Name: Enrolment No:	UPES

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

Course: Mechanics (PHYS 1012) **Semester: I**
Programme: BSc (H) Physics
Time: 03 hrs. **Max. Marks: 100**

Instructions: Use suitable diagrams/illustrations whenever you think they will be required. All questions are compulsory. Question no 9 and 11 have internal choices. Bold face letters in the question are vector quantities.

SECTION A

S. No.		Marks	CO
Q 1	Sate principle of conservation of total energy and liner momentum of an isolated system of particles.	[4]	**CO2**
Q 2	Explain what is a Newtonian's Fluid? Differentiate between laminar and turbulent flow.	[4]	**CO2**
Q 3	Calculate the angular momentum of a star of mass 2.0×10^{30} kg and radius 7.0×10^{5} km. If it makes one complete rotation about its axis once in 20 days, what is its kinetic energy?	[4]	**CO3**
Q 4	Explain the relation between the total energy, potential energy and kinetic energy for a body oscillating with simple harmonic motion (SHM).	[4]	**CO1**
Q 5	What should be the orbiting speed to launch a satellite in a circular orbit 900 km above the surface of the Earth? (take mass of earth=6.0×10^{24} kg, radius of Earth= 6.4×10^{6} m).	[4]	**CO3**

SECTION B

Q 6	Prove that total energy of a particle moving in a conservative force field remains constant during its motion.	[10]	**CO1**
Q 7	Write down all three Kepler's Law of planetary motion. Derive the second law based on conservation of angular momentum of a planet.	[10]	**CO1**
Q 8	Calculate the moment of inertia of a solid sphere of mass M and radius R about the axis through its center.	[10]	**CO4**
Q 9	Calculate the percentage contraction of a rod of length L moving with a velocity of	[10]	**CO4**

	2.4×10^8 m/s in a direction inclined at 60^0 to its own length.		
	Or		
	An event occurs at x= 100 m, y=5 m, z=1 m and t=10^{-4} s in a frame of reference S. Find the coordinates of this event in S' which is moving with velocity 2.7 x 10^8 m/s along the xx' axes using Lorentz transformation equations.	[10]	**CO4**
	SECTION-C		
Q 10	a) Define an elastic material. Derive the following relation $2G \times (1+\sigma_P) = Y$, where Y is Young's modulus, G is shear modulus and σ_P is Poisson's ratio of a given elastic material.	[10]	**CO2**
	b) Assuming frame S' is moving with velocity v relative to S frame along $x \leftrightarrow x'$ axis only, establish the relationship $\{u_x = \frac{u_x' + v}{1+(\frac{u'v}{c^2})}\}$ for relativistic velocity transformation based on Lorentz transformation equations. (Where u_x and u_x' are the x-components of velocities of particle in frame S and S' and c is the speed of light)	[10]	**CO2**
Q 11	a) A disc and a circular hoop (having same radii and masses) start moving down from the top of an inclined plane at the same time. Which one will have greater speed on reaching the bottom and why?	[10]	**CO3**
	b) An 8.0 kg body executes SHM with amplitude 30 *cm*. The restoring force is 60 *N* when the displacement is 30 *cm*. Find (i) Period (ii) Acceleration, speed, kinetic energy and potential energy when the displacement is 12 *cm*.	[10]	**CO3**
	Or		
	a) A diver weighing 750 *N* dives from a board 10 *m* above the surface of a pool water. Use the principle of mechanical energy to find his speed at a point above 5.0 *m* the water surface, neglecting the air friction.	[10]	**CO3**
	b) Find the amplitude, frequency and period of an object vibrating at the end of a spring, if the equation from its position, as a function of time is $x = 0.25\cos(\frac{\pi}{8})t$. What is the displacement of the object after 2.0 s?	[10]	**CO3**

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SECTION A

S. No.		Marks	CO
Q 1	Show that a conservative force (***F***) can be expressed as a gradient (∇U) of potential energy i.e. $F=\nabla U$	[4]	**CO2**
Q 2	State the principle of conservation of angular momentum ***L*** and show that under a central force motion, it remains conserved i.e. $\frac{dL}{dt}=0$.	[4]	**CO2**
Q 3	Water flows through a capillary, whose internal diameter is 1 cm at a speed of 1.0 m/ s . What should be the diameter of the nozzle if the water is to emerge at 21 m/s ?	[4]	**CO3**
Q 4	Differentiate between inertial mass and gravitational mass.	[4]	**CO1**
Q 5	What should be the minimum velocity, for a satellite, to orbit close to earth around it. (Take g=9.8 m/s^2, and radius of earth =6.4×10^6 m).	[4]	**CO3**
	SECTION B		
Q 6	Find the position of centre of mass of a thin rod of mass *M* and *L* with respect to left end of this rod.	[10]	**CO1**
Q 7	Derive the expression of a gravitational potential outside to a solid sphere of homogeneous density.	[10]	**CO1**
Q 8	Calculate the moment of inertia of a hollow sphere of mass M and radius R of homogeneous sensity about its diameter.	[10]	**CO4**
Q 9	Calculate the speed of the space shuttle if its length is 100 m on earth and 99 m to an	[10]	**CO4**

	observer when it is in motion.		
	Or		
	What is the linear momentum of a proton moving with speed of 0.86c. (take rest mass of proton=1.67×10^{-27} kg and speed of light c=3.0×10^{8} m/s)	[10]	**CO4**
SECTION-C			
Q 10	a) Derive tangential and radial components of a velocity vector and acceleration by assuming that particle moves in a two dimensional polar (r, θ) coordinate system.	[10]	**CO2**
	b) State the postulates of special theory of relativity. Derive the following expression for relativistic energy: $E=\sqrt{E_0^2+P^2c^2}$. (assuming E= total energy, E_0= rest mass energy and P is total liner momentum of a particle).	[10]	**CO2**
Q 11	a) A disc and a circular hoop (having same radii and masses) start moving down from the top of an inclined plane at the same time. Determine which one will have greater speed on reaching the bottom and why?	[10]	**CO3**
	b) A conical pendulum is formed by attaching a 53 g pebble to a 1.4 m string. The pebble swings around in a circle of radius 25 cm. (a) What is speed of pebble? (b) What is acceleration? (c) What is tension in the string?	[10]	**CO3**
	Or		
	a) A diver weighing 750 N dives from a board 10 m above the surface of a pool water. Use the principle of mechanical energy to find his speed at a point above 5.0 m the water surface, neglecting the air friction.	[10]	**CO3**
	b) A car of mass 1300 kg is constructed using a frame supported by four springs. Each spring has a spring constant 2×10^{4} N/m . If two people are riding in the car have a combined mass of 160 kg, find the frequency of vibration of the car, when it is driven over a pot hole in the road. Assume the weight is evenly distributed.	[10]	**CO3**