

**PYL 100: ELECTROMAGNETIC WAVES AND QUANTUM MECHANICS**

Max marks: 25

Date: 9<sup>th</sup> October 2015

Time: 1 hr

*Attempt all the questions.*

Q.1. a) Using the concept of phase velocity  $v_p$  and group velocity  $v_g$  prove that  $v_g < v_p$  in a dispersive medium. 1.5

b) Define wave function and discuss its physical significance. Without derivation, write down the time independent Schrodinger equation. 1.5+1

c) Explain quasineutrality and collective behavior of a plasma. 1.5

d) Our eye receives 120 photons per second of the visible light of wavelength 5600 Å. Find the total energy received by the eye at the threshold, if it is opened for 3 seconds. 2

Q.2. Derive dispersion relation for an electromagnetic wave propagation in an ordinary ion-electron plasma and explain the cutoff mechanism. Discuss various velocities obtained based on the dispersion curve. 4+2

Q.3. Write down Maxwell's equations that are used to study the electromagnetic wave propagation in a conducting medium. Without derivation, write down the dispersion relation applicable in this situation and explain symbols used in it. Based on the real and imaginary parts of the wave number, discuss the attenuation of the wave and explain it physically. Hence, find the enhancement in depth an electromagnetic wave can penetrate in copper medium if the frequency of the wave is reduced from  $10^4$  Hz to 100 Hz. Take  $\sigma = 5.8 \times 10^7 (\Omega m)^{-1}$  and  $\mu = \mu_0$  for copper. 1+1.5+2 +2

Q.4. A uniform plane electromagnetic wave in air with  $E = 100 \cos(\omega t - 4x - 3z)$  V/m is incident (parallel polarization) on a dielectric slab ( $z \geq 0$ ) with  $\mu_r = 1$ ,  $\epsilon_r = 2.5$  and  $\sigma = 0$ . Find i) the angle the electric field makes with the normal, ii) the electric field of the reflected wave, and iii) the Brewster's angle. 1.5+2+1.5

Values of physical constants (SI units):

$$\mu_0 = 4\pi \times 10^{-7}, \epsilon_0 = 8.85 \times 10^{-12}, c = 3 \times 10^8, h = 6.6 \times 10^{-34}$$