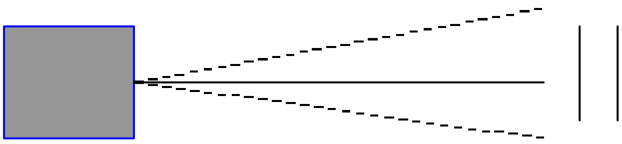
TEST 1 PHYS1231

(15 Marks)

1.(a) A thin metal strip, clamped at one end (as shown below), vibrates with SHM at a frequency $u = 5Hz$ and with amplitude 10mm. The angle of deflection is small and you may neglect horizontal motion.



(i) Write down the full expression for the vertical displacement, *x*, of the end of the strip which includes time and phase information.

(ii) Find expressions for the velocity and acceleration of the end of the strip.

(iii) Give expressions for, and find the numerical values of, the maximum velocity and acceleration.

(b) A small particle of mass 2 g is now placed on the end of the strip considered in part (a). The strip vibrates with SHM at a reduced frequency of 3Hz. Calculate the maximum amplitude of vibration for which the particle remains in contact with the strip.

(18 Marks)

2. (a) A glass U-tube containing liquid of density r may be set into oscillation by lowering the level a small distance *x* in one arm of the tube and then 'releasing' the fluid.

(i) Provide a clearly labelled sketch of this arrangement showing all forces and variables. You may neglect viscosity.

(ii) Derive the equation of motion of the fluid, assuming SHM oscillations of small amplitude.

(b) Three fluids with widely differing viscosities are introduced into the U-tube in turn, and the oscillations are observed for each fluid. The three fluids show undamped (zero viscosity), lightly damped and heavily damped SHM, respectively. Sketch the form of the amplitudes of oscillation as a function of time (i.e. an approximate graph of oscillation amplitude versus time) for the three cases. Mark clearly on your sketch the envelope for the oscillations, and give an equation for the envelope in each case.

(14 Marks)

3. A string is fixed at one end (x=0). Travelling waves on the string are described by the expressions

$$y_1 = 0.20\ \sin(2.0x - 4.0t) \text{ and } y_2 = 0.20\sin(2.0x + 4.0t)$$

where x and y are in metres and t is in seconds. The two waves produce a standing wave pattern.

(i) Find the equation describing the standing wave.

(ii) Calculate the maximum instantaneous amplitude of the wave at x=0.45m.

(iii) Find the first two values of x (with x>0) at which the other end of the string could be fixed.

(iv) Find the maximum amplitude of the string fixed at both ends and the position x at which it occurs.

$$\left[\sin A + \sin B = 2\sin\frac{(A+B)}{2}\cos\frac{(A-B)}{2}\right]$$

(14 Marks)

4.(a) Light of wavelength $l = 546nm$ illuminates, from above, a thin bi-convex lens resting on a glass plate. This optical set produces circular interference fringes. The whole arrangement is in air.

(i) State the phase changes for rays reflected by the lens and the glass plate.

(ii) Calculate the thickness of the air gap between the lower surface of the lens and the glass plate, at the position of the 5th bright ring.

(b) If the arrangement of part (a) is now immersed entirely in a transparent fluid of refractive index n, the 5th bright ring is observed at the (new) position formerly occupied by the 3rd dark ring. Find the refractive index n of the transparent fluid.

(19 Marks)

5. A two-slit interference arrangement (Young's experiment) is illuminated by light of wavelength $l = 600nm$. The slits are each of width 0.1mm and have a centre-to-centre separation of 0.5mm. An interference pattern is observed on a screen 1.0m away, in front of the slits.

(i) Calculate the linear separation of the fringes on the screen.

(ii) Sketch a diagram showing the light *intensity* as a function of angular position at the screen, for the first 7 fringes to one side of the central maximum. Label all features of your sketch clearly.

(iii) For the intensity of the fringes, derive an expression for the 'envelope' curve giving the intensity modulation of the interference fringes and calculate the intensity of the third order fringe relative to the central maximum.