# MECH4890 – Introduction to Nanosatellite Engineering

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| **Course Code:** MECH4890 | **Course Title:** Introduction to Nanosatellite Engineering |
| **Required Course Or Elective Course:** Elective | **Terms Offered (Credits):** Fall (3 credits) |
| **Faculty In Charge:**<br>Prof. Fan SHI | **Pre/Co-Requisites:**<br>[MATH1014 or MATH2011] and<br>[PHYS1111 or PHYS1112] |

**Course Structure:** Seminar (1 .5 hours/week), lab sessions (3 hour/week)

**Textbook/Required Material:** Handouts

**Bulletin Course Description:**

- This course will introduce the fundamental concepts of CubeSat. In this experiential learning course, several labs will be prepared focusing on orbits dynamics and how it affects space segment (spacecraft) operating conditions, inertial measurement system, solar panel and battery sizing. Every student should finish individual lab tasks. We will organize students in groups to work on a final project about the design of CubeSat and its applications.
- The course shall offer students with both hands-on experience software simulation and hardware (electronics) implementation. The topics in this course are introduced with concepts, physics, methods and case studies. After taking this course, we hope students will understand the fundamentals of satellite engineering. This course will train their common sense in technical and managerial aspects of engineering design projects with focus on aerospace applications.

**Course Topics:**

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| Week 1, | Introduction to nanosatellite: specifications and subsystems. |
| Week 2, | Industrial relevance and applications |
| Week 3 - 4, | Inertial measurement unit (IMU): Ardusat Demosat. |
| Week 5, | Orbital mechanics: Keplerian orbits simulation using NASA GMAT (General Mission Analysis Tool) |
| Week 6 – 7, | Orbit environment and CubeSat preliminary design:<br>Solar radiations: thermal, orbit disturbances, and power generation using Princeton Satellite Systems CubeSat Toolbox for MATLAB |
| Week 8 – 10, | Antenna link and apertures |
| Week 11 - 14, | Group lab project on design of CubeSat and its applications |

We will organize a site trip to one satellite manufacturing company in Hong Kong.

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| **Course Objectives:**<br>(correlated program objectives) | 1. To introduce basic and entry-level theory and terminology of spacecraft engineering (especially for Nanosatellite) (e.g. through introduction to IMU, Keplerian orbits, space thermal environment) (P-O3).<br>2. To provide students with hands-on experience of basic design tools currently used in the spacecraft engineering industry (especially for Nanosatellite) (e.g. GMAT, Princeton Satellite System Cubesat Toolbox for MATLAB) (P-O3).<br>3. To provide students with an overview of the social and environmental impacts of the satellites industry (e.g. through introduction to the impact of space debris on the near Earth space environment) (P-O4).<br>4. To provide students opportunities to work on practical design / research projects to build up their confidence in tackling engineering problem in unfamiliar topics (with design of Cubesat project) (PO-1, PO-3, PO-5)<br>5. To demonstrate the relationship between theory and practice through derivation of equations from first principle (with i, Princeton Satellite System Cubesat Toolbox for MATLAB; and ii, preliminary ground station design project). (PO-5) |
| **Course Outcomes:**<br>(correlated course objectives and program outcomes) | A. Students will have some clear understanding and knowledge of the fundamental engineering and mathematical theories underlying spacecraft engineering (especially for nanosatellites) [1, 2] (POC3).<br>B. Be able to use software tools to simulate the operating condition of spacecraft (especially for Nanosatellite); enable students to see the relation between orbits dynamics and the design of both space and ground segments [3] (POC2, POC4, POC6)<br>C. Be able to understand and identify the impacts of the satellites industry [4] (POC9, POC10, POC12).<br>D. Delivery of design / proposal for engineering solutions related to the Nanosatellite topics (with i, Princeton Satellite System CubeSat Toolbox for MATLAB; ii, GMAT for orbit simulation; and iii, integrated knowledge for design of CubeSat) [5] (POC1, POC3, POC4, POC5, POC6, POC8) |
| **Assessment Tools:**<br>(correlated course outcomes) | Lab sessions – 45% [A,B]<br>Group presentation – 20% [A,B,C]<br>Group report – 35% [A,B,C] |

**BEng in Mechanical & Aerospace Engineering (4-year program)**
**Program Objectives:**

P-O1. Be able to communicate and perform as an effective engineering professional in both individual and team-based project environments,

P-O2. Have an international outlook with clear perspectives on the Pearl river Delta and Greater China,

P-O3. Be able to research, design, develop, test, evaluate and implement engineering solutions to problems that are of complexity encountered in professional practice and leadership,

P-O4. Clearly Consider the ethical implications and societal impacts of engineering solutions,

P-O5. Continuously improve through lifelong learning.

**Program Outcomes:**

POC1. ability to identify and formulate problems in multidisciplinary environment with an understanding of engineering issues and constraints;

POC2. ability to design and conduct experiments as well as analyze and interpret data;

POC3. ability to apply knowledge of mathematics, science, and engineering for problem solving in aerospace engineering and related sectors or for further education in a research career;

POC4. ability to develop specification and to design system, component, or process to meet needs;

POC5. ability to understand the design, operation, and maintenance of aircraft components and systems

POC6. ability to use modern engineering tools, techniques, and skills in engineering practice;

POC7. ability to communicate effectively;

POC8. ability to function in multi-disciplinary teams and provide leadership;

POC9. broadly educated with an understanding of the impact of engineering solutions on issues such as economics, business, politics, environment, health and safety, sustainability, and societal context;

POC10. clear understanding of professional and ethical responsibilities;

POC11. recognition of the need for life-long learning and continuing education;

POC12. international outlook with knowledge of contemporary issues.