** You may use an exam booklet if you need extra space for long answer questions **

Name:
Student Number:

Physics 200 Exam

December 15, 2009

Part I: 16 multiple choice questions
(separate booklet, one point each)

Part II: 9 multiple choice questions
(one point each, write your answers below)

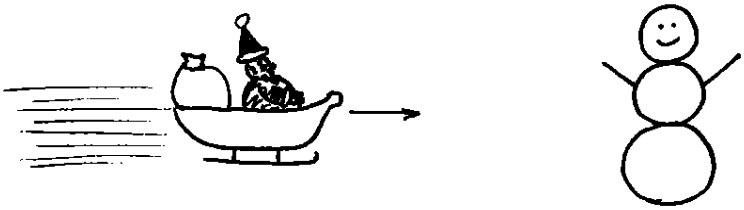
Part III: Long answer questions: explain your work
(25 points total)

50 points total

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

Write multiple choice answers for the questions in this booklet here!

FORMULA SHEET AT BACK



1) Santa Claus is travelling in his hyper-sleigh at velocity $v = \sqrt{3/4}\,c$. Which of the pictures below best represents the proportions of Frosty the Snowman as measured by Santa?

A) 

C) 

B) 

D) 

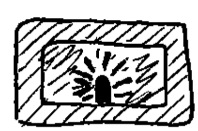
2) A distant supernova explodes just as the Physics 200 exam begins. In the frame of reference of a rocket travelling towards the supernova,

A) the supernova explodes after the Physics 200 exam begins.

B) the supernova explodes before the Physics 200 exam begins.

C) the supernova explodes at the same time as the Physics 200 exam begins.

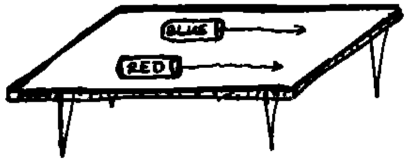
3) Inside a space probe, a tank of hydrogen gas explodes, heating up all the air inside the probe. Assuming there is no radiation emitted from the space probe during this time, we can say that



A) The total mass of the probe is greater after the explosion

B) The total mass of the probe is less after the explosion

C) The total mass of the probe is the same after the explosion



4) A blue laser and a red laser, with an 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 blue laser has emitted more photons.

C) The red laser has emitted more photons.

5) After the lasers in problem 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 moving at the same (nonzero) velocity.

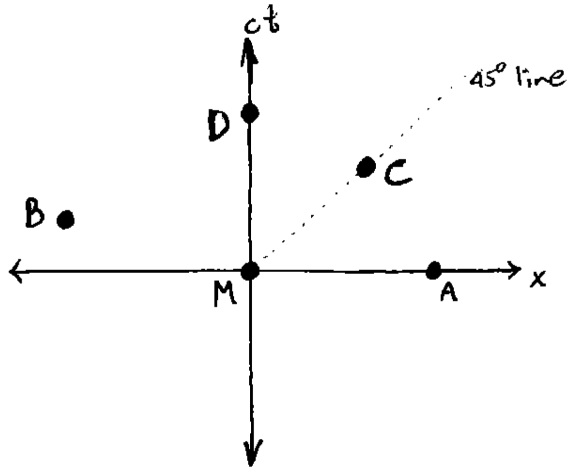
D) the lasers will move while the beams are on but both lasers will be motionless after they are turned off.

6) In order to make the GPS (global positioning system) work correctly, engineers make the clocks on the orbiting satellites run at a different rate from clocks on Earth so that they appear to be ticking at the same rate as the Earth clocks. In order for this to work, the engineers should make the orbiting clocks in orbit run

A) Faster than the clocks on Earth

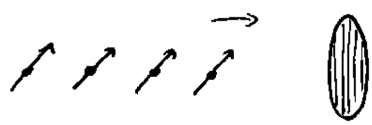
B) Slower than the clocks on Earth

(You should ignore gravitational time dilation for this question, though in reality it cannot be ignored!)



7) In the spacetime diagram above, which event is simultaneous with the event M in some frame of reference?

A) A B) B C) C D) D E) Both A and B



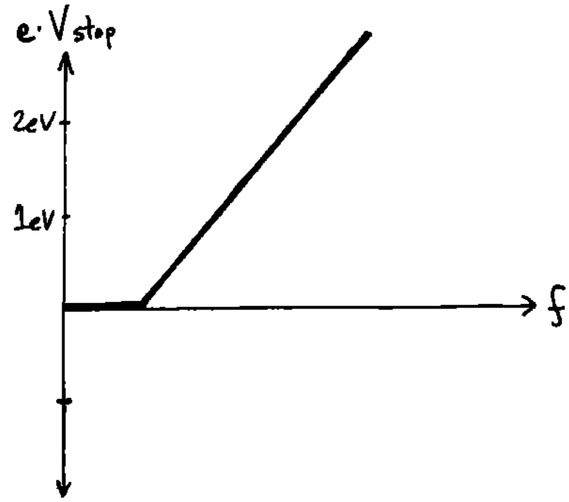
8) Four photons polarized at 45° are incident on a vertical polarizer as shown. Which of the pictures below represents the most likely outcome of this experiment? (i.e. the most likely of the ones shown)

A) 

B) 

C) 

D) None of these is possible

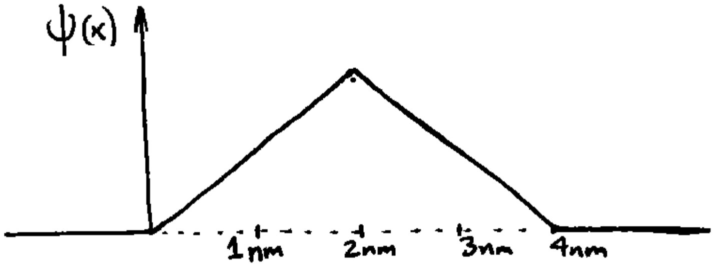


9) The graph above shows the stopping voltage plotted against frequency in a photoelectric effect experiment. For the metal used in the experiment, what is the minimum amount of energy required to remove an electron?

A) -2 eV B) -1 eV C) 0 eV D) 1eV E) 2 eV

(10) Describe the photoelectric effect and explain why it provides evidence for the photon picture of light. Answer as concisely as possible.

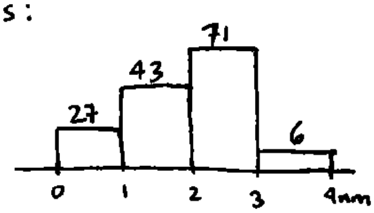
(4 points)



(11) a) The wavefunction for an electron in a short wire is shown above. A team of physicists prepares 16,000 electrons in this state and then measures the position of each of the electrons. They make a histogram showing the number of electrons that they find in each of the four intervals [0nm,1nm], [1nm,2nm], [2nm,3nm], and [3nm,4nm]. Draw what you expect their histogram to look like and indicate the expected number in each bin. Show your calculations and explain your work.

(5 points)

your answer should look something like this:



More room for #11 a)

11 b) If the experimenters had measured the velocity for these electrons instead of the position, what can you say about the range of values they would likely find? *(I'm not expecting a precise answer here)* (2 points)

(12)

In a radioactive gamma decay, a nucleus that is initially at rest decays by emitting a photon. The resulting nucleus is observed to have half the mass of the original nucleus. What is the speed of the new nucleus after the decay?

(5 points)

More room for #12

(13)

A rocket leaves the Earth at v=0.6c. After 1 second, a radio wave signal is sent towards the rocket from Earth.

a) If the rocket's clock is set to zero when it leaves the Earth, what time does the rocket's clock read when the signal is received? (3 points)

b) In the rocket's frame of reference, at what time does the radio signal leave Earth? (2 points)

(14) The allowed energies for an electron in a hydrogen atom are given by $E_n = -13.6\text{ eV} / n^2$. For a hot gas of hydrogen atoms, a discrete spectrum is observed, with light only at particular wavelengths. Determine the two longest wavelengths that are observed in the visible range (380nm to 750nm). (4 points)

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

$$E = hf \qquad I = I_0 \cos^2\theta$$

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

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

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

$$E' = \gamma(E - vp_x) \qquad \lambda = \frac{h}{|\vec{p}|}$$

$$\lambda \cdot f = c$$

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

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

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

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

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

$$u' = \frac{u - v}{1 - \frac{uv}{c^2}} \qquad e^{i\pi} = -1$$

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

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

$$I = (\Delta x)^2 + (\Delta y)^2 + (\Delta z)^2 - (\Delta t)^2 c^2 \qquad d\tau = dt\sqrt{1 - \frac{v^2}{c^2}}$$

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

1 light year = c × 1 year

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

$c \approx 3 \times 10^8$ 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

$\hbar = h/2\pi$

POSSIBLY USEFUL FORMULAE