3B5 Mechanics of Machines [5 Credits]

Lecturer: Associate Professor Ciaran Simms (csimms@tcd.ie)

Level: Junior Sophister

Semester: 1

Prerequisites: 1E7 Mechanics

Module Organisation

The module runs for 12 weeks of the academic year and comprises 3 lectures and 1 tutorial per week (except the study week). Total contact time is 44 hours.

Semester	Start Week	End Week	Lectures per week	Lectures total	Tutorials per week	Tutorials total
1	1	12	3	33	1	11

Module Description

This module addresses the theory and application of fundamental mechanics to machine configurations. This includes engines, whole body human and vehicle motion, linkages and friction devices. Together with the mechanics of solids module, the analysis provides the link between component motion and the resulting internal stresses due to inertia and contact forces. Modelling skills are developed together with the use of vector and matrix algebra in the synthesis of solutions to rigid body problems. The subject also introduces computing as a tool for the solution machine/linkage problems.

This module completes the essential requirements of an Engineer in the machine dynamics area and prepares students for project work focused on machine design and human movement. This subject also provides a good basis for study in multibody dynamics and robotics and biomechanics. It builds on earlier introductory modules in mechanics, mathematics and programming.

Learning Outcomes

On successful completion of this module, students will (be able to):

a) outline a practical methodology in the application of mechanics and vector analysis of real machine configurations and human body motion.
b) apply vector mathematics in mechanics;
c) analyse and redesign common elements in machine design and human motion;
d) apply and develop computer programmes to implement matrix analysis to model the forces generated in linkage systems.

Module Syllabus

- ***Review of Mechanics***
  Fundamentals of rigid body mechanics are reviewed starting with Newton's laws and with a particular emphasis on vector analysis.

- ***Kinematics***
  The theory of kinematics with particular emphasis on relative motion is analysed. The role of matrix and vector algebra is emphasised with attendant computer modelling using a Matlab environment.

- ***Linkages***
  Kinetic analysis is added to the kinematic models and some common four bar linkages are analysed.

- ***Balancing***
  Rotating and reciprocating engine balance is analysed. The utility of vector analysis for automotive engineering is firmly established. Practical balancing solutions are analysed.

- ***Vibration***
  This applies single degree of freedom theory to vibration transmission and isolation problems.

- ***Friction***
  Screw friction and clutch plate friction are analysed with reference to some common designs assuming simple Coulomb friction models.

Laboratory

Identification of the structural properties of a damped vibrating beam under free and forced harmonic oscillation. The objective of this laboratory is to measure natural frequencies of vibration and predict the observed response on the basis of fundamental mechanical models implemented in computer code.

Assignments

Development of computer models of machines and mechanisms using Working Model and Matlab software.

Teaching Strategies

Outline notes are provided in advance. Lectures are used to introduce new concepts and generate discussion and work through examples. Clickers technology is used where appropriate. Significant components of self-directed learning take place through the assignments and laboratory work. Computing implementations using Matlab routines are also incorporated into the lectures.

Tutorials follow a series of question sheets. The solutions for these are available on the web and are released gradually as the module progresses. The tutorials are given to class groupings and are informal.

Assessment Modes

The assessment is by a two-hour written examination held at the end of the academic year and an extended Matlab/Working Model assignment and a vibrating beam laboratory during the year. The written examination carries 70%, the assignments carry 20% and the laboratory accounts for 10% of the module marks.

Recommended Texts

- Kinematics and Dynamics of Machines, CE Wilson and J.P. Sadler (Pearson Prentice Hall)
- Dynamics , JL Meriam (Wiley)