EASTERN UNIVERSITY, SRI LANKA

FIRST EXAMINATION IN SCIENCE – 2017/2018

FIRST SEMESTER (August / September 2018)

PH 1013 GENERAL PHYSICS

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;

(i) velocity of the particle is $\vec{v} = \dot{r}\,\vec{e}_r + r\,\dot{\theta}\,\vec{e}_\theta$ ... (2% marks)

(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)

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

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

distribution in the plane of P is given by $I_{In} = 2I_0 \cos^2\gamma$, where $2\gamma = \frac{2\pi}{\lambda} d \sin\theta$ is the phase difference between the two interfering beams.

(b) Show that maxima and minima are observed at angles $\theta_m = \sin^{-1}\left[m\frac{\lambda}{d}\right]$ and $\theta_m = \sin^{-1}\left[\left(m+\frac{1}{2}\right)\frac{\lambda}{d}\right]$ respectively. ... (4% marks)

(c) Give a schematic plot for I_{Int} vs x_m ... (4% marks)

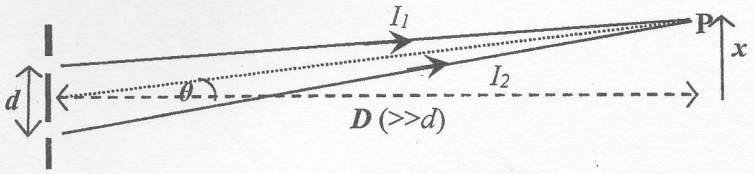

Figure 1

Question 6

(a) Describe what diffraction of light is, and distinguish Fraunhofer diffraction from Fresnel diffraction. ... (4% marks)

If diffraction effect is also taken into consideration, the above intensity distribution of the double slit is modified and given by

$$I_P = I_0^* \left(\frac{\sin\beta}{\beta}\right)^2 \cos^2\gamma, \qquad (1)$$

where $\beta = \frac{2\pi}{\lambda} b \sin\theta$ and b is the width of the slits.

(b) Obtain the conditions for principal maxima and minima of the diffraction term $I_{Dif} = I_0^* \left(\frac{\sin\beta}{\beta}\right)^2$. ... (4% marks)

The Fraunhofer diffraction pattern of double slits in the above arrangement is observed using a monochromatic laser light of wavelength 6000 Å, which is shown in the Figure 2. If $D = 6$ meters, then

(c) By measuring the $\sin\theta$ value of a bright fringe denoted by P_1, find its intensity (in terms of I_0^*) and the separation of the slits d. ... (8% marks)

(d) By using the 2nd missing order, find the width of the slits b. ... (5% marks)

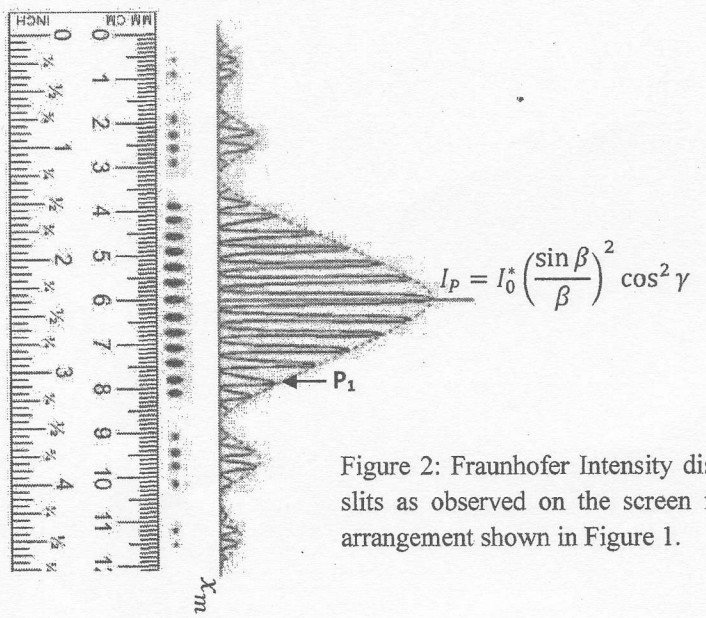

Figure 2: Fraunhofer Intensity distribution of double slits as observed on the screen in the experimental arrangement shown in Figure 1.

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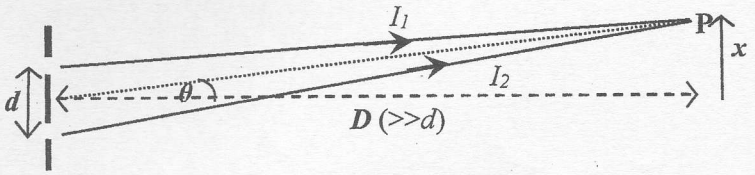

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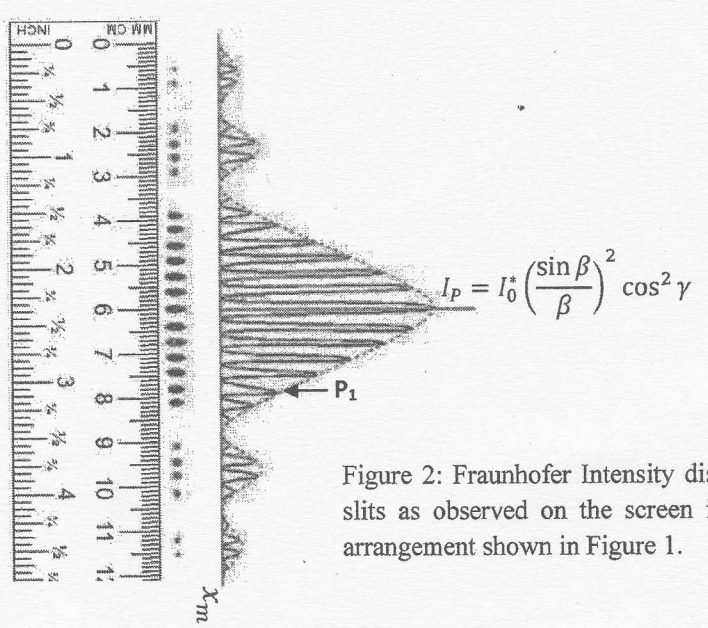

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