Ahmedabad University

School of Arts and Sciences

PHY111 - Classical Mechanics

End Semester Examination 2024 (Winter Semester)

Total Marks = 50 **Time – 1.5 hours**

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1. Derive the relativistic transformation rule for acceleration. [7]

2. A particle of rest mass m_0 and kinetic energy ($x\ m_0c^2$), where x is some number, strikes an identical particle at rest and sticks to it. What is the rest mass of the resultant particle? [5]

3. Show that $dx^2 + dy^2 + dz^2 - c^2dt^2$ remains invariant under the Lorentz transformation. [7]

4. The muon is an unstable particle that spontaneously decays into an electron and two neutrinos. If the number of muons at t = 0 is N_0, the number N at time t is

$$N = N_0 \exp(-t / \tau)$$

where $\tau = 2.20\ \mu s$ is the mean lifetime of the muon. Suppose the muons move at a speed of 0.95c.

   (a) What is the observed lifetime of the muons? [5]
   (b) How many muons remain after traveling a distance of 3.0 km? [5]

5. An observer sees two spaceships flying apart with speed of 0.99c. What is the speed of one spaceship as viewed by the other? [5]

6. One of the most prominent spectral lines of hydrogen is the Hα line, a bright red line with a wavelength of 656.1×10^{-9} m. What is the expected wavelength of the Hα line from a star receding with a speed of 3000 km/s? [5]

7. The free neutron is known to decay into a proton, an electron, and an antineutrino (of zero rest mass) according to $n \rightarrow p + e^- + \bar{\nu}$. This is called beta decay. The decay products are measured to have a total kinetic energy of (0.781 ± 0.005) MeV. Show that this observation is consistent with the Einstein mass-energy relationship. (m_n = 939.5656 MeV/c^2 , m_p = 938.2723 MeV/c^2 , m_e = 0.5110 MeV/c^2) [5]

8. A photon of energy Ei = hν scatters from a free particle at rest of mass m_0. The photon is scattered at angle θ with energy E_f = hν, and the particle flies off at angle φ. Find an expression for the final velocity **u** of the particle. [6]