Chapter 28: Special Relativity

Introduction.
- Intuition, pros and cons.
- Modern Questions
  - Blackbody radiation
  - Atomic Spectra
  - Relativity
- Einstein’s Relativity
- Relativity
  - The Concept:
    - Postulate 1
      - “Special”
  - The (old) Math: Galilean Relativity

- The Observation: Light Speed in different reference frames
  - Speed of Sound & a medium.
  - Speed of light & no medium.
  - Postulate 2: Constancy of the Speed of light.

28.3 The Relativity of Time: Time Dilation
- Rest Frame
- Relative Frame

Example 1: Fast motion
Say you hop an intergalactic liner, rev. up to a speed of \( \frac{3}{4} c \), and take off for some distant solar system. In order for this to satisfy certain ‘multicultural experience’ requirements of your school, you’ve got to keep a daily journal throughout your trip. If you write in your journal once a day, as you measure it, how often would that be as the school measured it?
- Time Dilation:
- Life time:
- Reality Check:

Example 2: Slow motion. The fastest any of us are likely to ever go, relative to anyone else, is about the speed of sound, 344 m/s. If you’re aboard a supersonic jet, going 344 m/s. If your friend on ground measures 2 hrs, how much shorter a time do you measure?
  - Doesn’t contradict everyday experience.
  - Confirmable.

- Subatomic particle lifetime
  - Muons

- Speed Limit
- Warning: Rest frame

28.4 The Relativity of Length: Length Contraction

Example 3: Fast
The distance from here to the center of the galaxy is 23,000 ly or 2.18×10^{20} m as measured by an Earth based telescope. If a space ship traveled there at 0.9990 c, A) how far would passengers measure the journey B) how much time would they measure its taking?

28.7 The Relativistic Addition of Velocities
- Relativity
  - Motivation Example: Moving Pool game.
  - Example: Speed of light

Example4: Fast
Upon our development of warp drive; the Vulcans come to visit and welcome us into the Federation. The Vulcan ship approaches the Earth at 0.50 c, then it launches a smaller landing pod which approaches us at 0.70 c. How fast does the ship see the pod moving?

Example5: Slow
Back to the pool game on the train. Say I’m in a ‘Bullet train’ moving forward at about 90 m/s (200 mph) relative to the ground. I hit the cue ball forward at 7 m/s, relative to me. How fast do you, on the ground, measure the cue ball moving? How does it compare with what you’d classically expect?

28.5 Relativistic Momentum
- Classical Momentum:
- Special Relativistic Momentum:
  - Classical Momentum doesn’t withstand special relativistic transformation.
- The practical problem with going near or at light speed

Example6: Fast
How fast must you go for your momentum to be 0.1% of the classical prediction above the classical prediction?

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4. Suppose that you are traveling on board a spacecraft that is moving with respect to the earth at a speed of 0.975 c. You are breathing at a rate of 8.0 breaths per minute. As monitored on earth, what is your breathing rate? (notes: You are stationary relative to the person breathing, yourself; the book’s equation transforms time not frequency so it may be convenient to find out what your minute looks like from earth).

6. An astronaut travels at a speed of 7800 m/s relative to the earth, a speed that is very small compared to c. According to a clock on earth, the trip lasts 15 days. Determine the difference (in seconds) between the time recorded by the earth clock and the astronaut’s clock [Hing: when v<<c, the following approximation is valid: \( \sqrt{1 - \left(\frac{v}{c}\right)^2} \approx 1 - \frac{1}{2} \left(\frac{v}{c}\right)^2 \)]

12. Suppose you are traveling in space and pass a rectangular landing pad on a planet. Your spacecraft has a speed of 0.85c relative to the planet and moves in a direction parallel to the length of the pad. While moving, you measure the length to be 1800 m and the width to be 1500 m. What are the dimensions of the landing pad according to the engineer who built it (i.e. someone stationary relative to the pad)? Note: 2^{nd} Pay special attention to the last two sentences on pg. 872 of the 5^{th} Edition of the text.