

(4)

that the interaction energy of two dipoles separated by a displacement \vec{r} is

$$U = \frac{1}{4\pi\epsilon_0} \frac{1}{r^3} [\vec{p}_1 \cdot \vec{p}_2 - 3(\vec{p}_1 \cdot \hat{r})(\vec{p}_2 \cdot \hat{r})]. \quad 5 + 5$$

5. Obtain the rate of work done on the charges of an arbitrary charge-current distribution by the electromagnetic field produced by it. Establish the energy conservation theorem. 5 + 5

6. Obtain the electric and magnetic components, \vec{E} and \vec{B} , of the electromagnetic field in terms of potentials \vec{A} and ϕ . Derive the condition of validity of Maxwell's equations under potential formulation. What is gauge invariance? Discuss Coulomb gauge. 2 + 4 + 4

7. Derive the wave equations for propagation of electromagnetic wave in free space. Under the plane wave solution, obtain the properties of the electromagnetic wave propagation. 5 + 5

(5)

8. On the basis of damped harmonic oscillation model for electron in the atom obtain the expression for dielectric constant $\epsilon(\omega)$. Discuss the low frequency behaviour of $\epsilon(\omega)$ and obtain Cauchy's dispersion formula. 5 + 5