26-3-18

DOON UNIVERSITY, DEHRADUN

Mid Semester Examination, Second Semester, 2017-18

School of Physical Sciences

Physics Core

Course: PHC-15: Wave and Optics

Time Allowed: 3Hours *Maximum Marks: 30*

Note: Attempt All Questions from Sections A, 3 questions for section B and 2 questions from section C.

SECTION: A Attempt all questions *(Marks: 1 X 6=6)*

1. Which of the following is an entirely longitudinal wave?
   (a) Water wave
   (b) Sound wave
   (c) Electromagnetic wave
   (d) A wave in a stretched string
2. The main factor which affects the speed of a sound wave is,
   (a) amplitude of the sound wave (b) intensity of the sound wave
   (c) loudness of the sound wave (d) properties of the medium
3. A particle moves on the x-axis according to the equation $x = A+B \sin\omega t$. The motion is a SHM with amplitude,
   (a) A (b) B (c) A + B (d) $\sqrt{A^2 + B^2}$
4. For a wave propagating in a medium, identify the property that is independent of the others.
   (a) Velocity (b) Wavelengths (c) Frequency (d) All these depend on each other
5. As a wave travels into a medium in which its speed increases its wavelength.....
   (a) decreases (b) Increases (c) remains the same
6. The Laplace's correction in the expression for the velocity of sound given by Newton is needed because sound waves:
   (a) Are longitudinal (b) Propagate isothermally
   (c) Propagate adiabatically (d) Are of long wavelengths

SECTION: B Attempt any 3 questions. *(Marks 4X3=12)*

1. (i) Define simple harmonic motion (SHM)? Obtain the expression for total mechanical energy of the particles executing SHM. Draw the graph for potential energy and kinetic energy of a linear oscillator as the function of time.

   (ii) Certain radar emits 9400-MHz radio waves in groups 0.08 μs in duration. The time needed for these groups to reach a target, be reflected and return back to the radar is indicative of the distance of the target. The velocity of these waves, like other electromagnetic waves is $c= 3 \times 10^8$m/s. Find
   a) wavelength of these waves,
   b) length of each wave group, which governs how precisely the radar can measure distances of the target, and
   c) number of waves in each group

2. (i) Two collinear SHM acting simultaneously on a particle are given by,

$X_1 = A1 \cos \omega t$

$X_2 = A2 \cos (\omega t+\phi)$

Show that the resultant motion of the particles is SHM. Also obtain the expression for the amplitude and phase constant of the resultant motion in terms of A_1, A_2 and ϕ.

(ii) Two SHMs are represented by the equations,

$Y_1 = 10 \sin (3t +\pi/4)$

$Y_2 = 5 (\sin 3t + \cos 3t)$

What is the ratio of their amplitudes?

3. (i) Deduce the formula for the longitudinal waves in a uniform rod.

(ii) Calculate the velocity of sound in (a) water and (b) steel. Given the density of steel = 7800 kgm^{-3}, Young's modulus of steel = 20 x $10^{10} Nm^{-2}$ and bulk modulus of water = 0.20 x 10^{10} Nm^{-2}.

4. (i) Define the term wave velocity, wavelength and frequency. How they are related?

(ii) What are transverse and longitudinal waves? Give one example of each. Obtain an equation for the displacement of a plane harmonic wave travels in a medium in positive x-direction.

SECTION: C Attempt any two questions ***(Marks: 6X2=12)***

1. (i) Obtain the equation of motion for two mutually perpendicular oscillations having same frequencies. Consider the cases when,

(a) The two component SHMs are in phase, $\phi = 0$

(b) The two component SHMs are out of phase, $\phi = \pi$

(c) The phase difference between the two component SHMs, $\phi = \pi/2$

(ii) A particle of mass 0.2 kg undergoes SHM according to the equation:

$x(t) = 3 \sin (\pi t+\pi//4)$ (t is in second and x is in meter)

(a) What is the amplitude of oscillation?

(b) What is the time period of oscillation?

(c) What is the initial value of *x*?

2. (i) Deduce the expression for the velocity of longitudinal waves in a column of a gas and hence obtain the Newton's formula. What is Laplace's correction to Newton's formula?

(ii) Show that characteristic impedance of a string to transverse wave is $Z = \sqrt{\mu T}$.

3. (i) What is standing wave? Derive the equation that describes a standing wave on a string of length L fixed rigidly at both ends. Describes the modes of vibrations.

(ii) State the characteristic features which distinguish a standing wave from travelling wave.