

Name:
Student Number:

Physics 200 Midterm #2
November 12, 2008

Questions 1-7: Multiple choice: 1 point each
Questions 8-10: Show your work

15 points available

PLEASE
WRITE
YOUR
MULTIPLE
CHOICE
ANSWERS
HERE!



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

formula sheet at the back (can be removed)

Problem 1



The figure above represents the photons in a beam of light with some fixed wavelength and intensity. If size represents photon energy in the picture, which of the pictures below best represents a beam of light with half the wavelength but double the intensity?

- A) →
- B) →
- C) →
- D) →

Problem 2

A physicist sets up a series of polarizers and finds that photons which are initially polarized in the vertical direction pass through all the polarizers with a net probability of exactly one quarter. If we send in a beam of vertically polarized light with an intensity 1600 W/m^2 through this series of polarizers, the intensity of the transmitted beam will be

- A) 100 W/m^2
B) 400 W/m^2
C) 800 W/m^2
D) 1600 W/m^2
E) 6400 W/m^2

Problem 3

An unstable nucleus of mass M decays into another nucleus of mass m by emitting an α particle. The original mass M is

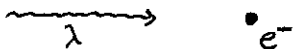
- A) Greater than $m + m_\alpha$
- B) Less than $m + m_\alpha$
- C) Equal to $m + m_\alpha$
- D) Could be any of the above.

Problem 4

Two protons (each with mass $938 \text{ GeV}/c^2$.) traveling with equal speeds close to the speed of light in opposite directions collide to produce a new particle of mass M . Assuming that no other particles are produced in the collision, the mass M must be

- A) less than $1876 \text{ GeV}/c^2$.
- B) equal to $1876 \text{ GeV}/c^2$.
- C) greater than $1876 \text{ GeV}/c^2$.
- D) Any of the above are possible.

BEFORE:



Problem 5

A photon of wavelength λ scatters off an electron that is initially stationary. After the collision, the photon's wavelength will be

- A) equal to λ
- B) greater than λ
- C) less than λ
- D) any of the above are possible

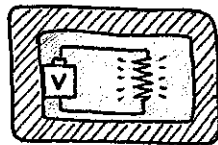
Problem 6

Four photons are sent into a polarizer oriented at 90° to the vertical. Their polarization states are

$$|90^\circ\rangle, \quad |0^\circ\rangle, \quad |45^\circ\rangle, \quad \text{and} \quad \frac{1}{\sqrt{2}}|0^\circ\rangle - \frac{1}{\sqrt{2}}|90^\circ\rangle$$

What are the possibilities for how many photons will pass through the polarizer?

- A) exactly 1 photon will pass through
- B) either 1 or 2 photons will pass through
- C) either 1, 2, or 3 photons will pass through
- D) either 2 or 3 photons will pass through
- E) any number (0, 1, 2, 3, or 4) might pass through



Problem 7

Suppose we build a sealed box which contains a battery connected to a heater which gradually heats the air inside the box. Assuming the box is completely isolated, and that the box neither absorbs nor emits any particles or radiation, what happens to the mass of the box (including its contents) as time passes?

- A) The mass increases.
- B) The mass decreases.
- C) The mass stays the same.

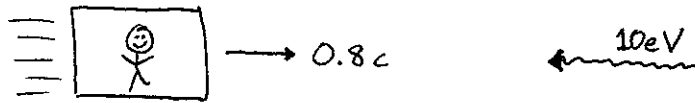
Problem 8

A beam of light with frequency $7.5 \times 10^{14} \text{ s}^{-1}$ is incident on a metal, and photoelectrons are observed with maximum velocity $5 \times 10^5 \text{ m/s}$. The same sample of metal is illuminated with a new light source, but this time electrons are observed with maximum velocity 10^6 m/s . What is the frequency of the new light source? (3 points)

Problem 9

A photon with energy 100MeV is incident on a stationary particle of mass $200\text{MeV}/c^2$. If the photon is completely absorbed to form a new particle, what is the speed of this new particle (relative to the speed of light)?

(3 points)



Problem 10

In some frame of reference, a photon with energy 10eV is traveling in the negative x direction. According to an observer traveling at speed $0.8c$ in the positive x direction relative to the original frame, what is the energy of the photon?

(2 points)