POSSESSION OF MOBILES IN EXAM IS UFM PRACTICE

Name of student ____________________ **Enrollment No.**__________

BENNETT UNIVERSITY, GREATER NOIDA

B.TECH/ TEST – END-SEMESTER MAJOR: FALL SEMESTER A.Y. 2017-2018

06.12.2017

COURSE CODE EPHY103L MAX. TIME: 2hour

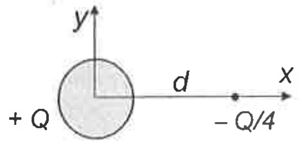
COURSE NAME : **Electromagnetism and Mechanics**

COURSE CREDIT: 5 MAX. MARKS: 60

EACH QUESTION CARRIES EQUAL MARK

ALL QUESTIONS ARE COMPULSORY

Q1 (a) Consider a uniform spherical charge distribution with total charge +*Q* and a point charge having a charge $-Q/4$ placed at a distance *d* from the centre of the sphere as shown in the figure. Obtain the position/positions where the net electric field will be zero.



(b) A spherical conductor of radius *a* and carrying a charge *Q* is surrounded by a dielectric with dielectric constant *K* from radius *a* to radius *b*. The region outside the sphere is free space. Calculate $\vec{D}$ and $\vec{E}$ everywhere.

Q2. a) An infinitely long cylinder of radius *R* has a uniform magnetization $\vec{M}$ parallel to the axis. What are the values of bound surface and volume currents? What will be the value of $\vec{B}$ in the region outside the cylinder? Give brief reasons for your answer.

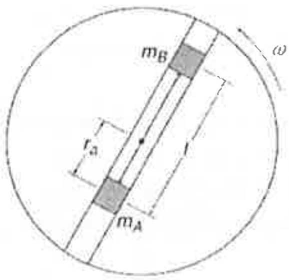
b) An infinitely long straight wire made of copper with magnetic susceptibility χ_m and of radius R carries a current I which is uniformly distributed across its cross section.

(i) Using Ampere's law obtain the values of the fields $\vec{H}$ and $\vec{B}$ within and outside the wire.

(ii) What will be the direction of magnetization in the wire?

Q3. a) An elevator starts from rest with a constant upward acceleration. It moves 2 m in the first 0.60 sec. A passenger is holding a 3 kg package by a vertical string. What is the tension in the string during the acceleration process?

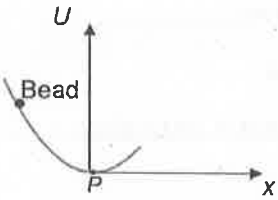
b) Two masses m_A and m_B slide without friction in a groove passing through the centre of the disk, which is rotating with a constant angular velocity ω. They are connected by a light string (of negligible mass) of length l, and are initially held in position by a catch, with mass m_A at distance r_a from the centre. At t = 0, the catch is removed and the masses are free to slide. Find d^2r_a/dt^2 immediately after the catch is removed, in terms of m_A, m_B, l, r_a, and ω. Neglect gravity.



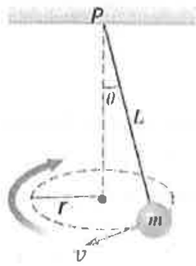
Q4. a) What is the definition of quality factor (Q) of a harmonic oscillator?

b) A 200 g mass is attached to a spring and it oscillates at 5 Hz with a Q of 50. Find the spring constant k and damping constant γ.

c) A bead of mass m slides on a frictionless wire (see figure). Its P.E. is given by $U = cx^2$ in the vicinity of point P, where x is measured from P and c is a constant. If the bead is displaced from P and released, it executes simple harmonic motion. Find out its period of oscillation.

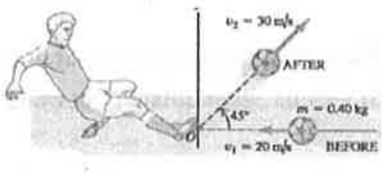


Q5. a) In which of the following two cases, escape velocity of an artificial satellite from earth's surface will be less - i) when projected vertically or ii) when projected at an angle θ with respect to the vertical?



b) A small ball of mass m is fastened to a string 24 cm (L) long and suspended from a pivot point P to make a conical pendulum. The ball describes a circle of radius r about a centre vertically under P and the string makes an angle (θ) of 11.55° with the vertical. Find the speed of the ball.

Q6. a) Suppose you have a choice between catching a 0.50 kg ball moving at a speed of 4.0 m/sec or a 0.10 kg ball moving at a speed of 20 m/sec. Which ball will be easier to catch? Justify your answer.

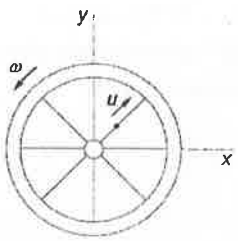


b) A soccer ball of mass 0.40 kg is moving to the left at a speed of 20 m/s. Then it is kicked and imparted a velocity at 45° upward and to the right with a magnitude of 30 m/s. Find the impulse of the net force and average net force, assuming collision time Δt = 0.01 sec.

Q7. a) A 200 g cylindrical object of radius 70 cm rolls down without slipping from rest down a driveway that is inclined at 30° to the horizontal and is 20 m long. How fast is the object going at the end of the driveway if friction is negligible?

b) A 1000 kg car is traveling north at 15 m/s when it accidentally collides with a 2000 kg truck traveling east at 10 m/s. As a result, two vehicles get thoroughly tangled and move away from impact point as one mass. What will be the velocity (magnitude and direction) of the wreckage just after the impact? (assume that during the collision no parts of either the truck or the car fall off).

Q8. a) A rocket is in elliptic orbit around the Earth. To put it into an escape orbit, its engine is fired briefly, changing the rocket's velocity by $\Delta\vec{V}$. Where in the orbit, and in what direction, should the firing occur to attain escape with a minimum value of $\Delta\vec{V}$?



b) A bead moves along the spoke of a wheel at a speed $u = (1 + 0.5t)$ meters per second. The wheel rotates with an angular velocity $\dot{\theta} = \omega = (1 + 0.5t)$ radians per second about an axis fixed in space. At $t = 0$, the bead is at the centre and the spoke lies along the x-axis. Find the velocity of the bead and angle of rotation of the spoke at $t = 2$ s.

Some useful formulas

- In Cartesian coordinates:

$$\nabla f = \frac{\partial f}{\partial x}\hat{\imath} + \frac{\partial f}{\partial y}\hat{\jmath} + \frac{\partial f}{\partial z}\hat{k}$$

$$\nabla . \vec{F} = \frac{\partial F_x}{\partial x} + \frac{\partial F_y}{\partial y} + \frac{\partial F_z}{\partial z}$$

$$\nabla \times \vec{F} = \left[\frac{\partial F_z}{\partial y} - \frac{\partial F_y}{\partial z}\right]\hat{\imath} + \left[\frac{\partial F_x}{\partial z} - \frac{\partial F_z}{\partial x}\right]\hat{\jmath} + \left[\frac{\partial F_y}{\partial x} - \frac{\partial F_x}{\partial y}\right]\hat{k}$$

- In spherical polar coordinates:

$$\nabla f = \frac{\partial f}{\partial r}\hat{r} + \frac{1}{r}\frac{\partial f}{\partial \theta}\hat{\theta} + \frac{1}{r\sin\theta}\frac{\partial f}{\partial \phi}\hat{\phi}$$

$$\nabla . \vec{F} = \frac{1}{r^2}\frac{\partial}{\partial r}(r^2 F_r) + \frac{1}{r\sin\theta}\frac{\partial}{\partial \theta}(\sin\theta\, F_\theta) + \frac{1}{r\sin\theta}\frac{\partial F_\phi}{\partial \phi}$$

$$\nabla \times \vec{F} = \frac{1}{r\sin\theta}\left[\frac{\partial}{\partial \theta}(\sin\theta\, F_\phi) - \frac{\partial F_\theta}{\partial \phi}\right]\hat{r} + \frac{1}{r}\left[\frac{1}{\sin\theta}\frac{\partial F_r}{\partial \phi} - \frac{\partial}{\partial r}(rF_\phi)\right]\hat{\theta} + \frac{1}{r}\left[\frac{\partial}{\partial r}(rF_\theta) - \frac{\partial F_r}{\partial \theta}\right]\hat{\phi}$$

- In cylindrical coordinates:

$$\nabla f = \frac{\partial f}{\partial r}\hat{r} + \frac{1}{r}\frac{\partial f}{\partial \phi}\hat{\phi} + \frac{\partial f}{\partial z}\hat{z}$$

$$\nabla . \vec{F} = \frac{1}{r}\frac{\partial}{\partial r}(rF_r) + \frac{1}{r}\frac{\partial F_\phi}{\partial \phi} + \frac{\partial F_z}{\partial z}$$

$$\nabla \times \vec{F} = \left[\frac{1}{r}\frac{\partial F_z}{\partial \phi} - \frac{\partial F_\phi}{\partial z}\right]\hat{r} + \left[\frac{\partial F_r}{\partial z} - \frac{\partial F_z}{\partial r}\right]\hat{\phi} + \frac{1}{r}\left[\frac{\partial}{\partial r}(rF_\phi) - \frac{\partial F_r}{\partial \phi}\right]\hat{z}$$

- Velocity and acceleration in polar coordinates:

$$\vec{v} = \dot{r}\hat{r} + r\dot{\theta}\hat{\theta}; \qquad \vec{a} = (\ddot{r} - r\dot{\theta}^2)\hat{r} + (r\ddot{\theta} + 2\dot{r}\dot{\theta})\hat{\theta}$$

- Value of acceleration due to gravity: $g = 9.8\, m/s^2$
- M.I. of a cylinder of mass M and radius R about its axis = $\frac{1}{2}MR^2$
- M.I. of a disk of mass M and radius R about an axis passing through its centre and perpendicular to its plane = $\frac{1}{2}MR^2$
- M.I. of a sphere of mass M and radius R about its axis = $\frac{2}{5}MR^2$