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АНГЛІЙСЬКА МОВА ЗА ПРОФЕСІЙНИМ СПРЯМУВАННЯМ

Методичні вказівки до практичних занять та самостійної роботи для здобувачів
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Англійська мова за професійним спрямуванням [Текст] : Методичні вказівки до практичних занять та самостійної роботи для здобувачів першого (бакалаврського) рівня вищої освіти освітньої програми 131 Прикладна механіка денної форми навчання/ уклад. Л. О. Доложевська. Луцьк : ЛНТУ, 2024. 44 с.

Видання містить теоретичний матеріал та практичні завдання, спрямовані на оволодіння здобувачами англійською мовою як засобом комунікації на професійному рівні, ознайомлення студентів із специфікою професійного мовлення та вироблення в них практичних навичок використання мови в спеціальності. Призначене для студентів II-го курсу ОП «Металообробне обладнання та роботизовано виробничі системи» підготовки бакалавра спеціальності 131 Прикладна механіка денної та заочної форм навчання.

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Foreword

The aim of this textbook is to provide students with the necessary language skills and terminology specific to the branch of mechanical engineering. The textbook focuses on developing the students' proficiency in English within the context of mechanical engineering technology, covering various aspects such as technical vocabulary, safety procedures, industry-specific writing skills.

It will provides students with a grounding in core principles and theories of mechanical engineering, such as mechanics, thermodynamics, fluid dynamics, materials science, and manufacturing processes. The textbook will also enhance students' ability to communicate effectively in a professional setting, such as providing clear instructions, writing reports, and conveying technical information.

The textbook supports the educational curriculum of mechanical engineering programs, ensuring that students learn what is necessary to meet academic and professional standards. It will help students develop essential skills, such as problem-solving, critical thinking, and technical analysis.

The book will be useful for both teachers and students.

Overall, the goal is to equip students with the language proficiency required for effective communication and collaboration in the professional environment of mechanical engineering. This may be particularly relevant for students pursuing careers in fields where proficiency in English is essential.

Unit 1.

WHAT IS ENGINEERING?

The word "engineering" derives from the Latin root *ingeniere*, meaning to design or to devise, which also forms the basis of the word "ingenious". Those meanings are quite appropriate summaries of the traits of a good engineer. At the most fundamental level, engineers apply their knowledge of mathematics, science, and materials—as well as their skills in communications and business—to develop new and better technologies. Rather than experiment solely through trial and error, engineers are educated to use mathematics, scientific principles, and computer simulations as tools to create faster, more accurate, and more economical designs.

Many students begin to study engineering because they are attracted to the fields of mathematics and science. Others migrate toward engineering careers because they are motivated by an interest in technology and how everyday things work or, perhaps with more enthusiasm, how not-so-everyday things work. A growing number of others are impassioned by the significant impact that engineers can have on global issues such as clean water, renewable energy, sustainable infrastructures, and disaster relief.

Regardless of how students are drawn to it, engineering is distinct from the subjects of mathematics and science. The objective of an engineer is to have built a device that performs a task that previously couldn't have been completed or couldn't have been completed so accurately, quickly, or safely. Mathematics and science provide some of the tools and methods that enable an engineer to test fewer mock-ups by refining designs on paper and with computer simulations, before any metal is cut or hardware is built. Therefore, "engineering" could be defined as the intersection of activities related to mathematics, science, computer simulation, and hardware.

Most engineers, while earning a degree in one of the major branches, end up specializing. The major branches of engineering have many subdivisions. For example, civil engineering includes the subdivisions of structural, transportation, urban, and construction engineering; electrical engineering includes the subdivisions of power, control, electronics, and telecommunications engineering.

Engineers develop their skills first through formal study in an accredited bachelor's degree program and later through advanced graduate studies and/or practical work experience under the supervision of accomplished and senior engineers. When starting a new project, engineers often rely on their reasoning, physical intuition, hands-on skills, and the judgment gained through previous technical experiences. The process of becoming a good engineer is a lifelong endeavor, and it is a composite of education and experience. One can make a good argument that it is not possible to build a lifelong career on only the material that was learned in college. As technologies, markets, and economies quickly grow and evolve, engineers are constantly learning new approaches and problem-solving techniques and informing others of their discoveries.

Exercises:

1. Match the words with their definitions:

Ingenious

Simulation

Subdivision

Intuition

Endeavor

- a. An attempt to achieve a goal.
- b. A smaller part of a larger field or subject.
- c. Clever, original, and inventive.
- d. A method of imitating the operation of a real-world process or system.
- e. The ability to understand something immediately, without the need for conscious reasoning

2. Fill in the blanks with the correct words:

Engineers use their _____ to make quick, insightful decisions during a project.

Civil engineering includes various _____ such as structural and transportation engineering.

Using computer _____, engineers can test designs before physical models are built.

Developing new technologies requires an _____ approach to problem-solving.

Becoming a successful engineer is a lifelong _____.

3. Answer the questions:

What is the origin of the word "engineering"?

What are the main tools and methods that engineers use to refine their designs?

Why might some students be attracted to engineering careers?

How is engineering distinct from the subjects of mathematics and science?

What does the author mean by "a lifelong endeavor"?

How does experience complement education in engineering?

Do you agree with the statement that one cannot build a lifelong career solely on college material? Why or why not?

Describe the process of becoming a skilled engineer.

4. *Decide whether the sentences are true or false. Correct the false sentences:*
Engineers often rely solely on trial and error to develop new technologies.
Mathematics and science are the only fields that engineers need to understand.
Civil engineering has no subdivisions.
Engineers continuously learn new techniques throughout their careers.
A good engineer can build a lifelong career solely based on what they learned in college.
5. *Discuss the following topic:*
"How do you think engineering affects our daily lives?"
6. *Choose one branch of engineering (e.g., civil, electrical, mechanical) and research its subdivisions, current trends, and notable projects. Prepare a poster or a slideshow to present your findings.*
7. *Write a short essay (150-200 words) on one of the following topics:*
The impact of engineering on global issues such as renewable energy and disaster relief.
The role of computer simulations in modern engineering.
Why continuous learning is essential for engineers.

Unit 2.

THE DESIGN PROCESS

In a broad view, mechanical design is the systematic process for devising a product or system that meets one of the global society's technical needs. Engineers conceive solutions to those problems and turn their conceptions into functioning hardware. Although a mechanical engineer might specialize in a field such as materials selection or fluid engineering, the day-to-day activities will often focus on design. In some instances, a designer will start from scratch and have the freedom to develop an original product from the concept stage onward. The technology that is developed could be so revolutionary as to create entirely new markets and business opportunities. Smartphones and hybrid vehicles are examples of how technology is changing the way people think about communication and transportation. In other cases, an engineer's design work will be incremental and focus on improving an existing product. Examples are the addition of a high-definition video camera to a cell phone and the small yearly variations made to an automobile model. Where does the life of a new product begin? First, a company will identify new business opportunities and define requirements for a new product, system, or service. Past, current, and potential customers are surveyed, online product reviews and feedback forums are studied, and related products are researched. Marketing,

management, and engineering all provide additional input to help develop a comprehensive set of system requirements.

In the next phase, engineers exercise their creativity and develop potential concepts, select the top concept using the requirements as decision criteria, develop details (such as layout, material choice, and component sizing), and bring the hardware to production. Will the product meet the initial requirements, and can it be produced economically and safely? To answer such questions, engineers make many approximations, trade-offs, and decisions along the way. Mechanical engineers are mindful that the level of precision needed in any calculation gradually grows as the design matures from concept to final production. Resolving specific details (Will a grade 1020 steel be strong enough? What must the viscosity of the oil be? Should ball or tapered roller bearings be used?) doesn't make much sense until the design gets reasonably to its final form. After all, in the early stages of a design, the specifications for the product's size, weight, power, or performance could change. Design engineers learn to be comfortable with order-of-magnitude calculations, and they are able to develop products even in the presence of ambiguity and requirements that might change over time.

From a macroscopic perspective, the mechanical design process can be broken down into four major stages:

- Requirements development
- Conceptual design
- Detailed design
- Production

(From An Introduction to Mechanical Engineering)

Exercises:

1. Match the words with their definitions:

Incremental

Revolutionary

Ambiguity

Precision

Viscosity

- a. The thickness or stickiness of a fluid.
- b. The quality of being open to more than one interpretation; uncertainty.
- c. Involving gradual changes or improvements.

- d. Involving or causing a complete or dramatic change.
- e. The quality of being exact and accurate

2. Fill in the blanks with the correct words:

The _____ of the oil must be carefully measured to ensure proper functioning of the machinery.

Adding a new feature to an existing product is often an _____ process.

Engineers strive for _____ in their calculations as the design progresses.

The introduction of smartphones was _____ for the communication industry.

Dealing with _____ is a common part of the design process.

3. Answer the questions:

What is the primary focus of a mechanical engineer's day-to-day activities?

How can new technology affect markets and business opportunities? Provide two examples from the text.

How do engineers use approximations and trade-offs in the design process?

What are the initial steps a company takes when developing a new product?

What are the four major stages of the mechanical design process?

Why do mechanical engineers need to be comfortable with order-of-magnitude calculations?

How does the level of precision change throughout the design process?

What challenges might engineers face when dealing with ambiguity in design requirements?

4. Decide whether the sentences are true or false. Correct the false sentences:

Mechanical engineers always start from scratch when designing new products.

The design process includes gathering input from marketing, management, and engineering.

Engineers never change the requirements once the design process has started.

Smartphones and hybrid vehicles are examples of incremental technology changes.

The level of precision in calculations decreases as the design matures.

5. Discuss the following question: "How do engineers balance creativity and practicality in their designs?" Prepare a list of points to share with the group.

6. *Choose a revolutionary technology (e.g., smartphones, hybrid vehicles) and research its development process, impact on society, and future prospects. Prepare a poster or a slideshow to present your findings.*
7. *Write a short essay (150-200 words) on one of the following topics:*
 - The importance of creativity in the mechanical design process.
 - The role of customer feedback in developing new products.
 - How revolutionary technology can change societal behaviors and create new markets.

Unit 3.

MANUFACTURING PROCESSES

Manufacturing technologies are so economically important because they are the means for adding value to raw materials by converting them into useful products. Of the many different manufacturing processes, each is well-suited to a particular need based on environmental impact, dimensional accuracy, material properties, and the mechanical component's shape. Engineers select processes, identify the machines and tools, and monitor production to ensure that the final product meets its specifications. The main classes of manufacturing processes are as follows:

- Casting is the process whereby liquid metal, such as gray iron, aluminum, or bronze, is poured into a mold, cooled, and solidified.
- Forming encompasses a family of techniques whereby a raw material is shaped by stretching, bending, or compressing. Large forces are applied to plastically deform a material into its new permanent shape.
- Machining refers to processes where a sharp metal tool removes material by cutting it. The most common machining methods are drilling, sawing, milling, and turning.
- Joining operations are used to assemble subcomponents into a final product by welding, soldering, riveting, bolting, or adhesively bonding them. Many bicycle frames, for instance, are welded together from individual pieces of metal tubing.
- Finishing steps are taken to treat a component's surface to make it harder, improve its appearance, or protect it from the environment. Some processes include polishing, electroplating, anodizing, and painting.

In casting, liquid metal is poured into the cavity of a mold, which can be expendable or reusable. The liquid then cools into a solid object with the same shape as the mold. An attractive feature of casting is that complex shapes can be produced as solid objects without the need to join any pieces. Casting is an efficient process for creating many copies of a three-dimensional object, and, for that reason, cast components are relatively inexpensive. On the other hand, defects can arise if the metal solidifies too soon and prevents the mold from filling completely. The surface finish of cast components generally has a rough texture, and they might require additional

machining operations to produce smooth and flat surfaces. Some examples of cast components include automotive engine blocks, cylinder heads, and brake rotors and drums.

One kind of a forming operation is called rolling, which is the process of reducing the thickness of a flat sheet of material by compressing it between rollers, not unlike making cookie or pizza dough. Sheet metal that is produced in this manner is used to make aircraft wings and fuselages, beverage containers, and the body panels of automobiles. Forging is another forming process, and it is based on the principle of heating, impacting, and plastically deforming metal into a final shape. Industrial-scale forging is the modern version of the blacksmith's art of working metal by hitting it with a hammer against an anvil. Components that are produced by forging include some crankshafts and connecting rods in internal combustion engines. Compared to castings, a forged component is strong and hard, and for that reason, many hand tools are produced this way.

The forming process known as extrusion is used to create long straight metal parts whose cross sections may be round, rectangular, L-, T-, or C-shaped, for instance. In extrusion, a mechanical or hydraulic press is used to force heated metal through a tool (called a die) that has a tapered hole ending in the shape of the finished part's cross section. The die is used to shape the raw material, and it is made from a metal that is much harder than what is being formed. Conceptually, the process of extrusion is not unlike the familiar experience of squeezing toothpaste out of a tube.

(From An Introduction to Mechanical Engineering)

Exercises:

1. Match the words with their definitions:

Casting

Forming

Machining

Joining

Finishing

- a. Processes where a sharp tool removes material by cutting.
- b. Operations used to assemble subcomponents into a final product.
- c. The process of treating a component's surface to improve its appearance or protect it.
- d. Shaping raw material by stretching, bending, or compression.
- e. Pouring liquid metal into a mold to create solid objects.

2. Fill in the blanks with the correct words:

_____ involves applying large forces to deform a material into a new shape.
_____ is used to create complex shapes as solid objects without joining pieces.
_____ operations include welding, soldering, and riveting.
Drilling, sawing, and milling are examples of _____ methods.
Processes such as polishing and painting are part of the _____ steps.

3. Answer the questions:

- Why are manufacturing technologies economically important?
- What are the main classes of manufacturing processes mentioned in the text?
- Why is casting considered an efficient process?
- What are the potential defects mentioned in the casting process? How do these defects impact the final product, and what might be done to mitigate them?
- Describe the process of casting and its advantages and disadvantages.
- What is the forming process known as rolling used for?
- How is extrusion conceptually similar to squeezing toothpaste out of a tube?

4. Decide whether the sentences are true or false. Correct the false sentences:

- a) Casting involves shaping material by stretching, bending, or compression.
- b) Forging is the modern version of the blacksmith's art of working metal with a hammer.
- c) Machining methods do not include milling or turning.
- d) Finishing steps are taken to treat a component's surface to make it harder or improve its appearance.
- e) Extrusion is used to create long straight metal parts with various cross-sectional shapes.

5. Discuss the following question: "Which manufacturing process do you think is the most important and why?" Prepare a list of points to share with the group.

6. Choose one manufacturing process (e.g., casting, forming, machining) and research its historical development, modern applications, and examples of products made using this process. Prepare a poster or a slideshow to present your findings.

7. Write a short essay (150-200 words) on one of the following topics:

The advantages and disadvantages of casting in manufacturing.

The importance of finishing steps in the production of mechanical components.

Compare and contrast the forming processes of rolling and forging.

Unit 4.

MACHINES

Machining refers to processes whereby material is gradually removed from a workpiece in the form of small chips. The most common machining methods are called drilling, sawing, milling, and turning. Machining operations are capable of producing mechanical components with dimensions and shapes that are far more precise than their cast or forged counterparts. One drawback of machining is that (by its very nature) the removed material is wasted. In a production line, machining operations are often combined with casting and forging when cast or forged components require additional operations to flatten surfaces, make holes, and cut threads.

Machining tools include drill presses, bandsaws, lathes, and milling machines. Each tool is based on the principle of removing unwanted material from a workpiece by means of the cutting action of sharpened blades. The drill press is used to bore round holes into a workpiece. A drill bit is held in the rotating chuck, and, as a machinist turns the pilot wheel, the bit is lowered into the workpiece's surface. As should be the case whenever metal is machined, the point where the bit cuts into the workpiece is lubricated. The oil reduces friction and helps remove heat from the cutting region. For safety reasons, vises and clamps are used to hold the workpiece securely and to prevent material from shifting unexpectedly.

A machinist uses a band saw to make rough cuts through metal. The blade is a long, continuous loop with sharp teeth on one edge, and it rides on the drive and idler wheels. A variable-speed motor enables the operator to adjust the blade's speed depending on the type and thickness of the material being cut. The workpiece is supported on a table that is capable of being tilted for cuts that are to be made at an angle. The machinist feeds the workpiece into the blade and guides it by hand to make straight or slightly curved cuts. When the blade becomes dull and needs to be replaced or if it breaks, the bandsaw's internal blade grinder and welder are used to clean up the blade's ends, connect them, and reform a loop.

A milling machine (or mill) is used for machining the rough surfaces of a workpiece flat and smooth, and for cutting slots, grooves, and holes. The milling machine is a versatile machine tool in which the workpiece is moved slowly relative to a rotating cutting tool. The workpiece is held by a vise on an adjustable table so that the part can be accurately moved in three directions (along the plane of the table and

perpendicular to it) to locate the workpiece precisely beneath the cutting bit. A piece of metal plate might be cut first to an approximate shape with a bandsaw, and then the milling machine could be used to form the surfaces smooth and the edges square to their final dimensions.

A machinist's lathe holds a workpiece and rotates it about the centerline as a sharpened tool removes chips of material. The lathe is therefore used to produce cylindrical shapes and other components that have an axis of symmetry. Some applications for using a lathe are the production of shafts and the resurfacing of disk brake rotors. A lathe can be used to reduce the diameter of a shaft by moving the cutting tool along the shaft's length as it rotates. Threads, shoulders that locate bearings on a shaft, and grooves for holding retaining clips can be made in this manner. Machine tools can be controlled by hand operation or by a computer.

Computer-aided manufacturing uses computers to control machine tools to cut and shape metals and other material with remarkable precision. Machining operations are controlled by a computer when a mechanical component is particularly complicated, when high precision is required, or when a repetitive task must be performed quickly on a large number of parts. In those cases, a numerically controlled machine tool is capable of faster and more precise machining than a human operator. Computer-controlled machine tools offer the potential to produce physical hardware seamlessly from a computer-generated drawing. With the ability to quickly reprogram machine tools, even a small general-purpose shop can produce high-quality machined components.

Some of the same technologies used to create rapid product prototypes for design evaluation are beginning to be used for custom production. Rapid or direct digital manufacturing is a class of additive fabrication techniques to produce custom or replacement parts. A mass-manufacturing line takes advantage of mechanical automation, but those systems are intended to produce many identical parts. Rapid manufacturing systems take precisely the opposite viewpoint: One-of-a-kind components are produced directly from a computer-generated electronic file. Electronic representation can be produced by using computer-aided design software or by scanning a physical object. This capability offers the potential for creating complex, customized products at a reasonable cost. While rapid prototyping typically uses thermoplastics, photopolymers, or ceramics to create the parts, rapid manufacturing technologies can now also use a variety of metals and alloys. This allows engineers to create fully functional parts extremely quickly. For instance, an electron beam melts metal powder in a vacuum chamber, creating very strong parts that can withstand high temperatures. Customized production is giving engineers the ability to manufacture a product as soon as someone orders it to one-of-a-kind specifications by taking advantage of rapid manufacturing technologies.

(From An Introduction to Mechanical Engineering)

Exercises:

1. Match the words with their definitions:

Machining

Drill press

Lathe

Computer-aided manufacturing (CAM)

Rapid manufacturing

- a. A machine tool used to rotate a workpiece about its centerline to remove material.
- b. The process of removing material from a workpiece to create precise dimensions and shapes.
- c. Using computers to control machine tools for cutting and shaping materials.
- d. A machine used to bore round holes into a workpiece.
- e. Techniques to produce custom or replacement parts directly from a computer-generated file.

2. Fill in the blanks with the correct words:

A _____ is used to bore round holes into a workpiece.

_____ involves creating parts directly from a computer-generated file, often using metals or alloys.

_____ allows for high precision in machining operations by using computers to control tools.

A _____ is used to produce cylindrical shapes and components with an axis of symmetry.

_____ refers to removing material from a workpiece to produce precise shapes and dimensions.

3. Answer the questions:

What is the primary focus of machining processes?

Name four common machining methods mentioned in the text.

Why might additional machining operations be required after casting or forging a component?

What are the main functions of a milling machine?

How does computer-aided manufacturing (CAM) benefit the machining process?

What advantages do computer-controlled machine tools offer to small general-purpose shops?

How does the ability to quickly reprogram machine tools benefit the manufacturing process?

What might be some challenges associated with using computer-controlled machine tools?

4. *Decide whether the sentences are true or false. Correct the false sentences:*

- 1) Machining operations can only produce rough and imprecise components.
- 2) A bandsaw is used to make rough cuts through metal and can cut at angles.
- 3) A lathe is used to create flat surfaces and cut slots in a workpiece.
- 4) Rapid manufacturing focuses on producing many identical parts quickly.
- 5) Computer-controlled machine tools can perform repetitive tasks quickly and with high precision.

5. *Discuss the following question: "How has technology changed the way machining operations are performed?" Prepare a list of points to share with the group.*

6. *Choose a specific machining tool (e.g., drill press, lathe, milling machine) and research its history, modern applications, and examples of products made using this tool. Prepare a poster or a slideshow to present your findings.*

7. *Write a short essay (150-200 words) on one of the following topics:*

The advantages and disadvantages of using computer-aided manufacturing (CAM).

The role of rapid manufacturing in modern production and its potential benefits.

Compare and contrast the functions of a milling machine and a lathe.

Unit 5.

CALCULATIONS AND DECISIONS

Over the years, engineers have developed a reputation for paying attention to details and getting their answers right. The public gives its trust to the products that engineers design and build. That respect is based in part on confidence that the engineering has been done properly.

Engineers expect one another to present technical work in a manner that is well documented and convincing. Among other tasks, engineers perform calculations that are used to support decisions about a product's design encompassing forces, pressures, temperatures, materials, power requirements, and other factors. The results of those calculations are used to make decisions—sometimes having substantial financial implications for a company—about what form a design should take or how a product will be manufactured. Decisions of that nature can quite literally cost or save a company millions of dollars, and so it is important that the decisions are made for the right reason. When an engineer offers a recommendation, people depend on it being correct.

With that perspective in mind, while your calculations must clearly make sense to you, they must also make sense to others who want to read, understand, and learn from your work—but not necessarily decipher it. If another engineer is unable to follow your work, it could be ignored and viewed as being confusing, incomplete, or even wrong. Good problemsolving skills—writing clearly and documenting each step of a calculation—include not only getting the answer correct, but also communicating it to others convincingly.

One of the important communication skills that you can begin developing is following a consistent problemsolving process for engineering analysis problems. You should view your solutions as a type of technical report that documents your approach and explains your results in a format that can be followed and understood by others. By developing and presenting a systematic solution, you will reduce the chance of having common—but preventable—mistakes creep into your work. Errors involving algebra, dimensions, units, conversion factors, and misinterpretation of a problem statement can be kept to a minimum by paying attention to the details. For the purpose of solving the problems, you should try to organize and present your work according to the following three steps, which also define the structure in which the examples are presented:

1. **Approach.** The intent of this step is to make sure that you have a plan of attack in mind for solving the problem. This is an opportunity to think about the problem up front before you start crunching numbers and putting pencil to paper. Write a short summary of the problem and explain the general approach that you plan to take, and list the major concepts, assumptions, equations, and conversion factors that you expect to use. Making the proper set of assumptions is critical to solving the problem accurately. For instance, if gravity is assumed to be present, then the weight of all the components in the problem may need to be accounted for. Similarly, if friction is assumed present, then the equations must account for it. In most analysis problems, engineers have to make important assumptions about many key parameters including gravity, friction, distribution of applied forces, stress concentrations, material inconsistencies, and operating uncertainties. By stating these assumptions, identifying the given information, and summarizing the knowns

and unknowns, the engineer fully defines the scope of the problem. By being clear about the objective, you are able to disregard extraneous information and focus on solving the problem efficiently.

2. **Solution.** Your solution to an engineering analysis problem will generally include text and diagrams along with your calculations to explain the major steps that you are taking. If appropriate, you should include a simplified drawing of the physical system being analyzed, label the major components, and list numerical values for relevant dimensions. In the course of your solution, and as you manipulate equations and perform calculations, it is good practice to solve for the unknown variable symbolically before inserting numerical values and units. In that manner, you can verify the dimensional consistency of the equation. When you substitute a numerical value into an equation, be sure to include the units as well. At each point in the calculation, you should explicitly show the units associated with each numerical value, and the manner in which the dimensions are canceled or combined. A number without a unit is meaningless, just as a unit is meaningless without a numerical value assigned to it. At the end of the calculation, present your answer using the appropriate number of significant digits, but keep more digits in the intermediate calculations to prevent round-off errors from accumulating.
3. **Discussion.** This final step must always be addressed because it demonstrates an understanding of the assumptions, equations, and solutions. First, you must use your intuition to determine whether the answer's order of magnitude seems reasonable. Second, you must evaluate your assumptions to make sure they are reasonable. Third, identify the major conclusion that you are able to draw from the solution, and explain what your answer means from a physical standpoint. Of course, you should always double-check the calculations and make sure that they are dimensionally consistent. Finally, underline, circle, or box your final result so that there is no ambiguity about the answer that you are reporting.
(From An Introduction to Mechanical Engineering)

Exercises:

1. *Match the words with their definitions:*

Documentation

Assumption

Consistency

Conversion factors

Significant digits

- a. Belief or acceptance that something is true without proof.

- b. Accuracy and precision in the context of numerical representation in calculations.
- c. Written records and evidence that support technical work.
- d. Ratios used to convert one unit of measurement to another.
- e. Uniformity in the application of methods and principles.

2. Fill in the blanks with the correct words:

Engineers rely on accurate _____ to ensure their calculations are trusted.

Making the proper set of _____ is critical to solving engineering problems accurately.

The use of _____ ensures that all steps in a calculation follow the same logic. _____ are essential when converting units from one measurement system to another.

Using the appropriate number of _____ helps to maintain the accuracy of final results.

3. Answer the questions:

Why is it important for engineers to document their work clearly?

What are some factors that engineers consider when performing calculations for product design?

Explain the significance of the approach step in solving engineering problems.

What should be included in the solution step of an engineering analysis?

Why is it important for problem-solving skills to include clear writing and documentation?

How can well-documented calculations prevent misunderstandings or errors?

What are the consequences of poorly documented engineering work?

4. Decide whether the sentences are true or false. Correct the false sentences:

Engineers do not need to document their assumptions when solving problems.

Presenting calculations with units is unnecessary as long as the numerical values are correct.

A well-documented engineering solution can help others understand and verify the work.

Engineers only need to focus on the final result, not the process leading to it.

Checking the dimensional consistency of an equation is a good practice in engineering calculations.

5. *Discuss the following question:* "How does clear documentation of engineering work build trust in the profession?" Prepare a list of points to share with the group.
6. Choose an engineering project or product (e.g., bridge construction, automobile design) and research the importance of detailed documentation and calculation in its development. Prepare a poster or a slideshow to present your findings.
7. *Write a short essay (150-200 words) on one of the following topics:*
 - The importance of clear communication in engineering documentation.
 - How making accurate assumptions can impact engineering solutions.
 - The role of systematic problem-solving in preventing errors in engineering calculations.

Unit 6.

BASE AND DERIVED UNITS

Given some perspective from the Mars Climate Orbiter's loss and the emergency landing of the Air Canada flight on the importance of units and their bookkeeping, we now turn to the specifics of the USCS and SI. Both the USCS and SI are made up of base units and derived units. A base unit is a fundamental quantity that cannot be broken down further or expressed in terms of any simpler elements. Base units are independent of one another, and they form the core building blocks of any unit system. As an example, the base unit for length is the meter (m) in the SI and the foot (ft) in the USCS.

Derived units, as their name implies, are combinations or groupings of several base units. An example of a derived unit is velocity (length/time), which is a combination of the base units for length and time. The liter (which is equivalent to 0.001 m^3) is a derived unit for volume in the SI. Likewise, the mile (which is equivalent to 5280 ft) is a derived unit for length in the USCS. Unit systems generally have relatively few base units and a much larger set of derived units. In an attempt to standardize the

different systems of measurement around the world, in 1960 the International System of Units was named as the measurement standard structured around the seven base units. In addition to the mechanical quantities of meters, kilograms, and seconds, the SI includes base units for measuring electric current, temperature, the amount of substance, and light intensity. The SI is colloquially referred to as the metric system, and it conveniently uses powers of ten for multiples and divisions of units.

The base units in the SI are today defined by detailed international agreements.

However, the units' definitions have evolved and changed slightly as measurement technologies have become more precise. The origins of the meter, for instance, trace back to the eighteenth century. The meter was originally intended to be equivalent to one ten-millionth of the length of the meridian passing from the northern pole, through Paris, and ending at the equator (namely, one-quarter of the Earth's circumference). Later, the meter was defined as the length of a bar that was made from a platinum-iridium metal alloy. Copies of the bar, which are called prototype meters, were distributed to governments and laboratories around the world, and the bar's length was always measured at the temperature of melting water ice. The meter's definition has been updated periodically to make the SI's length standard more robust and repeatable, all the while changing the actual length by as little as possible. As of October 20, 1983, the meter is defined as the length of the path traveled by light in vacuum during a time interval of $1/299,792,458$ of a second, which in turn is measured to high accuracy by an atomic clock.

In a similar vein, at the end of the eighteenth century, the kilogram was defined as the mass of 1000 cm³ of water. Today, the kilogram is determined by the mass of a physical sample that is called the standard kilogram, and like the previously used prototype meter, it is also made of platinum and iridium. The standard kilogram is kept in a vault in Sèvres, France, by the International Bureau of Weights and Measures, and duplicate copies are maintained in other laboratories throughout the world. Although the meter is today based on a reproducible measurement involving the speed of light and time, the kilogram is not. Scientists are researching alternative means to define the kilogram in terms of an equivalent electromagnetic force or in terms of the number of atoms in a carefully machined silicon sphere, but for the time being the kilogram is the only base unit in the SI that continues to be defined by a human-made artifact.

With respect to the other base units in the SI, the second is defined in terms of the time required for a certain quantum transition to occur in a cesium-133 atom. The Kelvin [abbreviated K without the degree (°) symbol] is based on the triple point of pure water, which is a special combination of pressure and temperature where water can exist as a solid, liquid, or gas. Similar fundamental definitions have been established for the ampere, mole, and candela.

(From An Introduction to Mechanical Engineering)

Exercises:

1. Match the words with their definitions:

Base unit

Derived unit

Prototype

Quantum transition

Triple point

- a. The specific combination of temperature and pressure where all three phases of a substance coexist in equilibrium.
- b. A unit of measurement that is fundamental and cannot be broken down into simpler units.
- c. A standard example used for comparison and calibration.
- d. A unit formed by combining base units.
- e. A change in energy level of an atom

2. Fill in the blanks with the correct words:

Velocity is an example of a _____ because it combines the units for length and time.

The Kelvin is based on the _____ of pure water.

The _____ meter is a bar made of platinum-iridium alloy.

The _____ for length in the SI is the meter.

The definition of a second is based on a specific _____ in a cesium-133 atom.

3. Answer the questions:

Why are units important in engineering and scientific measurements?

What are the base units in the SI system and what do they measure?

How has the definition of the meter evolved over time?

Why is the kilogram unique among the SI base units?

Explain the significance of the triple point of water in defining the Kelvin.

Why was it necessary to redefine the meter using the speed of light?

How does this new definition improve the robustness and repeatability of the meter?

What are the implications of this redefinition for scientific research and industry?

4. *Decide whether the sentences are true or false. Correct the false sentences:*

A base unit can be broken down into simpler units.

The meter was originally intended to be one ten-millionth of the length of the Earth's meridian through Paris.

The kilogram is defined by a reproducible measurement involving the speed of light.

The second is defined based on a quantum transition in a cesium-133 atom.

Derived units are independent of base units.

5. *Discuss the following question: "How do standardized units facilitate international collaboration in science and engineering?" Prepare a list of points to share with the group.*

6. *Choose one of the seven SI base units and research its historical development, current definition, and importance in scientific measurements. Prepare a poster or a slideshow to present your findings.*

7. *Write a short essay (150-200 words) on one of the following topics:*

The evolution of the definition of the meter and its importance in scientific measurements.

The challenges and significance of redefining the kilogram in terms of fundamental constants.

The importance of standardized units in global scientific communication.

Unit 7.

ESTIMATION IN ENGINEERING

In the later stages of a design process, engineers certainly make precise calculations as they solve technical problems. However, in the earlier stages of design, engineers nearly always make approximations when they solve technical problems. Those estimates are made to reduce a real system, as imperfect and nonideal as it may be, into its most basic and essential elements. Approximations are also made to remove extraneous factors that complicate the problem but that otherwise have little influence on a final result. Engineers are comfortable making reasonable approximations so

that their mathematical models are as simple as possible while leading to a result that is accurate enough for the task at hand. If the accuracy needs to be increased later on, for instance, as a design becomes finalized, then they need to incorporate more physical phenomena or details about the geometry, and the equations to be solved would likewise become more complicated.

Given that some imperfections and uncertainty are always present in real hardware, engineers often make order-of-magnitude estimates. Early in the design process, for instance, order-of-magnitude approximations are used to evaluate potential design options for their feasibility. Some examples are estimating the weight of a structure or the amount of power that a machine produces or consumes. Those estimates, made quickly, are helpful to focus ideas and narrow down the options available for a design before significant effort has been put into figuring out details.

Engineers make order-of-magnitude estimates while fully aware of the approximations involved and recognizing that reasonable approximations are going to be necessary to reach an answer. In fact, the term “order of magnitude” implies that the quantities considered in the calculation (and the ultimate answer) are accurate to perhaps a factor of 10. A calculation of this type might estimate the force carried by a certain bolted connection to be 1000 lb, implying that the force probably isn’t as low as 100 lb or as great as 10,000 lb, but it certainly could be 800 lb or 3000 lb. At first glance, that range might appear to be quite wide, but the estimate is nevertheless useful because it places a bound on how large the force could be. The estimate also provides a starting point for any subsequent, and presumably more detailed, calculations that a mechanical engineer would need to make. Calculations of this type are educated estimates, admittedly imperfect and imprecise, but better than nothing. These calculations are sometimes described as being made on the back of an envelope because they can be performed quickly and informally.

Order-of-magnitude estimates are made when engineers in a design process begin assigning numerical values to dimensions, weights, material properties, temperatures, pressures, and other parameters. You should recognize that those values will be refined as information is gathered, the analysis improves, and the design becomes better defined.

(From An Introduction to Mechanical Engineering)

Exercises:

1. Read the provided text carefully. Highlight or underline the sentences that explain why approximations are important in the early stages of the design process. Note down any new vocabulary or technical terms and look up their meanings.

2. In your own words, summarize why engineers make approximations in the early stages of the design process. Explain what is meant by "order-of-magnitude estimates."
3. Think of a real-world scenario where an engineer might need to make an order-of-magnitude estimate. Choose one scenario and outline the factors you would consider to make an order-of-magnitude estimate.
4. Review the example given in the text about estimating the force carried by a bolted connection. List the assumptions made in this estimate and explain their significance.
5. Write a brief essay discussing the importance of making reasonable approximations in engineering. Include at least one example from your own experience or research where an approximation led to a successful design decision.
6. Assume you are an engineer explaining your order-of-magnitude estimate to a client who is not an engineer. Prepare a short presentation (3-5 minutes) explaining your estimate, the assumptions, and why it's useful. After the presentation, the "client" should ask questions to clarify understanding.

Unit 8.

ENGINEERING MATERIALS

A wide variety of materials is available for engineering products, and choosing the correct ones is an important aspect of the design process. Mechanical engineers select materials in the context of both the product's purpose and the processes that will be used during its manufacture. The main classes of materials encountered in mechanical engineering are:

- Metals and their alloys
- Ceramics
- Polymers
- Composite materials

Electronic materials comprise another class that includes the semiconductors that are used widely in electronic, computer, and telecommunication systems. Devices such

as microprocessors and memory chips use metal materials, such as electrical conductors and ceramic materials as insulators.

Engineers select materials based on their performance, cost, availability, and past track record in similar applications. Because the production of engineering materials involves the consumption of natural resources and energy, environmental concerns are also factors involved in the selection process. The more manufacturing steps that are required to produce the material and form it into a final product, the greater the material's cost both economically and environmentally. The full life cycle of a material involves the use of natural resources, for instance, in the form of ores, processing raw materials, fabricating and manufacturing products, using the product, and then either disposing of the product or recycling its materials.

In selecting the materials to be used in a product, an engineer first needs to decide on the class of materials to use. Once the class has been chosen (for instance, metals and their alloys), an engineer next determines which material within the class is most appropriate (for instance, steel or aluminum). Many products are designed to use combinations of different classes of materials, each one best suited for a specific task. Automobiles, for instance, contain about 50–60% steel in the frame, engine, and drivetrain components; 5–10% aluminum for engine and body components; and 10–20% plastics used for trim and interior components. The remaining fraction includes glass for the windows, lead for the battery, rubber for the tires, and other materials.

(From An Introduction to Mechanical Engineering)

Exercises:

1. Match the terms on the left with their corresponding definitions on the right:

Terms	Definitions
1. Metals	A. A measure of a material's ability to withstand external forces without breaking.
2. Ceramics	B. A material made from two or more different substances.
3. Polymers	C. Materials composed of metallic elements, known for their conductivity.
4. Composite Materials	D. Synthetic materials made from long chains of molecules.
5. Mechanical Properties	E. Non-metallic, inorganic materials known for their hardness and brittleness.
6. Environmental Impact	F. Characteristics that describe how a material responds to mechanical forces.
7. Life Cycle	G. The effect that a product has on the environment throughout its existence.

Terms	Definitions
8. Stress	H. A complete process from raw material extraction to disposal or recycling.

2. *Fill in the blanks with the correct words:*

metals, ceramics, polymers, composite, life cycle, environmental impact, mechanical properties, stress

The _____ of a product includes all stages from raw material extraction to disposal or recycling.

_____ are known for their conductivity and are commonly used in structural applications.

_____ are inorganic materials that are typically hard and brittle, often used in high-temperature applications.

_____ consist of long chains of molecules and are used in a wide range of applications, from packaging to automotive parts.

Engineers consider the _____ when choosing materials to ensure minimal harm to the environment.

A _____ material is made from two or more different substances to combine their properties.

The _____ of a material describe how it behaves under mechanical forces such as tension, compression, and shear.

When a material is subjected to _____, it experiences forces that can cause deformation or failure.

3. *Choose the correct answer for each question:*

Which class of materials is known for being hard and brittle, often used in high-temperature applications?

A. Metals B. Ceramics C. Polymers D. Composite

Which of the following best describes composite materials?

A. They are synthetic materials made from long chains of molecules.

B. They are made from two or more different substances to combine their properties.

- C. They are metallic elements known for their conductivity
- D. They are inorganic materials that are typically hard and brittle

The complete process from raw material extraction to disposal or recycling is known as:

- A. Environmental Impact
- B. Mechanical Properties
- C. Stress
- D. Life Cycle

Which term refers to the effect that a product has on the environment throughout its existence?

- A. Life Cycle
- B. Mechanical Properties
- C. Environmental Impact
- D. Stress

What do mechanical engineers consider when selecting materials for a product?

- A. Performance, cost, availability, and past track record
- B. Only the cost and availability
- C. Environmental impact and aesthetics
- D. Durability and colour

4. *Decide whether the sentences are true or false. Correct the false sentences:*

Composite materials are made from a single type of substance.

The environmental impact of a material is not a factor considered by engineers during the selection process.

Metals are typically non-conductive and used in high-temperature applications.

The life cycle of a product includes stages from raw material extraction to disposal or recycling.

Polymers are synthetic materials that consist of long chains of molecules.

5. *Think of a real-world scenario where an engineer might need to select materials for a product. Include materials for a new smartphone design and materials for a bridge construction. Choose one scenario and outline the factors you would consider to select the appropriate materials. Identify the*

class of materials you would choose first, and then specify which material within that class you would select.

6. *Write a brief essay discussing the importance of considering the full life cycle of a material in the selection process. Include at least one example from your own experience or research where life cycle analysis influenced material selection.*
7. *Select two different classes of materials (e.g., metals and polymers) and compare their properties, cost, and environmental impact. Create a comparison chart that highlights the key differences and similarities.*
8. *Choose a specific product (e.g., a bicycle) and analyze which parts could be made from metals, ceramics, polymers, and composite materials. Justify your choices based on the properties and performance requirements of each part. Discuss how different materials can be combined in a single product to optimize performance and cost.*

Unit 9.

METALS AND THEIR ALLOYS

Metals are relatively stiff and heavy materials; in other words, from a technical standpoint, they generally have large values for their elastic modulus and density. The strength of metals can be increased by mechanical and heat treatments and by alloying, which is the process of adding small amounts of other carefully chosen elements to a base metal. From a design standpoint, metals are a good choice to use in structures and machines that must carry large forces. On the negative side, metals are susceptible to corrosion, and, as a result, they can deteriorate and weaken over time. Another attractive feature of metals is that many methods exist to make them, shape them, and attach them. Metals are versatile materials because they can be manufactured by casting, extrusion, forging, rolling, cutting, drilling, and grinding. Some metals, by virtue of their processing and alloys, have high degrees of ductility, that is, the ability of a material to withstand a significant amount of stretching before it fractures. A ductile material has a wide region over which plastic deformation occurs; the steel that is used in paper clips is a good example of a ductile metal. A brittle material like glass, on the other hand, exhibits essentially no plastic deformation. For obvious reasons, ductile metals are well-suited for use in structures

and machines because, when they become overloaded, the materials give prior warning by noticeably stretching or bending before they break.

- The 3003 grade aluminum alloy is often produced in the form of wide flat sheets, and it can be easily bent and shaped to form boxes and covers for electronic equipment, among other products. Used for machined mechanical components that are subjected to moderate forces, the 6061 alloy is available either annealed (A) or tempered (T6). Annealing and tempering are processing steps that involve heat treatment to improve the material's strength.
- Copper alloys include brasses (which are yellowish alloys of copper and zinc) and bronzes (which are brownish alloys of copper and tin). These materials do not have particularly high strengths, but they are resistant to corrosion and can be easily joined by soldering. Copper alloys are used in gears, bearings, and tubing in condensers and heat exchangers.
- Grade 1020 steel is a common, easily worked, and relatively inexpensive medium-grade alloy of steel. The 4340 grade is a higher-strength and more expensive material than grade 1020. Although all steels are comprised primarily of iron and a small fraction of carbon, they are differentiated based on mechanical and heat treatments and on the presence of additional alloying metals, including carbon, manganese, nickel, chromium, and molybdenum.
- For stainless steels, the 316 alloy is used for corrosion-resistant nuts, bolts, and pipe fittings, and the higher-strength material 440C is used to form the raceways of rolling element bearings.
- Titanium alloys are strong, lightweight, and corrosion-resistant. On the other hand, they are also far more expensive and difficult to machine than other metals. Titanium is used in chemical industrial pipes, gas turbine blades, high-performance aircraft structures, submarines, and other demanding material applications.

(From An Introduction to Mechanical Engineering)

Exercises:

1. Match the terms on the left with their corresponding definitions on the right:

Terms	Definitions
1. Elastic modulus	A. The process of adding small amounts of elements to a base metal to improve properties.
2. Density	B. Ability of a material to withstand significant stretching before fracturing.
3. Alloying	C. Amount of mass per unit volume of a material.
4. Corrosion	D. The deterioration of materials due to chemical reactions with their environment.

Terms	Definitions
5. Ductility	E. A measure of a material's stiffness or resistance to elastic deformation.
6. Annealing	F. Permanent deformation of a material subjected to stress beyond its elastic limit.
7. Tempering	G. A heat treatment process that improves a metal's strength and toughness.
8. Plastic deformation	H. A heat treatment process that softens a metal and improves its ductility.

2. Fill in the blanks with the correct vocabulary words from the provided list:

density, annealing, corrosion, elastic modulus, ductility, tempering, plastic deformation, alloying

_____ is the measure of a material's stiffness, indicating how much it will deform under a given stress.

The _____ of a material is its mass per unit volume.

_____ involves adding small amounts of other elements to a base metal to improve its properties.

_____ occurs when metals deteriorate due to chemical reactions with their environment.

_____ is the ability of a material to withstand significant stretching before it fractures.

_____ is a heat treatment process that softens metals and improves their ductility.

_____ is a heat treatment process that increases the strength and toughness of metals.

When a material undergoes _____, it experiences permanent deformation beyond its elastic limit.

3. Choose the correct answer for each question:

Which property describes a material's ability to withstand significant stretching before it fractures?

A. Elastic modulus B. Ductility C. Density D. Corrosion

What is the process called when small amounts of other elements are added to a base metal to improve its properties?

A. Annealing B. Tempering C. Alloying D. Plastic deformation

Which term refers to the deterioration of metals due to chemical reactions with their environment?

A. Elastic modulus B. Ductility C. Corrosion D. Tempering

What heat treatment process softens a metal and improves its ductility?

A. Alloying B. Annealing C. Tempering D. Plastic deformation

Which of the following metals is known for its high strength, lightweight, and corrosion resistance, but is difficult to machine?

A. Aluminum B. Copper C. Steel D. Titanium

4. *Decide whether the sentences are true or false. Correct the false sentences:*

Metals generally have high elastic modulus and density values.

Alloying is a process used to decrease the strength of metals.

Corrosion is a desirable property in metals used for structural applications.

Ductile metals are advantageous in structures because they show visible signs of deformation before breaking.

Titanium alloys are inexpensive and easy to machine compared to other metals.

5. *Write a brief essay about the importance of choosing the right metals and their alloys for different products.*

Unit 10.

CERAMICS

When you think of ceramics, images of coffee mugs, dinner plates, and artwork probably come to mind. Engineering ceramics, on the other hand, are used in the automotive, aerospace, electronics, telecommunications, computer, and medical industries for applications encompassing high temperatures, corrosion, electrical insulation, and wear resistance. Ceramics are produced by heating naturally occurring minerals and chemically treated powders in a furnace to form a rigid mechanical component.

Ceramics are hard, brittle, crystalline materials that can comprise metals and nonmetals. Ceramics have large values of the elastic modulus, but, because they are brittle and tend to break suddenly when overloaded, ceramics are not appropriate for

supporting large tensile forces. Mechanical components made from ceramics become significantly weakened by the presence of small defects, cracks, holes, bolted connections, and so forth.

An important characteristic of ceramics is that they can withstand extreme temperatures and insulate other mechanical components from heat. Ceramics are used as thermal barrier coatings to protect turbine blades from the high temperatures developed in jet engines. The space shuttle used tens of thousands of lightweight ceramic tiles to insulate the spacecraft's structural frame from temperatures that reached 2300°F during reentry.

Some examples of ceramics are the compositions of silicon nitride (Si_3N_4), alumina (Al_2O_3), and titanium carbide (TiC). Alumina is sometimes formed into a honeycomb-like support structure that is used in an automobile's exhaust system and catalytic converter. Because of its mechanical, electrical, and thermal characteristics, the advanced ceramic AlTiC (64% Al_2O_3 and 36% TiC) is used in computer hard disk drives to support the recording heads above the surface of the rotating disks. Engineers and physicians are finding an increasing range of applications for ceramic materials in medical applications, including the repair or replacement of human hips, knees, fingers, teeth, and diseased heart valves. Ceramics are one of the few materials that can withstand the corrosive environment of the human body's interior for an extended length of time. Ceramic implants and coatings of ceramics on metallic joint replacements have been found to stimulate bone growth and protect the metallic portions of an implant from the immune system.

(From An Introduction to Mechanical Engineering)

Exercises:

1. Match the words with their definitions:

Ceramics

Elastic modulus

Thermal barrier coatings

Alumina

Corrosion

Titanium carbide

Catalytic converter

Immune system

- a. A measure of a material's stiffness.
- b. Protective layers used to insulate components from heat

- c. A ceramic material also known as Al_2O_3
- d. A process that gradually destroys materials
- e. A ceramic material also known as TiC
- f. A device in the exhaust system of a car that reduces harmful emissions
- g. The body's defense mechanism against foreign substances
- h. Rigid, brittle materials made by heating minerals and powders

2. Fill in the blanks with the correct words from the exercise above:

_____, also known as Al_2O_3 , is commonly used in automotive exhaust systems.

_____ are used in many industries for their high-temperature and wear-resistant properties.

_____ is an important measure when considering the stiffness of ceramics.

The space shuttle was insulated with _____ to protect it from high reentry temperatures.

Ceramic implants stimulate bone growth and protect against the body's _____.

Because they are resistant to _____, ceramics are suitable for medical implants.

_____ is a ceramic material used in computer hard disk drives.

The _____ in an automobile helps to reduce emissions by converting toxic gases.

3. Choose the correct answer for each question:

Which of the following materials is used in thermal barrier coatings?

- a) Titanium carbide b) Alumina c) Silicon nitride d) All of the above

What characteristic makes ceramics suitable for use in high-temperature environments?

- a) High ductility b) High tensile strength c) High thermal resistance d) Low density

What is a common application of ceramics in the automotive industry?

- a) Engine blocks b) Exhaust systems c) Windshields d) Tires

Which property of ceramics is beneficial for medical implants?

- a) Elasticity b) Corrosion resistance c) Electrical conductivity d) Magnetism

4. Answer the questions:

What comes to mind when you hear the word "ceramics"? How do everyday ceramics differ from engineering ceramics?

Why do you think ceramics are used in such a wide range of industries?

Describe the process of creating ceramic materials and their unique properties.

Explain why ceramics are suitable for use in high-temperature environments.

Discuss the applications of ceramics in the medical field and their benefits over other materials.

Compare and contrast ceramics with metals in terms of their mechanical properties and typical uses in engineering.

5. *Prepare a short presentation on one specific type of ceramic material (e.g., alumina or titanium carbide). Include its properties, common uses, and why it is preferred in those applications. Give a presentation on the role of ceramics in the automotive industry, discussing specific components and why ceramics are chosen for these applications.*
6. *Present a hypothetical problem where a new high-temperature component for a jet engine is needed. Discuss what materials might be suitable, focusing on the properties of ceramics that make them ideal for this application. Discuss the challenges and solutions when working with brittle materials like ceramics in high-stress environments.*
7. *Debate Topic: "Ceramics should replace metals in all high-temperature applications." Discuss the pros and cons of ceramics versus metals.*

Unit 11.

POLYMERS

Plastics and elastomers are two types of polymers. The root of "polymer" is a Greek word meaning "of many parts," and it emphasizes the fact that polymers are giant molecules formed as long chains of smaller, building-block molecules. These polymer macromolecules have enormous molecular weights, and they can contain hundreds of thousands of atoms. Each macromolecule is made up of a large number

of simpler units that are joined together in a regular repeating pattern. Polymers are organic compounds; that is, their chemical formulation is based on the properties of the element carbon. Carbon atoms are able to attach themselves to one another more than other elements can, and other atoms (such as oxygen, hydrogen, nitrogen, and chlorine) are attached to those carbon chains. From a chemical standpoint, therefore, engineering polymers are formed from large-chained molecules having a regular pattern and based on carbon.

Rubber and silk are two naturally occurring macromolecules, but chemists and chemical engineers have developed hundreds of useful macromolecular materials. Synthetic polymers are classified into two groups: plastics (which can be extruded into sheets and pipes or molded to form a wide range of products) and elastomers (which are compliant in a manner characteristic of rubber). Unlike the first two classes of materials—metals and their alloys and ceramics—plastics and elastomers are relatively soft materials. They typically have an elastic modulus that is many times smaller than metals. In addition, their properties also change significantly with temperature. At room temperature, polymers may stretch and behave elastically, but, as the temperature is lowered, they become brittle. These materials are not well suited for applications where strength is required or for operation at elevated temperatures. Nevertheless, plastics and elastomers are widely used and are remarkable engineering materials. They are relatively inexpensive, lightweight, good insulators against heat and electricity, and easy to shape and mold into complex parts.

Plastics are one of the most utilized engineering materials in any industry, and some of the most common forms are polyethylene, polystyrene, epoxy, polycarbonate, polyester, and nylon. Elastomers, the second category of polymers, are the synthetic rubber-like macromolecules that are elastic and stretchable in a manner that is characteristic of rubber. Elastomers can be greatly deformed and still return to their original shape after being released.

In one of their largest applications, elastomers are used to make tires for vehicles ranging from mountain bikes to aircraft. Other elastomers include the polyurethane foam that is used to insulate buildings, silicone sealant and adhesive, and neoprene, which is resistant to chemicals and oils. Elastomers are also used to make supports and mounting blocks that can reduce the vibration produced by a machine. Vibration isolation mounts that incorporate elastomers are used to attach an automobile's engine to its chassis and to isolate the hard disk drive in a laptop or tablet computer from shock and vibration in the event the computer is accidentally dropped.

(From An Introduction to Mechanical Engineering)

Exercises:

1. *Match the words with their definitions:*

Polymers

Macromolecules

Elastomers

Elastic modulus

Synthetic polymers

Extrude

Neoprene

Vibration isolation mounts

- a. Large molecules composed of repeating structural units
- b. The measure of a material's ability to resist deformation
- c. Polymers that are elastic and stretchable like rubber
- d. Materials created by chemical processes rather than occurring naturally
- e. A synthetic rubber that is resistant to chemicals and oils
- f. The process of shaping material by forcing it through a die
- g. Devices that use elastomers to reduce the vibration produced by machines
- h. Substances consisting of large molecules formed from many smaller units

2. *Fill in the blanks with the appropriate vocabulary:*

_____ are giant molecules with enormous molecular weights.

_____ can be greatly deformed and still return to their original shape.

One of the applications of _____ is making tires for vehicles.

_____ is a measure of a material's stiffness or resistance to elastic deformation.

_____ can be forced into shapes such as sheets and pipes.

_____ are used to reduce the vibration produced by machines.

_____ are created through chemical engineering processes.

_____ is a type of synthetic rubber used in adhesives and sealants.

3. *Choose the correct answer for each question:*

Which of the following is an example of a naturally occurring macromolecule?

a) Polyethylene

- b) Rubber
- c) Neoprene
- d) Polycarbonate

What characteristic makes elastomers particularly useful in vibration isolation mounts?

- a) High tensile strength
- b) Elasticity
- c) High density
- d) Brittleness

Which polymer is commonly used to make lightweight and strong plastic products?

- a) Nylon
- b) Silicone
- c) Neoprene
- d) Epoxy

What is a major disadvantage of polymers compared to metals and ceramics?

- a) High cost
- b) Poor insulation properties
- c) Inability to operate at high temperatures
- d) Difficulty in shaping and molding

4. *Answer the questions:*

What are some everyday products that are made from plastics and elastomers?

How do these materials compare to metals and ceramics in terms of their properties and applications?

Discuss the environmental impact of using synthetic polymers. What are some ways to mitigate these impacts?

Describe the process of creating synthetic polymers and their typical applications.

Explain the difference between plastics and elastomers and provide examples of each.

Discuss why polymers are not suitable for applications requiring high strength and temperature resistance.

Discuss the challenges of using elastomers in high-temperature environments. What solutions could engineers explore to overcome these challenges?

5. *Prepare a short presentation on the properties and applications of a specific type of plastic (e.g., polycarbonate or polystyrene). Include why this plastic is chosen for particular uses and any potential disadvantages.*
6. *Give a presentation on the role of elastomers in the automotive industry, focusing on their use in tires and vibration isolation mounts. Discuss how their properties make them suitable for these applications.*
7. *Present a hypothetical problem where a new product needs to be lightweight, durable, and easy to mold. Discuss what types of polymers would be suitable and why.*
8. *Write a short essay (150-200 words) on one of the following topic:*
"Synthetic polymers should be replaced with natural materials whenever possible." Highlight the advantages and disadvantages of synthetic versus natural materials

Unit 12.

COMPOSITE MATERIALS

As their name implies, composites are mixtures of several materials, and their formulation can be customized and tailored for specific applications. Composite materials are generally comprised of two components: the matrix and the reinforcement. The matrix is a relatively ductile material that holds and binds together the strong reinforcing particles or fibers embedded in it. Some composite materials comprise a polymer matrix (usually epoxy or polyester) that is reinforced by many small-diameter fibers of glass, carbon, or Kevlar®.

Composites are not well-suited for high temperatures because, like plastics and elastomers, the polymer matrix softens as the temperature increases. The main idea behind fiber-reinforced composites is that the strong fibers carry most of the applied force. Other examples of composite materials are concrete that has been reinforced with steel rods, automobile tires that include steel reinforcing belts in an elastomer

matrix, and power transmission belts that use fiber or wire cords to carry the belt's tension.

Composite materials are an example of the adage that "the whole is greater than the sum of its parts" in that their mechanical properties are superior to those of the constituent materials alone. The primary advantages of composites are that they can be made very stiff, strong, and lightweight. However, the additional processing steps necessary to produce these materials raise their cost.

The widespread usage of fiber-reinforced composite materials began in the aerospace industry, where weight is at a premium. A substantial amount of an aircraft's weight can be reduced by incorporating composite materials into the airframe, horizontal and vertical stabilizers, flaps, and wing skins. Approximately 30% of the external surface area of the Boeing 767 commercial airliner is formed from composite materials.

As the technology of composites has matured and costs have decreased, these materials have been adopted in automobiles, spacecraft, boats, architectural structures, bicycles, skis, tennis rackets, and other consumer products.

(From An Introduction to Mechanical Engineering)

Exercises:

1. Match the words with their definitions:

Composite materials

Matrix

Reinforcement

Polymer matrix

Kevlar

Ductile

Epoxy

Fibers

- a. The component in composites that provides the primary structural strength
- b. A strong, lightweight synthetic fiber used in composites
- c. The part of a composite that binds and supports the reinforcing material
- d. A mixture of materials tailored for specific applications
- e. Flexible and capable of being drawn out into a thin wire
- f. A type of polymer used as a matrix in composites
- g. The small-diameter strands that provide strength in composites
- h. A matrix made from polymers like epoxy or polyester

2. *Fill in the blanks with the appropriate vocabulary words from the exercise above:*

_____ materials are tailored mixtures used in various applications for enhanced properties.

The _____ holds and binds the reinforcing particles in a composite.

_____ is a type of strong fiber used to reinforce composites.

A _____ matrix is commonly made from epoxy or polyester.

_____ can be easily shaped and molded due to their ductility.

The primary role of _____ in a composite is to provide structural strength.

The _____ component in composites is crucial for binding the materials together.

High-performance materials like _____ are used in applications where weight reduction is crucial.

3. *Choose the correct answer for each question:*

What are the main components of composite materials?

- a) Metals and ceramics
- b) Matrix and reinforcement
- c) Polymers and elastomers
- d) Concrete and steel

Which material is often used as a reinforcement in polymer matrix composites?

- a) Steel rods
- b) Carbon fibers
- c) Rubber
- d) Copper wires

What is the primary advantage of using composite materials in aerospace?

- a) High temperature resistance
- b) Low cost
- c) Weight reduction
- d) Easy processing

Why are composites not suitable for high-temperature applications?

- a) They are too expensive
- b) The polymer matrix softens at high temperatures
- c) They are too heavy
- d) They have poor mechanical properties

4. *Answer the questions:*

What are some everyday products that use composite materials?

How do these products benefit from the properties of composites?

Discuss the environmental impact of producing and disposing of composite materials.

What are some sustainable alternatives or practices?

Describe the process of creating composite materials and their typical applications.

Explain the difference between the matrix and reinforcement in a composite material and provide examples of each.

Discuss why composites are unsuitable for high-temperature applications and what alternatives might be used.

Compare and contrast the properties of composite materials with those of metals and ceramics in terms of their mechanical properties and typical uses in engineering.

- 5. Prepare a short presentation on the advantages and applications of fiber-reinforced composites in the automotive industry. Include why these materials are chosen and any potential disadvantages.
- 6. Give a presentation on the use of composite materials in the construction industry, focusing on their benefits for architectural structures. Discuss how their properties make them suitable for these applications.
- 7. Present a hypothetical problem where a new product needs to be strong, lightweight, and cost-effective. Discuss what types of composite materials would be suitable and why.
- 8. Discuss the challenges of using composites in high-temperature environments. What solutions could engineers explore to overcome these challenges?

9. *Write a short essay (150-200 words) on one of the following topics:*

"Composite materials should replace traditional materials in most engineering applications." Mention the advantages and disadvantages of composites versus traditional materials.

REFERENCES:

1. Dubicka Iw., O’Keffe M., Dignen B., Hogan M., Business Partner Level B1+. Student’s Book. – Pearson, 2020. – 160 p.
2. Jonathan Wickert, Kemper Lewis, An Introduction to Mechanical Engineering. - Cengage Learning, 2013. – 449p.
3. https://en.wikipedia.org/wiki/Glossary_of_mechanical_engineering

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