Chapter 3 Questions
Special Relativity

1. Suppose Michelson and Morley had no mirrors with which to build their experimental apparatus. Can you design another apparatus to test for the effects of the ether?

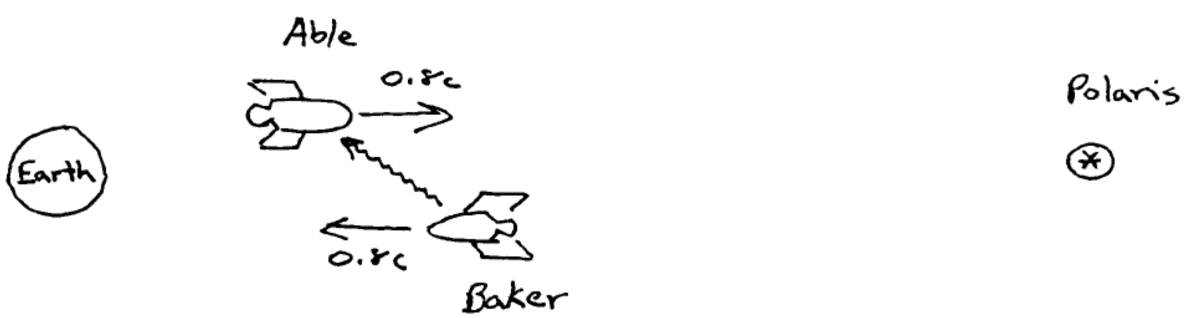
2. Cite an example showing that motion appears different as seen from different frames of reference, if one frame is moving with respect to the other.

3. Einstein made two fundamental assumptions in developing the special theory of relativity. What are they? How do they resolve the contradiction in Newtonian physics?

4. What is "special" about the special theory of relativity?

5. A nova explodes near the north star, Polaris, while Able is outbound. At the same time, as seen from Earth Base, a second nova explodes at a point opposite in the sky, in the Southern Cross. What time relationship does Able see between the two novas?

6. Able is traveling away from Earth at 0.8c (80% the speed of light) toward the north star, Polaris. Meanwhile, Baker rockets at 0.8c away from Polaris, returning to Earth Base. Baker signals Able with a light beam as they pass. What is the velocity of the light signal as measured by Able?



7. Does Baker see any change in his own clock as he travels 0.8c? Is it true you can live longer if you travel at high velocity? Explain.

8. As seen by an outside observer, what rate does a clock tick traveling at 0.5c? at 0.8c? 0.99c? What happens to the apparent length of rulers at these velocities?

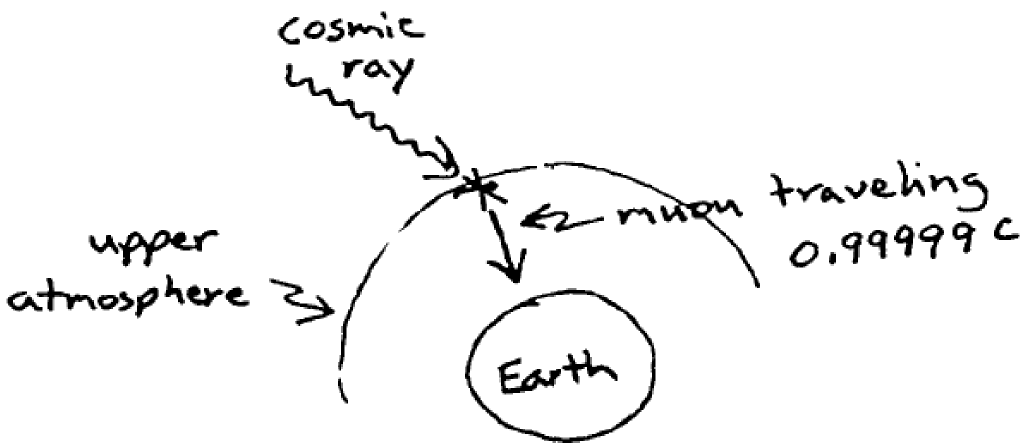
9. A Klingon spaceship passes Earth at a relative velocity of 0.99c. How much does the Klingon clock slow, as seen from Earth? What happens to clocks on Earth, as seen by anobserver in the Klingon ship?

10. The Stanford Linear Collider, a particle accelerator, accelerates an electron to 0.999999 c. What is the mass of the electron at this velocity? (The rest mass of an electron is $0.911 \times$

$10^{-27} gm.$) How much energy has been invested inthe electron? ($1\ {gm \cdot cm^2}/{sec^2}$ is one erg of energy.)

11. The Stanford Linear Collider is two miles long. How long does the Collider appear to the electron in the previousproblem?

12. A cosmic ray produces a muon 100 km. above the Earth's surface. The velocity of the muon is 0.99999 c directly downward, toward the Earth. Will it reach Earth's surface? A muon at rest disintegrates in about 2×10^{-6} seconds.



13. How much energy is released if one gram of uranium is converted to energy in a fission reactor?

14. Each second, the sun converts 594 million tons of hydrogen to 590 million tons of helium. How much energy is released in the process? One ton is approximately 1000 kg. If you base your calculations on kilograms and use a value of $3 \times 10^8 m/sec$ for the speed of light, you will derive an answer in units of energy called "Joules." One Joule of energy will raise the temperature of a cubic centimeter of water (1mL) by 0.25 degree centigrade. How much water can you raise in temperature from $0\ ℃$ to $100\ ℃$ (boiling temperature) with the energy released from the sun in one second?

15. Imagine it was possible to travel faster than light. (It's not.) What would happen to time? To length? To mass? Why is the speed of light "the ultimate speed limit?"

Demonstrations
Chapter 3

1. Find a rolling chair or cart that rolls smoothly in a straight line. Have a friend sit in the chair and toss a ball straight up and down. How does the path of the ball appear to your friend while she is at rest? How does the path of the ball appear to an outside observer (e.g. the other members of the class)? Now push your friend in a straight line at uniform speed. How does the path of the ball appear to her while she is in motion? How does the ball's path appear to the rest of the class?

2. Use the rolling frame of reference described above. This time, while the ball is in the air, suddenly accelerate or decelerate the chair. How does the path of the ball appear to the person in the chair? To the rest of the class? What is the apparent "force" on the ball that "pushes" it away from your friend?

3. Your school laboratories may have access to a Michelson interferometer and laser. If so, align the laser and mirrors so the beams from the two light paths overlap. Spread the output beam with a concave lens, so you can see the interference pattern. What happens to the interferencepattern if you change the length of one of the paths? Put the apparatus on a cart, and reproduce the Michelson-Morley experiment: do you see any change in the interference pattern as you rotate the cart relative to the presumed "ether current?"