Name:
Student Number:

Physics 200 Midterm #2

November 18, 2009

Questions 1-9: Multiple Choice/Short Answer: 1 point each
Questions 10-12: Show your work

18 points total

MULTIPLE CHOICE ANSWERS:

#1	
#2	
#3	
#4	
#5	
#6	
#7	
#8	
#9	

Formula sheet at back
(you can remove it)

Problem 1

For the statements:

1) Mass can be converted into kinetic energy.
2) Kinetic energy can be converted into mass.

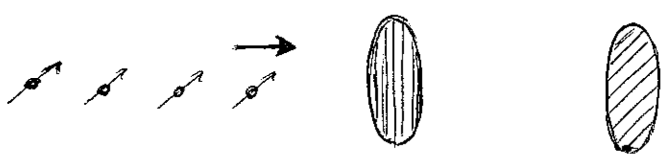
A) Only 1 is true.
B) Only 2 is true.
C) Both 1 and 2 are true.
D) Neither 1 nor 2 are true.

Problem 2

A stable Helium-4 nucleus has two protons and two neutrons. We can conclude that:

A) $m_{He} = 2m_p + 2m_n$
B) $m_{He} < 2m_p + 2m_n$
C) $m_{He} > 2m_p + 2m_n$
D) Any of the above may be true.

Problem 3



Photons polarized at 45° to the vertical are incident on two polarizers, the first oriented at 0° and the second at 45°. For photons that pass through the first polarizer, we can say that

A) They will definitely pass through the second polarizer.
B) They will definitely not pass though the second polarizer.
C) On average, half of them will pass through the second polarizer.
D) There is no way to predict the likelihood that these photons will pass through the second polarizer.

Problem 4

A photon is incident on a polarizer oriented at 90° to the vertical. For which initial polarization state can we predict with certainty whether or not the photon will pass through?

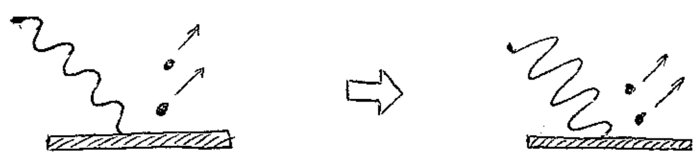
A) $|0°\rangle$
B) $|45°\rangle$
C) $1/\sqrt{2}|0°\rangle + 1/\sqrt{2}|90°\rangle$
D) All of the above
E) None of the above

Problem 5

In a certain exothermic (i.e. releasing energy) nuclear fusion reaction, deuterium (2 neutrons, one proton) and tritium (3 neutrons, one proton) fuse into a Helium nucleus (2 neutrons, 2 protons) and eject a neutron in the process, $D + T \rightarrow He + n$. For this reaction,

A) $m_D + m_T = m_{He} + m_n$
B) $m_D + m_T < m_{He} + m_n$
C) $m_D + m_T > m_{He} + m_n$
D) Any of the answers above could be correct depending on what frame of reference we measure the masses in.

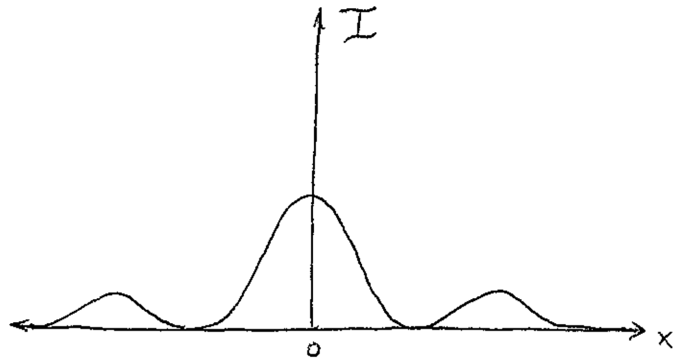
Problem 6



Electrons are observed to be emitted when a beam of light is incident on a metal. If we change the light so that the amplitude of the electromagnetic wave is increased but the wavelength remains the same, we will find that

A) The current of electrons coming out of the metal will increase but their maximum kinetic energy will not change.
B) The current of electron coming out of the metal will stay the same but their maximum kinetic energy will increase.
C) The current of electrons and their maximum kinetic energy will both stay the same.
D) The current of electrons and their maximum kinetic energy will both increase.

Problem 7



The graph shows a plot of intensity versus position on the screen for an interference pattern produced in a double slit experiment with light. If we send four individual photons through the same apparatus, which of the following statements is correct?

A) Two of the photons will hit the screen at $x<0$ and two of the photons will hit the screen at $x>0$.
B) Each photon will hit the screen directly behind one of the slits.
C) The number of photons hitting the screen at $x>0$ could be anything between 0 and 4, but is most likely 2.
D) Since the photons are identical, each photon distributes its energy onto the screen in the same way, with the energy distribution matching the classical intensity pattern.

Problem 8

An electron is in a state $3/5|x_1\rangle - 4/5|x_2\rangle$. If we do a measurement of position, we are most likely to find the electron at

A) x_1
B) x_2
C) $3/5\ x_1 - 4/5\ x_2$
D) $9/25\ x_1 + 16/25\ x_2$
E) All positions between x_1 and x_2 are equally likely.

Problem 9

If we perform the measurement of problem 8 a large number of times on electrons with the same initial state, the average value of the position measurements will be

A) x_1
B) x_2
C) $3/5\ x_1 - 4/5\ x_2$
D) $9/25\ x_1 + 16/25\ x_2$
E) $1/2\ (x_1 + x_2)$

Problem 10

A certain metal is found to emit electrons with maximum kinetic energy 5eV when it is illuminated with 200nm light. What is the maximum wavelength light that will cause electrons to be emitted? (3 points)

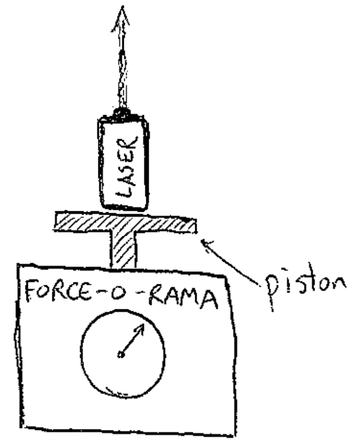
Problem 11

A particle of mass M travels at velocity v in the $+\hat{x}$ direction. At some time, it decays into two photons, one with energy 8 MeV traveling in the $+\hat{x}$ direction, and one with energy 2MeV traveling in the $-\hat{x}$ direction. Determine the velocity v and the mass M of the original particle.

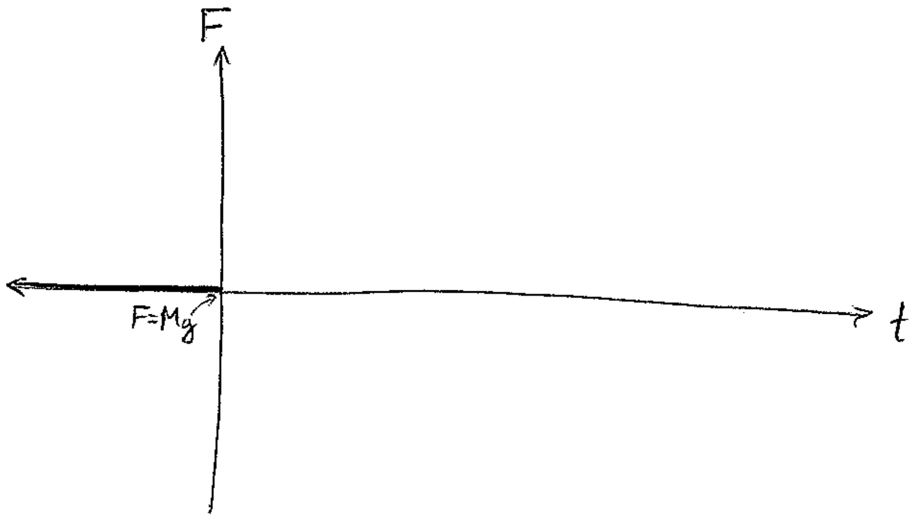
(give v as a fraction of c and M in units of MeV/c^2).

(4 points)

Problem 12



A battery-powered laser with power P has mass M. The laser is placed pointing upwards on a scale that exactly measures the downward force on the piston (initially the scale will read Mg). If the laser is turned on at time t=0, sketch on the graph below what the scale will read in the region t>0. Explain your result, and if possible, give quantitative expressions for any features of your graph (e.g. slope). (2 points)



Scrap

scrap

$$E = \frac{-13.6\,eV}{n^2}$$

$$\vec{F} = \frac{d\vec{p}}{dt}$$

$$E = hf$$

$$I = I_o \cos^2\theta$$

$$\lambda' = \lambda + \frac{h}{m_e c}(1 - \cos\theta)$$

$$E^2 = p^2c^2 + m^2c^4$$

$$v\gamma = c\sqrt{\gamma^2 - 1}$$

$$E' = \gamma(E - vp_x)$$

$$\lambda = \frac{h}{|\vec{p}|}$$

$$\lambda \cdot f = c$$

$$p_x' = \gamma\left(p_x - \frac{v}{c^2}E\right)$$

$$v = \frac{p}{E}\cdot c^2$$

$$\gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}}$$

$$x' = \gamma(x - vt) \qquad x = \gamma(x' + vt')$$

$$t' = \gamma\left(t - \frac{v}{c^2}x\right) \qquad t = \gamma\left(t' + \frac{v}{c^2}x'\right)$$

$$\Delta x \Delta p \geq \frac{\hbar}{2}$$

$$u' = \frac{u - v}{1 - \frac{uv}{c^2}}$$

$$e^{i\pi} = -1$$

$$\Delta T = \frac{v^2}{c^2}\frac{L_1 + L_2}{c}$$

$$\vec{p} = \gamma m \vec{v}$$

$$\lambda_{obs} = \lambda\gamma\left[1 - \cos\theta \frac{v}{c}\right]$$

$$I = (\Delta x)^2 + (\Delta y)^2 + (\Delta z)^2 - (\Delta t)^2 c^2$$

$$d\tau = dt\sqrt{1 - \frac{v^2}{c^2}}$$

$$E = \gamma m c^2$$

1 light year = $c \times$ 1 year

$$-\frac{\hbar^2}{2m}\frac{\partial^2\psi}{\partial x^2} + V\psi = i\hbar\frac{\partial\psi}{\partial t}$$

$c \approx 3 \times 10^8$ m/s

$h = 6.6 \times 10^{-34}$ J·s

$$E = hf - W$$

1 eV $= 1.6 \times 10^{-19}$ J

$m_e = 9.1 \times 10^{-31}$ kg

$\hbar = h/2\pi$

$hc \approx 1.24 \times 10^3$ eV·nm

POSSIBLY USEFUL FORMULAE