Name:
Student Number:

# Physics 200 Midterm #2

November 16, 2011

Questions 1-8: Multiple Choice: 1 point each
Questions 9-11: Show your work: 9 points total

Multiple choice answers:

| | |
|---|---|
| #1 | |
| #2 | |
| #3 | |
| #4 | |
| #5 | |
| #6 | |
| #7 | |
| #8 | |

Formula sheet at the back (you can remove it)


**Question 1:** Two identical objects of mass m collide and stick together. We can say that the mass M of the final object is

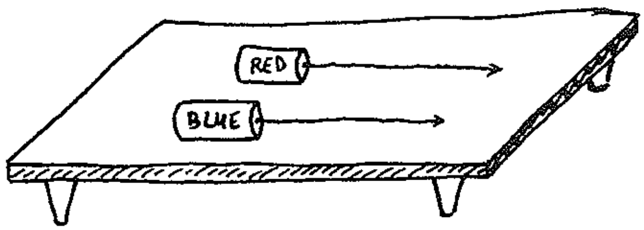
A) less than 2m.
B) greater than 2m.
C) equal to 2m.
D) Any of the above is possible.


**Question 2:** When a third polarizer is inserted between two other polarizers, it is found that the intensity of the transmitted light beam doubles. We can say that the probability of a single photon passing through all three polarizers

A) is four times larger than before.
B) is twice as big as before.
C) is √2 times as big as before.
D) is the same as before (this probability is not related to the intensity).
E) cannot be determined relative to the previous probability from the information given unless we are also given the angles of the polarizers.

**Question 3:** A UFO emits 500nm light in all directions. If the UFO flies horizontally at velocity 3/5c directly over UBC, the observed wavelength of the UFO's light when the UFO is directly overhead is

A) 250nm
B) 400nm
C) 500nm
D) 625nm
E) 1000nm




**Question 4:** A blue laser and a red laser, with identical total power of 1mW, sit motionless on a frictionless table. The lasers are each turned on for one minute and then turned off again. We can say that

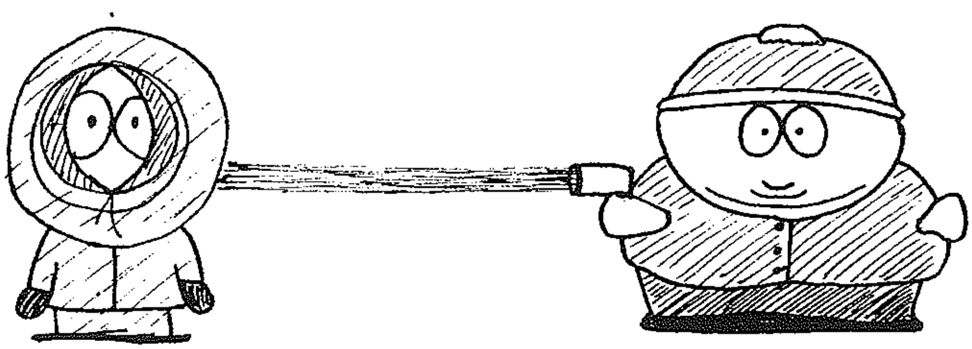
A) The two lasers have emitted the same number of photons
B) The red laser has emitted more photons
C) The blue laser has emitted more photons

**Question 5:** After the lasers in question 3 are turned off, we can say that:
(*assume the lasers have equal mass)*

A) the blue laser will be moving faster
B) the red laser will be moving faster
C) both lasers will be travelling at the same (nonzero) speed
D) the lasers will move while the beams are on but both lasers will be motionless after they are turned off.

**Question 6:** A beam of electrons produces an interference pattern in a double slit experiment. Which of the following statements is most correct:

A) Each electron goes through a certain slit, and we can determine which slit by looking where it hits the screen.
B) Each electron goes through a certain slit; the probabilities for going through the two slits are determined by which quantum superposition the electron is in.
C) Each electron goes through a certain slit, but there is no way to know which one or even predict the relative probability.
D) Each electron actually goes through both slits, and the probabilities for hitting various places on the screen are determined by which quantum superposition the electron is in.
E) Each electron actually goes through both slits; there is no way to predict the probabilities for where on the screen the electron will hit.



**Question 7:** Cartman illuminates Kenny with a monochromatic light source but finds that no photoelectrons are ejected. To succeed in ejecting electrons (as efficiently as possible), Cartman should

A) stand closer to Kenny.
B) use a higher-intensity light source.
C) use higher-frequency radiation.
D) use a longer-wavelength source.
E) None of the above: electrons will never be ejected because Kenny and his clothing are not made of metal.

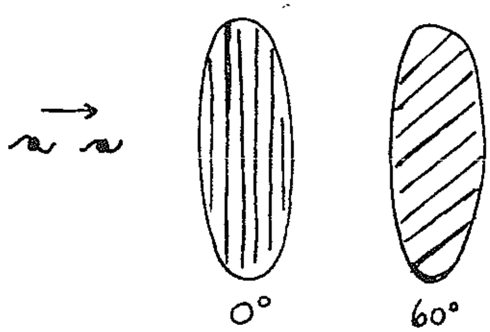
**Question 8:** In a photoelectric effect experiment, light from source B results in photoelectrons with twice the maximum kinetic energy as light from source A. We can conclude that

A) Source B has double the wavelength compared with source A.
B) Source B has half the wavelength compared with source A.
C) Source B has less than half the wavelength compared with source A.
D) Source B has more than half the wavelength compared with source A.
E) Source B has the same wavelength but twice the total power as source A.

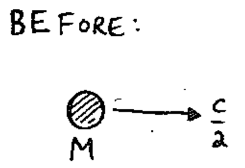
**Question 9:** Two photons are each prepared in a polarization state

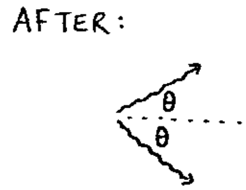
$$\frac{1}{\sqrt{2}}|0°\rangle + \frac{1}{\sqrt{2}}|90°\rangle$$

and sent towards a pair of polarizers, with the first oriented at 0° and the second oriented at 60° as shown:




Calculate the probability that exactly one of them will pass through both polarizers. **(4 points)** extra space for question 9:




**Question 10:** An unstable particle of mass M is travelling at speed v= ½ c when it decays into two photons, each moving at an angle θ to the direction of the original particle's motion.

a) The two photons must have the same energy. Explain why. (***1 points***)

b) Determine the angle θ. (***3 points***) extra space for question 10:

QUESTION 11: A spaceship accelerates from rest by emitting light from the rear of the ship. Find the mass of the ship when it has reached speed $v = \frac{3}{5}c$.

(** this question is only worth 1 POINT, so you should probably finish the others before working on it **)

Initial mass of the ship: $M$

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

$$E = hf$$

$$I = I_0 \cos^2\theta$$

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

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

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

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

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

$$\lambda \cdot f = c$$

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

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

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

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

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

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

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

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

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

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

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

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

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

$$E = \gamma mc^2$$

1 light year = c × 1 year

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

$c = 3 \times 10^8$ 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

$\hbar = h/2\pi$

POSSIBLY USEFUL FORMULAE