Subject Description Form

Subject Code	AAE4203
Subject Title	Guidance and Navigation
Credit Value	3
Level	4
Pre-requisite/ Co-requisite/ Exclusion	**Pre-requisite:** AAE3004 Dynamical Systems and Control **OR** AAE4301 Avionics Systems
Objectives	1. To provide a fundamental understanding and knowledge of conventional and modern design and working principles of navigation and guidance for unmanned autonomous systems (UAS); and 2. To provide the basic mathematical concepts of navigation by inertial and satellite approaches and guidance laws; and 3. To provide an expansive view into the technological trends of future UAS navigation and guidance systems designs.
Intended Learning Outcomes	Upon completion of the subject, students will be able to: a. Understand and explain the working principles of navigation and guidance systems for unmanned autonomous systems (UAS); and b. Competently apply the fundamental mathematical concepts of UAS navigation; and c. Critically evaluate the characteristics, purposes, and design procedures of UAS navigation and guidance systems; and d. Identify the technological and design trends of future UAS navigation.
Subject Synopsis/ Indicative Syllabus	**Inertial Navigation System –** reference frames; principles of inertial navigation; gyroscope and accelerometer; attitude estimation and Euler angles. **Satellite Navigation System** – principles of satellite navigation; basic principle of the GNSS single point positioning, measurements modeling. Introduction to the GNSS real-time kinematic positioning for unmanned autonomous systems (UAS) navigation. **Integrated Navigation System –** Kalman filter and estimation theory; integration of inertial and satellite navigation; redundancy and consistency check. **Vision navigation in UAS –** Visual sensor model, the basic principle of visual matching, feature tracking, and visual positioning and navigation. **State Estimation for UAS** – Concepts of state estimation, the basic principle of the state estimation based on Kalman filtering, factor graph optimization. The example

<table>
<tr><td></td><td>of the state estimation in UAV positioning and navigation

Case Studies - Design and discussion of navigation and guidance systems for various air vehicles. Technological trends in future UAS navigation and guidance systems.</td></tr>
<tr><td>Teaching/Learning Methodology</td><td>Lectures are used to deliver the fundamental concepts, theory, mathematical background and technical knowledge related to unmanned autonomous systems (UAS) Guidance and Navigation (outcomes a, b, c and d).

Tutorials are used to provide a deeper understanding of the theoretical material, and to put theoretical material into use via practical examples and demonstrations (outcomes b and c).

Homework assignments, in the form of quiz and problems and case studies, and mini group research project, are used to allow students to reflect on and deepen their knowledge on a selected topic (outcomes a, b, c and d).

A reading week will be assigned in week 7. Student will be provided with tutorial and materials for reading during the week 7 without in classroom lecture.

<table>
<tr><td rowspan="2">Teaching/Learning Methodology</td><td colspan="4">Intended subject learning outcomes to be covered</td></tr>
<tr><td>a</td><td>b</td><td>c</td><td>d</td></tr>
<tr><td>1. Lecture</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr>
<tr><td>2. Tutorial</td><td></td><td>✓</td><td>✓</td><td></td></tr>
<tr><td>3. Mini Group Project</td><td></td><td></td><td>✓</td><td>✓</td></tr>
<tr><td>4. Homework assignments</td><td>✓</td><td>✓</td><td></td><td></td></tr>
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<tr><td>Assessment Methods in Alignment with Intended Learning Outcomes</td><td>
<table>
<tr><td rowspan="2">Specific assessment methods/tasks</td><td rowspan="2">% weighting</td><td colspan="4">Intended subject learning outcomes to be assessed</td></tr>
<tr><td>a</td><td>b</td><td>c</td><td>d</td></tr>
<tr><td>1. Homework assignments</td><td>15%</td><td>✓</td><td>✓</td><td></td><td></td></tr>
<tr><td>2. Test</td><td>15%</td><td>✓</td><td>✓</td><td></td><td></td></tr>
<tr><td>3. Mini Group Project</td><td>20%</td><td></td><td></td><td>✓</td><td>✓</td></tr>
<tr><td>4. Examination</td><td>50%</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr>
<tr><td>Total</td><td>100 %</td><td colspan="4"></td></tr>
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<tr><td></td><td colspan="2">Explanation of the appropriateness of the assessment methods in assessing the intended learning outcomes:

Overall Assessment:

0.5 × End of Subject Examination + 0.5 × Continuous Assessment

All homework assignments are designed to assist and enhance the understanding of the fundamental theories and concepts taught during the course of the subject, and to be sufficiently practical to allow students to apply the theories and concepts in practice.

Test and Examination serve to evaluate the student's ability in all of the intended learning outcomes.</td></tr>
<tr><td rowspan="9">Student Study Effort Expected</td><td>Class contact:</td><td></td></tr>
<tr><td>▪ Lecture</td><td>30 Hrs.</td></tr>
<tr><td>▪ Laboratory/Tutorial</td><td>6 Hrs.</td></tr>
<tr><td>Other student study effort:</td><td></td></tr>
<tr><td>▪ Week 7 Reading Week</td><td>3 Hrs.</td></tr>
<tr><td>▪ Continue Assessment</td><td>35 Hrs.</td></tr>
<tr><td>▪ Self-study</td><td>36 Hrs.</td></tr>
<tr><td>Total student study effort</td><td>110 Hrs.</td></tr>
<tr><td>Reading List and References</td><td colspan="2">1. David Wyatt, Aircraft Flight Instruments and Guidance Systems: Principles, Operations and Maintenance, Routledge, latest edition.

2. Lawrence, Modern Inertial Technology – Navigation, Guidance, and Control latest edition, Mechanical Engineering Series, Springer, latest edition.

3. Modern Navigation, Guidance and Control Processing Volume-II, Ching-Fang Lin, Prentice Hall Series in Advanced Navigation, Guidance and Control and Their Applications.</td></tr>
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