Ay 7B Worksheet
Week 1

Version 1

1. **Beginnings**

   What are Einstein's Postulates, which lead to the Theory of Special Relativity?

2. **Relativistic Cookies**

   It's Girl Scout Cookie season, and those girl scouts need a lot of cookies to sell. In order to help out, you decide to start up a bakery that will produce all the cookies they need. In order to meet the large demand, you're making your cookies on an automated production line that moves the dough continuously through from mixing to baked and packaged product. And also to do it fast enough, you've made the conveyor belt move everything through at a speed of $0.8c = 240,000,000$ m s$^{-1} = 540,000,000$ mph! At one station, the dough is cut into individual cookies by a circular cutter that is 5 cm in diameter.

   Examining some of the finished cookies, you notice a problem: they're not circular! You measure that the cookies are still 5 cm wide, as they should be, but they are the wrong length (where width is the direction across the conveyor belt and length is the direction along it). Finally you realize that relative to the cutter, the dough is length contracted due to its motion. What length of dough is actually getting cut? Are the cookies too long or too short?

3. **Traveling to the Stars**

   Sammy Spaceman and Earthly Earl are twin brothers who have always loved the idea of traveling to the stars. When one day NASA offered them both the chance to go to τ Ceti (the nearest single star that is similar to the Sun), Sammy Spaceman jumped at the opportunity. Earthly Earl, on the other hand, turned it down due to not wanting to be away from his family for the very long time the trip would take. After all, τ Ceti is 11.7 lightyears away.

   Wishing your boring brother farewell, you, Sammy Spaceman, hop into the rocket and blast off. In practically no time at all you've reached your cruising speed of $0.95c$. As you sit still in your rocket, the rest of the universe passes you by rather rapidly. Since this causes the distance to τ Ceti to be length contracted, how long will it take for you to get there? Presuming that once you arrive, you then quickly turn around and head back to Earth at the same speed, how long will the total round trip take you? (Hint: Ignore just how lame and anti-climactic it would be to travel that far just to immediately go back home.)

All the while as you've been traveling, from your point of view Earth flew quickly away from you and then quickly back while you've just sat in your rocket. This means that since they were moving, their clocks were time dilated. How long has Earthly Earl been sitting around on Earth waiting for you to return (total time since you left)? Are you now older or younger than your twin brother?

4. **Barnyard Olympics** Training to be an Olympic athlete, Polly the Pole Runner asks her friend Barny the Farmer to use his farm as a training ground. In the Space Olympics (the year 3022), one of the events is to run fast enough carrying an 80 foot pole so that it shrinks to half its size according to an outside observer. How fast will Polly need to run?

   As added incentive to have her achieve the necessary speed, Barny has her run through his 40 foot barn. At the instant that all 40 feet of the pole (from Barny's point of view) are inside his barn, he flips a switch that closes the front and back door of the barn simultaneously (and then instantly opens them back up again). So for a brief moment, Barny sees that he has Polly and her entire pole confined in his barn.

   However, consider the problem from Polly's Frame. To her, the pole is stationary (and 80 feet long), and the barn is speeding towards her. How large is the barn from her point of view? Clearly her 80 foot pole cannot fit completely inside the shrunken barn, so how do you rectify this with Barny's observations? Is Polly really safe?

Ay 7B Worksheet
Week 1

Version 2

1. **Beginnings**

   What are Einstein's Postulates, which lead to the Theory of Special Relativity?

2. **Relativistic Cookies**

   It's Girl Scout Cookie season, and those girl scouts need a lot of cookies to sell. In order to help out, you decide to start up a bakery that will produce all the cookies they need. In order to meet the large demand, you're making your cookies on an automated production line that moves the dough continuously through from mixing to baked and packaged product. And also to do it fast enough, you've made the conveyor belt move everything through at a speed of $0.8c = 240,000,000$ m s$^{-1} = 540,000,000$ mph! At one station, the dough is cut into individual cookies by a circular cutter that is 5 cm in diameter.

   Examining some of the finished cookies, you notice a problem: they're not circular! You measure that the cookies are still 5 cm wide, as they should be, but they are the wrong length (where width is the direction across the conveyor belt and length is the direction along it). Finally you think about how the cookies are seeing things and realize that as the cutter appears to be rushing over it (from the dough's point of view), it is length contracted. What length of dough is actually getting cut? Are the cookies too long or too short?

3. **Traveling to the Stars**

   Sammy Spaceman and Earthly Earl are twin brothers who have always loved the idea of traveling to the stars. When one day NASA offered them both the chance to go to τ Ceti (the nearest single star that is similar to the Sun), Sammy Spaceman jumped at the opportunity. Earthly Earl, on the other hand, turned it down due to not wanting to be away from his family for the very long time the trip would take. After all, τ Ceti is 11.7 lightyears away.

   Wishing your antisocial brother farewell, you, Earthly Earl, sit back and relax as you watch your brother set off on a lonely mission all by himself. In practically no time at all he reaches his cruising speed of $0.95c$. How long (as measured by you) will it take for Sammy Spaceman to get to τ Ceti? Presuming that once he arrives, he then quickly turns around and heads back to Earth at the same speed, how long will the total round trip take him? (Hint: Ignore just how lame and anti-climactic it would be to travel that far just to immediately go back home.)

All the while as he was traveling, however, his clock was time dilated due to his motion. How long will he have measured the total trip to take? Are you now older or younger than your twin brother?

4. **Barnyard Olympics** Training to be an Olympic athlete, Polly the Pole Runner asks her friend Barny the Farmer to use his farm as a training ground. In the Space Olympics (the year 3022), one of the events is to run fast enough carrying an 80 foot pole so that it shrinks to half its size according to an outside observer. How fast will Polly need to run?

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