Assignments for MEEG 4003 Intermediate Dynamics

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Text: *Engineering Mechanics: Dynamics*, (or *Engineering Mechanics: Statics and Dynamics*), 1991 Jong and Rogers, Oxford University Press

Objectives: This course is aimed at developing in students the concepts and skills related to the analysis and prediction of conditions of bodies in central-force motion, use of rotating reference frames, and rigid bodies under the action of unbalanced force systems in 3 dimensions. Problems related to motion of a gyroscope are the required additional work for graduate students.

Content:

Each student is advised to do all *Developmental Exercises* interspersed in the sections assigned.

A. Review of Central-force Motion and Plane Kinematics

1. **Review of Central-Force Motion**
   Gravitational force ♦ Motion under a central force ♦ Governing differential equations ♦ Trajectories of spacecraft ♦ Kepler's laws of planetary motion
   Sections: 12.8-12
   Problems: 12.70, 78, 80
2. **Review of Use of Nonrotating Reference Frames**
   Types of plane motion of a rigid body ♦ Translation ♦ Rotation ♦ Linear and angular motions ♦ General plane motion: Chasles' theorem ♦ Velocities in relative motion ♦ Velocity center ♦ Accelerations in relative motion ♦ Acceleration center ♦ Parametric method
   Sections: 15.1-10
   Problems: 15.15, 25, 29, 33, 35, 36, 47, 50, 57, 70, 79, 84, 96, 98, 107
3. **Use of Rotating Reference Frames**
   Time derivatives of rotating unit vectors ♦ Time derivatives of a vector in two reference frames ♦ Velocities in different reference frames ♦ Accelerations in different reference frames ♦ Interpretations for Coriolis acceleration
   Sections: 15.11-16
   Problems: 15.109, 113, 114, 116, 117, 118, 119, 120, 131

B. Motion of Rigid Bodies in Three Dimensions

1. **Kinematics of Rigid Bodies in Space**
   Time derivatives of a vector in two reference frames ♦ Velocities in different reference frames ♦ Addition theorem for angular velocities ♦ Accelerations in different reference frames ♦ Addition theorem for angular accelerations
   Sections: 19.1-3
   Problems: 19.2, 4, 5, 6, 9, 10, 11, 12, 13, 15
2. **Moments and Products of Inertia of a Mass in Space**
   Moments and products of inertia of a mass ♦ Rotation of axes: principal axes of inertia ♦ Determination of eigenvalues and eigenvectors of inertia matrices
   Sections: 19.4-5
   Problems: 19.21, 24, 28, 29, 31, 35, 37
3. **Kinetics of Rigid Bodies in Space**
   Momentum of a rigid body in space ♦ Kinetic energy of a rigid body in space ♦ Equations of motion for a rigid body ♦ Translational motion ♦ Euler's equation of motion for a rigid body about its mass center G ♦ Euler's equation of motion for a rigid body about a fixed point O ♦ Euler's equations of motion for $\boldsymbol{\Omega} \neq \boldsymbol{\omega}$ ♦ Motion of a gyroscope: precession, nutation, and spin ♦ Forced steady precession ♦ Torque-free steady precession ♦ Space cone ♦ Body cone
   Sections: 19.6-10
   Problems: 19.41, 43, 44, 48, 49, 51, 54, 55, 57, 60, 64, 65