MODULE DESCRIPTION FORM

DEPARTMENT OF MECHANICAL AND AEROSPACE ENGINEERING

ME512 SPACEFLIGHT MECHANICS

Module Registrar: Prof M Vasile massimiliano.vasile@strath.ac.uk	**Taught To (Course): Cohorts for whom class is compulsory / optional**	
Other Lecturers Involved: Dr Jinglang Feng	**Credit Weighting: 10 (ECTS 5)**	**Semester 1**
Elective class	**Academic Level: 5**	**Suitable for Exchange: Y**

Required prerequisites

Note: It is the responsibility of ALL students to ensure that they satisfy the prerequisite knowledge for this module BEFORE adding as part of curriculum selection. If unsure, please contact the Module Registrar or discuss with your Programme/Year Adviser of Studies.

Physics
Fundamentals of kinematics and dynamics, forces and momenta, work and energy, equations of relative motion,

Mathematics:
Fundamentals of linear algebra, vectors & matrices, calculus, geometry

Numerical Methods:
Solution of linear and nonlinear equations; integration of ordinary differential equations

Programming:
Knowledge of basic programming principles:
- manipulation of scalar, vectors and matrices variables;
- use of operators, expressions and statements (including conditional statements);
- algorithms, structured programming logic and flow diagrams;
- computer arithmetic and errors.

Ability to construct flow charts to summarise key steps of a problem.

Ability to develop and implement effective algorithms (MATLAB is the officially supported language/environment for this module, but the assignments and courseworks can be done in any programming language).

Module Format and Delivery (HOURS i.e. 1 credit = 10hrs of study):

Lecture	Tutorial	Laboratory	Groupwork	External	Online	Project	Assignments	Private Study	**Total**
24						26		50	100

Educational Aim

This module aims to provide basic elements of spaceflight mechanics, including fundamentals of orbital mechanics, orbit transfer analysis and space mission design. The two-body problem will be solved from first principles to allow one to derive position and velocity of an object at a given time. This analysis will then be used to investigate various modes of orbit transfer, the observability of a space object from ground and the ground coverage of space. The course will provide also some basic elements of orbit perturbations Finally, the various elements of the class will be brought together to illustrate the mission analysis and design process.

Learning Outcomes

On completion of the module the student is expected to be able to:

LO1 Derive position and velocity of an orbiting satellite at a given time.

LO2 Design and analyse orbit transfers using impulsive manoeuvres.

LO3 Analyse the long term evolution of orbits under the effect of the main perturbations.

Syllabus

The module will teach the following:

1. Dynamical Systems: Review of the basic concepts and methods of kinematics and dynamics.
2. Two-Body Problem: Full solution of two-body position-time problem.
3. Basics perturbation effects on orbital motion.
4. Orbit Transfer: Use of impulse manoeuvres for two-body orbit transfer and orbit correction.
5. Basic elements of space mission analysis and design.

Assessment of Learning Outcomes

Criteria

For each of the Module Learning Outcomes the following criteria will be used to make judgements on student learning:

LO1 Derive position and velocity of an orbiting satellite at a given time.
C1.1 Students should demonstrate the ability to calculate the position and velocity vectors of a satellite at a given time.
C1.2 The student should demonstrate the ability to study the ground track and ground coverage of an orbiting satellite.

LO2 Design and analyse orbit transfers using impulsive manoeuvres.
C2.1 The students should demonstrate the ability to calculate the required Δv and time of transfer given the departure and arrival orbits.
C2.2 The student should demonstrate the ability to produce a complete launch window analysis for an interplanetary mission.
C2.3 The student should demonstrate the ability to calculate basic impulsive manoeuvres to re-phase satellites in a constellation.

LO3 Analyse the long term evolution of orbits under the effect of the main perturbations.
C3.1 The students should demonstrate the knowledge of the main actions that perturb the two-body motion and their long term effects
C3.2 The students should demonstrate the ability to compute the secular and long term variation of the orbital elements for a planet-centred orbit under the effect of the main perturbations.
C3.3 The student should demonstrate the ability to analyse the evolution of the ground track for a planet-centred orbit under the effect of the main perturbations.
C3.4 The student should demonstrate the ability to design geocentric orbits fulfilling a number of given requirements, by exploiting the effect of the main perturbations
C3.5 The students should demonstrate the ability to design appropriate impulsive manoeuvres to correct the effects of perturbations.

The standards set for each criterion per Module Learning Outcome to achieve a pass grade are indicated on the assessment sheet for all assessment.

Principles of Assessment and Feedback
(within Assessment and Feedback Policy at: https://www.strath.ac.uk/professionalservices/staff/policies/academic/)

Student assessment is achieved through one single project broken down in three progress reviews and a final examination. At each progress review the students will deliver part of the project in the form of a power point presentation. Feedback and help is provided to the students at each of the progress reviews where the deliverables are discussed. The project, either partially or fully, can be submitted or resubmitted at any of the progress reviews for marking and feedback. Only the final mark at the deadline will be counted. The completion of the project is mandatory to sit the exam.

Assessment Method(s) Including Percentage Breakdown and Duration of Exams *(individual weightings)*

Examination				Coursework		Practical		Project	
Number	Month(s)	Duration	***Weighting***	Number	***Weighting***	Number	***Weighting***	Number	***Weighting***
								1	100%
								*All LOs	

* ***L/Os:*** *Indicate which Learning Outcomes (L01, L02, etc) are to be assessed by exam/coursework/project/practical as required.*

Coursework / Submissions deadlines: The final submission deadline for the whole project is one week after the end of the course.

Resit Assessment Procedures: ^^Project submission prior to commencement of the August exam diet.

^^Students must contact the module Registrar for details as soon as results confirm that a resit is required.

PLEASE NOTE:
Students must gain a project mark of at least 50% to pass the module. Students who fail the module at the first attempt will be re-assessed by the August diet. This re-assessment will consist of a new project. No marks from any previous attempts will be transferred to a new resit attempt.

Recommended Reading

***Purchase recommended **Highly recommended reading *For reference	
***	"Spaceflight Dynamics", W.E. Wiesel, McGraw-Hill, 1996.
*	"Orbital Motion", A.E. Roy, Adam Hilger, 1988.

Additional Student Feedback
(Please specify details of when additional feedback will be provided)

Date	Time	Room No
During project reviews	At the time of the reviews	Check timetable webpages for details

Session: 2021/22

Approved:

Course Director Signature:	**E Henderson**
Date of Last Modifications:	**31/08/2021**

(Updated July 2021-MAE)

MODULE TIMETABLE

Module Code:	**ME512**	**Module Title:**	**Space Flight Mechanics**

Brief Description of Assessment:

Formative assessment: Project with 3 intermediate reviews - worth in total 100%.

Reviews follow the usual lifecycle of a space mission design project. The three reviews are: Preliminary Design Review (PDR), Mid-Term Review (MTR), Consolidated Design Review (CDR). The project is developed individually. At each review students will present their progress towards the completion of the project and will receive verbal feedback on the status of their work. At each review each student will be asked questions to assess their understanding of the work done up that review. Depending on the quality of the work presented during the review and the answers to the questions (all questions are strictly on the work presented at the review) the student will receive a number of points (up to 20 for PDR and MTR and up to 60 for CDR). At each review the assessors will also check if shortfalls of previous reviews were properly addressed by the student. If the student properly addressed the shortfalls of previous reviews the points assigned for each of the previous reviews are updated to reflect the corrections/improvements made by the student.

NB: The final mark will be the sum of the marks of the summative and formative assessments (pass mark for Level 5 classes is 50%)

Assessment Timing:-

Indicate on the table below the start/submission dates for each assignment/project and the timing of each exam/assessment using the dropdowns provided.

Please note: Timings can and will change, this should only be used as a guide.

Semester One	W&D Wk	WK1	WK2	WK3	WK4	WK5	WK6	WK7	WK8	WK9	WK10	WK11	Exam Period
	Choose an item. Choose an item.	Choose an item. Choose an item.	Choose an item. Choose an item.	Choose an item. Choose an item.	PDR	Choose an item. Choose an item.	Choose an item. Choose an item.	MTR	Choose an item. Choose an item.	Choose an item. Choose an item.	CDR	Choose an item. Choose an item.	Coursework Submit

Semester Two	C&D Wk	WK1	WK2	WK3	WK4	WK5	WK6	WK7	WK8	WK9	WK10	WK11	Exam Period