Problem Sheet - 7
(E.M. Theory and Special Theory of Relativity)

1. A plane electromagnetic wave polarised perpendicular to plane of incidence is incident obliquely on the interface of two simple dielectric media. Using boundary conditions obtain the expressions for reflection and transmission coefficients.

2. Explain how Maxwell modified Ampere's circuital law.

3. The intensity of sunlight hitting the earth is about $1300\text{W}/m^2$. Find the amplitude of electric and magnetic fields.

4. Write down Maxwell's equations in free space. Obtain the wave equations for electric and magnetic field intensity from them.

5. State and establish Poynting's theorem.

6. In the presence of plane e.m. wave $\vec{E} = \vec{E}_0 exp[i(wt - \vec{k}.\vec{r})]$, the permittivity of a gaseous medium becomes complex and is given by

$$\epsilon = \epsilon_0[1 + \frac{Ne^2}{m\epsilon_0}\Sigma\frac{f_j}{[(\omega_j^2 - \omega^2) - i\gamma_j\omega]}]$$

   where the symbols have their usual meanings. Consider now a dilute gas having a single resonance frequency ω_0. Assume further $\gamma << \omega_0$. Hence show that the index of refraction assumes its maximum and minimum values at points where the absorption coefficient is half maximum.

7. Consider the frames S,S' and S" are all parallel. S' and S" are moving along x axis in the positive direction. Velocity of S' with respect to S is β_1c and that of S" with respect to S' is β_2c. Show that Lorentz transformation equations from S to S" are given by

$$x'' = \gamma(x - \beta ct), y'' = y, z'' = z, ct'' = \gamma(ct - \beta x)$$

   where

$$\gamma_i = \frac{1}{(1 - \beta_i^2)^{1/2}}, (i = 1, 2, 3); \beta = \frac{\beta_1 + \beta_2}{1 + \beta_1\beta_2}$$

   and

$$\gamma = \gamma_1\gamma_2(1 + \beta_1\beta_2)$$

   What conclusion do you draw from the result?

8. A space traveller with velocity v synchronises his clock (t'=0) with the earth friend (t=0). The earth friend then observes both clocks simultaneously, t directly and t' through a telescope. Show that when t' reads one hour, t reads

$$\left(\frac{1+\beta}{1-\beta}\right)^{1/2} \qquad ;\beta = v/c$$

9. Light is travelling through a medium of refractive index n. The medium is travelling with respect to some observer in the same direction as that of light with a velocity v. What is the velocity of light in the medium as measured by the observer?

10. Describe briefly the results of Michelson-Morley experiment.

11. What is space-like interval? Explain whether there is any violation of the principle of causality in relativity for two events separated by space-like interval.

12. Starting from the expression for force as rate of change of relativistic momentum and using the expression for energy given by $E = T + m_0c^2$, show that the acceleration is not always parallel to force. Hence define 'longitudinal' and 'transverse' mass.