UNIVERSITY OF NAIROBI

DEPARTMENT OF PHYSICS

SPH 201: MECHANICS II

Problem Set 4: Relativity

These Problems are Group based. Each individual TO SUBMIT SOLUTIONS TO ANY TWO problems

Constants: G = 6.7 × 10^{-11} Nm^2Kg^{-2} ; g = 10 ms^{-2} ; Radius of Earth = 6,300Km; M_e = 5.98 × 10^{24} Kg;

Galilean and Special Relativity

1. According to an observer on the ground, how many seconds are ticked out by a clock in an airplane moving overhead at 300ms^{-1} while the observer's clock ticks out exactly 1000 s?

2. A rocket ship moving with speed 0.80c relative to the Earth shoots a pulse of light out along its line of motion. Find the speed of the pulse relative to the Earth

3. A 30-year-old astronaut leaves behind a 10-year-old daughter just as he sets out on a space voyage. When he returns to Earth, she is 25 and he is 32. How long was he gone according to Earth clocks and what was his average speed during the trip?

4. At t = 1 s (in frame S), an explosion occurs at x = 5 km. What is the time of the event for the observer in frame S' if for him it occurs at x' = 35.35 km?

5. According to an observer on the Earth, a spaceship is going east with a speed of 0.6***c*** and is going to collide head on in 5 s with a comet going west at 0.80***c***.
   (i) How fast does the spacecraft see the comet to be approaching?
   (ii) According to their clocks, how much time to they have to get out of the way?

6. Suppose you find yourself riding a bicycle in a city where the speed of light is very low, roughly 30km/h. What weird effects will you notice under this circumstances?

7. Consider the piece of paper on which you are writing on. Which of the following properties of the piece of paper are absolute, that is, independent of whether the paper is at rest or in motion relative to you?
   (a) The thickness of the paper
   (b) The mass of the paper
   (c) The volume of the paper
   (d) The speed of the light reflected by the paper and
   (e) The colour of the coloured print on the paper.

8. Frame S' has a speed V = 0.6***c*** relative to S. Clocks are adjusted so that $t = t' = 0$ at $x = x' = 0$.
   (a) An event occurs in S at $t = 2\times10^{-7}$ sec. at a point for which x = 50m. At what time does the event occur in S' ?
   (b) If the second event occurs at (10m, 3×10^{-7} sec) in S, calculate the time interval between the events as measured in S'.

9. As measured by S, a flashbulb goes off at x = 100km, y = 10km, z = 1 km and t = 0.5 ms. What are the coordinates x', y', z', and t' of this event as determined by a second observer, S', moving relative to S at -0.8c along the common xx' axis

10. A certain strain of bacteria doubles in number each 20 days. Two of these bacteria are placed on a spaceship and sent away from the earth for 1000 earth days. During this time, the speed of the ship was 0.995c. How many bacteria would be aboard when the ship lands on the earth?
