

$$v = \frac{\Delta x}{\Delta t}$$

$$\frac{\text{speed 1} \pm \text{speed 2}}{1 \pm \frac{(\text{speed 1})(\text{speed 2})}{c^2}}$$

$$\begin{aligned} (\Delta S)^2 &= (c\Delta t)^2 - [(\Delta x)^2 + (\Delta y)^2 + (\Delta z)^2] \\ &= (c\Delta t)^2 - (\Delta x)^2 \end{aligned}$$

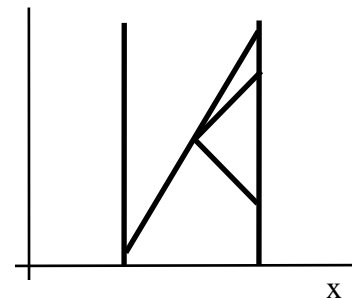
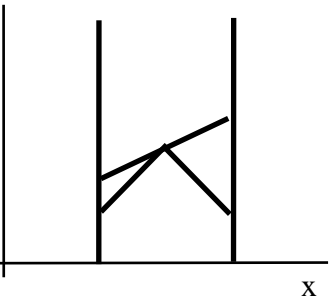
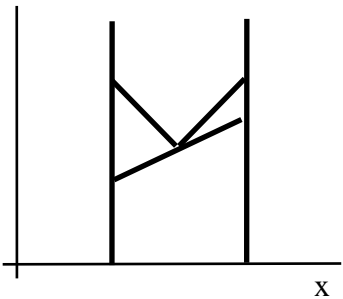
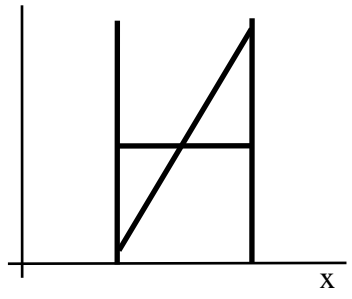
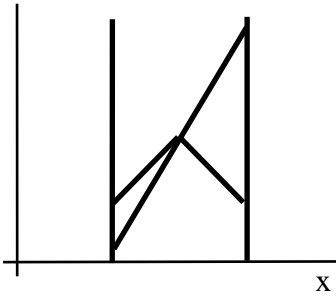
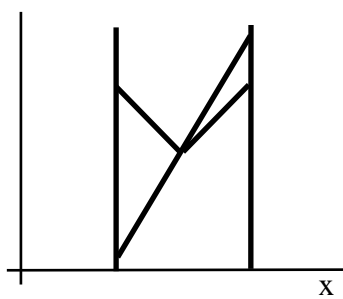
$$\Delta t_{proper} = \Delta t_{2-clock} \sqrt{1 - (v/c)^2}$$

$$L_{other} = L_{rest} \sqrt{1 - (v/c)^2}$$

$$(\Delta S)^2 = (\Delta S')^2$$

1) A cosmic ray particle moving down toward Earth at constant speed decays 3.0 ms after it was produced as measured in the frame in which the particle is at rest. According to observers in the Earth frame, the particle traveled a distance of 4.0 lt-ms between its production and its decay. (note: 1 ms = 1 millisecond = 1×10^{-3} s). How fast was the particle moving?

2) The starship Voyager leaves planet A, traveling at constant speed towards planet B. Half-way through the journey, it sends two radio signals: one back to planet A and one toward planet B. Which of the following diagrams best shows a valid space-time plot for the situation described above? Indicate the diagram *and label the world lines of planet A, planet B, Voyager, and the radio signals*.



3) The spacetime diagram shows the worldlines of Earth and a Rocket, as well as several labeled events (A, B, and C).

a) Determine the speed of the Rocket relative to the Earth.

b) Classify the spacetime interval between the pair of events AB: (circle one)

space-like light-like time-like

c) Classify the spacetime interval between the pair of events AC: (circle one)

space-like light-like time-like

d) Classify the spacetime interval between the pair of events BC: (circle one)

space-like light-like time-like

e) Order events A, B, and C from earliest to latest in the Rocket's reference frame. Indicate any ties with an = sign.

Earliest Latest

f) As measured by observers on a comet moving at constant speed with respect to the Earth (in the same direction as the Rocket), events A and C happen at the same time. Determine the speed of this comet with respect to the Earth.

g) According to observers in the comet frame (see part f), what is the distance between the events A and C?

