SPECIAL RELATIVITY

- **First Postulate: Principle of Relativity** ➔ All the laws of physics are the same for uniformly moving observers.
  ➢ A man juggling oranges on an airplane moving at a constant 600 mph will see no difference between that and juggling in his living room.
  ➢ I.e., *motion is relative*.

- **Second Postulate: Principle of the Constancy of the Speed of Light** ➔ Light forms in free space with a speed $c$ that is independent of the motion of the source.
  ➢ The speed of light, $c$, is a constant regardless of the velocity of the light source.
  ➢ It does not matter how fast the source or the observer are moving away from or towards each other. The speed of light is absolute.

**Time Dilation**

- *Time is relative.*
- Imagine a light-clock, in which a pulse of light bounces back and forth between mirrors while a machine counts the number of times (similar to the tick-tock of a clock).
- Now imagine we place that clock on a spaceship moving at very high speeds (a fraction of the speed of light).
  ➢ Relative to the pilot of the ship, the pulse will travel straight up and down.
  ➢ Relative to a stationary observer, the light pulse travels a longer, diagonal path, which takes more time between tick-tocks.
  ➢ The stationary observer sees time run slower on the moving ship.

- Only really effects time at very high speeds (some percentage of the speed of light).
  ➢ A commercial plane can fly top speed for about 70,000 years and only lose about 1 s.
Variable | Meaning | Units
--- | --- | ---
t | Time experience by moving object | 
t₀ | Time experienced by stationary observer | 
v | Velocity of moving object | Meters per second (m/s)

### The Twin Paradox
One twin stays at home while another travels 100 light years total at a speed nearly that of light.

- The twin who stayed home will have aged nearly 100 years.
- The twin who traveled will have aged nearly 2 years.

### Example Problem 1

Joe and Bob are 18 year old twins. Joe leaves Earth on a spaceship and spends the next 4 years travelling at 85% the speed of light (0.85c). How old is Bob when he returns?

### Length Contraction

- A moving observer measures an object to have a length that is shorter than the length measured by an observer at rest with respect to the object.
- The captain of a starship will perceive the distance between two stars as shorter than an astronomer at rest.
- A consequence of time dilation.
- An object moving at near light speeds will also appear contracted to a stationary observer.
\[ L = L_o \sqrt{1 - \frac{v^2}{c^2}} \]

<table>
<thead>
<tr>
<th>Variable</th>
<th>Meaning</th>
<th>Units</th>
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<tbody>
<tr>
<td>L</td>
<td>Moving length</td>
<td>Meters (m)</td>
</tr>
<tr>
<td>(L_o)</td>
<td>Proper length</td>
<td>Meters (m)</td>
</tr>
<tr>
<td>(v)</td>
<td>Velocity of moving object</td>
<td>Meters per second (m/s)</td>
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**Example Problem 2**

An observer on Earth sees a spaceship at an altitude of 4350 km moving downward toward Earth with a speed of 0.970c. What is the distance from the spaceship to Earth as measured by the spaceship’s captain?