Bago University
Department of Physics
Second Semester Examination, September 2019

Third Year (BSc)
(Physics Specialization)

Phys 3108
Electromagnetic Wave Theory
Time Allowed: (3) Hours

Answer any Six questions.

1 (a) Deduce Ohm's Law from field theory point of view.

(b) Starting with Ampere's Law, derive Maxwell's equation in integral form based on this law.

2 (a) State Maxwell's equations in integral form and in differential form in free space.

(b) A parallel-plate capacitor with radius 'R' and separation 'd' has a voltage applied at the center as given by $V = V_0 \sin \omega t$. As a function of radius r (for $r < R$), find (i) the displacement current density $J_d(r)$ and (ii) the magnetic field $H(r)$. Take $d << R$.

3 (a) How do you understand a dispersive medium? Are the phase velocity and group velocity the same or different in a dispersive medium?

(b) In a homogeneous region where $\mu_r = 1$ and $\varepsilon_r = 50$, $\vec{E} = 20\pi e^{(i\omega t - \beta x)} \hat{a}_x \, (V m^{-1})$, $\vec{B} = \mu_0 H_m e^{(i\omega t - \beta x)} \hat{a}_y$. Find ω and H_m if the wavelength is 178 cm.

4 (a) Draw the curves for $E_y = \sin(\beta x - \omega t)$ at three instants of time $t = 0$, $t = T/4$ and $t = T/2$. Also state the phase point and its direction.

(b) At 100kHz a lossless medium has constants $\mu_r = 1$ and $\varepsilon_r = 81$. These constants are approximately by distilled water. Find (i) Z/Z_0, (ii) λ/λ_0, (iii) V/V_0 and (iv) the index of refraction.

5 (a) Distinguish between standing wave and pure standing wave. How do you understand energy velocity?

(b) 3 GHz radio waves from the sun have a flux density of $10^{-20} \, W m^{-2} Hz^{-1}$. (i) What is the Poynting vector for a 1 GHz bandwidth assuming the flux density is constant over this bandwidth? (ii) What is the rms electric field assuming that the power in the 1 GHz bandwidth is at a single frequency? (iii) What is the radio power output of the sun for 1 GHz bandwidth assuming that the sun radiates isotropically? The earth-sun distance as 150 Gm.

6 (a) Explain the instantaneous energy density, peak energy density and average peak energy density. Classify the media according to the value of the ratio $\sigma/\omega\varepsilon$.

(b) A medium has constants $\sigma = 0.1 \, mho \, m^{-1}$, $\mu_1 = 1$, $\varepsilon_1 = 40$. Assuming that these values do not change with frequency does the medium behave like a conductor or a dielectric at (i) 50 Hz (ii) 10 GHz.

7 (a) Explain the transmission-line cell and obtain the impedance of transmission-line cell.

(b) A plane traveling wave has a peak electric field $E_0 = 8 \, V m^{-1}$. If the medium is lossless with $\mu_r = 2$ and $\varepsilon_r = 5$, find (i) velocity of the wave, (ii) peak Poynting vector, (iii) average Poynting vector, (iv) impedance of medium and (v) peak value of the magnetic field 'H'.

8 (a) How do you understand attenuation factor and phase factor? Explain.

(b) A medium has constants $\sigma = 10^2 \, mho \, m^{-1}$, $\mu_r = 4$, $\varepsilon_r = 5$. If the constants do not change with frequency find the 1/e and one percent depth of penetration at (i) 50 Hz, (ii) 4 MHz.

Use if necessary: $\mu_0 = 4\pi \times 10^{-7} \, H m^{-1}$, $\varepsilon_0 = 8.85 \times 10^{-12} \, F m^{-1}$, $Z_0 = 377 \, \Omega$