Glendale Unified School District School

High School

October 6, 2020

Department:	Career Technical Education
Course Title:	Honors Robotics 3-4: Engineering Technology, Computer Aided Design & Additive Manufacturing (Revision)
Course Code:	5469V/5470V
Grade Level(s):	10-12
School(s) Course Offered:	Glendale High School
UC/CSU Approved (Y/N, Subject):	Yes, "g" General Elective credits, honors designation
Course Credits:	10
Recommended Prerequisite:	Robotics 1-2: Introduction to Engineering and Manufacturing
Recommended Textbook(s):	Additive Manufacturing Technologies, Rapid Prototyping to Direct Digital Mfg. Author: Gibson, I., Rosen, D., and Stucker, B. Publisher: New York: Springer, 2010. Print. ISBN: 978-1441911193
Course Overview:	Honors Robotics 3-4: Engineering Technology, Computer Aided Design & Additive Manufacturing is the concentrator course (2nd year) in a three-course sequence for the Engineering Technology Industry Sector. The course deepens the skills and knowledge of an engineering student within the context of efficiently creating the products all around us. Students use Computer Aided Design (CAD) experience through the use of Computer Aided Manufacturing (CAM) software. CAM transforms a digital design into a program that Computer Numerical Controlled (CNC) mills, 3D Printers, and laser cutting machines use to transform raw material into a product designed by a student.

First Semester-Course Content

Unit 1: **Introduction and Overview** (*3 weeks*)

STANDARDS
Anchor Standards: 6.2, 6.3, 6.4, 6.7
Pathway Standard: B7.1, B10.1
Common Core Standards: S-ID-1, S-IC-6

A. In this unit, students are introduced to the definition of engineering design intent and prototyping in the context of product development, and further in the context of a product lifecycle from it's inception until it is ready to be mass manufactured. In previous course, students are introduced to the engineering design process as a whole; however, in this course they focus on the prototyping stage, namely creating the prototype, testing and improving it until it is ready for final manufacturing. Additive manufacturing is introduced as the technology used to prototype ideas, bringing them to life for the first time, allowing them to be tested and improved upon. This unit will also contain the details of processes and materials in additive manufacturing, such as using Polylactic Acid (PLA), which is the safest material to protype with as it is plant based and produces the least by-products.

B. Students are frequently presented with quizzes and test questions. The questions are typically true/false, multiple choice, or multiple selection in nature and often include written questions, visual diagrams and interactive web-based activities.

Unit 2: **Foundational Mathematics** (*1 week*)

STANDARDS
Anchor Standard: 5.1, 5.2,
Pathway Standard: B3.3, B7.4
Common Core Standards: 11-12.10, F-IF-4

A. The foundational mathematics unit includes numerous lessons and exercises on mathematical concepts and techniques necessary for performing measurements and estimations and for performing calculations in a production environment in general. For that reason, the unit begins with instruction on the basic skills of rounding decimal numbers and arithmetic order of operations. Although students have already learned these low level skills in prior math classes, the review reinforces a strong understanding and builds student confidence to a point where these simple mathematical operations can be applied quickly and mentally in a manufacturing environment, without the need to refer to a textbook or notes.

B. Students are frequently presented with quizzes and test questions. The questions are typically true/false, multiple choice, or multiple selection in nature and often include written questions, visual diagrams and interactive web-based activities.

Unit 3: **Applied Geometry and Trigonometry** *(2 weeks)*

STANDARDS
Anchor Standard: 5.1, 5.2,
Pathway Standard: B3.3, B7.4
Common Core Standards: C-14, RSTL-11-12.3

A. The applied geometry and trigonometry unit provides students a solid foundation of mathematical knowledge necessary for understanding engineering drawings. The unit begins with instruction on geometric concepts of parallel, perpendicular, and bisecting lines, and then moves to defining polygons and calculating perimeter, and then defining circles and calculating circumference, diameter, and radius. Finally, students learn about the unit circle, and how to recognize standard position angles, and how to find the coordinates of points along the unit circle which occur at standard position angles. By building knowledge and skills in geometry and trigonometry, students are better prepared to interpret engineering drawings and perform calculations needed to find unknown dimensions, locations, or measurements.

B. Students are frequently presented with quizzes and test questions. The questions are typically true/false, multiple choice, or multiple selection in nature and often include written questions visual diagrams and interactive web-based activities.

Unit 4: **Measuring Tools** *(4 weeks)*

STANDARDS
Anchor Standard: 8.1, 8.7, 10.1, 10.2, 11.1
Pathway Standard: B1.0, B1.2, B2.4, B3.3, B7.4, B11.0, B11.5
Common Core Standards: S-ID-1, WS-11.12.8

A. In the Measuring Tools Unit students learn every workpiece must be designed and manufactured accurately to size within close limits. The student gains insight on how careful measuring of the workpiece is necessary to ensure proper fit and satisfactory operation of each part when it is assembled with other parts. Inaccurate and careless measurements are costly. A good design engineer and technologist must be responsible for accurate and precise work. Students must be able to use measuring tools with speed and accuracy as discussed in this unit.

B. Students are each given 3d printed components and are asked to perform various measurements such as length, thickness, and diameter on different geometric features of the component. Students record their measurements to a page. Each student then exchanges their component with one given to a different student, and

performs the activity again, independently taking measurements of a different component. The students compare notes with each other and clear up any points of discrepancy or confusion by demonstrating the technique used to measure and to read the measurement, and validating their procedure with the instructor.

Unit 5: **Engineering Drawing Interpretation** *(2 weeks)*

STANDARDS
Anchor Standard: 2.1, 2.2, 2.5, 3.6, 5.3,
Pathway Standard: B1.0, B1.1, B1.4
Common Core Standards: N-Q-2, N-Q-3

A. In this unit, students learn how to interpret engineering drawings and the role they play in manufacturing both in conjunction with and aside from digital solid model data. The unit begins with an overview of ANSI and ISO as two different standards organizations, each with fundamentally different standards for presenting model data views in an engineering drawing. Students also learn how to read and interpret other drawing attributes such as the title block, notes, callouts, and line styles. The unit then teaches different methods of dimensioning including location and datum dimensioning and where each is applicable. Finally, tolerancing is discussed in concept, style, and interpretation. Students learn classical unilateral, bilateral, and block tolerancing styles and learn a basic introduction to geometric dimensioning and tolerancing as defined by the ASME Y14.5-2009 standard. Finally, students learn how tolerance can affect the fitment of mating pieces and why tolerance must be considered to prevent ambiguous fitment when either a clearance fit or interference fit is desired.

B. Students are provided a tangible three-dimensional model of an object featuring multiple surfaces, edges, steps, and holes. The students then determine which orientation to classify as the front view, and proceed to sketch it by hand along with the other five orthographic projections. Students sketch the projected views following both ANSI third-angle and ISO first-angle standards. The drawings are checked for accuracy in relative scale and for proper representation of the part using geometry lines and hidden lines. The forward approach to drawing creation beginning with the 3D model assists students in developing the spatial skills needed to visualize a 3D component from its representation as 2D views when following the reverse approach of interpreting provided engineering drawings in later coursework.

Unit 6: **Computer Aided Modeling and Design** *(6 weeks)*

STANDARDS
Anchor Standard: 3.1, 4.5, 7.4, 10.1
Pathway Standard: B2.5, B3.3, B7.4, B10.1

Common Core Standards: S-ID-1, RSL 11-12.4. RSIT 11-12.7.

A. This unit begins with an overview of the modeling software to be used, such as SOLIDWORKS, Fusion360 or equivalent 3D modeling software. Students will learn all the tools in the modeling software to create parametrically designed and fully constrained sketches, extrusions, holes, construction features and many other part design features. This unit will also cover the differences between "blobs", undefined solid models, compared to fully defined and constrained models that encompass the requirements of Model Based Design (MBD's) according to current industry standards. Discussions will include introductory information about 3D laser scanning. Students are frequently presented with quizzes and test questions. The questions are typically true/false, multiple choice, or multiple selection in nature and often include written questions as well as visual diagrams.

B. Unit Assignment: Students will be assigned a few different industry parts to model and finally given a project to model an object such as a toy car of their own creation to practice 3D modeling skills and techniques. High marks will result from projects that show understanding of parametrically designed, fully defined and constrained sketches and models.

Unit 7: **Additive Manufacturing Preparation; Model Slicing** *(5 weeks)*

STANDARDS
Anchor Standard: 1.0, 2.1, 2.3, 4.1, 4.4, 5.1, 5.2, 9.2, 9.7, 10.3
Pathway Standard: B2.0, B2.1, B2.2, B5.9, B6.1, B10.0, B10.1, B10.4
Common Core Standards: SEP-5, A-CED-2, G-CO-2

A. In this unit, students will learn the essence of slicing software that is based on the 3D printers to be used. Students will learn the details of size parameters and limitations of the machines, techniques to work around the limitations, and skills to print with the best outcomes based on the customer/stakeholder needs for the prototype. This unit will cover how to export the 3D modeled part files into stereolithographu (STL) files, load the STL files to the slicing software, which will then prepare the g-code telling the 3D printer how to build the part.

B. Students are frequently presented with quizzes and test questions. The questions are typically true/false, multiple choice, or multiple selection in nature and often include written questions as well as visual diagrams. Students are presented with different prototype print request scenarios, including physical parts, sketches, models and drawings; students must choose the appropriate settings and orientation for the model to be printed in.

Second Semester-Course Content

Unit 8: **Engineering Design Lab Safety** (*2 weeks*)

STANDARDS
Anchor Standards: 6.2, 6.3, 6.4, 6.7
Pathway Standard: B7.1, B10.1
Common Core Standards: S-ID-1, S-IC-6

A. In this unit, general lab safety is covered as well as personal protective equipment and safety precautions before, during, and after the machining process. General lab safety instruction includes lessons about evacuation routes and procedures, maintaining a clean and orderly workspace, use of compressed air, and locations of first-aid kits and fire extinguishers. The lesson on personal protective equipment discusses eye and ear protection, proper work attire, respiratory protection, and entanglement hazards. After the general safety and personal protective equipment lessons, students are taught safety practices used before machining. Students then learn about safety precautions during machining such as avoiding distractions, maintaining one operator in control, and keeping hands away from machines that are powered on. All students must pass a safety test before being allowed to work in the lab.

B. Students are frequently presented with quizzes and test questions. The questions are typically true/false, multiple choice, or multiple selection in nature and often include written questions, visual diagrams and interactive web-based activities.

Unit 9: **FDM System; 3D Printing** *(3 weeks)*

STANDARDS
Anchor Standard: 1.0, 2.1, 2.3, 4.1, 4.4, 5.1, 5.2, 9.2, 9.7, 10.3
Pathway Standard: B5.9, B6.1, B10.0, B10.1, B10.4
Common Core Standards: SEP-6, A-CED-2, G-CO-2

A. In this unit, students review the safety and operating procedures of the FDM System, the 3D printers. This unit covers maintenance of the 3D printers, including routine checks prior to and immediately following 3D printing, including the necessity to keep constant monitoring of print progress each 15 minutes according to printer manufacturer requirements. Students will learn how to calibrate build plates, load and unload filament, and troubleshoot frequently encountered issues such as jammed extruder heads while maintaining safety and awareness of extremely hot temperatures nozzle and build plates are at during operational times. Students will learn proper techniques of removing and waste management of support material and build plate debris.

B. Students will watch demonstrations of techniques and be presented with quizzes and test questions. The questions are typically true/false, multiple choice, or multiple selection in nature and often include written questions, visual diagrams and interactive web-based activities. The students will then take turns performing

procedures discussed above while monitored by instructor until they are ready as demonstrated to operate 3D printers without guidance. Instructor will always monitor prints while printers are running.

Unit 10: **Product Development Cycling** *(4 weeks)*

STANDARDS
Anchor Standard: 1.0, 2.1, 2.3, 4.1, 4.4, 5.1, 5.2, 9.2, 9.7, 10.3
Pathway Standard: B5.9, B6.1, B10.0, B10.1, B10.4
Common Core Standards: ETS1.A, ETS1.B, ETS1.C

A. Students will review the overall context of skills they've learned in units above and now perform product development cycling, going through the procedure of creating 3D models, converting their files to STL and gcode, and finally printing out the models then improving them. They will also now learn how to test the parts and the skills for finding how and what is needed to improve the part, including involving other students to test their products and conduct surveys for how they can improve their products. Students will learn how to assess a customer's request for prototype model and to the price point of the product.

B. In this assignment, students are given customer product development scenarios from vague concepts to exact models, and they practice by writing and presenting about how they would assess the customer's product development needs such as how they would proceed with modeling, 3D printing, testing, and improving the product.

Unit 11: **CNC Machine Overview** *(3 weeks)*

STANDARDS
Anchor Standard: 1.0, 2.1, 2.3, 4.1, 4.4, 5.1, 5.2, 9.2, 9.7, 10.3
Pathway Standard: B5.9, B6.1, B10.0, B10.1,B10.3, B10.4
Common Core Standards: ETS1.A, ETS1.B, ETS1.C

A. This unit expands the scope of engineering and engineering technology by enriching students with Machine shop skills that their machining counterparts will be working with. Engineers and Engineering Technologists with enriched manufacturing knowledge have the downstream perspective of what machinists need in their line of work from the engineers to properly create mass manufacturing parts such as molds or unique parts that are created with subtractive manufacturing with CNC Machines. This unit will also introduce how to safely and effectively setup and operate a Haas CNC mill. This unit begins with an overview of the various types of commonly-used tools found in CNC machining such as end mills, drills, taps, and corner rounding tools. Types of tool materials such as carbide and high speed steel are discussed as well as tool geometry including the number of cutting flutes. The theory of chip formation in the cutting process is briefly discussed, to the extent necessary to understand how chip load is affected by other cutting parameters such as feed and

speed. Common cutting speeds measured in units of surface feet per minute for various materials are presented, and students build an understanding of how and why cutting speeds are driven by material properties. Students learn and practice using the mathematical equations for calculating speed and feed rate in both milling and turning operations. Finally, students learn how to calculate tapping operation feed rates based upon spindle speed and thread pitch.Students are frequently presented with quizzes and test questions. The questions are typically true/false, multiple choice, or multiple selection in nature and often include written questions as well as visual diagrams.

B. Students are frequently presented with quizzes and test questions. The questions are typically true/false, multiple choice, or multiple selection in nature and often include written questions visual diagrams and interactive web-based activities.

Unit 12: **Engineering Technology as a Career** *(4 weeks)*

STANDARDS
Anchor Standard: 11.1, 11.2, 11.4
Pathway Standard: B1.4, B3.3, D1.0, D1.1, D10.0, D10.2
Common Core Standards: ETS2, ETS2.A, ETS2.B

A. In this unit, students come to learn the various industries and sectors that offer a career in Engineering or Engineering Technology. Students learn that this trade involves highly skilled occupations that take place in very clean, high-tech environments and require a great variety of knowledge and skills to perform successfully. Students conduct research on various types of Engineering and Engineering technology employers and occupations and report back with their findings. Additionally, students develop a personal resume indicating their skills and certifications gained through the class. Students gain valuable insight into Engineering and Engineering Technology as a career either through a field trip to an Engineering field facility such as Boeing or JPL or by a professional in the industry visiting the class as a guest speaker.

B. Professional Resume and Career Goals Presentation: In this assignment, students use word processing software to write and format a professional resume that can later be used to assist in gaining entry level employment in the manufacturing industry sector. The resume lists the student's occupational objective, educational experience, software skills, hands-on skills, and certifications. The resumes are checked for proper spelling, grammar, diction, and formatting. In the Career Goals Poster, students create slides that outline the outcomes of their research of Engineering or Engineering Technology fields and functions they are interested in and have found. Students will present slides, reaffirming what they've learned and enriching the research of other students.

Final Project/Exam:

1. Students will each create a report and presentation for a unique Product Development Scenario that they are presented with, including a series of 3D printed prototypes. Report will explain in detail the context of product development within the engineering design process, specifically explaining prototyping, testing and improving the product within the different stages of the prototype evolution. Presentation will outline key points of report and include data-driven diagrams explaining reasons for product issues from testing and improvement strategies. Students exhibit their work and reflect on their learning before a panel of industry partners.
2. Assignments: Update Professional Resume and Cover Letter- Each student updates their professional resume and cover letter for inclusion in their Product Development portfolios.
3. Professional Interview- At the conclusion of the course, students engage in a formal interview with an Engineering partner and receive feedback on their skills and abilities.
4. Exhibition of Learning –Each student prepares and delivers an exhibit of their learning and accomplishments to a panel of industry partners. The exhibition of learning features evidence of growth in college and career readiness, student reflections on learning, as well as the final project and samples of work featured in the student's course notebook and portfolio.

Additional Course Materials:
Title: Haas VF / HS Series CNC Machine Programming Workbook,
Author: Haas Automation
Publisher: Haas Automation, Edition: 2006

Title: Machining Fundamentals
Author: John R. Walker and Bob Dixon
Publisher: The Goodheart Willcox Company, Inc., Edition: 10th Edition, 2019

Title: Immerse2Learn
Author/Editor/Compiler: i2L
Affiliated Institution or Organization: US Dept of Labor
URL: http://web.immerse2learn.com/web/my- login/

Title: OHSA
Author/Editor/Compiler: Various Contributors - US Department of Labor
Affiliated Institution or Organization: US Dept of Labor
URL: https://www.osha.gov/