Engineering Physics
ENGPHYS 3SP3
Space Systems Engineering
Undergraduate Studies
Fall 2025
Course Outline

INSTRUCTOR OFFICE HOURS AND CONTACT INFORMATION

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Office Hours:

Arrangement of meetings based on requests and availability

TEACHING ASSISTANT OFFICE HOURS AND CONTACT INFORMATION

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Office Hours:
Arrangement of meetings based on requests and availability

COURSE WEBSITE/ALTERNATE METHODS OF COMMUNICATION

1. Avenue to Learn will host the official course website for course materials, communications, submission of work and grading. http://avenue.mcmaster.ca/ . It is the students' responsibility to regularly check the course webpage for updates and announcements.

2. Lectures will be held in person. Attendance is recommended as lecture recordings will not be posted.

3. Appointments can be scheduled by sending an email to the instructor to organize a time to meet. Questions are also welcome over email about the course. For mark disputes, please wait until the solutions for the assignment are posted before emailing the instructor or the teaching assistants about marks.

CLASS FORMAT

Course Dates: 09/02/2025 - 12/042025

Units: 3

Course Delivery Mode: All classes are in-person. McMaster is an in-person university.

Course Description:

A survey of topics required for the development of space missions from a systems engineering perspective. Topics include introduction to systems engineering, launch and space environments, orbital mechanics, spacecraft systems and subsystems, spacecraft dynamics.

Prerequisite(s): Registration in Level III or above of an Engineering or Honours Physics program.

Antirequisite(s): None

The course is scheduled as follows: Wednesday 7 – 10 pm, see Mosaic or Avenue to Learn for location

There will be no lecture recording; therefore, recordings will not be posted.

COURSE INTENDED LEARNING OUTCOMES

By the end of this course, students will be able to understand, identify and apply systems engineering concepts to space missions and projects and will understand the multidisciplinary collaboration required to realize space missions and projects.

Course concepts include:

- Definition of systems and systems engineering
- Systems engineering design process and Requirements Engineering
- Space system project life cycle
- Verification and validation
- The role of standardization in space systems
- Spacecraft systems and subsystems: hierarchy and functional decomposition
- Technological aspects of space systems: realization, launching, environment
- Orbital mechanics

- Students should know and understand
    - Engineered system, systems engineering definitions and principles
    - Space systems development context: life-cycle, relevant standardization, roles of planning and documenting
    - Systems engineering processes: design, PA/QA, V&V
    - Launch and space environment factors and effects affecting space systems
    - Space, Spacecraft – Satellite systems types and hierarchy
    - Spacecraft subsystems: functions and technologies
    - Spacecraft dynamics
    - Orbital mechanics, types of orbits, orbital parameters, related coordinate systems and coordinate transforms
    - Realization of space systems
- In relation to space systems and projects students should be able to
    - Analyze space mission or system project needs and purpose.
    - Investigate the problem to be solved – mission, define engineering problems and solutions, elicit requirements
    - Identify system life-cycle phases, milestones and related systems engineering activities
    - Perform functional analysis and definition
    - Define levels of decomposition and structure of the product/system tree
    - Define, justify, trace and flow down requirements from mission level to sub-systems

- Analyze, define, calculate orbital parameters and related coordinate transforms and related coordinate parameters
- Select, adapt and expend techniques of systems engineering in application to space systems

ENGINEERING ACCREDITATION: GRADUATE ATTRIBUTES AND LEARNING OUTCOMES

The Canadian Engineering Accreditation Board (CEAB) is a division of Engineers Canada and is responsible for accrediting undergraduate engineering programs across Canada. Accreditation by the CEAB ensures that the engineering programs meet a national standard of quality and cover essential educational requirements. Graduate Attributes are a set of qualities and skills that the CEAB expects engineering graduates to possess. These attributes are a benchmark for the learning outcomes of accredited engineering programs. This section lists the Graduate Attribute Indicators associated with the Learning Outcomes in this course. The Graduate Attributes defined in this section are measured for Accreditation purposes only and will not be directly taken into consideration in determining a student's grade in the course.

Outcomes	Indicators
A knowledge base for engineering: Demonstrated competence in university level mathematics, natural sciences, engineering fundamentals, and specialized engineering knowledge appropriate to the program.	*– Demonstrate competence in mathematics.* *– Demonstrate competence in physical sciences.* *– Demonstrate competence in engineering fundamentals appropriate to engineering discipline.* *– Demonstrate competence in specialized engineering knowledge appropriate to engineering discipline.*
Investigation: An ability to conduct investigations of complex problems by methods that include appropriate experiments, analysis and interpretation of data, and synthesis of information in order to reach valid conclusions.	*– Demonstrate ability to define an engineering problem.* *– Demonstrate ability to formulate a strategy to solve an engineering problem.* *– Demonstrate ability to reach substantiated conclusions.*
Design: An ability to design solutions for complex, open-ended engineering problems and to design systems, components or processes that meet specified needs with appropriate attention to health and safety risks, applicable standards, and economic, environmental, cultural and societal considerations.	*– Demonstrate ability to define and plan the investigation successfully (whether experimental or analytical).* *– Demonstrate ability to conduct an investigation successfully.* *– Demonstrate ability to analyse and interpret data to reach valid conclusions.*
Design: An ability to design solutions for complex, open-ended engineering problems and to design systems, components or processes that meet specified needs with appropriate attention to health and safety risks, applicable standards, and economic, environmental, cultural and societal considerations.	*– Demonstrate ability to define and plan the investigation successfully (whether experimental or analytical).* *– Demonstrate ability to conduct an investigation successfully.* *– Demonstrate ability to analyse and interpret data to reach valid conclusions.*
Use of engineering tools: An ability to create, select, apply, adapt, and extend appropriate techniques, resources, and modern engineering tools to a range of engineering activities, from simple to complex, with an understanding of the associated limitations.	*– Demonstrates ability to identify and select appropriate engineering tool(s) and resources.* *– Demonstrates ability to apply appropriate engineering tool(s) and resources* *– Demonstrates ability to create/develop/adapt appropriate engineering tools*

COURSE SCHEDULE

The course is organized as follows:

• 1 lecture per week, 3 hours, Wednesday evenings 7pm-10pm

A weekly breakdown of the course schedule

Date/Week	Topic
Week 1 (Sept 3)	Introduction
Week 2 (Sept 10)	Systems Engineering - Design Process and Requirements Engineering
Week 3 (Sept 17)	Space System Life-cycle: Phases and V-model, System Decomposition, Interfaces, PBS/WBS/OBS, TRL, Risk etc.
Week 4 (Sept 24)	Realization and Transition: MAIT, QA/PA, Risks, V&V, Models
Week 5 (Oct 1)	Introduction to Orbital Mechanics
Week 6 (Oct 8)	Satellite(S/C) systems and sub-systems; launching, orbits and environment
Week 7 (Oct 15)	Mid-term Recess, No Lecture
Week 8 (Oct 22)	Space environment: radiation, thermal, vacuum, other factors
Week 9 (Oct 29)	Orbits in 3D: coordinate frames, time, Earth orbits
Week 10 (Nov 5)	Introduction to Spacecraft Dynamics
Week 11 (Nov 12)	Satellite Attitude Determination and Control Systems
Week 12 (Nov 19)	Satellite Communication
Week 13 (Nov 26)	Wrapping up, the end: examples, Q&A
Week 14 (Dec 3)	No Lecture

Since this course is delivered as a single extended lecture each week covering a wide range of topics, attendance is highly encouraged. Lecture notes will be available, but they are designed to complement the lecture and will not always be a complete standalone reference.

REQUIRED/OPTIONAL MATERIALS AND FEES

Required Texts:

"NASA systems engineering handbook NASA SP-2016-6105 Rev2" Hirshorn, Steven R., Linda D. Voss, and Linda K. Bromley. National Aeronautics and Space Administration, 2017. Available free online:

NASA Systems Engineering Handbook

Recommended Additional Texts:

- Fortescue, Peter, Graham Swinerd, and John Stark, "Spacecraft systems engineering". John Wiley & Sons, 2011.
- Curtis, Howard D. "Orbital mechanics for engineering students." Butterworth-Heinemann, 2013.
- Wertz, James Richard, David F. Everett, and Jeffery Puschell. "Space mission engineering: the new SMAD.", 2011.
- W. Larson, D. Kirkpatrick, J. Sellers, D. Thomas, D. Verma "Applied Space Systems Engineering", McGraw Hill, 2009.
- David D. Walden et al, "INCOSE Systems Engineering Handbook", Wiley, 2023, 5th edition
- ISO/IEC/IEEE 15288:2023 Systems and software engineering — System life cycle processes
- ESA Standards, Policies, Technical Memoranda and Handbook available at https://ecss.nl/standards/

Other Materials:

The course may use MATLAB or Python for some assignment problems.

COURSE ASSESSMENT DETAILS

Component	Due Date	Weight
Introduction to Systems Engineering	Week 2 (Sept 10)	8%
Requirements Engineering	Week 3 (Sept 17)	8%
Space system life-cycle	Week 4 (Sept 24)	8%
Quality and Standards	Week 5 (Oct 1)	8%
Orbital Mechanics	Week 6 (Oct 8)	8%
Spacecraft Systems and sub-systems	Week 8 (Oct 22)	8%
Space Environment	Week 9 (Oct 29)	8%
Orbits in 3D	Week 10 (Nov 5)	8%
Spacecraft Dynamics	Week 11 (Nov 12)	8%
Spacecraft Communication	Week 13 (Nov 26)	8%
Final Exam	Week 15 (Dec 09)	36%
Total (Best 8 out of 10 assignments counted)		100%

Assessment for this course will be based on weekly homework assignments and a take-home final exam. Homework assignments will be handed out at the end of each week's lecture and due at the beginning of the following week's lecture, except the mid-term recess week. Ten (10) will be handed total. Best eight (8) out of ten (10) assignment will be counted.

The final exam will be take-home, released to the class on Avenue to Learn at a specified time during the final exam period and due on a fixed date within the exam period. Date and duration are from December 5th to December 9th noon.

GRADING SCALE

The McMaster 12 Point Grading Scale

Grade	Equivalent Grade Point	Equivalent Percentages
A+	12	90-100
A	11	85-89
A-	10	80-84
B+	9	77-79
B	8	73-76
B-	7	70-72
C+	6	67-69
C	5	63-66
C-	4	60-62
D+	3	57-59
D	2	53-56
D-	1	50-52
F	0	0-49

COURSE POLICY ON MISSED WORK, EXTENSIONS, AND LATE PENALTIES

MSAF policy:

- Missed homework assignment with the MSAF will receive a grade 0%.
- Just missed (without MSAF) homework assignments will receive a grade 0%.
- Any other missed or late work (without valid long-term absence or SAS accommodation) will receive a grade of 0%.
- Up to two (2) missed homework assignments with the MSAF are counted as the worst in those 10 total assignments, allowing best 8 out 10 to be counted.
- Late homework assignment will receive a grade 0%.
- Late final exam up to three days will receive a grade of 25% less, after three days will receive a grade 0%.
- Long-term absences please contact the faculty office and instructor.

GENERATIVE AI

USE PROHIBITED

Students are not permitted to use generative AI in this course. In alignment with McMaster academic integrity policy, it "shall be an offence knowingly to … submit academic work for assessment that was purchased or acquired from another source". This includes work created by generative AI tools. Also state in the policy is the following, "Contract Cheating is the act of "outsourcing of student work to third parties" (Lancaster & Clarke, 2016, p. 639) with or without payment." Using Generative AI tools is a form of contract cheating. Charges of academic dishonesty will be brought forward to the Office of Academic Integrity.

APPROVED ADVISORY STATEMENTS

EQUITY, DIVERSITY, AND INCLUSION

Every registered student belongs in this course. Diversity of backgrounds and experiences is expected and welcome. You can expect your Instructor to be respectful of this diversity in all aspects of the course, and the same is expected of you.

The Department of Engineering Physics and the Faculty of Engineering are committed to creating an environment in which students of all genders, cultures, ethnicities, races, sexual orientations, abilities, and socioeconomic backgrounds have equal access to education and are welcomed and treated fairly. If you have any concerns regarding inclusion in our Department, in particular if you or one of your peers is experiencing harassment or discrimination, you are encouraged to contact the Chair, Associate Undergraduate Chair, Academic Advisor or to contact the Equity and Inclusion Office.

ACADEMIC INTEGRITY

You are expected to exhibit honesty and use ethical behaviour in all aspects of the learning process. Academic credentials you earn are rooted in principles of honesty and academic integrity. **It is your responsibility to understand what constitutes academic dishonesty.**

Academic dishonesty is to knowingly act or fail to act in a way that results or could result in unearned academic credit or advantage. This behaviour can result in serious consequences, e.g. the grade of zero on an assignment, loss of

credit with a notation on the transcript (notation reads: "Grade of F assigned for academic dishonesty"), and/or suspension or expulsion from the university. For information on the various types of academic dishonesty please refer to the *Academic Integrity Policy*, located at https://secretariat.mcmaster.ca/university-policies-procedures-guidelines/

The following illustrates only three forms of academic dishonesty:
1. plagiarism, e.g. the submission of work that is not one's own or for which other credit has been obtained.
2. improper collaboration in group work.
3. copying or using unauthorized aids in tests and examinations.

AUTHENTICITY / PLAGIARISM DETECTION

Some courses may use a web-based service (Turnitin.com) to reveal authenticity and ownership of student submitted work. For courses using such software, students will be expected to submit their work electronically either directly to Turnitin.com or via an online learning platform (e.g. A2L, etc.) using plagiarism detection (a service supported by Turnitin.com) so it can be checked for academic dishonesty.

Students who do not wish their work to be submitted through the plagiarism detection software must inform the Instructor before the assignment is due. No penalty will be assigned to a student who does not submit work to the plagiarism detection software. **All submitted work is subject to normal verification that standards of academic integrity have been upheld** (e.g., on-line search, other software, etc.). For more details about McMaster's use of Turnitin.com please go to www.mcmaster.ca/academicintegrity.

COURSES WITH AN ON-LINE ELEMENT

McMaster is committed to an inclusive and respectful community. These principles and expectations extend to online activities including electronic chat groups, video calls and other learning platforms.

Some courses may use on-line elements (e.g. e-mail, Avenue to Learn (A2L), LearnLink, web pages, capa, Moodle, ThinkingCap, etc.). Students should be aware that, when they access the electronic components of a course using these elements, private information such as first and last names, user names for the McMaster e-mail accounts, and program affiliation may become apparent to all other students in the same course. The available information is dependent on the technology used. Continuation in a course that uses on-line elements will be deemed consent to this disclosure. If you have any questions or concerns about such disclosure, please discuss this with the course instructor.

ONLINE PROCTORING

Some courses may use online proctoring software for tests and exams. This software may require students to turn on their video camera, present identification, monitor and record their computer activities, and/or lock/restrict their browser or other applications/software during tests or exams. This software may be required to be installed before the test/exam begins.

CONDUCT EXPECTATIONS

As a McMaster student, you have the right to experience, and the responsibility to demonstrate, respectful and dignified interactions within all of our living, learning and working communities. These expectations are described in the *Code of Student Rights & Responsibilities* (the "Code"). All students share the responsibility of maintaining a

positive environment for the academic and personal growth of all McMaster community members, **whether in person or online**.

It is essential that students be mindful of their interactions online, as the Code remains in effect in virtual learning environments. The Code applies to any interactions that adversely affect, disrupt, or interfere with reasonable participation in University activities. Student disruptions or behaviours that interfere with university functions on online platforms (e.g. use of Avenue 2 Learn, WebEx or Zoom for delivery), will be taken very seriously and will be investigated. Outcomes may include restriction or removal of the involved students' access to these platforms.

Academic Accommodation of Students with Disabilities

Students with disabilities who require academic accommodation must contact Student Accessibility Services (SAS) at 905-525-9140 ext. 28652 or sas@mcmaster.ca to make arrangements with a Program Coordinator. For further information, consult McMaster University's *Academic Accommodation of Students with Disabilities* policy.

Academic Advising

Academic Advisors are available to assist you with any problems or questions you may have. This includes course selections, changes to your enrolment, McMaster Student Absence Form (MSAF), Religious, Indigenous, or Spiritual Observances (RISO) forms, exams, taking courses at another university (for credit at McMaster), Petitions for Special Consideration, and much more. Below is the contact information for the Office of the Associate Dean (Academic) in the Faculty of Engineering:

JHE-Hatch 301
https://www.eng.mcmaster.ca/programs/academic-advising
(905) 525-9140 ext. 24646

Physical and Mental Health

For a list of McMaster University's resources, please refer to the Student Wellness Centre.

Requests for Relief for Missed Academic Work

In the event of an absence for medical or other reasons, students should review and follow the Academic Regulation in the Undergraduate Calendar "Requests for Relief for Missed Academic Term Work". An abbreviated version is provided below.

The University recognizes that students periodically require relief from academic work due to extenuating circumstances. Students seeking relief for missed academic term work are expected to read the ***McMaster Student Absence Form Policy***. The Policy aims to manage these requests by taking into account the needs and obligations of students, instructors and administrators. It is the prerogative of the instructor of the course to determine the appropriate relief for missed term work in their course. Any concerns regarding the granting of relief should be directed to the Faculty Office.

1. **Relief for missed academic work worth less than 25% of the final grade resulting from medical or personal situations lasting up to three (3) calendar days:**

    - Use the McMaster Student Absence Form (MSAF) on-line self-reporting tool. No further documentation is required.
    - Students may submit requests for relief using the MSAF once per term.

- An automated email will be sent to the course instructor, who will determine the appropriate relief. Students must immediately follow up with their instructors. Failure to do so may negate the opportunity for relief.
- The MSAF cannot be used to meet a religious obligation or to celebrate an important religious holiday.
- The MSAF cannot be used for academic work that has already been completed or attempted.
- An MSAF applies only to work that is due within the period for which the MSAF applies, i.e. the 3-day period that is specified in the MSAF; however, all work due in that period can be covered by one MSAF.
- The MSAF cannot be used to apply for relief for any final examination or its equivalent. See *Petitions for Special Consideration* above.

2. **For medical or personal situations lasting more than three (3) calendar days, and/or for missed academic work worth 25% or more of the final grade, and/or for any request for relief in a term where the MSAF has been used previously in that term:**

    - Students must report to their Faculty Office to discuss their situation and will be required to provide appropriate **supporting documentation**.
    - If warranted, the Faculty Office will approve the absence, and the instructor will determine appropriate relief.

ACADEMIC ACCOMMODATION FOR RELIGIOUS, INDIGENOUS OR SPIRITUAL OBSERVANCES (RISO)

Students requiring academic accommodation based on religious, indigenous or spiritual observances should follow the procedures set out in the RISO policy. Students should submit their request to their Faculty Office ***normally within 10 working days*** of the beginning of term in which they anticipate a need for accommodation or to the Registrar's Office prior to their examinations. Students should also contact their instructors as soon as possible to make alternative arrangements for classes, assignments, and tests.

COPYRIGHT AND RECORDING

Students are advised that lectures, demonstrations, performances, and any other course material provided by an instructor include copyright protected works. The Copyright Act and copyright law protect every original literary, dramatic, musical and artistic work, **including lectures** by University instructors

The recording of lectures, tutorials, or other methods of instruction may occur during a course. Recording may be done by either the instructor for the purpose of authorized distribution, or by a student for the purpose of personal study. Students should be aware that their voice and/or image may be recorded by others during the class. Please speak with the instructor if this is a concern for you.

EXTREME CIRCUMSTANCES

The University reserves the right to change the dates and deadlines for any or all courses in extreme circumstances (e.g., severe weather, labour disruptions, etc.). Changes will be communicated through regular McMaster communication channels, such as McMaster Daily News, A2L and/or McMaster email.