Burlington County Institute of Technology

Westampton Campus

Career and Technical Programs

Career Cluster: *Science, Technology, Engineering & Mathematics*
Program Name: *Engineering, General*
Program Title: *Engineering Technology*
CIP Code: *140101*

Board Approval Date: December, 2023

Program of Study

- ➔ Grade 9
  - Freshman Engineering Clinic (RCBC ENG 151)
  - Engineering Graphics and CAD I (Stockton 2180)
- ➔ Grade 10
  - Introduction to Mechanical Design (RCBC MET 220)
  - Materials and Manufacturing (RCBC MET 235)
  - CNC Programming (RCBC MET 210)
- ➔ Grade 11
  - Intro to Computer Science I - C++ Programming (RCBC CSE 110)
  - Engineering Graphics and CAD II
  - Electrical Circuits (RCBC EET 121)
- ➔ Grade 12
  - Engineering Statics (RCBC EGR 201 / Stockton 2300)
  - Robot Vehicles
  - Finite Element Analysis / Computer Aided Engineering
  - Engineering Senior Project
  - Engineering School to Work (optional)

➔ Program Descriptor

- Engineering is a multi-level program for students interested in pursuing careers in the fields of mechanical and civil engineering. Students will build a deep foundational knowledge in mathematics and basic sciences and that will prepare them for higher level education. The program includes theory and practical applications of engineering theory, design, manufacturing, structural analysis, and research. The students will also learn about the career and postsecondary education opportunities of the trade. Due to the heavy use of technology in the engineering sector, students will also be introduced to using computer software pertinent to the educational outcomes of the program.

➔ Program Outcome

- Graduates of this program will be able to communicate technical information both verbally and in writing effectively, demonstrate mathematical skills and application of scientific principles in problem solving, and apply critical thinking and problem solving skills to analyze data, in the creation of experimental procedures and analysis of the outcome.

➔ Work Based Learning Opportunities

- School-Based Enterprise: Students work closely with industry professionals to design, prototype, and fabricate a viable product. Students could be a collaborative group from several shops to diversify knowledge, perspective, and experiences.
- Hazardous Cooperative Education: Students will work with professionals at companies such as Radwell and OPEX in entry level positions.

➔ Industry Valued Credentials

- AutoCAD
- AutoDesk Inventor
- OSHA 10

➔ Post-Secondary Articulations

- Rowan College at Burlington County
    - CAD Fundamentals (EGR 110)

- Circuits I (EET 121)
- Digital Circuits (EET 240)

Course Descriptions

1. Grade 9
    a. Freshman Engineering Clinic: *The Freshman Engineering Clinic is an introductory course that provides students with a comprehensive foundation in engineering disciplines. This hands-on program delves into basic engineering mathematics, precision in calculations, and units of measurement with an emphasis on significant digits. Students will explore the principles of vectors, technical writing, and the engineering design process. Additionally, the course covers essential topics related to mechanical drive elements, including gear, belt, and chain drive systems, as well as RPM and torque calculations. In the realm of motion actuation, students will gain knowledge about motors, solenoids, and pneumatics. Basic electronics concepts such as alternating and direct current, voltage, resistance, electrical power, Ohm's Law, and components like capacitors, inductors, diodes, LEDs, phototransistors, and power switching will also be introduced. This course offers an engaging and interactive learning experience for students entering the field of engineering.*
    b. *Engineering Graphics and CAD I: This course offers a comprehensive introduction to the world of engineering graphics and Computer-Aided Design (CAD). Students will explore the fundamental principles of creating detailed engineering drawings, both in traditional formats and using modern CAD software. Topics covered include various types of engineering drawings, including pictorial and perspective representations, and industry-standard practices for technical documentation. Students will gain hands-on experience with industry-leading CAD tools such as AutoCAD and PTC OnShape, learning essential drawing commands and techniques. Additionally, the course delves into reverse engineering, prototyping, and 3D printing, allowing students to bring their designs to life. Throughout the course, students will apply the Engineering Design Process, honing their problem-solving and*

design skills. By the end of the course, students will be proficient in producing precise engineering drawings and technical documentation, making them well-prepared for careers in the field of engineering and design.

2. Grade 10
    a. Introduction to Mechanical Design: *Introduction to Mechanical Design is a comprehensive course that delves into the fundamental principles of mechanical engineering and design. Students will embark on a journey through the world of mechanisms, exploring graphical linkage synthesis, positional and dynamics analysis of linkages, and the intricacies of uncommon linkages such as the four-bar linkage and slider-crank systems. The course emphasizes hands-on learning, including mechanism design using CAD software, prototyping, and manufacturing of mechanical systems. Students will also gain a deep understanding of structural design and design considerations, including component tolerancing for efficient assembly. By the end of this course, students will possess the skills and knowledge necessary to tackle real-world mechanical design challenges with confidence.*
    b. Materials and Manufacturing: *This course provides a comprehensive exploration of engineering materials and the processes involved in modern manufacturing. Students will delve into the physical and chemical properties of engineering materials, gaining a deep understanding of how these properties influence material selection and application. Mechanical properties, such as strength, elasticity, and durability, will be studied in the context of material behavior under various conditions. The course covers a wide range of manufacturing topics, including production systems and chains, tooling, and manufacturing methods, giving students insights into the entire manufacturing process. Product engineering, product life cycles, and computer-aided manufacturing (CAM) will be examined to understand how products are conceived, designed, and produced. Additionally, sustainable manufacturing practices will be emphasized, addressing the environmental and ethical considerations in modern manufacturing processes. Through hands-on projects and real-world case studies, students will develop a strong foundation in materials science and manufacturing technology, preparing them for careers in engineering and related fields.*
    c. CNC Programming: *This course delves into the world of Computer Numerical Control (CNC) programming, offering students an immersive experience in the principles and techniques of CNC machining. Beginning with the historical evolution and philosophy behind CNC, students explore the various types of CNC controls and gain a fundamental understanding of programming CNC machines.*

Topics include absolute and incremental movement, cutting speeds, stock shapes, and the intricacies of tool pathing. Through hands-on practice, students learn to manually code in G-Code and post-process G-Code generated from Computer-Aided Manufacturing (CAM) software. Practical CNC operations on milling machines, routers, and lathes are covered in-depth, with a strong emphasis on safety, quality control, and machine maintenance. By the end of this course, students will have acquired the skills and knowledge required to program CNC machines effectively, ensuring precision, reliability, and safety in the manufacturing process.

3. Grade 11
    a. *Intro to Computer Science I - C++ Programming:* This course is an introduction to the fundamental concepts of programming and problem solving. It focuses on simple data types, control structures, and introduction to array and string data structures and algorithms, as well as debugging techniques and the social implications of computing. It emphasizes good software engineering principles and developing fundamental programming skills in the context of a language that sports the object-oriented paradigm. The lab component provides hands-on programming experience that is vital for beginning programmers in various fields of engineering.
    b. *Engineering Graphics and CAD II:* .Engineering Graphics and CAD II is an advanced course designed to provide students with a deeper understanding of computer-aided design (CAD) software and its applications in engineering. This course delves into the intricacies of Autodesk Inventor and Solidworks, teaching students how to create complex 3D models and assemblies. Through hands-on projects, students will explore parametric modeling, equations, and linked dimensions, enabling them to design more sophisticated and customizable components. The course also covers sheet metal design, weldments, and bill of materials generation. Collaboration, project management, and scheduling are emphasized, preparing students for real-world teamwork and organization. In addition, the class introduces students to electrical circuits, covering topics from basic conduction and voltage to complex AC analysis and inductance properties. Students will gain essential skills in geometric dimensioning and tolerancing (GD&T) and manufacturing quality assurance. This course equips students with a comprehensive skill set, combining CAD proficiency with a solid foundation in electrical circuits and design principles, making them well-prepared for diverse engineering challenges.
4. Grade 12

a. *Engineering Statics:* Engineering Statics is a fundamental course that provides students with a comprehensive understanding of the principles governing the equilibrium of objects and structures in static conditions. Through a structured curriculum, students will delve into topics such as concurrent force systems, equilibrium of particles and rigid bodies, and the analysis of trusses, frames, and machines. This course explores critical engineering concepts, including internal forces in structural members, friction, and moments of inertia. Students will also learn to apply the method of virtual work to solve complex engineering problems. By the end of this course, students will have developed a strong foundation in statics, enabling them to analyze and design stable structures and systems essential for various engineering disciplines. Practical applications and hands-on problem-solving will be emphasized throughout the course to prepare students for real-world engineering challenges.
b. *Robotic vehicles* - This course provides an introduction to robotics, ground vehicles, and aerial vehicles. The students will learn the basics of mechanical, electrical, and software engineering in relation to creating a robotic vehicle. Studies will include lessons on gearing, powertrains, electric motors, battery management, sensors, and software-based decision making. The students will create a robot vehicle that utilizes engineering design principles.
c. *Finite Element Analysis/Simulations:* Fundamental concepts for the development of finite element analysis are introduced. The element stiffness matrices are developed using shape functions defined on the elements. Aspects of global stiffness formulation, consideration of boundary conditions, and nodal load calculations are presented. Use of pre-existing computer software will be utilized, along with use of student written code using C++/#, MATLAB, Python, or Java.
d. *Senior Project:* In the Senior Project course for engineering, students engage in a real-world-like professional setting, adhering to structured timelines and participating in regular status meetings. Emphasizing leadership and collaborative skills, the course involves students in the Clinic component managing tasks and guiding junior peers, while those in team projects research existing solutions and work towards unique design creations. The course's core focus is on preparing students for the workforce by acclimating them to professional schedules and the dynamics of teamwork, culminating in a project that bridges academic learning with practical application.
e. *Engineering School to Work* (optional): This experience is available to qualified students that have the ability to demonstrate their skills and proficiencies in a practical setting. Students will earn credit and income during their school to work experiences in their field of study. Students must provide their own

transportation to available themselves for this opportunity. This experience is coordinated by the school to work coordinator and have the recommendation of the instructor.

Curriculum Maps

Course: Safety	Unit: OSHA 10	Length: 1 Week

Standards

- 9.3.12.AG-FD.1 Develop and implement procedures to ensure safety, sanitation and quality in food product and processing facilities.
- 9.3.12.AC-CST.5 Apply practices and procedures required to maintain jobsite safety.
- 9.3.12.AR.2 Analyze the importance of health, safety and environmental management systems, policies and procedures common in arts, audio/video technology and communications activities and facilities.
- 9.3.12.ED.4 Evaluate and manage risks to safety, health and the environment in education and training settings.
- 9.3.HT-RFB.2 Demonstrate safety and sanitation procedures in food and beverage service facilities.
- 9.3.HU-ED.5 Evaluate safety and sanitation procedures associated with the early childhood education environment to assure compliance and prevent potential hazards.
- 9.3.LW.4 Conduct law, public safety, corrections and security work tasks in accordance with employee and employer rights, obligations and responsibilities, including occupational safety and health requirements.
- 9.3.LW-ENF.8 Explain the appropriate techniques for managing crisis situations in order to maintain public safety.
- 9.3.MN.3 Comply with federal, state and local regulations to ensure worker safety and health and environmental work practices.
- 9.3.MN-HSE.3 Demonstrates a safety inspection process to assure a healthy and safe manufacturing environment.
- 9.3.MN-HSE.5 Evaluate continuous improvement protocols and techniques in health, safety and/or environmental practices.

- 9.3.12.TD.5 Describe transportation, distribution and logistics employee rights and responsibilities and employers' obligations concerning occupational safety and health.
- 9.3.12.TD-HSE.1 Describe the health, safety and environmental rules and regulations in transportation, distribution and logistics workplaces.
- 9.3.12.TD-OPS.3 Comply with policies, laws and regulations in order to maintain safety, security and health and mitigate the economic and environmental risk of transportation operations.

Essential Question(s)

- Why is it important to practice safety?
- What do safe practices look like in my industry?
- How can I keep myself and others safe?

Content

- Walking working surfaces
- Emergency action plans
- Fire protection
- Electrocution hazards
- Personal protective equipment
- Hazard communication
- Materials handling, storage, use and disposal.

Skills

- Explain why OSHA is important to workers.
- Explain workers rights under OSHA
- Discuss employer responsibilities under OSHA.
- Discuss the use of OSHA standards.
- Explain how OSHA inspections are conducted.
- Utilize helpful worker safety and health resources.

- Identify hazards in the workplace associated with walking and working surfaces.
- Identify best practices for eliminating or controlling hazards associated with walking and working surfaces in the workplace.
- Recognize employer requirements to protect workers from walking and working surface hazards.
- Recognize benefits of an Emergency Action Plan.
- Identify elements of the Fire Protection Plan.
- Identify conditions under which evacuation actions may be necessary in an emergency situation.
- Identify conditions under which shelter-in-place may be necessary in an emergency situation.
- Identify characteristics of an effective emergency escape route.
- Recognize the five types of fire extinguishers, including the types of fires they can extinguish.
- Review requirements for proper maintenance of portable fire extinguishers.
- Identify major electrical hazards.
- Describe types of electrical hazards.
- Describe electrical protection methods.
- Recognize employer requirements to protect workers from electrical hazards.
- Recall employer responsibilities toward affected employees regarding PPE.
- Identify when face and head protection should be used.
- Recall which types of hand and foot protection should be used in a specific situation.
- Recognize the differences between respirator types.
- Identify the differences between full-body protection levels.
- Identify the employer's responsibilities under the HCS, including training requirements.
- Identify components of a Hazard Communication program.
- Describe requirements of the different types of Hazard Communication labels.
- Locate pertinent information about chemicals on labels, including other forms of hazard communication, to ensure "right to understanding" provisions of GHS requirements.
- Identify types of material handling equipment.
- Describe hazards associated with material handling activities (e.g., storage, use, and disposal).
- Identify methods to prevent hazards associated with material handling equipment.
- Recognize employer requirements to protect workers from material handling hazards

- Identify the main causes of machinery accidents.
- Recognize basic machinery parts that expose workers to hazards.
- Recognize workplace situations involving machinery that requires guarding.
- Identify the requirements for safeguards.
- Identify types of machine guards including types of devices used to safeguard machines.
- Identify strategies to control chemical hazards.
- Identify strategies to control biological hazards.
- Identify strategies to control physical hazards.
- Identify strategies to control ergonomic hazards.
- Identify OSHA requirements pertaining to bloodborne pathogens.
- List the potential routes of exposure from bloodborne pathogens.
- Identify the risks associated with Human Immunodeficiency Virus (HIV), Hepatitis B, and Hepatitis C Virus.
- Identify methods of preventing transmission of bloodborne pathogens & managing occupational exposures.
- Restate methods of the safe disposal of sharps.
- Recount steps which should be taken in the event of an exposure to a potential bloodborne pathogen.
- Recognize risk factors associated with work-related musculoskeletal disorders (MSD)s.
- Identify good posture.
- Describe safe lifting techniques.
- Identify ergonomic control methods for eliminating/reducing work-related MSDs.
- Identify the number one cause of death for U.S. teens.
- List eight risk factors for young drivers.
- Identify the biggest risk factor for young drivers.
- Define distracted driving.
- Provide examples and/or causes of distracted driving.
- Identify the biggest risk factor for distracted driving
- Discuss the risk of having other young passengers in the car.
- List some actions employers should take to keep employees safe while driving.
- List some actions employees can take to safely drive on the job.
- Define the term violence.

- Recall who is at risk for encountering workplace violence.
- Describe workplace violence prevention strategies.
- Identify how to StartSafe and StaySafe to prevent or lessen workplace violence.
- Recognize the costs of workplace accidents.
- Recognize the benefits of implementing an effective safety and health program.
- Describe the elements of an effective safety and health program.
- Identify three methods to prevent workplace hazards.

Assessments

- OSHA 10 Assessment and Certificate

Course: CTE	Unit: Career Awareness	Length: Woven Throughout

Standards

- 9.2.12.CAP.1: Analyze unemployment rates for workers with different levels of education and how the economic, social, and political conditions of a time period are affected by a recession.
- 9.2.12.CAP.2: Develop college and career readiness skills by participating in opportunities such as structured learning experiences, apprenticeships, and dual enrollment programs.
- 9.2.12.CAP.3: Investigate how continuing education contributes to one's career and personal growth.
- 9.2.12.CAP.4: Evaluate different careers and develop various plans (e.g., costs of public, private, training schools) and timetables for achieving them, including educational/training requirements, costs, loans, and debt repayment.
- 9.2.12.CAP.5: Assess and modify a personal plan to support current interests and postsecondary plans. ·

- 9.2.12.CAP.6: Identify transferable skills in career choices and design alternative career plans based on those skills.
- 9.2.12.CAP.7: Use online resources to examine licensing, certification, and credentialing requirements at the local, state, and national levels to maintain compliance with industry requirements in areas of career interest.
- 9.2.12.CAP.8: Determine job entrance criteria (e.g., education credentials, math/writing/reading comprehension tests, drug tests) used by employers in various industry sectors.
- 9.2.12.CAP.9: Locate information on working papers, what is required to obtain them, and who must sign them.
- 9.2.12.CAP.10: Identify strategies for reducing overall costs of postsecondary education (e.g., tuition assistance, loans, grants, scholarships, and student loans)
- 9.2.12.CAP.11: Demonstrate an understanding of Free Application for Federal Student Aid (FAFSA) requirements to apply for postsecondary education
- 9.2.12.CAP.12: Explain how compulsory government programs (e.g., Social Security, Medicare) provide insurance against some loss of income and benefits to eligible recipients.
- 9.2.12.CAP.13: Analyze how the economic, social, and political conditions of a time period can affect the labor market.
- 9.2.12.CAP.14: Analyze and critique various sources of income and available resources (e.g., financial assets, property, and transfer payments) and how they may substitute for earned income
- 9.2.12.CAP.15: Demonstrate how exemptions, deductions, and deferred income (e.g., retirement or medical) can reduce taxable income.
- 9.2.12.CAP.16: Explain why taxes are withheld from income and the relationship of federal, state, and local taxes (e.g., property, income, excise, and sales) and how the money collected is used by local, county, state, and federal governments. ·
- 9.2.12.CAP.17: Analyze the impact of the collective bargaining process on benefits, income, and fair labor practice. ·
- 9.2.12.CAP.18: Differentiate between taxable and nontaxable income from various forms of employment (e.g., cash business, tips, tax filing and withholding). ·

- 9.2.12.CAP.19: Explain the purpose of payroll deductions and why fees for various benefits (e.g., medical benefits) are taken out of pay, including the cost of employee benefits to employers and self-employment income.
- 9.2.12.CAP.20: Analyze a Federal and State Income Tax Return
- 9.2.12.CAP.21: Explain low-cost and low-risk ways to start a business.
- 9.2.12.CAP.22: Compare risk and reward potential and use the comparison to decide whether starting a business is feasible.
- 9.2.12.CAP.23: Identify different ways to obtain capital for starting a business

Essential Question(s)

- How does one prepare for a career?
- How does one improve marketability?
- Why is career planning important?
- What are the risks in starting a business?

Content

- There are strategies to improve one's professional value and marketability.
- Career planning requires purposeful planning based on research, self-knowledge, and informed choices.
- An individual's income and benefit needs and financial plan can change over time.
- Securing an income involve an understanding of the costs and time in preparing for a career field, interview and negotiation skills, job searches, resume development, prior experience, and vesting and retirement plans
- Understanding income involves an analysis of payroll taxes, deductions and earned benefits.
- There are ways to assess a business's feasibility and risk and to align it with an individual's financial goals

Skills

- Act as a responsible and contributing community member and employee.
- Attend to financial well-being.
- Consider the environmental, social and economic impacts of decisions.

- Demonstrate creativity and innovation.
- Utilize critical thinking to make sense of problems and persevere in solving them.
- Model integrity, ethical leadership and effective management.
- Plan education and career paths aligned to personal goals.
- Use technology to enhance productivity, increase collaboration and communicate effectively.
- Work productively in teams while using cultural/global competence.

Assessments

- Career Research Project
- Resume/Cover Letter

Course: Freshman Engineering Clinic — Length: Semester

Standards

- 9.3.ST.1 Apply engineering skills in a project that requires project management, process control and
- quality assurance.
- 9.3.ST.2 Use technology to acquire, manipulate, analyze and report data.
- 9.3.ST.3 Describe and follow safety, health and environmental standards related to science,
- technology, engineering and mathematics (STEM) workplaces.
- 9.3.ST.4 Understand the nature and scope of the Science, Technology, Engineering & Mathematics
- Career Cluster and the role of STEM in society and the economy.
- 9.3.ST.5
- Demonstrate an understanding of the breadth of career opportunities and means to those
- opportunities in each of the Science, Technology, Engineering & Mathematics Career

- Pathways.
- 9.3.ST.6 Demonstrate technical skills needed in a chosen STEM field

Essential Question(s)

- How do different engineering disciplines contribute to solving real-world challenges, and what are the key characteristics that distinguish them?
- How can mathematical concepts, such as rounding, significant digits, and unit conversions, be effectively applied to solve engineering problems and ensure precision in measurements?
- What is the role of vectors in engineering, and how are they used to represent and manipulate physical quantities and forces in various applications?
- What are the essential stages of the engineering design process, and how can this structured approach be employed to develop innovative solutions to complex problems?
- How do mechanical drive systems, motion actuation components, and electronic circuits interact within engineering systems, and how can their performance be optimized for specific applications?

Content

- Engineering Disciplines: Understand the various branches and disciplines within the field of engineering.
- Basic Engineering Mathematics: Be familiar with fundamental mathematical concepts relevant to engineering.
- Rounding: Know how to round numbers to the appropriate decimal places or significant figures.
- Significant Digits: Understand the concept of significant figures and how to use them in calculations.
- Units and Conversion: Be able to convert between different units of measurement commonly used in engineering.
- Vectors: Grasp the principles of vectors and vector operations.
- Technical Writing: Develop effective technical writing skills for documentation and reports.
- Engineering Design Process: Learn the stages and steps involved in the engineering design process.
- Experimental Design: Understand how to plan and conduct experiments for engineering analysis.

- Mechanical Drive Elements: Gain knowledge of gear drive systems, belt drive systems, and chain drive systems.
- RPM & Torque Calculations: Calculate and analyze rotations per minute (RPM) and torque in mechanical systems.
- Motion Actuation: Study motors, solenoids, and pneumatics as components of motion control.
- Basic Electronics: Comprehend fundamental principles of electronics, including AC and DC circuits.
- Voltage, Resistance, and Electrical Power: Learn about voltage, resistance, electrical power, and their relationships.
- Ohm’s Law: Understand Ohm's Law and its applications in electronic circuits.
- Capacitors and Inductors: Know the functions and characteristics of capacitors and inductors.
- Diodes and LEDs: Familiarize yourself with diodes and light-emitting diodes (LEDs) in electronics.
- Phototransistors: Understand phototransistors and their applications in sensing light.
- Power Switching: Learn how to control power in electronic circuits.

Skills

- Define and describe various engineering disciplines, highlighting their unique features and applications.
- Apply basic engineering mathematics to solve engineering problems, including algebraic equations and trigonometric functions.
- Round numbers and apply significant figures correctly when performing calculations and reporting results.
- Convert units of measurement confidently, including length, mass, time, and others commonly used in engineering.
- Perform vector operations, such as addition, subtraction, and scalar multiplication, to solve engineering-related problems.
- Communicate effectively through technical writing, producing clear and organized documentation and reports.
- Demonstrate an understanding of the engineering design process by identifying and applying its key stages.
- Plan and execute experiments with precision, including developing hypotheses, designing procedures, and analyzing data.
- Analyze and design mechanical drive systems, including gear drives, belt drives, and chain drives.

- Calculate and apply RPM and torque values in mechanical systems to optimize performance.
- Identify and select appropriate motion actuation components, such as motors, solenoids, and pneumatics, for specific applications.
- Explain the principles of basic electronics, including alternating current (AC) and direct current (DC) circuits.
- Calculate voltage, resistance, and electrical power in electrical circuits using Ohm's Law and relevant formulas.
- Design and analyze circuits involving capacitors and inductors, considering their behavior in electronic systems.
- Understand the functionality and applications of diodes, LEDs, and phototransistors in electronic devices.
- Implement power switching mechanisms in electronic circuits to control electrical power distribution.

Assessments

- Engineering Design Project:
  - Task: Students work in teams to identify a real-world problem and apply the engineering design process to create a solution. They must present their project, including design specifications, prototypes, and testing results, demonstrating their understanding of the engineering design process.
    - Assessment Criteria: Assessment will be based on the clarity of problem identification, creativity and feasibility of the solution, application of relevant engineering concepts, teamwork, and the ability to communicate and justify design decisions.
- Technical Report and Presentation:
  - Task: Each student selects a specific engineering topic covered in the course (e.g., significant digits, gear drive systems, electrical circuits) and conducts in-depth research. They then create a technical report summarizing their findings and prepare a presentation to explain the topic to the class.
    - Assessment Criteria: Assessment will be based on the depth of research, the clarity and organization of the technical report, the effectiveness of the presentation, and the ability to convey complex engineering concepts to peers.

Course: Engineering Graphics and CAD I	Length: Semester

Standards

- 9.3.ST.1 Apply engineering skills in a project that requires project management, process control and
- quality assurance.
- 9.3.ST.2 Use technology to acquire, manipulate, analyze and report data.
- 9.3.ST.3 Describe and follow safety, health and environmental standards related to science,
- technology, engineering and mathematics (STEM) workplaces.
- 9.3.ST.4 Understand the nature and scope of the Science, Technology, Engineering & Mathematics
- Career Cluster and the role of STEM in society and the economy.
- 9.3.ST.5 Demonstrate an understanding of the breadth of career opportunities and means to those
- opportunities in each of the Science, Technology, Engineering & Mathematics Career Pathways.
- 9.3.ST.6 Demonstrate technical skills needed in a chosen STEM field.
- 9.3.ST-ET.1 Use STEM concepts and processes to solve problems involving design and/or production.
- 9.3.ST-ET.4 Apply the elements of the design process.

Essential Question(s)

- How can engineering drawings and technical documentation serve as a universal language for communicating design concepts and specifications in the field of engineering?
- What are the key differences between orthographic, pictorial, and perspective views in engineering drawings, and how do these representations impact the design and manufacturing processes?
- How does the integration of CAD software, such as AutoCAD and PTC OnShape, enhance efficiency and precision in the creation of engineering drawings and 3D models?
- What role does the Engineering Design Process play in guiding the development of innovative engineering solutions and products, and how can it be applied effectively in real-world design challenges?

- In what ways does the use of 3D printing and prototyping technology revolutionize the product development process, and what are the practical implications for engineers and designers?

Content

- Types of Engineering Drawings:
  - Understand different types of engineering drawings, including orthographic, pictorial, and perspective views.
- Industry Standard Practices:
  - Familiarize yourself with industry-standard practices for creating engineering drawings and technical documentation.
- AutoCAD Basics:
  - Learn the basics of AutoCAD software, including its interface, drawing commands, and tools for creating and editing drawings.
- PTC OnShape:
  - Gain proficiency in using PTC OnShape, another essential CAD software, and become familiar with its drawing commands and features.
- Reverse Engineering:
  - Explore the concept of reverse engineering, where you dissect and understand existing products to create accurate drawings and models.
- Prototyping and 3D Printing:
  - Discover the process of prototyping and 3D printing, including how to turn your digital designs into physical prototypes.
- Technical Documentation:
  - Learn how to create detailed technical documentation that includes dimensions, tolerances, annotations, and other critical information.
- Engineering Design Process:
  - Apply the Engineering Design Process to solve real-world design challenges, from problem identification to prototype creation.
- Drawing Commands:

        - Master a variety of drawing commands and techniques in AutoCAD and PTC OnShape to accurately represent engineering designs.
    - Problem-Solving Skills:
        - Develop strong problem-solving skills as you tackle design challenges and create engineering drawings.
    - Precision and Detail:
        - Pay meticulous attention to precision and detail when creating engineering drawings, ensuring accuracy in measurements and annotations.
    - Collaboration:
        - Understand the importance of collaboration in engineering and design projects and effectively communicate your ideas through drawings and documentation.
    - Technical Communication:
        - Improve your technical communication skills by effectively conveying complex engineering concepts through drawings and documentation.
    - Application of Knowledge:
        - Apply the knowledge gained in the class to real-world engineering and design scenarios, making connections between theory and practice.
    - Safety:
        - Prioritize safety when working with CAD software, prototyping tools, and 3D printing equipment, following safety guidelines and best practices.
    - Professionalism:
        - Cultivate professionalism in your approach to engineering graphics, CAD work, and collaborative projects.
    - Creativity:
        - Encourage creative thinking to develop innovative solutions and designs within the scope of engineering and CAD.

Skills

- Engineering Drawing Proficiency:

        - Create accurate engineering drawings, including orthographic, pictorial, and perspective views, adhering to industry-standard practices.
    - CAD Software Competence:
        - Demonstrate proficiency in using AutoCAD and PTC OnShape software, including familiarity with drawing commands, tools, and the software interface.
    - Reverse Engineering Skills:
        - Analyze and reverse engineer existing products, extracting essential information to create precise engineering drawings and models.
    - Prototyping and 3D Printing:
        - Successfully convert digital designs into physical prototypes using 3D printing technology and prototyping processes.
    - Technical Documentation Mastery:
        - Develop comprehensive technical documentation that includes dimensions, tolerances, annotations, and all necessary information for manufacturing and assembly.
    - Engineering Design Process Application:
        - Apply the Engineering Design Process to address real-world design challenges, from defining problems to creating functional prototypes.
    - Drawing Commands Proficiency:
        - Master various drawing commands and techniques in both AutoCAD and PTC OnShape to accurately represent complex engineering designs.
    - Problem Solving and Critical Thinking:
        - Enhance problem-solving skills and critical thinking abilities while tackling engineering and design projects and overcoming design constraints.
    - Precision and Detail Orientation:
        - Exhibit precision and meticulous attention to detail when creating engineering drawings, ensuring accuracy in measurements and annotations.
    - Effective Collaboration:
        - Collaborate effectively with peers on engineering and design projects, sharing ideas, and integrating feedback for improved solutions.

- Technical Communication Skills:
  - Communicate complex engineering concepts clearly and concisely through drawings and technical documentation.
- Application of Knowledge:
  - Apply theoretical knowledge gained in class to practical engineering and design scenarios, making connections between theory and real-world applications.
- Safety Awareness:
  - Prioritize safety when working with CAD software, prototyping tools, and 3D printing equipment, following safety guidelines and protocols.
- Professionalism and Ethics:
  - Demonstrate professionalism and ethical conduct in all aspects of engineering graphics and CAD work.
- Creative Problem Solving:
  - Foster creative thinking to develop innovative and efficient design solutions within the framework of engineering and CAD.

Assessments

- Engineering Drawing Portfolio:
  - Students compile a portfolio of engineering drawings and technical documentation created throughout the course. This portfolio should include orthographic drawings, pictorial representations, and 3D models designed using AutoCAD and PTC OnShape.
  - Each drawing or model should be accompanied by explanatory notes that detail the design intent, dimensions, and any relevant industry standards.
  - The portfolio will be evaluated based on the accuracy, clarity, and completeness of the drawings, as well as the effective use of CAD software.
- Design Challenge and Presentation:
  - Students are presented with a real-world engineering design challenge, such as creating a mechanical component or product.

- Working individually or in teams, students must apply the Engineering Design Process to conceptualize, design, and document their solution.
- They will use CAD software to create detailed engineering drawings, 3D models, and technical documentation for their design.
- Finally, students present their design and documentation to the class, explaining their design choices, considerations, and how they followed industry standards.

Course: Introduction to Mechanical Design Length: Semester

Standards

- Demonstrate an understanding of the breadth of career opportunities and means to those
- opportunities in each of the Science, Technology, Engineering & Mathematics Career
- Pathways.
- 9.3.ST.6 Demonstrate technical skills needed in a chosen STEM field.
- 9.3.ST-ET.1 Use STEM concepts and processes to solve problems involving design and/or production.
- 9.3.ST-ET.4 Apply the elements of the design process.
- 9.3.MN-QA.6 Implement continuous improvement processes to maintain quality products.
- 9.3.MN-QA.7 Identify inspection processes that ensure products meet quality specifications.

Essential Question(s)

- How do mechanical systems and linkages play a crucial role in various engineering applications and industries?
- What are the fundamental principles and techniques used to design and analyze mechanical linkages and mechanisms effectively?

- How can graphical representations and CAD software be used to create and visualize complex mechanical systems?
- What are the key factors to consider when designing mechanical systems to ensure structural integrity and functionality?
- In what ways can prototyping and testing contribute to refining and optimizing mechanical designs for real-world applications?

Content

- Introduction to Mechanisms
  - Understanding the basics of mechanical systems and linkages.
- Graphical Linkage Synthesis
  - Techniques for creating and analyzing graphical representations of linkages.
- Four-Bar Linkages
  - In-depth study of four-bar linkages and their applications.
- Slider-Crank Mechanisms
  - Analysis and design of slider-crank systems, including their role in various machines.
- Inverted Slider-Crank Mechanisms
  - Examination of inverted slider-crank linkages and their unique characteristics.
- Uncommon Linkages
  - Exploration of less conventional linkages used in mechanical systems.
- Positional Analysis of Linkages
  - Techniques for determining the positions and movements of linkages.
- Dynamics Analysis of Linkages
  - Understanding the dynamic behavior of linkages, including forces and motion.
- Mechanism Design in CAD
  - Utilizing computer-aided design (CAD) software for designing mechanical systems.
- Prototyping and Manufacturing Mechanisms
  - Hands-on experience in building physical prototypes of designed mechanisms.
- Structural Design and Design Considerations

        - Principles of designing structurally sound mechanical systems, considering factors like materials and loads.
    - Tolerancing of Components for Assembly
        - Exploring the importance of component tolerances for successful assembly and function.

Skills

- Understand Mechanical Systems:
    - Define and explain fundamental concepts related to mechanical systems and mechanisms.
- Create Graphical Linkages:
    - Demonstrate the ability to create graphical representations of various mechanical linkages.
- Analyze Four-Bar Linkages:
    - Perform positional and dynamic analysis of four-bar linkages and evaluate their applications.
- Explore Slider-Crank Mechanisms:
    - Analyze, design, and comprehend the functionality of slider-crank mechanisms in different contexts.
- Investigate Inverted Slider-Crank Systems:
    - Identify and explain the characteristics and applications of inverted slider-crank linkages.
- Examine Uncommon Linkages:
    - Explore and describe less conventional mechanical linkages and their potential uses.
- Conduct Positional Analysis:
    - Determine the positions and movements of linkages using appropriate techniques.
- Perform Dynamics Analysis:
    - Analyze the dynamic behavior of mechanical systems, including force calculations and motion predictions.
- Utilize CAD for Mechanism Design:
    - Proficiently use computer-aided design (CAD) software to design and model mechanical systems.

Assessments

- Linkage Design Project:

- Task: Students are given a real-world engineering problem that requires the design of a mechanical linkage system to achieve a specific motion or function. They must use the principles and techniques learned in the course to design, analyze, and create a CAD model of the linkage. The assessment includes the submission of detailed drawings, calculations, and a presentation explaining their design choices and how it meets the project requirements.

- Mechanism Analysis Report:
  - Task: Students are provided with a complex mechanical system or mechanism. They are required to perform both positional and dynamic analyses of the mechanism, using appropriate software tools and mathematical methods. Students will submit a comprehensive report detailing their analysis, including diagrams, equations, and explanations of their findings, demonstrating their ability to analyze and understand the behavior of mechanical systems.

Course: Materials and Manufacturing	Length: Semester

Standards

- 9.3.ST.6 Demonstrate technical skills needed in a chosen STEM field.
- 9.3.ST-ET.1 Use STEM concepts and processes to solve problems involving design and/or production.
- 9.3.ST-ET.4 Apply the elements of the design process.
- 9.3.MN-PRO.3 Make continuous improvement recommendations based on results of production process
- audits and inspections.
- 9.3.MN-PRO.4 Coordinate work teams when producing products to enhance production process and
- performance.
- 9.3.MN-PRO.5 Demonstrate the safe use of manufacturing equipment.
- 9.3.MN-QA.2 Recommend and implement continuous improvement in manufacturing processes.
- 9.3.MN-QA.3 Coordinate work teams to create a product that meets quality assurance standards.

- 9.3.MN-QA.4 Employ project management processes using data and tools to deliver quality, value-added products.

Essential Question(s)

- How do material properties influence the selection of materials for specific engineering applications?
- What are the key principles and best practices of sustainable manufacturing?
- How does computer-aided manufacturing (CAM) enhance precision and efficiency in production?
- What ethical considerations are involved in materials sourcing and manufacturing practices?
- How can quality control measures ensure the reliability and consistency of manufactured products?

Content

- Engineering Materials:
  - Understand the different types of engineering materials, including metals, polymers, ceramics, and composites, along with their unique properties and applications.
- Physical Properties:
  - Familiarity with the physical properties of materials, such as density, thermal conductivity, electrical conductivity, and melting point, and how these properties affect material selection.
- Chemical Properties:
  - Knowledge of chemical properties, including reactivity, corrosion resistance, and chemical composition, and their importance in material performance.
- Mechanical Properties:
  - Understanding of mechanical properties, including tensile strength, hardness, elasticity, and fatigue resistance, and their significance in material behavior under load.
- Manufacturing Processes:
  - Awareness of various manufacturing processes, such as casting, machining, welding, and 3D printing, and their suitability for different materials and applications.
- Production Systems:

        - Understanding of production systems and supply chains, including concepts of lean manufacturing, production scheduling, and quality control.
    - Tooling:
        - Knowledge of tooling and cutting tools used in manufacturing, including their types, selection criteria, and maintenance.
    - Product Engineering:
        - Insight into the product engineering process, from concept development and design to prototyping and testing.
    - Product Life Cycles:
        - Awareness of product life cycle stages, including introduction, growth, maturity, and decline, and their implications for manufacturing and sustainability.
    - Computer-Aided Manufacturing (CAM):
        - Proficiency in using CAM software to create, simulate, and optimize manufacturing processes.
    - Sustainable Manufacturing:
        - Understanding of sustainable manufacturing practices, including waste reduction, energy efficiency, and environmental impact assessment.
    - Materials Selection:
        - The ability to select appropriate materials for specific engineering applications based on performance requirements and constraints.
    - Safety Protocols:
        - Adherence to safety protocols and guidelines when working with materials and manufacturing equipment.
    - Quality Control:
        - Knowledge of quality control methods and techniques to ensure product quality and reliability.
    - Ethical Considerations:
        - Awareness of ethical considerations in manufacturing, such as environmental responsibility and ethical sourcing of materials.
    - Problem-Solving Skills:

        - Ability to analyze manufacturing challenges, troubleshoot issues, and propose solutions for process improvement.
    - Communication Skills:
        - Effective communication of technical information, both in writing and verbally, for collaboration with team members and stakeholders.
    - Hands-on Experience:
        - Practical experience with manufacturing equipment and processes through hands-on projects and laboratory work.
    - Environmental Impact:
        - Understanding of the environmental impact of manufacturing processes and the ability to explore eco-friendly alternatives.
    - Industry Standards:
        - Familiarity with industry standards and regulations related to materials and manufacturing.

Skills

- Materials Selection:
    - Evaluate and select appropriate materials for specific engineering applications based on their properties and requirements.
- Material Testing:
    - Conduct tests to determine the physical, chemical, and mechanical properties of materials, including tensile tests, hardness tests, and impact tests.
- Manufacturing Processes:
    - Demonstrate proficiency in various manufacturing processes, such as machining, casting, welding, and additive manufacturing (3D printing).
- Computer-Aided Manufacturing (CAM):
    - Use CAM software to program and control CNC (Computer Numerical Control) machines for precision manufacturing.
- Prototyping:

        - Create prototypes of engineering components or products using rapid prototyping techniques and equipment.
    - Quality Control:
        - Apply quality control methods to monitor and ensure the precision and consistency of manufactured parts and products.
    - Tooling and Equipment Operation:
        - Operate and maintain manufacturing tools and equipment safely and efficiently.
    - Product Lifecycle Understanding:
        - Understand and analyze the entire product lifecycle, from design and production to distribution and disposal.
    - Supply Chain Management:
        - Comprehend the principles of supply chain management, including logistics, inventory management, and production planning.
    - Sustainability Practices:
        - Implement sustainable manufacturing practices, including waste reduction, energy efficiency, and environmental impact reduction.
    - Computer Skills:
        - Utilize computer software for drafting, modeling, and simulating manufacturing processes and products.
    - Technical Drawing:
        - Create technical drawings and schematics using industry-standard drafting techniques and CAD software.
    - Problem-Solving:
        - Identify and troubleshoot manufacturing challenges, proposing innovative solutions for process improvement.
    - Safety Protocols:
        - Adhere to safety protocols and guidelines when working with materials, machinery, and manufacturing processes.
    - Ethical Considerations:

        - Recognize and address ethical considerations related to manufacturing, including environmental responsibility and ethical sourcing.
    - Project Management:
        - Plan and manage manufacturing projects, including budgeting, scheduling, and resource allocation.
    - Communication Skills:
        - Effectively communicate technical information through written reports, presentations, and collaboration with team members and stakeholders.
    - Hands-On Skills:
        - Gain practical, hands-on experience by participating in laboratory experiments and real-world manufacturing projects.
    - Environmental Impact Analysis:
        - Evaluate the environmental impact of manufacturing processes and propose eco-friendly alternatives.
    - Compliance with Industry Standards:
        - Ensure compliance with industry standards, regulations, and quality control requirements in manufacturing practices.

Assessments

- Materials Analysis and Selection Project:
    - For this assessment, students are given a list of engineering applications (e.g., automotive components, electronic devices, construction materials) and a set of material properties (e.g., strength, thermal conductivity, cost). Each student or group of students must research and analyze the materials best suited for each application based on the given properties. They must justify their choices and provide a comprehensive report detailing the rationale behind their selections.
- Sustainable Manufacturing Case Study:
    - In this assessment, students choose a real-world manufacturing company and conduct a case study on its sustainability practices. They research the company's environmental initiatives, energy efficiency measures, waste reduction strategies, and ethical considerations in its supply chain. Students then create a presentation or report highlighting the company's sustainable manufacturing efforts, their impact on the environment, and potential areas for improvement.

Course: CNC Programming	Length: Semester

Standards

- 9.3.ST.6 Demonstrate technical skills needed in a chosen STEM field.
- 9.3.ST-ET.1 Use STEM concepts and processes to solve problems involving design and/or production.
- 9.3.ST-ET.4 Apply the elements of the design process.
- 9.3.MN-PRO.3 Make continuous improvement recommendations based on results of production process
- audits and inspections.
- 9.3.MN-PRO.4 Coordinate work teams when producing products to enhance production process and
- performance.
- 9.3.MN-PRO.5 Demonstrate the safe use of manufacturing equipment.
- 9.3.MN-QA.2 Recommend and implement continuous improvement in manufacturing processes.
- 9.3.MN-QA.3 Coordinate work teams to create a product that meets quality assurance standards.
- 9.3.MN-QA.4 Employ project management processes using data and tools to deliver quality, value-added
- products.

Essential Question(s)

- What is the history and significance of CNC technology, and how has it revolutionized modern manufacturing processes?
- How do CNC machines interpret and execute G-Code instructions, and what are the key principles involved in programming them for specific tasks?
- What safety measures and best practices should be followed when working with CNC machines to ensure the well-being of both operators and equipment?

- How can CNC programming and operation contribute to achieving precision and quality control in machining processes, and what techniques can be employed to monitor and maintain these standards?
- What are the key considerations for selecting appropriate stock shapes, defining machining features, and planning tool pathing to optimize efficiency and accuracy in CNC operations?

Content

- Understanding CNC Basics:
  - The concept of CNC and its historical significance.
  - Different types of CNC controls and their applications.
- Programming Fundamentals:
  - Basic principles of CNC programming.
  - Absolute and incremental movement in CNC.
  - Calculating cutting speeds for machining operations.
- Stock Shapes and Features:
  - Knowledge of basic stock shapes commonly used in CNC machining.
  - Understanding different machining features and tool pathing.
- Manual G-Code Programming:
  - Proficiency in manually writing G-Code instructions for CNC machines.
- Post-Processing G-Code:
  - Ability to process G-Code generated by Computer-Aided Manufacturing (CAM) software.
- CNC Machine Operation:
  - Practical experience in operating CNC milling machines, routers, and lathes.
- Safety Protocols:
  - General safety guidelines for working with CNC machines.
  - Safe practices during CNC machining operations.
- Quality Control:
  - Implementing quality control measures to ensure precision and accuracy in machining.
- Housekeeping and Maintenance:
  - Proper maintenance and housekeeping procedures to keep CNC machines in optimal condition.

Skills

- Master CNC Basics:
  - Understand the fundamentals of CNC technology, including its history, significance, and different types of CNC controls.
- Programming Proficiency:
  - Develop the ability to create CNC programs using basic programming principles, including absolute and incremental movement and cutting speed calculations.
- Stock and Feature Knowledge:
  - Identify and work with various stock shapes used in CNC machining.
  - Demonstrate expertise in selecting appropriate machining features and planning tool pathing for efficient operations.
- Manual G-Code Programming:
  - Write G-Code instructions manually to program CNC machines accurately.
- Post-Processing Skills:
  - Successfully process G-Code generated by CAM software to prepare CNC machines for operation.
- CNC Machine Operation:
  - Operate CNC milling machines, routers, and lathes with confidence, demonstrating the ability to load programs and oversee machining processes.
- Safety Awareness:
  - Apply general safety protocols and precautions when working with CNC machines to ensure a safe working environment.
- Quality Control and Precision:
  - Implement quality control practices to maintain precision and accuracy in machining operations.
- Machine Maintenance and Housekeeping:
  - Perform routine maintenance tasks and practice good housekeeping to keep CNC machines in optimal working condition.

Assessments

- CNC Programming Project:
  - Task: Each student will be assigned a specific CNC machining project, such as creating a customized part or component.
  - Assessment Criteria: Students must independently program the CNC machine, including generating the G-Code instructions, selecting appropriate tooling, defining tool paths, and setting machining parameters.
  - Evaluation: The quality of the machined part, adherence to safety protocols, and the accuracy of the CNC program will be evaluated.
- CNC Knowledge Test:
  - Format: A written test consisting of multiple-choice questions, short answer questions, and problem-solving scenarios.
  - Assessment Criteria: The test will assess students' theoretical knowledge of CNC programming principles, machine operation, safety protocols, and best practices.
  - Evaluation: Students will be evaluated based on their understanding of CNC concepts, ability to solve practical CNC programming problems, and their grasp of safety measures.

Course: Intro to Computer Science I-C++ Programming	Length: Semester

Standards

- 9.3.ST-SM.1 Apply science and mathematics to provide results, answers and algorithms for engineering and
- technological activities.
- 9.3.ST-SM.2 Apply science and mathematics concepts to the development of plans, processes and projects
- that address real world problems.
- 9.3.ST-SM.3 Analyze the impact that science and mathematics has on society.

- 9.3.ST-SM.4 Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data.
- 9.3.IT-PRG.8 Perform quality assurance tasks as part of the software development cycle.
- 9.3.IT-PRG.6 Program a computer application using the appropriate programming language.
- 9.3.IT-PRG.7 Demonstrate software testing procedures to ensure quality products.

Essential Question(s)

- What is the significance of programming in problem-solving, and how does it impact various fields of engineering and technology?
- How can you effectively use programming concepts such as variables, data types, and control structures to solve real-world problems with C++?
- What are the key principles of object-oriented programming (OOP), and how do they enhance software development in C++?
-
- What ethical considerations and social implications should programmers be aware of when developing software and applications, and how can responsible computing be practiced?
- How does debugging and troubleshooting play a crucial role in the software development process, and what strategies and tools are available for identifying and rectifying programming errors in C++ code?

Content

- Introduction to Computer Science and Programming:
  - Overview of computer science
  - Role of programming in problem-solving
  - Historical context of programming languages
  - Understanding the software development process
- C++ Programming Environment Setup:
  - Setting up a development environment

        - Installing a C++ compiler
        - Writing and running basic C++ programs
        - Debugging tools and techniques
    - Fundamental Programming Concepts:
        - Data types and variables
        - Arithmetic operations
        - Input and output operations
        - Writing and interpreting expressions
        - Control structures (if statements, loops)
    - Array Data Structures:
        - Understanding arrays
        - Array initialization and manipulation
        - Iterating through arrays
        - Multidimensional arrays
    - String Data Structures and Algorithms:
        - String manipulation and operations
        - Searching and sorting algorithms for strings
        - Working with character arrays
    - Object-Oriented Programming (OOP) in C++:
        - Principles of OOP
        - Classes and objects
        - Constructors and destructors
        - Inheritance and polymorphism
    - Software Engineering Principles:
        - Code organization and modularization
        - Code documentation and comments
        - Code reusability and maintainability
        - Best practices in programming
    - Debugging Techniques:

        - Identifying and fixing common programming errors
        - Using debugging tools and techniques
        - Strategies for error prevention
    - Social Implications of Computing:
        - Ethical considerations in computer science
        - Privacy and security issues
        - Intellectual property and copyright
        - Impact of technology on society
    - Hands-On Programming Labs:
        - Practical exercises and projects to reinforce programming concepts
        - Writing and debugging C++ code
        - Applying programming skills to real-world problems

Skills

- Understand Programming Fundamentals:
    - Define key programming concepts, including variables, data types, and control structures.
    - Explain the significance of programming in problem-solving.
- Set Up a C++ Development Environment:
    - Install and configure a C++ compiler and development environment.
    - Write, compile, and run basic C++ programs.
- Apply Fundamental Programming Concepts:
    - Use appropriate data types and variables in C++ programs.
    - Perform basic arithmetic and input/output operations.
    - Construct and evaluate expressions.
- Utilize Control Structures:
    - Implement conditional statements (if-else) for decision-making.
    - Create loops (for, while) for iterative tasks.
- Work with Array Data Structures:
    - Declare and manipulate arrays.

        - Perform operations on arrays, such as searching and sorting.
    - Manipulate String Data:
        - Perform string operations and manipulations.
        - Apply searching and sorting algorithms to strings.
    - Implement Object-Oriented Programming (OOP) Concepts:
        - Define classes and objects in C++.
        - Implement constructors and destructors.
        - Apply inheritance and polymorphism principles.
    - Follow Software Engineering Practices:
        - Organize code effectively, using modularization.
        - Document code with comments and maintain proper code structure.
        - Apply best practices for code reusability and maintainability.
    - Debug and Troubleshoot Code:
        - Identify and rectify common programming errors.
        - Utilize debugging tools and techniques to diagnose issues.
    - Consider Social and Ethical Implications:
        - Discuss ethical considerations in computer science and programming.
        - Recognize privacy, security, and intellectual property issues.
        - Understand the impact of technology on society.
    - Complete Hands-On Programming Projects:
        - Independently write, debug, and test C++ programs.
        - Apply learned concepts to practical programming projects.

Assessments

- Programming Projects Portfolio:
    - Students will complete a series of programming projects throughout the course, each focusing on specific concepts learned in class.
    - They will compile their completed projects into a portfolio that showcases their understanding of C++ programming, problem-solving skills, and adherence to good software engineering practices.

        - The portfolio will be assessed based on code quality, correctness, efficiency, documentation, and adherence to object-oriented programming principles.
    - In-Class Coding Assessment:
        - During a designated in-class assessment, students will be given a coding problem to solve using C++.
        - They will have a limited time to write code to address the problem, simulating real-world coding challenges.
        - The assessment will evaluate their ability to apply programming concepts, syntax, and problem-solving skills under time constraints.

Course: Engineering Graphics and CAD II	Length: Semester

Standards

- 9.3.ST.1 Apply engineering skills in a project that requires project management, process control and quality assurance.
- 9.3.ST.6 Demonstrate technical skills needed in a chosen STEM field.
- 9.3.ST-ET.1 Use STEM concepts and processes to solve problems involving design and/or production.
- 9.3.ST-ET.3 Apply processes and concepts for the use of technological tools in STEM.
- 9.3.ST-ET.4 Apply the elements of the design process.

Essential Question(s)

- How can Autodesk Inventor and Solidworks be leveraged to create precise 3D models and assemblies for engineering designs, and what are the key differences between these CAD software applications?
- What strategies and best practices are essential for effective project management, scheduling, and successful collaboration within engineering teams when working on complex design projects?

- How does Geometric Dimensioning and Tolerancing (GD&T) contribute to accurate communication of design specifications and quality control in engineering drawings, and what are its practical applications in industry?
- What fundamental electrical concepts, including current, voltage, resistance, and power, are crucial for understanding and designing electrical circuits, and how do they impact circuit behavior?
- How can knowledge of capacitance, inductance, transformers, and RC time constants be applied to the analysis and design of DC and AC circuits, and what are the real-world applications of these concepts in electrical engineering and electronics?

Content

- Proficiency in Autodesk Inventor and Solidworks:
  - Students should have a basic understanding of these CAD software programs, including navigation, creating sketches, and basic 3D modeling.
- Knowledge of Parametric Modeling:
  - Understanding the concept of parametric modeling and how to use equations and linked dimensions to control design parameters.
- Sheet Metal Design:
  - Familiarity with the principles of sheet metal design, including creating bends, flanges, and sheet metal parts.
- Weldment Design:
  - Understanding how to create weldments, including weldment profiles, structural members, and cut lists.
- Bill of Materials (BOM) Generation:
  - Knowledge of how to create and manage BOMs in CAD software.
- Basics of Project Management:
  - Understanding the fundamentals of project management, including scheduling, task allocation, and teamwork.
- Geometric Dimensioning and Tolerancing (GD&T):
  - Familiarity with GD&T symbols and how they are used to communicate design requirements.
- Electrical Circuit Fundamentals:

        - Basic knowledge of electrical circuits, including concepts like current, voltage, resistance, and power.
    - Understanding of Conduction:
        - Knowing how electrical conduction works and how materials conduct electricity.
    - AC and DC Circuit Analysis:
        - Ability to analyze simple series and parallel circuits with resistors, capacitors, inductors, and transistors.
    - Capacitance and Inductance Properties:
        - Understanding the properties of capacitors and inductors and their applications in circuits.
    - Transformers:
        - Knowledge of transformer principles and how they are used to step up or step down voltage.
    - RC Time Constant Calculations:
        - Proficiency in calculating RC time constants in circuits.
    - Scientific Notation and Prefixes:
        - Understanding scientific notation and common SI prefixes used in engineering.
    - Problem-Solving Skills:
        - Developing problem-solving skills to apply CAD and electrical circuit concepts to real-world engineering challenges.
    - Communication and Collaboration:
        - Effective communication and teamwork skills for collaborating with peers on projects and assignments.
    - Safety Awareness:
        - An awareness of safety protocols when working with electrical circuits and CAD software.
    - Project Documentation:
        - The ability to document and present engineering projects effectively.
    - Critical Thinking:
        - Developing critical thinking skills to analyze complex design and circuit problems.
    - Troubleshooting Skills:
        - Proficiency in troubleshooting electrical circuits and CAD models for errors or issues.

Skills

- CAD Software Proficiency:
  - Utilize Autodesk Inventor and Solidworks proficiently for 3D modeling and assembly design, including creating sketches, extrusions, and assemblies.
  - Apply parametric modeling techniques to design, allowing for efficient changes to dimensions and features.
  - Create sheet metal parts, including bends, flanges, and sheet metal assemblies, while understanding design considerations for sheet metal fabrication.
  - Develop weldment designs, incorporating structural members, weldment profiles, and generating cut lists.
  - Generate and manage bill of materials (BOMs) using CAD software, ensuring accurate documentation of components and quantities.
- Project Management and Collaboration:
  - Demonstrate project management skills by creating schedules, allocating tasks, and collaborating effectively within a team for engineering projects.
- Geometric Dimensioning and Tolerancing (GD&T):
  - Interpret and apply geometric dimensioning and tolerancing (GD&T) symbols to accurately communicate design requirements and tolerances.
- Electrical Circuits Fundamentals:
  - Understand the fundamentals of electrical circuits, including concepts such as current, voltage, resistance, and power.
- DC and AC Circuit Analysis:
  - Analyze and design simple DC and AC circuits, including series and parallel configurations, using resistors, capacitors, inductors, and transistors.
  - Apply knowledge of capacitance and inductance properties in circuit design and analyze their impact on circuit behavior.
- Transformers and RC Time Constants:
  - Comprehend the principles of transformers and their applications in voltage transformation.
  - Calculate RC time constants for circuits, demonstrating an understanding of time-dependent responses in capacitive and resistive elements.

- Fundamental Electrical Concepts:
  - Communicate engineering concepts effectively, using scientific notation and SI prefixes appropriately.
- Problem Solving and Critical Thinking:
  - Develop problem-solving skills to tackle complex design and circuit challenges, demonstrating critical thinking abilities.
- Teamwork and Communication:
  - Collaborate with peers in team projects, showcasing effective communication and teamwork skills.
- Safety and Protocols:
  - Prioritize safety awareness when working with electrical circuits and CAD software, following established safety protocols.
- Documentation and Reporting:
  - Create comprehensive project documentation, including technical reports and presentations.
- Troubleshooting and Error Correction:
  - Exhibit proficiency in troubleshooting electrical circuits and CAD models, identifying and rectifying errors and issues effectively.
- Practical Application:
  - Apply acquired knowledge and skills to real-world engineering scenarios, emphasizing practical application.
- Critical and Analytical Thinking:
  - Develop the ability to think critically and analytically to assess and enhance engineering designs and circuitry.

Assessments

- CAD Modeling and Assembly Project
  - Objective: Demonstrate proficiency in CAD modeling and assembly design using Autodesk Inventor or Solidworks.
    - Description: Students will be tasked with designing a complex mechanical assembly using CAD software, incorporating various components, parametric modeling techniques, and precise geometric dimensioning and tolerancing (GD&T). They must also generate a bill of materials and

cut lists for the assembly. The assessment will include a detailed design review and a presentation of the CAD model and its functionality.

- Electrical Circuit Analysis
  - Objective: Apply knowledge of electrical circuits, including DC and AC circuit analysis, to solve practical engineering problems.
    - Description: Students will be given a set of electrical circuits with varying complexities, including resistors, capacitors, inductors, and transformers. They must analyze these circuits using appropriate mathematical methods, calculate voltage, current, and power values, and determine circuit behavior in both DC and AC scenarios. The assessment will include written reports detailing the analysis process and solutions.

Course: Electrical Circuits	Length: Semester

Standards

- 9.3.ST.1 Apply engineering skills in a project that requires project management, process control and quality assurance.
- 9.3.ST.6 Demonstrate technical skills needed in a chosen STEM field.
- 9.3.ST-ET.1 Use STEM concepts and processes to solve problems involving design and/or production.
- 9.3.ST-ET.3 Apply processes and concepts for the use of technological tools in STEM.
- 9.3.ST-ET.4 Apply the elements of the design process.

Essential Question(s)

- How do voltage, current, and resistance interact in an electrical circuit, and how does this relationship impact the design and function of electronic devices?

- What are the differences between series and parallel circuits, and how do these differences affect the behavior and analysis of electrical circuits?
- How do capacitors and inductors influence an electrical circuit, particularly in terms of energy storage, timing, and filtering?
- In what ways do alternating current (AC) and direct current (DC) differ, and how do these differences manifest in real-world applications?
- How do transformers work, and why are they essential in the transmission and distribution of electrical power?

Content

- Conduction:
  - Understanding how electric charge moves through materials.
- Current:
  - Grasping the flow of electric charge in a circuit.
- Voltage:
  - Learning about the electrical potential difference between two points in a circuit.
- Scientific Notation and Prefixes:
  - Being proficient in expressing and interpreting large and small numbers commonly used in electronics.
- Resistance, Ohm's Law, and Power:
  - Understanding the relationship between voltage, current, and resistance, and how they relate to electrical power.
- Series Circuits, Potentiometers, and Voltage Dividers:
  - Knowing how components are connected in a series and the use and application of potentiometers and voltage dividers.
- Parallel Circuits:
  - Understanding the characteristics of components connected in parallel.
- Alternating Current (AC):
  - Learning about AC properties and how they differ from direct current (DC).

- Capacitance Properties:
  - Grasping the ability of a component to store an electric charge.
- RC Time Constant Calculations:
  - Understanding how to calculate the time constant in resistor-capacitor (RC) circuits.
- Inductance Properties:
  - Learning about the ability of a component to induce a voltage when the current flowing through it changes.
- Capacitive & Inductive Reactance:
  - Understanding how capacitors and inductors resist changes in voltage and current.
- Transformers:
  - Learning about the principles and applications of transformers in circuits.
- DC Analysis of Series/Parallel Networks with Resistors, Capacitors, Transistors, and Inductors:
  - Being able to analyze circuits that contain these components in various configurations.
- AC Analysis of Series/Parallel Networks with Resistors, Capacitors, Transistors, and Inductors:
  - Understanding the analysis of these components in AC circuits.

Skills

- Conduction:
  - Explain the principles of electrical conduction in different materials.
- Current:
  - Measure and calculate electric current in various circuit configurations.
- Voltage:
  - Understand and measure voltage in circuits, distinguishing between AC and DC.
- Scientific Notation and Prefixes:
  - Use and interpret scientific notation and metric prefixes in electrical calculations.
- Resistance, Ohm's Law, and Power:
  - Calculate resistance, apply Ohm's Law in different circuit scenarios, and compute electrical power.
- Series Circuits, Potentiometers, and Voltage Dividers:
  - Construct and analyze series circuits, use potentiometers, and calculate voltages in voltage dividers.

- Parallel Circuits:
  - Build and analyze parallel circuits, understanding the distribution of voltage and current.
- Alternating Current (AC):
  - Describe the properties of AC and differentiate it from DC.
- Capacitance Properties:
  - Understand the function of capacitors and calculate their values in circuits.
- RC Time Constant Calculations:
  - Calculate the time constants in RC circuits and understand their implications.
- Inductance Properties:
  - Explain inductance and calculate inductive reactance in circuits.
- Capacitive & Inductive Reactance:
  - Understand and calculate the reactance caused by capacitors and inductors in AC circuits.
- Transformers:
  - Describe the function of transformers and understand their application in circuits.
- DC Analysis of Series/Parallel Networks with Resistors, Capacitors, Transistors, and Inductors:
  - Analyze DC circuits containing these components, calculating current, voltage, and resistance.
- AC Analysis of Series/Parallel Networks with Resistors, Capacitors, Transistors, and Inductors:
  - Conduct similar analyses for AC circuits, understanding the phase relationships and reactance.

Assessments

- Practical Lab Assessment:
  - Students will participate in a hands-on lab where they construct and analyze both series and parallel circuits. They will be required to measure and calculate current, voltage, and resistance in these circuits, demonstrating their understanding of Ohm's Law. Additionally, students will construct a circuit incorporating a capacitor and an inductor, observing and explaining the effects of capacitance and inductance. This assessment will evaluate their ability to apply theoretical knowledge to practical situations, their proficiency in using electrical measurement tools, and their understanding of circuit behavior.
- Project-Based Assessment:

- Students will be assigned a project where they design a simple electronic device or system that utilizes both AC and DC components. This project will require them to apply concepts of voltage, current, resistance, as well as the use of transformers. The project will be accompanied by a written report explaining their design choices, the principles of electrical circuits applied, and how alternating and direct current are utilized in their design. This assessment will test their ability to integrate various concepts learned in the class, their creativity in design, and their ability to communicate technical information effectively.

Course: Engineering Statistics | Length: Semester

Standards

- 9.3.ST.1 Apply engineering skills in a project that requires project management, process control and quality assurance.
- 9.3.ST.2 Use technology to acquire, manipulate, analyze and report data.
- 9.3.ST.3 Describe and follow safety, health and environmental standards related to science, technology, engineering and mathematics (STEM) workplaces.
- 9.3.ST.4 Understand the nature and scope of the Science, Technology, Engineering & Mathematics Career Cluster and the role of STEM in society and the economy.
- 9.3.ST-ET.2 Display and communicate STEM information.
- 9.3.ST-ET.3 Apply processes and concepts for the use of technological tools in STEM

Essential Question(s)

- How do the principles of force, torque, and vector operations govern the behavior of physical systems in both natural and engineered contexts?

- In what ways do mathematical concepts such as algebra, trigonometry, and calculus provide essential tools for solving complex engineering problems?
- What are the conditions for static equilibrium, and how can these principles be applied to analyze and design stable structures and systems?
- How do free-body diagrams and vector mathematics contribute to our understanding and analysis of forces acting on a body?
- In what ways do the concepts of friction, moments of inertia, and centroids impact the design and functionality of engineered systems and structures?

Content

- Basic Principles and Mathematics:
  - Basic principles of physics, including force, torque, and vector operations.
  - Fundamental mathematical skills, such as algebra, trigonometry, and calculus.
- Equilibrium and Forces:
  - The concept of equilibrium and the conditions required for an object to be in static equilibrium.
  - How to represent forces and moments as vectors and apply vector mathematics.
  - Understanding of free-body diagrams and their role in analyzing forces acting on a body.
- Distributed Forces and Structural Analysis:
  - Knowledge of distributed forces and how to determine centroids and centers of gravity.
  - The ability to calculate internal forces within structural members in statically determinate systems.
- Friction and Moments of Inertia:
  - Concepts of friction, including static and kinetic friction coefficients.
  - Calculations involving moments of inertia and second moments of area for different shapes.
- Advanced Analysis Techniques:
  - Familiarity with methods like the method of virtual work for solving static equilibrium problems.
- Problem-Solving and Application:
  - Problem-solving techniques and critical thinking skills for analyzing complex engineering scenarios.
  - Application of engineering principles to real-world scenarios and practical problem-solving.

Skills

- Apply Basic Physics Principles:
  - Students will be able to explain and apply fundamental physics principles, such as force, torque, and vector operations, in problem-solving.
- Utilize Mathematical Skills:
  - Students will demonstrate proficiency in using algebra, trigonometry, and calculus to solve physics and engineering problems.
- Understand Equilibrium Concepts:
  - Students will comprehend the concept of equilibrium and identify the conditions necessary for an object to achieve static equilibrium.
- Represent Forces and Moments as Vectors:
  - Students will be adept at representing forces and moments using vector mathematics and applying these concepts in practical scenarios.
- Analyze Free-Body Diagrams:
  - Students will understand and construct free-body diagrams to analyze forces acting on a body effectively.
- Determine Centroids and Centers of Gravity:
  - Students will gain knowledge of distributed forces and develop the skill to calculate centroids and centers of gravity for various objects.
- Calculate Internal Forces in Structural Members:
  - Students will be capable of calculating internal forces in structural members of statically determinate systems.
- Understand and Apply Concepts of Friction:
  - Students will understand the concepts of static and kinetic friction and apply these principles in relevant engineering problems.
- Perform Inertia and Area Moment Calculations:
  - Students will be able to carry out calculations involving moments of inertia and second moments of area for different geometric shapes.

- Use the Method of Virtual Work:
    - Students will become familiar with and apply methods like the method of virtual work for solving static equilibrium problems.
- Develop Problem-Solving and Critical Thinking Skills:
    - Students will enhance their problem-solving techniques and critical thinking skills for analyzing complex engineering scenarios.
- Apply Engineering Principles in Real-World Contexts:
    - Students will be able to apply engineering principles to practical, real-world scenarios and develop solutions for engineering problems.

Assessments

- Comprehensive Project-Based Assessment:
    - Description: Students will design a small-scale engineering project, such as a bridge, building, or mechanical device. This project will involve applying equilibrium, force analysis, vector operations, and mathematical calculations. Students will submit a detailed report including free-body diagrams, calculations for centroids, centers of gravity, internal forces, and moments of inertia, while addressing friction and material strengths. The project aims to integrate theoretical knowledge with practical application, focusing on the comprehensive analysis of a structural or mechanical system.
- Cumulative Written Examination:
    - Description: This examination will encompass all major topics of the course. It will include problems for calculating forces, moments, centroids, and moments of inertia, along with theoretical questions on equilibrium, vector mathematics, and principles of friction. The exam will also involve interpreting or constructing free-body diagrams and applying the method of virtual work for static equilibrium problems. It is designed to test students' mathematical skills, conceptual understanding, and application of these concepts in various contexts.

Course: Robotic Vehicles	Length: Semester

Standards

- 9.3.ST.1 Apply engineering skills in a project that requires project management, process control and quality assurance.
- 9.3.ST.6 Demonstrate technical skills needed in a chosen STEM field.
- 9.3.ST-ET.3 Apply processes and concepts for the use of technological tools in STEM.
- 9.3.ST-ET.4 Apply the elements of the design process.
- 9.3.ST-ET.5 Apply the knowledge learned in STEM to solve problems.

Essential Question(s)

- How do the principles of mechanical, electrical, and software engineering converge to create efficient and functional robotic vehicles?
- What are the key considerations in selecting and integrating components such as electric motors, gears, and powertrains in the design of robotic vehicles?
- How do battery management systems and power distribution impact the performance and efficiency of robotic vehicles?
- In what ways do sensor technologies and software-based decision-making algorithms contribute to the autonomy and adaptability of robotic vehicles?
- What are the ethical implications and safety considerations in the design and deployment of robotic vehicles, especially in public and shared spaces?

Content

- Fundamentals of Robotics:
    - Understanding the history, evolution, and current trends in robotics. Introduction to various types of robots including ground and aerial vehicles.
- Basic Mechanical Engineering Principles:

        - Knowledge of mechanical systems, including gearing and powertrain systems, essential for the design and operation of robotic vehicles.
    - Electric Motors:
        - Understanding different types of electric motors used in robotics, their working principles, and application in robotic vehicles.
    - Battery Management and Power Systems:
        - Learning about different types of batteries, their management systems, and how they are integrated into robotic vehicles for optimal performance.
    - Sensor Technology:
        - Familiarity with various sensors (like lidar, ultrasonic, infrared) used in robotics for navigation, obstacle avoidance, and environment sensing.
    - Software Engineering for Robotics:
        - Introduction to software development for robotics, including programming languages, algorithms, and software-based decision-making processes.
    - Control Systems:
        - Understanding how control systems are designed and implemented in robotic vehicles, including basic concepts of automation and feedback mechanisms.
    - Engineering Design Principles:
        - Application of engineering design principles in the creation of a robot vehicle, focusing on problem-solving, design, testing, and iteration.
    - Project Management:
        - Basics of project management as it relates to engineering projects, including planning, execution, and teamwork.
    - Safety and Ethics in Robotics:
        - Discussions on the safety considerations and ethical implications of robotics and autonomous systems.
    - Hands-On Project:
        - Applying the learned concepts to create a robotic vehicle, integrating mechanical, electrical, and software components to achieve a functional design.
    - Troubleshooting and Problem Solving:

- Techniques for identifying and solving problems in robotic systems, including mechanical failures, electrical issues, and software bugs.

Skills

- Understand Robotics Fundamentals:
  - Demonstrate knowledge of the basic principles of robotics, including the history, types, and applications of robotic systems, especially ground and aerial vehicles.
- Apply Mechanical Engineering Concepts:
  - Utilize mechanical engineering principles to design and understand the mechanical aspects of robotic vehicles, such as gearing and powertrains.
- Design and Implement Electric Motor Systems:
  - Show proficiency in selecting, integrating, and utilizing electric motors in robotic vehicle designs.
- Manage Battery and Power Systems:
  - Effectively manage and integrate battery systems and power management solutions in robotic vehicles.
- Incorporate Sensor Technologies:
  - Integrate and apply various sensor technologies in robotic vehicles for navigation, obstacle detection, and environmental sensing.
- Develop Software for Robotics:
  - Demonstrate the ability to develop and implement software solutions for control, navigation, and decision-making in robotic systems.
- Design and Test Control Systems:
  - Design, implement, and test control systems for robotic vehicles, ensuring effective automation and response.
- Apply Engineering Design Principles:
  - Use engineering design principles to create a functional and effective robotic vehicle, encompassing mechanical, electrical, and software aspects.
- Execute Effective Project Management:

        - Manage a project effectively from conception to completion, including planning, execution, and teamwork.
    - Adhere to Safety and Ethical Standards:
        - Recognize and apply safety and ethical considerations in the design and operation of robotic vehicles.
    - Complete a Hands-On Robotics Project:
        - Successfully design and build a robotic vehicle, integrating knowledge from mechanical, electrical, and software engineering disciplines.
    - Troubleshoot and Problem Solve:
        - Develop the skills to effectively troubleshoot and solve problems in robotic systems, covering mechanical, electrical, and software issues.

Assessments

- Design and Development Project:
    - Description: Students will be required to design and develop a small-scale robotic vehicle. This project will encompass the integration of mechanical components (like gearing and powertrains), electrical systems (including electric motors and battery management), and software (for control and decision-making). The project will involve both individual research and team collaboration, culminating in a working prototype that demonstrates the application of theoretical concepts. Students will present their projects, highlighting the design process, challenges faced, solutions implemented, and the functionality of their robotic vehicle.
- Cumulative Written Examination:
    - Description: This exam will test students' understanding of the theoretical concepts covered in the course. It will include a mix of multiple-choice, short answer, and problem-solving questions related to mechanical design (gearing, powertrains), electric motors, battery management, sensor technologies, and software-based decision-making. The examination will assess students’ ability to apply these concepts in hypothetical scenarios, requiring them to demonstrate their understanding of how these various components and systems interact within a robotic vehicle.

Course: Finite Element Analysis/Simulations	Length: Semester

Standards

- 9.3.ST-SM.4 Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data.
- 9.3.ST.1 Apply engineering skills in a project that requires project management, process control and quality assurance.
- 9.3.ST-ET.1 Use STEM concepts and processes to solve problems involving design and/or production.
- 9.3.ST-SM.1 Apply science and mathematics to provide results, answers and algorithms for engineering and technological activities.

Essential Question(s)

- How do the principles of finite element analysis (FEA) apply to real-world engineering problems and how can they be used to predict and solve complex structural and mechanical issues?
- What are the critical steps in developing and applying element stiffness matrices in FEA, and how do they influence the accuracy and reliability of simulation results?
- In what ways do boundary conditions and nodal load calculations impact the outcomes of FEA simulations, and how can they be effectively managed?
- How does the choice of programming language (C++, C#, MATLAB, Python, or Java) affect the development of custom FEA software, and what are the key considerations in this process?
- What role does mesh generation and refinement play in the accuracy of FEA results, and how can one effectively balance computational efficiency with precision in simulations?

Content

- Introduction to Finite Element Analysis (FEA):
  - Understanding the history, basic principles, and applications of FEA in various engineering fields.
- Element Stiffness Matrices:
  - Learning how to develop element stiffness matrices, including the understanding of linear and nonlinear analysis.
- Shape Functions:
  - Gaining knowledge about shape functions and how they are defined on elements in finite element methods.
- Global Stiffness Formulation:
  - Understanding the process of assembling global stiffness matrices from individual element stiffness matrices.
- Boundary Conditions in FEA:
  - Learning about different types of boundary conditions (such as fixed, rolling, and free) and their implications in FEA simulations.
- Nodal Load Calculations:
  - Understanding how to calculate and apply nodal loads in FEA models.
- Use of Pre-Existing FEA Software:
  - Gaining proficiency in using commercial or open-source FEA software for simulations and analysis.
- Programming for FEA:
  - Developing basic programming skills in languages such as C++, C#, MATLAB, Python, or Java for writing custom FEA codes.
- Mesh Generation and Refinement:
  - Understanding the concepts of mesh generation, mesh refinement, and their impact on the accuracy of FEA results.
- Error Analysis and Validation:
  - Learning how to conduct error analysis in FEA and validate simulation results against theoretical or experimental data.
- Practical Applications and Case Studies:

        - Studying various case studies to understand the application of FEA in real-world engineering problems.
    - Interpreting and Reporting FEA Results:
        - Developing skills to interpret FEA results effectively and report them in a professional and understandable manner.

Skills

- Understand the Principles of FEA:
    - Explain the basic principles and applications of Finite Element Analysis in various engineering contexts.
- Develop Element Stiffness Matrices:
    - Proficiently develop element stiffness matrices and understand their role in FEA.
- Apply Shape Functions:
    - Use shape functions effectively in defining elements within the finite element method.
- Formulate Global Stiffness Matrices:
    - Assemble global stiffness matrices from individual element stiffness matrices.
- Manage Boundary Conditions:
    - Understand and apply different types of boundary conditions in FEA simulations.
- Calculate Nodal Loads:
    - Skillfully calculate and apply nodal loads in finite element models.
- Utilize FEA Software:
    - Proficiently use pre-existing FEA software for conducting simulations and analyses.
- Program FEA Solutions:
    - Write basic code for FEA in programming languages such as C++, C#, MATLAB, Python, or Java.
- Conduct Mesh Generation and Refinement:
    - Perform mesh generation and refinement, understanding their impact on FEA results.
- Perform Error Analysis and Validation:
    - Conduct error analysis and validate FEA results against theoretical or experimental data.
- Apply FEA in Practical Scenarios:

        - Apply FEA to real-world case studies and engineering problems.
    - Interpret and Report Results:
        - Effectively interpret FEA results and present them in a clear, professional manner.

Assessments

- Project-Based Assessment on FEA Application:
    - Description: Students are tasked with conducting a finite element analysis on a given engineering problem, such as a structural component under load or a mechanical system under stress. This project will require them to develop stiffness matrices, apply appropriate boundary conditions, and calculate nodal loads. Students must use either pre-existing FEA software or their own code written in a chosen programming language. The final submission includes a comprehensive report detailing the analysis process, findings, and a discussion on the accuracy and limitations of their simulation.
- Cumulative Written Examination:
    - Description: This exam covers all the major theoretical and practical aspects of the course. It includes a mix of multiple-choice, short answer, and problem-solving questions that test students' understanding of element stiffness matrices, shape functions, global stiffness formulation, boundary conditions, and nodal load calculations. The examination also assesses students' knowledge of mesh generation, error analysis, and the application of different programming languages in FEA. Students are required to demonstrate their ability to critically analyze FEA problems and apply theoretical concepts to hypothetical scenarios.

Course: Engineering Senior Project | Length: Semester

Standards

- 9.3.ST.1 Apply engineering skills in a project that requires project management, process control and quality assurance.
- 9.3.ST.2 Use technology to acquire, manipulate, analyze and report data.
- 9.3.ST.3 Describe and follow safety, health and environmental standards related to science,
- technology, engineering and mathematics (STEM) workplaces.
- 9.3.ST.4 Understand the nature and scope of the Science, Technology, Engineering & Mathematics
- Career Cluster and the role of STEM in society and the economy.
- 9.3.ST.5 Demonstrate an understanding of the breadth of career opportunities and means to those opportunities in each of the Science, Technology, Engineering & Mathematics Career Pathways.
- 9.3.ST.6 Demonstrate technical skills needed in a chosen STEM field.

Essential Question(s)

- How do engineering principles and practices intersect to address real-world problems?
- What role does innovation play in the field of engineering, and how can engineers balance creativity with technical feasibility?
- How do effective project management and teamwork contribute to the success of engineering projects?
- In what ways do ethical considerations and societal impacts influence engineering decisions and designs?
- How can engineers continuously adapt to the evolving landscape of technology and industry standards?

Content

- Project Management:
  - Understanding project timelines and deadlines
  - Skills in planning, organizing, and managing engineering projects
  - Risk assessment and mitigation strategies
  - Budgeting and resource allocation
- Technical Skills and Knowledge:
  - Advanced knowledge in their specific engineering domain (e.g., mechanical, electrical, civil, software)

        - Application of engineering principles to solve complex problems
        - Proficiency in relevant software tools and technologies
    - Research and Development:
        - Conducting comprehensive literature reviews
        - Identifying and engaging with domain experts
        - Developing hypotheses and designing experiments or prototypes
        - Analyzing data and synthesizing research findings
    - Design and Innovation:
        - Principles of engineering design and creative problem-solving
        - Developing and evaluating design alternatives
        - Implementation of design thinking in project development
    - Collaboration and Teamwork:
        - Effective communication skills within a team
        - Leadership and mentorship skills, especially for those in the Clinic component
        - Conflict resolution and team dynamics management
        - Interdisciplinary collaboration and leveraging diverse skill sets
    - Professionalism and Ethics:
        - Understanding of professional and ethical responsibilities
        - Awareness of the societal, environmental, and global impacts of engineering solutions
        - Adherence to industry standards and regulations
    - Documentation and Presentation:
        - Meticulous documentation of project progress and findings
        - Development of technical reports and presentations
        - Skills in presenting complex technical information to varied audiences
    - Self-Reflection and Evaluation:
        - Ability to assess personal and team performance
        - Understanding of continuous learning and improvement in professional practice

Skills

- Execute Effective Project Management:
  - Plan, organize, and manage an engineering project from initiation to completion.
  - Adhere to project timelines and meet key milestones and deadlines.
- Demonstrate Advanced Technical Proficiency:
  - Apply specialized knowledge in their engineering discipline to solve complex problems.
  - Utilize relevant software tools and technologies effectively.
- Conduct Comprehensive Research:
  - Perform thorough literature reviews and identify gaps in existing knowledge.
  - Engage with experts and incorporate their insights into the project.
- Develop and Implement Innovative Design Solutions:
  - Create, evaluate, and refine engineering designs.
  - Implement design thinking and problem-solving methodologies in project development.
- Collaborate Effectively in Teams:
  - Work collaboratively in diverse teams, demonstrating effective communication and conflict resolution skills.
  - Assume leadership roles, particularly in guiding and mentoring junior students in the Clinic component.
- Uphold Professional and Ethical Standards:
  - Exhibit a clear understanding of professional and ethical responsibilities.
  - Evaluate the societal, environmental, and global implications of engineering projects.
- Communicate Technical Information Clearly:
  - Document project processes and findings comprehensively.
  - Present complex technical information effectively to a variety of audiences.
- Reflect on Personal and Team Performance:
  - Assess and critique their own performance and that of their team.
  - Identify areas for personal growth and professional development.
- Innovate and Adapt to Challenges:
  - Demonstrate flexibility and adaptability in solving unforeseen challenges during the project.
  - Show initiative in seeking new solutions and approaches.

- Integrate Knowledge and Skills in a Capstone Project:
  - Synthesize knowledge and skills gained throughout their academic career in a comprehensive capstone project.
  - Deliver a final project that demonstrates a high level of technical competence and innovation.

Assessments

- Capstone Project Presentation and Defense:
  - Description: Students will complete a comprehensive capstone project that involves designing, developing, and implementing an engineering solution. At the end of the course, they present their project to a panel that may include teachers, industry professionals, and peers. The presentation should cover the project's objectives, design rationale, development process, challenges faced, and the final outcomes. Following the presentation, students engage in a defense session where they respond to questions and critiques from the panel.
    - Purpose: This assessment evaluates students' ability to apply their technical knowledge, problem-solving skills, and creativity in a real-world context. It also assesses their communication skills, ability to justify their design decisions, and respond thoughtfully to feedback.
- Project Portfolio and Reflection:
  - Description: Students compile a comprehensive portfolio documenting their project's journey, including initial concepts, design iterations, research notes, meeting minutes, technical drawings or schematics, and any other relevant materials. Alongside the portfolio, students submit a reflective essay discussing their learning experience, challenges faced, how they overcame them, and their personal and professional growth throughout the project.
    - Purpose: This assessment focuses on students' ability to document and track their project systematically, showcasing their organizational and project management skills. The reflective essay encourages self-assessment and critical thinking, allowing students to introspect on their learning process and the development of their skills.

Resources

➔ Course Resources

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