Time dilation and length contraction A61

speed of light in vacuum: c = 299'792'458 $\frac{m}{s}$

***Time dilation**: Time elapses slower in a reference frame in motion (from the perspective of an "observer at rest")*

1. Peter is riding on an airplane with 900.0 $\frac{km}{h}$. He's holding a flashlight pointing it in the same direction as the plane travels. At the same time, a little ball is rolling forward inside the airplane with 5.00 $\frac{m}{s}$. Rose is observing this from the ground.

a) What is the velocity of the ball from Peter's perspective?
b) What is the velocity of the ball from Rose's perspective?
c) What is the velocity of the ball from Roses's perspective, if the ball is rolling towards the back of the plane?
d) What is the flashlight's speed of light from Peter's perspective?
e) What is the flashlight's speed of light from Rose's perspective?
f) What is the flashlight's speed of light from Rose's perspective, if Peter is pointing the flashlight in the opposite direction as the plane travels?

2. Peter is travelling on a spacecraft with $100.00 \cdot 10^6$ $\frac{km}{h}$, away from Rose. He's travelling with his nice, new, and very accurate watch.

a) From Rose's perspective, does Peter's watch go faster or slower than her own?
b) What time does Rose's watch show, after 12.00 hours have passed on Peter's watch?

3. Peter is travelling in his spacecraft at a very high speed. On his watch he reads that he's been travelling for 7 h, 45 min and 33 s. Rose, who stayed at home, says that he's been on the way for 12 s longer.
What is the relative velocity between Peter and Rose?

4. Peter wants to stay young by travelling fast on his spacecraft. Rose is staying home on Earth. Calculate the velocity required, if only half the time is to pass, compared to the time that passes from Rose's perspective.

5. A myon is a negatively charged elementary particle. Its mass is 200 times greater than the mass of an electron, and on average it decays within 2.2 μs (from the perspective of an inertial reference frame moving with it; "observer at motion").
How long does it "live" if it moves with 99.94 % of the speed of light? (from the perspective of an "observer at rest")

***Length contraction**: Distances are shorter in a reference frame in motion (from the perspective of an "observer at rest")*

6. Peter is travelling on a spacecraft with $100.00 \cdot 10^6 \frac{km}{h}$, away from Rose. He's travelling with his nice new, very accurate ruler of 1.000 m length, holding it in the direction he travels. Rose has the exactly same ruler on Earth.

a) From Rose's perspective, is Peter's ruler shorter or longer than her own?
b) What is the length of Peter's ruler from Rose's perspective?
c) What is the length of Rose's ruler from Peter's perspective?

7. Peter is travelling in his spacecraft at a very high speed. From his perspective, his ruler's length is 1'000.0 mm. From Rose's perspective (on Earth), Peter's rule has a length of only 999.9 mm. Determine the velocity of Peter's spacecraft relative to Earth.

8. Peter is travelling at $1.50 \cdot 10^8 \frac{km}{h}$. From Rose's perspective (on Earth) the spacecraft's length is 568 m.
Calculate the length of the spacecraft from Peter's perspective.

9. A myon is a negatively charged elementary particle. Its mass is 200 times greater than the mass of an electron, and on average it decays within 2.2 μs (from the perspective of an inertial reference frame moving with it; "observer at motion").

a) What is the distance it covers until it decays, from the perspective of the myon, if it travels at 99.94 % of the speed of light?
b) What is the distance it covers until it decays, from the perspective of an "observer at rest", if it travels at 99.94 % of the speed of light?

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solutions:

2. b) 12 h 3 min 7 s
3. $3.2 \cdot 10^7 \frac{km}{h}$
4. $2.6 \cdot 10^8 \frac{m}{s}$
5. 63.5 μs
6. b) 996 mm c) 996 mm
7. $1.526 \cdot 10^7 \frac{km}{h}$
8. 574 m
9. a) 659 m b) 19 km