

YOSEMITE REGIONAL OCCUPATIONAL PROGRAM

The Physics of Electronic Robotics

CBEDS Codes: 4647

<u>JOB TITLES</u>	<u>DOT NO.</u>
Computer Systems Hardware Technician	033.167-010
Electrical Engineer (<i>After Post Secondary</i>)	003.061-010
Electrical Repairer (any industry)	829.261-018
Electromechanical Technician (inst. & app.)	710.281-018
Electronic-Communications Technician	003.161-014
Robot Technician (machinery mfg.)	638.261-026

Course description: The **Physics of Electronic Robotics** is an integrated Physics and Engineering Technology program that will allow students to study physics and pre-engineering in a unique way that blends a traditional science course with the principles of engineering and technology. In addition to classroom activities, experiments and labs, students will investigate physics through the design and fabrication of robotic and automated systems. Areas of study include motion and forces, matter and energy, heat and thermodynamics, waveforms, electricity and magnetism. Robotic competitions, design challenges and project based activities will be used to assess student's skills and abilities.

Recommended Prerequisites: Algebra 1-2

DURATION: 180-360 total hours

CREDIT: 5 Credits per semester to meet UC "d" Lab Science Requirement

5 Credits per semester to meet UC "g" Elective Requirement

MEETS UNIVERSITY OF CALIFORNIA ENTRANCE REQUIREMENTS: Yes

MEETS CALIFORNIA STATE UNIVERSITY REQUIREMENTS: Yes

ARTICULATED WITH POSTSECONDARY INSTITUTIONS: No

INSTRUCTIONAL MATERIALS

Basic Text(s):

Conceptual Physics, Paul G. Hewitt, 3rd Edition 2006, Prentice-Hall, ISBN: 10-013166311
Electricity and Electronics Gerrish, Dugger and Roberts Goodheart-Willcox, 2002 ISBN: 1-56637-436-7

Supplementary Text(s):

Web Based Reference Materials
Instructor Generated Materials

Instructional Content

Instruction will include:

Student Outcomes

At the end of instruction, the student will be able to:

Hours

CL=Classroom
CC=Comm. Class.

I. Motion and Forces	Goal: The student will be able to demonstrate competency in the ability to understand and explain the elements of motion and forces.	Anchor/CR	CTE	
<p>A. Newton's Laws of Motion</p> <ol style="list-style-type: none"> 1. First Law of Motion (Inertia) <ol style="list-style-type: none"> a. Constant speed calculations b. Balanced and unbalanced forces (at rest, in motion) 2. Second Law of Motion <ol style="list-style-type: none"> a. Acceleration calculations b. Effects of constant force against a mass 3. Third Law of Motion <ol style="list-style-type: none"> a. Observation of action/reaction b. Action/reaction – equal/unequal masses <p>B. Force – Gravity, Magnetic, Nuclear Strong, Nuclear Weak</p> <ol style="list-style-type: none"> 1. Universal Law of Gravitation <ol style="list-style-type: none"> a. Effects of gravity on a mass on the Earth's surface b. Effects of gravity on a mass moving perpendicular to the force of gravity. 2. Law of Magnetism <ol style="list-style-type: none"> a. Fields – properties and interactions b. Flux density c. Permanent & electromagnets 3. Introduction to Nuclear Forces, Weak and Strong <p>C. Forces – Scalars and Vectors</p> <ol style="list-style-type: none"> 1. Scalars and Vectors Defined 2. Calculating Resultant Forces 3. Torque – Rotational Systems <ol style="list-style-type: none"> a. Calculation of torque <p>D. Force in the Four Energy Systems (Mechanical – Electrical – Thermal – Fluid)</p> <ol style="list-style-type: none"> 1. Force in the mechanical system <ol style="list-style-type: none"> a. Units of force in the mechanical system b. Calculating and measuring force 2. Force in the electrical system (Electric and Magnetic Phenomenon) <ol style="list-style-type: none"> a. Units of force in the Electrical system b. Calculating and measuring force in unit c. Ohm's Law d. Series and parallel DC circuits 3. Force (pressure) in the fluid system <ol style="list-style-type: none"> a. Units of force in the mechanical system b. Calculating and measuring force 4. Force in the thermal system (ΔT) <ol style="list-style-type: none"> a. Units of force in the mechanical system b. Calculating and measuring force <p>E. Force and Motion in Mechatronic Devices</p> <ol style="list-style-type: none"> 1. Design and assembly of robotic device <ol style="list-style-type: none"> a. Planning, designing and assembly b. Tools, safety, soldering & assembly c. Programming and testing 	<p>A. Pass an examination on the theory and applications of Newton's Laws and the effects these principles have on the movement of objects. Further, be able to correctly answer questions and complete labs that pertain to other recognized forms of force or force like quantities.</p> <p>B. Be able to calculate the resultants of Multiple vector forces and understand the principles encompassing the various forces studied in this unit.</p> <p>C. Be able to measure and calculate the resultants of two vector forces.</p> <p>D. Be able to measure force in the four energy systems.</p> <p>E. Be able to design, assemble and test a robotic device that uses servos and motors that will produce an output meeting specified criteria.</p>	<p>1.0 5.0 9.0 10.0 11.0 12.0 CR 1 4 5</p>	<p>B4.1 B4.2 B4.5 B5.0 B5.1 B5.2 B5.4 B5.5</p>	

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<p>I. Motion and Forces- continued 2. Testing and operating robotic device a. Work input/output. Efficiency calculations b. Performance review and evaluation 1. Program editing/revision</p>		Anchor/CR	CTE	
<p>II. Conservation of Energy and Momentum A. Potential Energy 1. Defining, measuring and calculating potential energy 2. Storage of potential energy 3. Transferring and converting forms of energy 4. Storage of electrical energy a. Batteries & capacitors 5. Storage of mechanical energy a. Weights and balances 6. Storage of fluid energy a. Reservoirs and tanks (vessels) 7. Storage of thermal energy a. Insulation B. Kinetic Energy 1. Defining, measuring and calculating kinetic energy 2. Transferring kinetic energy in the four energy systems 3. Converting kinetic energy a. Transducers 1. Motors, generators, solenoid, Engines 4. Energy control a. Automated control methods b. Manual control methods C. Measuring and Calculating Momentum 1. Define momentum as a separately conserved quantity 2. Instruments and methods used to measure and calculate Momentum 3. The flywheel in momentum storage D. Model Rocketry (Forces at work) 1. Thrust – Drag – Gravity – Stability 2. Model rocket design, fabrication and Launch E. Construction and testing of a simple DC motor. F. Direct conversion of heat to electricity 1. Thermocouple/thermopile G. Conversion of solar to electrical energy 1. Solar Cell – solar array H. Chemical reaction to electricity 1. Primary cells, secondary cells I. Mechanical energy to electricity 1. Generator-alternator A. Direct current B. Alternating current J. Piezo electric effect 1. Pressure to electricity K. Static electricity A. Friction to electrical charge L. Alternative energy sources for everyday tasks 1. Solar cooker 2. Solar powered vehicles</p>	<p>Goal: The student will be able to demonstrate competency in the ability to understand and explain the elements of energy and momentum.</p> <p>A. Pass a test on the elements of potential Energy in the four energy systems. Be able to measure and calculate the energy stored in apparatus characteristic of the four energy systems.</p> <p>B. Pass a test on the elements of kinetic Energy in the four energy systems. Be able to measure and calculate the kinetic energy that is moved in the mechanical , thermal, electrical and fluid energy systems.</p> <p>C. Be able to calculate and measure inertia and momentum in the mechanical system using a flywheel and pendulum.</p> <p>D. Build and launch a model rocket. Observe the relationship between engine size, rocket mass and acceleration on speed and height of rocket travel.</p>	<p>1.0 5.0 10 11 CR 1 4 5 6 7 9 10 12</p>	<p>B5.0- B6.0 EEU B2.0 B3.0</p>	

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III. Heat and Thermodynamics	Goal: The student will be able to demonstrate competency in the ability to understand and explain the elements of heat transfer and thermodynamics. To do this, they will do the following:	Anchor/CR	CTE	
<p>A. Conversion and Transfer of Thermal Energy</p> <ol style="list-style-type: none"> 1. Heat flow and work 2. First Law of Thermodynamics <ol style="list-style-type: none"> a. Heat engine (hot to cold) 3. Second Law of Thermodynamics <ol style="list-style-type: none"> a. Heat transfer in a closed system <p>B. Heat Sinks – Transfer Systems</p> <ol style="list-style-type: none"> 1. Use of heat sinks with solid state devices 2. Cooling with machines and systems 3. Peltier Junction thermoelectric cycling 4. Refrigeration concepts <p>C. Direct conversion of heat ΔT to electricity</p> <ol style="list-style-type: none"> 1. Thermocouple/thermopile 	<p>A. Pass an exam that will demonstrate acquired knowledge of the facts pertaining to the conversion and transfer of heat.</p> <p>B-C. Successfully complete lab activities that Require the observation and measurement of heat that is transferred through specified means.</p>	<p>CR 1 4 5 7 9 10 12</p>	<p>B4.3 B5.4</p>	
<p>IV. Properties and Characteristics of Waveforms</p> <p>A. Waveforms as Energy Carriers</p> <ol style="list-style-type: none"> 1. Sound waves, radio waves, light waves 2. Waveforms over liquids (ocean waves) 3. Waveforms through solids (earthquakes) <p>B. Polarity in Waveforms</p> <ol style="list-style-type: none"> 1. Longitudinal, transverse, horizontal, vertical, circular <p>C. Frequency and Speed of Waveforms</p> <ol style="list-style-type: none"> 1. Speed through solids 2. Speed of sound 3. Speed of electromagnetic waves <p>D. Electromagnetic Spectrum</p> <p>E. Doppler Effect</p> <p>F. Discoveries of Tesla and the Tesla Coil</p>	<p>Goal: The student will be able to demonstrate competency in the ability to understand and explain the elements of electromagnetic waveforms.</p> <p>B. Pass an exam that will demonstrate acquired knowledge of the facts pertaining to the production and characteristics of audio, radio and light waves.</p> <p>C. Complete projects that requires students to create, observe, measure and utilize different types and frequencies of electromagnetic waves.</p>	<p>1.0 5.0 10.0 11.0 CR 1 4 5 7 9 12</p>	<p>B4.4</p>	
<p>V. Electric and Magnetic Phenomena</p> <p>A. Conductors, Resistors, Insulators and Circuits</p> <p>B. DC Circuit Analysis</p> <ol style="list-style-type: none"> 1. Ohm's Law, Kirchoff's Law, Series and Parallel Circuits 2. Power Dissipation <p>C. Fundamentals of Semiconductors</p> <ol style="list-style-type: none"> 1. Transistors, Diodes, Integrated Circuits <p>D. Magnetic Fields Around Conductors</p> <ol style="list-style-type: none"> 1. Inductors, inductance and induction 2. Effects on frequency – impedance and reactance <p>E. Construction and testing of a simple DC Motor</p> <p>F. Electrostatic Fields</p> <ol style="list-style-type: none"> 1. Capacitors and capacitance 2. Effects on frequency – reactance 3. Electrical charges <p>G. Conversion of solar to electrical energy</p> <ol style="list-style-type: none"> 1. Solar cell – solar array <p>H. Chemical reaction to electricity</p> <ol style="list-style-type: none"> 1. Primary cells / secondary cells 	<p>Goal: The student will be able to demonstrate competency in the ability to understand and explain the fundamentals of electricity, the characteristics of current flow and the relationship between electricity and electromagnetism/electromagnetic waves. Additionally, they will be able to:</p> <p>D. Pass an exam that will demonstrate acquired knowledge of the facts pertaining to electricity and magnetism.</p> <p>B. Calculate and solve for series and parallel circuit results using Ohms and Kirchoffs laws.</p> <p>E. Be able to identify and test individual electronic components.</p> <p>F. Be able to complete fabrication projects to include the design and assembly of electronic devices.</p> <p>G. Be able to make a simple DC motor and measure its performance.</p>	<p>1.0 2.0 5.0 10.0 11.0 CR 1 4 5 6 7 9 10 12</p>	<p>B4.0- B4.5</p>	

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<p>V. Electric and Magnetic Phenomena-continued</p> <p>I. Mechanical energy to electricity</p> <ol style="list-style-type: none"> 1. Generator – alternator <ol style="list-style-type: none"> a. Direct current b. Alternating current <p>J. Peizo electric effect</p> <ol style="list-style-type: none"> 1. Pressure to electricity <p>K. Static electricity</p> <ol style="list-style-type: none"> 1. Friction to electrical charge <p>L. Alternative energy sources for everyday tasks</p> <ol style="list-style-type: none"> 1. Solar cookers 2. Solar powered vehicles 	<p>F. Convert electrical energy into controlled mechanical energy using motors, servos and control circuits.</p> <p>G. Produce heat or work from alternative energy sources.</p>	<p>Anchor/CR</p>	<p>CTE</p>	
<p>VI. Units of Measure</p> <p>A. Systems of Measure</p> <ol style="list-style-type: none"> 1. System International (metric) <ol style="list-style-type: none"> a. Force, mass, electrical, distance, speed, temperature 2. English System <ol style="list-style-type: none"> a. Force, mass, electrical, distance, speed, temperature 3. Scientific Notation 4. Measurement instruments and devices 	<p>Goal: The student will be able to demonstrate competency in the ability to understand and explain scientific and technological units of measure.</p> <p>A. Students will apply correct units of measure and perform conversions as necessary while completing labs or projects and when solving problems.</p>	<p>1.0 5.0 10.0 11.0</p> <p>CR 1 4 5</p>	<p>B3.0-3.8</p>	
<p>VII. Laboratory Practices</p> <p>A. Lab Safety Procedures</p> <p>B. Proper Care and Use of Tools</p> <p>C. Materials and Processes</p> <p>D. Eye Care</p>	<p>Goal: The student will be able to demonstrate competency in the ability to safely perform and complete assigned lab projects and exercises.</p>	<p>2.0 6.0</p> <p>CR 1 4 5 6-9 10 12</p>	<p>B5.0 B9.0</p>	
<p>VIII. Investigation and Experimentation</p> <p>A. Collection and Interpretation of Data</p> <p>B. Use of Mathematical Operations to Determine Outcomes</p> <p>C. Development of Hypothesis' and Theories</p> <p>D. Critical Thinking in Planning and Problem Solving</p> <p>E. Teamwork in Completing Projects</p> <ol style="list-style-type: none"> 1. TQM – Teamwork Solutions <p>F. Self-Evaluation</p> <ol style="list-style-type: none"> 1. Rubrics in assessment 2. Qualitative assessment <p>G. Oral and Written Reports</p>	<p>Goal: The student will be able to demonstrate competency in the ability to use commonly applied experimental and investigative processes.</p> <p>A. Students will be able to collect and process observations and data using established formula and math tools.</p> <p>B. Students will use critical thinking skills to solve problems and complete projects.</p> <p>C. Students will work in teams and use the TQM process to complete projects. They will share their work by making power point presentations.</p>	<p>1.0 5.0 10.0 11.0</p> <p>CR 1 4 5 6-9 10 12</p>		
<p>IX. Digital Electronics</p> <p>A. Logic Circuits</p> <ol style="list-style-type: none"> 1. Identification and analysis of gate circuits 2. Using the seven basic gates in devices 3. Truth tables and Boolean equations <p>B. Digital Converters</p> <ol style="list-style-type: none"> 1. A to D Analog to Digital Converters 2. D to A Digital to Analog Converters <p>C. Displays and Display Drivers</p> <p>D. Clock and Timing Circuits</p> <p>E. Digital Device Design and Fabrication</p> <ol style="list-style-type: none"> 1. Breadboarding and proto-typin 	<p>Goal: The student will be able to demonstrate competency in the ability to pass tests, breadboard circuits and analyze the performance of digital circuits and devices. In doing so, each student will:</p> <p>A. Identify each of the primary gate circuits and correctly draw the truth tables.</p> <p>B. Use A-D and D-A converters to change digital to analog information.</p> <p>C. Fabricate circuits that will show sequential information using LED's for display elements.</p>	<p>1 5 10</p> <p>CR 1 4 5 6-9 10 12</p>	<p>EEU B2.0</p>	

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<p>IX. Digital Electronics - continued</p> <p>2. Device fabrication</p> <p>a. Chemical etching P-C boards</p> <p>b. Device assembly</p> <p>1. Soldering techniques</p> <p>2. Component identification & handling</p> <p>a. Electro Static Discharge (ESD)</p> <p>c. Testing and troubleshooting</p> <p>1. Programming and configuration</p> <p>a. Software design</p> <p>b. Programming languages for digital devices</p> <p>1. C, C+, C++ and derivatives</p> <p>2. Programming Lab Robot Controllers</p> <p>a. Input/output routines</p> <p>b. Programming and using sensors</p> <p>c. Use of solenoids and motors</p> <p>F. Interfacing Digital Circuits</p> <p>1. Keyboard, mouse and other input devices</p> <p>2. Monitor, printer and other output devices</p>	<p>D. Breadboard, test and analyze digital circuits.</p> <p>E. Develop programs that will drive robotic devices that interface digital circuits with motors and servos.</p> <p>F. Complete a project that interfaces an electronic control device to a mechanical device.</p> <p>G. Connect and or configure keyboards, pointing devices, monitors, printers and other peripheral equipment to a computer system and troubleshoot for a repair when necessary</p>	<p>Anchor/CR</p>	<p>CTE</p>	
<p>X. Analog Electronics</p> <p>A. Components</p> <p>1. Properties and characteristics</p> <p>2. Symbols and applications</p> <p>3. Identification and testing</p> <p>B. Circuits</p> <p>1. Power supplies</p> <p>2. Amplifiers</p> <p>3. Switches and controllers</p>	<p>Goal: The student will be able to demonstrate competency in the ability to pass tests, assemble devices, test devices and operate analog electronic equipment.</p> <p>A. Students will be able to assemble, test and utilize an analog audio amplifier and/or a linear power supply.</p>	<p>1.0</p> <p>2.0</p> <p>5.0</p> <p>10.0</p> <p>11.0</p> <p>CR</p> <p>1</p> <p>4</p> <p>5</p>	<p>B3.1-</p> <p>B3.8</p>	
<p>XI. Aeronautics and Aviation</p> <p>A. Forces of Flight</p> <p>1. Gravity</p> <p>2. Lift</p> <p>a. Bernoulli's Principle</p> <p>b. Newton's Lift (reactive lift)</p> <p>3. Drag</p> <p>4. Thrust</p> <p>5. Buoyant Force (Balloons)</p> <p>B. Aircraft – Airframe and Power Plant</p> <p>1. Wings, fuselage, empennage, engine</p> <p>a. Characteristics and design factors</p>	<p>Goal: The student will be able to demonstrate competency in the ability to pass tests, on the elements of physics that are applied in the field of aeronautics and aviation.</p> <p>A. Students will assemble and fly model airplanes in order to observe and understand applications of Newton's Laws and Bernoulli's Principle</p> <p>B. Students will pass tests showing they are familiar with the common components of a manufactured aircraft.</p>	<p>1.0</p> <p>2.0</p> <p>5.0</p> <p>10.0</p> <p>11.0</p> <p>CR</p> <p>1</p> <p>4</p> <p>5</p> <p>6</p> <p>7</p> <p>9</p> <p>10</p> <p>12</p>		
<p>XII. Structures and Shapes</p> <p>1. Beam and truss design</p> <p>a. Strength of shape and materials analysis</p> <p>b. Stress factors and analysis</p> <p>c. Mass of structure to load ratio</p>	<p>Goal: The student will be able to fabricate engineered structures.</p> <p>A. Class participants will design and build trusses, towers or "boomilevers" that will be capable of supporting masses or weights that are at least 200 times greater than the mass of the engineered structure.</p>	<p>CR</p> <p>1</p> <p>4</p> <p>5</p> <p>6</p> <p>7</p> <p>9</p> <p>10</p> <p>12</p>	<p>A7.1-</p> <p>A7.4</p>	

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XIII. Computer Systems	Goal: The student will be able to demonstrate competency in the ability to set-up a personal computer workstation and small network.	Anchor/CR	CTE	
<ul style="list-style-type: none"> A. Computer System Configuration and Set-up <ul style="list-style-type: none"> 1. Operating system (OS) <ul style="list-style-type: none"> a. Characteristics b. Configuration B. Applications Software – Configuration and use <ul style="list-style-type: none"> 1. Word processor, presentation software, specialty software C. Peripherals – Configuration and Setup D. Networking – Configuration and Setup E. System Diagnostics and Troubleshooting F. Problem Solving with Computers G. Computer Drawing and Illustration H. Entry level Programming 	<ul style="list-style-type: none"> A. Connect and or configure keyboards, pointing devices, monitors, printers and other peripheral equipment to a computer system and troubleshoot for a repair when necessary. B. Set-up, configure and be able to diagnose problems with personal computer systems. C. Set-up and configure a residential gateway router/switch and form a network of three or more computers as a workgroup 	<ul style="list-style-type: none"> 1.0 2.0 5.0 10.0 11.0 CR 1 4 5 7 10 12 	<ul style="list-style-type: none"> EEU C2.0 C2.1- C2.10 	
<ul style="list-style-type: none"> XIV. Robotics and Automation A. Types of Robots <ul style="list-style-type: none"> 1. Industrial Robots <ul style="list-style-type: none"> a. Operation characteristics and programming 2. Recreational Robots <ul style="list-style-type: none"> a. Operation characteristics and programming 3. Experimental Robots <ul style="list-style-type: none"> a. Operation characteristics and programming 4. Safety and Observation Robots <ul style="list-style-type: none"> a. Operation characteristics and programming B. Design, Fabricate and Program Robots <ul style="list-style-type: none"> 1. Build and program mobile competition robot 2. Build and program robotic arm (simulate industrial robot) 3. Program an observation C. Principles of Robotics <ul style="list-style-type: none"> 1. Rigid Body Transformations 2. Kinematics of Manipulators and Robots 3. Dynamics of Manipulators and Robots 4. Trajectory Generation 5. Joint Actuation and Sensing 6. Introduction to Manipulator and Robot Control 	<ul style="list-style-type: none"> Goal: The student will be able to demonstrate competency in the ability to understand and explain elements of robotics and automation similar to that found in manufacturing. They will do this by: A. Being able to identify the types of robots used in hobby, entertainment and industrial applications. B. Designing and assembling robots for competition in events like FIRST, VEX or the Science Olympiad. C. Passing a test that evaluates the students ability to understand the fundamental principles of robotics. 	<ul style="list-style-type: none"> 1.0 2.0 5.0 10.0 11.0 CR 1 4 5 6 7 9 10 12 	<ul style="list-style-type: none"> B3.0- B11.0 	