Department of Mechanical Engineering

ME452– Dynamics of Space Flight

Elective

Catalog Description: **ME 452 (3-0-3)**

An introduction to the mechanics of space flight. After a brief introduction to the physics of the solar system, the dynamics of space flight are developed from the Newtonian viewpoint. Covers the performance and propulsion methods of rocketry.

Prerequisites: Mech 236 – Dynamics
Math 222 – Differential Equations

Textbook(s) Materials Required:

H. D. Curtis, Orbital Mechanics for Engineering Students, Elsevier, 2005

Reference(s) (Not Required):

Power-point lecture and other notes e-mailed to students

Course Supervisor: Dr. A. Rosato

Pre-requisite by Topic

1. Calculus
2. Ordinary differential equations
3. Dynamics

Course Objectives[1]:

1. To develop the student's understanding of equations for central force motion (A, B, C)
2. To develop the student's understanding Kepler's Laws and the connection to Newtonian mechanics (A, B, C)
3. To develop student's skills in analyzing circular, elliptic, parabolic and hyperbolic trajectories (A, B, C)
4. To provide the student with an understanding of the two-body problem and the restricted three-body problem (A, B, C, D, E)
5. To provide the student with the ability to analyze an orbit in three dimensions using orbital elements (A,B,C,D,E)
6. To provide the student the ability to carry out a preliminary orbit determination (A, B, C, D)

Topics[2]:

1. Review of dynamics (i.e. linear and angular momentum and kinematics of a point mass (3 hrs)
2. Motion equations in an inertial frame, two-body problem (3 hrs)
3. Orbit equations derivation (3 hrs)
4. Circular, parabolic, elliptic and hyperbolic orbits (6 hrs)
5. Perifocal frame and restricted 3-body problem (3 hrs)
6. Orbital position as a function of time (4.5 hrs)
7. State vector and geocentric frame – orbital elements (4.5 hrs)
8. Transformation from geocentric equatorial to perifocal frame (3 hrs)
9. Gibbs' method, Lambert's problem (6 hrs)

Evaluation Method:

1. In-class Exams

2. Participation in class/Homework
3. Final Exam

Schedule: Lecture Recitation: 3 hours, per week
Professional Component: Engineering Science
Program Objectives Addressed: A, B, C, D, E
Course Outcomes[3]:

Objective 1
1.1 Students will review the dynamics of point masses. (1,2,3) (a,e,i,k)
1.2 Students will revisit Newton's Laws (linear and angular momentum). (1,2,3) (a,e,i,k)
1.3 Students will demonstrate an understanding of the time derivative of a moving vector and motion relative to moving reference frame. (1,2,3) (a,c,e,m,k)
1.4 Students will apply relative motion concepts to an Earth inertial system (1,2,3) (a,e,k)

Objective 2
2.1 Students will demonstrate an understanding of equations for the two body problem. (1,2,3) (a,e,m,k)
2.2 Students will learn the derivation of the relative motion equation. (1,2,3) (a,e,m,k)
2.3 Students will demonstrate an understanding of the orbit equation as Kepler's first law. (1,2,3) (a,e,m,k)
2.4 Students will demonstrate an understanding of Kepler's second law. (1,2,3) (a,e,k)
2.5 Students will demonstrate an understanding of the derivation of the basic orbit equation and its relationship to the conic sections. (1,2,3) (a,e,m,k)
2.6 Students will demonstrate an understanding of circular, elliptic, parabolic and hyperbolic orbits. (1,2,3) (a,e,k)

Objective 3
3.1 Students will demonstrate an understanding of the orbital position as a function of time (a,e,m,k) (1,2,3)
3.2 Students will learn to solve for the orbital position for various trajectories. (a,e,k) (1,2,3)

Objective 4
4.1 Students will demonstrate an understanding of the celestial sphere. (1,2,3) (a,e,k)
4.2 Students will demonstrate an understanding of the inertial geocentric equatorial reference frame. (1,2,3) (a,e,k)
4.3 Students will demonstrate an understanding of the state vector that defines the orbital characteristics. (1,2,3) (a,e,k)
4.4 Students will demonstrate an understanding of the transformation of the state vector to the six classical orbital elements. (1,2,3) (a,e,m,k)

Objective 5
5.4 Students will demonstrate an understanding of how to determine the satellite orbit through observations made from the earth. (1,2,3) (a,e,k)
5.5 Students will demonstrate an understanding of the orbit determination from three position vectors. (i.e., Gibbs' problem) (1,2,3) (a,e,k)
5.6 Students will demonstrate an understanding of finding the orbit from two position vectors and the time interval between them. (i.e., Lambert's problem) (1,2,3) (a,e,m,k)

Prepared by: A. Rosato **Date: November 14, 2006**

[1] Capital Letters in parenthesis refer to the Program Objectives of the Mechanical Engineering
Department. Listed in Sec 2 d Tables B-2-9, B-2-12. Table B-2-8 links Program Objectives with the ABET a-k Criterion

[2] Topi**c** numbers in parenthesis refer to lecture hours. (three hours is equivalent to 1 week)

[3] Outcome numbers in parenthesis refer to evaluation methods used to assess the student performance. Lower case letters in parenthesis refer to ABET a-k outcomes.