Министерство образования и науки Российской Федерации
Нижнекамский химико-технологический институт (филиал)
федерального государственного бюджетного образовательного учреждения
высшего профессионального образования
«Казанский национальный исследовательский технологический университет»

Т.И. Анисимова, И.М. Белова

ENGINEERING

УЧЕБНОЕ ПОСОБИЕ

ЧАСТЬ I

Нижнекамск
2014

УДК 4И(Англ)
А 67

Печатается по решению редакционно-издательского совета Нижнекамского химико-технологического института (филиала) ФГБОУ ВПО «КНИТУ».

Рецензенты:
Меркель Р.В., кандидат психологических наук;
Ганиева Г.Р., кандидат филологических наук.

Анисимова, Т.И.
А 67 ***Engineering*** : учебное пособие, ч.I / Т.И. Анисимова, И.М. Белова. - Нижнекамск : Нижнекамский химико-технологический институт (филиал) ФГБОУ ВПО «КНИТУ», 2014. – 78с.

Данное пособие предназначено для аудиторной и самостоятельной работы студентов бакалавриата и СПО. Цель пособия – подготовить студентов к работе с документацией технического характера.

В пособии представлены материалы для развития навыков работы с техническими текстами. Содержит теоретические и практические материалы, необходимые для изучения в течение курса по дисциплинам «Иностранный язык» и «Иностранный язык в сфере профессиональной коммуникации». Также может использоваться в качестве дополнительного материала для студентов технических профилей всех форм обучения.

Подготовлено на кафедре иностранных языков НХТИ КНИТУ.

УДК 4И(Англ)

TEXT 1

What Is Engineering?

In order to understand what engineering is and what engineers do, we start with a definition of engineering. Engineering is the application of science and mathematics to pro-duce useful devices and systems. For example, electrical engineers use their knowledge of physics and mathematics to design the electronic components and circuits that allow nearly instantaneous communication anywhere around the world. Chemical engineers use their knowledge of basic chemistry to design efficient processes for converting a barrel of crude oil into the gasoline that powers automobiles. To do these tasks, engineers must have a very solid grounding in the basic sciences and mathematics.

What is the basic knowledge that supports electrical and computer engineering? Most important to electrical and computer engineers are sophisticated mathematical skills. Physical and chemical systems often can only be understood through relatively complex mathematical models. A mathematical model is a representation of a physical system using equations. These equations aid in the understanding of the physical process, allow engineers to predict the behavior of a system in new applications, and help in designing new devices. Engineering would still be in the Dark Ages without the invention of calculus and other mathematical tools.

Physics is one of the basic sciences in which electrical and computer engineers must be well versed. The understanding of how matter is structured and how it reacts to external stimuli is fundamental to understanding complex systems and designing new devices. For example, inside your computer is an array of electronic devices designed to perform certain functions. Many of these devices are fabricated from very pure silicon and are formed into integrated circuits, also known as microchips. Information is stored in a computer in the form of electrons. The presence of electrons in a structure formed in the silicon may be used to signify a “1,” and the absence of electrons will signify a “0.”

Computations are performed by moving these bunches of electrons through various circuits. To design computing devices, engineers must understand the physics of how electrons interact with matter, how they can be stored, and how they can be moved around. Chemistry also tells us how matter interacts and how complex forms of matter are made. Chemistry has been a branch of science studied by those learning to be electrical engineers.

Computers have become increasingly important in society. This is doubly true in engineering, where calculations and modeling of devices, processes, and structures are increasingly performed by engineers using computers. Many manufacturing processes are controlled by computers, and even consumer devices like the automobile are controlled by onboard computers. Contemporary engineers cannot do their jobs without using computers, and so need a solid grounding in the basics of computer science—how computers work and how to program them to perform useful tasks.

Becoming an engineer involves much more than just studying engineering. Engineering starts with a good fundamental knowledge of the engineering sciences — mathematics, physics, chemistry, and computer science.

So far, we have only talked about the scientific and technical background required to be an engineer. There are also many important nontechnical skills required of engineers. Engineers must be effective communicators, able to convey their ideas through written reports as well as oral presentations. Engineers must also function well as members of a team since engineering projects are rarely performed by an engineer working alone. Rather, projects generally involve teams of engineers from several engineering disciplines who must work together effectively to complete a project. Engineers must also be able to work with nontechnical team members. Engineers must know at least the fundamentals of business principles in- their industry since projects that are not economically sound and that do not make good business sense will not go forward.

As we discuss what engineering is, we should also look at others who work with engineers — scientists and technicians. Although engineers use the results of science in their everyday work, most engineers are not scientists. Scientists study nature and try to discover the fundamental laws that govern nature. Their concerns are most often with gathering new knowledge; they are generally less interested in applying this knowledge. Engineers are concerned with how to use scientific knowledge to produce useful devices or processes. In the course of their work, engineers often must design and run experiments to gain the knowledge that they need, so sometimes they do function as scientists. However, the engineer`s goal is rarely to gain knowledge alone, but is rather to use that knowledge for practical ends.

Most engineering companies employ a large number of technicians or technologists. These are people charged with building prototypes of new devices, running experiments and recording experimental data, building machines that help in designing new products, and maintaining the machinery needed to support the engineering functions of a company. Technicians generally receive less training than engineers and are not expected to have the sophisticated mathematical skills that engineers require. Of course, there is never a sharp line of demarcation between what engineers do and what technicians do. Depending on the company or the individual engineer, engineers will often do maintenance on machines, run experiments themselves, and build prototypes. Likewise, experienced technicians often perform some of the engineering work required for a new project.

TEXT 2

The Engineering Profession

As you begin your study of engineering, you may not realize that you are preparing yourself to be a member of a profession. What does this mean? In this section we will explore what a profession is and see what rights and obligations professionals have.

The terms profession and professional have many meanings today. Profession is often used synonymously with occupation or job, and professional is used to distinguish someone who is paid for his or her work rather than being an amateur. Professional is also used to indicate that someone has a great deal of experience and can be counted on to do a good job. None of these is the sense of the word profession that we examine here. Rather, we will consider a more traditional view of professions. There are four basic attributes of professions:

- the work involves sophisticated skills, judgment, and discretion, and it is not routine or capable of mechanization;
- it requires extensive formal education, not just an apprenticeship or on-the-job training;
- special societies or organizations controlled by members of the profession are allowed to play a major role in setting standards for admission to the profession and standards of conduct for members of the profession;
- the work serves some important aspect of the public good.

As by-products of this, the members of the profession are generally held in high esteem by society and are largely allowed to regulate their own activities. The paradigms, or major examples, of professions in modern society are medicine and law.

Is engineering a profession? Let's examine engineering in light of the definitions given above. Certainly engineering involves sophisticated skills. It requires a very skilled practitioner to design a computer or a wireless telephone network. Judgement is exercised by engineers in their work as they must decide which of several different designs, components, or materials to choose from. Discretion is required as engineers are called upon to keep information on new designs and on their clients strictly confidential. It may seem that engineering can be mechanized. After all, much of the design work done by a modern electrical or computer engineer is done on a computer. However, the computer is merely a tool for engineers. By itself, the computer cannot yet design another computer or even a computer chip. The computer greatly aids engineers in doing these tasks, but engineering is certainly not mechanized.

Does engineering require extensive formal education? Before practicing as an engineer, you must first complete a four-year undergraduate program from an accredited college of engineering. Many engineering jobs require additional classroom work, and most require that skills be continually upgraded through continuing education. This last point is especially important in engineering. Technology changes very rapidly, and as technologies evolve, so must our engineering skills. It is imperative that engineers know how to access information rapidly and learn new knowledge and skills. As a student, one of your goals must be to learn how to teach yourself because many of the skills you will need as an engineer in the future will have to be learned on the job.

Does engineering serve the public good? This question can be answered by simply looking around you. Many of the indispensable tools of modern life, such as computers, telecommunications equipment, and lighting, were created by electrical and computer engineers. The safety of society has also been enhanced through the work of electrical and computer engineers. For example, automotive safety has improved through anti-lock braking systems designed by engineering teams, including electrical and computer engineers.

Using the definition given earlier, it is clear that engineering is a profession. As you begin your studies of engineering, you should keep in mind that you are embarking on a profession as ancient, as learned, and as important as medicine or law. With the benefits of being a member of a profession - high pay, high status in society, subsidized education, and a degree of self-governance - there are obligations that go along with professional status.

TEXT 3

Codes of Ethics

All professional societies have given thought to the duties and responsibilities of their members. These are generally spelled out in documents called codes of ethics. A code of ethics provides a framework for ethical judgments of the professional. It serves as a means of collective recognition by members of a profession's responsibilities, and it helps create an environment where ethical behavior is the norm. All of the engineering professional societies have codes of ethics, including the IEEE. The IEEE code is included in Appendix B of this book.

It is worth taking a few minutes now to look at the IEEE code of ethics to try to understand some of the obligations of the profession you will be joining. The heart of any engineering code is the responsibility of engineers to ensure that their work will not adversely impact the health or safety of the general public. In other words, in return for our status in society, engineers must promise to hold paramount the safety of the public.

One way in which the engineering profession differs from others is with regard to licensure. Physicians and lawyers all must be licensed by the state in which they reside before being allowed to practice their profession. Most engineers do not need licenses to call themselves engineers and practice their professions. For example, large companies such as IBM employ many electrical and computer engineers who do not have a license. Licensure of engineers, including electrical and computer engineers, is offered by every state in the United States. Generally, though, most electrical and computer engineers don't seek or need a license. Among engineers, only civil engineers are required to be licensed. A civil engineer needs licensure in order to certify that a structure is built according to acceptable standards and will meet state and city building codes. The climate in which engineering is practiced is changing, and there is a trend now towards increased licensure for all engineers.

TEXT 4
Entrepreneurship

In our modern high-technology society, electrical and computer engineers often find themselves involved in starting new companies. In the course of our work we often have the kernel of an idea for a new product. The act of starting a new venture to produce this product or exploit a new idea is called entrepreneurship. Many large corporations seek to facilitate an entrepreneurial environment so that employees will be interested in innovating.

There are three steps to entrepreneurship: invention, innovation, and marketing. As an engineer, you may think that you will only be involved in the first two of these. Engineers clearly have roles in the discovery of new ideas and invention of new products and in working to develop these ideas until they are ready for market. In the modern economy, engineers often participate in commercializing their ideas as well. Many small start-up companies do not have the resources to employ full-time marketing personnel, so this task can fall to engineers. This is especially true in the many start-up companies that only have three or four employees.

The importance of entrepreneurship to modern engineering is manifested in courses on entrepreneurial engineering taught by many schools of engineering in the U.S. These courses cover topics related to financing new businesses (raising venture capital and finding investors, for example), developing viable business plans, managing small high-tech companies, and marketing ideas in a high-tech economy. In the absence of such courses, many engineering programs encourage students to take some business courses to prepare for the modern marketplace.

TEXT 5
What Is Computer Engineering?

Computer engineering has emerged as a separate engineering discipline over the last 20 years as electrical engineers interested in computing technology have forged a new field. Since its origins are in electrical engineering, computer engineering shares many similarities with electrical engineering. The focus of computer engineering is on designing and building computers and computer systems. Although at one time this was a fairly narrow field, today it is quite extensive, encompassing not only the design of computer hardware but also the design of networks used to connect computers and the software used to run them.

Sometimes it is hard to see the difference between electrical engineers, computer engineers, and computer scientists. Generally, computer scientists are interested in designing the software used by computers. Although they need extensive knowledge about the hardware that makes up the computer, their focus is primarily on constructing algorithms to implement calculations and the efficient design of software to run computers. Computer engineers need to understand the complexities of software - you can't design a computer without knowing the software that will run on it - but focus primarily on the design of the hardware that runs the software.

Electrical engineers generally design and build hardware used in applications other than computers. Of course, many modern electronic systems are computer controlled. Every automobile produced today has a microcontroller, which is essentially a mini-computer, underneath the hood. This is used to monitor and control all of the functions of the engine to ensure that the automobile operates as efficiently as possible. Often an electrical engineer will do the computer design and work on developing the software for these types of applications.

Confused? You should be because many practicing engineers are not able to say where electrical engineering ends and computer engineering begins. Many engineers work in an area that bridges the gap between these two fields. So how do you decide if electrical or computer engineering is the right choice for you? There is no right answer to this question. Many people trained as electrical engineers learn the skills needed to function as a computer engineer on the job. Likewise, many individuals trained in computer engineering make the transition to electrical engineering. A good guide is to decide how much you like computer programming. Although no engineer can be without good programming skills in the modern engineering marketplace, the computer skills required by computer engineers are often more extensive than those required of electrical engineers. So if you like computers and are interested in how they are put together, computer engineering is probably the right career choice for you.

TEXT 6

Other Engineering Fields

Before ending our discussion of the nature of engineering, it will be valuable to mention some of the other fields of engineering. Even if you are sure that you want to be an electrical or computer engineer, you will almost certainly find yourself working on multidisciplinary teams during the course of your engineering career. For example, the design of an automobile requires the skills of mechanical engineers to design the engines and drive trains, electrical engineers to design the electrical systems and controls, computer engineers to work on the computerized monitoring and control systems, manufacturing engineers to design the assembly lines and robots to build the automobile, as well as other engineering and nontechnical professionals. Most engineering projects will require the skills of different types of engineers, so it will be beneficial to at least get a rough idea of what the other types of engineering are so that you will be able to better interact with the other engineers working on your project. The following is a brief description of some of the major types of engineering other than electrical and computer engineering. There are many books that give in-depth discussions of these fields beyond what is presented here.

Mechanical engineering focuses on the design and production of mechanical systems. There are many such systems around us in the everyday world. Mechanical engineers design large-scale systems as diverse as automobiles, refrigeration systems, and robots. They also work on very small-scale systems such as computer disk drives and miniaturized medical implants.

Civil engineering is concerned with the design and building of the infrastructure of cities and communities. Civil engineers work on roads, bridges, and sewer systems, and design the structures of large buildings. Civil engineers work closely with architects to ensure that new buildings are structurally sound and can withstand the forces of nature, such as wind and earthquakes, to which they will be subjected. An example of some of the work done by civil engineers - a scale model of the design for the reconstruction of the intersection of two interstate highways in Albuquerque, New Mexico.

As the name implies, aerospace engineers are concerned with the design of flying machines, including commercial and military aircraft and vehicles launched into space. Aerospace engineers have expertise in the flow of air around airplanes, and design the wings, control surfaces, and the fuselage of airplanes. Aerospace engineers can also find, themselves working in the automotive industry, applying their knowledge of air flow to help design more fuel-efficient automobiles or even faster race cars.

Nuclear engineers are trained in the technology used to harness the energy of the atom. They design nuclear reactors for power stations and ships and are helping to design fusion reactors that might one day provide a new source of commercial power. Nuclear engineering also has applications in medicine. Many branches of medicine rely on diagnostic and therapeutic techniques that utilize short-lived nuclear isotopes. Nuclear engineers are involved in the design and running of reactors that produce these valuable materials

Executing a design is only the first step in getting a new product into the marketplace — the product must then be manufactured. Manufacturing engineers are knowledgeable in manufacturing methods and can design the best way to make a product. They deal with the mechanics of manufacturing such as assembly lines and robots. They also must consider human factors such as the efficient and safe use of assembly personnel in the design of manufacturing processes. Manufacturing engineering is closely related to industrial engineering and is sometimes considered a subdiscipline of mechanical engineering

An area of engineering that is becoming increasingly important is biomedical engineering. This area incorporates many different activities and crosses boundaries with many of the traditional engineering disciplines. Biomedical engineering studies ways to use engineering principles to design devices that help in the treatment of disease or that car be used to replace biological materials. For example, biomedical engineering meets electrical engineering in the design of diagnostic medical equipment such as ultrasound imagers or patient-monitoring devices. Biomedical engineering meets mechanical engineering in work on prosthetic devices and artificial muscles

TEXT 7

Where Do Electrical and Computer Engineers Work?

The answer to the question of where electrical and computer engineers work may seem very obvious. Many of these engineers are employed by the well-known engineering companies such as IBM, Intel, Boeing, or Ford. However, you may be surprised to see the wide variety of other places that employ electrical and computer engineers. Any company that uses electrical- or computer-based control systems as part of their manufacturing equipment will require the services of electrical and computer engineers. For example, clothing manufacturers such as Oshkosh B'Gosh®, brewers such as Anheuser-Busch, and fast-food restaurant corporations such as McDonalds all employ electrical and computer engineers.

Engineers also work for small companies. Many of the innovative new products coming into the market came from very small companies. The federal government recognizes the importance of small companies in fostering innovation in our economy by sponsoring programs specifically designed to aid innovative small businesses. Many engineers prefer the atmosphere in small companies where new ideas can often be brought to market more rapidly than in larger companies.

1. Power

Perhaps the way in which electrical engineering most touches people s everyday lives is in the area of electrical power. Electrical engineers are involved in many aspects of the design and building of power distribution systems. Many electrical engineers are employed by construction companies to help with the design of generating facilities. In the course of this design work, electrical engineers work closely with mechanical, chemical, and nuclear engineers. Electrical engineers are also involved in helping to supervise the construction of these plants. Once the generating plant is built, there is a need for a power distribution system to deliver the power to businesses and homes. Electrical engineers are also involved in designing the network of transmission lines used to deliver power to customers.

It is important to also mention the aspects of power distribution electrical engineers are not involved in. The actual wiring of buildings and houses is performed by licensed electricians, not engineers, although the codes that establish the standards for how this wiring is done are written by engineers.

Electrical engineers also work on the development and implementation of alternative power sources. There are many potential sources of alternative energy that are being explored including solar photovoltaics, wind turbines, and fuel cells. Much of the research and development in this area is being performed by electrical engineers.

2. Electronics

Another area where electrical engineering directly impacts the lives of consumers is in electronics. Electrical engineers designed the earliest versions of radio and television, and they continue to work on these types of products today. Circuit design has moved beyond these origins to include electronics for a wide variety of devices that impact our lives all day long. For example, both commercial and military airplanes use very sophisticated electronic circuits to help control the aircraft and to help keep the pilot aware of other aircraft in the area. Systems used to control heating and air conditioning in buildings and homes require electronic circuits to operate efficiently. Many large manufacturing companies require the services of electrical engineers to help design one-of-a-kind electronic circuits to efficiently manufacture their product. The functions of modem automobiles are controlled by a variety of electronic devices that help ensure proper engine performance, monitor problems that may occur in the engine, and control safety features such as antilock braking systems.

Electronic design engineers must have detailed knowledge about what devices — transistors, integrated circuits, or resistors, for example —are available and how to combine them into a useful circuit. In performing a design, electrical engineers must ensure that the circuit operates as planned and that it also can be produced economically, will operate efficiently, and will operate correctly for a long time. Electronics engineers must often work closely with manufacturing engineers in designing a product that does its intended job and can be manufactured easily and at a reasonable cost. Electronics engineers often use computer-based design software such as PSPICE to help in their design work.

3. Computers

Computer engineering has evolved from being one of the specialties within electrical engineering to now being a distinct engineering discipline. Because of its origins and close ties to electrical engineering, computer engineering students are still generally trained in university departments that combine both fields. Computer engineers are concerned primarily with the design of computer hardware, the circuitry that enables a computer to perform its required tasks. Hardware design involves detailed knowledge of computer architecture, the basic structure of computer systems. It would be impossible to design computers without also having in-depth knowledge of computer software, especially operating systems. Computer engineers are also responsible for designing the networks through which computers communicate with each other.

Computer engineers are employed in many different settings. Obviously, computer companies such as IBM, Gateway, or Dell employ large numbers of computer engineers. However, since nearly all electronic systems today involve some level of computer control, computer engineers find employment in a variety of engineering settings. For example, all modem automobiles have onboard computers that control the operations of the engine. The automobile industry employs many computer engineers to design these systems. Computer engineers work in teams with computer scientists and electrical engineers.

4. Electromagnetics

Electrical engineers have harnessed electromagnetic phenomena to build many useful devices. Electromagnetics refers to the propagation of information by time-varying electric and magnetic fields. The design of antennas that send and receive television or cell phone signals, the design of radars that allow aircraft to fly safely, and the development of microwave communication systems are all activities of electrical engineers working in electromagnetic. Given the breadth of devices that utilize electromagnetic, engineers working in this area will work closely with electronics engineers to ensure that the antennas used for radio signals interface correctly with the sending and receiving electronics. They will also work with wireless communication experts to help design the most efficient antennas for cell phone applications.

5. Signal Processing

The signals produced in many applications are often corrupted by the presence of electrical noise. Noise is an unwanted transient voltage or current that is present in all electrical systems. Noise can come from phenomena internal to an electrical device or from external signals that are accidentally picked up. Noise is a problem because it severely limits the ability of a device to detect interesting signals. For example, a radio signal from a distant source cannot be detected since its amplitude is smaller than that of the noise. One of the tasks of signal processing is to try to find ways to pull meaningful signals out of die noise. Signal processing can also involve developing methods for converting analog information into its digital equivalent. An analog signal can be changed to digital by sampling the signal periodically and assigning a digital number to each level of the signal. Signal processing is used to make this conversion. Oftentimes, the information that is generated this way involves a huge amount of information. Signal processing is also concerned with compressing this information - using special algorithms to reduce this data to a more manageable size and to later reconstruct the original data.

Both electrical and computer engineers find employment in signal processing. Efficient processing of signals is vital to computers, but it finds application in many other areas as well. For example, radio astronomers generate large amounts of data during scans of the sky. Electrical and computer engineers help in the development of signal processing tools to improve this process. Signal processing is also important in many medical applications. As medical devices produce data, there is a need for engineers to develop efficient means for processing and utilizing this information.

6. Image Processing

Image processing is similar in many respects to signal processing, but instead focuses mainly on the processing of information in pictorial form. Image processing involves the skills of both computer and electrical engineers. The challenges of image processing involve taking very large amounts of information - a typical image displayed on a computer screen requires megabytes of information - and making that information useful. This might involve developing methods to enhance the contrast in an image to bring out important features or altering the colors in the image to make it easier to detect important information. Storage of information also presents challenges due to the large size of image files on a computer. These files must be compressed, as discussed in the previous section, in order for them to be stored efficiently.

Image processing finds application in numerous areas. For example, engineers with image processing skills are employed by companies making medical diagnostic equipment. Their skills help to make machines that generate high-quality and easily interpreted images that help physicians make accurate diagnoses. Astronomers use image processing to take electronic images of celestial objects and process them to yield useful information. In the automotive industry image processing can be used to understand the combustion processes taking place in an engine. By using specialized optical equipment, engineers can detect the chemical processes taking place within an automobile engine. This information can then be processed to form an image of what is taking place. These types of images help automotive engineers "tune" their engine designs. Electrical and computer engineers are even employed in the entertainment industry, using image processing techniques to create special effects in movies.

7. Biomedical

The biomedical engineering field employs many different types of engineers, including electrical and computer engineers. Biomedical engineering is concerned with the engineering of new medical diagnostic and treatment tools and new processes for delivering therapy to patients. An MRI system is used to help diagnose a variety of diseases. Of course, mechanical and chemical engineers have skills that are directly applicable to medicine as well. Electrical and computer engineers contribute to this field through the design of new electronic equipment, much of it computer based, which allows physicians to do their job better. Specific skills related to biomedical engineering are electronics, signal and image processing, and computer engineering.

8. Optoelectronics

Optoelectronics is a relatively new field that straddles the line between electronics and optics. Optoelectronics experts have worked to develop optical sensors and optical emitters, including lasers. Optoelectronic components are incorporated into CD and DVD players and laser printers, all of which utilize miniature lasers. Optoelectronics has changed the way communication systems operate. Until recent, all voice and data communications were over wires or microwave links. The development of optical fiber technology has allowed for telephone conversations and data communications such as the internet to be carried over optical cables. These optical systems are faster and are able to carry more information than traditional wire technologies.

Optoelectronics experts are also attempting to change the way computers function. Currently, computers operate by directing the flow of electrons in an electronic circuit. There are fundamental limits to how fast this type of computing can be run. In the future, it is possible that computing could be performed by directing the flow of photons, the fundamental unit of light, instead of the flow of electrons. So far, efforts in this direction have only yielded very primitive computing systems, but as advances continue this will change.

9. Plasmas

Most of you are not familiar with the word plasma, or you know of it only as a component of blood. To engineers and physicists, plasmas are sometimes known as the "fourth state of matter," not exactly like a gas, liquid, or solid. For our purposes, a plasma is a collection of electrons, ions, and neutral atoms or molecules, generally in a gaseous form. Even though a plasma is gaseous, the presence of charged particles means that it behaves very differently from a gas. Plasmas are all around us. In fact, most of the matter in space is in the form of a plasma.

Plasmas also have many engineering uses. Many homes and businesses contain plasma-based devices. For example, fluorescent lightbulbs contain a light-emitting plasma of argon and mercury. Neon signs contain plasmas as well. Plasmas are also important in the microelectronics and" integrated circuit industry. Plasmas are used to etch transistor patterns into silicon to form integrated circuits. In fact, the high density of devices located on an integrated circuit is only possible when plasma etching is used during the process. Electrical engineers working in plasmas are typically employed by lighting companies such as General Electric and by integrated circuit fabrication companies such as Intel. Plasma engineers also work for companies such as Applied Materials that manufacture the plasma machines required to manufacture integrated circuits.

10. Robotics

Although robots are not utilized in the home (except in the form of toys), robotics is a very important technology in industry. Modern manufacturing processes are highly dependent on robots to perform repetitive tasks quickly and accurately. Robots are found on automobile assembly lines, integrated circuit fabrication facilities, and in food processing plants. Both electrical and computer engineers have roles in the design of robotic systems. Robots require very sophisticated control systems to ensure that they perform their tasks correctly. Robots are generally computer controlled, so computer engineers also make major contributions to the design of robotic systems. Many robots are autonomous - they carry their own power supply and are not connected to any external computers. Autonomous robots require communication systems between the operator and the robot, which are based on electromagnetic communication systems. Many specialties of electrical and computer engineering are involved in robotics.

Electrical and computer engineers working in robotics work closely with manufacturing engineers to help design robots for industrial production-line applications. They also work with mechanical engineers who are generally responsible for designing the mechanical aspects of die robot.

We have seen that there are many different specializations within the field of electrical and computer engineering. We have presented only a partial list of all the different areas of electrical and computer engineering in which you might choose to specialize. Although these specialties sometimes seem very separate, in today's engineering world, engineers work in teams, which incorporate specialists from different engineering fields as well as different specialties within each field. As you progress in your study of electrical and computer engineering, you will have the opportunity to choose a specialty depending on your interests and take a few courses in this area. Keep in mind that many of the specialties listed here did not exist even thirty years ago. And there are many specialties that existed 30 years ago that are not important today. Because electrical and computer engineering change so quickly, it is important to prepare yourself to be able to switch specialties often during your professional career. You can do this by ensuring that you learn how to learn new topics on your own.

TEXT 8

Engineering Design

1. Design versus analysis

There is a big difference between analytical problems and design problems. Analytical problems are very familiar to students. These are the same types of problems that you probably called "word problems" or "story problems" in elementary school. In engineering, analytical problems are often referred to as closed-ended problems. In this type of problem there is generally only one correct answer, often given in the back of the textbook. This is the type of problem that students are generally most familiar with and most comfortable solving. It is nice to know that there is a correct answer, and with the proper diligence, it can be found.

Design problems, in contrast, are open-ended problems. There is no unique correct answer that everyone trying to solve the problem will get. The open-ended nature of engineering design is reflected in the diversity of the marketplace. For example, there are several companies that manufacture cell phones. They are all trying to solve the same design problem - to produce a portable, handheld, global-communications device that will be economically accessible to nearly everyone. Although each of these companies is attempting to solve the same problem, the solutions they devise are different from each other, sometimes radically so. No two cell phones is identical in function, cost, capability, or appearance. Each one of these designs solves the basic problem, so all are a solution to the problem. But, are all of these solutions equally good? Of course, not. Each solution has its good points and its bad points. In this case, the marketplace ultimately decides which solution is the best. Sometimes the lack of a single right answer worries students, making work on design problems harder and more stressful than it should be. Instead, the lack of a right answer should be viewed as liberating. With a design problem, you are limited only by your creativity, and you are not forced to work within the confines of the "right" answer.

2. The engineering design process

The engineering design process can be described in many different ways. In this book, a nine-step design sequence will be presented. This basic design sequence is equally applicable to the design of hardware and software. It is important to note that this process is not linear - moving from a starting point directly to an ending point. Rather, design is an iterative process sometimes requiring that the engineer revisit previous steps as the design proceeds. This is indicated in the figure by the arrows that connect the various design steps back to previous steps.

The design process begins with deciding on the needs of the customer. In consultation with the customer, a set of specifications for the final product and a project plan are developed. Up to this point, no real "design" has yet taken place, but rather a great deal of planning and thinking about the nature of the final product has been done. The technical work begins with the development of a block design. This is a functional design, still at a very conceptual level. No actual electrical components or lines of computer code are developed at this step. Also, alternative block designs are developed and evaluated. Next, detailed designs (with alternatives) for each part of the block design are mapped out. After much work and evaluation, the best alternative or alternatives are chosen. The design is then tested to verify that it works properly, and the design is turned over to be manufactured. Finally, it is delivered to the customer. Each of these steps will now be described in more detail.

1. Decide on needs

Having an idea for a new device or product is only the very beginning of the design process. Sometimes this is done by the customer coming to the engineer with a need. Sometimes it is the engineer who has the idea or who sees the need for a new product. At this point, a great deal of thinking and research is done to determine whether the idea is feasible, whether it has already been done, and whether the idea can be sold.

2. Develop product specifications

In this step of the process, detailed thinking goes on to decide how the device should perform, how much it will cost, what it will look like, and when it will be available. Specifications are often developed in consultation with the customer. Interestingly, the specifications that are laid out at the beginning of the design process are not necessarily the same ones that will exist when the product finally hits the market. Specifications are moving targets. An engineer often finds that one or more of the specifications can't be met and must be changed in order for the project to go forward. Or, the specifications might need to be tightened in order to be competitive in a rapidly changing marketplace. Changing the specifications in consultation with the customer is a normal part of the design process.

3. Develop a project plan

The project plan is the basic road map used by engineers to efficiently complete a project. The planning stage can often take a great deal of time, but it is nonetheless essential to successful designs. The more complex the project and the more engineers involved in it, the more important good planning is. It sometimes seems like planning is wasted effort and takes time away from actually performing the design. However, careful planning actually makes the design process run more smoothly and efficiently. This is analogous to taking a long trip by car. Most of us wouldn't begin a driving trip from New York to Los Angeles without first consulting a road map. We could probably complete the trip eventually without planning and without a map. But it's unlikely we would find the fastest route this way. Much time would be wasted in wrong turns and dead ends. Likewise, engineers need to plan how to attack a problem in order to ensure that it will be successfully completed in the least amount of time.

4. Develop a block design

At first, the design is performed at a functional level rather than at a detailed level. This is often done as a block design where functional blocks and their interactions are mapped out. At this point the design is still fairly conceptual, with specific details about choices of components made at a later stage in the design process.

In any design it is essential that engineers not limit themselves to just one design concept, but rather develop several ideas simultaneously. The block-design stage is the perfect place to start this. At first, it may seem inefficient and a waste of time to work on more than one design. However, there are several advantages to working on several alternative designs simultaneously. Frequently an idea from one design will be applicable in another design, or ways to combine two designs together to form a better design may become apparent as work on several alternatives continues. Having several fairly well-developed designs can also save time later on. If the design concept that is ultimately chosen turns out to not be feasible, it is smart to have a backup design ready to be implemented in its place.

5. Generate detailed designs of each block

At this stage the engineer is ready to perform detailed designs of each of the blocks mapped out in the previous step. The design at this point is at the component level, with individual transistors, integrated circuits, or lines of software being selected. As with the block-design step, it is important to generate alternative designs at this point, too.

6. Select the best alternative

After the detailed designs are generated, it is time to select the most promising design from among the alternatives. In order to make an informed choice, engineers will now perform very detailed calculations and analysis to verify that the designs will work as planned. This might also include a circuit simulation using computer software such as PSPICE, which is capable of analyzing complex circuits. Finally, a prototype of the design will be built and extensively tested to verify that it works as planned. A final design will be selected based on this extensive analysis of how the device will perform.

7. Test and verify the design

After a prototype of the design is built, testing begins. Generally this testing is quite extensive and may include basic tests to see if the design functions as planned and meets the specifications, tests to see how long the design can be expected to last, and also tests to see how it performs in extreme conditions:, such as excessive heat or vibration.

8. Manufacture

An engineer's work doesn't end when he or she has verified that the design is working properly. The design engineer will often work closely with the manufacturing engineers to ensure that the device is fabricated properly and works as planned after the manufacturing process. Also at this stage, design modifications might be required to make the design more easy or less expensive to manufacture.

9. Deliver

The essential last step is to deliver the finished product or device to the customer.

3. A simple application of the engineering design process

Without knowing it, you have probably already used the multistep design process outlined in the previous section for making decisions in your life. For example, when you decided where to go to college, you probably went through a version of this process using many of these steps. Some will have used paper and pencil to do a "design," while others may have simply done it in their heads. To help illustrate the engineering design process, let's look at a simple example of how you might use this process in your life - the purchase of a home computer.

The first step is to decide on your needs. You won't necessarily have done this all at once, but you have probably been forming ideas about what you need for a while through seeing what computers other people have, reading about various computers in newspapers or magazines, assessing what you need for your classes, or evaluating the shortcomings of your current computer. Your needs might be for a computer with basic word processing and internet capabilities. You might also want to be able to write your own programs and need a computer capable of running C++. Depending on what you will be doing, you might want to have excellent graphics capabilities.

Once you've decided on your basic needs and made a list of them, you are ready to develop a set of specifications. These might include what type of processor the computer will have and at what speed it will operate. The specifications will include what software will be needed for the tasks you will perform and what kind of graphics card will provide you with the capabilities that you need. And, of course, the overall price that you are willing to pay will be part of your specifications. You probably will want to write down all of these specifications before you begin shopping.

Next you will develop a plan for making your computer purchase. Are you going to shop at electronics stores or a local computer specialist? Are you going to buy the individual components and build the computer system yourself? Are you going to shop for a computer on-line using your current computer? When do you want to have the purchase completed?

It was mentioned before that not every step of the design process is applicable to all situations. In the case of our purchase of a computer system, developing a block diagram and performing a detailed design are probably not applicable. The "design" work was done when you developed your set of specifications. One aspect of these two steps that is applicable is identifying alternatives. At this point, you will have decided on one or possibly a few potential systems by different manufacturers that will meet your needs. It is good to have these alternatives in mind in case your first choice is no longer available, or when you "test drive" the system it doesn't perform as well as you thought it would.

The next step is to select the best alternative. This will be based on your research by reading literature produced by the manufacturers, talking with salespersons, or looking on the Web. At this point you might find that it will be necessary to compromise on your specifications. You may not be able to get everything you want in one computer, or you may need to get fewer features in order to get the price that you want. This is part of the engineering design process - assessing trade-offs to arrive at the optimal system.

Testing and verifying your computer "design" is somewhat difficult in this example. You probably can't really see how a new computer performs until you get it home and try out all of its features. Some idea of its performance can be gained from using it at the store where you bought it. Of course, most retailers will let you return the computer up to a few weeks after purchase if it doesn't meet your needs.

The manufacturing and delivery steps in this example consist of unpacking the boxes, connecting the cables, plugging the computer in, and using it!

As you can see, the basic process by which engineering designs are carried out have a great deal of similarity to decision-making processes that we utilize every day. In a sense, you have already been an engineer for many years!

4. Example of the design process: the evolution of the internet

Now it's time to look at the engineering design process as it applies to modern technology. In this example, we will look at how the modern computer network, known popularly as the Internet, was developed. In this example, the design will not be done by an individual or even by people working for the same company. The design of the Internet took many years and the involvement of many different organizations. In describing this, the various steps of the engineering design process will not be spelled out explicitly. Nevertheless, you will be able to see how many of the steps of this process came into play as the Internet evolved.

The Internet started life as a military research project. In the 1960s, while the Cold War raged, there was a concern that during a nuclear war, a few well aimed hits on communication centers could completely disable the military's communications system and restrict the country's ability to retaliate and fight a war. The U.S. government funded studies during the early 1960s on how to solve this problem. The basic idea that came out of these studies was a network with multiple independent nodes. If such a network (or networks) could be built, then when one node in the system went down, the other nodes would still be able to function. Messages could be communicated around bad nodes, rather than be stopped by a nonfunctioning node. In the early thinking about this, each node was to consist of a high-speed computer. This thinking about a multinode network culminated in the funding of a research project by the Defense Department's Advanced Research Projects Agency (ARPA), to determine whether such a network was feasible.

In the fall of 1969, the first node of this network was installed at UCLA, with four other nodes running by the end of the year. The network was called ARPANET. This fledgling network proved its value immediately. Individual computers could be programmed from other sites, and scientists could share their computing resources over the network. The number of nodes in ARPANET grew rapidly with 37 nodes in place by the end of 1972.

One thing became apparent immediately. There was a great deal of enthusiasm among the people with access to the network for using ARPANET as a very fast post-office system. This was the origin of e-mail. Rapidly, most of the traffic on the network became messages, both work related and personal, rather than the shared computer files originally envisioned. In the early seventies, ARPANET grew, aided by its basic structure. The fact that each node was independent of the others and there was no centralized control meant that additional nodes could be added easily. Simultaneously, other computer networks were being developed, most using the same communications protocol as ARPANET.

By 1983 ARPANET had outgrown its military origins. The Pentagon became concerned with the security of ARPANET, especially since it was connected to various other nonmilitary networks. So the military uses of ARPANET were moved onto a different network called MILNET, that was independent of ARPANET. By this time, ARPANET had become only a small part of the overall computer network in the U.S. About this time the network became known as the Internet.

In 1984 the National Science Foundation developed its own network, NSFNET, designed to enhance the communication between scientists around the country. The NSFNET showed continual technical improvement throughout the late 1980s, using higher speed links to connect more powerful computers. Other government agencies got into the act as well, developing their own high-speed networks. Internet development in the 1980s culminated in the disconnecting and retirement of the original ARPANET in 1989. No one even noticed when the "grandfather" of the Internet was removed from the network. The late 1980s also saw commercial involvement in the Internet explode, as many companies and entrepreneurs began to see the vast commercial potential of the Internet.

Growth of the Internet continued throughout the nineties and into the early 21st century. Today the Internet can be accessed from nearly every home in the United States. Children access the Internet in their schools, and most businesses are on the network. There are currently hundreds of thousands of nodes in the current Internet stretching worldwide.

TEXT 9

Additional Design Considerations

There are many aspects to a good design that don't necessarily show up in the product specifications. Even though these might not be specifically mentioned when a project is initiated, a good engineer will keep these in mind as a design project progresses. Many of these fall under the heading of "accepted engineering practice." Engineers are expected to make all of their designs in accordance with this standard. A few of these other considerations will be discussed in this section.

1. Teamwork

Most engineering design projects are performed by teams of engineers working together. Often, these teams will involve many different types of engineers. For example, a team formed to develop electronic control systems for automobiles would probably have both electrical and mechanical engineers on it. Having excellent technical skills is essential for any engineer, but to be successful, an engineer must also know how to work successfully as part of a team. Rarely will an engineer be able to work exclusively by herself. In this section, some important aspects of teamwork will be discussed.

Every member of a team brings a different set of skills to a project. These might be different technical abilities or different knowledge. Each team member will also bring to the project different interaction styles and approaches to working with others. For example, some people might be very good at working on detailed technical tasks but not be very good at synthesizing the various parts of a project into a whole. Some people have good leadership skills that help move a team forward, while others are better at working on a piece of the project individually. Some people are good at communicating ideas, while others are better at challenging the thinking of other team members to help develop new ideas. It isn't important that every individual on a team be identical. In fact teams without diversity generally don't function very well. Instead, it is important to have a blend of individual traits that overall will lead to an effective and efficient team. Some companies even administer personality tests, such as the Myers-Briggs type indicator test, to its employees to aid in finding the right blend of individuals when forming teams.

Every team needs people who are competent in the technologies pertinent to the project, but successful teams also need people who are task oriented, who strive for high quality, and who are goal oriented. Teams also need people who are flexible and who can see the "big picture," rather than just the details. All teams need good communicators who can ensure that written and oral reports convey the required information and who can also ensure that everyone on the team understands the project goals. The communicators also facilitate the participation of everyone on the team. It is nice to have someone on the team who is constantly challenging the methods and ideas of the group and the way the project is being handled. All of these traits don't generally show up in any one individual or in all of the team members. On effective teams, there is a blending of personality types that results in all of these traits being present in the team as a whole.

What are some of the characteristics of effective teams? Effective teams are those that have good leadership and a clear purpose. They work informally and have open discussions with an agreement that any disagreements will be civilized and not personal. In good teams everyone participates and everyone listens to other team members. There are very clear roles and work assignments for every team member. And generally, effective teams have a blending of different personal styles.

2. Concurrent engineering

In the previous section it was mentioned that engineering design projects are generally performed by teams of engineers. Often, these teams are multidisciplinary in that there are different types of engineers - electrical, computer, mechanical, or manufacturing - working on the same team. In most corporations today, the engineering design process is performed using a method called concurrent engineering, which is the topic of this section.

In the typical old models of the engineering design process, various tasks were handled sequentially. Engineers were grouped according to specialties, mostly within academic disciplines, such as electrical or mechanical engineering. For example, electrical engineers working for a large corporation might be grouped into departments with names such as digital design, antenna design, or analog design. They would work mostly with other electrical engineers. Of course, the successful completion of a project would require that the engineers interact with other engineers from different departments, but this was typically done at meetings between the two groups.

To illustrate how this system worked, let's look at a part of the design process for a hypothetical computer. The initial block diagram for a new computer would be done by an electrical engineering group. This design would then be passed along to a software design group, which would develop the initial block diagrams for the software. After the software blocks were ready, the electrical engineering group would make the necessary modifications to their block diagrams and begin the detailed design. Simultaneously, the software group would design and develop the required software. Once the detailed electronic design was completed, the plans would be sent to the group who designed the case for the computer. If any problems occurred, there would be meetings between the two groups to reach a solution. Once the plans for the case, the hardware, and the software were completed, the design would be passed to the manufacturing group to ensure that there were no problems with building the system as designed. This process continued with various groups becoming involved as needed until the final design was produced.

This model for the engineering organization had its efficiencies. For example, grouping engineers together by discipline allowed engineers to specialize and become very good at their area. They could also easily help each other out - there was generally another engineer of the same type sitting at the next desk. The disadvantage of this system was that often the time required to complete a design was very long, slowed down by the need to pass the design along from one group to another as new aspects were added. There was not always a group of engineers who had the "big picture" in mind.

The concurrent engineering model changes this completely. In concurrent engineering, the design is performed by multidisciplinary teams. A multidisciplinary team tasked with designing a computer might include digital circuit engineers, power supply engineers, plastics engineers, and software engineers working together on the same team from the beginning of the project. Generally, manufacturing engineers are included on the team as well, to ensure that manufacturing problems are addressed at the beginning of the design process rather than after the design is completed and is ready for manufacture. With concurrent engineering, design teams often include nonengineers as well. Marketing experts or purchasing specialists might also be included on the team to avoid problems in these areas. Sometimes, customers are even invited to participate in the design process as team members to help ensure that the final product will be acceptable.

Concurrent engineering has been shown to greatly reduce the time required to bring a new product to market. This reduction has come about chiefly through addressing issues early in the design cycle that would otherwise not be addressed until the "other" engineers were sent the design. Although the changeover to concurrent engineering has not taken place everywhere yet, most major engineering employers now perform design according to this model. It is important, even at this early stage of your career that you learn to appreciate what other types of engineers do and learn how to work on multidisciplinary teams.

3. Safety

Often, issues of safety are not explicitly mentioned in the specifications for a new product. However, it is expected that all products meet minimum standards of safety. It is neither legally nor ethically acceptable for an engineer to participate in a project that is not safe. The code of ethics of the IEEE states explicitly that an engineer is responsible for ensuring the safety of those who will use his or her designs.

Deciding what is safe and what is not is a big challenge for engineers. There are many legal requirements and safety standards that an engineer is required to follow, and these provide a good foundation for producing safe designs. Often, a design is in a new area where little is known about safe design. How does an engineer deal with this? First, an engineer must recognize that nothing is 100% safe. There are ways that any product can be misused, and there are often unanticipated failures in a design. It is the engineer's job to try to anticipate and prevent these things.

How can products be engineered to be safe? Making a design safe should be a natural outcome of the design process. As was mentioned in the basic steps of design, several alternative designs should be generated as part of normal engineering. As each of these designs is evaluated for its ability to meet the specifications, it should also be evaluated for its impact on safety as well. As die decision is being made regarding which alternative to pursue, safety should be given equal weight with all of the other design considerations.

4. Environment

As with safety, the protection of the environment is also an important consideration in any design. The IEEE code of ethics requires electrical and computer engineers to produce their designs in accordance with sound environmental principles. This includes ensuring that the generation of hazardous wastes during the production process is minimized. It is also important to ensure that once the product has exceeded its useful life, there are ways to recycle it or to minimize its negative impact on the environment during disposal.

5. Design for testability

Often, the specifications for a product will spell out the test procedure that will be used to verify that the product works as it is supposed to. It is up to the design engineer to ensure that the product is designed in such a way that the testing can be performed easily It's a good idea to place easily accessible test areas throughout the device, especially on the prototype. This makes it easy to troubleshoot the design or even fix it later. By incorporating testability in the original design, the whole design process can be made more efficient.

6. Design for manufacturability

In today's marketplace, where new products must be brought out in increasingly short times, it is essential to incorporate manufacturability into designs from the start. One of the major costs of producing a product is the cost of assembly. There are many designs that amply meet the specifications, but are not easily assembled. Anything that is complicated to assemble requires specialized and expensive workers, adding cost to the overall design. So design engineers must work closely with the manufacturing specialists to incorporate manufacturability into the design. This often means that at the stage where design alternatives are being evaluated, one criterion that should be used is manufacturability, even though it is not likely to be mentioned in the specifications.

7. Esthetics

Esthetics in a design is often felt to be in the realm of artist, not engineers. However, as mentioned before, engineering is an inherently creative enterprise, so engineers should also consider the esthetic aspects of their design. Much of the pleasure of being an engineer comes from seeing your design work well and succeed on the marketplace. Engineers often describe the "warm feeling" they get when they first plug in their new design and see it work. Much satisfaction can also be derived from performing designs that are pleasing to the eye. This can involve laying out components in a pleasing manner or helping to design a unique looking case for a new product. Although esthetics are rarely included in the specifications, it is easy for the engineer to include this in her design and to use it as one of the criteria, although perhaps a lower level one, when choosing among alternative designs. Having good technical skills is almost worthless without also having the ability to effectively communicate the results of your work. Frequently, engineering students believe that only their technical skills matter, and therefore they don't focus much on courses involving communication, such as writing and composition or speech. This view could not be more wrong. Engineers who wish to advance within their profession must also possess high-quality communication skills. Many of the interactions that engineers have with their manager and nearly all of the interactions with higher levels of management occur through memos, reports, or formal oral presentations. Engineers who don't present themselves effectively on paper or in a presentation will be the last to receive promotions and indeed will find it hard to get hired in the first place. Engineers are also responsible for interacting with customers, suppliers, or government agencies. Doing this effectively requires good communication skills. Engineering information is communicated through various types of written documents and drawings. In this section, we will look at various types of engineering communications in depth.

8. Engineering logbooks

One type of communication that engineers do is designed only for the engineer himself. Logbooks, sometimes also called lab books, are a means for recording all the work done on a project in a single place. The engineer uses the logbook to record all calculations that were made, detail all of the design work, record test data, and even to record information about meetings and contacts with suppliers or customers. Generally, the engineer is the only one who will see the logbook, although some companies insist on keeping logbooks when an engineer leaves the company.

At first, it may seem tedious and inefficient to do all of your work in a logbook. However, it is generally very helpful later on to have all of the data pertinent to a project recorded in a single place. This makes it easier to find information about the project later on when the details about it may be hard to remember. Keeping information in a single book is far superior to keeping it on individual sheets of paper that can become lost or destroyed. One important function of a logbook is to satisfy the legal requirements for defending a patent. If there is a dispute about who has invented something first, courts often examine logbooks. If the logbook appears complete, with dated entries, and nothing erased or removed, it will aid in establishing whose work came first.

9. Memos

Perhaps the simplest and most often used form of engineering communication is the memo. Although memos tend to be short, the fact that they are used so often makes them a very important document for engineers. Memos are used for a variety of purposes, including setting up meetings, soliciting information from other engineers or suppliers, and briefly communicating the status of a project. Memos might be written to your manager or to other members of your organization. Memos are generally written by the individual engineer.

10. Progress reports

Often, a customer or manager will require that the engineers provide periodic progress reports. These reports detail what has happened during the reporting period and what work is contemplated for the next period. This type of report provides good channels of communication between the engineer and his customer or between the engineer and management, and it allows for timely reporting of any problems that may come up. Periodic reports may be weekly, monthly, yearly, or any other convenient period. Depending on the type of report and to whom it is sent, an engineer generally prepares this report herself.

11. Feasibility studies

A feasibility study is a much longer document than the previous two. Early in a project, engineers might be required to assess the feasibility of a project and write a feasibility report on their results. A feasibility study requires a lot of background work and preliminary design to answer the important questions about whether the contemplated project can be done, whether it makes economic sense to pursue it, and whether it can be done in a reasonable amount of time. A feasibility study is often sent to a potential customer or upper management of the engineers company.

12. Proposals

In order to begin a project, engineers must often complete a proposal. This is a detailed document laying out die plans and costs to complete a project. Proposals frequently go out to potential customers or to higher levels of management within the company to obtain permission and resources to start a new project. Generally, a customer has received several competing proposals. Although technical considerations are usually most important, the proposal that is most effective in presenting the ideas will garner more consideration. In many companies, especially larger ones, engineers work closely with technical writers to produce high-quality proposals.

13. The engineering design report

After a project is completed, an engineering design report is frequently prepared. This is a detailed report on how die design was done and how well it worked. The report might be prepared for the customer who paid for the design, or it might go to the upper management of your company. The engineering design report contains information on the problem being addressed and any background information that was used in working on the design. The report provides information on how the design was performed, how it was tested, and what test results were obtained. The engineering design report might also include recommendations for improvements to the design.

The engineering design report is valuable to the customer, since it gives the information required to modify the design at a future time or to make any needed improvements to the design. It might also be useful to the engineers own colleagues who might need to do a similar project in the future. It can even be useful a few years later when the engineer is asked to do another similar design; having the old report helps prevent "reinventing the wheel." In larger companies, technical writing specialists will be responsible for writing this report, although the engineers who worked on the project will help with the writing process.

14. Technical manual

Often, a customer will ask for a technical manual, sometimes called an owner's manual. This differs from the engineering design report in that the focus is on how to operate and maintain the device rather than on how the device was designed. A good technical manual will teach the customer how to use the device properly, will show the customer how and when to perform routine maintenance, and will allow the customer to perform simple troubleshooting and repair should there be a problem. Like the engineering design report, the technical manual is generally prepared by a technical writer with significant input from the engineers.

15. Engineering drawings

Frequently, the best way to convey engineering information is through a drawing. The most commonly used type of engineering drawing in electrical and computer engineering is the schematic diagram, which is a symbolic representation of electrical components and the way they are interconnected.

Schematics show what components are to be used in a design, how they are interconnected, and what types of voltages or waveforms should appear at various places in the circuit. Schematics allow the designer to visualize his thoughts about the design, and also to allow other engineers to understand a circuit and technicians to properly build the circuit. A schematic drawing is indispensable for anyone trying to repair a circuit that is not working correctly.

16. Oral presentations

Engineering communication can take the form of oral reports. These can be as simple as an informal presentation at a department meeting, or as formal as a talk at a meeting of an engineering professional society. There can also be oral versions of many of the written documents that were described previously. For example, an engineer might be asked to give an oral proposal to a potential customer or to higher management in addition to the written proposal. These oral reports are generally fairly formal. It is important for an engineer to be able to communicate effectively orally as well as in writing.

TEXT 10

Creativity

It was mentioned earlier that engineering is an inherently creative profession. Bringing a design from concept to finished product requires new solutions and new ideas. Although some people seem to naturally be highly creative, everyone can learn methods to help enhance their creativity. In this section, a few ideas on opening up creativity will be presented.

We will start by discussing the implications of the split-brain theory on the creative process. The human brain is divided into two halves, called for convenience the right side and the left side. Scientists who have studied the brain have found that various human activities are housed on different sides of die brain. For example, in right-handed persons the left hemisphere of the brain tends to concentrate verbal and symbolic logical reasoning skills. The right hemisphere concentrates the spatial and holistic reasoning processes. (This is opposite in left-handed people.) Educational processes are dominated by left-brain learning, mostly because these types of activities are easier for a teacher to evaluate and measure. Most of the courses you will take in engineering will emphasize these types of left-brain activities. However, engineering design also requires right-brain processes, especially holistic analysis and synthesis.

Let’s look at a few words that can be used to describe the two sides of the brain. Attributes of the left side (in right-handers) are precision, logic, linearity, and order. The right side can be described as experimental, imaginative, creative, and risk taking. Clearly both sides of the brain will be necessary to produce a successful engineering design. Not only are the right-hemisphere skills not generally taught or developed in traditional educational settings, but some would argue that these skills are suppressed. How, then, can an engineer develop some of these skills?

To answer this question, let's first look at some things that can stifle creativity.

- *Habits*. Often, we are so set in our ways that we don't entertain any creative or new thoughts for very long.
- *Fear of failure*. Sometimes, we are so scared that we will fail or our ideas will not work, that we suppress these new ideas.
- *Cultural blocks*. Often, the culture of our organization does not value creativity, but instead emphasizes doing things the same way they have always been done.
- *Narrow-mindedness*. Many people think very narrowly and can't "think outside of the box" to look at things in new ways.
- *Negativity*. Many good ideas have been stifled by colleagues who feel threatened by new ideas or who are not themselves capable of creative thinking. You have probably already encountered many of these stiflers of creativity in your life.

The first step to opening up creativity, both individually and for a team, is to recognize the stiflers of creativity that you encounter. Once you understand their nature, many can be overcome or worked around to help open up creativity.

Other solutions range from the personal to the institutional. An easy personal way to open up creativity is to spend some time eating and writing with your nondominant hand. By exercising the other side of your brain this way, you can often stimulate the underused creative side of your brain. Another easy way to open up creativity is to engage in "information gathering." Look at a diverse set of materials to get new ideas and to broaden your thinking. This can be done by looking at different magazines or journals than you normally do, by surfing the Web, or just by asking questions of new people.

Opening up creativity in a team environment is sometimes a little harder, since there are more people involved. The best way to accomplish this is through a process called brainstorming, where the team meets for the sole purpose of coming up with new ideas. The idea is for die team to be freewheeling and to let the new ideas flow. To accomplish this, it is important to not criticize or evaluate the ideas during the brainstorming session, as this might inhibit some team members from contributing. There is plenty of time to evaluate the ideas later. Even wild ideas that would never work may stimulate a useful idea from a different team member. After the ideas have dried up, then the evaluation period begins. Here some ideas are thrown away, while others are combined or modified. Although this may seem like an inefficient use of time, the best new ideas often come out of brainstorming sessions like this.

TEXT 11

Intellectual Property

In the course of design work, engineers often generate intellectual property, which is information that gives the company a competitive advantage over other companies in the same business. Often, when a new company is starting and seeking investors, the first thing potential investors look for is whether the new venture has sufficient intellectual property to be competitive and survive. Intellectual property takes many forms, including information about new designs and processes, financial practices of the company, or even information about corporations customers and suppliers. Corporations protect their intellectual property by various legal means, including maintaining trade secrets, patents, copyrights, and trademarks.

Trade secrets are perhaps the most fundamental type of intellectual property. Keeping information within a company prevents any outsiders from benefiting from it. Much of the information that an engineer handles in the course of her work will be labeled "proprietary," "for internal use only," or "secret." When hired by a company, employees frequently are required to sign an agreement specifying that they will not divulge this sort of information to anyone outside of the company. A legendary example of this (and it may be more legend than true!) is the formula for Coca-Cola. It is said that this formula is a closely held trade secret, known to only a handful of people. Similarly, the computer chip manufacturers such as Intel closely guard information on chip yields (the number of good devices on a semiconductor wafer compared with the total number of devices fabricated) so that the competition will not know how well their processes work. If a secret is successfully held within a corporation, this is the best way to protect intellectual property.

A patent is a grant by the United State government (or other governments) giving an inventor the right to exclude others from making, using, or selling the patented invention for a specified period of time. Currently, this protection lasts for 20 years from the date that a patent is first filed. Although a patent gives exclusive rights to the inventor, sometimes obtaining a patent is not the best way to protect intellectual property. The government requires that all patents be published and accessible to everyone. By doing this, you tell the competition what you are doing and allow them to invent their own variations on your patent. Patents are granted to the original inventor, who must be a person, not a corporation. Rights to a patent may be assigned to a corporation, and indeed most companies require employees to assign patents that are generated in the course of their work to the corporation.

There are two types of patents: design patents and utility patents. Despite the name, design patents cover only the appearance of an invention, not its structure or utility. Design patents only run for 14 years. An example of a design patent would be one for the unique appearance of a computer monitor, but the patent would not cover the electronics inside.

Utility patents cover mechanical, chemical, or electrical inventions and can include devices, products, and processes. What can a utility patent be issued for? New and useful processes, machines, manufactures, compositions of matter, or biotechnology can be patented. New and useful improvements on things that have already been patented may also be patented. In order to be patented, things must be useful and operable. Perpetual-motion machines violate the basic laws of thermodynamics, are not "operable," and therefore are not patentable.

What cannot be patented? There are many categories of things that cannot be patented. Devices that have already been invented by someone else (even if they didn't bother to obtain the patent) and devices already for sale or described in a publication more than one year prior to the filing date of the patent cannot be patented. Methods of doing business cannot be patented, nor can the basic laws of science. (Imagine the impact on society if someone were granted a patent for Newton's laws of gravitation!)

Recently, the U.S. patent office began issuing patents for computer software. In the past, software was not patentable, yet, software companies felt the need for some protection for their products. It was never clear whether copyright law was the proper protection for software either. This is an area of law that is still developing and will be unclear for a few more years.

Copyrights exclude others from copying or using your creative work. Copyrights cover books, works of art, music, photographs, and even notes. This type of intellectual property protection is less often used by engineers, although as mentioned before computer software is sometimes protected through copyright. Copyrights have much longer terms than patents, generally for the lifetime of the author plus a fixed number of years thereafter.

A trademark is a mark, word, or symbol that is applied to commercial goods. If the commerce is across state lines, then federal registration of die trademark is possible. Trademarks are unique symbols or product names that a company wishes to retain for its own exclusive use. Trademarks are granted for a period of 10 years, but can be renewed indefinitely as long as the company keeps using it. Trademarks are more often of interest at a corporate and marketing level and rarely are important to an engineers' work.

TEXT 12

Computer Applications

As computer systems become more intelligent, they are used in a wider variety of work situations where previously it was necessary to employ people. Hospitals can increasingly use computers where highly trained people were required to deal with life-threatening situations. Computers can also be used in airports where highly trained experts were previously required to ensure safety and the police can make more use of computers to detect and investigate increasingly sophisticated crimes.

One of the uses considered in this unit is police speed traps used to catch drivers that are breaking the official speed limit. In earlier systems, radar equipment was used to bounce radio waves off the moving car. A small processor, known as a microprocessor, calculated the speed of the car from the changes in the radio waves and triggered an ordinary camera with a flashgun to take a photograph of the car if it was speeding. The details were stored on a smart card (a plastic card with a built-in computer system that can store large amounts of data). When the smart card was taken back to the police station, the driver's details were obtained from the DVLC (Driver and Vehicle Licensing Centre) database i.e. the central computerized records of all licensed drivers and vehicles.

Newer systems prevent 'surfing' i.e. where the driver only slows down as they pass through the speed trap, by using two computerized units with digital cameras placed at a fixed distance apart. Each unit records the time that a vehicle passes it, as well as photographing and identifying the car license number using OCR software (optical character recognition software that changes picture images of letters and numbers into digital form for use by a computer system).

The computer then uses the difference in recorded times to calculate the speed of the vehicle. The registration numbers of vehicles exceeding the speed limit are immediately downloaded (copied from the computer to a server computer) to the computer at police headquarters where each vehicle is matched with the DVLC database. Standard letters are then printed off addressed to the vehicle owners using mail merge (a word processing feature that produces a separate standard letter containing details obtained from each record in a database).

There are many ways in which computer systems can be used in large supermarkets, particularly for financial calculations and in stock control using EPOS tills (electronic point of sale cash tills). Each item on a supermarket shelf has a barcode label with a barcode (a standard set of vertical bars of varying thickness used to identify products) printed on it. The barcode number system giving standard price and item code numbers used throughout Europe is known as EAN (European Article Number). The barcodes are read by scanner devices called barcode readers that are attached to the EPOS tills. When a checkout operator moves the barcode label across the scanner, the label is scanned and the barcode number for that item is read. The scanner signals are converted to a digital form (where the changing signal is either off or on) and sent to the supermarket branch computer. The branch computer checks the digital EAN code against a computer database (a type of applications program used for storing information so that it can be easily searched and sorted) that holds a record of each type of item. In this way the item and the price of the item can be identified and the sale of the product can be recorded by the computer. The item and the price are shown on the EPOS till display and printed on a paper receipt.

Computers are also used to provide cash to users and to process bank cards such as Visa cards using an ATM (automatic teller machine - the type of machine used by banks for enabling customers to withdraw money from their bank accounts).

TEXT 13
Peripherals

EPOS (electronic point of sale) tills used in supermarkets form part of a computer system with various input and output peripheral devices attached to the till, including: electronic scales for weighing produce, barcode reader for looking up prices using barcodes, swipe card reader for reading bank cards, numeric keypad for inputting prices manually, LCD (liquid crystal display) screen for outputting purchase details.

Digital cameras are gradually being developed that are as good as conventional cameras. They have various electronic devices inside, including:

- LCD (Liquid Crystal Display) screen used as a view-finder and for viewing the pictures after they have been taken.
- CCD (Charge-Coupled Device) consisting of thousands of photo-transistors (light-sensitive transistors — a transistor is an electronic switch). It creates the pictures as a set of dots or pixels (picture elements).
- Memory cards e.g. flash cards — solid state memory (electronic integrated circuits, i.e. chips, used for storing the pictures).

There is no delay in getting pictures from digital cameras because there is no film requiring chemical processing. They can be attached to a computer to directly transfer pictures for editing using special software and unwanted pictures can be deleted. Two important features when buying a digital camera are:

- picture quality or resolution. The resolution of a camera is measured in pixels and given as two numbers, indicating how many pixels there are across the image and how many going down the image e.g. 1280 by 960 (or 1280 x 960).

- the number of pictures the camera can store. The higher the resolution, i.e. the more pixels, the more memory is required to store the pictures. Data can be compressed to allow more pictures to be stored.

Storage devices are used to store data and programs that are not being used by the processor. They usually consist of:

- storage media in the form of a circular disk or a tape where the data is stored
- a disk or tape drive that moves the media past a read/write head that reads the data from and writes data to the storage media.

Types of storage devices include:

- magnetic devices (that use magnetism) - magnetic tape made of a magnetic coated flexible plastic; hard disks made of magnetic coated aluminium disks.
- optical devices (that use laser light):
    - CD-ROM - compact disk read only memory
    - CD-/+RW - re-writable compact disk
    - DVD-ROM - digital versatile disk read only memory
    - DVD-/+RW – re-writeable digital versatile disk CD-MO
- electronic devices USB flashdrive - CD-MO- electronic flash memory that acts like a disk drive

Read and write media enable the user to both read data from and write data to the media. Read only media can only be used for reading data, i.e. the stored data cannot be changed in any way. Removable storage enables the user to change the media and transfer it to another computer. Fixed storage does not allow the media to be changed or transferred to another computer.

Other factors that vary between storage devices include:

- the speed at which the drive moves the media past the read/write head and reads or writes data to the storage media
- the capacity of the media i.e. how much data can be stored on each disk or tape
- the cost of the drive and the media.

There are various types of printers for outputting text and graphics to paper. Some types of printers are mono (print in black and white only) and others can print in colour. The speed, quality and cost of printing varies between different types of printer. Some are designed for printing text and are not really suited to printing graphics.

- Data can take many forms and there is a wide variety of input, output, storage and communication peripherals. Units of measurement used in data storage include:
- bit - a binary digit i.e. a 1 or a 0
- byte - 8 bits = 1 character i.e. a letter, numerical digit or a punctuation mark megabyte (MB) - 1,048,576 bytes (approximately one million bytes)
- gigabyte (GB) - 1,073,741,824 bytes (approximately one thousand million bytes) terabit - 1,099,511,627,776 bits (approximately one thousand gigabits)
- micron - one millionth of a metre
- angstrom - the approximate radius of an atom

TEXT 14

Operating Systems

The OS (operating system) is the set of computer programs that allow the user to perform basic tasks like copying, moving, saving and printing files. It also provides an interface between (i.e. provides communication between) applications programs (e.g. word processors or spreadsheets) and the computer hardware. As a user interacts with an applications program on the screen, the applications program communicates with the operating system and the operating system communicates with the computer hardware. The work of the operating system takes place in the background and is not always obvious to the user.

The most important program in art OS is the supervisor program. It remains in memory all the time that the computer is operating, and manages the OS. It loads other parts of the OS into memory when they are needed. Programs that remain in memory while the computer is in use are known as resident programs. Programs that only, stay in memory while they are being used are known as nonresident programs.

Some operating systems are command driven (i.e. the user runs a program by typing. When the command is typed at the prompt and the Enter key is pressed, the command is processed and the output is displayed on the screen. OS commands are usually short words or abbreviations (e.g., date, logout, password).

Unix is a command driven operating system used on all sizes of computers, but mostly large multi-user, multi-tasking mainframe computers. It is available in many versions, such as Linux, Minix, HP-UX, Xenix, Venix, Ultrix, A/UX, AIX, Solaris and PowerOpen. Other command driven operating systems mentioned in this unit include: VAX/VMS, MVS VM OS/390, NetWare and Linux.

Some operating systems have a GUI (graphical user interface) that allows the user to use a mouse to click on icons on the screen or choose commands from a list of choices known as a menu. Operating systems with graphical interfaces mentioned in this unit include: MacOS, Linux, Windows XP, BC OJ, Palm and Windows Media Centre Edition.

TEXT 15

Multimedia

Multimedia is the term used to refer to a combination of text, graphics, animation, sound and video.

MP3 (MPEG Audio Layer 3) is a standard way of storing compressed digital audio files (usually music). Digital audio is created by sampling sound 44,000 times a second and storing a code number to represent each sound sample. The files are compressed by removing any sounds that are inaudible to the human ear, making them much smaller than files created using other digital audio storage standards, such as WAV. The size of an audio files commonly measured- in megabytes (MB) (millions of bytes). The frequency of a sound is measured in kilohertz (kHz) (thousands of cycles per second). MP3 files have extra code added, called tags that give the user information about the file e.g. the performer's name, a URL (uniform resource locator i.e. a web address) or a graphic such as an album cover.

Because of their small size, MP3 files are more suitable for transferring across the Internet (the connection of computer networks across the world). Some Internet websites (sets-of related pages stored on a Web server on the World Wide Web) are devoted to providing MP3 files for downloading (copying from a server computer to a client computer). The user can create their own music compilations (combinations of files) by listening to each file using a computer program, such as Windows Media Player, and choosing what files to download. They can then use a computer program called an MP3 player to listen to the files and control the sound. MP3 players let the user group songs into play lists and randomize the selections. They also have sound control features such as spectrum analyzers, graphic equalizers and frequency displays. A track info button allows the user to see the information stored in the MP3 file tag. The appearance of MP3 players can be changed using programs called skins (or themes). MP3 players often include a program, called a ripper, that lets the user rip (extract) a song from a CD (compact disk) and convert it to a standard WAV file. Another program called an encoder is used to convert WAV files into MP3 files or vice versa. Recorder programs are also available that enable the user to create audio CDs using a writable CD-ROM drive. Special MP3 player devices are also available that enable the user to listen to MP3 files without a computer.

MIDI (Musical Instrument Digital Interface) is a standard way of connecting musical instruments, music synthesizers and computers. A piece of electronics called a MIDI interface board is installed on each device to enable the device to communicate using MIDI standards. As music is being played, it can be displayed on a monitor screen as a musical score, then edited using a computer program that uses all the features of a mixing desk (an electronic device for mixing sounds together), stored and printed. MIDI systems do not store the actual sound. Instead the sound is encoded (stored as MIDI messages) in the form of 8-bit bytes (units of capacity equal to eight binary digits i.e. Is and Os) of digital information. A bit is a binary digit i.e. a 1 or a 0, and a byte is a group of 8 bits. The MIDI messages commonly consist of instructions that tell the receiving instrument what note to play, how long and how loud it should be played, including a number that indicates which instrument to play. Each instrument is represented by a different number e.g. 67 is a saxophone.

A DVD-ROM, commonly referred to as a DVD (digital versatile disk - previously known as digital video disk), is a development of CD- ROM (compact disk read only memory). It is an optical storage media (a storage media that uses laser light to store data) that provides large amounts of storage space for multimedia files. A DVD-ROM drive (a storage device for reading DVD disks) uses blue laser light (rather than the red laser light used by CD-ROM drives) to read information from the disk. Both sides of the disk can be used for storing files and each side can have two separate storage layers. The data transfer rate of a DVD (the speed that data can be read from a DVD) is also faster than that of a CD-ROM. The capacity of a DVD is commonly measured in gigabytes (GB) (thousands of millions of bytes).

MPEG is a method of compressing and decompressing video signals. MPEG stands for Motion Picture Experts Group, an organization that develops standards for audio and video compression.

TEXT 16

Computing Support Officer

Computing support involves setting up and maintaining computing systems, troubleshooting hardware and software problems and training computer users.

A hard disk drives is used for storing programs and data as separate files. Windows Explorer is the name of the program included with Microsoft Windows operating systems for managing stored files. The program opens in a window which if divided into two parts called panes. The line separating the panes is called a divider and can be moved, using a mouse to change the size of the panes. Using a program such as Windows Explorer, the user can divide the drive into virtual storage areas called folders (or directories) and give each folder a different name (or label). Each folder can contain other folders called subfolders (or subdirectories). The user can then copy or move files into different folders and subfolders. Windows Explorer displays drives and folders in the left-hand pane (called the navigation pane) in the form of a tree diagram with the folders indented below the drive they are stored in and subfolders indented below the folder they are stored in. A small box called a toggle box with a + (plus) or – (minus) sign inside is displayed in the box, the folders and subfolders. When a + is displayed in the box, the folders and subfolders inside the drive or the folder are hidden (in the text in this unit the Computing Officer refers to this as the drive being compacted). When the user clicks on the box, the folders and subfolders stored in that drive or folder are displayed with lines known as guidelines indicating what folders belong inside what drives. The toggle box sign also changes to a minus. Therefore, by clicking on the box, the user can expand and contract the display to show or hide folders and subfolders.

To create a new folder, the user uses the mouse to select the drive or folder that will contain the new folder. They then click on the File button on the menu bar at the top of the screen. This opens the File menu and they choose the new option on the File menu. They then choose a Folder from the submenu. This creates a folder called ‘New Folder’ inside the drive or a folder that was selected at the beginning and gives the user the option of renaming the new folder. When a particular drive or folder is selected, the folders, subfolders and files it contains are displayed in a similar tree diagram in the right-hand pane. The user can drag files from one folder to another on the screen using the mouse. To do this they select the file and hold down the left mouse button. As they move the cursor with the mouse, the file moves with it. They can drop a file into another folder by moving the cursor over the name of the folder and letting go of the left mouse button. The user can reverse a change they have made by using the Undo command on the Edit menu on the menu bar at the top of the screen.

The main operating system's background screen is called the desktop. In Microsoft Windows operating systems, the desktop has a bar along the bottom of the desktop called the status bar. This is used to indicate what programs are currently open. By changing the status bar property setting, it can be made to only appear on the display screen when the cursor is moved down to the bottom of the screen. It disappears again when the cursor is moved away from the status bar. At the far left of the status bar is a button icon called the Start button. Clicking on the start button causes the Start menu to open up. By selecting the Programs on the start menu, users can normally select the Windows Explorer option on the submenu to start the Windows Explorer program. Another way of starting programs is to choose the Run command option on the Start menu. This opens up a dialog box (a message window with different options for the user to choose) with a text box and some command buttons inside it. The user can then start a program by typing the name of the program file in the text box and clicking on the OK command button.

TEXT 17

Digital Electronics

Electronics can be roughly divided into two areas: analog electronics and digital electronics. In analog electronics, the signals of interest can take on any values within a large range. For example, the output of an amplifier might be any voltage between - 5 V and +5 V. Digital electronics is based on the binary number system, and the outputs take on only two values. These two values are used to represent either a one or a zero. During switching, voltages in digital circuits might have intermediate values, but the voltages of main interest are those corresponding to a one or a zero. Digital electronics is the basis of operation of computers.

1. The Binary Number System

In a computer, numbers are represented using the binary number system, or base 2. In the binary system, all numbers are represented by only two numerals, 0 and 1. In contrast, most of the math that you are familiar with is decimal, or base 10. The reason computers utilize the binary system is that transistors, internal to a computer chip, act as simple switches - they're either on or off. This makes representing information as either a one or a zero very useful. So, the use of binary numbers is driven by the available electronic technology. All decimal numbers can be represented by an equivalent binary number, so using the binary number system does not limit the ability of a computer to make calculations.

2. Logic Families

There are many ways to implement logic circuits. Each is characterized by different ways of connecting transistors together, different power supply voltages, and different voltages corresponding to the logic-one and logic-zero levels. Each type of implementation is called a logic family. Each family consists of numerous different integrated circuit chips, but within the family, the type of circuitry and voltage levels are the same. This is an important concept since only chips within the same family are compatible with each other. Chips from different families can be used together, but additional circuitry to buffer die voltages from one chip to another may be required. The most commonly used logic families are TTL (transistor-transistor logic), ECL (emitter-coupled logic) and CMOS (complementary metal oxide semiconductor). As you progress in your career, you will learn more about each of these logic families and how they work.

When designing a circuit, how do you choose from among these different families? The choice of a logic family depends on the requirements of your application. Each family has different switching speeds, different power consumption, and different voltage levels. The application usually determines the best logic family to use.

3. Simple Logic Functions

A complete description of all the functions that can be implemented using digital logic circuits would be a book in itself, so we won't attempt to do that here. Rather, we will look at a few

Perhaps the most basic logic function consists of taking a 1 and turning it into a 0 or taking a 0 and turning it into a 1. This very important function is implemented using a circuit called an inverter. The function of this and other logic circuits is generally presented using a truth table, which shows what the output is for various inputs. Rather than presenting voltage levels, a truth table shows logic functions only in terms of 1s and Os. This way, the truth table is the same regardless of the logic family chosen. Notice that an inverter is only a two-terminal device. There is a single input and a single output.

Another simple, yet very important, logic function is called the AND function: The AND is defined as: The output of an AND gate is a one only when both of the inputs are a one. If any of the inputs is a zero, then the output is a zero. The simplest AND gate is a two-terminal AND gate. AND gates with more inputs are possible, but there is always just a single output.

The final basic logic function that we will look at is the OR function. The OR is defined as: The output of an OR gate is a one if any of the inputs is a one. A zero will appear at the output only when all of the inputs are zero. As with AND gates, OR gates can have multiple inputs, but always have just a single output.

TEXT 18

Engineering Tools for Computer Engineers

1. Computers

Computers have become an indispensable tool in modem laboratories and engineering workplaces. Many laboratories, both at universities and in industry, are equipped with computers that can be used to control electrical test equipment, such as meters and oscilloscopes, and can record measurement parameters and test data. These computers can be used to coordinate the activities of several test equipment tools through a local network. Often, engineers must write simple computer programs that enable computers and test equipment to "talk" to each other. Computers can also be used as virtual instruments, simulating the properties of real test equipment.

2. Application software

Electrical and computer engineers use a vast array of computer software in the course of their work. Software tools are used to aid in designing new devices, to analyze the operation of existing devices, and to help with tasks such as analyzing data. Computers can even be used to run experiments and tests. In this section we will look at some of the types of software tools used by engineers.

3. Problem Solving Software

Engineers frequently find themselves needing to solve complicated problems with matrices, complicated integrals, or large systems of simultaneous linear equations. These tasks can be greatly simplified using one of several problem-solving software packages such as MATLAB, MATHCAD, Mathematica, or MAPLE. Many engineering schools require students to learn to use one of these software packages, sometimes even in a first course on computer programming. These programs are very powerful, allowing engineers to perform complex mathematical operations quickly and relatively painlessly. Data can be imported from other software, can be analyzed, graphed, and the results exported to other software.

4. Circuit Simulation

A collection of electrical components organized to perform a specific job is called a circuit. Electrical and computer engineers often design circuits in the course of their work, and need tools to help with this process. A very powerful tool for circuit analysis and design is circuit simulation software such as PSPICE. Circuit simulators allow an engineer to enter all of the components and interconnections of a circuit into a computer program. The computer then calculates various information, about how the circuit operates, such as output voltages for a given input signal, effects of changes in component temperature on circuit performance, or the effects of changing frequencies on the output. The software also prints graphs of pertinent outputs.

Circuit simulators frequently can also produce output files that can be used by circuit board manufacturers to lay out and fabricate a printed wiring board for the circuit the engineer has designed. This means that the engineer doesn't need to perform the tedious board layout step by hand. Most electrical and computer engineering students will receive training in how to use a circuit simulator during the course of their undergraduate program, and they will be able to use these skills in circuit analysis, electronics, and project courses.

5. Data Acquisition and Control

Often when testing the performance of a circuit or system, an engineer must make numerous measurements of circuit parameters. In the old days this was done by hand. The parameters of a circuit were set, and the measuring equipment was connected. All of the pertinent data were recorded by hand in a notebook. The parameters were then changed and the new data recorded. This tedious process continued until all of the required data was obtained. Often this type of procedure could take many days to complete, and it would often be done by a team of technicians. Once the data were obtained, the engineer then produced graphs of the information to aid in understanding and visualizing the results.

Data-acquisition and control software has streamlined and taken much of the tedium out of this process. Using software such as LABVIEW, the engineer now connects the test equipment to a personal computer. The control software can automatically run the test sequence that the engineer programs, changing the test parameters and recording the data. After the test sequence is completed, the software generates graphs and tables of the data as needed. Using this type of software greatly decreases the time required to run experiments and tests.

6. Spreadsheets

Spreadsheets are most often associated with making financial calculations. However, software such as Excel or Lotus 123 also finds some application in engineering. Spreadsheets can import data generated in experiments and perform calculations on that data. For example, many light sensors such as photodiodes produce an output voltage that is proportional to the intensity of light being measured. The engineer is more interested in die light level than the voltage and might import the "raw" voltage measurements into a spreadsheet, where they are converted to light levels by appropriate programming of the spreadsheet. The new set of data can then be exported to other applications, or it can be plotted by the spreadsheet. Often, the plotting functions in spreadsheets are not powerful enough for engineering applications, and the data can be exported to more powerful plotting software that will be described later.

7. Databases

Often engineers generate large amounts of data in gathering background information for a design or in testing a new design. Storing and retrieving this type of information can be very tedious and complicated. In addition, organizing the information in a meaningful way is often difficult. Database software such as Access can help simplify this process. Databases are most often found in financial and business settings, but can also be very useful to engineers.

Database software allows you to store large amounts of information, label it according to several of its attributes, and then retrieve the information according to these labels. For example, during testing; you might generate data on output voltage, current, and frequency for every set of input conditions. Using a database, you can record each set of test data. Then you can instruct the software to retrieve all of the voltage data or all of the current data. Or you can specify a range of input conditions to display.

This type of software generally allows for graphing of data and aids in the preparation of reports.

8. Graphing

There is an old saying, "One picture is worth a thousand words." This is especially true of engineering graphs. While it is sometimes useful to present data in tables, there is nothing like a graph to instantly give a picture of what is going on and to make it clear whether there are any discernable trends in the data. Producing graphs in engineering is aided by the use of graphing software. There are many different graphing packages available, and many of them are designed for specific applications such as business, science, or engineering. The graphing capabilities within MATLAB can be used on many problems, as illustrated by the following two examples.

9. Word Processing

It may seem odd to include word processors in a description of software important to engineers. Most of you have already used word processors, but aren't engineers yet! However, it is important for engineers to be able to effectively communicate their ideas to others. This communication is often in the form of written reports. The preparation of written reports is greatly aided by the use of word processing software such as Word or WordPerfect. These programs allow engineers to easily compose a document, edit the document, and produce a high-quality printout. Graphs and tables generated by other software packages can be imported and pasted directly into word processor documents. Producing quality engineering documents used to require the services of typists, draftsmen, and printers. Now all of these functions can be incorporated into a document on the engineers own computer.

10. Presentation Preparation

Engineers frequently must make oral presentations of their work. Unlike a speech, these presentations require the use of visual aids to help the audience understand what is being said. Software such as Power Point has been developed to aid in producing high-quality, visually exciting presentations. This type of software allows you to import graphs, pictures, and text generated in other software packages and to combine them in a common format. You can generate paper copies of your presentation or simply leave it on the computer; these programs can also run projectors that display your presentation.

11. Programming languages

Commercial software packages are used by engineers to aid in analyzing data and in designing new devices. These packages are often referred to as application software. During your engineering career, you will almost certainly encounter tasks for which there is no appropriate software available on the market. For example, you might have two pieces of test equipment that must "talk" to each other over a network in order to make the measurements you need. It is unlikely that there is software available for every combination of two instruments available on the market. Or perhaps you may need to perform a specific type of calculation not available on any application software package. To solve this problem, you will have to develop your own algorithm and translate it into a computer program. This computer program will be written in one of the high-level computer languages such as C.

Computer languages such as C allow you to do tasks such as performing complicated mathematical calculations, accessing test instruments, and acquiring information. In many ways a high-level computer language is like the everyday language we are used to. However, in this case it is used to translate your thoughts into statements that can be interpreted and understood by a computer. Once you are familiar with a computer language, you can easily translate the algorithms you have developed into computer "code" that can be understood by your computer. To do this, several lines of code are written that tell the computer what to do and how to interact with the other instruments on the network.

All undergraduate engineering programs require that students be able to perform basic computer programming. These skills will be valuable in solving problems during your undergraduate program and also in your professional career. Computer programs used to solve engineering problems may be as short as a few lines and can be written and debugged in a matter of a few hours. Other problems might require more extensive programming with hundreds or thousands of lines of code and a lengthy development time.

TEXT 19

Data Mining

Data mining is simply filtering through large amounts of raw data for useful information that gives businesses a competitive edge. This information is made up of meaningful patterns and trends that are already in the data but were previously unseen. The most popular tool used when mining is artificial intelligence. Artificial intelligence technologies try work the way the human brain works by making intelligent guesses, learning by example, and using deductive reasoning. Some of the more popular artificial intelligence methods used in data mining include neural networks, clustering, and decision trees.

Neural networks look at the rules of using data which are based on the connections found or a sample set of data. As a result, the software continually analyses value and compares it to the other factors, and it compares these factors repeatedly until it finds patterns emerging. These patterns are known as rules. The software then looks for other patterns based on these rules or sends out an alarm when a trigger value is hit.

Clustering divides data into groups based on similar features or limited data ranges. Clusters are used when data isn't labeled in a way that is favourable to mining. For instance, an insurance company that wants to find instances of fraud wouldn't have its records labeled as fraudulent or not fraudulent. But after analyzing patterns within clusters, the mining software starts to figure out the rules that point to which claims are likely to be false. Decision trees, like clusters, separate the data into subsets and then analyze the subsets to divide them into further subsets and so on for a few more levels. The final subsets are then small enough that the mining process can find interesting patterns and relationships within the data.

Once the data to be mined is identified, it should be cleansed. Cleansing data frees it from duplicate information and erroneous data. Next, the data should be stored in a uniform format within relevant categories or fields. Mining tools can work with all types of data storage from large data warehouses to smaller desktop databases to flat files. Data warehouses and data marts are storage methods that involve archiving large amounts of data in a way that makes it easy to access when necessary. When the process is complete, the mining software generates a report. An analyst goes over the report to see if further work needs to be done, such as refining parameters, using other data analysis tools to examine the data, or even scrapping the data if it's unusable. If no further work is required, the report proceeds to the decision makers for appropriate action.

The power of data mining is being used for many purposes, such as analyzing Supreme Court decisions, discovering patterns in health care, pulling stones about competitors from Presolving bottlenecks in production processes and analyzing sequences in the human genetic makeup. There is really no limit to the type of business area or study where data mining can be beneficial.

TEXT 20

Microelectronics and Microminiaturization

The intensive effort of electronics to increase the reliability and performance of its products, while reducing their size and cost, led to the results that hardly anyone could predict. The evolution of electronic technology is sometimes called a revolution: a quantitative change in technology gave rise to qualitative change in human capabilities. There appeared a new branch of science – microelectronics.

Microelectronics embraces electronics connected with the realization of electronic circuits, systems and subsystems from very small electronic devices. Microelectronics is a name for extremely small electronic components and circuit assemblies, made by film or semiconductor techniques. A microelectronic technology reduced transistors and other circuit elements to dimensions almost invisible to unaided eve. The point of this extraordinary miniaturization is to make circuits long-lasting, low in cost, and capable of performing electronic functions at extremely high speed. It is known that the speed of response depends on the size of transistor: the smaller the transistor, the faster it is. The smaller the computer, the faster it can work.

One more advantage of microelectronics is that smaller devices consume less power. In space satellites and spaceships this is very important factor.

Another benefit resulting from microelectronics is the reduction of distances between circuit components. Packing density increased with the appearance of small-scale integrated circuit, medium-scale IC, large-scale IC and very-large-scale IC. The change in scale was measured by the number of transistors on a chip. There appeared a new type of integrated circuits, microwave integrated circuit. The evolution of microwave IC began with the development of planar transmission lines. Then new IC components in a fineline transmission line appeared. Other more exotic techniques, such as dielectric waveguide integrated circuits emerged.

Microelectronic technique is continuing to displace other modes. Circuit patterns are formed with radiation having wavelength shorter than those of light.

Electronics has extended man's intellectual power. Microelectronics extends that power still further.

TEXT 21

Active Electrical Components

1. Background

Resistors, capacitors, and inductors, are all two-terminal passive devices. This means that they do not need an external power source in order to function properly in an electronic system.

Active electrical components, however, require an external source of power in order to operate. Up until 1947, most active electronic devices were vacuum tubes, which had been around since the early 1900s. Many electronic functions were possible using tubes, but there were serious limitations. First, tubes generally required fairly high voltages to operate, of the order of 250-300 V, at a minimum. In addition, they dissipated a tremendous amount of heat, which had to be disposed of in some manner. Also, because of the manner in which they operated, they wore themselves out and had to be replaced periodically. Finally, vacuum tubes were expensive to produce and fragile, since they were made with glass envelopes.

Vacuum tubes have largely been replaced in modem electronics by solid-state devices such as transistors and integrated circuits. Surprisingly, though, there are several niche applications where tubes still find usefulness. For example, there are many who feel that audio amplifiers based on transistor technology provide a very harsh sound compared to vacuum tube amplifiers, which provide a warmer sound. Tubes still find use in some of the more expensive audio systems currently on the market. The military is interested in microtubes - very tiny vacuum tubes - for applications where radiation exposure might cause problems. These microtubes do not suffer from the serious radiation-induced failures that can plague transistor-based electronics.

2. Transistors

Most of the problems with vacuum tubes were solved by the invention of the transistor at Bell Laboratories by Walter Brattain, John Bardeen, and William Shockley in 1947. These scientists later won the Nobel prize in physics for this work. The transistor was simultaneously small, required little power to operate, was mechanically very rugged, operated at very low voltages (12 V or less), and was extremely simple in structure compared to die typical vacuum tube. In addition, unless subjected to electrical overload, they lasted virtually forever.

So, what is a transistor? It is simply a piece of semiconductor material that has been chemically treated in certain areas in order to give it the desired electrical properties. Semiconducting materials conduct electricity much better than insulators, but much poorer than a conductor. A typical transistor has three terminals. The transistor has the ability to allow a small current at the base terminal to control a much larger current in the collector lead. Thus, the transistor functions as a current amplifier. Also, by controlling the base current, it is possible to either have the collector current turned off completely or turned on completely. Thus, the transistor can also function as an electronic switch.

In order to use die transistor in either of these two applications, it is necessary to put the transistor in a circuit consisting of the transistor itself and associated resistors, capacitors and a voltage source, such as a battery. The voltage amplifier can change a sinsusoidal voltage signal at the input terminals of amplitude 0.012 V into a sinusoidal voltage signal of amplitude - 0.4 volt at die output terminal. Thus, the voltage amplifier "inverts" the input signal and multiplies it by a factor of 33.3. You will learn how to analyze and design such circuits in your electronics courses in the curriculum, typically in the first semester of your junior year.

3. Integrated Circuits

It didn't take too long after the invention of the transistor for die next step in modern electronics to take place. By 1958, projects were underway designed to find ways to fabricate transistors and the associated passive components required to form amplifiers and memories, for example, on the same piece of semiconductor material. Thus, die circuit could now be fabricated on a single semiconductor "chip," or integrated circuit. This technology has now been developed to the point where it is possible to produce very complicated circuits, such as microprocessors (die heart of the computer on your desk), containing millions of transistors, on a single chip. Integrated circuits have been developed for a number of specific applications, both analog and digital. There are literally thousands of different integrated circuits available on the market. This can be seen by examining a catalog from one of the many companies selling electronic parts and equipment.

LM324 is a typical integrated circuit chip. Chips like this can be purchased at Radio Shack stores, in single quantities, for a price of approximately $1.00. Note that there are 14 individual pins on this chip. Typically, pin 1 is marked in a distinctive fashion so that it won't be inserted into a socket or printed circuit board incorrectly. The operating parameters and schematic diagrams for a large number of integrated circuits are shown in "data books" put out by individual manufacturers. Many popular electronic hobbyist books show a number of electronic projects, which require little or no background in electricity or electronics that can be built using common integrated circuits. You will use many, many integrated circuits in your career.

TEXT 22

Engineering Tools for Electrical Engineers

1. General ideas and safety considerations

Before discussing specific tools, it is important to discuss how to use these tools safely. When working with electrical equipment of any type, safety should always be uppermost in your mind. Not only do mistakes or carelessness pose danger to yourself and others, but expensive equipment can easily be damaged, delaying the completion of your experiment or project.

When working with unfamiliar equipment, it is best to start by taking a little time to study the operation manual. This will ensure that the type of measurement being attempted is actually possible with that instrument. In addition, you should determine the maximum levels of voltages and currents that can be applied to the instrument. Be certain that the voltages or currents expected in the experiment don't exceed these maximum values.

When hooking up a circuit, the best safety procedure is to always connect the source of power last and disconnect it first when tearing down the experiment. If necessary, label on small strips of paper where to hook up voltages of different levels in your experiment. When dealing with DC circuits, standard practice is to use red wires (also called leads) for positive voltages and black leads for the negative side of voltage sources.

Never assume that any circuit is "dead" just because all power switches are turned off. Switches are mechanical devices and will eventually wear out, causing the switch to fail. If a switch fails in a closed position and you think the power is turned off, you may be killed or seriously injured if you touch circuit points that you think are off. Use a voltage meter every time to determine that the voltage is actually what you think it should be.

In making measurements, it is always true that applying the measuring instrument changes the quantity being measured. In other words, the very act of trying to measure some quantity introduces an error into the measurement of that quantity. It is your responsibility to know the characteristics and limitations of your measuring instruments. You should be able to predict how much error you will be introducing into the measurement before the measurements are taken.

Your time in the laboratory will be much more pleasant and productive if you have an organized plan to do your work. This is in contrast to hoping that simply "twisting knobs" will allow you to get the required data.

2. Meters

There are many types of meters used for making electrical measurements. Older types are analog meters, which are typically read by noting the position of a needle on a scale. Newer meters generally have numerical, or digital, readouts. The most common type of meter is termed a VOM meter, a volt, ohm, milliamp meter, which can be used to measure voltage, resistance, and current. The quantity being measured and the range of the quantity being measured are adjusted by knobs on the face of the instrument. It is important that you make sure that you have selected the proper range for the value of the quantity that you expect to observe. For safety purposes, to avoid burning up the meter, it is good practice to always start with the maximum range of the variable to be measured and then go to lower ranges until the meter indicates the measurement is within range.

You should realize that the lower the cost of the measuring instrument, the higher the probability that it will introduce high levels of error into the measurement.

3. Oscilloscopes

An oscilloscope is a measuring instrument that is designed to observe time-varying voltages or currents on a screen, allowing measurements of the amplitude and time characteristics of the signal. Computers can also be used as "virtual" oscilloscopes when equipped with the proper hardware and software. Virtual instruments are often not as versatile in making measurements as the equivalent stand-alone instrument, but the ease in sharing data with other applications, such as a spreadsheet, more than makes up for this deficiency.

There are many controls on an oscilloscope, and it takes a considerable amount of practice to learn how to become proficient in the use of this instrument. One of the goals of the laboratory courses in electrical and computer engineering curricula is to help you become proficient in the use of an oscilloscope.

TEXT 23

Flexible Manufacturing

The emergence of the flexible manufacturing system represents a significant departure from conventional manufacturing methods. An FMS is a production facility consisting of flexible machines or work stations connected by an automated material handling system, all under the control of one or more computers.

The FMS technology has a relatively brief history. The progress of computing machines has made it possible to introduce a wide-scale automation of all branches of industry which gave rise to1 independent development of automation processes:

- Automated Data Processing (the appearance of Automated Control Systems and Computer-Aided Designing (CAD));

- Automation of Production Technology (the appearance of Numerically-Controlled Equipment, Computer-Aided Manufacturing (CAM) and Industrial Robots).

The development of Flexible Manufacturing Systems began with the appearance of industrial robots, processing centers, microcomputers, computer-aided designing, etc. followed by the introduction of robotized complexes, flexible modules, automated lines and shops and at last automated factories provided with flexible technology and computer-based artificial intelligence.

It seems almost certain that the main reasons for designing and implementing FMS are the economic benefits of the system. They include first of all greater productivity, which means a greater output and a lower unit cost on a smaller floor space.

It is possible to say that the FMS is the system where the time spent on the machine can be as high as 90% and the time spent on cutting can again be over 90%. Compare this to stand alone numerically-controlled machines (NC), where the part from stock to finished item spends only 5% of its productive time on the machine tool.

High utilization of capital equipment in the FMS over that of stands alone machines results in fewer machines being needed to carry out the same work.

High product quality is improved because the product is more uniform and consistent. This also leads to greatly reduced costs of rework.

Furthermore, the ability of FMS to produce whatever mix of parts is required on demand, greatly reduces work-in-process time. This reduction may be explained by the variety of causes which reduce the time a part is waiting for metal-cutting operations, such as:

- the concentration of all the equipment required to produce parts in a small area (within the FMS).
- the reduction in the number of fixtures required and the number of machines a part must travel to because processes are combined on machining centers.

- efficient computer scheduling of parts batched into and within the FMS.

One other important fact ought to be mentioned. While FMS requires fewer machine operators, or none at all, the remaining staff (i.e. production engineers, computer programmers and maintenance engineers) have to be highly skilled.

With correct planning for available floor space, an FMS can be designed for low production volumes, and as demand increases, new machines can be added easily to provide extra capacity flexibility required.

The main thing is that flexibility is characterized by the system's ability to adapt to change in the composition of the lots and of the machining processes and sequences, which means that it is able to respond to changing market and consumer demands.

Summing it up, it is possible to say that in all countries the introduction of FMS made it possible to greater increase equipment utilization and product quality, reduce the equipment idle time and cut down the number of attending personnel.

TEXT 24

Nanotechnology

Broadly speaking, the term 'nanotechnology’ refers to the analysis, processing, design, and optimization of materials, devices, and multi-component systems with nanoscale dimensions (approximately 100nm or less). The field has gained an interdisciplinary character over the last several years, as common features of nanoscale science and technology have been clarified and agreed upon. Since innovation is often most fruitful at boundaries between disciplines, nanotechnology holds the promise to promote discovery and devise applications throughout science engineering. A characteristic of what qualities as a nanotechnology, as distinct from good molecular-scale attention to details (like the stiffness or strength of a products constituent structural materials), is that it usually involves the application of nanoscience technique A from specially a to application B in specialty B. Thus, if one uses DNA as a template for self-assembling electronics, one is using the tools of molecular biology to explore novel fabrication techniques for complex integrated electronic devices.

Since upon seventh century, artisans employed nanotechnology, but they didn’t call it by that name. Technicians protected the secrets and skills of their trade of stained glass making, a knowledge base covering the acquisition, purification, and processing of raw materials, and the procedures of concocting a melt from which a durable tinted glass with a chosen color was produced. Although details are sketchy, these centuries-gone tradespeople no doubt pulverized salts of silver, copper, iron, cobalt, or gold under precise processing recipes to produce specific colored glass when mixed with the basic ingredients of sand, potash, and lime.

Nanotechnology is inherently disruptive in the sense of Clayton Christiansen’s seminal best-seller, The Innovator’s Dilemma. Marketplace winners and losers change hands based on investment boldness or caution, and we can’t predict which of many possibilities will be the wiser strategy. Players in niche markets can grow to market dominance or be acquired by the big players trying to stay big. Fast time-to-market costs money and can cripple the early entrant, while the next guy gets the benefit of the beginner’s experience but carries none of the debt the beginner accrued. Every major city in the US seems to be vaguely banking on biotech, nanotech, or nanobiotech to beat the next major city to prosperity. Texas may claim to be the Nanotechnology State, but so may New Jersey, while Pennsylvania may claim that it is the friendliest to new business, etc. One thing is for sure:the role of government in the two pillars of foundational research and early-stage inverstment is crucial.If country A invests more in these two areas than country B,maybe it will gain long-term over those promoting more laissez-faire economic theories. Who but govemment will wonder whether nanofiber cause the same risk as asbestos, or if nanoparticlel in the environment biomagnify to cause unexpected health riss, as was the case with DDI? On the negative side, government can be so enamored of nano, or so focused on their pet nanotechnplogy, that in will overspent, misspend, or miss opportuties – surely if you create a request for proposals that would provide money for anti-gravity technology, people will apply for and spend that money.

We should also consider the danger of unintended consequences. In its earlyadoption years, asbestos seemed all benefit and no danger. Another historical example is coal dust: both it and asbestos are now known to be biohazards, have nanoscale dimensions, and, further, are mimicked in compositionебышяуб and shape by nanofibers and nanoparticles. Additionally, the size of nanostructures allows reacton rates to change. Just as ice particles assist CFCs in eating up ozone, unexpected chemical pathways may be exposed by new chemicals, new formulauons and new structures released into the environment. We must remember that unintended consequences are rarely beneficial. The potential danger of nanotechnology comes from the same place that the potential benefit comes: new materials and material formats and formulations.

One of the most certain outcomes of nanotechnology is widespread material property improvements that would penetraate all areas of production, from raw materials analysis to process improvements. Composite materials and multifuncional, system-like (hierarchical) materials will proliferate. Catalysis will benefit from nqnostructuring of materials, and we will have more control of reaction rates and thus chemical pathways than is dreamed of today. There will be a growing toolbox of sensors and actuators and smart technologies that transform chemistry as a bulk process to a pinpoint, targetable process. Mesoscale behavior of material, such as electrically or magnetically or PH-tunable quantun dots, will promote new types of diagnostics, sensors, and actuators. Environmental remediation, from trapping pollutants to decomposing them to purifying air and water, are very likel to have a big impact in future society. Also, efficient solar power will be turtner aqvanced by improved solar cells in term of manufacture, tange of materials to serve as solar cells, and sunlight conversion efficiency. So while the hype is here now, there are undoubtedly many gains to be realized at the hand of nanotechnology; it is likely inevitable that the positive will far outweigh the negative, and the nagative will be slowly eradicadet as we learn more about the possibilities and limitations of the nanoparadigm.

The interdisciplinary nature of nanotechnology, combined with the etremely fast pace of the field, means that continuing interdisciplinaryeducation for business, government, and the general public is necessary. Various books have been published on nanoscience and nanotechnology, and universities are offering courses on the subject. Moreover, there are numerous websites dedicated to the field, providing technical information as well as commentary. Education team has developed Nanopedia, the Web encyclopedia of nanotechnology as a platform for educating people about nanotechnology, whether they are looking for a quick overview, a lesson plan for a seminar course, or a searchable encyclopedia of the technology and its underlying science.

TEXT 25

Ready for the Bazillion-Byte Drive?

Thinking about writing your memoirs - putting your life story down on paper for all eternity? Why not skip the repetitive strain injury and just capture your whole life on full-motion video, putting it all in a device the size of a sugar cube? It might not be as far off as you think.

Currie Munce, director of IBM's Advanced HDD Technology Storage Systems Division, has one avowed goal: Build bigger storage. Recently Munce and his fellow Ph.Ds restored Big Blue's lead in the disk space race with a new world record for areal (bit) density: 35.3 gigabits per square inch - roughly three times as dense as any drive shipping at press time.

During the 1990s, areal density doubled every 18 months, keeping pace with the transistor density gains predicted by Moore's Law. But increasingly daunting technical challenges face those who would push the storage envelope further. 'I think magnetic recording technology has another good 5 to 10 years,' says Munce. ‘After that, we'll see substantial difficulties with further advances at the pace people are accustomed to.'

From here on, a phenomenon called superparamagnetism threatens to make densely-packed bits unstable. Provided that new developments continue to thwart superparamagnetic corruption, scientists speculate that the theoretical limit for discrete bit recording is 10 terabits per square inch (1 terabit = 1,000 gigabits).

Approaching this limit will require new technologies. Two possible contenders are atomic force microscopy (AFM) and holographic storage. AFM would use a spinning plastic disk, perhaps inside a wristwatch, and a tiny, 10-micron cantilever with a 40-angstrom tip (an angstrom represents the approximate radius of an atom) to write data. In theory, AFM will allow densities of 300 to 400 gigabits per square inch.

While AFM is still in the lab, holographic storage is closer to reality. According to Rusty Rosenberger, optical program manager for Imation, 'We are targeting a 5-inch disk with 125GB of storage and a 40MB-per-second transfer rate.' Future iterations of holographic systems should improve substantially.

The three-dimensional nature of holography makes it an appealing storage medium because 'pages' of data can be superimposed on a single volume - imagine transferring a whole page of text at once as opposed to reading each letter in sequence. Hans Coufal, manager of IBM's New Directions in Science and Technology Research division, predicts that the fast access rates and transfer times of holographic storage will lead to improved network searches, video on demand, high-end servers, enterprise computing, and supercomputing.

Meanwhile, also-ran technologies are thriving. Tape, first used for data storage in 1951 with the Univac I, has been revitalized by the corporate hunger for affordable archiving solutions. In the consumer arena, says Dataquest analyst Mary Craig, recordable CD-ROMs and DVDs will remain the dominant high-capacity removable storage media for the next decade. Despite their failure to match the areal density gains of hard disks, optical disks are cheap to produce, making them ideal for software distribution (until a mature digital rights management system facilitates online delivery). Finally, solid state options such as flash cards can't yet match the pricing of hard disks at high capacities.

Further out, scientists salivate over the prospect of data manipulation and storage on an atomic level. Because consumer demand for capacity is lagging behind what technology can deliver, bringing new storage options to the masses will depend on seeing the need for more space.

Литература

1. Biological Science: A Molecular Approach. BSCS, Sixth edition, The Colorado College, Colorado Springs, Colorado
2. Dr Wilfred Funk, Normal Lewis. 30 Days to a more powerful vocabulary. Новинтел, 1991.
3. Hornby A.S. Oxford Student's Dictionary of Current English. М.: Просвещение, 1984
4. Курашвили Е.И. Английский язык для студентов-физиков. М.: Астрель, 2001.
5. Кутепова М.М. Английский язык для химиков. М.: Высшая школа, 2002.
6. Орловская И.В., Самсонова Л.С., Скубриева А.И. Учебник английского языка для технических университетов и вузов. М.: издательство МГТУ им. Н.Э.Баумана, 2001.
7. Парахина А.В. Пособие по переводу технических текстов с английского языка на русский. М.: Высшая школа, 1972.
8. Полякова Т.Ю., Синявская Е.В., Селезнева Г.А. Достижения науки и техники XX века. М.: Высшая школа, 2004.
9. Полякова Т.Ю., Синявская Е.В., Тынкова О.И., Улановская Э.С. Английский язык для инженеров, М.: Высшая школа, 2000

10. Серебренникова Э.И., Круглякова И.Е. Учебник английского языка для химико-технологических вузов. М.: Высшая школа, 1987.
11. Судовцев В.А. Учись читать литературу по специальности: учебное пособие для вузов. М.: Высшая школа, 1985.
12. Чебурашкин Н.Д. Хрестоматия по техническому переводу. М.: Просвещение, 1975.

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Учебное издание

Анисимова Тамара Ивановна
кандидат педагогических наук, доцент

Белова Ирина Михайловна

ENGINEERING

УЧЕБНОЕ ПОСОБИЕ
часть I

Корректор Белова И.М.
Худ. редактор Федорова Л.Г.

Сдано в набор 23.10.2014.
Подписано в печать 27.10.2014.
Бумага писчая. Гарнитура Таймс.
Усл. печ. л. 5.   Тираж 100.
Заказ №1.

НХТИ (филиал) ФГБОУ ВПО «КНИТУ»,
г. Нижнекамск, 423570, ул. 30 лет Победы, д. 5а.