SAMPLE QUESTIONS FOR PHYSICS HONOURS FOURTH SEMESTER

UNIT-I: SPECIAL THEORY OF RELATIVITY

1. What is a *reference frame*?
2. What are *inertial* and *non-inertial frames* of references? Give examples.
3. What is a *Galilean transformation*?
4. Is the acceleration of a particle invariant under Galilean transformation?
5. Show that Newton's second law is invariant under Galilean transformation.
6. Write down *inverse Galilean transformations.*
7. Show that the Galilean transformations are inadequate to describe a light pulse.
8. Discuss on *ether drag hypothesis*?
9. Draw the experimental set-up of Michelson-Morley's experiment. Discuss its experimental result.
10. Explain the negative results of Michelson-Morley's experiment.
11. What is the significance of the null results of Michelson-Morley's experiment?
12. State the basic postulates of special theory of relativity.
13. What is the basic difference between the two types of theories of relativity?
14. State Lorentz transformation equations.
15. Establish Lorentz transformation equations.
16. How are Lorentz transformations different from Galilean transformations?
17. Show that Lorentz transformation equations reduces to Galilean transformation equation when $v \ll c$.
18. Show that $x^2 + y^2 + z^2 - c^2t^2$ is invariant under Lorentz transformations.
19. Explain the *simultaneity*.
20. Show that the space and time interval between two events individually are not invariant but space-time interval is invariant under Lorentz transformation.
21. *Simultaneity is not absolute but relative*- explain.
22. Explain (a) *Lorentz-Fitzgerald contraction* &(b) *time dilation.*
23. What are meant by *proper length* and *proper time interval*?
24. Explain *'twin paradox'.*
25. State and explain the relativistic law of addition of velocities.
26. Explain how *length contraction, time dilation* and *mass variation* expressions might be used to indicate that c is the limiting speed in the universe.
27. Show that the addition of a velocity to the velocity of light gives the velocity of light.
28. Derive the law of variation of mass with velocity.
29. Derive an expression for the (i) kinetic energy, (ii) rest-mass energy and (iii) total energy of relativistic particle.**Or,**
30. **Establish Einstein's mass-energy relation. Discuss the importance of mass-energy relation. Give at least two examples in support of mass-energy equivalence.**
31. Show that expression for the relativistic kinetic energy reduces to non-relativistic kinetic energy when $v \ll c$.
32. Obtain the relation between relativistic momentum and energy. **Or,**
33. Derive the relation, $E^2 = p^2c^2 + {m_0}^2c^4$, where symbols have their usual meanings.
34. Show that $E^2 - p^2c^2$ is invariant under Lorentz transformation.
35. A spaceship is moving at 0.3 times the speed of light relative to the earth. If the spaceship has a length of 15 meters, how long will it appear when observed from the earth?

36. Explain why a particle cannot move faster than velocity of light.
37. Show that D' Alembertian operator $\Box^2 = \frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2} + \frac{\partial^2}{\partial z^2} - \frac{1}{c^2}\frac{\partial^2}{\partial t^2}$ is Lorentz invariant.
38. Prove that to a stationary observer, the moving clock appears to go slow.
39. Obtain Einstein's formula for *addition of velocities.* Hence show that c is the ultimate speed. Also show that the law is in conformity with the principle of constancy of speed of light.
40. With the help of Lorentz transformations find an expression $x^2 - c^2 t^2$ in terms of x' and t'.**Ans.** $(x'^2 - c^2 t'^2)$
41. Show by direct applications of Lorentz transformations that $x^2 + y^2 + z^2 + w^2$ is invariant, where $w=ict$, $i=\sqrt{-1}$
42. Establish the relation giving the variation of *mass* with *velocity* of a particle.
43. Derive the relation,

$$m=\frac{m_0}{\sqrt{1-\frac{v^2}{c^2}}}$$

where symbols have their usual meanings.
44. Derive relativistic expression for the KE of a particle. Show that it reduces to classical expression when $v \ll c$.
45. Obtain the relation $E = mc^2$. What is mass-energy equivalence?
46. By what factor is the density of an object increased when it is moving with velocity v?
47. Find the velocity if the mass of a particle is double to its rest mass.
48. Show that the rest mass of a particle of momentum p and kinetic energy T is given by

$$m_0 = \frac{p^2 c^2 - T^2}{2Tc^2}$$

49. Show that a particle with rest mass zero travels with the speed of light.
50. An electron and positron practically at rest come together and annihilate each other. Calculate the energy released.
51. Establish transformation equations for momentum and energy.

+ Numerical Problems

UNIT-II: MAGNETOSTATICS

1. Define *Lorentz force*.
2. Does a magnetic field do any work on a moving charge?
3. Find an expression for force on a current carrying wire placed in a magnetic field.
4. State and explain Biot-Savart's law in vector form.
5. *Write down Biot-Savart law for line current, surface current and volume current element.*
6. Find an expression for magnetic field due to long straight wire using Biot-Savart law.
7. *Find the magnetic field on the axis of a circular coil of 'n' turns and radius 'a'. Also show graphically, the variation of magnetic field with axial distant.*
8. *Show that magnetic field due to short solenoid is ,*$B = \frac{\mu_0 I n}{2}(cos\theta_1 - cos\theta_2)$*. Also show that the magnetic field at any end is half that at any point well inside for a long solenoid.*
9. Find an expression for force per unit length in a current carrying straight wire due to another current carrying conductor placed parallel to each other.
10. Find the magnetic field at the centre of a square coil.
11. State and prove Ampere's circuital law.
12. Using Ampere's circuital law, find the magnetic field both inside and outside the wire.
13. Using Ampere's circuital law, find the magnetic field due to a solenoid.
14. Using Ampere's circuital law, find the magnetic field due to a toroid.
15. *Show that in case magnetic field,* $\vec{\nabla}.\vec{B} = 0$.
16. *What is the physical significance of*$\vec{\nabla}.\vec{B} = 0$?
17. *Show that in case magnetic field,* $\vec{\nabla} \times \vec{B} = \mu_0 \vec{J}$
18. *What is vector potential? Find a general expression for vector potential for current element* $d\vec{l}$.
19. Find the vector potential due to a straight wire carrying current I and hence find the magnetic field.
20. Show that magnetic vector potential due to current loop is, $\vec{A} = \frac{\mu_0}{4\pi}\frac{\vec{m}X\vec{r}}{r^3}$. Using the expression for vector potential for current loop, find the magnetic field due an electrical dipole.
21. Derive Biot-Savart's law and Ampere's circuital law from the concept of *magnetic vector potential.*

Numericals

22. *An electron is rotating* n *times per second around the nucleus in a circular orbit of radius a. Find the magnetic field at the nucleus.*
23. *A wire carrying current I is bent in the form of a regular* n*-sided polygon. The distance of any vertex from the centre of the polygon is r. find the magnetic field at its centre. Discuss the case when* $n \to \infty$.
24. A uniform magnetic field of 1.5 tesla applied X- direction. An electron of energy 1 MeV moves along Z-direction. Calculate the force on it.

25. A 10 cm long wire carrying a current of 1 amp is held at an angle 30^0 with the direction of a uniform magnetic field of strength 1 Wb/m^2. Calculate the force acting on the wire.
26. A current of 1 amp flows in each of two conducting wires parallel to each other. The separation between the wires is 2 cm. Find the force per unit length of one wires.
27. A solenoid 1 m long and radius 4 cm has 1000 turns and is carrying a current of 1 A. find the magnetic field at the centre.
28. A steady current I flows down a long cylindrical conductor of radius a. The current density at a distance r from the axis of the conductor is proportional to r. calculate the magnetic field both inside and outside the wire as a function of r.
29. A current distribution gives rise to the magnetic vector potential $\vec{A}(x,y,z) = x^2 y\hat{\imath} + y^2 x\hat{\jmath} - xyz\hat{k}$ (T-m). Find the corresponding magnetic field at (-1, 2, 5).