UNIVERSITY OF RUHUNA

BACHELOR OF SCIENCE (GENERAL) DEGREE LEVEL II (SEMESTER II)

EXAMINATION–NOVEMBER/DECEMBER 2016

SUBJECT: PHYSICS

COURSE UNIT: PHY 2214 **TIME: Three (03) hours**

Answer **all** questions in **Part I** (M.C.Q) and **only FIVE (05)** questions from **Part II**

PART I

Answer **all** Questions – (30 minutes)

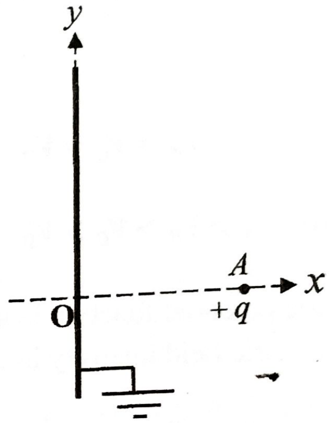
(Mark the correct answers in the given answer sheet)

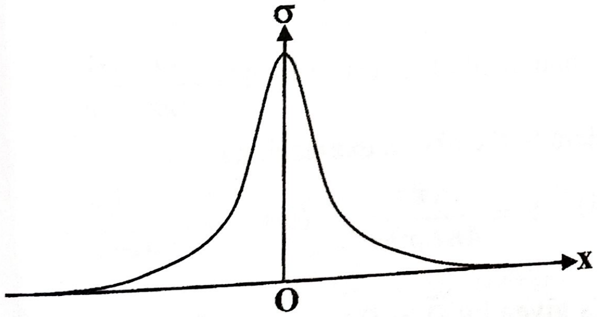
All symbols have their usual meaning.

1. What is the differential form of Gauss's law?

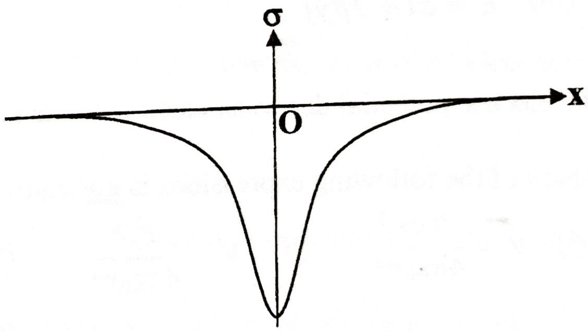
   (i) $\nabla.\vec{D} = \frac{\rho}{\varepsilon}$ (ii) $\nabla.\vec{E} = \frac{\rho}{\varepsilon_0}$ (iii) $\nabla.\vec{E} = \rho$ (iv) $\nabla.\vec{B} = \rho$

2. A $+q$ charge is placed at the point A, near infinitely large, grounded, conducting plate perpendicular to x-axis as shown in the figure. The variation of induced charge density (σ) on the conducting plate is correctly represented by the figure





(i)



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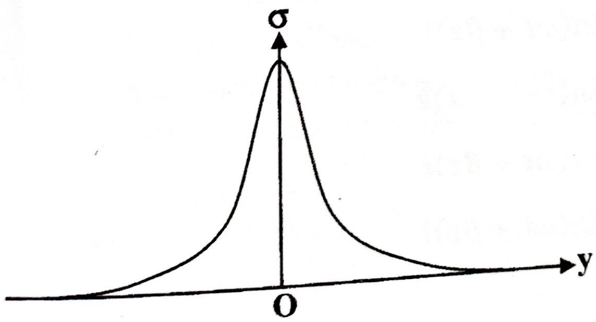

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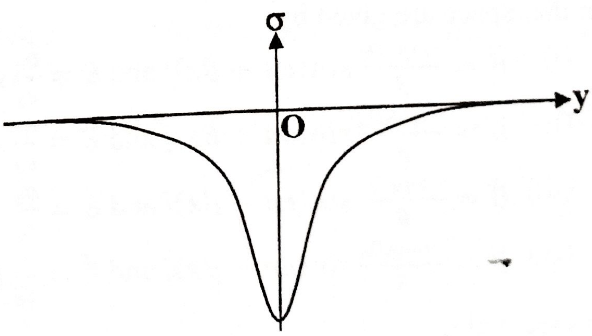


(iv)

3. The velocity of light in free space is equal to

(i) $\sqrt{\varepsilon_0/\mu_0}$ (ii) $\sqrt{\mu_0/\varepsilon_0}$ (iii) $\sqrt{\varepsilon_0\mu_0}$ (iv) $1/\sqrt{\varepsilon_0\mu_0}$

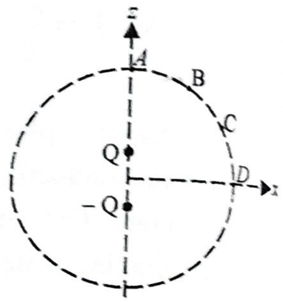
4. Electric potential at a point on the equatorial plane of an electric dipole with dipole moment p located at a distance r from the electric dipole is

(i) zero (ii) $P/4\pi\varepsilon_0 r$ (iii) $P/4\pi\varepsilon_0 r^2$ (iv) $P/4\pi\varepsilon_0 r^3$

5. Electric field vectors of two dielectric media at an interface are given by $\vec{E}_1 = 2\hat{\imath} + 4\hat{\jmath} - 3\hat{k}$ and $\vec{E}_2 = 2\hat{\imath} - 4\hat{\jmath} - 3\hat{k}$. Which of the following could be the possible interface?

(i) *ZOX* plane (ii) *XOY* plane (iii) *YOZ* plane (iv) *X+Y=1* plane

6. Figure shows an electric dipole located along the z axis. If the electric potentials at the points A, B, C and D are V_A, V_B, V_C and V_D respectively,



(i) $V_A = V_B = V_C = V_D$ (ii) $V_A < V_B < V_C < V_D$

(iii) $V_A > V_B > V_C > V_D$ (iv) $V_A = V_B = V_C = V_D = 0$

7. Electric potential function in a space is given by $V = \propto x + \beta y^2$. Here α and β are constants. The electric field intensity in that space is given by

(i) $\vec{E} = \alpha\frac{x^2}{2}\hat{\imath} + \beta\frac{y^3}{3}\hat{\jmath}$ (ii) $\vec{E} = -\alpha\frac{x^2}{2}\hat{\imath} - \beta\frac{y^3}{3}\hat{\jmath}$

(iii) $\vec{E} = \alpha\hat{\imath} + 2\beta y\hat{\jmath}$ (iv) $\vec{E} = -\alpha\hat{\imath} - 2\beta y\hat{\jmath}$

8. The electric potential due to an electric dipole in usual symbols is given by $V = \frac{Q}{4\pi\varepsilon_0}\frac{s\cos\theta}{r^2}$.

Which of the following expressions is **not** equivalent to the above expression?

(i) $V = \frac{P\cos\theta}{4\pi\varepsilon_0 r^2}$ (ii) $V = \frac{\vec{P}.\hat{r}}{4\pi\varepsilon_0 r^3}$ (iii) $V = \frac{\vec{P}.\vec{r}}{4\pi\varepsilon_0 r^3}$ (iv) $V = \frac{\vec{P}.\hat{r}}{4\pi\varepsilon_0 r^2}$

9. In a free space the electric displacement vector is given by $\vec{D} = D_0 sin(\omega t + \beta z)\hat{\imath}$. $\vec{B}$ and $\vec{E}$ in that space are given by

(i) $\vec{B} = \frac{-\omega\mu_0 D_0}{\beta} sin(\omega t + \beta z)\hat{\imath}$ and $\vec{E} = \frac{D_0}{\varepsilon_0} sin(\omega t + \beta z)\hat{\jmath}$

(ii) $\vec{B} = \frac{-\omega\mu_0 D_0}{\beta} sin(\omega t + \beta z)\hat{\jmath}$ and $\vec{E} = \frac{D_0}{\varepsilon_0} sin(\omega t + \beta z)\hat{k}$

(iii) $\vec{B} = \frac{-\omega\mu_0 D_0}{\beta} sin(\omega t + \beta z)\hat{\imath}$ and $\vec{E} = \frac{D_0}{\varepsilon_0} sin(\omega t + \beta z)\hat{\imath}$

(iv) $\vec{B} = \frac{-\omega\mu_0 D_0}{\beta} sin(\omega t + \beta z)\hat{\jmath}$ and $\vec{E} = \frac{D_0}{\varepsilon_0} sin(\omega t + \beta z)\hat{\imath}$

respectively.

10. The maximum number of spin quantum states allowed for a given magnetic quantum state of an electron in an atom is

(i) 1 (ii) 2 (iii) n - 1 (iv) n

11. Which of the following statements is incorrect according to Dalton's atomic theory?

(i) Elements are made of extremely small particles called atoms.
(ii) Atoms of a given element are identical in size, mass and other properties.
(iii) Atoms can be subdivided, created or destroyed.
(iv) Atoms of different elements combine in simple whole number ratios to form chemical compounds.

12. Emitted radiation of a cavity behaving as a blackbody depends on the,

(i) temperature of the cavity (ii) shape of the cavity
(iii) material made up of the cavity wall (iv) both temperature and shape of the cavity

13. The spectral line of the limiting member of Balmer series in hydrogen atom corresponds to a transition from,

(i) $n = \infty$ to $n = 1$ (ii) $n = \infty$ to $n = 2$ (iii) $n = 2$ to $n = 1$ (iv) $n = 3$ to $n = 2$

14. Atomic spectra is an example of

(i) line spectra (ii) continuous spectra (iii) band spectra (iv) both (i) and (ii)

15. Electrons are held in an atom due to

(i) Coulomb force (ii) nuclear force (iii) atomic force (iv) both (i) and (ii)

16. The rest mass of a x-ray photon is

(i) greater than the mass of a proton (ii) greater than the mass of an electron
(iii) very small value (iv) zero

17. Which of the following statements is correct?

(i) Maximum kinetic energy of a photoelectron is directly proportional to the intensity of incident radiation.
(ii) Maximum kinetic energy of a photoelectron is inversely proportional to the intensity of incident radiation.
(iii) Maximum kinetic energy of a photoelectron is independent of the intensity of incident radiation.
(iv) Maximum kinetic energy of a photoelectron is directly proportional to the square root of intensity of incident radiation.

18. The energy of a photon can be written as

(i) $E = \sqrt{p^2c^2 + m_0^2c^4}$

(ii) $E = \frac{1}{2}m_0v^2 + m_0c^2$

(iii) $E = pc$

(iv) $E = m_0c^2$

19. Which of the following statements is not true?

a) The Michelson-Morley experiment is probably the most famous null experiment.
b) According to the Einstein's postulates, the laws of physics are the same in all inertial frames of reference.
c) The value of the speed of light in free space is not the same in all inertial frames of reference.

(i) a only (ii) c only (iii) b and c only (iv) a and c only

20. Velocity transformations become Galilean transformations when

(i) velocity v is much less than the speed of light.
(ii) velocity v is much greater than the speed of light.
(iii) velocity v is equal to the speed of light.
(iv) velocity v is equal to the square of the speed of light.

21. It is the year 3000. The measured length of a rocket as measured by an observer at rest, when it passes by at a speed of 0.3c is 100m. What is the length of the rocket at rest?

(i) 108.4m (ii) 104.8m (iii) 108m (iv) 104m

22. For a light-like event displacement,

(i) $c^2\Delta t^2 < \Delta r^2$ (ii) $c^2\Delta t^2 < \Delta r^2$ (iii) $c^2\Delta t^2 = \Delta r^2$ (iv) $c^2\Delta t^2 \geq \Delta r^2$

23. According to special theory of relativity, momentum of a particle of rest mass m_0 and speed v is

(i) m_0v (ii) γm_0v (iii) γm_0c (iv) $(\gamma - 1)m_0v$

24. Relative velocity of two particles moving with speed of light in opposite directions is,

(i) 0 (ii) 2c (iii) c (iv) $c/2$

25. With respect to an observer, length contraction of a moving object happens

(i) along the direction of motion of the object
(ii) perpendicular to the direction of motion of the object
(iii) along the direction of motion of the object as well as perpendicular to the direction of motion
(iv) angle of 45° to the direction of motion of the object

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UNIVERSITY OF RUHUNA

B.Sc. General Degree Level II (Semester II) Examination – NOVEMBER/DECEMBER 2016

Subject: PHYSICS

Course Unit: PHY2214

Time: 02 hours & 30 minutes

Part II

Answer at least 01 (ONE) question from each of the parts A, B and C.

Answer FIVE (05) Questions only.

(All symbols have their usual meaning)

$h = 6.626 \times 10^{-34}$ Js

$\varepsilon_0 = 8.854 \times 10^{-12} C^2 N^{-1} m^{-2}$

$\mu_0 = 1.26 \times 10^{-8}$ Hm^{-1}

$e = 1.6 \times 10^{-19} C$

$c = 3 \times 10^8 ms^{-1}$

$m_e = 9.1 \times 10^{-31}$ kg

1 a.m.u = 1.66×10^{-27} kg

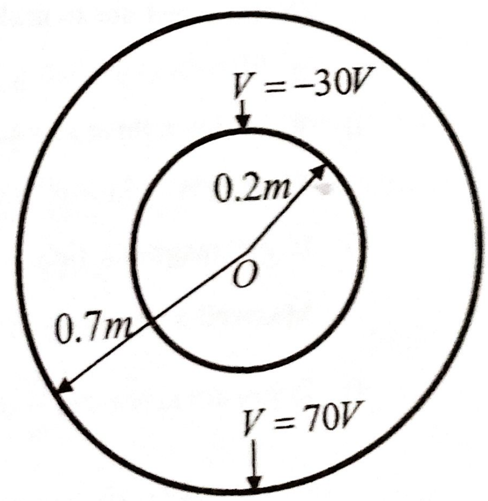
In spherical coordinates:

Laplace equation $$\nabla^2 V = \frac{1}{r^2}\frac{\partial}{\partial r}\left(r^2\frac{\partial V}{\partial r}\right) + \frac{1}{r^2 sin\theta}\frac{\partial}{\partial\theta}\left(sin\theta\frac{\partial V}{\partial\theta}\right) + \frac{1}{r^2 sin\theta}\frac{\partial^2 V}{\partial\varphi^2} = 0$$

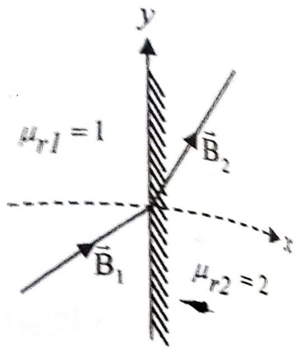
Del operator $$\nabla = \frac{\partial}{\partial r}\hat{r} + \frac{1}{r}\frac{\partial}{\partial\theta}\hat{\theta} + \frac{1}{rsin\theta}\frac{\partial}{\partial\varphi}\hat{\varphi}$$

Part A

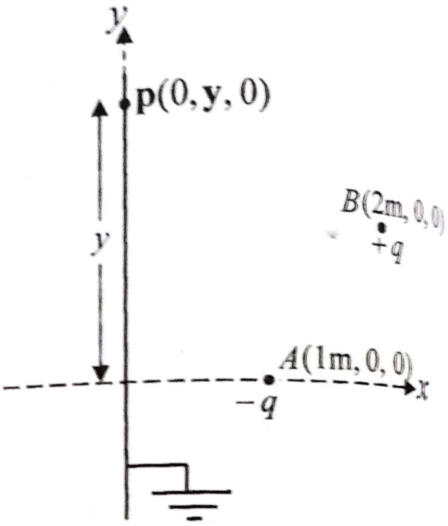
1. a) Figure shows two thin conducting concentric spherical shells placed in free space. The voltage of inner spherical shell of radius $0.2m$ is $-30V$ and the voltage of outer spherical shell of radius $0.7m$ is $70V$. Obtain expressions for V, $\vec{E}$ and $\vec{D}$ for the region between two shells, using the Laplace equation.



b) Following figure shows a current free interface between two magnetic media. If $\vec{B}_1 = \hat{\imath} + \hat{\jmath} + \hat{k}$, calculate $\vec{H}_1$, $\vec{H}_2$ and $\vec{B}_2$ using the given data in the diagram.



2. Two point charges of $-q$ and $+q$ are placed at points $A(1m, 0, 0)$ and $(2m, 1m, 0)$ respectively, near an infinitely large, grounded, conducting plate placed on yoz plane as shown in the figure.



a) Indicate the magnitude and location of image charge(s) required to replace the conducting plate.

b) Show that the electric field intensity at the point $P(0,\ y, 0)$ is given by

$$\vec{E} = \frac{q}{2\pi\varepsilon_0}\left(\frac{1}{(1+y^2)^{3/2}} - \frac{2}{(y^2-2y+5)^{3/2}}\right)\hat{\imath}$$

c) If $q = 1C$, calculate the magnitudes of $\vec{E}$ at the points on the y axis when $y = 0$ and $y = 1m$.

d) What would be the total induced charge on the grounded plate?

(Note:-Need not to make a calculation)

3. a) Write down three characteristics of a free space.

b) Write down Maxwell's equations in electrodynamics for a free space.

c) If the magnetic field intensity vector in a free space is $\vec{H} = H_0 cos(\omega t - \beta x)\hat{k}$, use Maxwell's equations in electrodynamics to obtain expressions for $\vec{D}$ and $\vec{E}$.

d) If you are given that $\frac{\beta}{\omega} = \sqrt{\varepsilon_0\mu_0}$, show that the $|E|/|H|$ value depends only on the values of μ_0 and ε_0. Hence calculate the value of $|E|/|H|$.

e) Sketch the variations of $\vec{E}$ and $\vec{H}$ along the x-axis at $t = 0$.

Part B

4. a) (i) Write down the equation for the Compton shift. What are the independent and dependent quantities of the Compton shift?

(ii) What is Compton wavelength? Distinguish between Compton shift and Compton wavelength.

b) (i) Show that the kinetic energy of the recoil electron in Compton scattering is given by, $hv\frac{\frac{hv}{m_0c^2}(1-cos\emptyset)}{1+\frac{hv}{m_0c^2}(1-cos\emptyset)}$

(ii) Obtain an expression for the maximum kinetic energy of the recoil electron.

5. a) Write down de-Broglie equation. Derive an expression for de-Broglie wavelength of a matter particle of mass *m* in terms of its kinetic energy, *E*.

b) Calculate the de-Broglie wavelength for fast moving cricket ball of mass 1g and speed 1 cms^{-1}. Can this wavelength be observed? Discuss.

c) Calculate the wavelengths for a photon and electron of energy 10 eV each. Which one has a shorter wavelength? Explain the reasons for the difference.

6. a) (i) Discuss, briefly, Exothermic and Endothermic reactions.

(ii) Calculate the Q-value of the following decay processes and discuss the differences.

1) $^{57}_{27}Co \rightarrow ^{57}_{26}Fe + ^{0}_{1}e^{+} + ^{0}_{0}\nu$ 2) $^{14}_{6}C \rightarrow ^{14}_{7}N + ^{0}_{-1}e^{-} + ^{0}_{0}\bar{\nu}$

Masses in a.m.u

Co – 56.936294, C – 14.003242, Fe – 56.935396, N – 14.003074, e – 5.485 x 10^{-4}

b) A small building has become accidentally contaminated with radioactivity. The longest-lived material in the contaminated building is Strontium-90. $^{90}_{38}Sr$ has an atomic mass 89.9077 u and its half–life is 29.1 years. Assume that the building is initially contaminated with 5.0 kg of this substance, uniformly distributed throughout the building.

(i) How many nuclei are present at initially?

(ii) Find the decay constant of $^{90}_{38}Sr$.

(iii) Find the initial activity.

(iv) If the safe level of the building is defined as less than 10.0 decays/min, how long will the building be unsafe?

Part C

7. a) (i) What is meant by Simultaneity?

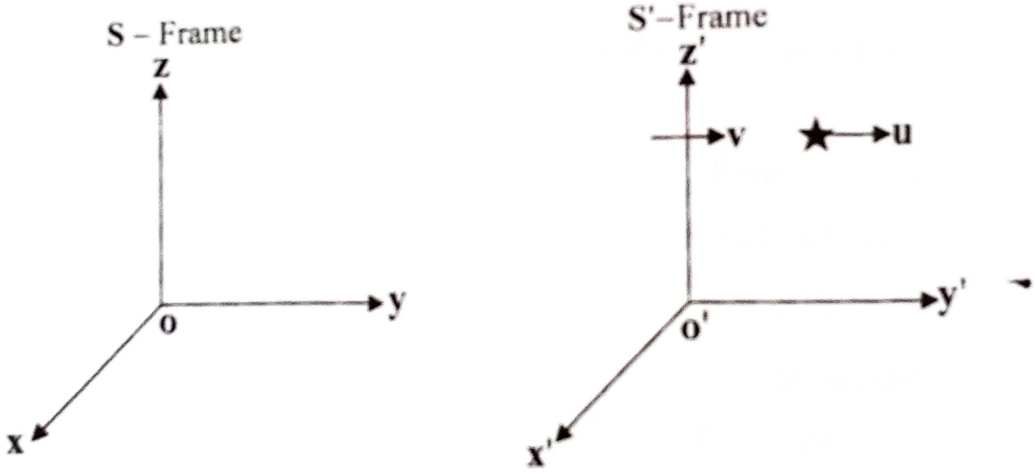
(ii) A bird at rest observes light from a firecracker, A, arrive at $t = 3\ \mu s$ which is exploding at $x = 600$ m and light from another firecracker, B, arrive at $t = 5\ \mu s$ which is exploding at $x = 1200$ m. Did the firecrackers explode simultaneously in the reference frame of the bird?

b) The electrons in the Australian Synchrotron travel at 0.999997c relative to the laboratory frame. The circumference of the Synchrotron beam path is 216 m.

(i) How long does it take for an electron to complete one cycle of the beam path in the laboratory reference frame?

(ii) How long does it take in the electron's reference frame?

8. Consider a particle travels in y- direction at velocity u with respect to inertial frame S. Frame S' moves at velocity v with respect to S.



a) Derive the velocity transformation equation for y - component.

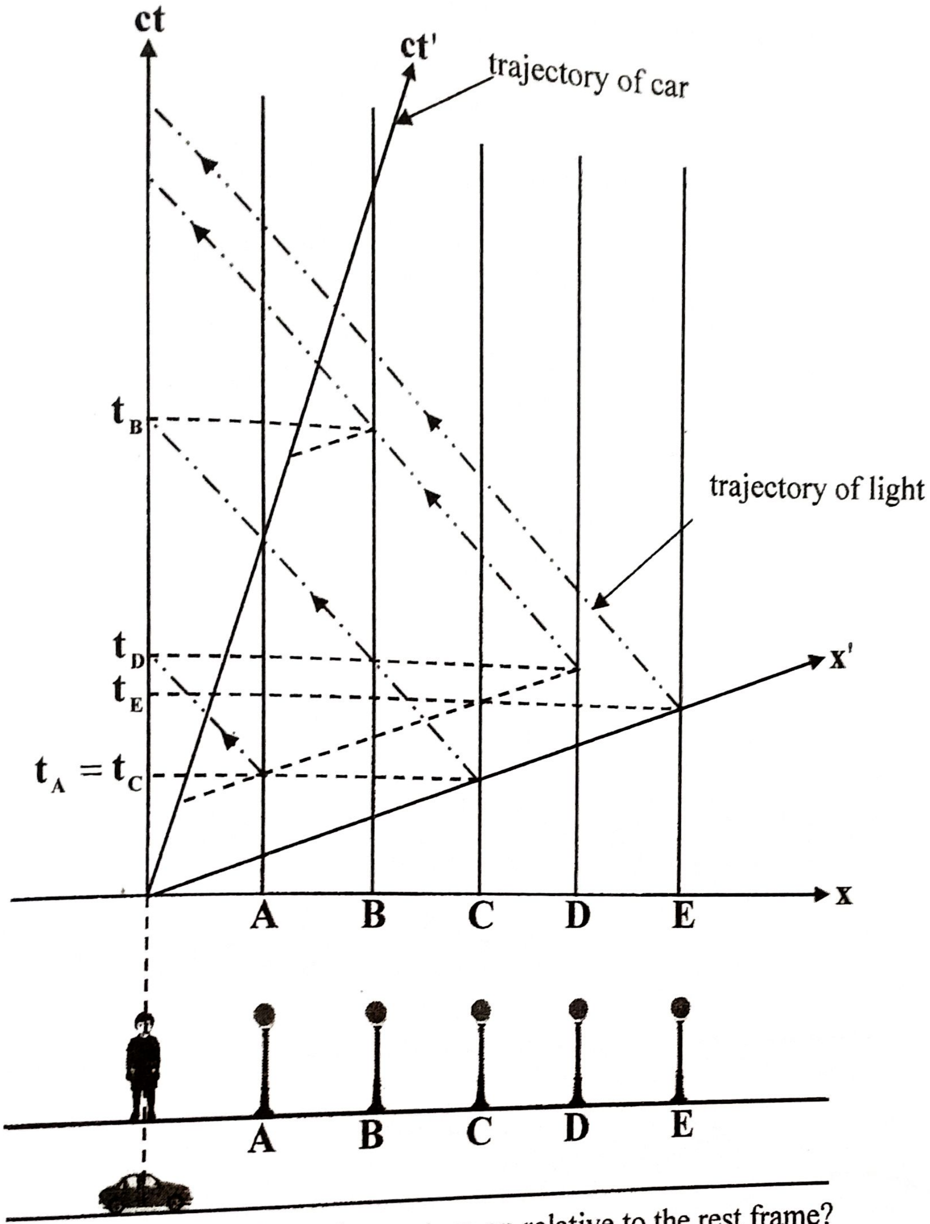
b) Hence write down the inverse velocity transformation for y - component.

c) A spaceship moves away from earth with speed v and fires a shuttlecraft in the forward direction at a speed v relative to the spaceship. The pilot of the shuttlecraft launches a probe in the forward direction at speed v relative to the shuttlecraft.

(i) Calculate the speed of the shuttlecraft relative to the earth.

(ii) Calculate the speed of the probe relative to the earth.

9. Five street lamps A, B, C, D and E are located on a straight line along the x – axis in a rest frame $(S \equiv (ct, x))$ with equal distance apart. They turn on at times t_A, t_B, t_C, t_D and t_E respectively, relative to the rest frame. This situations are indicated in the following space–time diagram.



a) What is the order in which the lamps turn on relative to the rest frame?

b) What is the order in which the light of the lamps reach the observer at x=o?

c) A car is $(S' \text{ frame} \equiv (ct', x'))$ moving at constant velocity relative to the rest frame. At $t' = t = 0$, it is at $x' = x = 0$. The space and time axes in the moving frame (ct' and x') of the car are tilted with respect to those of the rest frame as shown in the space-time diagram. What is the order in which the lamps turn on relative to the frame S'?

d) What is the order in which the light of the lamps reach the observer riding in the car?

e) When the light from street lamp D reaches the car where would be the car, between which street lights?

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