Short question answers:

1. A uniform plane wave has a wavelength of 2cm in free space and 1 cm in a perfect dielectric ($\sigma = 0, and\ \mu_r \simeq 1$). Determine the relative permittivity of the dielectric.
2. Show that Maxwell's equations predicts the existence of electric and magnetic waves.
3. Are scalar and vector potentials measurable? Justify your answer.
4. Justify the statement that in electromagnetic waves, electric field vector is more important than magnetic field vector
5. A Babinet compensator is inserted between two crossed nicols and oriented at 45^o to the polarizer. Draw the appearance pattern emerging from the analyzer for monochromatic as well as for white light.
6. A glass tube of length 20 cm, filled with sugar solution produces an optical rotation of 15^o . This solution is diluted to one-forth of its initial concentration, calculate the optical rotation produced by 30 cm long tube.
7. Do static electromagnetic fields possess linear and angular momentum? Give reasons.
8. An electromagnetic wave of frequency 10^{15} Hz propagates in a conductor of conductivity $5.8x10^7$mho/m. Find the ratio of the peak values of conduction and displacement current.
9. Starting from Maxwell equations prove (a) coulomb law (b) continuity equation

Questions:

1. A plane electromagnetic wave , with its electric field (E) is in the plane of incidence is incident at the interface of two dielectrics characteristics by refractive index $n_1\ and\ n_2$. Write expressions for Fresnel's equation for E vector parallel to the plane of incidence show that (a) $\frac{E_r}{E_i} = 0$ when $\theta_i + \theta_t = \frac{\pi}{2}$
   (a) Using the above equation derive Brewster law which states that if when $\theta_i = \theta_p = tan^{-1}\frac{n_2}{n_1}$ the reflected light is linearly polarized.
2. Show that a uniform , plane e.m. wave when incident on a sharp interface between two homogeneous, isotropic, linear dielectric remains frequency invariant on suffering either reflection or transmission.
3. Show that Maxwell's equations can be expressed as two coupled second order partial differential equations in terms of scalar and vector potentials. How does the above equations get simplified using Lorentz gauge? .
4. Show that although electromagnetic vector and scalar potentials are not unique in themselves they define the fields $\vec{E}$ and $\vec{B}$ uniquely.
5. Establish the law of conservation of energy for the electromagnetic field. Explaining the meaning of various terms involved in it, obtain the dimension of Poynting vector.

6. In an anisotropic media, prove that D,E,K vectors of electromagnetic wave are coplanar.
7. A beam of light is passed through a polarizer. if the polarizer is rotated with the beam as an axis, the intensity I of the emergent beam does not vary. What are the possible states of polarization of the incident beam? How to ascertain its state of polarization with the help of the given polarizer and a QWP?

Problems:

1. A100-V/m plane wave of frequency 300MHz travels in the positive Z direction in a medium having $\epsilon_r = 9$, $\mu_r = 1$ and,σ=0. Write the complete time domain expression for field vectors.

2 The expression for the instantaneous electric field vector of a uniform plane wave propagating in negative x-direction in a medium is given by $\vec{E} = \hat{y}\, 2 \times 10^3 \exp[2\pi(9 \times 10^{15} t + 6 \times 10^7 x)]\, V/m$ what is (a) The phase velocity of propagation (b) Wavelength of wave (c) Refractive index of medium (d) The direction of the $\vec{H}$ field.

3 An optical fiber has a core of refractive index 1.5 which is cladded with a material of refractive index 1.48. Show that all rays making an angle less than 14° with fiber axis will be guided through the fiber.

4. A beam of light is passed through a polarizer. if the polarizer is rotated with the beam as an axis, the intensity I of the emergent beam does not vary. What are the possible states of polarization of the incident beam? How to ascertain its state of polarization with the help of the given polarizer and a QWP?
5. (a) For the glass –air interface (n_1=1.5 ,n_2=1.0) calculate the critical angle. (b) Assuming λ=6x10-7 m and the angle of incidence to be 60 degree. Calculate the distance (in the rarer medium) in which the field reduces by a factor of 2.

Application Based

1.For a y polareised e.m wave incident normally at the interface of two media characteristics by intrinsic impedances η_1 and η_2 . The electric field associated with incident (E_i) , reflected (E_r) and transmitted (E_t) are given by $E_i = \hat{j} E_{io} e^{j(\omega t - k_1 x)}$ $E_r = \hat{j} E_{ro} e^{j(\omega t + k_1 x)} E_t = \hat{j} E_{to} e^{j(\omega t - k_2 x)}$

(a). Obtain the corresponding magnetic field. (b) Show that the ration of amplitude of (i) incident and reflected (ii) incident and transmitted waves are given by

$$r = \frac{E_{or}}{E_{oi}} = \frac{\eta_2 - \eta_1}{\eta_2 + \eta_1} \qquad t = \frac{E_{ot}}{E_{oi}} = \frac{2\eta_2}{\eta_2 + \eta_1}$$

2. Consider a y-polarized e.m wave (propagating along the x-axis) incident normally on the interface of a dielectric (characterized by μ_1 and ε_1) and a good conductor (characterized by σ_2, μ_2 and ε_2). By good conductor we imply

$$g = \frac{\sigma_2}{\omega \varepsilon_2} \geq 1.$$

Show that the reflectivity is approximately given by $R = 1 - 2\sqrt{\frac{2\omega\mu_2\varepsilon_1}{\sigma_2\mu_1}}$

3. An e.m wave propagating in free space is described by the equation

$$E = \hat{x}E_o \cos(\omega t - kz) - \hat{y}E_o \sin(\omega t - kz)$$

(i) Determine the state of polarization of wave

(ii) Determine the magnetic field and the Poynting vector.