1. Instructor:

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2. Period and date:

Start date :

End date :

3. Course Description & Aim:

Robotic Engineering is a course for the students who are interested in the design, engineering and programming of robots or another technical career. The Robotics Engineering course is designed to explore the past, current and future use of automation technology in industry and everyday use. Robotics is a lab-based course that uses a hands-on approach to introduce the basic concepts of robotics, focusing on the construction and programming of autonomous mobile robots. Course information will be tied to lab experiments; students will work in groups to build and test increasingly more complex mobile robots, culminating in an end-of-semester robot contest. Students will be divided into groups and complete a variety of robot construction and programming activities within the confines of these groups. Students trace the history, development, and influence of automation and robotics. They learn about mechanical systems, energy transfer, machine automation and computer control systems. Students use a robust robotics platform to design, build, and program a solution to solve an existing problem.This course will introduce basic concepts and techniques used within the field of mobile robotics. analyze the fundamental challenges for autonomous intelligent systems and present the state of the art solutions. Among other topics, it will discuss:

- Kinematics
- Sensors
- Vehicle localization
- Map building
- SLAM
- Path planning
- Exploration of unknown terrain

4. **Course syllabus** Robotics Course Outline

Proposed Robotic Course

No	Main topic	Highlight point	Hours
1	**Introduction**	Welcome to Robotics! Pass out notebooks and have the students write responses to the following reflection questions What is a Robot? What are examples of a robot? What can robots do? What can't robots do? How are robots used in our daily lives? What is possible with a Robot? Should Robots look like humans or should they look like machines? Why does it matter? How can you prove it is a Robot and not a remote controlled machine?	
2	**Linear Algebra**	Vectors Matrices and Important Matrices Operations Scalar Multiplication & Sum Matrices to Represent Affine Transformations Combining Transformations Positive Definite Matrix Gaussian Elimination Jacobian Matrix	
3	**Robot part and sections _1**	What is a sensor? i)Takes readings from physical environment and turns it into an electrical message/signal ii) Sensors we will work with: (1) Touch- hit something and it reacts (2) Light- can sort by color or detect light from dark (3) Sonar/ultrasonic- tells how far away things are (4) Sound- (5) Proximity Sensors (6) Range Sensor Kinect (7) Wolfram in 3D The processor? i)It is the logic circuitry that responds to and processes the basic instructions that drive a computer.	
4	**Robot part and sections _2**	What is an actuator and motors? Brief on motors(DC and servo) Brief on motors(DC and servo) Dc motor and encoders resolutions P, I,.D and Pi,PD , and PID controlling loop	
5	**Robot Control Paradigms**	Classical / Hierarchical Paradigm Classical Paradigm as Horizontal/Functional Decomposition Reactive / Behavior-based Paradigm Characteristics of Reactive Paradigm Behaviors Potential Field Methods Corridor Following with Potential Fields Characteristics of Potential Fields Reactive Paradigm Hybrid Deliberative/Reactive Paradigm	
6	**Kinematics**	Kinematic equations Forward kinematics Inverse kinematics Robot Jacobian Velocity kinematics	

		Static force analysis Locomotion of Wheeled Robots Instantaneous Center of Curvature Differential Drive Differential Drive: Forward Kinematics Non-Holonomic Constraints Holonomic vs. Non-Holonomic Drives with Non-HolonomicConstraints Drives without Non-HolonomicConstraints Dead Reckoning and Odometry Introduction and Axioms of Probability Theory	
		Law of Total Probability Bayes Formula Normalization Bayes Rule with Background Knowledge Conditional Independence State Estimation Recursive Bayesian Updating Typical Actions State Transitions Bayes Filters: Framework Markov Assumption Kalman filters Particle filters Hidden Markov mode Dynamic Bayesian ne Partially Observable M Processes (POMDPs) Probabilistic Localization	
9	**Probabilistic Motion Models**	Robot Motion Dynamic Bayesian Network for Controls, States, and Sensations Probabilistic Motion Models Coordinate Systems Typical Motion Models(Odomerty-based Velocity-based (dead reckoning)) Reasons for Motion Errors of Wheeled Robots Odometry Model Noise Model for Odometry Calculating the Probability Density Calculating the Posterior Given x, x', and Odometry Application Rejection Sampling Velocity-Based Model Noise Model for the VelocityBased Model	
10	**Probabilistic Sensor Models**	Sensors for Mobile Robots Beam-based Sensor Model Typical Measurement Errors of an Range Measurements Proximity Measurement Beam-based Proximity Model Resulting Mixture Density Influence of Angle to Obstacle Scan-based Model Scan Matching and Properties of Scan-based Model Additional Models of Proximity Sensors Landmarks Vision-Based Localization Probabilistic Model Distributions	
11	Bayes Filter - Discrete Filters	Discrete Bayes Filter Algorithm Piecewise Constant Representation Grid-based Localization Sonars and Occupancy Grid Map	

		Tree-based Representation	
12	Bayes Filter - Particle Filter and MCL	Sample-based Localization (sonar) Mathematical Description Function Approximation Importance Sampling Principle Particle Filters Resampling Algorithm Mobile Robot Localization Sample-based Localization (sonar)	
13	Bayes Filter - Kalman Filter	Kalman Filter Gaussians Properties of Gaussians Discrete Kalman Filter Components of a Kalman Filter Kalman Filter Updates in 1D Linear Gaussian Systems: Initialization Linear Gaussian Systems: Dynamics Linear Gaussian Systems: Observations Kalman Filter Algorithm	
14	Bayes Filter - Extended Kalman Filter	Components of a Kalman Filter EKF Linearization: First Order Taylor Expansion EKF Algorithm EKF_localization	
15	Grid Maps and Mapping With Known Poses	Why Mapping? The General Problem of Mapping The General Problem of Mapping with Known Poses Grid Maps Estimating a Map From Data Static State Binary Bayes Filter Inverse Sensor Model for Sonars Range Sensors Resulting Occupancy and Maximum Likelihood Map Difference between Occupancy Grid Maps and Counting	
16	SLAM - Simultaneous Localization and Mapping	SLAM: Simultaneous Localization and Mapping What is SLAM? The SLAM Problem SLAM Applications Map Representations Feature-Based SLAM Why is SLAM a Hard Problem? Graphical Model of Full SLAM Graphical Model of Online SLAM EKF SLAM: SLAM Techniques	
17	SLAM - Landmark-based FastSLAM	Some review on SLAM FastSLAM FastSLAM Complexity	
18	SLAM - Grid-based FastSLAM	Grid-based SLAM Rao-Blackwellization A Graphical Model of Mapping with Rao-Blackwellized PFs Mapping with RaoBlackwellized Particle Filters Particle Filter Example Pose Correction Using Scan Matching and Scan-Matching Example Motion Model for Scan Matching Mapping using Scan Matching FastSLAM with ImprovedOdometry Graphical Model for Mapping with Improved Odometry FastSLAM with Scan-Matching Comparison to Standard FastSLAM	
19		Graph-Based SLAM	

	SLAM - Graph-based SLAM	Idea of Graph-Based SLAM	
20	Techniques for 3D Mapping	Why 3D Representations Popular Representations Point Clouds 3D Voxel Grids Elevation Maps Extended Elevation Maps Types of Terrain Maps Multi-level surface map Octree-based Representation	
21	Iterative Closest Point Algorithm	SVD ICP with Unknown Data Association Basic ICP Algorithm Normal-Space Sampling ICP Application Closest Compatible Point Projection	
22	Path and Motion Planning	Motion Planning Classic Two-layered Architecture Dynamic Window Approach Motion Planning Formulation	
23	Multi-Robot Exploration	Exploration Decision-Theoretic Formulation of Exploration Single Robot Exploration Multiple Robot Levels of Coordination The Coordination Algorithm Multi-Robot Exploration and Mapping of Large Environments	
24	Information Driven Exploration	Tasks of Mobile Robots Exploration and SLAM Mapping with Rao-Blackwellized Particle Filter (Brief Summary) Factorization Underlying Rao-Blackwellized Mapping Example: Particle Filter for Mapping Combining Exploration and SLAM Decision-Theoretic Approach The Uncertainty of a Posterior Computing the Entropy of the Map Posterior Computing the Entropy of the Trajectory Posterior Dual Representation for Loop Detection Trajectory graph , Occupancy grid Loops	

5. Course Objectives

In this course, students will:

1. Explore the broad scope of robotic applications
2. Learn the basic components and building blocks of robots
3. Develop the robot construction skills
4. Learn to program the robots
5. Program autonomous mobile robots to achieve challenging tasks

6. Essential Questions

1. How can robotics technology further impact our future in a positive way?
2. What are the required components, factors and skills to build a high performance functioning robot?
3. How to construct an autonomous mobile robot.
4. How to program an autonomous mobile robot.

7. Course Format

1. Lectures.
2. Video and multimedia presentations.
3. Group work and discussions.
4. Laboratory investigations.
5. Group competitions and activities.
6. Mini- and term projects.
7. Homework assignments.

8. Assessment Methods (This course is divided into):

NO			
1.	Entering the robotics world	a. Introduction to robotics c. Safety and project management	b. STEM careers
2.	Robotics: Mechanics	a. Materials, construction & motion	b. Motors & gears
3	Robotics: Electricity	a. Electricity & batteries	b. Remote controllers
4	Robotics: Sensing & controlling	a. Microcontrollers	b. Sensors
5	Programming: Motion	a. Setup & fundamentals	b. Movements
6	Programming: Sensing & controlling	a. Radio control	b. Sensing
7	Project: ***Exploring one the existence platform which we have in RARL***	a. Planning b. Design	c. Implementation d. Testing e. Presentation & documentation
8	Challenges		

10. Course Requirements and Materials Needed

1. LAB

2. Hardware: Designed System, accessories and tools (provided by school).(we have in my lab)

3. Software: ROBOTC license (provided by school_ we have in my lab)).

11. Grading Scale and exam marks

- A = 90-100 %
- B = 80-89 %
- C = 70-79 %
- D = 60-69 %
- F = Below 60 %

NO	ACTIVITIES	PERCENTAGES
1	Mid-term Exam	30%
2	End-of-term Exam	30%
3	Homework	20%
4	Laboratory and Design Project	20%

10. Expectations

1. Attend class daily, on time and ready to work.
2. Participate and contribute to group assignments and projects.
3. Maintain a daily, complete, organized engineering journal.
4. Have all assignments done and submitted when they are due.
5. Review work done each day.
6. Spend an appropriate amount of time preparing for tests.
7. Exercise safety and common sense at all times.
8. Have a mutual respect for fellow students and their right to an education.\

Reference Book:

1. **Probabilistic Robotics (Intelligent Robotics and Autonomous Agents series) Hardcover – August 19, 2005**
2. **Mobile Robots: Inspiration to Implementation, Second Edition 2nd Edition by Sebastian Thrun , Wolfram Burgard ,Dieter Fox Joseph L. Jones , Bruce A. Seiger , Anita M. Flynn**
3. **Vehicles: Experiments in Synthetic Psychology 58042nd Edition by Valentino Braitenberg ,**
4. **Introduction to Autonomous Mobile Robots, by R. Siegwart, I. R. Nourbakhsh, MIT Press, 2011.**
5. **Principles of Robot Motion, by H. Choset, K. M. Lynch, S. Hutchinson, G. Kantor, W. Burgard, L. E. Kavraki and S. Thrun, The MIT Press, 2005**
6. **Introduction to AI Robotics, by R. R. Murphy, The MIT Press, 2000**
7. **Computational Principles of Mobile Robots, by G. Dudek and M. Jenkin, Cambridge University Press, 2000**
8. **Probabilistic Robotics, by S. Thrun, W. Burgard, and D. Fox, The MIT Press, 2005**