INSTITUTEOFAERONAUTICALENGINEERING
(Autonomous)
Dundigal, Hyderabad-500043

AERONAUTICAL ENGINEERING

TUTORIAL QUESTION BANK

Course Title	**SPACE MECHANICS**				
Course Code	AAE016				
Programme	B.Tech				
Semester	VII	AE			
Course Type	Core				
Regulation	IARE - R16				
Course Structure	**Theory**			**Practical**	
	Lectures	**Tutorials**	**Credits**	**Laboratory**	**Credits**
	3	1	4	-	-
Chief Coordinator	Dr. P.K. Mohanta				
Course Faculty	Dr. P K Mohanta, Associate Professor Mr. Kasturi Rangan, Assistant Professor				

COURSE OBJECTIVES:

The course should enable the students to:	
I	Impart the knowledge in two-body, restricted three-body and n-body problem, Hamiltonian dynamics, canonical transformations, Poincare surface sections.
II	Analyze the basic Newtonian dynamics and spacecraft altitude dynamics
III	Provide necessary knowledge to study the satellite and interplanetary trajectories and formal approaches for handling coordinate transformations
IV	Solve the orbital problem related to Earth satellite orbits using Hamilton's and generate interplanetary orbits in the frame work of restricted three-body problem.

COURSE OUTCOMES (COs):

CO 1	Understand and develop basic concepts in Space Mechanics
CO 2	Obtain a clear understanding of the Two Body Problem.
CO 3	Develop a clear understanding of the perturbed satellite orbit, and its various implications.
CO 4	Develop a Complete understanding of the Ballistic Missile Trajectories
CO 5	Understand the various aspects of low-Thrust trajectories

COURSE LEARNING OUTCOMES (CLOs):

AAE016.01	Describe the solar system, reference frames, and coordinate systems.
AAE016.02	Explain the celestial sphere, the ecliptic, a motion of vernal equinox, sidereal time, solar time, standard time, and the Earth's atmosphere
AAE016.03	Define and describe the many body problem, and the Lagrange-Jacobi identity
AAE016.04	Recognize and describe the circular restricted three body problem, liberation points, and relative motion in the N-body problem.
AAE016.05	Derive and describe the Equations of motion. Specifically, the general characteristics of motion for different orbits. Understand the relations between position and time for different orbits.
AAE016.06	Define and describe the expansions in elliptic motion, and orbital elements.
AAE016.07	Explain the relation between orbital elements and position and velocity. Launch vehicle ascent trajectories, general aspects of satellite injection.
AAE016.08	Launch vehicle ascent trajectories, general aspects of satellite injection.
AAE016.09	Discuss the dependence of orbital parameters on in-plane injection parameters.
AAE016.10	Launch vehicle performances, and orbit deviations due to injection errors
AAE016.11	Explain special and general perturbations, such as the Cowell's method, & Encke's method.
AAE016.12	Understand the method of variations of orbital elements, and the general perturbations approach
AAE016.13	Define the two-dimensional interplanetary trajectories, fast interplanetary trajectories.
AAE016.14	Understand 3D interplanetary trajectories.
AAE016.15	Discuss about the launch of interplanetary spacecraft, and understand the trajectory of the target planet.
AAE016.16	Define and understand the boost phase, the ballistic phase, trajectory geometry and optimal flights.
AAE016.17	Define the time of flight and the re-entry phase.
AAE016.18	Define the position of the impact point and the influence coefficients.

AAE016.19	Understand the equations of motion.
AAE016.20	Understand the constant radial thrust acceleration, constant tangential thrust (Characteristics of the motion), Linearization of the equations of motion, and Performance analysis.

TUTORIAL QUESTION BANK

UNIT –I				
INTRODUCTION TO SPACE MECHANICS				
Part - A(Short Answer Questions)				
S.NO	**QUESTIONS**	**Blooms Taxonomy Level**	**Course Outcomes**	**CLOs**
1.	What are the constituents of solar system?	Understand	CO 1	AAE016.01
2.	Classify the meteors in its size. Explain each one.	Remember	CO 1	AAE016.01
3.	What is comet?	Understand	CO 1	AAE016.01
4.	Define the celestial sphere	Remember	CO 1	AAE016.01
5.	Define the ecliptic of the sun.	Remember	CO 1	AAE016.01
6.	What is local time	Understand	CO 1	AAE016.01
7.	Describe the vernal equinox	Remember	CO 1	AAE016.01
8.	Describe a geocentric reference frame	Remember	CO 1	AAE016.01
9.	Describe a heliocentric reference frame	Remember	CO 1	AAE016.02
10.	Define the sidereal time	Understand	CO 1	AAE016.02
11.	Define the solar time	Remember	CO 1	AAE016.02
12.	Define the mean solar time	Remember	CO 1	AAE016.03
13.	Define the Ephemeris time and atomic time	Understand	CO 1	AAE016.03
14.	Define the Julian Date	Remember	CO 1	AAE016.03
15.	What are Kepler's first law of planetary motion?	Remember	CO 1	AAE016.04
16.	What are Kepler's second law of planetary motion?	Understand	CO 1	AAE016.03
17.	What are Kepler's third law of planetary motion?	Understand	CO 1	AAE016.04
18.	What is Bode's law?	Understand	CO 1	AAE016.04
19.	What is Astronomical Unit?	Understand	CO 1	AAE016.04
20.	What do you understand by natural satellite?	Remember	CO 1	AAE016.04
Part - B (Long Answer Questions)				
1	Write short note about International Standard atmosphere.	Remember	CO 1	AAE016.01

2	What is lapse rate, explain its significance.	Understand	CO 1	AAE016.01
3	Write short notes on Newton's Law of Universal Gravitation with suitable diagram.	Remember	CO 1	AAE016.02
4	Describe in detail about the Euler Equations of Motion.	Understand	CO 1	AAE016.01
5	What do you understand by N-body problem? Explain with suitable diagram and equation.	Understand	CO 1	AAE016.01
6	Define and explain how the Potential Energy per unit mass U, is used in Space mechanics theory.	Understand	CO 1	AAE016.01
7	What do you mean by orbital parameters? Explain with suitable diagram.	Understand	CO 1	AAE016.02
8	What do you mean by general and restricted Two-Body Problem? Explain with suitable diagram.	Understand	CO 1	AAE016.02
9	Explain the difference between major and minor planets.	Understand	CO 1	AAE016.02
10	Write the equation for the conservation of mass, and briefly describe.	Understand	CO 1	AAE016.02
11	Classify the planetary positions in solar system.	Remember	CO 1	AAE016.03
12	Write the conservation of angular momentum equation.	Remember	CO 1	AAE016.04
13	Write short notes on Lagrangian points with suitable diagram.	Understand	CO 1	AAE016.04
14	Why international date line is not passing through the land. Explain its significance.	Understand	CO 1	AAE016.04
15	Distinguish the different between stars and planets.	Remember	CO 1	AAE016.04
16	What are the causes of seasonal change, describe with suitable diagram.	Remember	CO 1	AAE016.04
17	Describe all the different reference frames. Discuss the relative orientation of the various reference frames.	Understand	CO 1	AAE016.03
18	Write and briefly describe the equation for apparent moments	Understand	CO 1	AAE016.03
19	Write the detail requirements of necessity for International Standard Atmosphere.	Remember	CO 1	AAE016.03
20	Write short notes on standard time zones of the world, and its significance.	Understand	CO 1	AAE016.03
Part - C (Analytical Questions)				
1	The period of revolution of a satellite is 106 min. Find the apogee altitude if the perigee altitude is 200 km. ($\mu = 3.986 \times 10^5$ km^3/s ^{2})	Understand	CO 1	AAE016.01
2	Find the period of revolution of a satellite if the perigee and apogee altitudes are 250 and 300 km, respectively.	Understand	CO 1	AAE016.01
3	In Rotation, derive the equation for rotation,	Remember	CO 1	AAE016.01

4	Derive all the newton's laws where it was modified to include the non-inertial frames	Understand	CO 1	AAE016.04
5	Write and derive the terms for dragging, centripetal acceleration, and relative acceleration.	Remember	CO 1	AAE016.04
6	What do you mean by parking space, explain with suitable diagram the Lagrangian points.	Understand	CO 1	AAE016.04
7	Derive the equation for rotational motion	Understand	CO 1	AAE016.04
8	Derive the equations for 3-body restricted systems.	Remember	CO 1	AAE016.04
9	Explain details on Bode's law of solar syatems.	Understand	CO 1	AAE016.01
10	Derive the Lagrange-Jacobi identity, and derive its various aspects in Space mechanics.	Understand	CO 1	AAE016.01
UNIT -II				
THE TWO BODY PROBLEM				
Part – A (Short Answer Questions)				
1	What is Newton's Law of motion.	Remember	CO 2	AAE016.05
2	What is Kepler's 1st law of planetary motion, explain with diagram.	Remember	CO 2	AAE016.05
3	What is orbit?	Remember	CO 2	AAE016.06
4	What do you understand by ground trace.	Understand	CO 2	AAE016.06
5	Define orbital elements	Understand	CO 2	AAE016.05
6	What do you understand by gravity turn.	Remember	CO 2	AAE016.05
7	What is Kepler's 2st law of planetary motion, explain with diagram..	Understand	CO 2	AAE016.05
8	Define the in plane orbital parameters.	Understand	CO 2	AAE016.05
9	What do you understand by launch vehicle ascent trajectories	Understand	CO 2	AAE016.06
10	Define a geosynchronous satellite.	Remember	CO 2	AAE016.06
11	What do you mean by retrograde orbit.	Understand	CO 2	AAE016.05
12	Define a polar orbit	Remember	CO 2	AAE016.06
13	What is transfer orbit?	Understand	CO 2	AAE016.06
14	Define uniform circular motion.	Remember	CO 2	AAE016.06
15	What do you mean by Kepler's third law of planetary motion.	Understand	CO 2	AAE016.06
16	Define the periapsis and apoapsis	Understand	CO 2	AAE016.06
17	What is orbital angle, depict by a neat diagram.	Remember	CO 2	AAE016.06
18	Define the flight path angle	Remember	CO 2	AAE016.06
19	Define the ascending and descending nodes.	Understand	CO 2	AAE016.06
20	Define the latitude and longitude.	Remember	CO 2	AAE016.06
Part - B (Long Answer Questions)				

1	What is the relationship between geodetic latitude and geocentric latitude?	Understand	CO 2	AAE016.05
2	What is the equation for the declination in an orbit?	Understand	CO 2	AAE016.05
3	Define the equation for the relative orbit and provide the equation used for the orbit.	Understand	CO 2	AAE016.05
4	Define the orbital speed and provide its equation.	Remember	CO 2	AAE016.06
5	Explain the orbital parameter. Draw the neat sketch to describe.	Understand	CO 2	AAE016.06
6	What are the injection error, and its impact on orbit?	Understand	CO 2	AAE016.06
7	Describe the initial pitch-over angle and provide an equation for the same.	Understand	CO 2	AAE016.05
8	Discuss why multi-stage launch vehicle are employed?	Remember	CO 2	AAE016.06
9	Explain why the satellites are launched east-ward direction.	Understand	CO 2	AAE016.06
10	Discuss what is global optimization, in the context of space flight mechanics.	Understand	CO 2	AAE016.06
11	Discuss the various propulsion methods present in the vehicle models.	Remember	CO 2	AAE016.06
12	What is an n-body problem? What are the limitations in n-body problem?	Understand	CO 2	AAE016.06
13	Discuss the take-off mass, dry mass, and payload mass.	Understand	CO 2	AAE016.06
14	Define the energy of an orbit; specifically the kinetic and potential energy.	Remember	CO 2	AAE016.05
15	Show that P= $\frac{2\pi}{\sqrt{\mu}} a^{\frac{3}{2}}$	Remember	CO 2	AAE016.05
16	Discuss why it is important to reduce the two body problem to a one-body problem.	Understand	CO 2	AAE016.05
17	Show that for satellite a) $rp = a(1-e)$ b) $ra = a(1+e)$	Understand	CO 2	AAE016.06
18	Draw the different points of liberation.	Remember	CO 2	AAE016.06
19	Define the type of orbits and their characteristics.	Remember	CO 2	AAE016.05
20	What is conic section, draw the neat diagram to depict their chacteristics.	Understand	CO 2	AAE016.06
Part - C (Analytical Questions)				
1	Draw a diagram for the satellites and the escape and capture of comets and meteorites.	Understand	CO 2	AAE016.05
2	Describe the various two-body orbits such as	Understand	CO 2	AAE016.05

	circle, ellipse, parabola, and hyperbola.			
3	Discuss and derive the equation for the non-rotating reference frame for the earth.	Understand	CO 2	AAE016.06
4	Derive and present the equation for the gravitational attraction. In addition, present the equation for the acceleration due to gravity.	Understand	CO 2	AAE016.06
5	The period of revolution of a satellite is 106 min. Find the apogee and perigee velocity if the perigee altitude is 250 km. Assume GM = 3.986 $\times 10^5$ km^3/s^2.	Understand	CO 2	AAE016.06
6	Find the period of revolution of a satellite if the perigee and apogee altitudes are 250 and 300 km, respectively. Find apogee and perigee velocity. Assume R_e= 6378.137 Km.	Understand	CO 2	AAE016.06
7	Derive the equations of motion for a particle in an inverse-square law field.	Understand	CO 2	AAE016.06
8	Define and calculate the equatorial orbits calculated with an inverse square law model.	Understand	CO 2	AAE016.06
9	Derive the equation for the total energy in a point mass gravitational field.	Understand	CO 2	AAE016.06
10	Discuss the interchange between the potential and kinetic energies in a conservative system.	Remember	CO 2	AAE016.06
UNIT –III				
PERTURBED SATELLITE ORBIT				
Part – A (Short Answer Questions)				
1	Why it is difficult to keep the satellite at low earth orbit?	Remember	CO 3	AAE016.07
2	What are the causes of perturbation of low earth orbit?	Understand	CO 3	AAE016.07
3	Why it's better to design a circular orbit at low earth altitudes than an Ellipse?	Remember	CO 3	AAE016.08
4	Explain the advantages of design in high altitude earth orbits.	Understand	CO 3	AAE016.08
5	Define the synchronous orbit.	Remember	CO 3	AAE016.07
6	Draw and explain a trajectory for sending a satellite to high altitude earth orbit.	Understand	CO 3	AAE016.07
7	Define Hohmann transfer method with suitable illustration.	Remember	CO 3	AAE016.08
8	What do mean by coplanar transfer?	Remember	CO 3	AAE016.07
9	Explain the technique of out of plane transfer.	Remember	CO 3	AAE016.07
10	What are the mathematical relation of position r_a and r_p in terms of semi major axis and eccentricity.	Understand	CO 3	AAE016.08
11	What do you mean by orbit perturbation?	Understand	CO 3	AAE016.08
12	What are the causes of perturbation of satellite orbit?	Understand	CO 3	AAE016.08
13	Write the earth gravitational effect on perturbation	Understand	CO 3	AAE016.08

	of satellite.			
14	Explain about celestial influence like lunisolar effect on orbit perturbation	Remember	CO 3	AAE016.07
15	How the solar radiation pressure effect on perturbation of satellite orbit?	Understand	CO 3	AAE016.07
16	Discuss the effect of atmospheric drag on satellite path displacement.	Understand	CO 3	AAE016.07
17	Write the tidal friction effects on satellite path perturbation.	Remember	CO 3	AAE016.07
18	Explain the mutual gravitation disturb the path and cause change of the orbit.	Remember	CO 3	AAE016.08
19	What is J_2 and how it effects to satellite motion?	Remember	CO 3	AAE016.08
20	What is J_3 effect on satellite orbit.	Understand	CO 3	AAE016.08
Part – B (Long Answer Questions)				
1	What is a low altitude Earth orbit? What are the significances of designing Low altitude Earth Orbit?	Understand	CO 3	AAE016.08
2	Explain about direct ascent and method of putting satellite at low earth orbit with suitable diagram.	Understand	CO 3	AAE016.08
3	Describe the problem associated with low earth orbit design and cause of perturbation.	Remember	CO 3	AAE016.08
4	Calculate the design methodology fixation of perigee and apogee distance in low earth orbit and explain.	Remember	CO 3	AAE016.08
5	What is high altitude Earth orbit? Describe the uses of high altitude earth orbit. Explain the types of orbit possible at high altitude.	Understand	CO 3	AAE016.08
6	What is a synchronous orbit? Write the characteristics of geostationary orbit. What are the methods of sending satellite to synchronous orbit?	Understand	CO 3	AAE016.08
7	What are the cause of in plane disturbances and method of correction of the trajectory?	Remember	CO 3	AAE016.07
8	Explain about the Hohmann transfer method and explain it with suitable diagram.	Understand	CO 3	AAE016.08
9	Explain the methodology used on satellite transfer. Discuss the difference between in plane and out of plane transfer.	Remember	CO 3	AAE016.08
10	What are the orbital parameters required to design an orbit? What are the limitations on design?	Understand	CO 3	AAE016.08
11	Discuss briefly the various cause of satellite perturbation.	Understand	CO 3	AAE016.07
12	Signify the cause of perturbation by the earth oblateness.	Understand	CO 3	AAE016.08
13	Justify the effect of J_2 on stability of satellite orbit.	Remember	CO 3	AAE016.07
14	Explain the effect of critical inclination and the earth triaxiality on satellite motion.	Remember	CO 3	AAE016.08
15	What do you mean by J_3. Explain about the frozen orbit.	Understand	CO 3	AAE016.08
16	What is east-west station keeping and why it is essential?	Understand	CO 3	AAE016.08

17	What do you mean by critical inclination? Explain its impact on satellite motion.	Understand	CO 3	AAE016.08
18	What is a sun-synchronous orbit? Explain with diagram.	Remember	CO 3	AAE016.08
19	What is a frozen orbit? Explain about J3 effect.	Understand	CO 3	AAE016.08
20	What is Tsiolkovsky rocket equation.	Remember	CO 3	AAE016.08
	Part - C (Analytical Questions)			
1	Write notes on Cowell's Method of perturbation.	Understand	CO 3	AAE016.08
2	Write notes on Encke's Method of perturbation.	Understand	CO 3	AAE016.07
3	Write details on Hohmann transfer with suitable diagram.	Remember	CO 3	AAE016.08
4	What are the perturbing factors are considered during three dimensional interplanetary trajectories.	Understand	CO 3	AAE016.08
5	What is the significance of launch window for launch of interplanetary trajectory?	Remember	CO 3	AAE016.08
6	For ISS what are the dominating perturbing forces?	Understand	CO 3	AAE016.08
7	Write the sequence of launch vehicle ascent trajectories.	Remember	CO 3	AAE016.07
8	Write the perturbing factors of on various satellite orbit.	Understand	CO 3	AAE016.08
9	What are the satellite injection errors are anticipated?	Remember	CO 3	AAE016.08
10	What are the parameters considered for the performance of launch vehicle.	Understand	CO 3	AAE016.08
	UNIT -IV			
	BALLISTIC MISSILE TRAJECTORIES			
	Part – A (Short Answer Questions)			
1	Write about ballistic missile problems.	Remember	CO 4	AAE016.09
2	Write down the geometry of the trajectory of a ballistic missile.	Remember	CO 4	AAE016.09
3	Write the flight path angle equation.	Understand	CO 4	AAE016.09
4	Define maximum range trajectory.	Understand	CO 4	AAE016.09
5	Define time of free flight.	Remember	CO 4	AAE016.09
6	Write about the errors occurring on range.	Understand	CO 4	AAE016.09
7	Define burnout point.	Understand	CO 4	AAE016.09
8	Write short notes about zenith.	Remember	CO 4	AAE016.09
9	Define burn out flight path angle	Remember	CO 4	AAE016.09
10	Explain down range errors.	Understand	CO 4	AAE016.10
11	Describe the general ballistic problem.	Remember	CO 4	AAE016.11
12	Explain geometry of the trajectory of a ballistic missile.	Understand	CO 4	AAE016.10
13	Describe the maximum range trajectory.	Remember	CO 4	AAE016.10

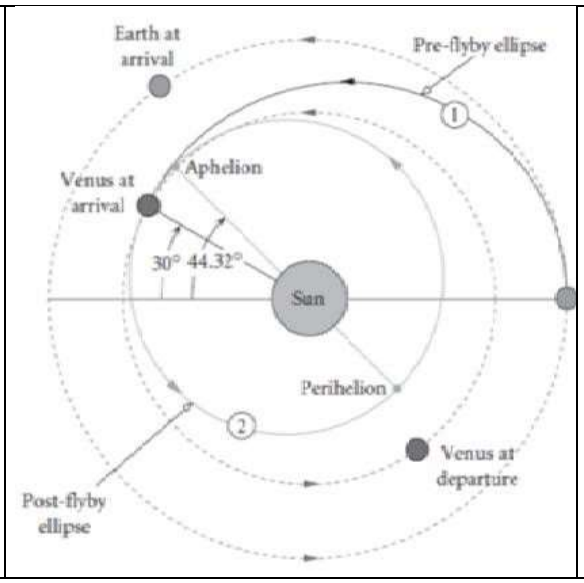
14	Explain in detail about the launching errors.	Remember	CO 4	AAE016.10
15	Describe about the cross range error	Remember	CO 4	AAE016.10
16	Explain the various down range errors.	Understand	CO 4	AAE016.10
17	Explain errors in burn out in flight path angle.	Remember	CO 4	AAE016.10
18	Describe the movement of the target due to the earth rotation.	Remember	CO 4	AAE016.10
19	Describe in detail about the time of free flight.	Understand	CO 4	AAE016.10
20	Explain the effect of lateral displacement.	Remember	CO 4	AAE016.10
	Part – B (Long Answer Questions)			
1	Define the general problems of ballistic missile. Illustrating trajectory of a ballistic missile, mark the flight path and explain.	Understand	CO 4	AAE016.10
2	Derive the free flight range equation.	Understand	CO 4	AAE016.10
3	Determine the flight path angle equation.	Remember	CO 4	AAE016.09
4	Find out the maximum and minimum range of trajectory for ballistic missile.	Understand	CO 4	AAE016.10
5	Define the term "time of free flight", what are the parameters to be considered and during free flight conditions?	Understand	CO 4	AAE016.09
6	"A ballistic missile was observed to have a burnout speed and altitude" for free flight range. Justify it.	Remember	CO 4	AAE016.09
7	Determine the time duration of free flight for a ballistic missile.	Understand	CO 4	AAE016.11
8	What do you mean by launching error? Determine the lateral displacement effect on burnout point.	Understand	CO 4	AAE016.09
9	What is a cross range error? Explain about it.	Understand	CO 4	AAE016.09
10	With suitable diagram explain about the effect of down-range displacement of the burnout point.	Understand	CO 4	AAE016.10
11	Calculate the errors in burnout flight path angle $\emptyset_{bo}$	Understand	CO 4	AAE016.10
12	Determine the down range errors caused by incorrect burnout height.	Understand	CO 4	AAE016.10
13	What are the effects on ballistic trajectory due to the earth rotation?	Understand	CO 4	AAE016.09
14	How it can be compensated for initial velocity of the missile due to the earth rotation?	Remember	CO 4	AAE016.09
15	Determine the compensation through movement of the target due to the earth rotation.	Understand	CO 4	AAE016.10
16	What values of $\emptyset$ may be used in $\sin\frac{\psi}{2} = \frac{Q_{bo}}{2-Q_{bo}}$? Why?	Understand	CO 4	AAE016.10
17	What are the various phases of ballistic missile? Draw and explain each.	Understand	CO 4	AAE016.10
18	Describe in details about the influence coefficients on ballistic missile.	Remember	CO 4	AAE016.09
19	Write a brief description on the general ballistic missile problem.	Understand	CO 4	AAE016.10

20	Write the various phases of Geometry of the Trajectory of a ballistic missile with suitable diagram.	Understand	CO 4	AAE016.10
Part - C (Analytical Questions)				
1	The following measurements were obtained during the testing of an ICBM: v_{bo} = .926DU/TU, r_{bo} = 1.05DU $\emptyset_{bo}$ = 10°, R_p= 60$n.\ mi$ R_{re}=300n.mi What is R_t =?	Understand	CO 4	AAE016.09
2	A ballistic missile is launched from a submarine in the Atlantic (30°N, 75°W) on an azimuth of 135°. Burnout speed relative to the submarine is 16000ft/sec and at an angle of 30° to the local horizontal. Assume the submarine lies motionless in the water during the firing. What is the true speed of the missile relative to the centre of the rotating earth?	Understand	CO 4	AAE016.10
3	A ballistic missiles burnout point is at the end of the semi-minor axis of an ellipse. Assuming burnout altitude equals re-entry altitude, and a spherical earth, what will the value of Q be at re-entry?	Understand	CO 4	AAE016.10
4	What is the minimum velocity required for a ballistic missile to travel a distance measured on the surface of the earth of 5040n.mi? Neglect atmosphere and assume r_{bo}=1DU.	Understand	CO 4	AAE016.10
5	A ballistic missile is capable of achieving a burnout velocity of 0.83 DU/TU at an altitude of 1.06DU. What is the maximum free-flight range of this missile in nautical miles? Assume a symmetrical trajectory.	Understand	CO 4	AAE016.10
6	A rocket testing facility located at 30°N, 100°W launches a missile to impact at latitude of 70°S. a lateral displacement, ΔX; in the launch causes the rocket to burnout east of the intended burnout point. In what direction will the error at impact be?	Remember	CO 4	AAE016.10
7	Assuming that the maximum allowable cross-range error at the impact point of a Ballistic missile is 1.0n.mi where the free flight range of the ballistic missile is 5400n.mi, how large can Δx and Δβ be?	Understand	CO 4	AAE016.10
8	In general will a given Δ$\emptyset_{bo}$cause a large error in a high or low trajectory? Why?	Understand	CO 4	AAE016.09
9	Assuming Δr_{bo} = 1.0DU for a ballistic missile, what is the minimum burnout velocity required achieving a free-flight range of 1800 n.mi?	Remember	CO 4	AAE016.10
10	Show that for maximum range: Q_{bo} = 1 − $e^2$where e is the eccentricity.	Understand	CO 4	AAE016.09

	UNIT-V			
LOW THRUST TRAJECTORIES				
Part - A (Short Answer Questions)				
1	Write about patched conic approximation	Remember	CO 5	AAE016.12
2	Define Bodes law	Remember	CO 5	AAE016.12
3	Define heliocentric orbit.	Understand	CO 5	AAE016.12
4	Define phase angle of departure.	Remember	CO 5	AAE016.14
5	Define synodic period	Understand	CO 5	AAE016.13
6	Write about fast interplanetary trajectories	Remember	CO 5	AAE016.14
7	Write about trajectory types	Remember	CO 5	AAE016.14
8	Define selenocentric orbit.	Understand	CO 5	AAE016.13
9	What are planet locations?	Understand	CO 5	AAE016.15
10	Define effective collision	Remember	CO 5	AAE016.15
11	Explain about the heliocentric orbit.	Remember	CO 5	AAE016.14
12	Describe about the phase angle at departure	Understand	CO 5	AAE016.15
13	Explain about the escape from the earth's sphere of influence.	Understand	CO 5	AAE016.14
14	Explain about the arrival of target planet.	Remember	CO 5	AAE016.15
15	Explain effective collision cross section.	Remember	CO 5	AAE016.15
16	Explain in detail about the process in locating planets.	Understand	CO 5	AAE016.14
17	Describe synodic period with respect to interplanetary trajectories.	Remember	CO 5	AAE016.14
18	Describe the process of gravity assist maneuver.	Understand	CO 5	AAE016.14
19	Explain fast inter planetary trajectories.	Understand	CO 5	AAE016.14
20	Describe about the patched conic approximation.	Understand	CO 5	AAE016.14
Part - B (Long Answer Questions)				
1	Explain about Bode's law.	Remember	CO 5	AAE016.12
2	What are the orbital elements and physical constants of planetary distribution?	Understand	CO 5	AAE016.12
3	What do you mean by Patch conic? Explain briefly. Why it is required on interplanetary trajectory?	Remember	CO 5	AAE016.14
4	Describe briefly about the Helio centric transfer orbit with suitable diagram.	Understand	CO 5	AAE016.13
5	Calculate velocity and time required on Helio centric transfer.	Understand	CO 5	AAE016.14
6	What is a phase angle at departure? Explain through suitable figure.	Understand	CO 5	AAE016.15
7	What is a synodic period and how will you determine it?	Understand	CO 5	AAE016.13
8	With suitable drawing explain the method of escaping from the earth's sphere of influence.	Understand	CO 5	AAE016.14

9	Determine the energy and velocity desired for escaping from the earth's sphere of influence.	Understand	CO 5	AAE016.14
10	Explain through suitable drawing, method of space vehicle at another approaching planet.	Remember	CO 5	AAE016.14
11	Determine ξ_t, h_t, v_2 *and* $\phi_2$for approaching space vehicle at some other planet in interplanetary mission.	Understand	CO 5	AAE016.14
12	Give a brief account on effect of collision cross section and evaluate it through suitable sketches.	Understand	CO 5	AAE016.14
13	What is a non-polar interplanetary trajectory? Write the relationship for Δv.	Understand	CO 5	AAE016.15
14	Determine the synodic period of Mars.	Remember	CO 5	AAE016.15
15	What is launch vehicle staging, explain with suitable expression?	Understand	CO 5	AAE016.14
16	What are the governing parameters to measure the performance of launch vehicle?	Understand	CO 5	AAE016.13
17	What do you understand by constant radial thrust acceleration	Understand	CO 5	AAE016.14
18	What do you understand by constant tangential thrust acceleration?	Understand	CO 5	AAE016.13
19	What is costing and gravity turn of launch vehicle.	Understand	CO 5	
20	What are the various methods of interplanetary trajectory?	Understand	CO 5	AAE016.14
Part - C (Analytical Questions)				
1	A spacecraft is launched on a mission to Mars starting from a 300 km circular parking orbit. Calculate (a) the delta-v required; (b) the location of perigee of the departure hyperbola; (c) the amount of propellant required as a percentage of the spacecraft mass before the delta-v burn, assuming a specific impulse of 300 seconds. $\mu_{sun} = 1.327 \times 10^{1}$ ^{1} km^3/s^2, $\mu_{earth} = 398600$km^3/s^2 and orbital radii of the earth and Mars, $R_{earth} = 149.6 \times 10^{6}$ km and $R_{Mars} = 227.9 \times 10^{6}$ km.	Understand	CO 5	AAE016.12
2	What do you understand by the heliocentric transfer orbit.	Remember	CO 5	AAE016.12
3	What do you understand by escape from the earth's sphere of influence?	Remember	CO 5	
4	Find the distance from the Sun at which a space station must be placed in order that a particular phase angle between the station and earth will repeat itself every 4 years.	Understand	CO 5	AAE016.13
5	A spacecraft is on a 8000 km radius, circular orbit	Understand	CO 5	

	about Mars. A short duration, impulsive thrust in the direction of motion is applied to increase the spacecraft's velocity further. Find numerically the minimum velocity increment that is needed to cause the spacecraft to escape from the Mars gravitational field. (The gravitational parameter of Mars is 42.81×10^3 km $^3/s^2$.)			
6	Calculate the radius of the earth's sphere of influence with respect to the Sun.	Remember	CO 5	AAE016.15
7	Calculate the propellant mass required to launch a 2000kg spacecraft from a 180km circular orbit on a Hohmann transfer trajectory to Saturn. Calculate the time required for the mission and compare it to that of Cassini. Assume the propulsion system has a specific impulse of 300s.	Understand	CO 5	AAE016.15
8	With the use of Hohman transfer analysis calculate an estimate of the total Δv required to depart from Earth and soft land a craft on Mars. What would be an estimate of the return Δv? Give the answer in km/sec.	Understand	CO 5	AAE016.15
9	After a Hohmann transfer from earth, calculate the minimum Δv required to place a spacecraft in Mars orbit with a period of seven hours. Also calculate the periapse radius, the aimimg radius and the angle between periapse and Mars' velocity vector. $\mu_{sun} = 1.327 \times 10^{11}$ km$^3/s^2$, $\mu_{Mars} = 42830$ km$^3/s^2$ and orbital radii of the earth and Mars, $R_{earth} = 149.6 \times 10^6$ km and $R_{Mars} = 227.9 \times 10^6$ km, $r_{Mars} = 3396$ km.	Understand	CO 5	AAE016.15
10	A spacecraft departs earth with a velocity perpendicular to the sun line on a flyby mission to Venus. Encounter occurs at a true anomaly in the approach trajectory of -30^0. Periapse altitude is to be 300km. (a) For an approach from the dark side of the planet, (b) For an approach from the sunlit side of the planet.	Understand	CO 5	AAE016.15

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