Chapter 9 questions
A woman is on a train that is traveling with uniform velocity. We idealize the train as being on a perfectly smooth, straight track so that she experiences no accelerations.

8 How would the woman describe the horizontal velocity while the ball is dropping. Would an observer on the ground next to the tracks agree? The woman says the horizontal velocity is zero, while the observer on the ground says the ball has the same horizontal velocity as the train.

10 What would the woman obtain for the acceleration of the falling ball? What about the observer on the ground? Both agree on the acceleration of the ball.

12 Do the woman and observer agree on the ball’s initial momentum? What about the change in momentum as it falls? The woman sees the ball as having zero initial momentum while the observer sees the ball as having an initial horizontal momentum. Both agree on the change in momentum since both agree on the mass and acceleration of the ball.

A woman is on a train that is uniformly accelerating. We idealize the train so that the only acceleration is in the direction of the train’s horizontal motion.

18 Could the woman determine if the train was moving to the right or to the left without looking out the window? No.

20 The woman observes that the ball falls in a slanted line away from her. Compare the magnitude of the acceleration of the ball to that of gravity. The accelerations add (like vectors). The total acceleration is given by the pythagorean theorem with horizontal and vertical (gravity) components.

22 What would an observer on the ground see for the horizontal component of the ball’s horizontal velocity? The ball would maintain its initial horizontal velocity from the time at which it was dropped.

Chapter 10 questions
14 Two events happen simultaneously at the front and back of the train moving to the right. How are they seen on the ground? On the ground, the event at the back of the train happens first.
33 Explain how time dilation accounts for the muon traveling from high in the atmosphere to the ground? As seen on the ground, the lifetime of the muon is longer by the factor of $\gamma = 1/\sqrt{1 - (v/c)^2}$.

34 Explain how length contraction accounts for the muon traveling from high in the atmosphere to the ground? As seen in the frame of the muon, the distance from high in the atmosphere to the ground is shorter by the factor of $\gamma^{-1} = \sqrt{1 - (v/c)^2}$.

38 A train has paint cans that explode simultaneously 400m apart at front and back of the train. How far apart are the marks left on the ground where the train is observed moving to the right? The paint marks on the ground as measured by the train are 400m apart. Since the paint marks are moving, the 400m is their length-contracted separation so their actual separation is $\gamma \times 400m$. As observed on the ground, the cans on the train are closer together by a factor of $1/\gamma$, but because the can on the left explodes first, the paint marks are a distance of $\gamma \times 400m$ apart.

46 A deuterium and a tritium combine to make helium and a neutron plus kinetic energy. What must be the relation of the masses? The mass of the helium plus neutron is less than deuterium plus tritium.

Chapter 10 exercises

13 The conductor measures the train length to be 200m while the train is at the station. He then measures the train length while it is moving at 80% of the speed of light. What is the length then? The conductor on the train must still measure it to be 200m.

14 What does an observer on the ground measure for the length of the moving train? The moving train is length contracted by the gamma factor of $1/\sqrt{1 - 0.8^2} = 1.67$ giving 112m.

18 Calculate the impulse $F\Delta t$ needed to accelerate a 1kg mass to 80% of the speed of light, both classically and relativistically.

Impulse (by Newton’s 2nd law) is $F\Delta t = \Delta p$. We need the change in momentum, which starting from rest is the final momentum. Classically, $\Delta p = 1kg \times 0.8c = 2.4 \times 10^8$ kg m/s = N·s or a force of 7.6 N exerted over a year. In relativity, this number gets multiplied by the gamma factor $\gamma = 1/\sqrt{1 - 0.8^2} = 1.67$.