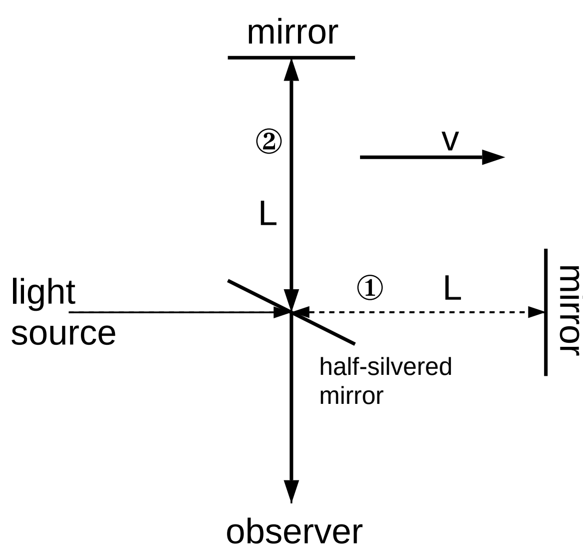
# Mid-Term Exam 1
# Physics 2130
# Modern Physics
# Wednesday September 25, 2001

Point distribution: Questions #1 - #14 are worth 5 points each. Question #15 is worth 20 points, and question #15 is worth 10 points. Alot your time accordingly.

**1.** Consider this question within the framework of classical physics (i.e., not relativity theory). Two electrons are ejected in opposite directions from a radioactive material at rest in the laboratory. Each electron has a speed of 0.67c as measured by a laboratory observer. What is the speed of one electron as measured by the other?

(a) 0.92 c
(b) 0 c
(c) 1.34 c
(d) 0.8 c

**2 - 5.** This set-up of the Michelson-Morley experiment is the basis for questions #2 - #5. Assume the aparatus is moving with velocity $v$ relative to the ether frame in the direction indicated. The length of both Arms 1 and 2 is $L$.




These are the possible answers for questions #2-#5.

(a) $L/(c+v) + L/(c-v)$
(b) $2L/c$
(c) $2L/\sqrt{c^2+v^2}$
(d) $2L/\sqrt{c^2-v^2}$

**2.** What is the time for a light wave to travel back and forth along Arm 1 of the interferometer using classical mechanics?
**3.** What is the time for a light wave to travel back and forth along Arm 2 of the interferometer using classical mechanics?

**4.** What is the time for a light wave to travel back and forth along Arm 1 of the interferometer using special relativity?

**5.** What is the time for a light wave to travel back and forth along Arm 2 of the interferometer using special relativity?

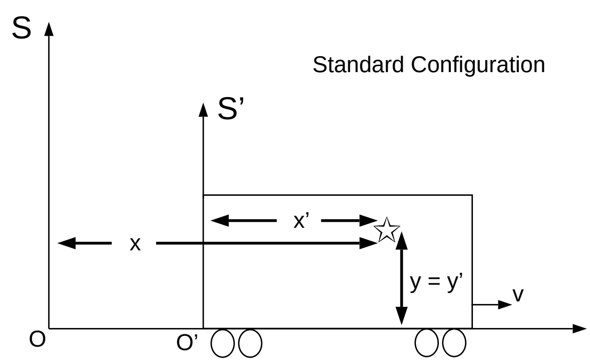
**6.** A space explorer travels to the nearest star, $\alpha-$Centauri, in a rocket with velocity $v = 0.8$c. $\alpha-$Centauri is 4 light years (cy) as measured from Earth. What is the distance as seen by the explorer?

(a) 2.4 cy
(b) 6.7 cy
(c) 3.2 cy
(d) 2.8 cy

**7.** How long will the same explorer in question #6 say the journey to the star lasts?

(a) 1.9 y
(b) 5 y
(c) 3.6 y
(d) 3 y

**8 - 9.** This is the configuration for two frames used in questions #8 and #9. $S'$ is moving in the $x-$direction with speed $v = 0.6$c relative to $S$.




**8.** An observer in frame $S$ sees an event to occur on the $x-$axis at $x = 10$ light-seconds (1 light-second = 1 cs = $10^8$m) at time $t = 4$ s. What is the position of the event observed in frame $S'$?

(a) 12.5 cs
(b) 9.5 cs
(c) 7.5 cs
(d) 6 cs

**9.** At what time will be event be observed in frame $S'$?

(a) 1.25 s
(b) 0 s
(c) -2.5 s
(d) -5 s

**10.** Redo problem #1 within the framework of relativity theory. Use the same set of answers listed there.

**11 - 13.** The following information is needed for questions #11 - #13. An electron is moving with a total energy of $E = 2$ MeV. (For the electon's rest mass use 0.5 MeV.)
**11.** What is the electron's momentum?

(a) 1.87 MeV/c
(b) 1.94 MeV/c
(c) 2.33 MeV/c
(d) 1.54 MeV/c

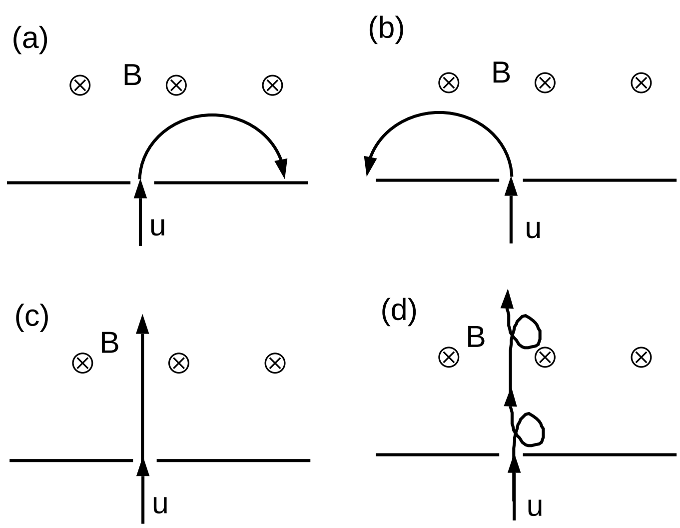
**12.** What is the electron's speed?

(a) 0.97 c
(b) 1.94 c
(c) 0.9 c
(d) 0.83 c

**13.** What is the electron's kinetic energy?

(a) 2.2 MeV
(b) 1.2 MeV
(c) 0 MeV
(d) 1.5 MeV

**14.** Which of the following figures accurately represents the expected trajectory of an electron injected into a region with a constant magnetic field pointing INTO the page?



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**15.** A group of $\pi$-ons is observed to travel at $v = 0.8c$ in the lab frame. The proper half-life for the $\pi$-ons is $\tau_{1/2} = 1.8 \times 10^{-8}$ s. There are initially 320 pions that travel in a tube that is 36 m in length as observed in the lab frame. Place your answers in the boxes provided.

**a.** From the $\pi$-on's point of view, how far does the lab move?

$\boxed{\phantom{xxxxxxxxxx}}$

**b.** From the $\pi$-on's point of view, how long does it take for the lab to complete its trip? Present your answer in terms of the number of proper $\pi$-on half-lives.

$\boxed{\phantom{xxxxxxxxxx}}$

**c.** How many $\pi$-ons will remain at the end of the trip?

**d.** How many $\pi$-ons would be predicted to remain using classical physics?

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**16.** A $\Lambda$-particle decays into a proton and a pion, $\Lambda \to p + \pi$, and it is observed that the proton is left at rest. No light, neutrinos or other objects are created in the decay. Using $m_\Lambda, m_p, m_\pi$ for the masses of the $\Lambda$, proton, and pion, respectively, show that the energy of the pion is:

$$E_\pi = \frac{\left(m_\Lambda^2 - m_p^2 - m_\pi^2\right) c^2}{2m_p}$$