Birla Institute of Technology & Science-Pilani, K. K. Birla Goa Campus

Second Semester 2022-2023

PHY F241 Mid-semester Examination (Open Text Book) Max. Marks: 60
Electromagnetic Theory-II Duration: 1.5 hours Date: 17 March 2023

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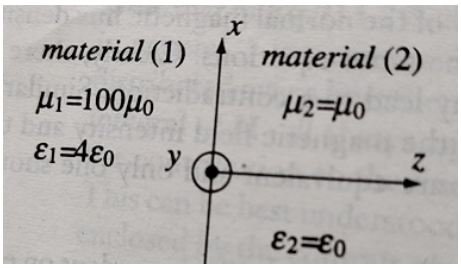
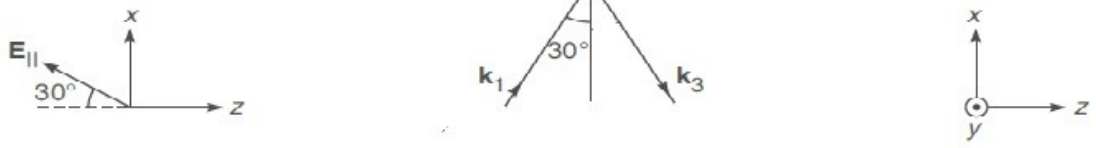
1. The electric field intensity in material (1) in the figure is given by $\overrightarrow{\mathbf{E}}(x,y,z,t) = k(\hat{\mathbf{x}}+2\hat{\mathbf{y}}-3\hat{\mathbf{z}})\cos(377t)$, where k is a constant. Calculate the electric field intensity ($\overrightarrow{\mathbf{E}}$) and electric flux density ($\overrightarrow{\mathbf{D}}$) in material (2). Assume that there are no charges on the interface.

[10 marks]



2. Consider a medium characterized by conductivity $\sigma = 0$, $\mu = \mu_0$ and $\epsilon = 4\epsilon_0$. If
$\overrightarrow{\mathbf{E}} = 20\sin(10^8 t - \beta z)\ \hat{\mathbf{y}}$ V/m
Find β and $\overrightarrow{\mathbf{B}}$ so that $\overrightarrow{\mathbf{E}}$ and $\overrightarrow{\mathbf{B}}$ represent electromagnetic fields. [15 marks]

3. Consider a linearly polarized electromagnetic wave (with its magnetic field vector $\overrightarrow{\mathbf{B}}$ along the y-direction, and with an electric field amplitude of $5\,V/m$) propagating in vacuum. It is incident on a dielectric interface at x=0 at an angle of incidence of 30^0. The frequency associated with the wave is $6\times10^{14}Hz$. The refractive index of the dielectric is 1.5 . Calculate the complete expressions for the electric fields associated with the incident, reflected and transmitted waves. [Hint: *First identify the plane of incidence, polarization vector and wave vector* $\vec{\boldsymbol{k}}$) [15 marks]



4. Consider an infinite parallel plate capacitor with the lower plate (at $z = -d$) carrying a surface charge density $-\sigma$ and the upper plate (at $z = +d$) carrying a charge density $+\sigma$.

   (a) Determine the Maxwell's stress tensor, in the region between the plates.

   (b) From the above, determine the electromagnetic force per unit area on the top plate.

   (c) What is the electromagnetic momentum per unit area, per unit time crossing the the $x-y$ plane?

   (d) if the capacitor plates are moving in the y direction at a constant speed v, what is the electromagnetic momentum in a region of area A?

[20 marks]