Perris Union High School District
Course of Study

A. COURSE INFORMATION

Course Title:

Math Applications in Robotics

❑ New
❑ Revised

If revised previous course name if changed

Transcript Course Code/Number:

(To be assigned by Educational Services)

Subject Area:

❑ Social Science
❑ English
■ Mathematics
❑ Laboratory Science
❑ World Languages
❑ Visual or Performing Arts
❑ College Prep Elective
❑ Other

Is this classified as a Career Technical Education course?
Yes
■ No

Grade Level

❑ MS
❑ HS
❑ 5
❑ 6
❑ 7
❑ 8
❑ 9
■ 10
■ 11
■ 12

Required for Graduation:
Yes
■ No

Credential Required to teach this course:

Single Subject: Mathematics

To be completed by Human Resources only.

Signature: [signature] Date: 12/10/2019

Meets UC/CSU Requirements?
■ Yes
No

Was this course *previously approved by UC* for PUHSD?
Yes
■ No
(Will be verified by Ed Services)

Meets "Honors" Requirements?
Yes
■ No

Meets "AP" Requirements?
Yes
■ No

Unit Value/Length of Course:
❑ 0.5 (half year or semester equivalent)
■ 1.0 (one year equivalent)
❑ 2.0 (two year equivalent)
❑ Other:

Submitted by: Stacey MacPherson
Site: Heritage High
Date: 10/24/2019

Approvals	**Name/Signature**	**Date**
Director of Curriculum & Instruction	[signature]	12-9-19
Asst. Superintendent of Educational Services		
Governing Board		

Prerequisite(s) (REQUIRED):

Algebra 1

Corequisite(s) (REQUIRED):

Geometry

Brief Course Description (REQUIRED):

This course emphasizes hands-on robotics activities with a concentration on mathematical modeling and computer programming for solving problems in math and science. As term projects, students prepare to participate in regional and statewide challenge competitions, which not only enhance their learning of robotics, math, and engineering, but also allow them to explore their creativity in writing, art, design, video editing, and film production. Through these project-based team activities, students develop critical thinking, problem solving, effective communication, and teamwork skills. Robotics activities allow students to reenact physically derived mathematical problems through robotics technologies to visualize situations, associate linear and exponential graphs with physical phenomenon, predict and identify key features of the graphs with robotic systems, and solve robotics problems through mathematical modeling and programming.

B. COURSE CONTENT

Course Purpose (REQUIRED):
What is the purpose of this course? Please provide a brief description of the goals and expected outcomes. Note: More specificity than a simple recitation of the State Standards is needed.

Topics covered include recognizing and developing patterns using tables, graphs and equations. Mathematical modeling is stressed as a methodology for approaching the solution to problems. Students will explore operations on algebraic expressions, and apply mathematical properties to algebraic equations. Students will problem solve using equations, graphs and tables and investigate linear relationships, including comparing and contrasting options and decision-making using algebraic models. Reinforcement of topics from two- dimensional geometry is integrated into this curriculum. This includes applications from the areas and perimeters, the Pythagorean Theorem and its applications, as well as geometric proportion. In addition, students will make relationships to robot movement using translations, rotations, and reflections, and geometric construction. Finally, introductory instruction in the area of mathematical probability is provided to reinforce numerical modeling. Robotics technology will be used to introduce and expand upon the areas of study listed above.

Course Outline (REQUIRED):

Detailed description of topics covered. All historical knowledge is expected to be empirically based, give examples. Show examples of how the text is incorporated into the topics covered.

Course overview:

Students will have the opportunity to learn about the historical development of robotics as a field. Math Application in Robotics will introduce students to the working principles and foundational knowledge of robotics, using mathematics. Students will work in small teams of three -four students to do research, design, program, and construct a mobile robot using Tetrix equipment. The goal is to have in class competitions amongst each team, and other schools at the high school or collegiate level. Lastly, the course will assist the students in preparing formal resumes, portfolios and business plans for the projects they develop that will include basic academic skills, communication skills, people skills, problem solving skills, and using safety and the usage of technology.

The following general concepts will be covered in robotics:

Students will gain competence as communicators both in written and oral form, via engineering notebooks, visual media presentations, and presenting their robot designs to their classmates or other technical forums that could include a robotics competition. They will engage in critical thinking, problem solving, and cooperative team work.

Unit 1 - Robot Basics Introduction

Students will know which robots were created successfully to replicate certain human movements and functions automatically and what robotic technology is still trying to perfect. Students will demonstrate their knowledge about the various types and uses of robots through research. Students will be able to distinguish between fictional and real world robots. Students will understand the advancements of robotic technology from past to present and future based on historical research to modern day uses and current R&D efforts.

Assignment:

Students will write an essay demonstrating their knowledge on the purpose of robots. Working in groups, students will develop a presentation that includes their initial concepts of robots and how they have changed after class discussions and research. Students will make a class presentation on one occupational title including job description and functions related to robotic technology.

Unit 2 - Robotics Concepts and Math Connections

Students will learn about the fundamentals of robotics will be exposed in general with the mathematics topics within engineering, history and development, role in industry, and various types of programming methods used.

Students will know and understand safety procedures and protocols before working around any automation projects, and robot assembling/programming activities. Students will demonstrate their understanding and knowledge of various industrial applications. Student will be introduced to the robot building and programming process through hands-on experience.

Assignment:
Students will research how mathematics is used in designing, building, and programming a robot. Students will create a visual project that demonstrates the application of mathematics in one of the fundamental aspects of a robot.

Unit 3 - Unit Conversions
Students will learn about the importance of measurements. Students will learn how to make quantitative observations (measurements) and use this information with scale factors to apply this to the build and movement of a robot. Students will learn about base units, the SI, or metric system, and how to apply conversion factors to manipulate the units for larger or smaller scale applications.

Assignment:
Unit Conversion Worksheets- These worksheets provide drill and practice on the conversion of metric units and English units into metric units. An example would be converting miles per hour into km/sec. Students will be working a variety of problems using known conversion factors. Unit conversions and unit analyses are a part of all problems and will be used throughout the course.

Gear Ratio Worksheets- Students will calculate gear ratios for a variety of gear pairs, then move on to gear trains with 3-5 gears. Students will use gain knowledge of motors and use it to determine what input rpm they need from a motor in order to achieve an output rpm using gears to gear up or down.

Labs:
Gear Ratio- Students will be given a task to create a Lego robot with a very low gear ration in order to push a heavy object. They will investigate what gear ratios are possible with the gears that exist in the robot kits, and propose a design to do the job. They will then create the design and physically test it. They will then do one design iteration to improve the design and retest it. The summary of this lab will be a short visual presentation on their final design.

Unit 4 - Motion & Graphing
Students will perform simple lab activities that involve motion and movement. They will graph their results, use graphs to analyze the data, make relationships, and discuss sources of error. Students will learn about the physical principles of speed, power, and torque. They will also learn about DC motors and how these principles apply to them. Students will apply these concepts on a sample mechanical system to calculate key details of the design. Using the following formulas, students will work with D.C. motors to experiment and find the most logical solution to the following questions.
Speed = Distance / Time
Rotational Speed = Rotational Cycles / Time
Rotational Speed = Degrees / Time
Torque = Force x Distance
Force = Torque / Distance
Where the Distance is the distance from the axis of rotation Power = Force x Velocity

Assignment:

Domino Lab Activity-Students will perform a simple lab activity that involves setting up a line of dominoes with a specific spacing between the dominoes. They will then topple the dominoes, time the toppling, and calculate the speed. They will do this for three more spacing values, and then graph the data. They will then determine the relationship between spacing and speed. This activity requires lab groups to determine a technique to topple the dominoes and then analyze the data and come up with sources of error. This activity is introducing the concepts of speed, distance, time, and using graphs to determine mathematical relationships between many variables.

Learning to Graph in Excel Activity-Graphing data and using statistical tools to find equations of a line, or fitting a curve to data is a key skill. This activity will have students create a spreadsheet from a given set of data, and then creating several types of graphs. Students will create an X/Y scatter plot, fit a line to it, and then find the equation and the R values of the line fit. Students will then create a spreadsheet of data that requires a calculation to find a new variable. They will have to set up an equation formula in Excel and use it to calculate the new variable. They will then plot this date and fit a curve to it. The set of graphs is the deliverable of this assignment.

Free-Fall from the Bleachers Activity- Students will discover how "real-life" gravity works by dropping three different types of balls off the bleachers and using the time to drop to calculate the acceleration due to gravity. They will then brainstorm with their lab group the reasons for their data results. This activity gets students to think about how shape and air resistance work in a real situation, and also how experimental variables like human reaction time are hard to control. This activity also gets students to recognize that equations are very idealized and they often neglect many effects to make calculations easier. The raw data, calculations, and analysis are the deliverables for this activity.

Graphical Vector Math Packet- calculations often involve quantities at angles, and we use vectors to represent those quantities and break them into their x and y components. Students will need to use these techniques throughout all the units in this course. This packet will consist of worksheets that cover three methods of vector math: the parallelogram method, the x/y component method using graphical analysis and the x/y component method using trigonometry. Each method will be modeled by the instructor, then students will do many examples to practice the method. Completion of this packet will ensure that students have mastered these techniques and they will be able to apply them in the next topic of projectile motion.

Projectile Motion Packet- this packet will consist of multiple worksheets that introduce the primary rules of projectile motion: x velocity is constant, y velocity is never constant, total velocity is a vector combination of x and y velocities, and y velocity can be considered to be zero at the top of a trajectory for an "up and over" projectile. Students will learn the concepts and the equations that model projectile motion and be able to do word problems with these equations. Projectile motion is often used in robot arm or launcher designs, and so it is a key skill for students to master. Students should be proficient at these types of problems when they have completed this packet.

Labs:
Projectile Motion- finding x distance relationship to launch height. Students will use a ramp placed on the lab table top and a marble. They will be given the task to develop a mathematical relationship between the height of launch and the distance that the ball travels horizontally. They will need to develop a procedure, document the procedure, and then produce graphs of their results and fit a curve to the results. Students will master the concept of time in the air being dependent only on y height of the table and the concept of x distance being dependent on x velocity and time. Students will create a formal lab report using Excel to create their graphs.

Marshmallow Tower Design Project- Students will apply their knowledge of force to an engineering design project. They will be given 30 pieces of spaghetti, 10 large marshmallows, and 20 small Marshmallows. The goal is to design the tallest tower that can support a 250 gram mass. Students will brainstorm a design, prototype design and test it, and be able to do one revision. The students will create a final design to be tested, and then write a summary as a group of what they used in their design and how they changed it based on test results.

Circular Motion Activity- Students will use an apparatus that consists of a string about 1.2 m long,, a cork, a handle to swing the apparatus by, and weights on one of the strings. They will start the cork end moving in a circle at constant speed. They will then use a stopwatch to time ten rotations, and measure the radius of the circle. They will repeat this process for a total of six different radius values. Students will then calculate velocity, and plot velocity squared versus radius. The slope of this line should be centripetal acceleration, based on the force equations that govern this physical arrangement.

Unit 5 - Robotics Design System
Students will learn about robotics in our world, and how the different aspects of STEM are all used in the field of robotics. This unit will also provide an introduction to the Tetrix (or other robotics kit) Robotics Design System, students will get an overview of the different subsystems within the Tetrix system and how they interact together. Students will then put this knowledge into practice as they follow step-by-step directions to build their first robot.

Assignment:
This unit will require students to build a simple robot using a kit. While they are building, they will learn about the various parts that are used in building robots and their function. Ultimately students will build and test their robots and answer learning questions in their Engineering Notebook based on their acquired knowledge.
1. How do robots benefit society?
2. Explain how the different subsystems work together.
3. How does the installation of sensors improve the functioning of the robot?

Writing Assignments (REQUIRED):
Give examples of the writing assignments and the use of critical analysis within the writing assignments.

Ongoing throughout the course, students will be expected to document their learning in an engineering notebook. They will document their projects: design process, changes and iterations in design, compare and contrast theoretical/expected outcomes with actual outcomes.

Students will write an essay demonstrating their knowledge on the purpose of robots. Working in groups, students will develop a presentation that includes their initial concepts of robots and how they have changed after class discussions and research. Students will make a class presentation on one occupational title including job description and functions related to robotic technology.

Students will create a visual project that demonstrates the application of mathematics in one of the fundamental aspects of a robot.

Students will write code that will enable their robots to perform simple movements.

Students will write a visual presentation on gear ratios/motor tests that were used in their simple design of their robot, present their design process and the outcome of their physical test results.

Students will present their graphical data analysis in written form as well as visual form for their projectile motion labs. They will need to write a report on how their data compares to the expected outcomes of the experiment.

After building a tower, students will need to prepare a summary of their group's original design ideas and the outcome of their tower. If changes were made to the tower, a detailed explanation of the process used in deciding on the change needed and a report of the test results due to changes. Students will report on whether or not the changes made were effective and met with their actual outcomes.Students will perform an error analysis if their changes did not meet with favorable results.

After a simple robotics build, students will answer essential questions based on their learning throughout the semester.
1. How do robots benefit society?
2. Explain how the different subsystems work together.
3. How does the installation of sensors improve the functioning of the robot?

INSTRUCTIONAL MATERIALS (REQUIRED)	
Textbook #1	
Title:	Edition:
Author:	ISBN:

Publisher:	Publication Date:
Usage: ❏ Primary Text ❏ Read in entirety or near	
Textbook #2	
Title:	Edition:
Author:	ISBN:
Publisher:	Publication Date:
Usage: ❏ Primary Text ❏ Read in entirety or near	
Supplemental Instructional Materials *Please include online, and open source resources if any.*	
Estimated costs for classroom materials and supplies (REQUIRED). *Please describe in detail.* If more space is needed than what is provided, please attach backup as applicable.	
Cost for class set of textbooks: $	Description of Additional Costs: Gears (conversions chapter) Motors with different speeds and torque (conversions chapter) Dominos (motion chapter) Various sized balls (motion chapter) 6 - 8 Robot kits for robotic arm and simple robot design (motion & robot design chapter) 18 Stopwatches (motion chapter) String (motion chapter) Corks, nuts, washers (motion chapter) Engineering notebooks Total cost is an estimate for an initial class set up. Recurring costs could be reduced for items that are reusable.
Additional costs:$	
Total cost per class set of instructional materials:	$ 10,000.00

Key Assignments (REQUIRED):
Please provide a detailed description of the Key Assignments including tests, and quizzes, which should incorporate not only short answers but essay questions also. How do assignments incorporate topics? Include all major assessments that students will be required to complete

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Unit 5 - Robotics Design System

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1. How do robots benefit society?
2. Explain how the different subsystems work together.
3. How does the installation of sensors improve the functioning of the robot?

Instructional Methods and/or Strategies (REQUIRED):

Please list specific instructional methods that will be use.

Hand on - project based learning
Direct Instruction
Collaborative groups
Labs

Assessment Methods and/or Tools (REQUIRED):

Please list different methods of assessments that will be used.

Performance based Project based Paper/Pencil Presentation (visual/oral) Labs

COURSE PACING GUIDE AND OBJECTIVES (REQUIRED)				
Day(s)	**Objective**	**Standard(s)**	**Chapter(s)**	**Reference**
	Robot Basics Introduction			
10	Robotics research, R&D, technology past/present etc.			
	Robotics Concepts and Math Connections			
15	Safety, types of programming, industrial applications of mathematics			
	Unit conversions			
35	Measurement systems & conversions, gear ratios, Torque vs. Speed	HS.N-Q.A.1 HS.N-Q.A.2 HS.N-Q.A.3 HS.A-CED.A.1 HS.A-CED.A.2 HS.A-CED.A.3 HS.A-CED.A HS.A-REI.A.1 HS.A-REI.B.3 HS.A-REI.D.10 HS.A-REI.D.11 HS.A-REI.D.12 HS.G-GMD.A.1		
	Motion & Graphing			
35	Graphing speed vs time vs distance, Best fit curves, Data calculations & analysis of data, vectors, projectile motion	HS.N-VM.A.1 HS.N-VM.A.2 HS.N-VM.A.3 HS.N-VM.B.4 (A,B&C) HS.A-REI.A.1 HS.A-REI.B.3		

		HS.A-REI.D.10 HS.A-REI.D.11 HS.A-REI.D.12 HS.F-IF.A.1 HS.F-IF.C.7.A HS.G-GPE.A.2 HS.S-ID.C.9		
20	Engineering design & prototype process, circular motion, velocity vs radius, centripetal acceleration and force	HS.A-REI.A.1 HS.A-REI.B.3 HS.A-REI.B.4.B HS.A-REI.D.10 HS.A-REI.D.11 HS.A-REI.D.12 HS.F-IF.C.7.A HS.F-IF.C.7.C HS.F-IF.C.7.E HS.A-TF.A.2 HS.G-CO.A.1		
	Robotics Design Systems			
65	Use all of the data and concepts learned up to this point in the class to design, develop and build a simple robot. Program the robot, present on the systems used in the development.	HS.F-IF.C.9 HS.F-BF.A.1.C HS.F-LE.A.1.B HS.G-CO.A.1 HS.G-CO.A.2 HS.G-CO.A.4 HS.G-CO.A.5 HS.G-SRT.C.8 HS.G-GMD.A.1 HS.G-MG.A.3 HS.S-ID.B.5 HS.S-ID.C.9 HS.S-IC.A.2 HS.S-IC.B.6		

C. HONORS COURSES ONLY
Indicate how much this honors course is different from the standard course.

D. BACKGROUND INFORMATION
Context for course (optional)
History of Course Development (optional)