4B17 MULTIBODY DYNAMICS [5 Credits]

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

Level: Senior Sophister

Semester: 1

Prerequisites: 3B5 Mechanics of Machines

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.

<table>
<thead>
<tr>
<th>Start Week</th>
<th>End Week</th>
<th>Lectures per week</th>
<th>Lectures total</th>
<th>Tutorials per week</th>
<th>Tutorials total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>12</td>
<td>3</td>
<td>33</td>
<td>1</td>
<td>11</td>
</tr>
</tbody>
</table>

Module Description
This module on the Dynamics of Multibody systems addresses kinematics and dynamics and is focused on applications in biomechanics. It reviews the fundamental matrix algebra required for kinematics and dynamics analysis and computations, introduces three-dimensional kinematics and dynamics, and covers the theory and procedures for modelling systems of rigid bodies connected by kinematic joints. Applications to human body modeling for gait and impact analysis, vehicle dynamics and robotics are considered.

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

a) Use vector and tensor algebra to describe three dimensional kinematics/dynamics
b) Apply the principles of Newtonian mechanics to the analysis of physical systems in which components can be modelled as essentially rigid
c) Analyze the motion of linked rigid body systems in 3-D including the formulation of constraints due to kinematic joints
d) Model contact interactions between rigid bodies using software such as MADYMO
e) Implement simulation of rigid body systems using the Principle of Virtual Power in computer code such as generalised software (Matlab) and in dedicated software (MADYMO)
f) Apply the above theory and computational methods to the analysis of vehicle systems and human gait and impact analysis and robotics.

Module Content
- Review of notation and matrix algebra
- 3D kinematics
- 3D dynamics
- Principle of Virtual Power
- Computational implementation
- Applications: Vehicle Dynamics, Gait and impact analysis

**Module Notes**
Blackboard

**Teaching Strategies**
This module is taught through a mix of podium lectures and computer-based tutorials and assignments. The students are given full notes for the podium lectures and outline code for the computer-based classes. The goal is to be able to implement analysis of real-world applications where rigid body approximations can give very strong insights into the motion of physical systems, especially during impact. Students also work on an assignment and take a written examination and an introductory computer laboratory. Significant components of self-directed learning take place through the assignments and laboratory work.

**Assessment Modes**
Written Exam (70%), assignment (25%) and computer-based laboratory (5%)

**Recommended Text(s)**

**Laboratory**
Matlab and Madymo impact simulations