THE OPEN UNIVERSITY OF SRI LANKA
B.Sc. DEGREE PROGRAMME -LEVEL 04
FINAL EXAMINATION - 2008/2009
PHU 2141/PHE 4141 - WAVES AND VIBRATIONS & GEOMETRICAL OPTICS.
DURATION : TWO AND HALF (2 ½) HOURS

Date : 14th January 2009 | Time : 9.30 a.m. – 12.00 noon

ANSWER ANY FOUR QUESTIONS ONLY.

(Assume acceleration gravity $g = 10N\ kg.^{-1}$ where necessary unless otherwise stated)

01. a) Define Simple Harmonic Motion, and explain the meaning of the terms amplitude, period, damping. Establish the relation between the amplitude, the period and the maximum velocity of a particle moving with simple harmonic motion.

b) A weighted test tube, which has an external cross-section of area $1.0cm^2$, floats vertically in water of density $1000Kgm^{-3}$ with a length 5.0 cm submerged.

What is the mass of the test tube?

c) Show that if the floating test tube is pushed vertically down a small distance and then is released, it will move up and dawn with a simple harmonic motion. What is the period of this motion?

02. Find, stating clearly any assumptions or conditions, an expression for the period of oscillation of a simple pendulum.

Such a pendulum is of length 1m with a bob of mass 0.2kg. The bob is drawn aside through an angle of 5^0 and released from rest. The subsequent motion is described by $x = aSin(\omega t + \varepsilon)$ where x is the displacement of the bob (in metres) and t the time (measured in seconds) from the instant of release. Find values of a, ω and ε.

What is the maximum velocity and maximum acceleration experienced by the bob?

What are maximum and minimum values for the tension in the string, and where is the motion do these occur?

The angular amplitude reduces to 4^0 in 100s. Find mean loss of energy per cycle.

03. a) What are damped vibrations?

The differential equation governing the motion of a damped simple harmonic vibrator is given by $m\frac{d^2x}{dt^2}+b\frac{dx}{dt}+kx=0$ where all the symbols have their usual significance.

Prove that the solution of this equation is given by; $x = Ae^{\frac{-b}{2m}t}Cos(\omega' t+\phi)$ where the frequency of motion is given by $\omega' = \sqrt{\frac{k}{m}-\left(\frac{b}{2m}\right)^2}$.

b) A damped harmonic oscillator consists of a block (m=2.0kg), a spring (k=10.0N/m), and damping force $F=-bv=-b\frac{dx}{dt}$. Initially, it oscillates with an amplitude of 25.0cm; because of damping, the amplitude falls to three fourth of this initial value at the completion of four oscillations.

i. What is the value of b?
ii. How much energy has been "lost" during these four oscillations?

04. a) Show that in terms of the tensile stress S and the volume density ρ, the speed V of transfers waves in a wire is given by $V=\sqrt{\frac{S}{\rho}}$. The linear density of a string is 1.6 x 10^{-4} kg m^{-1}. A transverse wave is propagating on the string and is described by the following equation;

$$y=(0.021m)Sin2\pi\left[(2.0m^{-1})x+(30s^{-1})t\right].$$

i. What is the wave speed?
ii. What is the tension in the string?

b) A stretched string has a mass per unit length of 5.0g/cm and a tension of 10N, A sinusoidal wave on this string has an amplitude of 0.12mm and frequency of 100Hz and traveling toward decreasing x. Write an equation for this wave.

05. a) i. Explain how stationary transverse waves form on a stretched string when it is plucked.

ii. State the factor that determine the frequency of the fundamental vibration of such a string and give the formula for the frequency of vibration in terms of there factors.

b) When two notes of equal amplitude but with slightly different frequencies f_1 and f_2 are sounded together the combined sound rises and falls regularly.

i. Explain this, and raw a diagram of the resulting wave form.

ii. Show that the frequency of these variations of the combined sound is $|f_1 - f_2|$.

c) Vibration from a 600 Hz tuning fork sets up standing waves in a string clamped at both ends. The wave speed for the string is 400m/s. The standing wave has four loops and amplitude of 2.0mm.

i. What is the length of the string?

ii. Write an equation for displacement of the string as a function of position and time.

06. Consider a longitudinal (compressional) wave of wavelength λ traveling with speed V along the x direction through a medium of density ρ. The displacement of the molecules of the medium from their equilibrium position is given by'

$$S = S_m Cos(kx - \omega t)$$

Show that the pressure variation in the medium is given by;

$$P = \left(\frac{2\pi\rho v^2}{\lambda} S_m\right) Sin(kx - \omega t).$$

a) A continuous sinusoidal longitudinal wave is sent along a very long coiled spring from an oscillating source attached to it. The frequency of the source is 25Hz and the distance between successive points of maximum expansion in the spring is 24cm. Find the wave speed.

b) If the maximum longitudinal displacement of a particle in the spring is 0.30cm and the wave moves in the negative direction of x –axis, write down the equation for the wave. Let the source be at x=0 and the displacement at x=0 be zero when t=0.