Relativity Workshop III: Spacetime

- Work in groups of 4 or 5, writing large on whiteboards so everyone can see
- Each person in the group should take turns contributing to the whiteboard
- Please consult with me as frequently as needed
- Numerical results provided at end

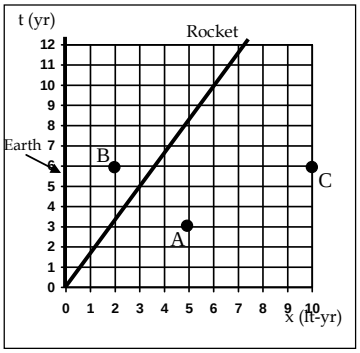
1) In your reference frame, two firecrackers explode 4 lt-ns apart at the same time. In your friend's frame, the distance between the two events is determined to be 5 lt-ns. What is the time between those events in your friend's frame?

2) Jack lights and holds a match, and 60 seconds later, it goes out. Cheri, riding in a rocket past these events at constant speed, notes that, as measured in her frame, the match burned for 100 seconds.
a) How far apart in Cheri's frame did these two events (lighting and going out) occur?
b) As measured by Cheri, how far did the lit match travel, and how fast was it moving?
c) As measured by Jack, how fast and how far did Cheri travel during the one minute the match was lit?

3) A train of rest length 40 lt-ns moves along the tracks at 0.8*c* and is struck by two lightning bolts. One bolt hits the front of the train and the other hits the back. According to track observers the bolts are simultaneous.
a) How far apart on the tracks did the lightning bolts strike?
b) According to riders on the train, how much time passed between the striking of the lightning bolts? Which occurred earlier?

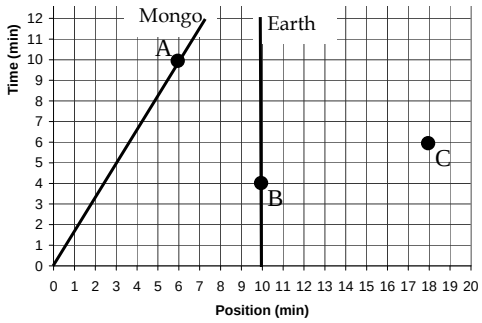
4) A spaceship crew wants to make the trip from Earth to Alpha Centauri (4 lt-yr apart in the Earth/Alpha Centauri rest frame) in only 3 years as measured by clocks on board their spaceship which travels at constant velocity. Determine how fast the spaceship must travel relative to Earth.

5) The spacetime diagram to the right shows the worldlines of Earth and a rocket, as well as several labeled events. Use the diagram to answer the following:
a) How fast is the rocket moving, relative to the Earth?
b) Order events A, B, and C from earliest to latest in Earth's reference frame.
c) Order events A, B, and C from earliest to latest in the Rocket's reference frame.



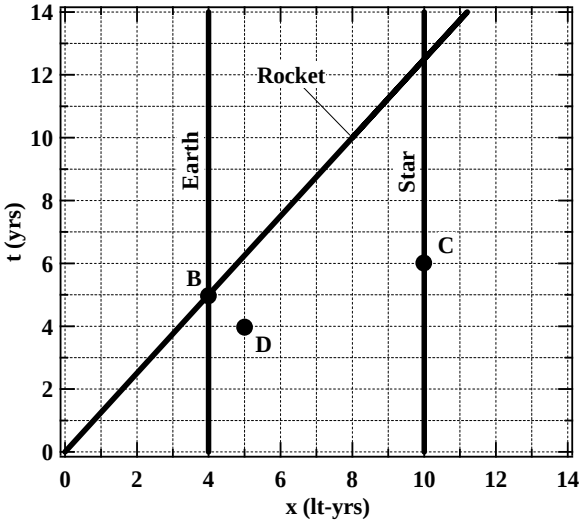
Spacetime diagram for 5)

6) The spacetime diagram to the right shows the wordlines of the planet Earth (stationary in the reference frame shown), the planet Mongo (on a collision course with the Earth), and several labeled events.
a) Order events A, B, and C from earliest to latest in Mongo's frame.
b) Event B is a Rocket passing by the Earth. In the Rocket Frame, events B and C are simultaneous. Draw and label the Rocket's worldline.
c) Determine the speed of the Rocket, as measured by Earth observers.



7) A giant solar flare occurs on the Sun, which is located 8 lt-min from the Earth. Scientists on the Earth detect the light from the flare. At precisely the instant the scientists on Earth detect the solar flare light, a Klingon space ship passes by the Earth at speed 0.8*c*, heading straight for the Sun.
a) Construct a spacetime diagram for this situation. Label the following three events:
A = Klingon ship hits Sun, B = flare occurs on Sun, C = Klingon ship passes Earth.
b) Order the events A, B, C, from earliest to latest, according to Earth-based observers.
c) Calculate the time intervals Δt between each pair of events (AB, AC, and BC), according to Earth observers.
d) Calculate the intervals $\Delta t'_{BA}$ between events B and A, but now according to Klingon ship observers.
e) Classify each of the intervals as space-like, time-like or light-like.

8) (This problem gives you practice with nearly all of the concepts and calculations related to our work with special relativity). The spacetime diagram shows the world lines of the Earth, a Star, and a Rocket, as well as several labeled events.



a) On the diagram, label as "A" the event "Rocket passes Star."

b) Determine the speed of the Rocket, as measured by Earth observers.

c) Determine the time between passing the Earth and Passing the Star, as measured by Rocket observers.

d) Determine the distance between the Earth and the Star, as measured by Rocket observers.

e) Draw the world line of a lost satellite passing the Earth at the same time as the Rocket, but going away from the Star at a speed that is ½ of the Rocket speed (as determined by Earth observers.) Label this line "Satellite."

f) Determine the speed of the satellite as measured by Rocket observers.

g) Order the events A, B, C, D, from earliest to latest, as observed in the Earth-Star frame.

h) Order the events A, B, C, D, from earliest to latest, as observed in the Rocket frame.

i) In some reference frame, the events C and D are simultaneous. In that frame, what is the distance between events C and D?

j) Explain why no one could ever measure the proper time between events C and D.

9) From the **Calendar** page for today go to the **Problem 9** link, follow the directions, and complete the exercises. This series of exercises gives you practice with nearly all of the concepts and calculations related to our work with special relativity

answers: 1) 3 s; 2a) 80 lt-sec; 2b) 80 lt-sec, 0.8 lt-sec/sec; 2c) 0.8 lt-sec/sec, 48 lt-sec; 3a) 24 lt-ns; 3b) 32 ns; 4) 0.8*c*; 5a) 0.6c; 5b) A, then B & C (simultaneous); 5c) A & C (simultaneous), then B; 6a) C, B, A; 6b) C, B, A; 6c) 0.25*c*; 7a) shown right; 7b) B then C then A; 7c) AB = 18 min, AC = 10 min, BC = 8 min; 7d) 30 min; 7e) BC = light-like, others = time-like; 8b) 0.8*c*; 8c) 4.5 yrs; 8d) 3.6 lt-yrs; 8f) 0.909*c*; 8g) D, B, C, A; 8h) C, D, B, A; 8i) 4.58 lt-yrs