Mahindra University Hyderabad
École Centrale School of Engineering
End Semester Examination

Program: B. Tech   Branch: CSE/ARI/CAM/MEC/MEE   Year: III   Semester: 2

Subject:- An introduction to Spacetime Physics (PH3203)

Date: 30/05/2025
Time Duration: 3 hours

Start Time: 10:00 AM
Max. Marks: 100

Instructions:

- Answer all the questions.
- All the best!

Q1:   (10 + 10 = 20 M)

The length of a spaceship is measured to be exactly half of its proper length.

(a) What is the speed of the spaceship relative to the observer's frame?

(b) What is the dilation of the spaceship's unit time?

Q2:   (15 + 5 = 20M)

(a) A spaceship at rest in a certain reference frame S is given a speed increment of 0.50c. Relative to its new rest frame, it is then given a further 0.50c increment. This process is continued until its speed with respect to its original frame S exceeds 0.999c. How many increments does this process require?

(b) A spaceship is moving directly toward Earth at a speed of 0.5c. The crew of the spaceship emits a laser beam aimed at Earth. According to the crew, the laser beam travels at speed c. What speed does an observer on Earth measure for the laser beam? Explain.

Q3:   (6 + 14 = 20 M)

(a) Show that the relativistic kinetic energy reduces to its classical form when $v \ll c$.

(b) A particle is accelerated so that its kinetic energy becomes n times its rest energy m_0c^2. Obtain the particle speed (in terms of c and n) and momentum (in terms of its rest mass m_0, the speed of light c and n)?

Q4:   (12 + 8 = 20 M)

(a) The earth receives radiant energy from the sun at the rate of 1350 $\frac{W}{m^2}$. Assuming that the average Earth-Sun distance is 1.5×10^{11} m and that the Sun's mass is about 2.0×10^{30} kg now, at what rate does it lose its rest mass due to its radiation?

· (b) An absorption line viewed from a stationary galaxy has a wavelength of 550 nm (green). The wavelength of the same line is measured as 450 nm (blue) from a galaxy A. How fast and in which direction is galaxy A moving?

Q5: $(12 + 8 = 20 \text{ M})$

(a) In 4D-Minkowski spacetime, define the spacetime interval between two events and show that it is invariant under Lorentz transformations.

(b) The world lines of a space vehicle are shown in the figures below. Explain the motion of the vehicle in each of the three cases.