Name: **Enrolment No:**	UPES

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES
End Semester Examination, December 2018

Course: Orbital Mechanics **Semester:** VII
Programme: B.Tech ASE, ASEA
Time: 03 hrs. **Max. Marks: 100**
Instructions: **Please assume any missing data**

SECTION A

S. No.		Marks	CO
Q1	State and explain Kepler's three laws of planetary motion	**4**	**CO1**
Q2	Classify Earth orbits based on altitude.	**4**	**CO1**
Q3	What do you mean by following: a) Synodic period b) Sidereal day	**4**	**CO2**
Q4	Illustrate the ecliptic plane. Thus explain vernal equinox.	**4**	**CO3**
Q5	Show that the speed of a satellite in an elliptic orbit at the either end of the minor axis is the same as that of a satellite in a circular orbit at that point.	**4**	**CO4**

SECTION B

Q6	Derive the equation of motion for the restricted three-body problem.	**10**	**CO3**
Q7	Derive an expression for sphere of influence radius.	**10**	**CO3**
Q8	A meteoroid is first observed approaching the earth when it is 402,000 km from the center of the earth with a true anomaly of 150°. If the speed of the meteoroid at that time is 2.23 km/s, calculate a) the eccentricity of the trajectory b) the altitude at closest approach c) the speed at closest approach	**10**	**CO1, CO2**
Q9	Derive expression for the orbital specific energy in terms of the orbital constants 'h' and 'e'. **OR** Derive expression for the orbital specific energy for elliptic orbit and show that it is independent of eccentricity.	**10**	**CO4**

SECTION-C

Q10	With a single delta-v maneuver, the earth orbit of a satellite is to be changed from a circle of radius 15 000 km to a coplanar ellipse with perigee altitude of 500 km and apogee radius of 22 000 km. a) Calculate the magnitude of the required delta-v and the change in the flight path angle $\Delta\gamma$. b) What is the minimum total delta-v if the orbit change is accomplished instead by a Hohmann transfer?	**20**	**CO4**

Q11	The space station and spacecraft A and B are all in the same circular earth orbit of 350 km altitude. Spacecraft A is 600 km behind the space station and spacecraft B is 600 km ahead of the space station. At the same instant, both spacecraft apply a $\Delta v_\perp$ so as to arrive at the space station in one revolution of their phasing orbits. a) Calculate the times required for each spacecraft to reach the space station. b) Calculate the total delta-v requirement for each spacecraft **OR** At point A on its earth orbit, the radius, speed and flight path angle of a satellite are r_A =12,756 km, v_A =6.5992 km/s and γ_A =20◦. At point B, at which the true anomaly is 150◦, an impulsive maneuver causes $\Delta v_\perp$=+0.75820 km/s and Δv_r =0. a) What is the time of flight from A to B? b) What is the rotation of the apse line as a result of this maneuver?	**20**	**CO3, CO4**

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S. No.		Marks	CO
	SECTION A		
Q1	Describe Geocentric Equatorial frame. Draw a well labeled diagram	**4**	**CO1**
Q2	Draw a well labelled diagram showing six orbital elements	**4**	**CO2**
Q3	Use Newton's cannonball experiment to explain an orbit.	**4**	**CO1**
Q4	State and explain Kepler's three laws of planetary motion	**4**	**CO3**
Q5	Define: a) Ecliptic plane b) GEO c) Sphere of influence d) Phasing maneuver	**4**	**CO4**
	SECTION B		
Q6	For two bodies in a circular orbit around sun, having a common apse line, show that phase angle varies linearly with time. If phase angle was θ at time 't' = 0, how long will it take to become θ again? Derive the expression both in terms of orbital angular velocity and time periods of the orbits	**10**	**CO1, CO2**
Q7	Derive equation of motion for restricted three body problem	**10**	**CO3**
Q8	Derive an expression for sphere of influence radius.	**10**	**CO3**
Q9	Find the total delta-v requirement for a bi-elliptical Hohmann transfer from a geocentric circular orbit of 7000 km radius to one of 105 000 km radius. Let the apogee of the first ellipse be 210 000 km. Compare the delta-v schedule and total flight time with that for an ordinary single Hohmann transfer ellipse. **OR** Two geocentric elliptic orbits have common apse lines and their perigees are on the same side of the Earth. The first orbit has perigee radius of r_p=7000km and e=0.3, whereas second orbit r_p=32,000km and e=0.5 a) Find the minimum total delta-v and the time of flight for a transfer from the perigee of the inner orbit to the apogee of the outer orbit. b) Do part (a) for a transfer from the apogee of the inner orbit to the perigee of the outer orbit.	**10**	**CO4**

SECTION-C			
Q10	A spacecraft is in a 200 km circular earth orbit. At t =0, it fires a projectile in the direction opposite to the spacecraft's motion. Thirty minutes after leaving the spacecraft, the projectile impacts the earth. What delta-v was imparted to the projectile? Neglect the atmosphere.	**20**	**CO4**
Q11	An earth satellite is in an 8000 km by 16 000 km radius orbit. Calculate the delta-v and the true anomaly θ_1 required to obtain a 7000 km by 21 000 km radius orbit whose apse line is rotated 25◦ counterclockwise. Indicate the orientation φ of Δv to the local horizon. **OR** It is desired to shift the longitude of a GEO satellite 12◦ westward in three revolutions of its phasing orbit. Calculate the delta-v requirement.	**20**	**CO3, CO4**