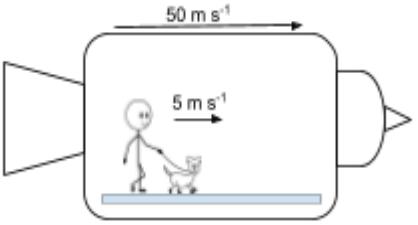
Our Dynamic Universe

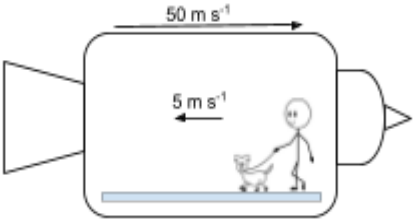
Special Relativity

1) Albert is taking his dog Schroddy for a walk in his spaceship. His spaceship is travelling at 50 ms^{-1} and Albert and Schroddy are walking as shown with a speed of 5 ms^{-1}
Niels and his cat Photon stand still and watch the spaceship pass by.



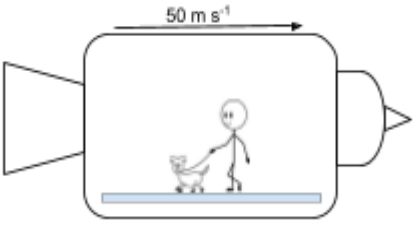
   a) What is Albert`s speed relative to the spaceship?
   b) What is Albert`s speed relative to Niels.

2) Albert`s spaceship passes the stationary Niels and his cat again. This time he is walking towards the back of the spaceship with a speed of 5 ms^{-1}.



   a) What is Albert`s velocity relative to the spaceship?
   b) What is Albert`s speed relative to Niels and his cat.

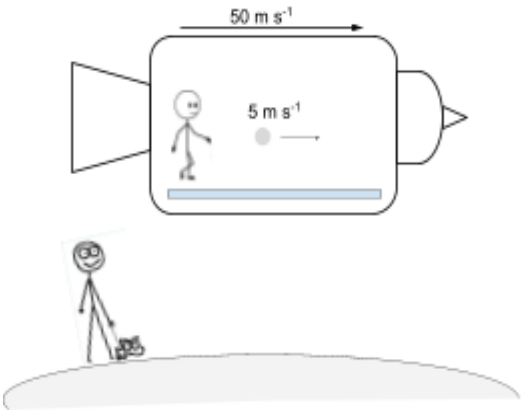
3) Albert stops walking his dog Schroddy to give him a pat.



   a) What is Albert`s velocity relative to the spaceship?
   b) What is Albert`s velocity relative to Niels and his cat?

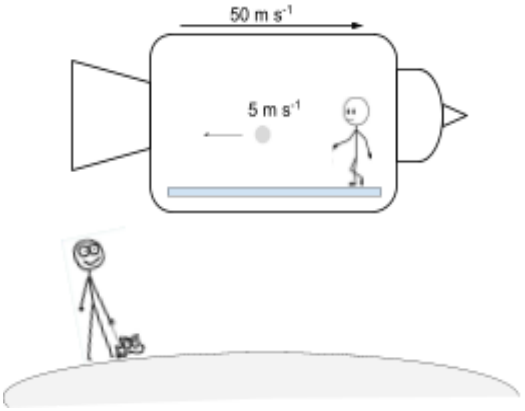
4) Albert stands on the spaceship and throws a ball forward with a speed of 5 ms^{-1}

   a) What is the ball's velocity relative to Albert?
   b) What is the ball's velocity according to Niels frame of reference?



5) Albert is at the front of the spaceship. He throws the ball towards the back with a speed of 5 ms^{-1}.

   a) What is the speed of the ball in Albert`s reference frame (ie the spaceship)
   b) What is the speed of the ball in Niels frame of reference?



6) A train travelling at 40 m s^{-1} approaches a station. As it passes the station a passenger gets up and walks towards the front of the train with a speed of 2 m s^{-1}

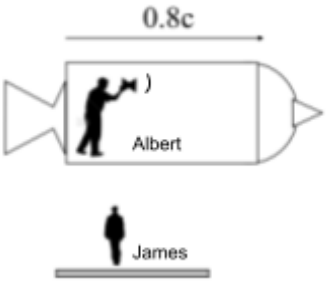
   a) What is the speed of the passenger relative to the train as a reference frame?
   b) What is the speed of the passenger as seen from the reference frame of the station platform?

7) A river flows from West to East with a speed of 18 ms^{-1} relative to the riverbank. A swimmer swims from East to west with a speed of 4 m s^{-1} relative to the river.

   a) What is the speed of the swimmer relative to the riverbank?
   b) What speed would the swimmer have to swim at to have a speed of 0 ms^{-1} relative to the riverbank?

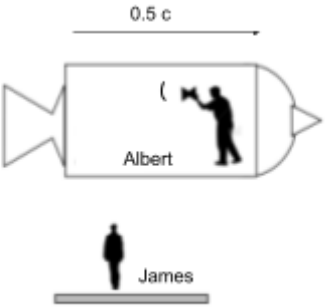
8) An airport`s moving corridor travels at 6 $ms^{-1}$ relative to the stationary floor. A traveller runs along the moving corridor at 6 m $s^{-1}$. What is the traveller`s speed relative to the stationary floor?

9) James watches Albert fire a pulse of light from a laser pen. The pulse of light travels at the speed of light, c. Albert`s spaceship is travelling at 0.8 c.



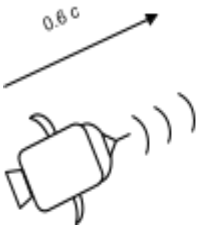
a) What is the speed of the light pulse in Albert`s frame of reference?
b) What is the speed of light in James` frame of reference?

10) James watches Albert fire a pulse of light from a laser pen towards the back of the spaceship which is travelling at 0.5 c The pulse travels at the speed of light.



a) What is the speed of the light pulse as measured in Albert`s reference frame?
b) What is the speed of the light pulse when measured in James` frame of reference?

11) A small spaceship travelling at 0.6 c sends a light pulse to another larger stationary spaceship.

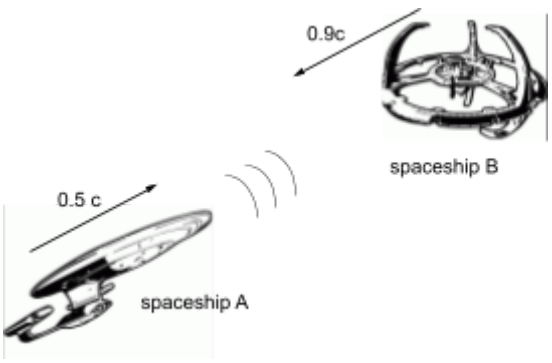


a) Calculate 0.6 c

b) What would the speed of the light pulse be to the small spaceship`s frame of reference?

c) What would be the speed of the light pulse measured from the larger spaceship`s frame of reference?

12) Spaceship A is travelling at a speed of 0.5c towards spaceship B travelling at 0.9c Spaceship A sends out a pulse of light towards spaceship B.



a) According the spaceship B what is the speed of the light pulse
b) According to spaceship A what is the speed of the light pulse?

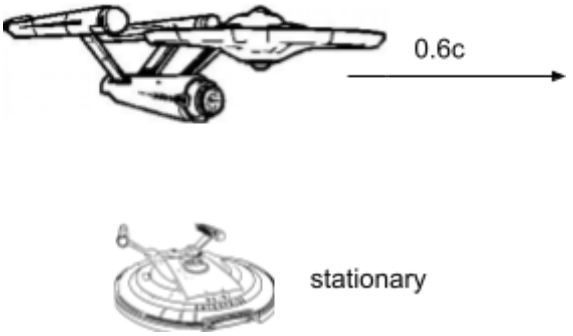
13) A spaceship travels at 1.5×10^8 m s^{-1} relative to an observer on a stationary space station. An experiment on the moving spaceship lasts for 5 seconds.

a) Find the speed of the moving spaceship in terms of the speed of light c.
b) Determine the time the experiment lasts from the observer on the space station.

14) A subatomic particle called a muon has a half life of 2.2×10^{-3} seconds.
A stationary observer watches the muon travelling at 0.8c.
Calculate the half life of muon as measured by the observer.

15) A star ship moves at a speed of 0.6c past a stationary spaceship.
On board the moving spaceship the captain flashes a light on the spaceship once every 10 seconds.

Determine the time between flashes as observed by the stationary spaceship.



16) The time dilation equation is given by the equation shown below:

$$t' = \frac{t}{\sqrt{1 - \frac{v^2}{c^2}}}$$

a) Explain what each of the symbols mean in the equation

b) A clock measures the time of an experiment to last 40 seconds.
What would an observer measure the time of the experiment to be if the clock passed by travelling at 1.5×10^8 m s^{-1}

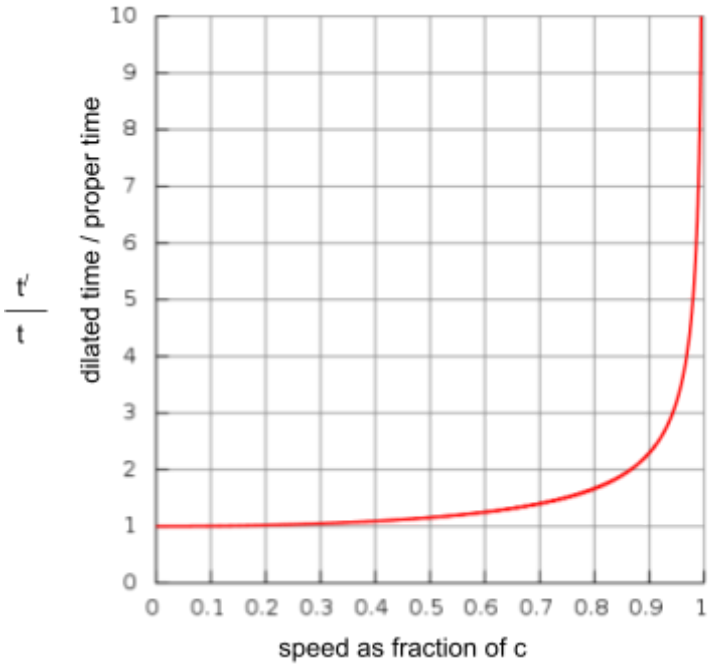
17) A biologist sets off on an interstellar journey in the year 2061. She conducts an experiment on board her spacecraft which is travelling away from the Earth at a speed of 90% the speed of light.

Red blood cell lives for 120 days.

a) State the speed of the spacecraft in terms of the speed of light c.

b) The biologist on board the spacecraft measures the lifetime of the cell to be 120 days. Determine would be the lifetime of the blood cell as measured by an observer back on Earth.

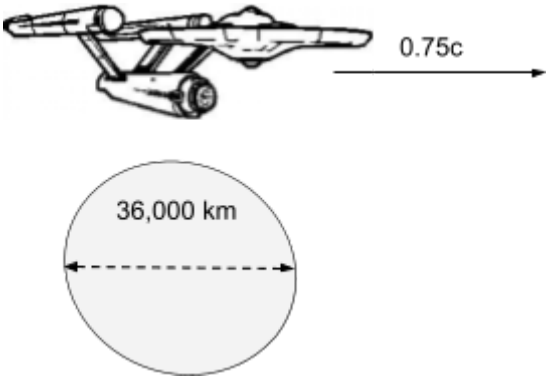
18) A physics student finds a graph about time dilation during an internet search.



Use your knowledge of physics to comment on the shape of the graph.

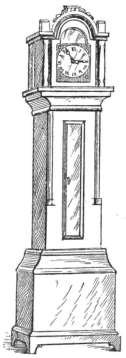
19) A subatomic particle travels at a speed of 0.988 c through a length of pipe measured to be 4 km from the inertial reference frame of the lab.
Determine the length of the track from the inertial reference frame of the moving particle.

20) A spaceship is travelling at a speed of 0.75c relative to a planet.



The planet has a diameter of 36,000 km. This is the diameter of the planet as measured from its inertial reference frame.
Determine the diameter of the planet as measured from the spaceship's inertial reference frame.

21) In a scene from a science fiction film a grandfather's clock sits on the captain's table in the space ship. The time between each tick is not 1 complete second. It is in fact 0.7 seconds.



Determine the speed that the space ship must travel to give a tick of 1 second in an observer's inertial frame which is at rest relative to the spaceship.

22) The length of the captain's table in a spaceship is 8 metres.

Determine the length of the table as seen from the stationary inertial frame of an observer when the spaceship passes at a speed of 0.75c relative to the observer.