



SCT 252-2 Physics II

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Number of questions: Five (05)  
Answer **Four** (04) questions  
Time allocation: Two (02) hours  
Total marks: 100

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1. a. Describe a simple harmonic motion (SHM).  
(5 mark)
- b. Obtain expressions for the velocity  $v(t)$ , acceleration  $a(t)$ , and the total energy  $E$  of an object experiencing a SHM.  
(10 marks)
- c. A block whose mass  $m$  is 680 g is fastened to a spring where spring constant  $k$  is 65 N/m. The block is pulled a distance  $x = 11$  cm from its equilibrium position at  $x = 0$  on a frictionless surface and released from the rest at  $t = 0$ . Find the angular frequency, the frequency, the amplitude, the maximum speed and the maximum acceleration of the resulting motion.  
(10 mark)
  
2. a. What is a damped oscillation?  
(5 mark)
- b. By considering an idealized damped simple harmonic oscillator, obtain an expression for the displacement function  $x(t)$  (without solving the differential equation). Identify all symbols in the expression.  
(10 mark)
- c. Hence, show that, in contrast to an undamped oscillator, the total mechanical energy of a damped oscillator is not a constant but varying exponentially with time.  
(5 mark)
- d. For a damped oscillator with  $m = 250$  g,  $k = 85$  N/m, and  $b = 70$  g/s, calculate the period of the motion. How long does it take for the mechanical energy to drop to one-half its initial value?  
(5 mark)

3. a. What are transverse and longitudinal waves?  
(5 mark)
- b. Applying Newton's second law, obtain an expression for the speed  $v$  of wave along a stretched ideal string to show that it is independent from the frequency  $f$  of the wave.  
(5 marks)
- c. Two strings (string 1 and 2) have been tied together with a knot and then stretched between two rigid supports. The strings have linear densities  $\mu_1 = 1.4 \times 10^{-4} \text{ kg/m}$  and  $\mu_2 = 2.8 \times 10^{-4} \text{ kg/m}$ . Their lengths are  $L_1 = 3.0 \text{ m}$  and  $L_2 = 2.0 \text{ m}$ , and string 1 is under tension of 400 N. Simultaneously, on each string a pulse is sent from the rigid support end towards the knot. Which pulse reaches the knot first?  
(5 mark)
- d. Obtain an expression for the average rate at which the kinetic energy is transmitted by a wave travelling in a string, *i. e.*,  $\left(\frac{dK}{dt}\right)_{avg}$ . Hence, obtain an expression for the average power  $P_{avg}$  transmitted in the string.  
(5 mark)
- e. A string has a linear density  $\mu = 525 \text{ g/m}$  and tension  $\tau = 45 \text{ N}$ . A sinusoidal wave with frequency  $f = 120 \text{ Hz}$  and amplitude  $y_m = 8.5 \text{ mm}$  travels along the string. At what average rate does the wave transport energy?  
(5 marks)
4. a. Describe the following basic phenomena of light.  
reflection, refraction, diffraction, interference, dispersion and scattering  
(5 mark)
- b. Give examples/event/processes from nature whose underlying principles are the phenomena you mentioned above.  
(5 mark)
- c. State Huygen's principle for the propagation of wavelets in a wavefront.  
(5 mark)
- d. A plane wave is travelling in a vacuum from left to right. At  $t = 0$ , it is at a certain position in its motion. Draw a diagram to show the position of the Huygen's wavelets in the wavefront after  $\Delta t$  time later.  
(5 mark)

- e. The law of refraction (Snell's law) can be derived using Huygen's principle. By considering the refraction of light at air/glass interface, drive the law of refraction of light at this interface.  
(5 mark)
5. a. Explain Young's double slit experiment. What kind of property of light is displayed in this experiment?  
(10 mark)
- b. Derive an expression for  $\theta$  to locate the 2<sup>nd</sup> order bright fringes in the interference pattern produced in a double slit experiment.  
(5 mark)
- c. In a typical experiment, the light of wavelength of 546 nm is used to illuminate the first slit in the double slit experiment. If the slit separation is 0.12 mm and the double slit-screen separation is 55 cm, what is the distance on screen between adjacent maxima near the center of the interference pattern?  
(5 marks)
- d. Explain how a Michelson Interferometer works with a diagram showing the instrument and the path of light rays inside the instrument.  
(5 marks)