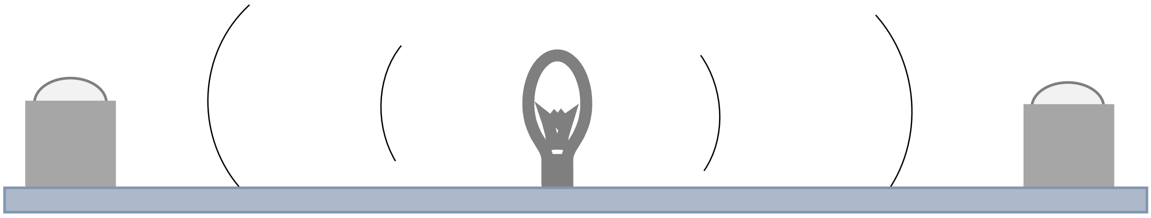
UNL 2201: Space, Time & Matter **Tutorial 6**

1) A light bulb is positioned on a laboratory table at the mid-point between two identical photo-detectors. A flash of the light bulb can be represented as an event L in *spacetime*, while the arrival of the light signal at the left-hand detector is the event L_{Left} , and its arrival at the right-hand detector is the event L_{Right} .



a) An observer A in the laboratory sees the two detectors register the arrival of the light flash simultaneously. On a *spacetime* diagram show the *lightcone* corresponding to the event L and then, by drawing the relevant *worldlines*, explain the observed simultaneity of the two events L_{Left} and L_{Right} by the stationary observer A.

b) Now, imagine that the table moves rightwards at a uniform velocity. By considering the new *worldlines* on the <u>same</u> spacetime diagram, show that the events L_{Left} and L_{Right} are no longer simultaneous according to A. Which event occurs first for this observer?

c) Next, imagine that a second observer B is co-moving with the table (*i.*e. B is also moving rightwards at the same speed as the table relative to A). The principle of relativity requires that B must observe the events L_{Left} and L_{Right} as simultaneous – why?

It appears therefore, that observer A and observer B observe the same two events in the same *spacetime* but arrive at different conclusions. According to special relativity, simultaneity is relative to the observer. But, can you explain the differing perceptions of A and B in terms of *lightcones* and *spacetime*?

(for answer see https://www.youtube.com/watch?v=ZfR1Jc6Zglo)

2) A traveller makes a journey between two towns A and B, taking the super-fast *Einstein Express.* Immediately before his train departs from station A, the traveller *synchronises* his wrist watch with the station clock, which reads 9 o'clock. The train then travels towards town B at a uniform velocity of 4/5 *c* and arrives at station B (which happens to be 864 million km away) exactly one hour later.

Upon arrival, the traveller again consults his wrist watch and finds that it reads 9.36 instead of 10 o'clock.

Is the traveller's wrist watch faulty?

3) If you see a person traveling through space at half the speed of light, you will also see his clocks running at:

a) half their normal rate
b) slower than half
c) slower, but not slowed to half
d) at their normal rate
e) backwards

4) The personal time lapse for all persons traveling between two events (for example lunch today and tomorrow), is the same regardless of which *(spacetime)* path is taken between the two events. Is this statement true or false?

5) A proton moving at ¾ the speed of light (relative to the laboratory) passes through two detectors 2m apart. Events 1 and 2 are the transits through the two detectors. What are the laboratory space and time separations between the two events, in meters? What are the space and time separations in the proton's rest frame?

6) In the twenty-third century a spaceship leaves Earth (Event 1) and travels at 0.95c, later arriving at Proxima Centauri (Event 2), which lies 4.3 light-years from Earth. What are the space and time separations between Events 1 and 2 as measured in the Earth frame, in years? What are the space and time separations between these events in the spaceship frame?

7) A space traveler takes off from Earth and moves at speed 0.99c toward the star Canopus, which is 99 ly distant. How much time will have elapsed by Earth clocks (a) when the traveller reaches Canopus and (b) when Earth observers receive word from the traveler that she has arrived? (c) How much older will Earth observers calculate the traveler to be (according to her) when she reaches Canopus than she was when she started the trip?

8) A spaceship is traveling between two planets, A and B and emits flashes of light every 6 minutes. It travels away from A and towards B. If its flashes are seen at 3 minute intervals on B, then on planet A the flashes are seen at:

(a) 3 minute (b) 6 minute (c) 9 minute (d) 12 minute intervals.

9) Suppose the spaceship (which leaves planet A at 12 noon) is able to abruptly turn around when it emits its 10^{th} flash and then returns to planet A at the same high speed. It continues sending flashes every 6 minutes and emits 10 in its hour of return. But these flashes are seen at 3 minute intervals on planet A. So although a clock aboard the spaceship will read 2:00 o'clock when the ship gets back (1 hour out and 1 hour back), clocks on planet A will read

(a) 2:00 o'clock also (b) 2:30 o'clock (c) neither of these.

10) When a spaceship passes the earth, an alien aged 20 Earth-years falls in love with a terrestrial student whom she sees on her monitor screen. At the time the student is also exactly 20 years old. The relationship is discouraged by the alien authorities and the spaceship continues to move at constant speed v = 0.998c*.* After one year (spaceship time) the alien is able to send a radio message to the student. How old is the student when the message arrives at Earth?