Principles of Engineering

Number of credits that may be earned: One-Half to One Grade level(s) to be served: 10-12

Brief description of the course (150 words or less):

This STEM course makes a contribution to the curriculum by providing opportunities for students and teachers to link content together and apply it to solve problems. More and more jobs demand advanced skills, requiring that people be able to learn, reason, think creatively, make decisions, and solve problems. An understanding of science, technology, engineering and math and their methods contribute in an essential way to these skills. Principles of Engineering is a team based advanced course designed for most students. The Principles of Engineering courses intention and purpose is to educate students in a “main line” method providing STEM education for everyone. While providing a STEM based education for all students, those interested in becoming practicing engineers clearly benefit from this course content.

(a) General requirements. This course is recommended for students in Grades 10-12.

(b) Introduction. This STEM course makes a contribution to the curriculum by providing opportunities for students and teachers to link content together and apply it to solve problems. More and more jobs demand advanced skills, requiring that people be able to learn, reason, think creatively, make decisions, and solve problems. An understanding of science, technology, engineering and math and their methods contribute in an essential way to these skills. Principles of Engineering is a team based advanced course designed for most students. Students who complete this course will engage in real world case studies and learning activities that focus on the engineering process and making the world a better place to live and work in. The Principles of Engineering courses intention and purpose is to educate students in a “main line” method providing STEM education for everyone. While providing a STEM based education for all students, those interested in becoming practicing engineers clearly benefit from this course content.

(c) Knowledge and skills.

(1) The student explores how time is a factor in engineering design. The student is expected to:

(A) Define “the racing spirit”
(B) Predict the effects of developing ideas under time constraints
(C) Describe transitional shift and dynamic shift in engineering development
(D) Illustrate how teams work together to accomplish goals

(2) The student understands and engages in teamwork and concurrent engineering. The student is expected to:
(A) Articulate the advantages of teamwork
(B) Describe characteristics of great teams
(C) Express the effects of a global marketplace
(D) Review team attributes
(E) Define the growth stages of a team
(F) Explain the modes of team action
(G) Classify leader attributes and leadership styles
(H) Participate and offer feedback in a simple team problem solving activity

(3) The student will apply systems and optimization techniques. The student will be able to:
(A) Review and give examples of input, process, output and feedback
(B) Construct a simple prototype based on parameters and a rubric

(4) The student will investigate the demands of the field of engineering. The student will be able to:
(A) Describe what pressures are prevalent in engineering design
(B) Critique tradeoffs in engineering and their effects on decisions
(C) Discuss product specifications and their role in engineering
(D) Contrast quality and efficiency as significant factors in engineering

(5) The student utilizes Gantt and Flow charts to plan the engineering design process. The student is expected to:
(A) Describe the components of a Gantt chart
(B) Construct basic Gantt charts
(C) Describe the components of a flow chart
(D) Construct basic flowcharts

(6) The student is able to apply techniques learned to a small scale industry based design challenge. The student is expected to:
(A) Design an innovative project for industry
(B) Present ideas to peers
(C) Develop a model that represents the innovation

(7) The student investigates mechanisms and how they work. The student is expected to:
(A) Describe the simple machines
(B) Identify the characteristics of simple machines
(C) Perform calculations of force and speed that involve simple machines

(8) The student investigates fluid power and its applications. The student is expected to:
(A) Define fluid power
(B) Illustrate how pressure distributes itself in a closed system
(C) Describe how air pressure can be controlled and monitored
The student investigates electrical circuits and its applications. The student is expected to:

(A) Demonstrate standard safety procedures and prevent injury from electrical shocks
(B) Describe and avoid conditions that can cause electrical shocks
(C) Communicate and demonstrate the correct use of a fuse
(D) Determine the basic requirements for and electrical circuit to function
(E) Determine the basic requirements of a series circuit
(F) Examine the differences and similarities of series and parallel circuits
(G) Identify the correct electronic/electrical symbols and arrange the components to form a circuit
(H) Identify and practice the procedures that should be followed to correctly and safely wire a circuit
(I) Describe the differences and similarities of series and parallel circuits
(J) Analyze and describe the relationship between voltage, current and resistance to power wattage rating for components
(K) Explore the relationship between electricity and magnetism

The student investigates ethics as they relate to engineering. The student is expected to:

(A) Discuss engineering code of ethics with peers through case studies
(B) Describe and apply strategies of risk benefit analysis
(C) Define contract law and breach of contract
(D) Argue the ethics of an industry designed case study with peers

The student researches and applies mechanical engineering techniques in a prototype. The student is expected to:

(A) Discuss the historical perspectives of trebuchets
(B) Generate solutions to mathematical calculations
(C) Choose and apply the appropriate mathematical formulas
(D) Give examples of trebuchet mechanics and construct a related design
(E) Research loads and limits on design components
(F) Explain the terms: potential energy, work, velocity, acceleration and efficiency
(G) Report evidence of simulation, experiment and analysis
(H) Develop spreadsheets to model iterations and maintain cost and weight accounting
Perform an analysis of trebuchet precision and accuracy

The student utilizes technical communications in the design process. The student is expected to:

(A) Describe effective communication methods
(B) Demonstrate oral and written communication skills through assignments and learning activities

The student examines and discusses sources for creative ideas. The student is expected to:

(A) Discuss dreams as inspirations for ideas
(B) Examine dreams and nightmares as creative influences
(C) Express self awareness

The student demonstrates knowledge of project management. The student is expected to:

(A) Construct and evaluate different types of bill of materials
(B) Perform costing of a one time and production project
(C) Prepare a project plan for a prospective client

The student applies theories of mechanism and simple machines to a prototype. The student is expected to:

(A) Examine and discuss simple machines
(B) Design and illustrate a Rube Goldberg device
(C) Construct a working model in a group setting
(D) Understand and apply design techniques to model a solution to a specific problem

The student researches classifications of materials and their characteristics. The student is expected to:

(A) Describe the historical periods of materials
(B) Classify and describe the characteristics of metals, ceramics, polymers and composites
(C) Investigate various characteristics and reactions of materials through specific experiments
(D) Research nanotechnology and predict its impact on the future

The student demonstrates knowledge of predictive analysis using Failure Modes and Effects Analysis. The student is expected to:

(A) Identify and evaluate potential failure modes
(B) Identify and evaluate potential causes of the failure mode
(C) Identify and quantify the impact of potential failures
(D) Identify and prioritize actions to reduce or eliminate the potential failure
(E) Implement action plan based on assigned responsibilities and completion dates
The student demonstrates knowledge of predictive analysis using Finite Element Analysis. The student is expected to:

(A) Understand the basic concepts of design analysis
(B) Describe how analysis can save time and money by reducing time consuming and expensive design cycles
(C) Describe the relationship between Parts, Assemblies and Drawings
(D) Define a structure
(E) Describe several types of trusses
(F) Understand what beams are
(G) Understand what factors provide strength in a beam
(H) Calculate a moment of inertia
(I) Understand the importance of triangular bracing in a structure
(J) Describe the stages of a Structural Analysis
(K) Understand the environment of the analysis including restraints and loads
(L) View the results of an analysis
(M) Understand the importance of cross bracing
(N) Find the maximum load
(O) View displacement plots
(P) Calculate the strength to weight ratio
(Q) Move components in the assembly
(R) Interpret interferences between assembly components
(S) Generate a change to a part while in the assembly
(T) Create a weldment cut list table
(U) Construct different drawing views of parts
(V) Create a section view and a detail view
(W) Insert and manipulate driving dimensions
(X) Create a Bill of Materials (BOM)

The student understands the problem solving method and can apply it in the design process. The student is able to:

(A) Define the terms analytic and creative problem solving
(B) Define the ten step design process
(C) Integrate the ten step design process while solving problems
(D) Assess a problem using the six step evaluation process
(E) Identify and describe estimation techniques
(F) Describe the terms divergence and convergence
(G) Investigate personal problem solving styles
(H) Identify and practice individual brainstorming strategies
(20) The student understands and engages in the design process through modeling. The student is able to:
(A) Define the term engineering design
(B) Classify anthropometric data and measurements from team members
(C) Calculate mean, median and mode of anthropometric data
(D) Construct and test designs for an ergonomically correct chair according to parameters and a rubric
(E) Report and present team design for an ergonomically correct chair
(F) Communicate the engineering design process
(G) Review and interpret the seven significant factors in design
(H) Perform the ten step design process
(I) Assess sample case studies using the ten step process
(J) Develop a solution using the engineering design process
(K) Generate team based solutions based on a request for proposal and a grading rubric
(L) Design and construct a outdoor shelter out of 90% recycled materials
(M) Present results of a team design to peers for critique

(21) The student investigates engineering work experience. The student is expected to:
(A) Discuss employment and experience as they relate to professional work
(B) Develop a list of skills and abilities
(C) Determine which skills could be improved with work experience and which will be developed in the classroom
(D) Develop a list of personal career priorities
(E) Develop a list of strong personal and educational abilities
(F) Develop a list of personal and educational abilities that need to be strengthened

(22) The student examines the relationship between society's wants and needs as they relate to the future. The student is expected to:
(A) Express ideas of "big picture" proportions
(B) Recognize technical progress rate
(C) Discuss change versus evolution
(D) Discuss seamless design
(E) Contrast environmental issues with the wants of society
(F) Predict the needs of society in the year 2088

(23) The student is able to apply techniques learned to a large scale industry based design challenge. The student is expected to:
(A) Develop Gantt chart and physical storyboards
(B) Design a prototype using 3D solid modeling software
(C) Select and manipulate appropriate materials
(D) Examine aesthetic components and their impact on customers
(E) Research the marketability of the prototype
(F) Explain the involvement of business and industry in the development of the solution
(G) Present valid data in the preparation and testing results of the prototype
(H) Solve appropriate calculations in the development of the prototype
(I) Present results of the team design to business and industry as well as peers

(24) The student investigates civil engineering design techniques. The student is expected to:
(A) Produce working drawings using industry standard software
(B) Describe surveys and how they work
(C) Determine elevations and contour lines in a sample exercise
(D) Construct a general sample terrain
(E) Validate elevations in a terrain
(F) Create a roadway within a site plan
(G) Create a parking lot within a site plan
(H) Design a pond within a site plan
(I) Combine elements learned with a site plan to generate cut sheets

(25) The student applies design techniques learned to a real world sports facility application. The student is expected to:
(A) Describe types of golf courses by setting
(B) Describe types of golf courses by length
(C) Interpret on-site factors that influence design
(D) Interpret off-site factors that influence design
(E) Determine environmental impacts of proposed design
(F) Predict and analyze cultural factors that influence the site design
(G) Generate team based solutions based on discussed parameters and a grading rubric
Description of the specific student needs this course is designed to meet:

Principles of Engineering provides students who have an interest in Science, Technology, Engineering and/or Math the advanced opportunities to explore and gain knowledge that can be applied in real world case studies. National certifications integrated into course offerings affords students the opportunity to bolster their credentials, leading them to significant opportunities in post secondary educational settings, or the professional world.

Major resources and instructional materials to be used in the course:

Curriculum resources and materials will include multiple sources in various formats to ensure student learning. Online course content, Industry standard software programs, field tested classroom hardware and hands on projects and experiments as well as teacher generated resources, and other resources as appropriate will be utilized to deliver this unique course.

Required activities and sample optional activities to be used:

Research, demonstrations, observations, applications, case studies and experiments will be required of all students. Students will be expected to demonstrate proficiencies as outlined by the course learning objectives as well as engage in individual and team oriented lessons.

Methods for evaluating student outcomes:

Students will be evaluated on how well they master the learning outcomes, essential knowledge and skills. Student profiles will collect all learning outcomes and national standards achieved through learning activities, case studies, experiments, quizzes and exams. Students will be quizzed in oral and written formats concerning their knowledge of various learning outcomes and technical content. Visual observation will be the basis for evaluation of how the students follow protocol, perform work safely, stay on task, and how they work as a team on group activities with their fellow students.