Time : 03 hour

Answer ALL Questions

Question 1

(a) Define and write down the mathematical expressions for "average velocity" and "instantaneous velocity".   ... (4% marks)

A particle located at position $x = 0$ at time $t = 0$, starts moving along the positive x-direction with a velocity v that varies as $v = kx^{\frac{1}{2}}$.

   (i) Find the expressions for displacement, velocity and acceleration of the particle as a function of t.   ... (9% marks)

   (ii) What is the average velocity of the particle over the first d distance of its path?.   ... (1% marks)

(b) A particle is moving in two dimensions and its position is given by the polar coordinates (r, θ). Show that the;   ... (2% marks)
   (i) velocity of the particle is $\vec{v} = \dot{r}\,\vec{e}_r + r\,\dot{\theta}\,\vec{e}_\theta$
   (ii) acceleration of the of the particle is $\vec{a} = \left(\ddot{r} - r\,\dot{\theta}^2\right)\vec{e}_r + \left(r\,\ddot{\theta} + 2\,\dot{r}\,\dot{\theta}\right)\vec{e}_\theta$.   ... (2% marks)

Where, $\vec{e}_r$ and $\vec{e}_\theta$ are the unit vectors along and perpendicular to the radial direction respectively.

(c) A particle moves in two dimensions $r = 2\theta$, where θ varies with time t as $\theta = t^2$. Show that the acceleration of the particle is $\vec{a} = 4(1 - 2\,t^4)\,\vec{e}_r + 20\,t^2\,\vec{e}_\theta$.   ... (2% marks)

Question 2

(a) Explain briefly what is meant by Conservative force, Work done and Work-Energy principle.   ... (3% marks)

(b) A particle is moving with a velocity $v(t)$ under the influence of a force $F(t)$. Show that the work done W by the force between the time interval t_1 to t_2 is,   ... (3% marks)

$$W = \int_{t_1}^{t_2} (\vec{F} \cdot \vec{v})\, dt,$$

(c) A particle of mass 5 Kg moves with an initial velocity $(10i - k)$ ms^{-1} under the influence of an external force $\vec{F} = 5\vec{i} + 10\vec{j} + 15\vec{k}$ N. Find the,

(i) power of the force at any time t sec. ... (2% marks)

(ii) work done by the force in the time interval t = 0 sec to t = 10 sec. ... (2% marks)

(iii) velocity and the position vector of the particle when t = 10 sec. ... (2% marks)

(iv) Calculate the kinetic energy of the particle when t = 10 sec and verify your answer by considering the relationship between work and energy. ... (2% marks)

Question3

(a) Briefly explain the meaning of *wavelength, frequency* and *amplitude* as applied to waves.

...(6% marks)

(b) Distinguish between *wave velocity* and *propagation velocity* in wave transmission.

...(2% marks)

(d) Briefly explain the *superposition* and *interference* of waves. ...(2% marks)

(e) Distinguish between *constructive* and *destructive* interference of waves. ...(2% marks)

(f) Briefly explain the *Doppler Effect* in sound waves. ...(2% marks)

(g) A ship is chasing a submarine. To detect the submarine, the ship uses sonar, sending out a sound wave and detecting the reflected sound. The submarine is moving at 8 ms^{-1} and the ship chases it at 20 ms^{-1}. If the ship sends out a 700 Hz sound wave, what frequency do they hear for the return wave? The speed of sound in water is 1500 ms^{-1}. ...(5% marks)

Question4

(a) Define the following terms in thermodynamics; *thermal physics, temperature, heat, internal energy,* and *thermal equilibrium*. ... (5% marks)

(b) Define the *Zeroth law* of thermodynamics. ...(2% marks)

(c) Briefly explain the *absolute zero* in thermodynamics? ... (2% marks)

(d) Brief the *ideal gas* and the *ideal gas law*. ... (3% marks)

A 3 liter tank contains oxygen gas at 20 °C and gauge pressure of 25 x 10^5 Pa. Estimate the mass of oxygen in the tank. You may use the molar mass of oxygen gas is 32 g/mol. Atmospheric pressure to be 1 x 10^5 Pa and Universal gas constant is 8.31 J/mol.K. ...(3% marks)

Question 5

(a) Describe what interference of light is. ... (3% marks)

A double slit experimental arrangement is shown in Figure 1, where the double slit is illuminated with monochromatic parallel beam of light. In such an arrangement, $I_1 = I_2 = I_0$ and the intensity