ELEC A121: ROBOTICS 1- MECHANICS & DESIGN

Item	Value
Curriculum Committee Approval Date	10/30/2024
Top Code	093500 - Electro-Mechanical Technology
Units	3 Total Units
Hours	90 Total Hours (Lecture Hours 36; Lab Hours 54)
Total Outside of Class Hours	0
Course Credit Status	Credit: Degree Applicable (D)
Material Fee	No
Basic Skills	Not Basic Skills (N)
Repeatable	No
Open Entry/Open Exit	No
Grading Policy	Standard Letter (S), • Pass/No Pass (B)

Course Description

This course covers robotic systems, engineering design, and mechanics. Students will learn to use the engineering design process to define a problem to be solved, establish requirements and specifications, and brainstorm solutions. During Lab, students will build robotic mechanisms, assemble robots according to instructions, and learn to solder. The course culminates with students prototyping the mechanical mechanisms for a robot of their design. Formerly known as ELEC A101. ADVISORY: ELEC A100 or concurrent enrollment. Transfer Credit: CSU.

Course Level Student Learning Outcome(s)

1. Students will be able to design and build a robot to carry out a specific function utilizing the engineering design process.
2. Students will be able to use fundamental math and physics laws to analyze robot mechanical systems.
3. Students will be proficient at communicating the progress and overall project outcome using industry-standard project management and documentation techniques.

Course Objectives

- 1. Demonstrate proficiency at executing the engineering design process in order to identify and solve specific problems.
- 2. Demonstrate the ability to document the design process in a professional manner.
- 3. Demonstrate the ability to use sketches to communicate design ideas.
- 4. Use Free Body Diagrams to analyze forces on simple structures.
- 5. Use fundamental physics concepts to calculate torque and gear ratios for a gearbox.
- 6. Identify common robot control systems and articulate their common applications.
- 7. Identify basic robot sensors and articulate their common applications.
- 8. Demonstrate proficiency soldering wires and electronic components.
- 9. Identify common robot drive systems and articulate common applications.
- 10. Identify common types of motors.
- 11. Demonstrate familiarity with hydraulic/pneumatic systems.

Lecture Content

A. Introduction to Robotic Systems1. Motion Systems2. Control Systems3. Sensors4. Mechanics B. Engineering Design Process1. Overview of the Process a. Define the Problem b. Research Prior Solutions c. Establish Requirements and Specifications d. Brainstorm Solutions e. Develop Prototypes f. Test2. Documentation3. Sketching ideas4. Quality brainstorming techniques5. Project Management a. Project progress tracking b. Status reports c. Communicating with a team C. Static Forces1. Strength of Materials2. Fasteners- Single and Multi Point3. Geometry of Supports and Structures4. Lever Arms and Free Body Diagram Analysis a. Principles of Leverage b. Vector based static analysis of simple structures D. Gears, Differentials, and Transmissions1. Torque vs. Speed2. Gear Ratios3. Self Locking Gearboxes4. Physics a. Leverage b. Force c. Torque d. Friction e. Conservation of Energy E. Introduction to Robotic Control Systems1. Overview of the capabilities and advantages/disadvantages to common control systems: a. Industrial Control (PLCs) b. PC Computers c. Embedded Computers d. Microcontrollers e. PSoCs f. FPGAs g. Real Time Operating Systems F. Motion Systems1. Wheels2. Hydraulics and Pneumatics a. Hydraulic vs Pneumatic Systems b. Physics n bsp; i. Pressure, Volume, Temperature ii. Pascal s Principle iii. Compressible vs. Non-Compressible Fluids c. Components i. Valves ii. Reservoirs iii. Cylinders3. Drive Systems a. Steering Drive b. Differential Drive c. Mecanum Drive d. Swerve Drive4. Motors a. DC Motors b. AC Motors c. Servos d. Stepper Motors G. Sensors1. Analog vs. Digital Sensors2. Overview of the capabilities of common sensors: a. Limit Switches b. Distance Sensors c. Light Sensors d. Encoders H. Wiring1. Soldering process and safety2. Cable management for moving robots and vehicles

Lab Content

Safety and Lab Familiarization Lab Procedures Tools Equipment Supplies Electromagnet Project Students use motor wire and a core to build a simple electromagnet. Students use benchtop power supplies to supply current. DC Motor Project Students use motor wire and a permanent magnet to construct a simple DC Motor. Soldering PCB Component Soldering- Kit Joining wire by soldering and heat-shrinking Winch Project Students build a winch to use a small motor to lift a 20lb weight. Report- Sketch of design Calculation of Gear Ratio Calculation of Torque at each stage Calculation of motor current/torque Theoretical vs. Actual Power- Calculate Actual Efficiency Vehicle Project Students assemble a simple robot from a kit. Instructions are provided and students assemble the robot to exact specifications. Students establish a wireless connection between the robot and a controller for verification of robot functions. Students demonstrate proper cable management for moving vehicles- Strain relief Proper use of zip ties vs. electrical tape Cable protection and avoidance of pinch points Group Capstone Project Students progress through the engineering design process in small groups to build a robot to solve a specific need. Students produce documentation throughout the process and implement project management strategies learned in lecture. Students culminate by prototyping the mechanical mechanisms and testing their designs. This project is intended to be primarily a mechanical design project, with minimal time spent on controls and

automation. Report- Working in groups, students produce a final report documenting all steps of their design process.

Method(s) of Instruction

- Lecture (02)
- DE Live Online Lecture (02S)
- DE Online Lecture (02X)
- Lab (04)
- DE Live Online Lab (04S)
- DE Online Lab (04X)

Instructional Techniques

Lecture Detailed whiteboard lectures with opportunity for student engagement. Independent in-class problem solving assignments with immediate review. Group based in-class problem solving assignments with immediate review. In-class review of previously assigned homework. Discussion of media provided and assigned via LMS. Review of material prior to exams. Lab Students complete projects individually and as groups. Lab projects reinforce lecture topics and are paced to coincide or lag the lecture content. Lab projects generate content that students use to generate reports and documentation, enhancing writing and critical thinking skills.

Reading Assignments

Students will spend approximately 2 hours reading from the textbook and instructor material provided via LMS.

Writing Assignments

Students will spend approximately 1 hour per week on writing assignments, including: Keep a journal of chronological notes taken during research, lecture, and laboratory experience. Author a technical report for each project written to industry standards for technical reports.

Out-of-class Assignments

Students will spend approximately 3 hours per week on out-of-class assignments, including: Researching topics as assigned. Preparing technical documents prior to laboratory projects. Completing technical reports after each project. Maintaining a portfolio of projects throughout the semester.

Demonstration of Critical Thinking

Students execute the design of a robot using the engineering design process. Students work individually and in groups to solve challenges presented in a project based form. Quizzes administered at the end of each topic to demonstrate mastery of the specific objective. Midterm and final exam administered to test ability to retain problem solving skills.

Required Writing, Problem Solving, Skills Demonstration

Exercises Group and individual Projects Quizzes Midterm Exam Final Exam Keep a journal of chronological notes taken during: a) research b) lecture c) laboratory experience. Maintain a portfolio of technical reports, research and class notes. Submit technical reports for lab projects containing results and analysis.

Eligible Disciplines

Electromechanical technology (industrial mechanical technology): Any bachelor's degree and two years of professional experience, or any associate degree and six years of professional experience. Electronics: Any bachelor's degree and two years of professional experience, or any associate degree and six years of professional experience. Engineering: Master's degree in any field of engineering OR bachelor's degree in any of the above AND master's degree in mathematics, physics, computer science, chemistry, or geology OR the equivalent. (NOTE: A bachelor's degree in any field of engineering with a professional engineer's license is an alternative qualification for this discipline.) Master's degree required. Title 5, section 53410.1 Engineering technology: Master's degree in any field of engineering technology or engineering OR bachelor's degree in either of the above AND master's degree in physics, mathematics, computer science, biological science, or chemistry, OR bachelor's degree in industrial technology, engineering technology or engineering AND a professional engineer's license OR the equivalent. Master's degree required. Industrial maintenance: Any bachelor's degree and two years of professional experience, or any associate degree and six years of professional experience. Robotics (computer integrated manufacturing): Any bachelor's degree and two years of professional experience, or any associate degree and six years of professional experience.

Textbooks Resources

1. Required VEX Robotics. Vexnet Inventors Guide, 2015 ed. Austin Texas: VEx Robotics, 2015

Other Resources

1. Resources provided via LMS. 2. OER: VEX Inventor's Guide (vexrobotics.com)