1. **Course Number and Course Title:**
   ELE 494-08 – Autonomous robotic systems

2. **Credits Hours:**
   3 – 0 – 3

3. **Prerequisites and/or Co-Requisites:**
   Prerequisites: ELE 353

4. **Name and Contact Information of Instructor:**
   Dr. Shayok Mukhopadhyay
   Office: EB1-232
   Email: smukhopadhyay@aus.edu
   Phone: (06) 515-2651

5. Office Hours: To be announced.

6. **Course Description (Catalog Description):**
   Covers wheeled mobile robot kinematics, localization and navigation. Examines path-planning techniques. Introduces robot swarm concepts, quadcopter drone dynamics, and Robot Operating System (ROS) concepts.

7. **Textbook and other Supplemental Material:**
   Textbook:
   - Introduction to autonomous mobile robots, 2nd edition, R. Siegwart, I.R. Nourbaksh, D. Scaramuzza, MIT Press, 2011

   References:
   - Introduction to robotics: Mechanics and Control, 3rd Edition, J.J. Craig, Pearson, 2004
   - Quad Rotorcraft Control, L.R.G. Carrillo, A.E.D Lopez, R. Lozano, C. Pegard, Springer, London, 2013.

8. **Learning Outcomes:**
   Upon completion of the course, students will be able to:
   1. Identify appropriate types of wheels, depending on a particular robotic application.
   2. Use a mobile robot kinematic model, and solve mobile robot trajectory tracking problems via input-output state feedback linearization.
   3. Select IR, Lidar, sonar, pressure, bump sensors enabling a robot to perceive the environment.
   4. Derive a basic Luenberger state estimator, and apply complimentary filters for state estimation.
   5. Derive Kalman filter equations, and explain how to use it for localization.
   5. Choose and compare path-planning algorithms for wheeled mobile robot motion planning.
   6. Derive quadcopter dynamic model equations.
   7. Formulate, and solve a swarm consensus problem.
   8. Use ROS to perform basic mobile robot motion simulation.

9. Teaching and Learning Methodologies:

Classes will typically include lectures where main points will be highlighted using slides/notes and the detailed description of the content will be worked on a whiteboard. In class discussion is encouraged.

10. Course Topics and Schedule:

Topic	Weeks
Introduction to different types of wheeled robots, and wheel selection.	1
Mobile robot kinematics, and trajectory tracking via input-output state feedback linearization, introduction to other tracking techniques.	1.5
Selection and wiring of IR, Lidar, sonar, pressure, bump sensor and other advanced sensors.	1
Luenberger estimator, complementary filters, deriving Kalman filter equations for localization.	3.5
Introduction to path planning algorithms (A*, RRT*).	1
Quadcopter dynamics and 3D trajectory tracking.	2.5
Multi-robot swarm consensus.	2
Simulation using the ROS platform.	1.5
Midterm, final review and finals.	2
Total:	**16**

11. Schedule of Laboratory and other Non-Lecture Sessions:

There are no labs associated with this class.

12. Out-of-Class Assignments with Due Dates:

Assignment	Due Date (tentative)
Quizzes	Surprise quizzes
Homework 1	Week 3
Homework 2	Week 6
Homework 3	Week 9
Homework 4	Week 13
Final Project	Week 15

13. Student Evaluation:

Assessment	Weight	Due Date (tentative)
Homework and quizzes	5%	As above
Two Midterm Exams	30%	March 03, April 09
Project	25%	Last day of classes
Final Exam	40%	As scheduled by Registrar

14. Contribution of Course to Program Outcomes

This course contributes to the accomplishment of the following program outcomes:

Program outcome	Emphasis in this course
(a) an ability to apply knowledge of mathematics, science, and engineering	●
(b) an ability to design and conduct experiments, as well as to analyze and interpret data	
(c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability	◑
(d) an ability to function on multidisciplinary teams	
(e) an ability to identify, formulate, and solve engineering problems	●
(f) an understanding of professional and ethical responsibility	
(g) an ability to communicate effectively	○
(h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context	
(i) a recognition of the need for, and an ability to engage in life-long learning	○
(j) a knowledge of contemporary issues	
(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.	◑

Emphasis: ● High; ◑ Medium; ○ Low; Blank – Nothing Specific Expected