Problems $1-4$ will be discussed in the tutorial.

1. (a) Calculate the magnitude of $\vec{E}$ and $\vec{B}$ fields associated with a monochromatic light beam with $2mW$ power ($\lambda = 632.8$nm) propagating in i) vacuum and ii) glass of refractive index 1.5. The beam cross-section is 0.5mm^2. Comment on the relative strengths of $\vec{E}$ and $\vec{B}$ fields and the way light propagates in a non-conducting medium.

   (b) Calculate the radiation pressure exerted by the light beam on a perfectly absorbing medium and also a perfectly reflecting medium.

2. A plane electromagnetic wave traveling in air ($\mu_r = 1$; $\epsilon_r = 1$) has $\mathbf{E} = \hat{y}10\, e^{i(4x-3z-\omega t)}$ Vm^{-1}. The wave falls on a dielectric medium with $\mu_r = 1$ and $\epsilon_r = 1.44$ at $z = 0$ (the surface of the medium is in x-y plane).

   (a) Find the expression for the electric field of the reflected wave.

   (b) Find the expression for the electric and the magnetic fields of the transmitted wave.

3. A light wave is incident from air on crown glass ($n = 1.52$) at an angle $\theta = \frac{\pi}{6}$. The beam is linearly polarized in the plane of incidence. Assume that the magnetic permeabilities are same across the boundary between the two media.

   (a) Determine the amplitude reflection and transmission coefficients, i.e., $\frac{E_{0R}}{E_{0I}}$ and $\frac{E_{0T}}{E_{0I}}$, respectively.

   (b) Find the angle at which the reflected wave would be completely extinguished.

4. Calculate the time averaged energy density of an electromagnetic plane wave in a conductor. Comment on the contributions due to the magnetic field and electric field in a conducting medium.

5. Consider a plane wave of angular frequency ω traveling in a conducting medium of conductivity σ. The electric field is given by $\mathbf{E} = E_0 e^{i(kx-\omega t)}\hat{y}$, where $k^2 = i\mu_0\sigma\omega$.

   (a) Find $\mathbf{B}$.

   (b) Fine the phase difference between $\mathbf{E}$ and $\mathbf{B}$.

   (c) Find the contribution of $\mathbf{E}$ and $\mathbf{B}$ to the energy density.

6. Calculate the reflection coefficient (R) for light beam having angular frequency $\omega = 4 \times 10^{15}$ rad/s at an air-to-silver interface. [Given, $\mu_{air} = \mu_{Ag} = \mu_0$; $\epsilon_{Ag} \approx \epsilon_0$; $\sigma = 6 \times 10^7 (\Omega m)^{-1}$].

7. Consider light traveling in air ($n = 1$) which is incident normally on the wall of a glass plate ($n_1 = 1.5$) of thickness a and eventually passes into water. Find the overall transmission coefficient T (from air to water) and plot it as a function of $k_1 a$ where k_1 is the wave-number of the light in glass. The refractive index of water is $n_2 = 1.3$.

8. Consider a plane polarized electromagnetic wave traveling along z direction in a dielectric of refractive index n_1 and incident normally on a ohmic conductor of conductivity σ and refractive index $n_2 = n_1(1+i\beta)$, where β is a dimensionless real number. The dielectric-conductor interface S_1 lies in the XY plane. The incident electromagnetic wave is linearly polarized in the x direction and the corresponding electric field is represented as $\vec{E}_I = E_{0I}e^{-i(\omega t - k_1 z)}\hat{x}$. Assume $\mu_1 \approx \mu_2 \approx \mu_0$ (the free space permeability). The amplitudes of reflected and transmitted electric fields are E_{0R} and E_{0T}, respectively.
   (a) Write down the expression for the incident magnetic field.
   (b) Write down the expressions for the electric field and magnetic field corresponding to the transmitted wave.
   (c) Find out the free charge density at S_1 using appropriate boundary conditions.
   (d) What is the free surface current density at S_1?
   (e) Write down the boundary conditions at the dielectric-conductor interface S_1 for the components of $\vec{E}$ and $\vec{B}$ fields parallel to the interface to find out the phase change undergone by the electric field vector of the reflected wave.