TYBSC Sem-VI 12/4/17 (55)
Special Theory of Relativity 2016-2017 Special
& Indtrn. Cosmology

Q.P. Code : 02142

[Marks:75]

[Time: $2\frac{1}{2}$ Hours]

N.B: Please check whether you have got the right question paper.
1. All questions are **compulsory.**
2. **Figures** to the **right** indicate **full** marks.
3. Draw **neat** diagrams wherever **necessary.**
4. Symbols have usual meaning unless otherwise stated.
5. Use of **log table** and **non-programmable** calculator is allowed.

Q.1 a) Attempt any **one:---**

i) Derive the relativistic equations for aberration of light and Doppler's effect in relativity. **(10)**

ii) State the postulates of special theory of relativity and using Lorentz transformation equations of space and time derive the formula for length contraction and time dilation. **(10)**

b) Attempt any **one:---**

i) A source of light emitting Sodium D2 line (5890 °A) and is moving along a circle with constant speed 0.6c relative to an observer fixed at the centre of the circle. Find the wavelength of light as observed by the observer. **(05)**

ii) ii) Show that the quantity $x^2 + y^2 + z^2 - c^2t^2$ is invariant under Lorentz transformation equations of space-time co-ordinates. **(05)**

Q.2 a) Attempt any **one:---**

i) Applying the principle of conservation of linear momentum to the perfectly elastic collision between two identical particles in inertial frame of reference, obtain an expression for relativistic mass. **(10)**

ii) Derive the expressions for longitudinal and transverse mass with respect to the direction of motion of two inertial frames. **(10)**

b) Attempt any **one:---**

i) Derive relativistic relation between total energy E and momentum p **(05)**

$$E^2 = p^2c^2 + m_o{}^2c^4.$$

ii) The density of silver is 10.5gm/cm^3 when it is at rest relative to an observer. What is its density when it is moving with relative velocity 0.8c. **(05)**

Given: $c = 3 \times 10^8$ m/s.

Q.3 a) Attempt any **one:---**

i) Derive the transformations for electric field intensity $\vec{E}$ using Lorentz transformations equations for force. **(10)**

ii) Two equal charges **+q** separated by distance **r** lying in XY plane relative to the frame S and having same X coordinate are moving with same velocity $\vec{u}$ along X axis relative to the frame S. Using Lorentz transformation of force find the resultant force exerted by the two charges on each other. **(10)**

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b) Attempt any **one:---** (05)

i) Show that the scalar product $\vec{E}.\vec{B}$ is invariant under Lorentz transformations of $\vec{E}$ and $\vec{B}$. (05)

ii) If charge `+q' is kept stationary in inertial frame S'. Determine the components of magnetic induction $\vec{B}$.in inertial S frame, assume that S' is moving with respect to S along x-x' axis with constant velocity v.

Q.4 a) Attempt any **one:---** (10)

i) Discuss in brief Optical, X ray and Radio Astronomy.

ii) Explain the phenomenon of gravitational red- shift of spectral line. Derive an expression for the modified frequency of the spectral line. (10)

b) Attempt any **one:---**

i) Explain the Twin Paradox in brief.

ii) With the help of Minkowski space time diagram explain the relativity of simultaneity.

Q.5 a) Attempt any **one:---**

i) A spaceship is 100 m long on the ground. When it is in flight it appears to be 98 m long, Find its speed. Given c = 3×10^8m/s.

ii) A vector is represented as $\vec{r'}=3\hat{\imath}+8\hat{\jmath}+5\hat{k}$ in a frame moving with a velocity given by v = 0.5c $\hat{\imath}$ related to a stationary frame. What is the vector representation in a stationary frame?

b) Attempt any **one:---**

i) Two identical particles of rest mass m_0 travelling in opposite directions, each with velocity v collide head on. The particles stick together after the collision forming a new particle of rest mass M_0, which is at rest. Show that though energy and momentum are always conserved, rest mass is not conserved ($M_0 > 2\ m_0$).

ii) The distance between the sun and the earth is 1.5×10^8 km and the earth receives energy at the rate of 1.34×10^3 watt/m^2. Find the annual loss of the mass of the sun.

C) Attempt any **one:---**

i) Show that $j_x^2 + j_y^2 + j_z^2 - c^2p^2$ is invariant under Lorentz transformations for current and charge density.

ii) If a small box has electric charge density as $1C/m^3$ when observed at rest. Determine its charge density when the box starts moving at speed of 0.8c with respect to observer.

d) Attempt any **one:---**

i) Give brief account of `Quasars'

ii) State and explain Hubble's Law.

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