3D Solid Modeling

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

Learning 3D design is an interactive process. Students learn best when they can explore the practical applications of the concepts that they learn. This STEM course has many activities and exercises that enable students to put design concepts into practice. Students create their ideas such as artificial heart components, extreme sports equipment, hip replacement parts, robotic arm components, musical instruments and their parts as well as many others. Ideas become reality in this course.

- General requirements. This course is recommended for students in Grades 10-12.
- Introduction. Learning 3D design is an interactive process. Students learn best when they can explore the practical applications of the concepts that they learn. This STEM course has many activities and exercises that enable students to put design concepts into practice. Students create their ideas such as artificial heart components, extreme sports equipment, hip replacement parts, robotic arm components, musical instruments and their parts as well as many others. Ideas become reality in this course.
- Knowledge and skills.
  - (1) The student demonstrates understanding of a user interface. The student is expected to:
    - Understand the interface
    - Describe the task pane interface
    - Describe view manipulation
  - (2) The student demonstrates understanding of a graphical user interface. The student is expected to:
    - Become familiar with Windows
    - Become familiar with the user interface
    - Understand File management, search, copy, save, starting and exiting programs
  - (3) The student demonstrates understanding of the sketcher. The student is expected to:
    - Explain fully defined sketches
    - Explain over defined sketches
    - Define and use geometric relations
    - Correctly use reference planes
    - Correctly use mirroring tools
    - Define geometric relations
  - (4) The student demonstrates and applies basic functionality in a 3d design. The student is expected to:
    - Develop an understanding of 3D modeling and recognition of an object in 3D space
    - Apply 2D sketch geometry, rectangle, circle, and dimensions
    - Understand 3D features that add and remove geometry including Extrude Base, Extrude Cut, Fillet and Shell
    - Complete the Box part
    - Develop a 3D part based on a selected plane, dimensions and features. Apply the design process to develop the box or switch plate out of cardboard or other material. Develop manual sketching techniques by drawing the switch plate
    - Apply a windows based graphical user interface
    - Math: Understand units of measurement, adding and subtracting material, perpendicularly, x-y-z coordinate system
(5) The student demonstrates understanding of sketched features. The student is expected to:
- Define the term boss
- Create symmetrical revolves
- Edit dimensions of a part
- Create loft design features
- Draw sweep features
- Create extrude features

(6) The student demonstrates understanding of basic operations in 3D solid modeling. The student is expected to:
- Reinforce the understanding of 3D features that add and remove geometry
- Apply 2D sketch geometry, rectangle, circle, and dimensions
- Create the Tutor1 part
- Engineering: Utilize 3D features to create a 3D part. Create a pencil sketch of a profile for chalk and an eraser
- Technology: Work with a common music/software case and determine the size of a CD container
- Math: Apply Concentric relations (same center) between circles. Understand conversion from millimeters to inches in an applied project.
- Apply width, height and depth to a right prism (box)
- Science: Apply volume of a right prism (box)

(7) The student demonstrates understanding of applied features. The student is expected to:
- Create custom views create offset planes
- Produce drawings using pattern features
- Describe the rotate, pan and zoom features
- Construct chamfer features on a part
- Create axis features on a part
- Define a reference plane

(8) The student demonstrates understanding of drawings. The student is expected to:
- Describe the feature manager design tree
- Define and demonstrate view use in Solidworks
- Construct section views
- Change drawing scales in Solidworks
- Construct a bill of materials
- Create dimensions to drawings
- Define driven and driving dimensions
- Create custom drawing templates
- Generate title blocks using the edit sheet mode
- Define ordinate dimension

(9) The student demonstrates understanding of revolve and sweep features. The student is expected to:
- Understand 3D features that add and remove geometry including Revolve and Sweep
- Explore Sketch tools such as ellipse, trim and centerline
- Create the Candelstick part
- Engineering: Explore different modeling techniques that are utilized for parts molded or machined in a lathe process. Modify the design to accept a candle of different sizes.
- Technology: Explore the difference in plastic design for cups and travel mugs
- Math: Axis and a profile a revolution to create a solid, 2D ellipse, and arcs
- Science: Volume and unit conversion for a container

(10) The student demonstrates understanding and applies the sweep feature. The student is expected to:
- Define the sweep feature
- Construct parts using the sweep feature

(11) The student demonstrates understanding of loft features. The student is expected to:
• Understand the 3D loft feature created from multiple profiles sketched on different planes
• Create the Chisel Part
• Engineering: Explore different design changes to modify the function of a product
• Technology: Knowledge of how thin wall plastic parts are developed from lofts
• Math: Understand tangency effects on surfaces
• Science: Estimate volume for different containers

(12) The student demonstrates understanding and applies the loft feature. The student is expected to:
• Define the loft feature
• Construct parts using the loft feature

(13) The student demonstrates understanding of pattern features. The student is expected to:
• Create an oblong cut
• Create a linear pattern
• Create a circular pattern
• Use an equation to drive a circular pattern

(14) The student demonstrates understanding of fillets. The student is expected to:
• Modify a part by adding different fillet types including face, constant radius and variable radius
• Use mirroring to assure symmetry
• Apply a library feature

(15) The student demonstrates understanding of parts in 3D solid modeling. The student is expected to:
• Describe parent/child features
• Describe how design tables can be used to drive dimensions
• Create embedded design tables
• Determine the correct sketch plane to use for the first feature

(16) The student demonstrates understanding of design tables. The student is expected to:
• Develop a Design Table with Microsoft EXCEL to create families of parts
• Explore how values in an EXCEL spreadsheet automatically change dimensions and features of an existing part to create multiple parts of different sizes and shapes
• Engineering: Explore family of parts with a Design Table. Understand how design intent can be built into a part to allow for changes
• Technology: Link an EXCEL spreadsheet with a part or an assembly and how they relate to a manufactured component.
• Math: Work with numerical values to change overall size and shape of a part and assembly.
• Math: Develop width, height and depth values to determine volume of the CD Storage box modifications.

(17) The student demonstrates understanding of assembly theory. The student is expected to:
• Create features in assemblies using mate features
• Create assemblies from part files
• Simulate motion in an assembly

(18) The student demonstrates understanding of basic assemblies. The student is expected to:
• Develop an understanding of 3D assembly modeling by combining Tutor1 part with Tutor2 part
• Apply 2D sketch tools to offset geometry and project geometry to the sketch plane
• Create Tutor2 part. Create Tutor assembly
• Engineering: Evaluate the current design; incorporate design changes that result in an improved product.
• Engineering: Review fastener selection based on strength, cost, material, appearance and ease of assembly during installation.
• Technology: Review different materials, safety in design of a Switch Plate
assembly
- Math: Apply angular measurements, axis, parallel, concentric and coincident faces, and linear patterns
- Science: Develop a volume from a profile revolved around an axis.

• (19) The student demonstrates understanding of toolbox basics. The student is expected to:
  • Develop an understanding of Toolbox, a component library of standard parts
  • Understand how library components are utilized in an assembly
  • Modify Toolbox part definitions and create new parts for the Toolbox library
  • Engineering: Select fasteners automatically based on hole diameter and depth. Utilize fastener vocabulary such as thread length, screw size and diameter
  • Technology: Utilize the Toolbox Browser and display of thread style
  • Math: Relate diameter of screw to screw size.
  • Science: Explore fasteners create from different materials

• (20) The student demonstrates understanding of drawing basics. The student is expected to:
  • Understand basic drawing concepts
  • Apply drawing standards to part and assembly drawings
  • Create a drawing template.
  • Create Tutorial drawing of part and assembly
  • Engineering: Apply engineering drawing standards to part and assembly drawings. Apply concepts of Orthographic projection to 2D standard views and Isometric views.
  • Technology: Explore associatively between different, but related file formats that change during the design process.
  • Math: Explore how numeric values describe overall size and features of a part.

• (21) The student demonstrates understanding of eDrawing basics. The student is expected to:
  • Create eDrawings from existing files
  • View and manipulate eDrawings
  • Measure and markup eDrawings
  • Create animations of eDrawings to display multiple views
  • Engineering: Mark up engineering drawings utilizing eDrawing comments.
  • Engineering: Understand how to communicate with manufacturing vendors.
  • Technology: Work with different file formats including animations. Understand attachments for email.

• (22) The student demonstrates understanding of visualization techniques in 3D solid modeling. The student is expected to:
  • Understand how to apply materials, scenes and lights to create a photorealistic images in jpeg format
  • Create an exploded view and develop an animation in .avi format
  • Engineering: Enhance a product market appeal with visualization and animation
  • Technology: Work with different file formats to enhance presentation skills

• (23) The student demonstrates understanding of assembly mates. The student is expected to:
  • Produce a working assembly drawing
  • Use mates to create geometric relationships between components in an assembly
  • Transfer parts into an assembly
  • Construct an assembly using incident, concentric, parallel and distance mates

• (24) The student demonstrates understanding of 3D sketching. The student is expected to:
  • Use a 3D sketch as a sweep path
  • Use a 3D sketch for a sweep or loft
  • Use a 3D sketch centerline for a loft
• Design routing systems with a 3D sketch
• (25) The student demonstrates understanding of advanced design in 3D solid modeling. The student is expected to:
  • Develop a design that is flexible, efficient, and well defined
  • Suppress features to create part configurations
  • Create a new part in the context of an assembly
  • Detect collisions in an assembly
• (26) The student demonstrates understanding of the design checker feature. The student is expected to:
  • Define design criteria
  • Verify design elements such as dimensioning standards, fonts, materials and sketches
• (27) The student demonstrates understanding of basic sheet metal design theory. The student is expected to:
  • Describe the use of the closed corner command
  • Determine how to select multiple edges for an edge flange
  • Differentiate the uses of a Horn tool
  • Describe how the K-factor is used when bending sheet metal to calculate the neutral axis location
• (28) The student demonstrates understanding of sheet metal design. The student is expected to:
  • Create a base flange
  • Draw a miter flange
  • Mirror a part and create new bends
  • Produce an edge flange and edit its sketch profile
  • Construct a mirrored feature
  • Construct and bend a tab
  • Construct a cut across a bend
  • Create a closed corner
  • Create a sheet metal drawing
• (29) The student demonstrates understanding of surfacing features. The student is expected to:
  • Describe how to create a filled surface using curvature types
  • Demonstrate how to remove holes from a surface
  • Differentiate surface bodies and solid bodies
• (30) The student demonstrates understanding of the application of surfacing features. The student is expected to:
  • Apply surface features including knits, sweeps and lofts to create a design
• (31) The student demonstrates understanding weldment features. The student is expected to:
  • Describe how end caps are applied
  • Describe how a mounting boss fastening feature can be positioned
• (32) The student demonstrates understanding the application of weldment features. The student is expected to:
  • Create a weldment using weld beads, gussets and end caps
  • Create cut lists before and after updates
  • Design custom properties of weldments
• (34) The student demonstrates understanding of predictive analysis and simulation. The student is expected to:
  • Introduction to physics simulation through forces, mass, materials, and stress analysis.
  • Analyze a hook by applying forces its faces
  • Engineering: Explore different iterations to save material and produce a safe product
  • Technology: Knowledge of the finite element analysis process
  • Math: Understand applications of linear equations and matrices
  • Science: Determine forces, stress, material properties, work with multiplo units
• (34) The student is able to apply techniques learned to a medium scale industry based design challenge. The student is expected to:
  • Create a timeline complete with formatting tasks, dates and persons
assigned to tasks
- Accurately represent how the prototype is used and or developed with complete drawings, pictures and or photos
- Convey a clear and concise message about the process taken to design the prototype, and its features
- Describe calculations, complete with detail, relevant formulas and labels
- Design drawings complete with detail and relevant materials and labels & associated back with a 3D model
- Perform a complete formatted cost analysis with pricing, sources and total costs per item
- Construct a prototype that is aesthetically pleasing, has no visible flaws with logos or colors that are appropriate
- (35) The student uses knowledge gained in previous lessons to engage in a national design certification. The student is expected to:
  - Understand the SolidWorks certification process
  - Summarize a CSWA basic part sample
  - Produce a CSWA assembly model
  - Construct a CSWA drawing
- (36) The student is able to apply techniques learned to a large scale industry based design challenge. The student is expected to:
  - Create a timeline complete with formatting tasks, dates and persons assigned to tasks
  - Accurately represent how the prototype is used and or developed with complete drawings, pictures and or photos
  - Design a prototype that is complete, matches the proposed design and needs little improvement
  - Create a 3D software model of the prototype
  - Select appropriate materials for the application and properly applied or manufactured
  - Describe the human/prototype interaction
  - Report the results of complete finite element analysis (FEA) or simulation
  - Construct a prototype that is aesthetically pleasing, has no visible flaws with logos or colors that are appropriate
  - Clearly state the problem to be solved
  - Review how business and industry were involved with the development of the prototype
  - Describe the sources for supplies and the utilization of appropriate materials for their application
  - Defend the data and information that is presented in the solution
  - Presents easy-to-follow information that is logical and adequately detailed.
  - Convey a clear and concise message about the process taken to design the prototype, and its features
  - Describe calculations, complete with detail, relevant formulas and labels
  - Design drawings complete with detail and relevant materials and labels & associated back with a 3D model
  - Perform a complete formatted cost analysis with pricing, sources and total costs per item
  - Accurately represent the team prototype and the process that was completed to generate the prototype
  - Conduct a presentation was with no bias and in a professional manner

Description of the specific student needs this course is designed to meet:

3D Solid Modeling provides students who have an interest in Science, Technology, Engineering and/or Math the opportunity to explore and become nationally certified. These national certifications are 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. Students who learn 3D Solid Modeling develop mechanical CAD, design validation, and data management skills that
are in high demand among employers. In the job market, engineers who know 3D Solid Modeling have a clear advantage.

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 student's follow protocol, perform work safely, stay on task, and how they work as a team on group activities with their fellow students.