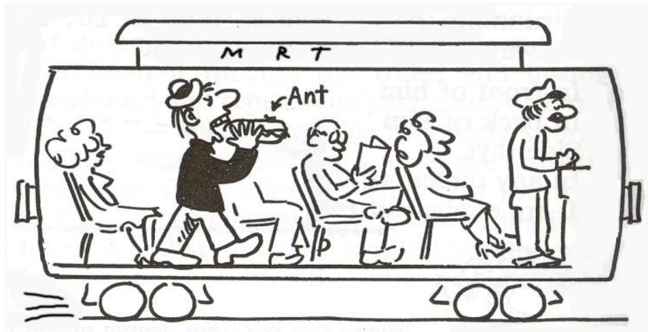
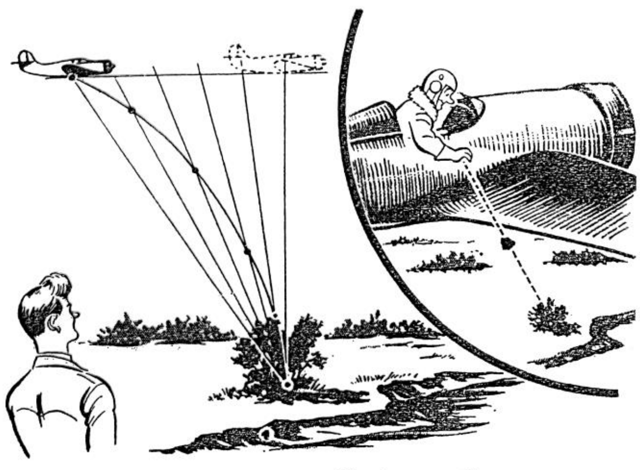
UNL2206, Nature's Threads: Tutorial 7

1) A MRT carriage is approaching the Somerset station at 1m/s. A person in the carriage is facing forward and walks forward with a speed of 20 cm/s relative to the seats in the carriage. The person also happens to be eating a hot-dog which is entering his mouth at the rate of 4 cm/s. An ant on the hot-dog is running to the end of the hot-dog, away from the person's



mouth. The distance between the ant and the end of the hot-dog towards which it is running, is diminishing at the rate of 2cm/s. Can you figure out how fast the ant is approaching Somerset station?

2) Consider a plane flying at a constant velocity and altitude. Analyse the motion of a projectile that is dropped out of the plane from the frame of reference of the airplane itself.



What do you understand by Galilean Relativity and explain how the motion of airplane and projectile illustrates this principle.

Use the Galilean transformations to obtain the trajectory of the projectile with respect to the Earth's frame (neglect the rotation of the Earth about its axis).

What can you say if instead you attached your reference frame to the freely falling projectile itself?

3) An airplane flies horizontally with a constant velocity of 600 km/h, at a height of 2km. Directly over a marker it releases an empty fuel tank. Neglecting air resistance, how far ahead of the marker does the tank hit the ground? At this instant of time, is the airplane ahead or behind the tank?

4) Two trains A and B are traveling in opposite directions along straight parallel tracks at the same speed v = 60 km/h. A light airplane crosses above them. A person on train A sees it cross at right angles, while a person on train B sees it cross the track at an angle θ_B = 30°.

(i) At what angle θ_{ground} does the airplane cross the track as seen by an observer on the ground?

(ii) What is the airplane's speed relative to the ground, v_{ground} ?

5) A boy can swim at a speed v_s = 1 m/s, and wishes to cross a river of width L = 100 m that is flowing at v_w = 0.5 m/s in order to reach his friend who is directly opposite him on the other bank. In what direction should the boy swim so as to reach his friend as soon as possible? How long will it take him?

6) Newton's mechanics is governed by his second law **F** = m**a** or in components, $F_x = m\, dx^2/dt^2$ and with similar equations for the y and z directions. To check whether this law is true, we would need to choose a co-ordinate system so as to be able to measure x, y and z in three perpendicular directions as well as the forces along these directions. These must each be measured from some point (ie the origin of the chosen co-ordinate system); show that it does not matter where we take this origin to be?

7) Next, show that it also does not matter in which direction the axes of the co-ordinate system are chosen.

8) Consider Newton's second law. How does it change from the point of view of an observer in uniform motion?

In what way is it different for an observer moving a) in a straight line with constant acceleration; b) moving in a circle at a constant speed?

9) Do Maxwell's equations change for observers in uniform motion with respect to one another?

Consider the following two cases:

a) The force between two charges in the rest frame seen by two observers, one at rest, the other in a frame that moves in a straight line with a uniform velocity with respect to the rest frame.

b) The force on a charge in a uniform magnetic field when the charge is moving in a straight line with a uniform velocity. (The observer is riding on the charge.)

10) Why, from the point of view of Newtonian physics, must the centre of the universe or the absolute motion of a body be legislated?

In what way does the situation change with the addition of Maxwell's electrodynamics?