Show ALL Computational Work

November 30, 1995

1. Define the following terms. (12 points)
   (a) Half-life
   (b) Doppler Effect
   (c) Alpha Particle
   (d) Red shift

2. (a) Briefly explain why it is necessary for there to be neutrons in the nucleus. (10 points)
   (b) Suppose that it has been reported that a new stable isotope has been discovered with atomic number 90 and atomic weight of 140. Should you believe it? Explain.

3. (a) For the reaction shown, find the unknown number of protons and neutrons in the original nucleus. (Do not worry about X the element symbol) (17 points)

   \[ ^A_XZ \rightarrow \beta^+ + ^{17}_{0}O \]

   (b) Write the basic equation for \( \beta^+ \) decay. (i.e. \( ? \rightarrow \beta^+ + ? + ? \))

   (c) We know the basic reaction that occurs in \( \beta^- \) decay can occur outside of a nucleus. Can \( \beta^+ \) decay occur outside of the nucleus? Briefly explain your answer.

4. The graph below shows the number of gas molecules as a function of energy (measured in units of electron volts). List all the information the graph gives about the energy distribution of the molecules. (10 points)

   ![Graph of number of molecules vs energy (eV)]
5. Suppose that the measured distribution of electrons from $\beta^{-}$ decay was as shown below. If this were the case, what would be the mass of the neutrino? (6 points)

6. It was stated in class that if the neutrino did not exist, the sun would have burned out long ago. Briefly explain this statement. (6 points)

7. Carbon 14 is produced in the atmosphere by the reaction

$$x + ^{14}N_7 \rightarrow p + ^{14}C_6$$

(a) What is $x$?

(b) Where do the $x$ particles come from? (10 points)

8. (a) State the principle of Galilean Relativity. (10 points)

(b) Express that principle as a symmetry principle (i.e. show how it is consistent with our definition of symmetry)
9. A boy is on a train which has a speed of 50 mph relative to the ground. He has a ball which he throws at 20 mph relative to the train in the same direction the train is moving.
(a) Relative to a an observer on the ground, how fast is the ball moving?
(b) If there is an observer on another train, moving 50 mph in the same direction as the boy’s train, how fast does the observer see the ball moving.
(c) If the boy faces the front of the train and blows a trumpet (speed of sound in still air is 600 mph), what speed will the ground observer measure for the sound waves from the trumpet?
(d) If there is an observer on the boys train and he is standing in front of the boy, what will that observer measure for the speed of the trumpet waves?
(Note: for (c) and (d) assume the train cars are completely open) (16 points)

10. When at rest, μ mesons have a half life of 2×10^{-6} sec. 1000 μ mesons, at Wilson Laboratory, are moving at a very high speed such that after 200×10^{-6} sec, 250 μ mesons have not decayed.
(a) According to a Wilson Lab observer, what is the half life of these μ mesons?
(b) What is the value of γ for these μ mesons?
(c) For an observer moving along with μ mesons, how much time did it take for the number of μ mesons to reach 250?
(d) How many meters would the μ mesons have traveled in Wilson Lab before 500 of them would have decayed? (20 points)
11. Indicate whether each statement below is True or False: (12 points)
   (a) In the Michelson - Morley experiment, it was observed that the speed of light is the same for all observers.
   (b) In the Michelson - Morley experiment, Lorentz theorized that both arms of the apparatus had to contract.
   (c) There is no way to detect absolute inertial motion.
   (d) An event occurs in observer A's rocket ship. Observer A and B are in relative motion and both measure the time for the event to occur. B may measure either a longer or shorter time than A measures, depending on the relative motion of the two rocket ships.
   (e) The observer who measures two events as being simultaneous must be at rest with respect to the two events.
   (f) Assume you could travel close to the speed of light in your car. According to you (sitting in the car) you would then have to give the engine more gas to accelerate since the mass of your car would be greater than if you were going at a slow speed.

12. A moon observer triggers two flash bulbs at equal distances from him at the instant a rocket passes him as shown below. (8 points)

   ![Diagram of a moon observer triggering two flash bulbs at equal distances from him at the instant a rocket passes him.]

   Will the rocket observer see both flashes simultaneously? If not, which one will she see first? Briefly explain.
13. Indicate whether each statement is True or False:  
(12 points)

[Assume the proper length between earth and Altair is 16 ly (light years)]

In the twin paradox:
(a) The Rocket is an inertial reference frame throughout the trip.
(b) According to the Rocket twin, during the trip, the distance from earth to Altair is 16 ly.
(c) According to the Earth twin, she saw red shifted signals from the Rocket twin for half the time 
she waited and blue shifted signals for the other half.
(d) The Earth twin received all the heart beats that the Rocket twin transmitted.
(e) The Rocket twin knew she was aging less because she knew her heart rate had slowed 
compared to the Earth twin.
(f) The Rocket twin claims that the distance she traveled on the outward trip from earth is the 
same as the distance traveled on the inward trip to earth.

14. A Rocket observer and a Platform observer both measure the length of the same stick. The 
Rocket observer measures its length to be 80 cm., while the Platform observer measures it to be 
20 cm.
(a) Assume one of the observers is at rest with respect to the stick. Which one?
(b) What is the value of $\gamma$ for this case?
(c) An event occurs in the Rocket frame such that the platform observer claims the time for the 
event to occur is 20 sec. What does the Rocket observer claim for the time interval for the 
event? (Note: the frames are the same as above)
(d) Briefly discuss how the Rocket observer explains the fact that the Platform observer 
measured a different length for the stick.  
(20 points)

(Note: Just saying "because of length contraction" is not adequate. We want you to explain the "logic")
15. A space platform fires two missiles in opposite directions such that both have a speed of \(0.95c\) relative to the platform. An observer on Missile 1 observes missile 2 to be traveling at a speed of: choose the correct statement(s). (6 points)

(a) exactly \(c\)
(b) 1.90 \(c\)
(c) a little greater than \(c\)
(d) a little less than \(c\)
(e) 0.95 \(c\)
(f) you cannot tell from the information given

**Possibly Useful Numbers**

\[c = 3 \times 10^8 \text{ m/sec}\]

\[= 1.86 \times 10^5 \text{ mi/sec}\]

\[= 1.0 \text{ Light year/year}\]
(a) $Z = 9$, $A = 17$

(b) $p \rightarrow n + e^+ + \nu$

(c) No, a free proton does not have enough mass (energy) to decay.

4) $(a) E_{\text{min}} = 20$ eV  $(b) \text{max # of molecules at } E \leq 40$ eV

5) $M_N = 0.1 \text{ MeV}$

7) $(a) \pi = \pi \text{ (neutron)}$

   $(b) \text{cosmic rays}$

8) $(a) 70 \text{ mph}$  $(b) 20 \text{ mph}$  $(c) 600 \text{ mph}$  $(d) 550 \text{ mph}$

10) $(a) 100 \times 10^{-6} \text{ sec}$  $(b) \gamma = 50$  $(c) 4 \times 10^{-6} \text{ sec}$  $(d) 3 \times 10^4 \text{ meters}$

11) $(a) F$  $(b) F$  $(c) T$  $(d) F$  $(e) F$  $(f) F$

12) No; sees flash from B first

13) $(a) F$  $(b) F$  $(c) F$  $(d) T$  $(e) F$  $(f) T$

14) $(a) \text{Rocket observer}$  $(b) Y = 4$  $(c) 5 \text{ sec}$

15) d