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Ref. No.: EX/PROD/PH/T/1B/115/2017(S)

B. PROD. ENGINEERING 1st Yr, 1st SEM.

SUPPLEMENTARY EXAM. 2017

PHYSICS – I

Time: 3 hours Full marks: 100

ANSWER ANY FIVE QUESTIONS.

1(a). Given the vector $\vec{A} = 3\hat{i} + 4\hat{j} - 4\hat{k}$, find a unit vector $\hat{B}$ that lies in the XY plane and is perpendicular to $\vec{A}$. Find also a unit vector $\hat{C}$ that is perpendicular to both $\vec{A}$ and $\hat{B}$.

Now let $\vec{V}$ be any arbitrary vector in 3 dimensions and let $\hat{n}$ be a unit vector in some chosen fixed direction. Show that the vector $\vec{V}$ can always be decomposed as: $\vec{V} = \left(\vec{V} \cdot \hat{n}\right)\hat{n} + \left(\hat{n} \times \vec{V}\right) \times \hat{n}$. [6 + 4]

(b). A particle of mass m moves in three dimensions according to the equations:

$$x = x_0 + at^2, \qquad y = bt^3, \qquad z = ct$$

Find the angular momentum $\vec{L}$ of the particle at any time t. Find also the force $\vec{F}$ acting on it; and from it calculate the torque $\vec{N}$ acting on the particle. Hence verify that the angular momentum theorem (relating the rate of change of $\vec{L}$ with $\vec{N}$) is satisfied. [10]

(2). (a) Define a *Central Force* and give a few examples. Show that a *Central force* is always a *conservative* force. [3 + 5]

(b). A particle moving on the 2-dimensional plane has its trajectory suitably described in polar coordinates. (r, θ) by the equation: $r = C_0 e^{\theta}$. It is given that the

angular velocity of the particle is constant. Find the expressions for the *radial* and the *tangential* acceleration of the particle. Hence show that the radial acceleration of the particle vanishes and its tangential acceleration is proportional to its distance from the origin. [8 + 4]

3(a). Explain the notion of a *rigid* body. A rigid body is undergoing pure rotation about an axis with angular velocity $\vec{\omega}$. What is the expression for its *Moment of Inertia* and explain how it is related to the rotational kinetic energy of the body.

Consider a right circular cylinder with radius R and length L. Find its moment of inertia about its principal axis (the axis running parallel to its length).[4 + 4 + 6]

3(b). The trajectory of a body undergoing simple harmonic motion in one dimension is given by: $x = A_0 \cos(\omega t + \phi)$. Obtain the expression for its total energy at any point of its trajectory, and show that it is conserved. [6]

4(a). A point mass moves under the action of an external force $\vec{F}$. Write down the expression for the total work done in moving the mass along an arbitrary closed loop, and hence establish that if $\vec{F}$ is conservative, this work done is zero.

4(b). Consider now the case of a force explicitly given by $\vec{F}(x,y) = A_0\left(x^2\hat{i} + xy^2\hat{j}\right)$ acting on the XY plane, with A_0 being a constant. Find the work done by this force on a body (of unit mass) when it undergoes a displacement on the XY plane from the point $(0,1)$ to the point $(2,2)$.

4(c). Find the gravitational potential at a point P, which is at a distantance R from the centre of a solid spherical shell of mass M (and inner and outer radii r_1 and r_2 respectively), and where $0 < r_1 < r_2 < R$. [6 + 6 + 8]

5(a). State Bio-Savart's law for the magnetic field due to a current element flowing through a wire. A square loop, each of whose sides is of length L carries a steady current I_0 and let P be a point at a distance R from the plane of the square and on/along the axis of the loop. (The axis is a line perpendicular to the plane of the

square and passing through the intersection point of its diagonals. Then find the value of the magnetic field at P. [3 + 9 = 12]

5 (b). Write down the expression for energy in an electrostatic field. Two positive charges of magnitude 6×10^{-10} and 4×10^{-10} Coulombs, are initially placed 10 cms apart. Find the work done in bringing the charges to a separation of 6 cm. (Given, $\epsilon_0 = 8.85 \times 10^{-12}\ C^2/Nm^2$). [8]

6(a). Derive the expression of magnetic field due to a circular current carrying loop. [5]

6(b). An infinite long wire is carrying a current of 2A. Find the magnetic field due to it at a distance of 4m from it. If now the same wire, carrying same amount of current is turned 100 times into a circle of radius 2m find the magnetic field at its center. [5]

6(c). Write Faradays law of electromagnetic induction. Explain it briefly. [5]

6(d). What do you mean by self inductance of a current carrying wire? Give its mathematical expression [5]

7(a). Derive the expression of self inductance of a solenoid. [5]

7(b). Derive the expression of effective inductance due to parallel combination of two current carrying inductors. [5]

7(c). Derive the expression of final charge in a capacitor during its charging state in a series combination of a resistor and capacitor. Draw a graph to depict the same. [5]

7(d). Examine whether the discharging of a charged capacitor of 0.1 microF, through an inductor of 100mH and a resistance of 200 ohm is oscillatory or not. If oscillatory find the frequency of oscillation. [5]

8(a). Derive the expression of current in a series L-R circuit. Draw a phasor diagram to show whether the voltage leads or lags the current. [5]

8(b). What do you mean by resonance in a series L-C-R circuit? What is the value of the resonance frequency in terms of L and C. Draw a graph to depict resonance? [5]

8(c). Explain the phenomena of interference of light. Give the expression of phase difference in case of maxima and minima. [5]

8(d). Derive the expression of fringe width in double slit experiment.[5]

9(a). What do you observe when a thin transparent sheet of refractive index n is placed in the path of one of the interfering light waves? Give the expression of the shift. [5]

9(b). What is the result if interference experiment is performed with white light? What is the colour of the central bright fringe? Explain polarization of light [5]

9(c). How is Newtons double slit experiment used to measure the refractive index of a Liquid? [5]

9(d). Give some application of Newtons ring experiment. State a modified set-up for the same experiment. [5]

10. Write SHORT NOTES on (Any three): [$6\frac{1}{2}$ X 3]

(*i*) Parallel and Perpindicular Axis Theorem (in the context of Moment of Inertia of rigid bodies).

(*ii*) Raidius of gyration of a rigid body.

(*iii*) Fresnel's Biprism.

(*iv*) Polarization of light.

(*v*) Potential and Electrostatic Field due to any Electric Dipole (of moment $\vec{\mu}$)

(*vi*) The phenomenon of Diffraction

(*vii*) Newton's Rings and the Colour of thin films.

(*viii*) Diffraction Grating.