School of Physics and Materials Science
Thapar Institute of Engineering & Technology, Patiala
APPLIED PHYSICS (UPH 004)

Tutorial Sheet # 4: Electromagnetic Waves

1. The height of a hill is expressed as $h(x, y) = 5(2\,x\,y - 3\,x^2 - 4\,y^2 - 18\,x + 28\,y + 6)$. Find the location and height of the peak.

2. Find the divergence of function $\mathbf{f} = 2\,\mathbf{k}$. Comment on the result.

3. Plot the function $\mathbf{f}(x, y) = x\,\mathbf{j} - y\,\mathbf{i}$. Also find the curl of this function.

4. A parallel plate capacitor is filled with a material having permittivity $\epsilon = 80\,\epsilon_0$, permeability $\mu = \mu_0$ and resistivity 0.25 Ω m. An alternating signal $V = V_0$ Sin $(2\,\pi\,\upsilon\,t)$ is applied across the plates of the capacitor. Calculate the ratio of conduction current density to displacement current density.

5. An alternating signal $V = V_0$ Sin $(2\,\pi\,\upsilon\,t)$ is applied across a piece of copper. Calculate the ratio of conduction current to displacement current if $\upsilon = 50$ Hz. The resistivity and permittivity of copper are given to be 1.68×10^{-8} Ω m, 5.4×10^{-11} $C^2/N\,m^2$.

6. A square loop of wire of side 5 cm is placed in a uniform magnetic field **B**, such that the normal to the plane of the loop subtends an angle of 60^o with direction of **B**. If the magnetic field strength is given by $(0.5 - 0.002t^3)$ tesla, then find the induced emf in the loop at t = 2 s.

7. Justify that $\mathbf{E}(x, t) = E_0\,e^{i(k\,x\,-\,\omega\,t)}\,\mathbf{j}$ and $\mathbf{B}(x, t) = B_0\,e^{i(k\,x\,-\,\omega\,t)}\,\mathbf{k}$ represent electric and magnetic field vectors of an electromagnetic wave propagating in free space.

8. The conductivity and relative permittivity for a given material are 5 S/m and 1 respectively. An electric field $E = E_0$ Sin $(2\,\pi\,\upsilon\,t)$ is applied across the material. Calculate the value of frequency υ, at which the peak values of conduction and displacement current densities become equal.

9. Calculate the phase difference between electric field and magnetic field inside a good conductor.

10. The resistivity, permittivity and permeability of copper are 1.68×10^{-8} Ω m, 5.4×10^{-11} $C^2/N\,m^2$ and 1.26×10^{-6} N/A^2. Calculate the skin depth for copper at optical frequencies ($\sim 10^{15}$ Hz). Also comment on the result.