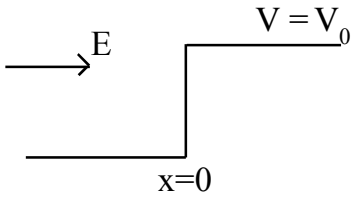
if for some state $|n\rangle = (2x^3 - 3x)e^{-x^2/2}$ find n and two other (unnormalised) eigen functions which are closest in energy to |n>. 5

13. (a) Show that $\langle p_x \rangle = -\left\langle \frac{\partial v}{\partial x} \right\rangle$ where symbols have their usual significance. $2^1/_2$

(b) Show that the transmission coffecient is zero in the following case where $E < V_0$. $2^1/_2$



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Ex./B.Sc./PHY/22/HO8/64/2018

BACHELOR OF SCIENCE EXAMINATION, 2018

(2nd Year, 2nd Semester)

PHYSICS (Honours)

Paper : HO 8

Time : Two hours Full Marks : 50

Use a separate Answer-Script for each group.

GROUP - A (25 marks)

(Special Theory of Relativity)

The figures in the margin indicate full marks.

Answer any ***five*** questions.

1. (a) Length of a moving rod can be defined as the product of its velocity and the time interval between the instant that one end point of the rod passes a fixed mark and the instant that the other end point passes the same mark. Show that this definition leads to space contraction.

(b) It takes 10^5 years for light to reach us from the farthest part of our galaxy. Is it possible for a man to travel out to that part of our galaxy at a constant speed in a reasonable time of say 50 years ? 3+2

2. (a) Show that two successive Lorentz Transformation (L.T) corresponding to speeds υ_1 and υ_2 are equivalent to a single L.T. corresponding to a speed of $\upsilon = (\upsilon_1 + \upsilon_2)/\left(1+\frac{\upsilon_1 \upsilon_2}{c^2}\right)$.

   (b) An observer on a railway platform sees two trains approaching each other at a speed of 7/5c. An observer on one train sees the other train approaching him with a speed of (35/37)c. What are the velocities of the trains relative to the observer on the platform? 2+3

3. (a) What is an interval? What are (i) Timelike (ii) Lightlike and (iii) Spacelike intervals?

   (b) Show that if the interval between two events is timelike in one inertial frame, it is possible to find another inertial frame in which the two incidents are happening in the same spatial co-ordinates (colocal). 2+3

4. (a) Give an account of the relativistic theory of Doppler effect.

   (b) Light of wavelength 6000 A is incident normally on a mirror which is receding with a velocity of 3 x 10^4 m/s in a direction away from the indicent light. Calculate the change in wavelength on reflection. 3+2

Show that $\xi \cot \xi = -\eta$ where $\xi = \sqrt{\frac{2mE}{\hbar^2}}\, a$

and $\eta = \sqrt{\frac{2m(v_0 - E)}{\hbar^2}}\, a$

Discuss about the energy levels. 3+1

(b) Show that the eigen values of Parity operator are ± 1. 1

11. (a) The wave function of the ground state of a harmonic oscillator of force constant k and mass 'm' is

$$\psi_0(x) = \left(\frac{\alpha}{\pi}\right)^{1/4} e^{-\alpha x^2/2} \text{ where } \alpha = \frac{m\omega_0}{\hbar} \text{ and } \omega_o^{\,2} = k/m.$$

obtain an expression for the probability of finding the particle outside the classical region. 3

(b) Find the commutation relation $[x^2, p_x]$ and $[f(x), p_x]$. 2

12. $a = \frac{x+ip}{\sqrt{2}}$ and $a^+ = \frac{x-ip}{\sqrt{2}}$ are the annihilation and creation operators such that $a|n\rangle = \sqrt{n}\ |n-1\rangle$ and $a^+|n\rangle = \sqrt{n+1}\ |n+1\rangle$

5. F_x, F_y and F_z denote the x, y and z components of force on a particle which has velocity u (u_x, u_y, u_z) in S frame. F_x', F_y' and F_z' denote the corresponding quantities in S' frame which is moving with velocity V w.r.t. the S frame along positive x–x′ axis. Find the general relation between the components of force (F_x', F_y', F_z') and (F_x, F_y, F_z). 5

6. A beam of identical unstable particles flying at a speed βc is sent through two counters separated by a distance L. It is observed that N_1 particles are recorded at the first counter and N_2 at the second counter, the reduction being solely due to the decay of the particles in flight. Show that the lifetime of the particles at rest is given by

$$\tau = L / In \frac{N_1}{N_2} \sqrt{\gamma^2 - 1c} \; .$$ 5

7. (a) Explain why magnetism is said to be a relativistic phenomenon.

   (b) Show that, $c^2 p^2 - \left(j_x^2 + j_y^2 + j_z^2 \right) = c^2 p_0^2$.

   (c) Show that $E^2 - c^2 B^2$ is invariant under a L.T.

GROUP - B (25 marks)

Answer any ***five*** questions.

8. For an infinite square well potential between 0 < x < l, the wave function is given by

$$\psi(x,0) = \frac{30}{l^5} x(l-x)$$

Find the expression of coefficient of the different eigen states and write down ψ(x,t). 3+2

9. (a) An electron is confined to the interior of a hollow spherical cavity of radius R with impenetrable walls. Write down schrodinger equation (time independent) interms of radial coordinate taking wave function ψ as independent of θ and ϕ. Find the energy levels.

   (b) Find the amplitude of zero point oscillation for a pendulum of length 1m and mass 10gm. Interprete the result. 2+2+1

10. (a) A particle is confined in an one dimensional potential well with energy E < V_0, which is given by,

$$\forall = \propto \; for \; x \le 0$$
$$= 0 \; for \; 0 < x < a$$
$$= v_0 \; for \; x \ge a$$