TUTURIAL SHEET – 1

AP - 101 (PHYSICS) SPECIAL THEORY OF RELATIVITY

1. An open car travelling at 100 m/s has a boy in it who throws a ball upward with a velocity of 20m/s. Write the equation of motion (giving position as function of time) for the ball as seem a) by the boy b)an observer stationary on the road. (Use Newtonian/Galilean formulation.)
2. The M-M experiment used an interferometer with arms of 11m and sodium light of wavelength 5900 A^o. The experiment would reveal a fringe shift of 0.005 fringes. What upper limit does a null result place on the speed of earth through ether?
3. As measured by O, a flash lamp goes off at x = 100km, y = 10km, z = 1km at t = 5×10^4 sec. What are the co-ordinates x', y', z', t' of the event as determined by the second observer O' moving w.r.t. O at a speed of 0.8c along x-x' axis.
4. Observer O notes that two events are separated in space and time by 600m and $8x10^{-7}$s. How fast an observer O' must be moving relative to O in order that events be simultaneous to O.
5. A cube has a volume (proper) of 1000 cm^3. Find the volume as determined by observer O' moving with a velocity of 0.8c relative to cube in a direction parallel to one edge.
6. Observers O & O' approach each other with a relative velocity of 0.6c. If O measures the initial distance to O' to be 20m, how much time it will take, as determined by O, before the two observers meet. Also find how much time it will take, as determined by O', before the two meet.
7. For an observer O, two events are simultaneous and occur at 600m apart. What is the time difference between these two events as determined by O', who measures their spatial separation as 1200m.
8. The equation for a spherical pulse starting from the origin at t=t'=0 is $x^2 + y^2 + z^2 + c^2 t^2 = 0$. Show from Lorentz transformation that O' will measure the same pulse to spherical.
9. A particle moves with a speed of 0.8c at an angle of 30^o to x-axis, as determined by O. What the velocity of the particle is as determined by O' moving with a speed 0.6c along common x-x' axis.
10. Consider a radioactive nucleus that moves with a constant speed of 0.5c relative to a laboratory frame. The nucleus decays and emits an electron with a speed of 0.9c relative

to the nucleus along the direction of motion. Find the velocity of electron in the laboratory frame.

11. Two spaceship A and B are moving towards each other. An observer on the ground measures the speeds of the spaceship to be 0.95c. Find the velocity of B spaceship relative to the A.
12. A body at rest spontaneously breaks up into two parts which move in opposite directions. The parts have rest masses of 3kg & 5kg each and respective speeds of 0.8c & 0.6c. Find the rest mass of original body. Is the rest mass conserved?
13. An electron moves in the lab frame with a speed of 0.6c, an observer moves with a velocity of 0.8c along the direction of the motion of electron. Find energy of electron as determined by observer.
14. Find the velocity of a particle at which it's mass become double of its rest mass.
15. A particle of rest mass m_0 moves with a speed of c/2 w.r.t. earth. What are its rest mass, momentum, total energy and kinetic energy?
16. Solar energy reaches the earth at the rate of 1.4 Kw/m^2 perpendicular to the direction of the sun. Calculate the mass decreases per second of the sun due to this energy loss. Take the mean radius of the earth's orbit is 1.5×10^{11}m.
17. A man leave the earth in a rocket that makes a round trip to the nearest star, which is 4 light years away, at a speed of 0.8c. How much younger will he be on his return to than his twin brother who stayed on the earth.
18. The proper mean life of an unstable particle is 2.6×10^{-8} sec. How fast must this unstable particle move so that it travel a distance of 20m before disintegrate?
19. At what speed should a spaceship move so that a clock kept in it would appears to lose 1 minute per hour to an observer on the earth.
20. Calculate the percentage contraction of a rod moving with a speed of 0.8c in a direction inclined at 60^0 to its own length. Also find the apparent orientation of the rod.
21. A pion at rest decays into a muon and a neutrino. Find the energy of the outgoing muon in terms of the two masses, m_π and m_μ. Assume neutrino as massless particle.
22. Two lumps of clay, each of rest mass m, moving with a speed of 3/5c towards each other, collides and stick together. Find the mass of the composite lump.