COURSE: Engineering Concepts (ET-EC)

UNIT: 2. Engineering Disciplines

INTRODUCTION

Annotation:

In this unit, students will learn about the many disciplines associated with engineering and the occupational outlook of the field. Students will also participate in activities representative of tasks performed by many of the engineering disciplines.

Grade(s):

	9th
X	10th
X	11th
X	12th

Time:

17 hours

Author:

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Note to Teacher:

This lesson was based on Chapter 5 of *Engineering Your Future* (Great Lakes Press, Second Ed.). Please refer to this text for class preparation.

Students with Disabilities:

For students with disabilities, the instructor should refer to the student's IEP to be sure that the accommodations specified are being provided. Instructors should also familiarize themselves with the provisions of Behavior Intervention Plans that may be part of a student's IEP. Frequent consultation with a student's special education instructor will be beneficial in providing appropriate differentiation.

FOCUS STANDARDS

GPS Focus Standards: Please list the standard and elements covered.

- ENGR-EC-1 – Students will describe the history and characteristics of engineering disciplines.
- ENGR-STEM-6 – Students will enhance reading by developing vocabulary and comprehension skills associated with text materials, problem descriptions, and laboratory activities associated with engineering and technology education.
- FS-CTAE-10 – Career Development: Learners plan and manage academic-career plans and employment relations.
- FS-CTAE-11 – Entrepreneurship: Learners demonstrate understanding of concepts, processes, and behaviors associated with successful entrepreneurial performance.

GPS Academic Standards:

National / Local Standards / Industry / ISTE:

UNDERSTANDINGS & GOALS

Enduring Understandings:

Students will learn that the field of engineering is broad and touches all aspects of society.

Essential Questions:

- What are the different engineering disciplines?
- What is the occupational outlook and expected salary of engineers?

Knowledge from this Unit: Factual information.

Skills from this Unit: Performance.

ASSESSMENT(S)

Assessment Method Type: Select one or more of the following. Please consider the type(s) of differentiated instruction you will be using in the classroom.

_____ Pre-test
__X__ Objective assessment - multiple-choice, true- false, etc.
- _X_ Quizzes/Tests
- _X_ Unit test

_____ Group project
_____ Individual project
_____ Self-assessment - May include practice quizzes, games, simulations, checklists, etc.
- __ Self-check rubrics
- __ Self-check during writing/planning process
- __ Journal reflections on concepts, personal experiences and impact on one's life
- __ Reflect on evaluations of work from teachers, business partners, and competition judges
- __ Academic prompts
- __ Practice quizzes/tests

_____ Subjective assessment/Informal observations
- __ Essay tests
- __ Observe students working with partners
- __ Observe students role playing

_____ Peer-assessment
- __ Peer editing & commentary of products/projects/presentations using rubrics
- __ Peer editing and/or critiquing

_____ Dialogue and Discussion
- __ Student/teacher conferences
- __ Partner and small group discussions
- __ Whole group discussions
- __ Interaction with/feedback from community members/speakers and business partners

_____ Constructed Responses
- __ Chart good reading/writing/listening/speaking habits
- __ Application of skills to real-life situations/scenarios

_____ Post-test

Assessment(s) Title:

Engineering Disciplines Quiz

Engineering Careers Test

Assessment(s) Description/Directions:

Students should complete the Engineering Disciplines Quiz to ensure that they understand the concepts taught in this lesson. The quiz and answer key can be found as an instructional material accompanying this lesson.

Attachments for Assessment(s): Please list.

- EC_2_Engineering Disciplines Quiz and Answer Key
- EC_2_Engineering Careers Test

LEARNING EXPERIENCES

Sequence of Instruction

1. Identify the Standards. Standards should be posted in the classroom for each lesson.

- ENGR-EC-1 – Students will describe the history and characteristics of engineering disciplines.
- ENGR-STEM-6 – Students will enhance reading by developing vocabulary and comprehension skills associated with text materials, problem descriptions, and laboratory activities associated with engineering and technology education.
- FS-CTAE-10 – Career Development: Learners plan and manage academic-career plans and employment relations.
- FS-CTAE-11 – Entrepreneurship: Learners demonstrate understanding of concepts, processes, and behaviors associated with successful entrepreneurial performance.

2. Review Essential Questions.

- What are the different engineering disciplines?
- What is the occupational outlook and expected salary of engineers?

3. Identify and review the unit vocabulary.

4. Assessment Activity.

Introduction

Begin a class discussion by asking students if they can name any engineering disciplines. As students name engineering disciplines, ask them if they have any ideas about what that particular discipline involves. After the student gives their answer, provide a little more information on that discipline.

Tell students that engineering careers continually evolve over time. Some disciplines have become extinct because of society's changing needs. As we progress through this new millennium it is inevitable that new engineering disciplines will develop and more will fall to the wayside.

Engineering Disciplines

1. Acoustical Engineering: plan, perfect, or improve the sound of an architectural space. This could mean examining the innumerable surfaces in a church or drawing CAD plans for a subwoofer enclosure

- Deals with 2 basic properties of sound: reflection and absorption
- Investigate how different noises and background sounds affect productivity in a building

- When a structure is being designed, the building's usage, the placement of essential equipment, and the amount and type of required space is considered. All of these decisions are dictated by function and once they are made, the acoustical engineer is brought in to set the mood of the environment
- When working in large, high-productivity office spaces the hardest sounds to eliminate are HVAC or air conditioning systems
- Acoustical engineers are in high demand, but there are very few of them

2. Automotive Engineering: plan, coordinate, and implement the specifications for a new car, engineering every part
   - Use computer-aided engineering programs to design and draw parts, combine parts into components, and integrate components into the car's systems
   - Take the aesthetic design developed by an automotive designer and make the mechanical aspects of the car fit into it
   - Challenges faced by automotive engineers are caused by emissions laws, cost of materials and development, performance requirements, and consumer demands
   - Requires a degree in engineering, interpersonal and communication skills, ability to multitask, technical knowledge, and design experience

3. Aerospace Engineering (Aero or Astronautical): design, develop, test, and help manufacture aircraft, missiles, and spacecraft
   - Develop new technologies for military and commercial use
   - Can be divided into 2 fields: aeronautical engineering (works will aircrafts) and astronautical engineering (works with spacecrafts)
   - Can specialize in many fields, ranging from propulsion to thermodynamics
   - Requires an engineering-related degree from a 2- or 4-year college, completion of a formal training program, and licensing or examination

4. Agricultural Engineering: concerned with the production and processing of agricultural products, which are critical to our ability to feed the ever-expanding world population
   - Can specialize in many fields, such as power machinery, bioengineering, soils and water, electrical technologies, and food processing
   - An example would be designing and implementing an irrigation system for crop production

5. Bioengineering (Biomedical, Biomechanical, Biochemical): the application of engineering principles to biological systems

- Examples of their work would be genetically modifying a plant or animal to produce a disease-resistant strain or developing the chemical process necessary to make an artificial kidney function
- Encompasses many fields of study, including chemistry, physics, technology, and medicine
- Biomedical engineering is one of the newest and fastest growing disciplines, and applies the fundamentals of engineering to meet the needs of the medical community
- Requires an undergraduate, and often graduate, degree in bioengineering

6. Chemical Engineering: take what chemists do in a laboratory, apply fundamental engineering, chemistry, and physics principles, and design and develop processes to produce products for use in our society
    - Different from other disciplines because it focuses on chemistry and the chemical nature of products and processes
    - Most common employment of chemical engineers is the design of large-scale chemical production facilities
    - Solve problems that involve the production and use of chemicals
    - Must develop processes that minimize harmful waste since many chemicals and their byproducts are dangerous to people and the environment
    - Requires a Bachelor's degree and strong math, science skills, and computer skills

7. Civil Engineering: designing and supervising the construction of roads, buildings, airports, tunnels, bridges, and water and sewage systems
    - Main objective is to design systems that are functional, efficient, durable, and minimize harm on the environment
    - Affected by population shifts, urban planning and renewal efforts, zoning laws, and building codes
    - Structural engineers are the most common type of civil engineers. They are concerned with the integrity of the structure of buildings, highways, and bridges
    - Other types of civil engineers are transportation engineers, surveyors, urban planning engineers, and construction engineers

8. Computer Engineering: design and build computer-related hardware products for many applications, such as personal computers, cell phones, automobiles, and even washing machines
    - Apply the theories and principles of science and mathematics to design hardware, software, networks, computer chips, and processors
    - Often work in teams
    - One of the fastest growing disciplines

- Different from computer science in that computer scientists focus on software and its optimization while computer engineers focus on computer hardware or the machine itself
- Security is becoming a huge concern of computer engineers

9. Construction Engineering: concerned with the management and operation of construction projects
    - Interested in improving construction methods and materials to make them safer, more reliable, cost effective, and environmentally friendly
    - Incorporate technical, financial, and legal requirements into a plan to meet project deadlines
    - Requires project management skills and knowledge of computer tools

10. Electrical Engineering: responsible for the design, development, testing, and supervision of the manufacturing of electrical equipment, such as household appliances or guidance systems for satellites
    - Work with all products and systems that use electricity
    - Concerned with making their designs efficient, long lasting, cost-effective, and safe
    - The most populated and traditional of the engineering disciplines
    - Because it's such a broad field, it can be divided into 8 areas: computers, communications, circuits and solid waste devices, control, instrumentation, signal processing, bioengineering, and power

11. Environmental Engineering: apply engineering principles in order to improve and maintain the environment
    - Uses science to make the world a safer place for humans and animals
    - 3 components of environmental engineering: disposal (disposing industrial and residential waste), remediation (cleaning a contaminated site), and prevention (reduce or eliminate the amount of waste from the manufacturing process)
    - Requires knowledge of engineering fundamentals and environmental laws and regulations

12. Fire Protection Engineering: design fire sprinkler, alarm, and exit systems, as well as aid in the investigation of fires and explosions
    - Work in private or public sector for consulting firms, petrochemical societies, federal agencies, insurance companies, and in health care industries
    - Analyze risk of major facilities and consult with architects on large projects

13. Food Process Engineering: concerned with providing healthier products to consumers, who increasingly rely on food products
    - Involved in the efficient and safe processing and delivery of food products
    - Design processing, handling, and packaging equipment for the food industry

- Can work in food, chemical, and pharmaceutical industries

14. Genetic Engineering: use science to research genes found in the cells of plants and animals to develop better products

- Demand for this discipline is growing
- The discipline is surrounded by complicated political, economic, and moral conflicts
- A common type is one that specializes in the study of a disease and its affects on humans
- Must follow rigid safety measures and work with dangerous chemicals, electron microscopes, and even gene guns to carry out their research
- Can be divided into 4 categories: human, animal, plant, and microorganism

15. Geological Engineering: use science to work with land and water

- Range of tasks vary due to the ever-growing and changing field
- Investigate sites for major land-related projects, such as bridges or tunnels
- Mitigate toxic waste and land contamination
- Use physics to predict the flow of water
- Build and maintain earth-related power sources, such as hydroelectric plants
- Requires a graduate degree

16. Industrial Engineering: design, improve, and install integrated systems of people, materials, and energy

- Involves the integration of technology, mathematical models, and management practices
- Traditionally the job is done on a factory floor, but the skills can be applied to many other applications and industries
- Focus on 4 main areas: production, manufacturing, human factors, and operations research
- Production is concerned with optimizing the process involved in making a product by reducing cost and production time, and increasing quality and reliability
- Manufacturing addresses the concerns of each individual production station in the production process and optimizes the actual material processing
- The human factors area studies the interfaces between people, machines, and objects
- Operations research involves mathematically modeling systems to identify ways to improve them

17. Manufacturing Engineering: applies science and math to the design, development, and implementation of manufacturing systems (i.e. they produce goods)

- Often involves the supervision of skilled craftsmen

- Make decisions about technology, machinery, people, and money to produce high-quality goods when people want them at affordable prices
- Often work in teams to launch new products
- Partner with design engineers, marketing specialists, supply chain managers, human resources, and accountants
- Must know how to use resources, including machines, robots, people, computer-based tools, information networks, and money
- Because manufacturing engineers work at the core of industrial companies, they learn the vital interests of the company and can easily advance into management and executive positions

18. Marine and Ocean Engineering: concerned with the exploration of oceans, the transportation of products over water, and the utilization of resources in the world's oceans, lakes, and seas

- Design and operate ships, boats, and submarines, especially their propulsion, navigation, and steering systems
- Design underwater pipelines, offshore drilling platforms, and offshore harbor facilities
- Study wave action and design ways to reduce erosion while protecting marine life
- Control and treat pollution in the ocean and find alternative sources of energy from the ocean

19. Materials Science Engineering: develop new materials, improve traditional materials, and produce materials that are economical and reliable through synthesis and processing

- Concerned with 4 components of materials: structure, properties, processes, and performance
- Structure – study the molecular bonding and chemical composition of materials
- Properties – optimize the strength, crack growth rates, hardness, and durability of materials
- Processes – different processes of creating materials give materials different properties, so materials engineers design processes that give each material its desired properties
- Performance – ensure that a material meets its performance demands by designing test procedures that make sure these requirements are met
- Examples of materials that materials science engineers work with would be metals, ceramics, plastics, and composites

20. Mechanical Engineering: design, produce, operate, and service machines and mechanical devices

- Second largest engineering discipline after electrical engineering
- Mechanical engineers are often involved in automating time-consuming or expensive procedures
- Composed of 2 main division: design and controls, and thermal sciences
- Design and controls is concerned with:

    - The strength of machine parts and the stress that each part will be subjected to
    - Developing tools that help the design engineer design a machine
    - Controlling machines through mechanical, hydraulic, and digital controls
    - Minimizing the unwanted noise of a machine
- Thermal science is concerned with:
    - The flow of fluids and energy between systems
    - Study and predict the temperature of machines parts, and design cooling devices for them
    - Heating, ventilating, and air conditioning of buildings
    - Performance and efficiency of large power generation plants, and developing alternative energy sources

21. Mineral and Mining Engineering: maintain the flow of raw materials by discovering, extracting, and processing minerals for products

- Explore land, the ocean floor, the earth's core, and asteroids for ore and mineral deposits
- Design mining tunnels, open pit mines, and blasting techniques while keeping the environmental impact to a minimum
- Purify and separate minerals through chemical and mechanical processes
- Design safer equipment for the dangerous mining industry
- Use mining knowledge to create subways systems and railroad tunnels

22. Nuclear Engineering: study nuclear energy, radiation, and their beneficial uses

- Work in nuclear plants to design and operate reactors
- Responsible for the production of nuclear fuel and safe disposal of radioactive waste
- Integrate nuclear power in the propulsion systems of ships, submarines, rockets, and satellites, which allows them to go years without refueling
- Find ways to use radiation to improve the medical and agricultural fields.
- Requires the ability to shift work to meet production schedules, identify hazards, and weigh risks and benefits constantly

23. Petroleum Engineering: concerned with maintaining the safe flow of petroleum, exploring for crude oil deposits, removing and transporting oil, and refining oil

- Use satellite and geological information to locate gas and oil deposits
- Design and operate oil drilling equipment and facilities, which can be on land or offshore platforms
- Extract oil safely and in a way that minimally harms the environment

- Design and operate the chemical process of refining petroleum into other products, like gasoline, motor oil, lubricants, and plastics

24. Robotics and Automated Systems Engineering: concerned with programming robots and systems to perform tasks autonomously

- One of the newest and most exciting disciplines
- Needed to design more efficient and skilled robots to assemble complex products and operate spacecrafts
- Requires the engineer to be competent in many programming languages and UNIX operating systems, as well as the ability to work in a team and communicate effectively
- Requires a Bachelor's degree in chemical engineering, computer science, or chemistry for entry-level jobs and a Master's or Doctorate degree is needed to become a senior engineer or executive

25. Software Engineering: responsible for the coding of computer software that results in a simple and friendly environment for computer users

- Can create programs for internal use in the office or coordinate technical systems and growth within a company
- One of the fastest growing professions in the United States
- Unlike many other engineers, software engineers work in a large office setting
- Requires a Bachelor's degree in a computer or technology related field, broad knowledge of computers and technology, and certification of fluency in certain programs

26. Structural Engineering: create safer structures and fit more people and objects per square inch into these structures

- Analyze and design almost any structure imaginable, such as skyscrapers, bridges, tunnels, canals, and space platforms
- Determine the best structural system, the sizes of columns, beams, walls, staircases, and foundations, and the type of reinforcement that each element requires
- Must design structures to withstand their own weight, plus natural forces such as gravity, wind, and earthquakes
- Prepare detailed structural sketches in accordance with standard specifications

Occupational Outlook:

- Expected to grow about as fast as the average for all occupations over the next decade (about 11%)
- Growth will vary by specialty
- Environmental engineers should experience the fastest growth

- Civil engineers should see the largest employment increase
- Overall job opportunities in engineering are expected to be good because the number of engineering graduates should be in rough balance with the number of job openings between 2006 and 2016
- Employers will rely on engineers to increase productivity and expand output of goods and services
- New technologies continue to improve the design process, enabling engineers to produce and analyze various product designs much more rapidly than in the past
- Technological advances are not expected to limit employment opportunities in engineering, like in other occupations, because engineers continue to develop new products and systems
- Offshoring of engineering work will slow domestic employment growth because there are many well-trained, often English-speaking engineers around the world willing to work for much lower salaries
- Many engineers work on long-term research and development projects continue during economic slowdowns so the occupation is less affected by the ups and downs of the economy
- It is important for engineers to continue their education throughout their careers because much of their value to employers depends on their knowledge of the latest technology

Salary Information:

Curriculum	Bachelor's	Master's	Ph.D.
Aerospace/aeronautical/astronautical	$53,408	$62,459	$73,814
Agricultural	49,764		
Architectural	48,664		
Bioengineering and biomedical	51,356	59,240	
Chemical	59,361	68,561	73,667
Civil	48,509	48,280	62,275
Computer	56,201	60,000	92,500
Electrical/electronics and communications	55,292	66,309	75,982
Environmental/environmental health	47,960		
Industrial/manufacturing	55,067	64,759	77,364
Materials	56,233		
Mechanical	54,128	62,798	72,763
Mining and mineral	54,381		
Nuclear	56,587	59,167	
Petroleum	60,718	57,000	

* Data comes from the Bureau of Labor Statistics' Occupational Outlook Handbook, 2008

Activities

A. Engineers learn to see new products in relation to their predecessors and competitors. They do this in order to avoid reinventing an existing product and to learn from the work of other engineers. Such product analysis leads to a deeper understanding of the design requirements that a product must meet. Part of this analysis involves examining the materials used in the manufacturing of the product. In this activity, students will look at changes in materials used in the manufacturing of everyday products over the last 75 years.

- Discuss reasons why different materials are used in products today compared to 75 years ago.
- Find examples of products whose materials have changed. Note: There were many design and material changes right before World War II.
- Evaluate the changes in materials and designs for these products:
    1. Electric kettle
    2. Microwave Oven
    3. Refrigerator
    4. Television
    5. Telephone
    6. Product of your choice

B. Students (individually or in groups) will research the engineering discipline that most interests them and use this research to prepare a report or presentation. The following information should be included:

- The nature of the work – what does an engineer in this discipline do?

- Job responsibilities and daily tasks
- Necessary training to enter in the field
- Advancement opportunities
- Future outlook of this discipline
- Average Salary
- Why this engineering discipline interests the student

C. Case Study

Municipal Solid Waste (MSW) – most commonly known as trash or garbage – consists of everyday items such as product packaging, grass clippings, old furniture, clothing, bottles, food scraps, newspapers, appliances, paint, and batteries. In 1999, U.S. residents, businesses, and institutions produced more than 230 million tons of MSW, which is approximately 4.6 pounds of person per day, up from 2.6 pounds per person per day in 1960.

Several management practices, such as source reduction, recycling, and composting, have been instituted to combat the growth of MSW. Source reduction involves altering the design, manufacture, or use of products and materials to reduce the amount and toxicity of waste. Recycling diverts items, such as paper, glass, plastic, and metals from the waste stream. These materials are sorted, collected, processed, and re-manufactured into new products. Composting decomposes organic waste, such as food scraps and yard trimmings, with microorganisms (mainly bacteria and fungi), producing a humus-like substance for enriching the soils where needed.

Other practices address those materials that require disposal. Landfills are engineered areas where waste is placed into the land. Landfills usually have liner systems and other safeguards to prevent groundwater contamination. Combustion is another MSW practice that has helped reduce the amount of landfill space needed. Combustion facilities burn MSW at a high temperature, reducing waste volume and generating electricity.

In this case study, each team's objective is to design and build a model of a waste management system for a human settlement on the moon. Follow the procedures for the case study below:

1. Your school, in many ways, is like a miniature town. It has systems for governance, health care, traffic control, recreation, and waste disposal. To get a better idea of how much waste your school generates each week, find out how many students, teachers, administrators, and other staff (and animals, if any) are typically in the buildings.
2. Next, interview the cafeteria staff and the custodial staff for the answers to these questions:
    a. What gets thrown away?
    b. How many pounds get thrown away every week? Calculate how many pounds of trash this is per person in the school using the number you came up with in the first step.
    c. Are there any items that can be recycled before disposal? If yes, what are the recycled items?
    d. Which items are biodegradable?
    e. Into what types of containers is the trash packed for removal?
    f. Where is the trash taken once it leaves the school?
    g. According to building codes, how many toilets must there be to accommodate all the people?
3. Waste is a hot topic in our culture. Why? Discuss what you know about the following phrases:
    a. Excessive packaging

b. Landfills
c. Toxic waste
d. Disposable plastic goods
e. Non-degradable material
f. Water pollution
g. Air pollution

4. In movies like those starring Indiana Jones, well-preserved, ancient artifacts are often found in the desert. Scientists also find artifacts in polar ice, like mastodons or ancient people, for example. Why do you think they have not decayed?
5. Review the Moon ABC's Fact Sheet. The Moon Base must be an enclosed, self-sustaining settlement. Just like your school, it must perform the basic functions of a town. Project teams are also responsible for designing and constructing several other types of systems (air supply, communications, electricity, food production and delivery, recreation, temperature control, transportation, and water supply). Your team's job is to dispose of the waste that could be generated by these other systems. Design a waste disposal system for the moon base. Be sure to decide what importance, if any, will be given to biodegradable materials, recycling, and the Moon outside of the constructed settlement.
6. Construct a model of this system based on your design. It must include the application of at least 4 facts from the Moon ABC's Fact Sheet. For example, how will the moon's gravity affect the design of your system? Maybe your system will be heavy but still portable by a few moon base workers because the moon's gravity is 1/6th of Earth's gravity.
7. Make a detailed and labeled sketch of your team's model.

Attachments for Learning Experiences: Please list.

- EC_2_Engineering Disciplines
- EC_2_Moon ABC's Fact Sheet

Notes & Reflections: May include notes to the teacher, pre-requisite knowledge & skills, suggestions, etc.

CULMINATING PERFORMANCE TASK (Optional)

Culminating Unit Performance Task Title:

1. Design and Materials Evolution
2. Engineering Career Investigation
3. Waste Management Systems Case Study

Culminating Unit Performance Task Description/Directions/Differentiated

Detailed directions for each activity can be found above under "Sequence of Learning and Instruction".

Attachments for Culminating Performance Task

Moon ABC's Fact Sheet *(to be used in the Waste Management Systems Case Study)*

UNIT RESOURCES

Web Resources:

Vocational Information Center: http://www.khake.com/index.html

http://en.wikipedia.org/wiki/Main_Page

http://www.howstuffworks.com/

Attachment(s): Supplemental files not listed in assessment, learning experiences, and performance task.

Materials & Equipment:

What 21st Century Technology was used in this unit:

X	Slide Show Software		Graphing Software		Audio File(s)
	Interactive Whiteboard		Calculator		Graphic Organizer
	Student Response System		Desktop Publishing		Image File(s)
	Web Design Software		Blog		Video
	Animation Software	X	Wiki		Electronic Game or Puzzle Maker
	Email	X	Website		