Fayoum University

Faculty of Engineering

1ST Year Civil Eng. Dept

Physics (2) – Final Exam (January,14th 2009)

Allowed Time : 3 hours

Fayoum University

Question (1):

- A (2.0 Kg) object is attached to a horizontal spring on a horizontal smooth surface. A horizontal force of (20.0 N) is required to hold the object at rest when it is pulled (0.2 m) from its equilibrium position. The object is now released from rest with an initial displacement (0.2m), and it undergoes a simple harmonic motion. Find (a) the spring constant, (b) frequency of oscillation, (c) maximum speed , (d) maximum acceleration, (e) total energy.
- A (10.6 kg) object oscillates at the end of a vertical spring whose spring constant ($K = 2.05*10^4$ N/m). The effect of air resistance is represented by damping constant (c = 30.0 N.s/m). (a) Calculate the damping frequency, (b) By what percentage does the amplitude of the oscillation decreases in each cycle.
- A (2.0 kg) object attached to a spring, moves without friction and is driven by an external force($F = 3 \sin(2\pi t)$). If the spring constant (K = 20 N/m) determine, (a) the period and (b) the amplitude of the motion at steady state condition.

Question (2):

- Two sinusoidal waves combining in a medium, are given by ($y_1 = 3 \sin(0.6\pi t - \pi x)$) and ($y_2 = 3 \sin(0.6\pi t + \pi x)$). (a) Determine the maximum transverse displacement of an element of medium at (x =0.25 m)., (b) Find the three smallest values of position (x) corresponding to antinodes.
- Two identical piano strings of length (L = 0.75 m) are each tuned to frequency (440 Hz). The tension in one of them is then increased by (1.0 %). If they are now struck. What is the beat frequency between the fundamental frequencies of the two strings.
- A train whistle (f_s =400 Hz) sounds higher or lower in frequency depending on whether it approaches or recedes (a) Prove that the difference in frequency between the approaching and receding train is $\Delta f = \frac{(2u/v)}{1-(u/v)^2} f_s$, where "u" is velocity of the train and "v" is the sound velocity. (b) Calculate this difference for (u =130 km/hr) take (v=340 m/s).

Question (3):

- A convex mirror has a radius of curvature of (r = 20 cm). If a point source is placed (14 cm) away from the mirror, where is the image?.

- A thin flake of mica whose thickness (2.44 μm), is used to cover one slit of the double-slit Young's experiment. The central point on the screen is occupied by the seventh (m=7) bright fringe. If the wavelength (λ = 550 nm), what is the index of refraction of mica.

- Sunglass lenses are often coated with thin film of transparent material like MgF_2 (n =1.38) in order to reduce the reflection from the glass surface (n = 1.50). Determine the minimum coating thickness needed to produce a minimum reflection (destructive interference) at (λ= 550nm).

Question (4):

- A single-slit is illuminated by light whose wavelengths are λ_1 and λ_2 , so chosen that the first diffraction minimum of λ_1 coincides with the second minimum of λ_2. What is the relationship between the two wavelengths.

- How many complete fringes between the <u>second</u> minima of the fringe envelope on either side of the central maximum for a double-slit pattern if (λ = 550 nm, d = 0.15 mm, a = 0.03 mm). what is the ratio of the intensity of the third fringe to one side of the center to that of the central maximum.

- In Newton's rings experiment, given that the diameters of two bright rings are (4 mm, and 4.8 mm). If the successive order of rings is not known, while there exists four bright rings between these rings. If the wavelength (λ = 500 nm) find out the radius of curvature.

Question (5):

- Light is reflected from a Lead-glass plate with index of refraction (n = 196). At what angle of incidence the reflected light is completely polarized.

- If a beam of polarized light has one-tenth of its initial intensity after passing through an analyzer, what is the angle between the axis of the analyzer and the initial amplitude of the beam.

- What is the decay constant λ, an element whose a half-life time 4.5*10^9 year.

- Complete the following nuclear decays

  $^{A}_{Z}X \Rightarrow {}_{..}^{..}Y + {}^{4}_{2}He$ and $^{A}_{Z}X \Rightarrow .... + {}_{-1}e + ...$

- The ^{226}Ra nucleus undergoes alpha decay . Calculate the disintegration energy Q for this process . Take the atomic masses to be (226.025406 amu) for ^{226}Ra and (222.017574 amu) for ^{222}Rn, and (4.002603 amu) for alpha particle.

GOOD LUCK TO YOU

Dr. MAGED KASSAB

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QUESTION (1):

(1.1) From the given information

(a) External force = spring restoring force =kx → k= force/ displacement = 20/0.2= 100 N/m

(b) $\omega = \sqrt{\frac{k}{m}} = \sqrt{\frac{100}{2}} = 5\sqrt{2} = 7.071 \quad rad/s \quad \Rightarrow f = \frac{\omega}{2\pi} = 1.125 \quad Hz$

© $u_{max} = A\omega = 0.2 * 7.071 = 1.414 \quad m/s$

(d) $a_{max} = \left|-\omega^2 A\right| = 10\, m^2/s$

(e) $E = \frac{1}{2}kA^2 = \frac{1}{2} * 100 * (0.2)^2 = 2\,J$

(1.2) $\omega = \sqrt{\frac{k}{m}} = \sqrt{\frac{2.05 * 10^4}{10.6}} = 43.977\, rad/s \qquad \gamma = \frac{c}{2m} = \frac{30}{2*10.6} = 1.415\, rad/s \quad << \omega$

(a) $\omega_1 = \sqrt{\omega^2 - \gamma^2} = 43.954 \;\; rad/s$

(b) $after\ one\ cycle \Rightarrow \quad t = T \quad and \quad A = A_0 \exp(-\gamma T)$

$$T = \frac{2\pi}{\omega_1} = 0.143\, s \quad \Rightarrow \quad decrease\,\% = \frac{A_0 - A}{A_0} = (1 - \exp(-\gamma T)) = 18.32\%$$

(1.3) (a) $T = \frac{2\pi}{motion\ frequency} = \frac{2\pi}{\Omega} = \frac{2\pi}{2\pi} = 1.0\, s$

(b) $A = \frac{F_m}{m\sqrt{(\omega^2 - \Omega^2)^2 + 4\Omega^2\gamma^2}} \qquad but \quad \gamma = 0 \Rightarrow \quad A = 0.276 \quad m$

QUESTION (2):

(2.1) (a) $y = y_1 + y_2 = 6\cos(\pi x)\cdot\sin(0.6\pi t) \qquad \Rightarrow \qquad A_{max} = 6\,m$

(b) $for\ antinodes \Rightarrow \quad \pi x = 0, \pi, 2\pi \quad \Rightarrow \quad x = 0, 1m, 2m$

(2.2) $Beat\ frequency = \left|f_1' - f_1\right| \qquad where \quad \frac{f_1'}{f_1} = \sqrt{1.01} \Rightarrow f_1' = 440 * \sqrt{1.01} = 442.2\,Hz$

$Beatf\ \ frequency = 442.2 - 440 = 2.2\,Hz$

$$approaching\ freq = f_{oA} = f_s * \frac{v}{v-u} \qquad receding\ freq. = f_{oR} * \frac{v}{v+u}$$

(2.3)
$$\Delta f = f_{oA} - f_{oR} = f_s * \frac{2uv}{v^2 - u^2} = f_s * \frac{2\left(\frac{u}{v}\right)}{1-\left(\frac{u}{v}\right)^2}$$

(b) $\Delta f = 85.767$ Hz

QUESTION (3):

(3.1) f=-10 cm, d_o=14 cm, d_i= ?

$$\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f} \qquad \Rightarrow \frac{1}{d_i} = \frac{1}{f} - \frac{1}{d_o} = -\frac{24}{140} \quad \Rightarrow \quad d_i = -5.83\ cm$$

(3.2) $(n-1)t = m\lambda \qquad \Rightarrow \qquad (n-1) * 2.44 * 10^{-6} = 7 * 550 * 10^{-9} \quad \Rightarrow \quad n = 2.758$

(3.3) $2nd = \left(m + \frac{1}{2}\right)\lambda \qquad \Rightarrow \quad for\ m = 0 \quad \Rightarrow d_{min} = \frac{\lambda}{4n} = \frac{550}{1.38 * 4} = 99.638\ nm$

QUESTION (4):

(4.1) $a \sin(\theta) = \lambda_1 = 2\lambda_2 \qquad \Rightarrow \quad \frac{\lambda_1}{\lambda_2} = 2$

(4.2) (a) d/a=5 → no. complete fringe between second minima= 9 + 8 = 17 fringes

(b) $\frac{I_3}{I_0} = \left(\frac{\sin(\beta)}{\beta}\right)^2 \qquad \beta = \frac{\pi a \sin(\theta)}{\lambda}, \quad and \quad \sin(\theta) = \frac{3\lambda}{d} \quad \Rightarrow \quad \frac{I_3}{I_0} = 0.255$

(4.3) (a) refer to the lectures notes

(b)
$$\frac{r_m^2}{R} = \left(m + \frac{1}{2}\right)\lambda \qquad and \qquad \frac{r_{m+5}^2}{R} = \left((m+5) + \frac{1}{2}\right)\lambda$$

$$\therefore \quad \left(r_{m+5}^2 - r_m^2\right) = 5\lambda R \qquad \Rightarrow \quad R = \frac{\left(2.4 * 10^{-3}\right)^2 - \left(2.0 * 10^{-3}\right)^2}{5 * 500 * 10^{-9}} = 0.704\ m$$

QUESTION (5):

(5.1) $\tan \Phi_B = \frac{n_2}{n_1} = \frac{1.96}{1.0} \qquad \Rightarrow \qquad \Phi_B = \tan^{-1}(1.96) = 62.969^o$

(5.2) It is possible if the third Polaroid sheet makes an angle θ with the optic axes of the polarizer where , 0<θ<90°

(5.3) $T_{\frac{1}{2}} = \frac{0.693}{\lambda}, \qquad \Rightarrow \quad \lambda = \frac{0693}{T_{\frac{1}{2}}} = \frac{0.693}{4.5 * 10^9} = 1.54 * 10^{-10} \quad decay / year$

(5.4) ${}_Z^A X \Rightarrow {}^{A-4}_{Z-2}Y + {}_2^4 He \qquad {}_Z^A X \Rightarrow {}_{Z-1}^{A}X + {}_{-1}e + \nu$

(5.5) $Q = (m_{P.} - m_{D.} - m_{\alpha}) * 931.5 = 4.87 \quad Me.v.$