Midterm Examination
Physics 206/4
February 14, 2017

Time Allowed: 1 1/4 hr.

Maximum Marks 30

NOTE: **Please explain your answers clearly. Failure to do so will invite penalty marks**

1. A mass of 0.5 kg stretches a spring 10.0 cm. The mass is pulled down an additional 3.00 cm and released, (a) find the **initial restoring force**, (b) the **period**, and (c) the **total energy** of the resulting simple harmonic motion. (1,1,2)

2. If the velocity of a disturbance in a steel rod is 2000 m/s and the frequency of vibration is 2000 Hz, find (a) the (a) **time period of oscillation** of each particle of rod, (b) **wavelength** of the disturbance., and (c) the density of the rod (Young's modulus of elasticity = 11x 10^{10} n/m^2. (1,1, 2)

3. The equation of a certain traveling transverse wave is $y = 100\sin 2\pi\left(\frac{t}{0.15} - \frac{x}{25}\right)$, where x and y are in centimeters and t is in seconds. Find (a) the **wavelength**, (b) the **frequency**, and (c) the **velocity** of propagation of the wave? (1,1,2)

4. A string of length 50 cm weighing 0.05 kg is taut between two fixed points of a wall. If the tension in the string 60 N, calculate the (a) **speed** of a sinusoidal wave in this string and (b) the frequency of the fundamental tone. (2, 2))

5. A siren emitting a sound of frequency 1200 Hz moves towards you, and away from a cliff at a speed of 15 m/s. (a) What is the **frequency** of sound you hear coming directly to you from the **siren**? (b) What is the **frequency** of sound you hear reflected from the **cliff**? (speed of sound = 340 m/s) (2,1)

6 The sound level at a distance of 2.0 m from a source is 100 dB. At what **distance** will the sound level be 10.0 dB? (4)

7 The index of refraction of glass is 1.52. Find (a) the speed of light in glass, (b) the angle of refraction in glass if light is incident on water-glass interface at an angle of 40°, and (c) the critical angle of incidence for air-water interface. { n (water) = 4/3} (3)

8. Find the **distance from mirror** of the image of a body 2.0 cm high when placed 15 cm in front of a convex mirror, whose radius of curvature is 40 cm. Is the image **real or virtual**? (1,1,1)

9. Point out whether the following statements are true or false.
   (a) Sound waves can travel through vacuum because they are longitudinal waves.
   (b) There is a phase change of $\pi/2$ when light wave traveling in a lighter medium is reflected by a denser medium.
   (c) The refractive index of glass depends on the wavelength of light.
   (d) Ultrasonic waves travel faster than audible sound waves in an identical medium. (4)

Please turn over to see formulae

Some useful expressions

S.H.M: $ma = -k'x$, $x = A\cos(\omega t + \phi)$, $\omega = 2\pi f$, $f = \frac{1}{T} = \frac{\omega}{2\pi}$,

$P.E \rightarrow V = \frac{1}{2} k' x^2$, $\frac{k'}{m} = \omega^2$, $v = \pm \omega \sqrt{(A^2 - x^2)}$

$E = (K.E + P.E) = \frac{1}{2} k' A^2 = \frac{1}{2} m v^2 + \frac{1}{2} k' x^2$, $T = \frac{2\pi}{\omega} = \frac{2\pi}{\sqrt{k'/m}}$,

(Simple Pendulum): $T = 2\pi\sqrt{\frac{L}{g}}$, **(Torsion Pendulum):** $T = 2\pi\sqrt{\frac{I}{K}}$ $\frac{I \rightarrow \text{moment of inertia}}{K \rightarrow \text{torsion constant}}$

Wave Motion: $y = A\sin 2\pi f\left(t - \frac{x}{v} + \phi\right)$, $y = A\sin(kx - \omega t + \varphi)$, $k = \frac{2\pi}{\lambda}$, $\omega = 2\pi f$, $\frac{\partial^2 y}{\partial^2 x} = \frac{1}{v^2}\frac{\partial^2 y}{\partial^2 t}$, $v = \lambda f$

(Energy/length): $E = 2\pi^2 f^2 \mu A^2$, $\vec{P} = (2\pi^2 f^2 \mu A^2)v$, $\mu \rightarrow$ **(Mass/Length)**

(Trans. w. Speed in Strings): $v = \sqrt{\frac{T}{\mu}}$ **(T→tension)**

Standing Wave: $y = \left\{2A\cos\left(\frac{2\pi x}{\lambda}\right)\right\}\sin(2\pi f t)$. $y = (2A\sin kx)(\cos\omega t)$

(String, both ends fixed)→ $f_n = \frac{v}{\lambda_n} = n\left(\frac{v}{2\ell}\right)$

(Rod): $f_n = n\left(\frac{v}{2l}\right) = \frac{n}{2l}\sqrt{\frac{M_y}{\rho}} \rightarrow$ **(Normal modes),** $v_R = \sqrt{\frac{M_Y}{\rho}}$

(gas) $v_g = \sqrt{\frac{\gamma P}{\rho}}$, $v = 331\sqrt{\frac{T}{273}}$ **(T→abs. temp.)**

(Doppler Effect): $f_0 = f_s\frac{(v - v_0)}{(v + v_s)}$ **(Source and observer moving away),**

(Sound level): $\alpha = 10\log\left(\frac{I}{I_0}\right)$, $I_o = 10^{-12}\ W/m^2$

(Snell's Law): $n_1 \sin i_1 = n_2 \sin i_2$ **Magnification→** $M = \frac{v}{u}$

(Mirror): $\frac{1}{u} + \frac{1}{v} = \frac{2}{R} = \frac{1}{f}$, $\frac{n_1}{u} + \frac{n_2}{v} = \frac{(n_2 - n_1)}{R}$

(Thin lens): $\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$, (**Power**) $P = \frac{1\,m}{f}$ $\frac{1}{f} = (n-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$ **(thin lens)**