MANU 265, Machine Dynamics

Syllabus, Term 2, 2020

Course Overview

Dynamics, a fundamental subject core to Mechanical and Manufacturing Engineering, this course will explore how forces act upon rigid bodies and the movements which are generated. Classes will cover the dynamics of systems of particles and then extend to rigid bodies in planar motion. Kinematics of rigid bodies will include relative and absolute motion analyses. Looking at the kinetics of rigid bodies in two dimensions, you will learn how to use Newton's second law equations of motion as well as work-energy and impulse-momentum principals, while gaining a practical understanding of their engineering applications. Advanced topics such as Gyroscopic motion, Kinematic of Gears, Cams and Flywheels, will also be covered. These topics can be categorized into three Modules, as described in the next section. You will master these topics by solving many problems, weekly quizzes, and three exams. There will be weekly tutorials in which you will learn how to use a simple Engineering software to build and analyze some mechanisms.

3 Credit [3-0-1]

Course description for calendar:

Classifications of mechanisms, velocity, acceleration and force analysis, graphical and computer-oriented vector methods, gears, gear trains, cams, and gyroscopic moment.

Instructor: Ahmad Mohammadpanah

Contact: mpanah@mail.ubc.ca

Date/Time

Pre-Requisite: MATH 101, MATH 152, PHYS 158, PHYS 170

Co-Requisite: MATH 255

Required Textbook:

1. Engineering Mechanics: Dynamics, by Meriam, et al.; 9th Edition

2. Kinematics, Dynamics, and Design of Machinery, by Waldron, et al.; 3rd Edition

   Note: A custom version which is a combination of chapters from these two books has been prepared by Wiley Publisher, entitled, "Machine Dynamics, MANU 265".

   https://www.wiley.com/WileyCDA/Section/id-832281.html

   Students can purchase the custom version instead of purchasing both books to save on cost.

Course Format

The course will be delivered through lectures supported by application examples in manufacturing engineering. Weekly tutorials are designed in which students learn how to use a simple Engineering software to build and analyze some mechanisms. There are some lab experiments in which students conduct tests with a simple mechanism and analyze the data.

The course syllabus is divided into three Modules as:

Syllabus

Module 1. Plane Dynamics of Particles

a. Kinematics of Particles

- Rectilinear and Curvilinear Motions
- Cartesian coordinate (x-y)
- Normal and Tangent Coordinate (n-t)

b. Kinetics of Particles

- Newton's second law
- Work and Energy
- Impulse and Momentum

Module 2. Plane Dynamics of Rigid Bodies

a. Kinematics of Rigid Bodies

- Degree of freedom in mechanisms

- Vector method for analysis of velocity and motion of simple mechanisms, such as Crank-shaft, and 4-link Mechanism
- Instantaneous Center of Zero Velocity

b. Kinetics of Rigid Bodies

- Euler's first law

Module 3. Advanced Topics

- Gyroscopic Motion
- Kinematics of Gears Train
  - Simple
  - Parallel
  - Planetary, Epicyclic Systems
- Flywheels
- Cams

Course Objectives

- Describe 2-D motion of rigid bodies, and compute velocities and accelerations of any point on a
- rigid body using vector and graphical methods.
- Compute inertial forces and moments of a rigid body.
- Compute applied forces and moments, to balance inertial forces and moments for a rigid body.
- Compute kinematic and kinetic (motion, force and moment) values for a moving body from Momentum and energy relationships (and vice-versa).
- Analysis of Mechanisms
- Cam and Gear Synthesis, displacement velocity and acceleration diagrams and their applications, gear trains,
- Analyze kinematics of Gears Trains, including – Simple, Parallel, and Planetary (Epicyclic) Systems
- Become familiar with gyroscopic moment and its applications

Learning Outcomes

- Define the terminology associated with rigid body motion analysis of machines
- Determine the kinematic chain and mobility, and perform the kinematic analysis of a given mechanism,
- Formulate inertial and external force balance on a moving mechanism
- Apply the fundamental principles of mathematics and statics to modeling dynamics of machinery,
- Determine displacement, velocity and acceleration of points on a moving mechanism using vector and graphical methods,
- Looking at the kinetics of rigid bodies in two dimensions, learn how to use Newton's second law and Euler's first law equations of motion as well as work-energy and impulse-momentum principals, while gaining a practical understanding of their engineering applications.
- Explain the fundamentals of machine design for desired kinematic or dynamic performance.
- Apply principles of machine dynamics on gear train and cam system design
- Analyze kinematics of Gears Trains, including – Simple, Parallel, and Planetary (Epicyclic) Systems
- Become familiar with gyroscopic moment and its applications
- Examine the professional and ethical consequences of mechanism design choices based on machine dynamic principles, and infer the impact of engineering solutions on human safety
- Communicate effectively in writing regarding principles of the machine dynamics aspects of engineering design.
- Take part effectively in multi-disciplinary teams in the conduct of mechanism design

Evaluation Criteria

- Weekly Quizzes: 10%
- Midterm 1: 10%
- Midterm 2: 10%
- Software Assignments: 10%

- Final Exam: 60%

The assessment strategy for this course is typical of many engineering courses, as we routinely assess students on the basis of their ability to recall and apply relevant facts and theories, to perform calculations correctly and evaluate their responses for plausibility, to demonstrate competence in design methodologies, and to be able to communicate technical information effectively.

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Assignments allow students to practice and apply newly learned techniques. They are frequently calculation-based and thus quite mathematical in nature. The topics in this course build upon each other, and so material presented early in the term is critical to the understanding of material presented later in the term. Giving some weight to weekly or bi-weekly assignments encourages students to practice the material covered in the course consistently throughout the term, which improves the overall outcome for the students. Because the students do have the ability to work with others and seek help during office hours, the emphasis on the assignments will be on achieving the correct solutions for the given problems.

Quizzes (or tests or midterms) during the term give the students an opportunity to demonstrate their knowledge in a controlled testing environment and may include a combination of calculation-based problems and illustration of knowledge of relevant facts. In this particular course, a quiz early in the term will be used to assess the students' understanding of the fundamental theorems and concepts before moving on to more complicated material. The first quiz will also serve to provide early feedback to the students so that they have the ability to correct misconceptions or problems early in the course. The midterm will consist of more complex problems than the quiz as it will be later in the term. The quiz will be marked with an emphasis on correct solutions, while the midterm will have additional emphasis on method and appropriate use of theorems and analysis procedures.

The cumulative final exam allows us the ability to verify that students have mastered a majority of the material covered in the class, again in a controlled environment where it is clear that the work is that of an individual student. Grading of the final exam will be based on both appropriate methods

and correctness of final solution. Some problems on the final exam may serve to assess only one of the stated learning outcomes and others may serve to assess a multiple learning outcomes in combination, thus giving the ability to assess the capacity of the students to solve both simple and complex problems.

Course Schedule *(tentative)*

Date	**Topics**
Week 1	Kinematics of Particles • Rectilinear and Curvilinear Motions • Cartesian coordinate (x-y) • Normal and Tangent Coordinate (n-t)
Week 2	Kinetics of Particles • Newton's second law • Work and Energy
Week 3	• Impulse and Momentum • System of Particles
Week 4	• Solving problems • Midterm 1
Week 5	Kinematics of Rigid Bodies • Degree of freedom in mechanisms
Week 6	• Vector method for analysis of velocity and motion of simple mechanisms, such as Crank-shaft, and 4-link Mechanism
Week 7	• Instantaneous Center of Zero Velocity • Kinetics of Rigid Bodies, Euler's first law
Week 8	• Kinetics of Rigid Bodies continue

	• Lab experiment 1 (slider mechanism)
Week 9	• Solving Practice Problems • Midterm 2
Week 10	• Introduction to Gears and Gear Terminologies,

Week 11	• Kinematics of Gears Train
	  ○ Simple
	  ○ Parallel
	  ○ Planetary, Epicyclic Systems

Week 12	• Gyroscopic moment
Week 13	Cams
Week 14	Solving Practice problems

Academic Integrity

The academic enterprise is founded on honesty, civility, and integrity. As members of this enterprise, all students are expected to know, understand, and follow the codes of conduct regarding academic integrity. At the most basic level, this means submitting only original work done by you and acknowledging all sources of information or ideas and attributing them to others as required. This also means you should not cheat, copy, or mislead others about what is your work. Violations of academic integrity (i.e., misconduct) lead to the breakdown of the academic enterprise, and therefore serious consequences arise and harsh sanctions are imposed. For example, incidences of plagiarism or cheating may result in a mark of zero on the assignment or exam and more serious consequences may apply if the matter is referred to the President's Advisory Committee on Student Discipline. Careful records are kept in order to monitor and prevent recurrences.

A more detailed description of academic integrity, including the University's policies and procedures, may be found in the Academic Calendar at

http://calendar.ubc.ca/vancouver/index.cfm?tree=3,54,111,0.