Subject:	ROBO
Course Number:	170
Descriptive Title:	Advanced Robotics I
Division:	Industry and Technology
Department:	Robotics
Course Disciplines:	Electronics and Computer Hardware Technology, Manufacturing Technology
Catalog Description:	This advanced course explores mobile robot applications with an emphasis on locomotion, mobile robot kinematics, perception, mobile robot localization, planning and navigation, and the design of rovers and its operations.
Prerequisite:	Robotics 150 with a minimum grade of C
Co-requisite:	
Recommended Preparation:	
Enrollment Limitation:	
Hours Lecture (per week):	1
Hours Laboratory (per week):	6
Outside Study Hours:	2
Total Course Hours:	126
Course Units:	3
Grading Method:	Letter Grade only
Credit Status:	Credit, degree applicable
Transfer CSU:	Yes
Effective Date:	
Transfer UC:	No
Effective Date:	
General Education ECC:	
Term:	
Other:	
CSU GE:	
Term:	
Other:	
IGETC:	
Term:	
Other:	
CalGETC:	
Term:	
Other:	

Student Learning Outcomes:	**SLO #1 MOBILE ROBOT ORIENTATION AND OVERVIEW** The student will be able to define what a mobile robot is, identify the purpose of mobile robots and related subsystems of the varying mobile robot types. **SLO #2 MOBILE ROBOT FABRICATION** The students will be able to perform successful 3D printing of hardware components as part of building a mobile robot. Materials and hand tools will be provided. **SLO #3 MOBILE ROBOT OPERATIONAL PERFORMANCE** By the end of this course, students will be able to construct, program and test a mobile robot.
Course Objectives:	1. Define a mobile robot. Identify the purpose/applications of mobile robots. 2. Explain the concepts behind mobile robot kinematics. 3. Articulate the different types of sensors used in mobile robots, and explain the trade-offs with respect to the system as a whole. 4. Differentiate between the various forms of planning and navigation challenges of a mobile robot in a variety of environments, including applying various algorithms to help a mobile robot navigate and achieve its goal/objective. 5. Demonstrate a basic understanding of the various subsystems involved in building and deploying a mobile robot. 6. Build a mobile robot with provided materials or 3D-printed parts, test, operate and debug errors. 7. Identify the various algorithms that can be applied for mobile robots. 8. Demonstrate mastery of mobile robots by having it perform a function to achieve a goal.
Major Topics:	I. MOBILE ROBOT OVERVIEW (Lecture, 1 hour) A. Types of mobile robots B. Deployment environments C. General issues II. LOCOMOTION (Lecture, 2 hours) A. Mechanisms in biological systems B. Legged mobile robots C. Leg configurations and stability D. Mobile robot dynamics E. Bipedal robots F. Wheeled mobile robots G. Wheel configurations H. Stability I. Maneuverability III MOBILE ROBOT KINEMATICS (Lecture, 2 hours) A. Representing positions B. Reference frames C. Kinematics constraints D. Types of wheels E. Maneuverability and steerability F. Workspace G. Path and trajectory H. Open loop control I. Feedback control IV. PERCEPTION (Lecture, 3 hours) A. Perception sensors B. Sensor selection criteria C. Characterizing sensor performance D. Resolution

E. Linearity and bandwidth
F. Sensitivity
G. Sensor error
H. Error correction methods
I. Combining measurements
J. Wheel and motor sensors
K. Internal and external perception sensors
L. Camera types and applications
M. Image processing
N. Image filtering and techniques
O. Perception algorithms
P. Geometric feature extraction

V. MOBILE ROBOT LOCALIZATION (Lecture, 3 hours)
A. Challenges
B. Sensor noise
C. Error and classifications
D. Navigation
E. Map-based approaches
F. Line extraction, simplifications and abstractions
G. Decomposition
H. Occupancy grid representation
A. Nongeometric features
J. Markov localization
K. Kalam filter localization
L. Localization issues
M. Landmark-based navigation
N. Positioning beacon systems
O. Route-based localizations
P. Autonomous map building
Q. Simultaneous Localization and Mapping (SLAM)
R. Expanded Kalman Filter (EKF) SLAM
S. Visual SLAM with single camera
T. Graph-based SLAM
U. Particle filter SLAM

VI. PLANNING AND NAVIGATION (Lecture hours, 2 units)
A. Path planning
B. Obstacle avoidance
C. Completeness
D. Configuration space
E. Graph search
F. Graph construction
G. Visibility graph limitations
H. Lattice graph
A. Deterministic graph search
J. Breadth and depth first search
K. Dijkstra's algorithm
L. A* and D* algorithms
M. Rapidly exploring random trees algorithm
N. Bug algorithm

VII. ROVER DESIGN AND OPERATIONS (lecture, 5 hours)
A. Excessive vibrations
B. Ionizing radiation
C. Planetary protection

	D. Power supply E. Avionics and flight software F. Thermal controls G. Mounting panel and sensors H. Heaters, heat rejection system, and heat demand I. Telecommunications J. Mobility system and rocker bogie suspension system K. Motors and wheels L. Sample acquisition, process and handling M. Robotic arm, turret, and arm mounts N. Cabling and drill O. Collection and Handling for In-Situ Martian Rock Analysis (CHIMRA) P. Dust removal tool Q. Navigation and remote sensing mast R. Engineering cameras S. Slip checks and rover driving T. Radiation assessment detector and environmental monitoring station U. Chemistry and camera complex V. Chemistry and mineralogy VIII. ROVER DESIGN (Lab, 30 hours) A. Goals and objective identification B. Drawing or CAD of Rover Design C. Subsystem identification D. Sensor selection E. Perception selection F. Navigation parameters G. Algorithm selection H. Science instrumentation IX. ROVER TESTING AND DEBUGGING (Lab, 50 hours) A. Testing rover on level platform B. Testing rover on rover yard surfaces C. Debugging hardware, software, sensor, errors D. Making adjustments on other subsystems where needed lab X. ROVER OPERATION (Lab, 28 hours) A. Performing goal on level platform B. Performing goal on simulated off-world surfaces.
Total Lecture Hours:	18
Total Laboratory Hours:	108
Total Hours:	126
A.1. Primary Methods of Evaluation (Part 1 - CCN courses only):	
Primary Method of Evaluation:	3) Skills demonstration
Typical Assignment Using Primary Method of Evaluation:	Identify different types of mobile robots. Examine components of a mobile robot and demonstrate knowledge of subsystems and how they interact with one-another. Submit Computer Aided Design (CAD) or hand drawing to the instructor for evaluation.
Critical Thinking Assignment 1:	Using CAD software or by hand design a miniature mobile robot (i.e. rover) based on a problem to be solved. Justify type, sensor selections, and subsystems. Submit robot design to the instructor.

Critical Thinking Assignment 2:	Present and demonstrate a rover with 3D-printed parts. Consult instructor for evaluation.
Other Evaluation Methods:	Class Performance, Completion, Matching Items, Multiple Choice, Performance Exams, Presentation, True/False, Written Homework, Laboratory Reports
If Other:	
Instructional Methods:	Discussion, Group Activities, Guest Speakers, Lab, Lecture, Multimedia presentations, Demonstration
If other:	
Work Outside of Class:	Journal (done on a continuing basis throughout the semester), Required reading, Study, Written work (such as essay/composition/report/analysis/research)
If Other:	
Up-To-Date Representative Texts:	Siegwart, R., Nourbakhsh, I., and Scaramuzza, D. Introduction to Autonomous Mobile Robots. 2011. MIT Press. Second Edition. (Discipline Standard)
Alternative Texts:	
Required Supplementary Readings:	Lakdawalla, E. The Design and Engineering of Curiosity. 2018. Springer. First Edition. (Discipline Standard)
Other Required Materials:	
Requisite	Prerequisite
Category	sequential
Requisite course:	Robotics 150
Requisite and Matching skill(s): Bold the requisite skill. List the corresponding course objective under each skill(s).	**Ability to diagnose hardware and software errors in a robotic system.** ROBO 150 - Diagnose hardware and software errors in robotic systems. **Ability to program robotic systems to execute operational tasks.** ROBO 150 - Program robotic systems to perform operational tasks using software.
Requisite Skill:	
Requisite Skill and Matching skill(s): Bold the requisite skill(s). if applicable	
Requisite course:	
Requisite and Matching skill(s): Bold the requisite skill. List the corresponding course objective under each skill(s).	
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each skill(s). if applicable	
Enrollment Limitations and Category:	
Enrollment Limitations Impact:	
Course Created by:	Joseph Weichman
Date:	10/03/2024
Original Board Approval Date:	04/28/2025
Effective Term:	Fall 2026