EASTERN UNIVERSITY, SRI LANKA

SECOND YEAR EXAMINATION IN SCIENCE – 1994/95 & 95/96
(August/September 1997) – REPEAT

PH 204 & 205 – PHYSICAL OPTICS AND WAVES & VIBRATIONS

Time: 02 hours.

Answer Four questions only, selecting at least Two from each section.

Section A

1. What are the conditions necessary for the production and observation of interference fringes? Show how these conditions are fulfilled in the Fresnel biprism arrangement. Obtain an expression for the phase difference of the interfering beams in the above arrangement.

   In an experiment with Fresnel biprism, fringes for light of wavelength 5×10^{-5} cm are observed with fringe width 0.2 mm at a distance 175 cm from the prism. The prism is made of glass of refractive index 1.5 and is 25 cm from the illuminated slit.

   Calculate the prism angle of one of the prisms in the biprism.

2. Explain what is meant by "fringes of equal thickness" and "fringes of equal inclination".

   What are the major differences between the circular interference fringes observed in Michelson Interferometer and in Newton's ring experiment, although their appearance are very similar.

   A film of oil of refractive index 1.7 is placed between an equi-convex lens and a flat plate in a Newton's rings arrangement. The refractive index of the glass is 1.5 and the focal length of the lens is 1 metre.

   (a) Draw a simple diagram to show how a single beam is divided to produce an interference pattern in Newton's rings arrangement.

   (b) Find the radius of the 10^{th} bright ring in the interference pattern when wavelength of used light is 6000 Å.

3. Distinguish Fraunhofer and Fresnel diffraction

   Describe Fraunhofer diffraction produced by a single slit and derive an expression for the intensity distribution of light.

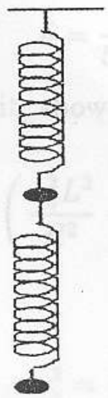
   Hence, obtain the conditions for minimas and maximas in the intensity distribution, and plot a graph of intensity distribution.

   If a slit of width 0.25 mm is illuminated normally with a parallel monochromatic light of wavelength 500 nm, and if the diffraction angle of first secondary maxima is given as $\sin^{-1}(0.0029)$, compare the intensities of principal maxima and first secondary maxima.

Section B

4. Describe 'free vibration' and 'damped vibration' with suitable examples by developing appropriate differential equations.

The given two equal masses m oscillate in the vertical direction as shown in figure.



(a) Write down the equation of motion of each mass.

(b) Show that the frequencies of the normal modes of oscillation in the system are given by

$$\omega^2 = (3 \pm \sqrt{5})\frac{k}{2m}$$

where k is the force constant of both spring.

(c) Show that the ratio of the amplitudes of two masses as

$$\frac{1}{2}(\sqrt{5} \pm 1).$$

(d) Show that the ratio of the total energies stored in two masses as

$$\frac{(3 \pm \sqrt{5})}{2}.$$

5. Derive the equation of motion of a particle of mass m subject to restoring and frictional forces of magnitude kx and $b\frac{dx}{dt}$ respectively, where x is its displacement, k and b are positive constant.

Show that $A \exp(-\gamma t) \cos(\omega t + \phi)$ is only a solution of the equation of motion for $4km > b^2$ and determine the value of γ, where ω, A and ϕ are real constants.

Comment on the physical meaning of this solution.

An object oscillates harmonically with a frequency of 0.5 Hz and its amplitude of vibration is halved in 2 sec. Find a differential equation of the oscillation.

6. Explain briefly what does the quality factor Q represent? Derive an equation for the quality factor Q considering the decay of energy.

(a) In a damped oscillator, if $\omega_\circ^2 - \omega^2 = 10^{-6}\omega_\circ^2$ then show that $Q \approx 500$. Where $\omega_\circ$ is the natural frequency and ω is the normal mode frequency. Show that the logarithmic decrement of the oscillatior as

$$\delta = \frac{\pi}{500}.$$

(b) In an electrical LCR series circuit, show that the quality factor is given as

$$\left(\frac{\omega_\circ^2 L^2}{R^2} - \frac{1}{4}\right)^{\frac{1}{2}}$$

where

$$\omega_\circ^2 = \frac{1}{LC}.$$