts of land that would otherwise have been uninhabitable.

No. 10, air conditioning and refrigeration technologies, underscores how seemingly commonplace technologies can have a staggering impact on the economy of cities and worker productivity. Air conditioning and refrigeration allowed people to live and work effectively in sweltering climates, had a profound impact on the distribution and preservation of our food supply, and provided stable environments for the sensitive components that underlie today's information-technology economy.

Referring to achievements that may escape notice by most of the general public, Wm. A. Wulf, president of the National Academy of Engineering, said, "Engineering is all around us, so people often take it for granted, like air and water. Ask yourself, what do I touch that is not engineered? Engineering develops and delivers consumer goods, builds the networks of highways, air and rail travel, and the Internet, mass produces antibiotics, creates artificial heart valves, builds lasers, and offers such wonders as imaging technology and conveniences like microwave ovens and compact discs. In short, engineers make our quality of life possible."

Selection Process

The process for choosing the greatest achievements began in the fall of 1999, when the National Academy of Engineering, an enormous non-profit organization of outstanding engineers founded under the congressional charter that established the National Academy of Sciences, invited discipline-specific professional engineering societies to nominate up to ten achievements. A list of 105 selections was given to a committee of academy members representing the various disciplines. The panel convened on December 9 and 10, 1999, and selected and ranked the top 20 achievements. The overarching criterion used was that those advancements had made the greatest contribution to the quality of life in the past 100 years. Even though some of the achievements, such as the telephone and the automobile, were invented in the 1800s, they were included because their impact on society was felt in the 20th century.

6.5.5 The Achievements

6.5.5.1 Here is the complete list of achievements as announced today by Mr. Armstrong

1) **Electrification** — the vast networks of electricity that power the developed world.

2) **Automobile** — revolutionary manufacturing practices made the automobile the world's major mode of transportation by making cars more reliable and affordable to the masses.

3) **Airplane** — flying made the world accessible, spurring globalization on a grand scale.

4) **Safe and Abundant Water** — preventing the spread of disease, increasing life expectancy.

5) **Electronics** — vacuum tubes and, later, transistors that underlie nearly all modern life.

6) **Radio and Television** — dramatically changed the way the world received information and entertainment.

7) **Agricultural Mechanization** — leading to a vastly larger, safer, less costly food supply

8) **Computers** — the heart of the numerous operations and systems that impact our lives.

9) **Telephone** — changing the way the world communicates personally and in business.

10) **Air Conditioning and Refrigeration** — beyond convenience, it extends the shelf life of food and medicines, protects electronics and plays an important role in health care delivery.

11) **Interstate Highways** — 44,000 miles of U.S. highways allowing goods distribution and personal access.

12) **Space Exploration** — going to outer space vastly expanded humanity's horizons and introduced 60,000 new products on Earth.

13) **Internet** — a global communications and information system of unparalleled access.

14) **Imaging Technologies** — revolutionized medical diagnostics.

15) **Household Appliances** — eliminated strenuous, laborious tasks, especially for women.

16) **Health Technologies** — mass production of antibiotics and artificial implants led to vast health improvements.

17) **Petroleum and Gas Technologies** — the fuels that energized the 20th century.

18) **Laser and Fiber Optics** — applications are wide and varied, including almost simultaneous worldwide communications, non-invasive surgery, and point-of-sale scanners.

19) **Nuclear Technologies** — from splitting the atom, we gained a new source of electric power.

20) **High-Performance Materials** — higher quality, lighter, stronger, and more adaptable.

6.5.5.2 What's the Point? Demonstrate your understanding of some of the details in the reading. Based on the text you just read, give short answers to the questions that follow

1. Who is Neil Armstrong? What is his profession?
2. When is National Engineers Week held? When was it first established?
3. Why was electrification chosen as the most important achievement?
4. How many engineering achievements were originally nominated for selection?
5. How many organizations participated in the project to select the top 20 achievements?
6. What is the function of the National Academy of Engineering?

6.5.5.3 Show your understanding of the reading. Based on the text you just read, choose the best answer to complete the statements

1. Many people consider _____________to be the first American engineer.

a) George Washington
b) Neil Armstrong
c) Wm. A. Wulf
d) Thomas Edison

2. The area of engineering that received the most recognition on the
list of top achievements is_____________.

a) power production
b) transportation
c) medicine
d) agriculture

3. The most important achievement affecting public health was _________.
a) imaging technology
b) laser surgery
c) antibiotics
d) safe water supply

4. Air-conditioning and refrigeration show how something that seems ordinary can ______________.
a) be very significant
b) be highly complex
c) be very popular
d) be taken for granted

5. The National Academy of Engineering is administered by __________.
a) the federal government
b) National Engineering Week
c) its own members
d) a major corporation

6.5.5.4 Understanding Words and Phrases. The words or phrases that fit these definitions are underlined in the text you just read. Use the context to try to figure out their meanings, and match them with the given definitions, Write the words or phrases in the spaces provided so that each letter fits in a separate space. Notice that each answer has a numbered letter. When you have written in all the answers, arrange the numbered letters in numerical order at the bottom of the page to spell a word that you know well!

Example: in large quantity, plentiful: *a b u n d a n t*

1) to be the basis (of something):___________________________
1

2) very large____
2

3) a difficult battle, a big effort:____________________________
3

4) generous to guests; favorable _________________________to living:
4

5) deep, thorough, far-reaching:_________________________
5
6) formal discussion and debate_________________________of an issue:
6
7) greatly pleased, very glad:_____________________________
7
8) a chase, a search; a work________________________________ activity:
8
9) neutral, fair, not prejudiced:____________________________
9
10) independent, self-governing:_____________________________
10

11) terribly hot and humid:_______________________________
11

Alexandre Gustave Eiffel designed the
Eiffel Tower for the Paris Exhibition
of 1889. This was his profession:_______________________________
1 2 3 4 5 6 7 8 9 10 11

7 Part 7. Topic “Semiconductor devices”

7.1 Read the following text

Semiconductor devices are electronic components that exploit the electronic properties of semiconductor materials, principally silicon, germanium, and gallium arsenide. Semiconductor devices have replaced **thermionic devices (vacuum tubes)** in most applications. They use **electronic conduction** in the solid state as opposed to the gaseous state or thermionic emission in a high vacuum.

Semiconductor devices are manufactured as single discrete devices or integrated circuits (ICs), which consist of a number—from a few devices to millions—of devices manufactured onto a single semiconductor substrate[1].

Semiconductor device fundamentals

The main reason semiconductor materials are so useful is that the behaviour of a semiconductor can be easily manipulated by the addition of impurities, known as **doping**[2]. Semiconductor conductivity can be controlled by introduction of an electric field, by exposure to light, and even pressure and heat; thus, semiconductors can make excellent sensors. **Current conduction** in a semiconductor occurs via mobile or "free" electrons and holes (collectively known as **charge carriers**). Doping a semiconductor such as silicon with a small amount of impurity atoms, such as phosphorus or boron, greatly increases the number of free electrons or holes within the semiconductor. When a doped semiconductor contains excess holes[3] it is called **"p-type"**, and when it contains excess free electrons it is known as **"n-type"**. The semiconductor material used in devices is doped under highly controlled conditions in a fabrication facility, or fab, to precisely control the location and concentration of p- and n-type dopants. The junctions which form where n-type and p-type semiconductors join together are called **p-n junctions**.

Diode

The **p-n junction diode** is a device made from a p-n junction. At the junction of a p-type and an n-type semiconductor there forms a region called the **depletion zone** which blocks current conduction from the n-type region to the p-type region, but allows current to conduct from the p-type region to the n-type region. Thus when the device is forward biased, with the p-side at higher electric potential, the diode conducts current easily; but the current is very small when the diode is reverse biased.

Exposing a semiconductor to light can generate **electron–hole pairs**, which increases the number of free carriers and its conductivity. Diodes optimized to take advantage of this phenomenon are known as **photodiodes**. Compound semiconductor diodes can also be used to generate light, as in light-emitting diodes and laser diodes.

Bipolar junction transistors[4] are formed from two p-n junctions, in either n-p-n or p-n-p configuration. The middle, or base, region between the junctions is typically very narrow. The other regions, and their associated terminals[5], are known as the **emitter** and the **collector**. A small current injected through the junction between the base and the emitter changes the properties of the base-collector junction so that it can conduct current even though it is reverse biased. This creates a much larger current between the collector and emitter, controlled by the base-emitter current.

Another type of transistor, **the field effect transistor** operates on the principle that semiconductor conductivity can be increased or decreased by the presence of an **electric field**. An electric field can increase the number of free electrons and holes in a semiconductor, thereby changing its conductivity. The field may be applied by a reverse-biased p-n junction, forming a **junction field effect transistor**, or JFET; or by an electrode isolated from the bulk material by an oxide layer, forming a **metal-oxide-semiconductor**[6] field effect transistor, or MOSFET.

The MOSFET is the most used semiconductor device today. The gate electrode is charged to produce an electric field that controls the conductivity of a "channel" between two terminals, called the **source** and **drain**. Depending on the type of carrier in the channel, the device may be an n-channel (for electrons) or a p-channel (for holes) MOSFET. Although the MOSFET is named in part for its "metal" gate[7], in modern devices polysilicon is typically used instead.

Semiconductor device materials

By far, silicon (Si) is the most widely used material in semiconductor devices. Its combination of low raw material cost, relatively simple processing, and a useful temperature range make it currently the best compromise among the various competing materials. Silicon used in semiconductor device manufacturing is currently fabricated into boules[8] that are large enough in diameter to allow the production of 300 mm (12 in.) wafers[9].

Germanium (Ge) was a widely used early semiconductor material but its thermal sensitivity makes it less useful than silicon. Today, germanium is often alloyed with silicon for use in very-high-speed SiGe devices; IBM is a major producer of such devices.

Gallium arsenide (GaAs) is also widely used in high-speed devices but so far, it has been difficult to form large-diameter boules of this material, limiting the wafer diameter to sizes significantly smaller than silicon wafers thus making mass production of GaAs devices significantly more expensive than silicon.

Other less common materials are also in use or under investigation.

Silicon carbide (SiC) has found some application as the raw material for blue light-emitting diodes (LEDs) and is being investigated for use in semiconductor devices that could withstand very high operating temperatures and environments with the presence of significant levels of ionizing radiation. IMPATT diodes have also been fabricated from SiC.

Various indium compounds (indium arsenide, indium antimonide[10], and indium phosphide) are also being used in LEDs and solid state laser diodes. Selenium sulfide is being studied in the manufacture of photovoltaic solar cells.

7.1.1 Study the list of common semiconductor devices

Two-terminal devices:

- Avalanche diode (avalanche breakdown diode) – лавинный диод
- DIAC (Diode Alternating Current Switch) - динистор
- Diode (rectifier diode) – выпрямительный диод
- Gunn diode – диод Ганна
- Laser diode – лазерный диод
- Light-emitting diode (LED) – светоизлучающий диод, светодиод
- Photocell - фотоэлемент
- PIN diode – кодовый диод
- Schottky diode – диод Шотки
- Solar cell – солнечный элемент
- Tunnel diode – туннельный диод
- Zener diode – стабилитрон, стабистор

Three-terminal devices:

- Bipolar transistor – биполярный транзистор
- Field effect transistor – полевой транзистор
- Thyristor – тиристор, управляемый диод
- Triac – симметричный триодный тиристор, симистор
- Unijunction transistor – однопереходный транзистор

Four-terminal devices:

- Hall effect sensor (magnetic field sensor) – датчик Холла

Multi-terminal devices:

- Charge-coupled device (CCD) – устройство с зарядовой связью
- Microprocessor - микропроцессор
- Random Access Memory (RAM) – оперативное запоминающее устройство
- Read-only memory (ROM) – постоянное запоминающее устройство

7.1.2 Semiconductor device applications

All transistor types can be used as the building blocks of logic gates[11], which are fundamental in the design of digital circuits. In digital circuits like microprocessors, transistors act as on-off switches[12]; in the MOSFET, for instance, the voltage applied to the gate determines whether the switch is on or off.

Transistors used for analog circuits do not act as on-off switches; rather, they respond to a continuous range of inputs with a continuous range of outputs. Common analog circuits include amplifiers and oscillators.

Circuits that interface or translate between digital circuits and analog circuits are known as mixed-signal circuits.

Power semiconductor devices are discrete devices or integrated circuits intended for high current or high voltage applications. Power integrated circuits combine IC technology with power semiconductor technology, these are sometimes referred to as "smart" power devices. Several companies specialize in manufacturing power semiconductors.

Component identifiers

The type designators of semiconductor devices are often manufacturer specific. Nevertheless, there have been attempts at creating standards for type codes, and a subset of devices follow those. For discrete devices, for example, there are three standards: JEDEC JESD370B in USA, Pro Electron in Europe and JIS in Japan.

Notes to the text

[1] substrat*e* - *подложка*

[2] dope – *допировать, изменять структуру полупроводника с целью получит те или иные свойства*

doped – *примесный, присадочный*

doping – *легирование, допирование*

dopant=doping agent – *примесь, диффузант*

[3] excess hole – *избыточная дырка*

[4] bipolar junction transistor – *биполярный плоскостной транзистор*

[5] associated terminals - *выводы*

[6] metal-oxide-semiconductor – *структура металл-оксид-полупроводник*

[7] gate - *затвор*

[8] fabricate into boules – *изготавливать в форме слитков*

[9] wafer – *плата, тонкий диск*

[10] indium antimonide – *антимонид индия*
[11] logic gates – *логические элементы*
[12] on-off switches – *релейные переключатели*

7.1.3 Expressions to be memorized

current conduction – электрическая проводимость
charge carriers – носители зарядов
fabrication facilities – производственное оборудование
bias – склонять, оказывать влияние
take advantage - воспользоваться
in part – частично, отчасти
by far - общепризнанно
raw material - сырье
be in use - использоваться
be under investigation - изучаться
operating temperature – рабочая температура
solid state – полупроводниковый, транзисторный
solar cells – солнечный элемент

7.1.4 Exercises

7.1.4.1 Practice the pronunciation of the following words

exploit, component, silicon, germanium, gallium, arsenide, gaseous, impurity, exposure, phosphorus, boron, photodiode, channel, polysilicon, compromise, diameter, sensitivity, indium, phosphide, selenium, photovoltaic

7.1.4.2 Look up the following words and word combinations in the dictionary

thermionic devices, discrete devices, integrated circuit, sensor, p-type, n-type, fabrication, junction, p-n junction, depletion zone, p-side, forward-biased, reverse-biased, light-emitting diode, base-collector junction, base-emitter current, field effect transistor, bulk material, gate electrode, source, drain, base-collector, designator

7.1.4.3 Translate sentences

1. We test the chemical and biological **properties** of the samples.
2. Russia could **exploit** its position as a major oil producer to push up world oil prices.
3. Gas and electricity have largely **replaced** coal for domestic cooking and heating.
4. Goods **manufactured** in automated factories are, as a rule, cheaper.
5. This course provides an opportunity to learn more about the **fundamentals** of film-making.

6. These violent incidents frequently **occur** without any warning.

7. The **amount** of money you pay each month depends on how much you earn.

8. Lime is added to the liquid o remove all the **impurities**, including both sulphur and phosphorus.

9. The number of road accidents has **increased** by 50 % over the last five years.

10. The first electric cars will probably **contain** a battery weighing nearly a thousand pounds.

11. The gap between the two surfaces must be **precisely** 3.75 centimeters.

12. I live in a block of flats at the **junction** of Cambridge Road and Kilburn High Street.

13. Specially treated copper wires **conduct** the signal from the amplifier to the speaker.

14. Sulphur dioxide and carbon dioxide are two common chemical **compounds**.

15. The role of management varies **significantly** from one industry to another.

16. Commuters are becoming more and more **commonly** used in the classroom as a teaching aid.

17. An **investigation** by airline officials has shown that the crash was caused by human error.

18. This material is designed to **withstand** temperatures of up to 200°C.

7.1.4.4 Give the synonyms to the following words

use, quality, produce, take place, basics, quantity, happen, have smth inside, become larger

7.1.4.5 Answer the questions

1. What are semiconductor devices? Which ones are well known?
2. What does the term “doping” mean?
3. How can semiconductor conductivity be controlled?
4. What increases the number of free electrons and holes within the semiconductor?
5. Why can semiconductors make excellent sensors?
6. What is the difference between n-type and p-type semiconductors?
7. Why is the semiconductor material doped under highly controlled conditions?
8. On what principle does the field effect transistor operate?

7.2 Text “History of Semiconductor Device Development”

7.2.1 Practice the pronunciation of the following words

radio ['reidiqu]
however [hau'evə]
surface ['sə:fis]
galena [gə'li:nə]

lead sulfide ['led 's□lfaid]
carborundum [ka:bə'r□ndəm]
silicon carbide ['silikən 'ka:baid]
mysterious [mi'stiəriəs]
diode ['daiəud]
nevertheless ['nevəðə'les]
behaviour [bi'heivjə]
immediately [i'mi:diətli]
impurity [im'pjuərəti]
mechanism ['mekəniz(ə)m]
vigorous ['vig(ə)rəs]
Chicago [Si'ka:gəu]
germanium [Gə:'meiniəm]

7.2.2 List of words and word-combinations

around the turn of the 20^{th}	в начале 20 века
cat's whisker	контактная пружина
troublesome	неудобный
push to do smth	заставлять, вынуждать
cavity magnetron	магнетрон с большим выходом энергии
on a whim	подчиняясь внезапному порыву
hunt down	выискивать
investigate	изучать, исследовать
finicky	изощренный, излишне разборчивый
crack	трещина, щель
conductance	электропроводимость
junction	соединение, переход
bind to	связывать
reversed	обратный
instantly	немедленно, тот час
solid-state	полупроводниковый, транзисторный
depletion region	область истощения
on demand	по (первому) требованию
military-grade	для военных целей

7.2.3 Read and translate the following text

Semiconductors had been used in the electronics field for some time before the invention of the transistor. **Around the turn of the 20th** century they were quite common as detectors in radios, used in a device called a **"cat's whisker"**. These detectors were somewhat **troublesome**, however, requiring the operator to move a small tungsten filament (the whisker) around the surface of a galena (lead sulfide) or carborundum (silicon carbide) crystal until it suddenly started working. Then, over a period of a few hours or days, the cat's whisker would slowly stop working and the process would have to be repeated. At the time their operation was completely mysterious. After the introduction of the more reliable and amplified vacuum tube based radios, the cat's whisker systems quickly disappeared. The "cat's whisker" is a primitive example of a special type of diode still popular today, called a Schottky diode.

During World War II, radar research quickly **pushed** radar receivers to operate at ever higher frequencies and the traditional tube based receivers no longer worked well. The introduction of the **cavity magnetron** from Britain to the United States in 1940 during the Tizzard Mission resulted in a pressing need for a practical high-frequency amplifier.

On a whim, Russell Ohl of Bell Laboratories decided to try a cat's whisker. By this point they had not been in use for a number of years, and no one at the labs had one. After **hunting** one **down** at a used radio store in Manhattan, he found that it worked much better than tube-based systems.

Ohl **investigated** why the cat's whisker functioned so well. He spent most of 1939 trying to grow more pure versions of the crystals. He soon found that with higher quality crystals their **finicky** behaviour went away, but so did their ability to operate as a radio detector. One day he found one of his purest crystals nevertheless worked well, and interestingly, it had a clearly visible **crack** near the middle. However as he moved about the room trying to test it, the detector would mysteriously work, and then stop again. After some study he found that the behaviour was controlled by the light in the room–more light caused more **conductance** in the crystal. He invited several other people to see this crystal, and Walter Brattain immediately realized there was some sort of **junction** at the crack.

Further research cleared up the remaining mystery. The crystal had cracked because either side contained very slightly different amounts of the impurities Ohl could not remove–about 0.2%. One side of the crystal had impurities that added extra electrons (the carriers of electrical current) and made it a "conductor". The other had impurities that wanted to **bind to** these electrons, making it (what he called) an "insulator". Because the two parts of the crystal were in contact with each other, the electrons could be pushed out of the conductive side which had extra electrons (soon to be known as the emitter) and replaced by new ones being provided (from a battery, for instance) where they would flow into the insulating portion and be collected by the whisker filament (named the collector). However, when the voltage was **reversed** the electrons being pushed into the collector would quickly fill up the "holes" (the electron-needy impurities), and conduction would stop almost **instantly**. This junction of the two crystals (or parts of one crystal) created a **solid-state diode**, and the concept soon became known as semi conduction. The mechanism of action when the diode is off has to do with the separation of charge carriers around the junction. This is called a **"depletion region"**.

Armed with the knowledge of how these new diodes worked, a vigorous effort began in order to learn how to build them **on demand**. Teams at Purdue University, Bell

Labs, **MIT**, and the University of Chicago all joined forces to build better crystals. Within a year germanium production had been perfected to the point where **military-grade diodes** were being used in most radar sets.

7.2.4 Write a short summary of the following in English

Полупроводник — материал, электрические свойства которого в сильной степени зависят от концентрации в нём химических примесей и внешних условий (температура, излучение и пр.).

Полупроводники – вещества, которые по своей удельной проводимости (specific conductivity) занимают промежуточное место между проводниками и диэлектриками (non-conductor) и отличаются от проводников сильной зависимостью удельной проводимости от концентрации примесей, температуры и различных видов излучения. Полупроводниками являются вещества, ширина запрещённой зоны (band-gap) которых составляет 0-6 электрон-вольта, например, алмаз можно отнести к широкозонным полупроводникам (large-band gap), а InAs к узкозонным (low-band gap).

В зависимости от того, отдаёт ли примесь электрон или захватывает электрон, примесь называют донорной или акцепторной (acceptor). Свойство примеси может меняться от того, какой атом в кристаллической решётки она замещает, в какую кристаллографическую плоскость встраивается.

Прежде всего следует сказать, что физические свойства полупроводников наиболее изучены по сравнению с металлами и диэлектриками. В немалой степени этому способствует огромное количество эффектов, которые не могут быть наблюдаемы ни в тех ни в других веществах, прежде всего связанные с устройством зонной структуры (energy-band structure) полупроводников, и наличием достаточно узкой запрещённой зоны. Конечно же основным стимулом для изучения полупроводников является технология производства интегральных микросхем - это в первую очередь относится к кремнию, но затрагивает другие соединения (Ge, GaAs, InSb) как возможные заменители (alternate materials).

Кремний — непрямозонный полупроводник (non direct gap semiconductor), поэтому очень трудно заставить его работать в оптических устройствах, и здесь вне конкуренции соединения типа $A^{III}B^{V}$ ($A^{III}B^{V}$ compound semiconductor, среди которых можно выделить GaAs (gallium nitride), GaN (gallium arsenide), которые используются в светодиодах.

Собственный полупроводник (intrinsic, pure semiconductor) при абсолютном нуле температуры (absolute zero point) не имеет свободных носителей в зоне проводимости (conduction, carrier band) в отличие от проводников и ведёт себя как диэлектрик. При легировании ситуация может поменяться.

Объёмные свойства (bulk properties) полупроводника могут сильно зависеть от наличия дефектов в кристаллической структуре. И поэтому стремятся выращивать очень чистые вещества, в основном для электронной промышленности. Легирующие примеси вводят для управления типом проводимости проводника.

8 Part 8. Topic "The Shrinking Word of Microelectronics"

8.1 Warm-ups

8.1.1 Answer the following questions

1) Could you imagine your life without electronics?

2) What achievements in the field of electronics have been made recently? How did they influence our life?

3) Do you know what the first computer looked liked?

8.1.2 Active Vocabulary. Translate the word-combinations and use them in the sentences of your own

cell phones
cash register
pay with your debit card
get an idea
at one time
a big reason
to look like
appliance
to have limitations
to make smth work
to be incredibly useful
undertook a bold experiment
to be a success
to make a discovery
to be compared to
to be unreliable
search out new materials
to be replaced by

8.2 Text "Small Beginnings: From Tubes to Transistors"

Electronics have become so **prevalent** in our world—in computers, cell phones, airplane control systems, space ships, DVD players, coffeemakers, etc., that it's difficult to imagine what life would be like without them. You couldn't read this page without them, couldn't walk through an automatic door at the supermarket, or have the bar code of your soda scanned, or have the **cash register** figure out your change, or pay with your debit card, or…well, you get the idea—our culture is powered by electronics.

It wasn't always like this of course. At one time electronics were **relegated** to just a few areas, such as radio and television. A big reason for this was because electronics themselves were big. If you've ever seen pictures of early TV sets and radios from the 1940s and 1950s they were large, cabinet-size devices that looked more like furniture than like **cutting-edge** electronics. And computers? The **predecessors** of the latest 12 inch, five pound laptops were machines like **ENIAC**, the world's first general purpose electronic computer, which was developed in the 1940s. ENIAC was so large it filled entire rooms! You would think with all that **bulk** it was powerful too. Wrong. Although ENIAC was a **marvel** for its time, its computing power is **dwarfed** by a simple modern pocket calculator. So, how did electronics **infiltrate** just about every appliance we use? They got smaller, and smaller, and smaller. Engineers have spent a good part of the last 50 years shrinking electronic components. This is the field of "microelectronics," the **guts** of modern electronics.

In the early days of electronics, that is before the 1950s, the basic electronic device was the **electron tube** (which is also commonly known as a **vacuum tube**), which had begun life years earlier as a modified **light bulb**, and stayed about that size. Electron tubes made early electronics such as radio possible, but they had some serious **limitations**. Their **filaments** burned out just like a light bulb, and to make something work you needed lots of them. ENIAC, for example, needed 18,000 tubes to function. But electron tubes were also incredibly useful. In a radio or phonograph, they could take an extremely weak signal and **amplify** it loudly enough so that it could fill a room. The electron tube could also be used like a switch, but unlike a regular switch it had no moving parts and so it could switch on and off incredibly fast. Computer engineers, who used electrical switches to construct **elaborate** "logic" **circuits**, chose to use the electron tube despite its size and tendency to fail.

During World War II, things began to change. Engineers **undertook a bold experiment** to try to pack an entire radar set into an **artillery shell**. They called their new device a "**proximity fuse**," because it could destroy by being near a target rather than requiring a direct hit. Even though they were a success, proximity fuses still *relied on electron tubes*, **albeit**, quite tiny ones. After the war, as **missiles** and rockets emerged, there *was an increasing need for compact*, **rugged** electronic systems for communication and navigation. The search was on for smaller and smaller electron tubes.

While some engineers worked on building better and smaller electron tubes, others were looking for ways to **do away** with tubes altogether and turned to *semiconductors,* a class of materials valued because they could be used as diodes (a diode is a one-way valve for electricity). One was **Russell Ohl** of Bell Telephone Laboratories. Ohl and his fellow researchers discovered that putting two slightly different types of a semiconductor called **germanium** together produced a device that acted like a **electron tube diode**.

Ohl's work was important, but an even bigger discovery was made in 1947 when **John Bardeen** and **Walter Brattain stumbled** on the "transistor," a slice of germanium with a few carefully placed wires touching it, that was not only a valve but also an amplifier. This was the **point-contact transistor**. As an added bonus, the transistor produced a fraction of the waste heat and was tiny compared to an amplifier tube—the whole device could fit on the end of a finger. *Not long afterwards* William **Shockley**, also of Bell Labs, made the **fragile** transistor into a rugged and *practical device* when he invented the "**junction" transistor**, a sandwich made up of layers of germanium. Bell Labs announced the point-contact transistor in 1948 and the junction transistor in 1951. The germanium transistor was a **milestone**, but it was unreliable and engineers **sought out** new materials with which to construct transistors.

They found an answer in **silicon**, another semiconductor that had been used in diodes. Silicon proved to be a better material for making transistors. It was this type of transistor, introduced by Texas Instruments in 1954, that revolutionized the technological world. Missiles became more accurate with onboard transistor guidance systems and computers became small enough to fit on board an aircraft. Perhaps the most famous transistorized product from this era was the pocketsize radio. By the end of the 1950s, the little transistor had replaced the hot, unreliable electron tube in nearly every existing type of electronic system. It also made electronic devices smaller, cooler (in temperature, that is), and less expensive. But engineers were not satisfied—they wanted to make things even smaller.

8.2.1 Exercises

8.2.1.1 Answer the questions

1. Can you prove that our culture is powered by electronics?
2. What was the reason that at one time electronics were relegated to just a few areas?
3. What do you know about ENIAC? What was its size? Was it powerful?
4. What was the basic electronic device before the 1950s?
5. What limitations did electron tubes have?
6. How was a semiconductor discovered? What are the main principles of its work?
7. What further discoveries were made?
8. How does a transistor work? What types of transistors do you know?
9. What materials were used in transistors? What proved to be a better material and why?

8.2.1.2 Internet search. Make mini-presentations on

a) how a transistor works;
b) how a semiconductor works;
c) the way and the reason transistors replaced electron tubes.

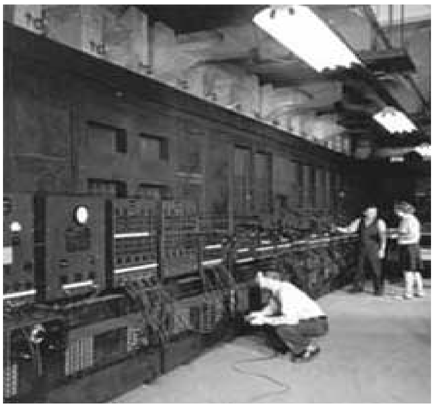
8.2.1.3 Internet recourses

1) http://www.ieee-virtual-museum.org

2) http://www.ieeeghn.org/wiki/index.php/Main_Page (*The IEEE Global History Network is dedicated to preserving and promoting the history of innovation in the fields of electrical engineering, electronics and computing, and all their related fields)*

3) http://semiconductormuseum.com *(Dedicated to Preserving the History of the Greatest Invention of the 20th Century)*

8.2.1.4 Comment on the pictures



Picture 1

Picture 2

Picture 3

1) A portion of ENIAC. A modern pocket-size calculator has more computing power.

2) A replica of the point-contact transistor created by John Bardeen and Walter Brattain, under the supervision of William Shockley in 1947. Courtesy: Lucent.

3) The first commercially produced silicon transistor, developed by Texas Instruments in the early 1950s. Courtesy: Texas Instruments.

8.3 Text "Transistors Launch the Computer Revolution"

If you ask someone who lived during the late 1950s or 1960s what they associated with the transistor, there is a good chance they'll say "transistor radio." And with good reason. The transistor radio revolutionized the way people listened to music, because it made radios smaller and portable. But, nice as a hand-held radio is, the real transistor revolution was taking place in the field of computers.

In a computer the transistor is usually used as a switch rather than an amplifier. Thousands and later tens of thousands of these switches were needed to **make up** the complicated logic circuits that allowed computers to **compute.** Unlike the earlier electron tubes (often called vacuum tubes), transistors allowed the design of much smaller, more reliable computers—they also addressed the seemingly **insatiable need for** speed.

The speed at which a computer can **perform calculations** depends heavily on the speed at which transistors can switch from "on" to "off." In other words, the faster the transistors, the faster the computer. Researchers found that making transistors switch faster required that the transistors themselves be smaller and smaller, because of the way electrons move around in semiconductors—if there is less material to move through, the electrons can move faster. By the 1970s, mass-production techniques allowed nearly microscopic transistors to be produced by the thousands on round **silicon wafers**. These were **cut up** into individual pieces and mounted inside a package for easier handling and **assembly**. The packaged, individual transistors were then wired into circuits along with other components such as resistors and **capacitors**.

As computers were produced in larger numbers, some kinds of logic circuits became fairly standardized. Engineers reasoned that standard circuits should be designed as units, in order to make them more compact. There were many proposals for doing this, but British engineer G. W. A. Dummer **proposed the idea** of making the entire circuit directly on a silicon wafer, instead of assembling the circuits from individual transistors and other components. Two engineers, Jack Kilby at Texas Instruments and Robert Noyce at Fairchild Semiconductor, invented such circuits—called integrated circuits—in 1958.

The first integrated circuits (ICs) were very simple and merely demonstrated the concept. But the idea of fabricating an entire circuit on a silicon wafer or "chip" with one process **was a real breakthrough**. Integrated circuits were so expensive that the first ones were **purchased** only by the military, which could justify the cost for **top-notch performance**. A little later, however, the integrated circuit would be mass-produced (largely to **meet the needs** of NASA's Apollo program and the United States' missile programs). When this happened it would revolutionize the design of computers.

8.3.1 Exercises

8.3.1.1 Discussion

What device do you associate with the transistor?
How is the transistor used in a computer?
When and how were integrated circuits invented?
Where were the first integrated circuits used?

8.3.1.2 True or False

1. What does the speed at which a computer can perform calculations depend on?
2. The real transistor revolution was taking place in the field of the transistor radio.
3. In a computer the transistor is usually used as a switch rather than an amplifier.
4. The faster the transistors, the faster the computer.
5. Robert Noyce was the first to propose the idea of making the entire circuit directly on a silicon wafer.
6. The first integrated circuits (ICs) were very complicated and expensive.

8.3.1.3 Make presentations about

1) G. W. A. Dummer
2) Robert Noyce
3) William Shockley
4) Russell Ohl
5) John Bardeen and Walter Brattain

8.4 Text "Chips, Anyone?"

Integrated circuits (ICs) seem to be nearly everywhere—they're in places such as your car's engine and your car's radio, telephones, iPods, and home thermostats; they're in virtually all the technologies you interact with every day from **ATMs** to X-ray machines. And, of course, they're in computers. Computers were one of the first places where ICs **took hold**, and they remain among the most **recognizable technologies** equipped with ICs.

Despite their **increasingly** small size, computers are extremely complicated technological systems. Inside a computer are a whole range of different chips that do everything from regulating power supplies and internal temperatures, to running sound and video systems, to controlling the spinning of hard drives and DVD burners. The most familiar chips are memory chips and microprocessors.

Memory **chips store information**, such as programs and data. The "main" memory chips that you see advertised are usually for storage of program data. These chips lose their data when power to the computer is turned off. Other memory chips store data permanently or until you change it, and there is some memory built into microprocessors and other types of chips.

The first Mosfet transistor, designed by M. M. Atalla, D. Kahng, and E. Labate in late 1959. Courtesy: Lucent.

Inside a typical main memory chip are tens of thousands or even millions of transistors—often in the form of a transistor called the metal oxide semiconductor or **MOS**, a device that was invented by Dawon Kahng and M. M. Attala. MOS transistors store information by switching on or off. In every computer, every piece of data is translated into a **binary** "code" of 0s and 1s. The letter "A" for example is translated into a binary number, 01000001. Then 01000001 is represented inside the chip as a set of transistors switched on (1) or off (0). A program like a web browser that deals with large amounts of text, displays pictures, accepts input from the user, and communicates with other computers needs millions of transistors to store all the coded information that passes through.

The microprocessor is another famous chip that **resides** in every computer. Unlike a memory chip, the microprocessor has many different functions, all carried out on one chip. Early computers had separate units (sometimes housed in different cabinets) for their mathematical and logic units, synchronization circuits or "clocks," register units where various logic operations take place, buffers where data is held, circuits to accept data from the outside world, and so on. To make computers smaller, more energy efficient, and to move data around inside them more quickly, engineers began "integrating" those separate units onto one or more chips, then integrating those chips into a single "microprocessor," or, in cases where engineers wanted to put a tiny computer into an industrial machine, a "microcontroller." Gary Boone and others at Texas Instruments, and Federico Faggin, Stanley Mazor, Tedd Hoff and others at Intel Corporation developed the first microprocessors and microcontrollers.

A chip is more than just a home for transistors. It also contains other elements needed to make a circuit, such as resistors, capacitors, and interconnecting conductors. But the usual way of comparing chips is to discuss the number of transistors on them. The first integrated circuits invented in 1958 had just a few transistors. The latest microprocessors have over 40 million.

Intel's Pentium 4 contains tens of millions of transistors. Courtesy: Intel

Intel executive Gordon Moore was the first to observe this growth and the increase in numbers is often known as Moore's Law.

To pack so many transistors and circuit elements onto one chip engineers have had to shrink the size of the parts. These smaller parts are, in fact, one of the major reasons for innovation in the integrated circuit field. The transistors that were about a centimeter wide in 1959 are now less than 200 billionths of a meter wide. That is so small that engineers are already predicting that the next generation of chips will have to be constructed in entirely new ways, perhaps assembled from individual molecules. This exciting new field is called "nanotechnology," and it may open up entirely new directions for electronics in the 21st century.

8.4.1 Complete the sentences

1. Integrated circuits (ICs) are used in _________________.
2. The most familiar chips are _________________________.
3. The "main" memory chips that you see advertised are usually for ___________.
4. Inside a typical main memory chip are ____________________ .
5. A program like a web browser that deals with large amounts of text, displays pictures, accepts input from the user, and communicates with other computers needs _________________________.
6. Unlike a memory chip, the microprocessor has ___________________.
7. To make computers smaller, more energy efficient engineers began ________________.
8. A chip also contains other elements needed to make a circuit, such as ________________.
9. The usual way of comparing chips ____________________.

10. Intel executive Gordon Moore was the first to _________________.

11. Engineers are already predicting that the next generation of chips will _________________.

12. The exciting new field, called "nanotechnology," may open up _________________.

8.5 Text "Nanotechnology"

With the integrated circuit growing smaller and smaller over the last decades, **one might wonder**, can they get any tinier? Engineers working in the field of nanotechnology believe they can and will. *Nanotechnology* refers to any new technology—a transistor, a tiny machine, a chemical—that is put together atom-by-atom or **molecule**-by-molecule. It usually also refers to the size of these technologies, which is defined as being 100 **nanometers** or less. A nanometer is one billionth of a meter. **By comparison**, today the smallest transistors on an IC are about 200 nanometers in size.

Renowned physicist Richard Feynman introduced the basic idea for nanotechnology in a 1959 speech called "There's Plenty of Room at the Bottom." Feynman predicted that tiny **assembly machines** made from a few molecules of matter could be built, and that these assemblers would be used to make other microscopic products. The result would be a system of production that would revolutionize the way things are made.

In the 1990s "micromachining" emerged as one of the first practical approaches to creating nanotechnologies. Using **etching techniques** pioneered in the field of integrated circuits, engineers began building microscopic machines with tiny **gears**, levers, and rotors. While most of these were simply demonstrations that such things could be built, engineers believed that these machines would soon be used in practical systems, such as microscopic, implantable, or injectable pumps to deliver drugs inside the body. Because of its relatively large scale, not everyone today agrees micromachining should still be part of the nanotechnology field, but it did **spawn** the important field of micro-electro-mechanical systems (**MEMs**). MEMs are currently used with integrated circuits, where tiny machines are combined with electronics on a silicon chip.

The connection between nanotechnology and electronics grew stronger when chip designers began to approach the limits of the **miniaturization** by conventional techniques. In the mid-1960s "Moore's Law" predicted that the size of features on integrated circuits would shrink dramatically over time and, in fact, transistors and other chip components shrank rapidly over the next four decades. But the **photolithographic** etching processes used to make transistors on an IC **impose** physical limits on the size of the transistors.

Many engineers and scientists are currently working on new, nanotechnological solutions to this problem, using tools such as the **atomic force microscope (ATF)** to build functional transistors from just a few atoms. They hope to find ways to build entire integrated circuits **"from the bottom up,"** by assembling them from atoms, rather than using today's **"top down"** methods. Recently, **nanoscale transistors** have been demonstrated using materials called **nanotubes**, which are **custom-made** variations on a complex carbon molecule called a **buckyball**.

If nanotechnology is the wave of the future, what is it doing for us today? Chemists have introduced new materials such as improved plastics that are stronger and better than earlier types of plastics. Another exciting area of progress is in quantum dots, which are microscopic crystals of semiconducting material that emit light when they are exposed to strong **ultraviolet** light. These dots can be used to detect cancer cells, and may soon be used to **illuminate** living spaces.

In electronics, nanotechnology is **making an impact** in cell phone and computer displays, where organic **LEDs (OLEDs)** are in production utilizing nano-engineered thin-film layers. Most computer hard discs are also made using a combination of a nano-engineered recording medium and a sensitive type of recording head made of giant **magnetoresistive (GMR) materials**. Filters using **nanoparticles** are capable of removing bacteria and viruses from drinking water in addition to larger particles. If nothing else, nanotechnology has helped us cut down on our dry cleaning bill: In 2003 the clothing store The Gap began selling trousers **impregnated** with a new stain resistant chemical developed through **nano-engineering.**

Other researchers are focusing their efforts on studying the way nanotechnologies will work, because at the nano-scale, the normal rules about the behavior of electrons, photons, and matter have to be thrown out. In fact, computer designers anticipate that future computers based on nanotechnology may eliminate transistors altogether. Another line of research is aimed at using **DNA**—the same material our bodies use to store genetic information. This would require the construction of custom DNA molecules and a way to get information in and out of the "computer" which might take the form of a flask of millions of molecules, suspended in a liquid. Nanotechnology is so new, and so little understood, that it is difficult to predict how it will develop. Many engineers, however, believe that it holds the key to the next generation of electronic devices, which will demand faster **computational** speeds and pack more components into smaller spaces than has been possible before.

8.5.1 Exercises

8.5.1.1 Discuss with your partner

1. What is a nanotechnology?
2. What basic idea for nanotechnology was introduces by Richard Feynman in his speech called "There's Plenty of Room at the Bottom"?
3. What is "micromachining"?
4. Is there any connection between nanotechnology and electronics?
5. What are nanoscale transistors?
6. Where is nanotechnology used nowadays?

8.5.1.2 Complete the table

THE FIELD NANOTECHNOLOGY IS USED IN	HOW IT IS USED/MAIN ACHIEVEMENTS
1. 2. 3. 4.	

8.5.1.3 Make a presentation on the topic "Nanotechnology is the Key to the Next Generation of Electronic Devices"

9 Part 9. Additional Texts for Reading

9.1 Text "Transistors"

A **transistor** is a three-terminal semiconductor device that can be used for amplification, switching, voltage stabilization, signal modulation and many other functions. The transistor is the fundamental building block of both digital and analog integrated circuits -- the circuitry that governs the operation of computers, cellular phones, and all other modern electronics.

The word transistor, coined by John Robinson Pierce in 1949, is a foreshortening of trans-resistance or transfer varistor (see the history section below).

Transistors are divided into two main categories: bipolar junction transistors (BJTs) and field effect transistors (FETs). Application of current in BJTs and voltage in FETs between the input and common terminals increases the conductivity between the common and output terminals, thereby controlling current flow between them. For more details on the operation of these two types of transistors, see field effect transistor and bipolar junction transistor.

In analog circuits, transistors are used in amplifiers, (direct current amplifiers, audio amplifiers, radio frequency amplifiers), and linear regulated power supplies. Transistors are also used in digital circuits where they function as electronic switches. Digital circuits include logic gates, random access memory (RAM), microprocessors, and digital signal processors (DSPs).

The transistor is considered by many to be one of the greatest inventions in modern history, ranking in importance with the printing press, automobile and telephone. It is the key active component in practically all modern electronics. Its importance in today's society rests on its ability to be mass produced using a highly automated process (fabrication) that achieves vanishingly low per-transistor costs.

Although millions of individual (known as discrete) transistors are still used, the vast majority of transistors are fabricated into integrated circuits (also called microchips or simply chips) along with diodes, resistors, capacitors and other electronic components to produce complete electronic circuits. A logic gate comprises about twenty transistors whereas an advanced microprocessor, as of 2006, can use as many as 1.7 billion transistors (MOSFETs) [1].

The transistor's low cost, flexibility and reliability have made it a universal device for non-mechanical tasks, such as digital computing. Transistorized circuits have replaced electromechanical devices for the control of appliances and machinery as well. It is often less expensive and more effective to use a standard microcontroller and write a computer program to carry out a control function than to design an equivalent mechanical control function.

Because of the low cost of transistors and hence digital computers, there is a trend to digitize information. With digital computers offering the ability to quickly find, sort and process digital information, more and more effort has been put into making information digital. As a result, today, much media data is delivered in digital form, finally being converted and presented in analog form by computers. Areas influenced by the Digital Revolution include television, radio, and newspapers.

The first patents for the transistor principle were registered in Germany in 1928 by Julius Edgar Lilienfeld. In 1934 German physicist Dr. Oskar Heil patented the field-effect transistor. It is not clear whether either design was ever built, and this is generally considered unlikely.

On 22 December 1947 William Shockley, John Bardeen and Walter Brattain succeeded in building the first practical point-contact transistor at Bell Labs. This work followed from their war-time efforts to produce extremely pure germanium "crystal" mixer diodes, used in radar units as a frequency mixer element in microwave radar receivers. Early tube-based technology did not switch fast enough for this role, leading the Bell team to use solid state diodes instead. With this knowledge in hand they turned to the design of a triode, but found this was not at all easy. Bardeen eventually developed a new branch of surface physics to account for the "odd" behaviour they saw, and Bardeen and Brattain eventually succeeded in building a working device.

Bell Telephone Laboratories needed a generic name for the new invention: "Semiconductor Triode", "Solid Triode", "Surface States Triode", "Crystal Triode" and "Iotatron" were all considered, but "transistor," coined by John R. Pierce, won an internal ballot. The rationale for the name is described in the following extract from the company's Technical Memorandum calling for votes: “Transistor. This is an abbreviated combination of the words "transconductance" or "transfer", and "varistor". The device logically belongs in the varistor family, and has the transconductance or transfer impedance of a device having gain, so that this combination is descriptive.” Pierce recalled the naming somewhat differently: “The way I provided the name, was to think of what the device did. And at that time, it was supposed to be the dual of the vacuum tube. The vacuum tube had transconductance, so the transistor would have 'transresistance.' And the name should fit in with the names of other devices, such as varistor and thermistor. And. . . I suggested the name 'transistor.'”

Bell put the transistor into production at Western Electric in Allentown, Pennsylvania. They also licensed it to a number of other electronics companies, including Texas Instruments, who produced a limited run of transistor radios as a sales tool. Another company liked the idea and also decided to take out a license, introducing their own radio under the brand name Sony. Early transistors were "unstable" and only suitable for low-power, low-frequency applications, but as transistor design developed, these problems were slowly overcome. Over the next two decades, transistors gradually replaced the earlier vacuum tubes in most applications and later made possible many new devices such as integrated circuits and personal computers.

Shockley, Bardeen and Brattain were honored with the Nobel Prize in Physics "for their researches on semiconductors and their discovery of the transistor effect". Bardeen would go on to win a second Nobel in physics, one of only two people to receive more than one in the same discipline, for his work on the exploration of superconductivity.

In August 1948 German physicists Herbert F. Mataré (1912–) and Heinrich Walker (ca. 1912–1981), working at Compagnie des Freins et Signaux Westinghouse in Paris, France applied for a patent on an amplifier based on the minority carrier injection process which they called the "transistron." Since Bell Labs did not make a public announcement of the transistor until June 1948, the transistron was considered to be independently developed. Mataré had first observed transconductance effects during the manufacture of germanium duodiodes for German radar equipment during WWII. Transistrons were commercially manufactured for the French telephone company and military, and in 1953 a solid-state radio receiver with four transistrons was demonstrated at the Düsseldorf Radio Fair.

Dynamic transistor characteristic could be displayed as curves on an early Transistor Curve Tracer

Development of the transistor

After the war, William Shockley decided to attempt the building of a triode-like semiconductor device. He secured funding and lab space, and went to work on the problem with Brattain and John Bardeen.

The key to the development of the transistor was the further understanding of the process of the electron mobility in a semiconductor. It was realized that if there was some way to control the flow of the electrons from the emitter to the collector of this newly discovered diode, one could build an amplifier. For instance, if you placed contacts on either side of a single type of crystal the current would not flow through it. However if a third contact could then "inject" electrons or holes into the material, the current would flow.

Actually doing this appeared to be very difficult. If the crystal were of any reasonable size, the number of electrons (or holes) required to be injected would have to be very large -– making it less than useful as an amplifier because it would require a large injection current to start with. That said, the whole idea of the crystal diode was that the crystal itself could provide the electrons over a very small distance, the depletion region. The key appeared to be to place the input and output contacts very close together on the surface of the crystal on either side of this region.

Brattain started working on building such a device, and tantalizing hints of amplification continued to appear as the team worked on the problem. Sometimes the system would work but then stop working unexpectedly. In one instance a non-working system started working when placed in water. Ohl and Brattain eventually developed a new branch of quantum mechanics known as surface physics to account for the behaviour. The electrons in any one piece of the crystal would migrate about due to nearby charges. Electrons in the emitters, or the "holes" in the collectors, would cluster at the surface of the crystal where they could find their opposite charge "floating around" in the air (or water). Yet they could be pushed away from the surface with the application of a small amount of charge from any other location on the crystal. Instead of needing a large supply of injected electrons, a very small number in the right place on the crystal would accomplish the same thing.

Their understanding solved the problem of needing a very small control area to some degree. Instead of needing two separate semiconductors connected by a common, but tiny, region, a single larger surface would serve. The emitter and collector leads would both be placed very close together on the top, with the control lead placed on the base of the crystal. When current was applied to the "base" lead, the electrons or holes would be pushed out, across the block of semiconductor, and collect on the far surface. As long as the emitter and collector were very close together, this should allow enough electrons or holes between them to allow conduction to start.

The Bell team made many attempts to build such a system with various tools, but generally failed. Setups where the contacts were close enough were invariably as fragile as the original cat's whisker detectors had been, and would work briefly, if at all. Eventually they had a practical breakthrough. A piece of gold foil was glued to the edge of a plastic wedge, and then the foil was sliced with a razor at the tip of the triangle. The result was two very closely spaced contacts of gold. When the plastic was pushed down onto the surface of a crystal and voltage applied to the other side (on the base of the crystal), current started to flow from one contact to the other as the base voltage pushed the electrons away from the base towards the other side near the contacts. The point-contact transistor had been invented.

While the device was constructed a week earlier, Brattain's notes describe the first demonstration to higher-ups at Bell Labs on the afternoon of 23 December 1947, often given as the birthdate of the transistor. The "PNP point-contact germanium transistor" operated as a speech amplifier with a power gain of 18 in that trial. Known generally as a point-contact transistor today, John Bardeen, Walter Houser Brattain, and William Bradford Shockley were awarded the Nobel Prize in physics for their work in 1956.

Origin of the term "transistor"

Bell Telephone Laboratories needed a generic name for their new invention: "Semiconductor Triode", "Solid Triode", "Surface States Triode" [sic], "Crystal Triode" and "Iotatron" were all considered, but "transistor", coined by John R. Pierce, won an internal ballot. The rationale for the name is described in the following extract from the company's Technical Memoranda (May 28, 1948) [26] calling for votes:

Transistor. This is an abbreviated combination of the words "transconductance" or "transfer", and "varistor". The device logically belongs in the varistor family, and has the transconductance or transfer impedance of a device having gain, so that this combination is descriptive.

Improvements in transistor design

Shockley was upset about the device being credited to Brattain and Bardeen, who he felt had built it "behind his back" to take the glory. Matters became worse when Bell Labs lawyers found that some of Shockley's own writings on the transistor were close enough to those of an earlier 1925 patent by Julius Edgar Lilienfeld that they thought it best that his name be left off the patent application.

Shockley was incensed, and decided to demonstrate who was the real brains of the operation. Only a few months later he invented an entirely new type of transistor with a layer or 'sandwich' structure. This new form was considerably more robust than the fragile point-contact system, and would go on to be used for the vast majority of all transistors into the 1960s. It would evolve into the bipolar junction transistor.

With the fragility problems solved, a remaining problem was purity. Making germanium of the required purity was proving to be a serious problem, and limited the number of transistors that actually worked from a given batch of material. Germanium's sensitivity to temperature also limited its usefulness. Scientists theorized that silicon would be easier to fabricate, but few bothered to investigate this possibility. Gordon Teal was the first to develop a working silicon transistor, and his company, the nascent Texas Instruments, profited from its technological edge. Germanium disappeared from most transistors by the late 1960s.

Within a few years, transistor-based products, most notably radios, were appearing on the market. A major improvement in manufacturing yield came when a chemist advised the companies fabricating semiconductors to use distilled water rather than tap water: calcium ions were the cause of the poor yields. "Zone melting", a technique using a moving band of molten material through the crystal, further increased the purity of the available crystals.

9.2 Text “Integrated Circuit”

A monolithic **integrated circuit** (also known as **IC**, **microchip**, **silicon chip**, **computer chip** or **chip**) is a miniaturized electronic circuit (consisting mainly of semiconductor devices, as well as passive components) which has been manufactured in the surface of a thin substrate of semiconductor material.

A hybrid integrated circuit is a miniaturized electronic circuit constructed of individual semiconductor devices, as well as passive components, bonded to a substrate or circuit board.

This article is about monolithic integrated circuits.

Integrated circuits were made possible by experimental discoveries which showed that semiconductor devices could perform the functions of vacuum tubes, and by mid-20th-century technology advancements in semiconductor device fabrication. The integration of large numbers of tiny transistors into a small chip was an enormous improvement over the manual assembly of circuits using discrete electronic components. The integrated circuit's mass production capability, reliability, and building-block approach to circuit design ensured the rapid adoption of standardized ICs in place of designs using discrete transistors.

There are two main advantages of ICs over discrete circuits: cost and performance. Cost is low because the chips, with all their components, are printed as a unit by photolithography and not constructed a transistor at a time. Performance is high since the components switch quickly and consume little power, because the components are small and close together. As of 2006, chip areas range from a few square mm to around 250 mm^2, with up to 1 million transistors per mm^2.

Advances in integrated circuits

Among the most advanced integrated circuits are the microprocessors, which control everything from computers to cellular phones to digital microwave ovens. Digital memory chips are another family of integrated circuit that is crucially important to the modern information society. While the cost of designing and developing a complex integrated circuit is quite high, when spread across typically millions of production units the individual IC cost is minimized. The performance of ICs is high because the small size allows short traces which in turn allows low power logic (such as CMOS) to be used at fast switching speeds.

ICs have consistently migrated to smaller feature sizes over the years, allowing more circuitry to be packed on each chip. This increased capacity per unit area can be used to decrease cost and/or increase functionality—see Moore's law. In general, as the feature size shrinks, almost everything improves—the cost per unit and the switching power consumption go down, and the speed goes up. However, ICs with nanometer-scale devices are not without their problems, principal among which is leakage current (see sub threshold leakage and MOSFET for a discussion of this), although these problems are not insurmountable and will likely be solved or at least ameliorated by the introduction of high-k dielectrics. Since these speed and power consumption gains are apparent to the end user, there is fierce competition among the manufacturers to use finer geometries. This process, and the expected progress over the next few years, is well described by the International Technology Roadmap for Semiconductors (ITRS).

Popularity of ICs

Only a half century after their development was initiated, integrated circuits have become ubiquitous. Computers, cellular phones, and other digital appliances are now inextricable parts of the structure of modern societies. That is, modern computing, communications, manufacturing and transport systems, including the Internet, all depend on the existence of integrated circuits. Indeed, many scholars believe that the digital revolution brought about by integrated circuits was one of the most significant occurrences in the history of mankind.

Classification and complexity

Integrated circuits can be classified into analog, digital and mixed signal (both analog and digital on the same chip).

Digital integrated circuits can contain anything from one to millions of logic gates, flip-flops, multiplexers, and other circuits in a few square millimeters. The small size of these circuits allows high speed, low power dissipation, and reduced manufacturing cost compared with board-level integration. The latest server processor from intel had 4 billion transistors on a chip. Analog integrated circuits perform analog functions like amplification, active filtering, demodulation, mixing, etc. ADCs and DACs are the key elements of mixed signal ICs. They convert signals between analog and digital formats. Analog ICs ease the burden on circuit designers by having expertly designed analog circuits available instead of designing a difficult analog circuit from scratch.

ICs generally can be classified into analog IC and digital ICs, according to the element's (circuit) function. Analog ICs, like sensors, power management circuits, and operational amplifiers, work by processing continuous signals, while digital ICs like microprocessors, DSPs, and micro controllers work using binary math to process "one" and "zero" signals. However, today's ICs often combine both analog and digital circuits on a single chip to create functions such as A/D converters and D/A converters. Such circuits offer smaller size and lower cost, but must carefully account for signal interference (see signal integrity).

The growth of complexity of integrated circuits follows a trend called "Moore's Law", first observed by Gordon Moore of Intel. Moore's Law in its modern interpretation states that the number of transistors in an integrated circuit doubles every two years. By the year 2000 the largest integrated circuits contained hundreds of millions of transistors. It is difficult to say whether the trend will continue (see technological singularity).

Manufacture

Fabrication

The semiconductors of the periodic table of the chemical elements were identified as the most likely materials for a solid state vacuum tube by researchers like William Shockley at Bell Laboratories starting in the 1930s. Starting with copper oxide, proceeding to germanium, then silicon, the materials were systematically studied in the 1940s and 1950s. Today, silicon monocrystals are the main substrate used for integrated circuits (ICs) although some III-V compounds of the periodic table such as gallium arsenide are used for specialised applications like LEDs, lasers, and the highest-speed integrated circuits. It took decades to perfect methods of creating crystals without defects in the crystalline structure of the semiconducting material.

Semiconductor ICs are fabricated in a layer process which includes these key process steps:

- Imaging
- Deposition
- Etching

The main process steps are supplemented by doping, cleaning and planarisation steps.

Mono-crystal silicon wafers (or for special applications, silicon on sapphire or gallium arsenide wafers) are used as the substrate. Photolithography is used to mark different areas of the substrate to be doped or to have polysilicon, insulators or metal (typically aluminium) tracks deposited on them.

- For a CMOS process, for example, a transistor is formed by the criss-crossing intersection of striped layers. The stripes can be monocrystalline substrate, doped layers, perhaps insulator layers or polysilicon layers. Some etched vias to the doped layers might interconnect layers with metal conducting tracks.
- The criss-crossed checkerboard-like (see image above) transistors are the most common part of the circuit, each checker forming a transistor.
- Resistive structures, meandering stripes of varying lengths, form the loads on the circuit. The ratio of the length of the resistive structure to its width, combined with its sheet resistivity determines the resistance.
- Capacitive structures, in form very much like the parallel conducting plates of a traditional electrical capacitor, are formed according to the area of the "plates", with insulating material between the plates. Owing to limitations in size, only very small capacitances can be created on an IC.
- More rarely, inductive structures can be simulated by gyrators.

Since a CMOS device only draws current on the transition between logic states, CMOS devices consume much less current than bipolar devices.

A (random access memory) is the most regular type of integrated circuit; the highest density devices are thus memories; but even a microprocessor will have memory on the chip. (See the regular array structure at the bottom of the first image.) Although the structures are intricate – with widths which have been shrinking for decades – the layers remain much thinner than the device widths. The layers of material are fabricated much like a photographic process, although light waves in the visible spectrum cannot be used to "expose" a layer of material, as they would be too large for the features. Thus photons of higher frequencies (typically ultraviolet) are used to create the patterns for each layer. Because each feature is so small, electron microscopes are essential tools for a process engineer who might be debugging a fabrication process.

Each device is tested before packaging using very expensive automated test equipment (ATE), a process known as wafer testing, or wafer probing. The wafer is then cut into small rectangles called dice. Each good die (N.B. die is the singular form of dice, although dies is also used as the plural) is then connected into a package using aluminium (or gold) wires which are welded to pads, usually found around the edge of the die. After packaging, the devices go through final test on the same or similar ATE used during wafer probing. Test cost can account for over 25% of the cost of fabrication on lower cost products, but can be negligible on low yielding, larger, and/or higher cost devices.

As of 2005, a fabrication facility (commonly known as a semiconductor fab) costs over a billion US Dollars to construct, because much of the operation is automated. The most advanced processes employ the following techniques:

- The wafers are up to 300 mm in diameter (wider than a common dinner plate).
- Use of 90 nanometer or smaller chip manufacturing process. Intel, IBM, and AMD are using 90 nanometers for their CPU chips, and Intel has started using a 65 nanometer process.
- Copper interconnects where copper wiring replaces aluminium for interconnects.
- Low-K dielectric insulators.
- Silicon on insulator (SOI)
- Strained silicon in a process used by IBM known as Strained silicon directly on insulator (SSDOI)

Packaging

The earliest integrated circuits were packaged in ceramic flat packs, which continued to be used by the military for their reliability and small size for many years. Commercial circuit packaging quickly moved to the dual in-line package (DIP), first in ceramic and later in plastic. In the 1980s pin counts of VLSI circuits exceeded the practical limit for DIP packaging, leading to pin grid array (PGA) and leadless chip carrier (LCC) packages. Surface mount packaging appeared in the early 1980s and became popular in the late 1980s, using finer lead pitch with leads formed as either gull-wing or J-lead, as exemplified by Small-Outline Integrated Circuit. A carrier which occupies an area about 30 – 50% less than an equivalent DIP, with a typical thickness that is 70% less. This package has "gull wing" leads protruding from the two long sides and a lead spacing of 0.050 inches.

Small-Outline Integrated Circuit (SOIC) and PLCC packages. In the late 1990s, PQFP and TSOP packages became the most common for high pin count devices, though PGA packages are still often used for high-end microprocessors. Intel and AMD are currently transitioning from PGA packages on high-end microprocessors to land grid array (LGA) packages.

Ball grid array (BGA) packages have existed since the 1970s.

Traces out of the die, through the package, and into the printed circuit board have very different electrical properties, compared to on-chip signals. They require special design techniques and need much more electric power than signals confined to the chip itself.

When multiple die are put in one package, it is called SiP, for System In Package. When multiple die are combined on a small substrate, often ceramic, it's called a MCM, or Multi-Chip Module. The boundary between a big MCM and a small printed circuit board is sometimes fuzzy.

9.3 Text "What is Nanotechnology?"

There's a lot of buzz—nanotechnology is "coming soon." But what is nanotechnology? Why doesn't anyone ever explain that? Well, it's not that easy. While experts agree about the size of nanotechnology—that it's smaller than a nanometer (that's one billionth of a meter) they disagree about what should be called nanotechnology and what should not. Looking back at the historical roots of nanotechnology helps us get a better grasp on what nanotechnology is and why it's important now, and how it will change the world in the future.

The story of nanotechnology begins in the 1950s and 1960s, when most engineers were thinking big, not small. This was the era of big cars, big atomic bombs, big jets, and big plans for sending people into outer space. Huge skyscrapers, like the World Trade Center, (completed in 1970) were built in the major cities of the world. The world's largest oil tankers, cruise ships, bridges, interstate highways, and electric power plants are all products of this era. Other researchers, however, focused on making things small. In the 1950s and 1960s the electronics industry began its ongoing love affair with making things smaller. The invention of the transistor in 1947 and the first integrated circuit (IC) in 1959 launched an era of electronics miniaturization. Somewhat ironically, it was these small devices that made large devices, like spaceships, possible. For the next few decades, as computing application and demand grew, transistors and ICs shrank, so that by the 1980s engineers already predicted a limit to this miniaturization and began looking for an entirely new approach.

As electronics engineers focused on making things smaller, engineers and scientists from an array of other fields turned their focus to small things—atoms and molecules. After successfully splitting the atom in the years before World War II, physicists struggled to understand more about the particles from which atoms are made, and the forces that bind them together. At the same time, chemists worked to combine atoms into new kinds of molecules, and had great success converting the complex molecules of petroleum into all sorts of useful plastics. Meanwhile geneticists discovered that genetic information is stored in our cells on long, complex molecules called DNA (about 2 meters of DNA is packed into each cell!) This and other work led to a greater understanding of molecules, which, by the 1980s, suggested entirely new lines of engineering research.

So, the roots of nanotechnology lie in the merging of three lines of thinking—atomic physics, chemistry, and electronics. Only in the 1980s did this new field of study get a name—nanotechnology. This new name was popularized by physicist K. Eric Drexler, who pointed out that nanotechnology had been predicted much earlier, in an almost-forgotten 1959 lecture by Nobel Laureate Richard Feynman, who proposed the idea of building machines and mechanical devices out of individual atoms. The resulting machines would actually be artificial molecules, built atom by atom. While the resulting molecule might itself be larger than a nanometer, it was the idea of manipulating things at the atomic level that was the essence of nanotechnology. But not only was this kind of manipulation impossible at the time, but few people had any idea why it would be useful to do it! With all the new research, however, Drexler revived Feynman's vision and helped introduce the general public to the basic concepts of nanotechnology.

Although nanotechnology dates from the 1950s, the biggest changes have occurred just in the past few years. In the late 1990s, research money began pouring in from corporate and government sources. In the space of just a few years governments around the world launched three major (and many other smaller) new research programs, including the National Nanotechnology Initiative in the U.S. and the nanotechnology branch of the European Research Area. Japan has its own huge nanotechnology program, with money coming from private industry and government agencies such as the Ministry of Trade and Industry.

9.4 Text "Nanotechnology in Today's World"

Nanotechnology is a science in its infancy, but that doesn't mean it hasn't been put to use. What exactly has been accomplished in nanotechnology so far? In general, all of today's practical nanotechnologies are those using nano-size particles of various materials, or nanometer-size features on integrated circuits (ICs), rather than the complex molecular machines that engineers first envisioned. These current nanotechnologies are still made by "top down" methods (like those used in conventional chemistry and IC manufacturing), rather than the largely unproven "bottom up" techniques predicted by nanotechnology's boosters.

Many current nanotechnologies, for example, consist of the ever-shrinking transistors, interconnecting wires, and other features on digital ICs. As of 2005, some integrated circuits now have transistors that measure about 50 nanometers across—well inside the accepted size-based definition of nanotechnology. But chips are still made using advanced versions of the lithographic processes developed in the 1950s, which layer on materials and then carve away at them to form the electronic circuits. They are not, in other words, constructed molecule-by-molecule from the bottom up. However, chip manufacturers point out that when working with extremely small circuit elements, the behavior of electrons changes, so entirely new principles are at work. Also, there is at least one new chip with a somewhat different claim to being "nanotechnological." This is IBM's "Millipede" memory chip, which draws its inspiration directly from the Atomic Force Microscope (AFM). Electronics manufacturers can also point to the latest generation of high-density computer hard drives, which have extremely thin coatings of just a few atoms' thickness applied to the surface of the disc by a process called chemical vapor deposition.

While such nanochips are beginning to appear in greater numbers, most of us more often encounter applications of nanotechnological materials that are made in "bulk" form and added to other products. By far the best known of these are the controversial "nanotechnology" trousers introduced by The Gap and Eddie Bauer stores in 2005. These were simply ordinary cotton pants, treated with nanoparticles of a new, stain-resistant chemical that attached itself to the cotton molecules.

Carbon nanotubes, which can now be made in large quantities at relatively low cost by companies like Hyperion Catalysis International Inc., are being incorporated into a wide range of other products. Because the fibers conduct electricity very well, Hyperion was able to mix them into plastic compounds, which auto makers can then mold into parts that conduct electricity. This is useful for preventing static electricity charges from building up on parts such as plastic fuel system components, where the static can eventually damage them or, in some cases, cause a spark. Nanotubes mixed into plastics are very strong and light, and have been used to make car body components, tennis rackets, and other items. They have also been used to improve battery performance, and may some day be used in other technologies that traditionally used ordinary carbon or metals to conduct charges. Infineon Technologies in Germany, for example, has demonstrated the use of the tubes to connect components on microchips. In 2002 they showed how nanotubes could be used to replace ordinary metal wires allowing them to carry more current but taking up less space. That would result in computer chips that can pack more circuits into less space; one of the longstanding goals of chip designers.

One very useful new material is the semiconductor quantum dot. While not used in electronic circuits, quantum dots are nonetheless made from the same silicon used in computer chips. These tiny bits of material are coming into widespread use in experimental biology and, in a limited way, in medical diagnosis. The dots can be coated with certain chemicals, which are specially formulated so that they bind themselves to particular things—such as RNA, cell walls, or other types of molecules found in cells. One interesting application of this technology is its use in analyzing DNA material taken from the body. These DNA "scanners," first introduced commercially by Matsushita Corporation, combine integrated circuit technology and quantum dots to analyze genetic material much more rapidly than was possible before, and may lead to more rapid assessment of diseases. A second use of coated quantum dots is injecting them into the body, where they circulate until they come in contact with whatever type of cell their coating is designed to attach itself to. Then when a powerful infrared light source is shone on the body, it penetrates the flesh, illuminates the massed quantum dots, and the reflections can be detected to provide a "live" picture of an organ, muscle, cancerous growth, or other internal part without the need for surgery. Unfortunately, not all of these quantum dots are suitable for injection into a living human body, and some are even poisonous, but bioengineers are working around that problem.

Even with these real-world applications, the current uses of nanotechnology (other than nano-size particles of various materials) remain very limited. In fact, several once-promising nanotechnology based systems introduced commercially in the 1990s did not meet with success, such as the nanotube–based Field Emission Displays proposed as competitors to other flat-panel information displays. However, researchers are rapidly making progress toward what some think of as true nanotechnologies—self-assembling, molecule size machines to perform all sorts of tasks (including manufacturing the nano-size materials made by other methods today). The nanotechnological future, we are told, is right around the corner.

9.5 Text "The Future of Nanotech"

The future of nanotechnology is largely a question mark. Futurists say we are entering a new era, somewhat like the Industrial Revolution of the 18th and 19th centuries. That revolution changed nearly everything about the way people lived. But no one at that time could have predicted how those changes would unfold. Could we be on the brink of another very rapid period of profound technological and social change?

The nanotechnological revolution, if it occurs, will be just as unpredictable in the long-term, but scientists and engineers have laid out some pretty fantastic forecasts for the near-future. For example, some see great promise for the use of nanotubes in super-strong materials. Even though the plastic composites made today using relatively short nanotubes are not yet much stronger than earlier types of composites, long nanotubes are expected to be used for extraordinary applications like the proposed "space elevator." This system would replace rockets for the transport of payloads and people into earth orbit.

Another major area where nanotechnologists predict stunning changes is in medicine. Imagine a world where no one gets seriously ill, grows older, or even dies (until they want to). That is what the prophets of nanotechnology say is in store for the 21st century. Today's nanotechnologies used in medicine offer only modest benefits, such as the ability to target diseased or cancerous cells, making them easier to locate.

In the near future, engineers tell us, that will change. Tiny molecular machines, perhaps based on complex, branched molecules called "dendrimers" will be injected into the body not only to locate cancers but also to find and repair cells damaged by disease or aging. Livers and hearts damaged by natural wear-and-tear, inherited diseases, poor nutrition, or alcoholism will be fixed or even replaced. Genetically based ailments such as Alzheimer's will be cured by replacing the faulty genes.

Some futurists have predicted that the most profound changes will be the result of the introduction of molecular assembly "factories," perahps even small small enough to fit on a desktop. These would, some say, make it possible for virtually anyone to design and build virtually anything, using nanorobots or perhaps a new technology called "nanoink," created by NanoInk founder Chad Mirkin. Nanotechnology researchers like K. Eric Drexler and Ralph Merkle say that this could be done by imitating and improving upon the "manufacturing" that DNA accomplishes inside the body.

In 1999, researchers such as Nadrian Seeman at New York University demonstrated the principle of using modified DNA molecules to build a tinymachine, and somewhat later Nanoink founder Chad Mirkin had demonstrated building up nanostructures by depositing layers of materials on a substrate.

These and other experiments have also led researchers to believe that they will eventually be able to assemble circuits atom-by-atom in order to create the next generation of computer chips. The circuits on these chips will be much smaller than what is currently possible, and will enable the building of much more powerful computers. What difference will that make? Some, like engineer Raymond Kurzweil, think that computers will have personalities and be as smart as humans within 20 years. We may even be able to "download" our own personalities into computers, to become virtual humans. With nearly unlimited computing power, programmers are sure they could create software that completely blows away anything possible today.

Not surprising, these amazing predictions have inspired fear as well as wonder. Environmentalists and others point out that nanotechnology may bring with it unexpected dangers. The nanomaterials being made today, like fullerenes, are often in the form of extremely small particles. Even when these particles are made from common materials like carbon, they may interact with the human body or the environment in ways that are unlike those of natural particles of the same materials. Some say that allowing nanoparticles to be included in products ingested or applied to the body may pose health risks for consumers.

Others predict that nanotechnology may get out of control, causing a huge man-made disaster. Eric Drexler and others, such as computer engineer Bill Joy of Sun Microsystems, warned in 2000 that self-replicating machines might run amok if they escape into the environment, competing with natural bacteria, plants, and people for natural resources. Then, in 2002 the public's awareness of nanotechnology—the bad side of nanotechnology—was greatly expanded when author Michael Crichton published his best-selling novel *Prey,* about tiny, self-duplicating nanorobots that band together to try to take over the world.

Whether public fears are founded in fact, it is true that the future of nanotechnology has inspired as much caution as optimism. Recently, in response to public outcry, researchers such as Dr. Vicky Colvin of Rice University have begun evaluating the risks and rewards of current nanotechnologies. Colvin and other engineers believe that, with wisdom, they can bring the wonders of nanotechnology into being while avoiding the pitfalls.

9.6 Text "The Transistor: A Little Invention with a Big Impact"

Today, when we refer to electronics, we are usually referring to things containing transistors. Transistors are devices that switch electric currents on and off or amplify electric currents. They use specially prepared substances to do this, and are used individually or in clusters of up to several million on integrated circuits. The transistor got its start in the 1940s when engineers began looking for a replacement for the electron tube, an earlier device for amplification and switching. The electron tube was based on the light bulb, so it was big, fragile, and created a lot of excess heat.

The three inventors of the transistor were John Bardeen, Walter Brattain, and William Shockley, who all worked at Bell Laboratories in New Jersey. In 1939, Brattain and Shockley began to work together on an electron tube replacement made of the chemical element germanium, a semiconductor. Germanium and other semiconductors had been used for many years in point-contact diodes, which consist of a small sample of semiconductor crystal with a permanent electrical connection at one end and an adjustable connection at the other. When the “cat’s whisker” is adjusted correctly, the diode acts as a one-way valve for electric current. Brattain and Shockley believed that they could modify the diode so that they could regulate the current the same way the grid in an electron tube regulates current. The device did not work. However, after putting the idea aside for a few years, they, along with John Bardeen, returned to it in the middle 1940s. They finally stumbled on a new way to connect the germanium crystal to a circuit that allowed it to amplify current.

After a little brainstorming and an office poll, the new device was named the “transistor,” which was short for “transfer resistor.” The point-contact transistor, as it was called, worked, but not very well. It was difficult to make and the early modelsoften failed unexpectedly. Shockley suggested a new design almost immediately, which became known as the junction transistor. A junction transistor consists of a single piece of semiconductor crystal, into which chemical impurities have been introduced to create three chemically different regions. The transistions between the regions are known as junctions. The impurities and junctions change the way that the crystal conducts electricity. By creating a sandwich of three different layers, the middle layer can be electrically stimulated so that it can affect the flow of electricity from the top to the bottom layers. It acts like a tiny hand on an electrical spigot. The first germanium junction transistors were introduced around 1950, and engineers quickly developed many different ways of making them so that they were cheaper, more useful, and easier to make in large quantities.

The military began using junction transistors almost immediately in airplanes and missiles, where engineers were trying to squeeze in complicated communication and guidance systems. Transistors were perfect for these military systems, because they were much smaller and used much less electrical current than vacuum tubes. Soon, they were used in hearing aids, portable radios, and all sorts of other electronic devices.

The three inventors of the transistor were awarded the Nobel Prize in physics in 1956 for their groundbreaking work. Shockley went on to become an entrepreneur in the transistor manufacturing business, while Bardeen became a professor and worked on superconductors. Bardeen later won a second Nobel Prize for that work.

Meanwhile, transistor development continued at a rapid pace. In 1954, Texas Instruments introduced the silicon transistor, made of a material that was even more rugged and reliable than germanium. By 1960, it was possible to make many transistors on a single, thin slab of silicon, cut them up into individual units, and then make them ready for use. This technique was modified so that the transistors were already connected into circuits before the silicon wafer was cut, leading to the “integrated” circuit.

As computers and other systems began relying on integrated circuits more heavily, engineers looked for ways to design simpler, high performance transistors. The MOSFET transistor, which stands for metal-oxide-semiconductor field effect transistor, was one of the key breakthroughs that made possible today's high-speed computer chips with billions of microscopic transistors. The transistor age may be coming to an end, however. In the near future, engineers expect that transistors built atom-by-atom, or circuits using DNA or some other complex molecule may replace the MOSFET.

9.7 Text "What is a Semiconductor?"

Semiconductor is one of the most common—but least understood—terms in the tech world. Simply defined, semiconductors are generally certain elements (such as silicon) and chemical compounds (such as lead sulfide) that allow, but still resist the flow of electricity. Somewhere between good conductors, such as copper, and poor conductors, such as glass, lie semiconductors, which are just OK conductors. If the semiconductor is only a mediocre conductor, why is it so important? Because semiconductors have a unique atomic structure that allows their conductivity to be controlled by stimulation with electric currents, electromagnetic fields, or even light. This makes it possible to construct devices from semiconductors that can amplify, switch, convert sunlight to electricity, or produce light from electricity.

In electronics the usefulness of semiconductors stems from the structure of the atoms that make up semiconductor crystals. For example, a silicon atom has four electrons in its outer orbital (the top "shell" of orbiting electrons). When heated to the melting point and refrozen, silicon atoms tend to form organized crystal structures or lattices. In a process called doping, phosphorus or arsenic atoms are mixed into the silicon. This disturbs the silicon's structure, giving the resulting crystal extra electrons. The crystal is changed from an OK conductor to a good conductor. Since electrons carry a negative charge, this type of crystal with extra electrons is known as an N-type or N-doped semiconductor.

Doping the crystal with boron or gallium also turns the crystal into a conductor, but it does so by leaving it with a shortage of electrons. Physicists say that the crystal has holes, which make the crystal positive or P-type. When N-type and P-type crystals come together, something surprising happens. The junction acts as a barrier to the flow of electricity in one direction but presents almost no resistance in the other direction. This one-way valve can be used in an electronic device called a diode. You can think of a diode as a door that only swings one way—you can go out, but you can't go back in.

Around the middle 1950s, engineers discovered that junction diodes made from a material called gallium arsenide emitted light (although it was only much later that usable lasers and LEDs were made this way). Alas, explaining this phenomenon introduces more vocabulary terms. Free electrons traveling through a semiconductor crystal have a fairly high level of energy, so they are said to be in the conduction band. When an electron meets a hole in the crystal, it tends to stay there. Holes are where an electron would normally be, and when a free electron "falls in," it releases energy in the form of a photon of light. When the energy difference or band gap between the high conduction band state and the lower state is small, as it is in silicon, the light is released at the invisible infrared frequencies. When the band gap is large, the emission is visible light. This happens in all types of diodes, but in an ordinary silicon diode the silicon itself absorbs most of the light. Light emitting diodes are constructed so that most of the light radiates outward. The device is usually mounted in a small reflector cup to help direct the light, and the whole assembly is packaged in translucent plastic.

A semiconductor laser diode, like the kind in a DVD player and other common systems, uses much the same principle, but uses special materials to create a larger band gap. A laser diode uses heterostructures, which are junctions of two different types of semiconductor materials, chosen so that the band gap is very large. The device also uses mirrors and other means to reflect light emitted from the junctions in order to stimulate the laser effect.

While a semiconductor diode is the simplest type of electronic device, semiconductors are also used to make transistors, integrated circuits, and many other types of electronic devices.

9.8 Text “Integrated Circuits”

An integrated circuit is a thin slice of silicon or sometimes another material that has been specially processed so that a tiny electric circuit is etched on its surface. The circuit can have many millions of microscopic individual elements, including transistors, resistors, capacitors, and conductors, all electrically connected in a certain way to perform some useful function.

The first integrated circuits were based on the idea that the same process used to make clusters of transistors on silicon wafers might be used to make a functional circuit, such as an amplifier circuit or a computer logic circuit. Slices of the semiconductor materials silicon and germanium were already being printed with patterns, the exposed surfaces etched with chemicals, and then the pattern removed, leaving dozens of individual transistors, ready to be sliced up and packed individually. But wires, a few resistors and capacitors might later connect those same transistors to make a circuit. Why not do the whole thing at one time on that slice of silicon?

The idea occurred to a number of inventors at the same time, but the first to accomplish it were Jack Kilby of Texas Instruments and Robert Noyce of Fairchild Semiconductor Incorporated. The idea caught on like wildfire because the integrated circuit had many of the advantages that had made the transistor attractive earlier. These advantages included small size, high reliability, low cost, and small power consumption. However, these circuits were difficult to make because if one component of the chip was faulty, the whole chip was ruined. As engineers got better and better at squeezing more and more transistors and other components onto a single chip, the problems of actually making these chips increased. When the transistors were shrunk down to microscopic size, even the smallest bit of dust could ruin the chip. That's why today, chips are made in special "clean rooms" where workers wear the "bunny suits" that we often see on TV.

Compared to the original integrated circuit, which was a simple device with just a few components, the number of components on today's' integrated circuits is amazing. In the 1960s, an engineer named Gordon Moore predicted that the number of elements on a chip would double every year (later revised to every two years) into the foreseeable future. "Moore's Law" has held true so far. Today, the Intel Pentium chip has over 100 million transistors on it, with the total number of components including resistors, capacitors, and conductors being even larger.

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