Syllabet for
MAE 4730/5730 Intermediate Dynamics

This syllabet is of the style required by ABET (Accreditation Board for Engineering and Technology). All undergraduate engineering courses at Cornell have such a syllabet. It is intended to be the core of a process of continual course improvement.

History of this course, 4730/5730.

For many decades, a course, somewhat like the one described below, was taught as TAM 570. Then, for many years, an overlapping but more applied course, MAE 571, was also taught by Francis Moon. Then, from fall of 2012 to fall 2017, those two courses, and also MASE 4770 (Vibrations) were merged in to a single course. In Spring 2018, it was decided to revert to, more-or-less, a combination of the former TAM 570 and former MAE 571. This involves removing vibrations, at least as a central topic, from the course, and teaching it, as used to be done before 2012, as a separate vibrations course. This allows, however, the return of 3D dynamics as a central topic, one that would otherwise get missed by many students.

Course catalogue description

> **MAE 4730/5730 - Intermediate Dynamics**
> Fall. 3 credits. Staff.
>
> The course emphasizes the classical dynamics of single= and multi-degree-of-freedom systems made up of particles and rigid-objects in 2 and 3 spatial dimensions. Three approaches are used: the Newton-Euler and Lagrangian approach, both using minimal coordinates; and also a 'maximal coordinate' approach using differential algebraic equations (DAEs). The course emphasizes finding equations of motion, solving them analytically (if possible) and numerically; and graphical presentation of solutions, including animations.
> **Prerequisites:** Math 2930 & 2940, and MAE 3260 or equivalents, or permission of the instructor.

Textbooks and/or other required material

This course could use, for example, *Principles of Dynamics* by Donald T. Greenwood, or *Dynamics of Particles and Rigid Bodies: A Systematic Approach* by Anil Rao, or equivalents.

4730 vs 5730

The lectures and readings will be the same. Students enrolled in 5730 will have some more advanced homeworks and projects and will be graded somewhat more strictly.

Course learning outcomes

On completion of this course:

1. Given a description in sketches and/or simple words, for a variety of dynamical mechanical systems consisting of particles and rigid objects interacting with various standard connections (e.g., strings, springs, hinges, rolling, surface sliding) and forces (e.g., gravity, friction, fluid drag), the student should be able to find the governing differential equations, solve the simple cases by hand, solve the more complex cases with numerical integration (MATLAB), graphically represent the results, including animations, and check the reasonableness of the results using extreme cases and conservations laws (momentum, angular momentum and energy) (MAE/ABET outcomes a, e, k).
2. A student will be proficient at writing Lagrange equations for simple conservative systems (MAE/ABET outcomes a, e).
3. A student will be able to formulate, setup, numerically solve, and interpret the equations and solutions of a 3D rigid object rotating in space (MAE/ABET outcomes a, e).

Topics covered

1. Newton-Euler equations, constraint kinematics (hinges, rolling, sliding, skate) and constraint forces.
2. Introduction to 2D multi-object systems.
3. Lagrange equations (but not their derivation).
4. Assembly of differential algebraic equations of motion
5. Conservation laws.
6. Numerical solution of ODEs in MATLAB. Simple animations in MATLAB.
7. Stability of equilibrium and steady-state solutions
8. Angular momentum, and its rate of change, for 3D systems

Class schedule: Two 75 minute lectures, or 3 50 minute lectures, per week.

Contribution of course to meeting MAE/ABET curriculum requirements

This course partially fulfills the requirement to complete three upper level MAE courses as a Major Approved Elective or it can be used to fulfill the Technical Elective requirement.

Relationship to ABET outcomes: This course meets ABET outcomes a, e and k.

Outcome Assessment

A review of prelims and the final exam will determine whether students mastered the subject. In addition, a questionnaire will be used to assess student views as to what learning mechanisms were most useful and on student perception of the educational impact of the course.

Person(s) who prepared this description and date of preparation

Andy Ruina: 4/6/2012, 4/26/2012, 3/20/2015, 5/29/2018, 7/25/2018
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