

M.A./M.Sc. Examination 2018

Semester - III

Mathematics

Course: MME-31 (Applied Stream) (Old) (Electromagnetic Theory and Special Theory of Relativity)

Time: Three Hours

Full Marks: 40

Questions are of value as indicated in the margin.
Notations and symbols have their usual meanings.

Attempt **any four** questions.

1. a) State and explain the Coulomb's law in electrostatics for two point charges. 1+1
b) What is an electric dipole? Define torque for a spatially uniform electric field \vec{E} . Find the potential and field due to an electric dipole. 1+1+1+1
c) Determine the potential energy of an electric dipole placed in an external electric field. 4
2. a) Starting from the expression for the electrostatic potential
$$\phi(\vec{r}) = \frac{1}{4\pi\epsilon_0} \int_V \frac{\rho(\vec{r}_0) dV_0}{|\vec{r} - \vec{r}_0|},$$
obtain the Poisson law : $\nabla^2\phi = -\rho/\epsilon_0$. 4
b) Derive the equation of continuity for a steady state current of electric charges. What is Ohm's law? Hence show that for a steady state current, the continuity equation reduces to the Laplace equation for the electrostatic potential. 3+2+1
3. a) Define magnetic scalar potential. Derive its expression for a closed current loop. 2+4
b) Explain the phenomenon of electromagnetic induction and hence establish the differential form of Faraday's law. 4
4. a) Write down the Maxwell's equation with their physical interpretations. 4
b) What do you mean by the 'energy density' of a magnetic field? Show that it is given by $u_m = \frac{1}{2} \mu_0 H^2$. 6
5. a) State the postulates of Einstein's special theory of relativity. 4
b) Discuss the Lorentz transformation formulae and deduce the length contraction and time dilation. 2+2+2
6. a) From the expression for the kinetic energy of a moving particle in relativistic mechanics, establish the universal equivalence between mass and energy. 6
b) Derive the expressions for the relativistic force and acceleration of a particle. 4