

NAME: BRAD ROBERTSSEAT Number: πMultiple choice: Each question is worth 5 points.

1. This exam is for a course in

A. Music appreciation.	B. Alchemy.	C. Cosmetology.
D. Feline anatomy.	<input checked="" type="radio"/> E. Physics.	F. I never knew nor cared. I just showed up at 8:00 AM everyday for the doughnuts.

2. The universe is currently expanding. Whether or not it will continue to expand is most directly determined by the universe's

A. net charge.	<input checked="" type="radio"/> B. total mass.	C. production of visible light.
D. total number of neutrinos.	E. average temperature.	F. color.

3. The wavelength of a bowling ball rolling down a bowling alley is

<input checked="" type="radio"/> A. very very very small compared to most physical quantities.	B. very very very big compared to most physical quantities.	C. about the same physical size as the bowling ball itself.
D. about the same as the width of the bowling alley.	E. non-sensical. (There is no such thing as a wavelength for physical objects.)	F. 42

4. A photon has zero rest mass. Therefore it is allowed to

A. travel at the speed of light.	B. travel faster than the speed of light.	C. travel infinite distances.
D. both A & B.	<input checked="" type="radio"/> E. both A & C.	F. all A, B, & C.

5. In a fission reaction, the total mass of the products must be

A. the same as the original materials.	B. greater than the original materials.	<input checked="" type="radio"/> C. less than the original materials.
D. none of these	E. There is no way to predict this.	F. 42

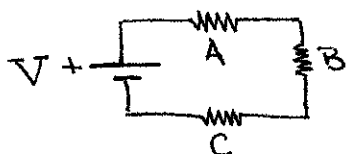
6. If
- polarized*
- light goes through a polarizer, to what percentage of the original intensity will the polarized light's intensity be?

A. 0 %	B. 10%	C. 50%
D. 90%	E. 100%	<input checked="" type="radio"/> F. It depends on the orientation of the polarizer.

7. Adam is riding his bicycle, traveling past you at a constant speed measuring $0.750c$. When he stops his bike, he says that he was riding for exactly one hour. How long do you say that he was riding his bike?

A. Exactly one hour.	B. Less than one hour.	<input checked="" type="radio"/> C. More than one hour.
D. Zero time.	E. More information is needed to know the answer.	F. 42

8. Three light bulbs of the same resistance are connected in *series* to a single battery, as shown. Which of the three will be the brightest?



A. Light bulb 'A'.	B. Light bulb 'B'.	C. Light bulb 'C'.	<input checked="" type="radio"/> D. All three will be exactly the same brightness.	E. More information is needed to answer this question.
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9. You push a magnet into a complete loop of wire. As a result, the wire exerts a force on the magnet that is

<input checked="" type="radio"/> A. "backward," pushing away from the wire.	B. "forward," pulling towards the wire.	C. left; perpendicular to the motion of the magnet.
D. right; perpendicular to the motion of the magnet.	E. More information is needed; specifically the orientation of the magnet.	F. None of these.

10. The "Bohr atom" is a model of an atom which shows

A. how multiple electrons must obey the Pauli exclusion principle.	<input checked="" type="radio"/> B. how electrons behaving as waves exhibit quantized energy states.	C. how nuclear reactions lose mass and convert this to energy.	D. A, B, & C are all correct.	E. None of these.
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11. A neutral conducting sphere is placed within an electric field. Inside the conducting sphere, the electric field is

A. greater in magnitude than the field outside the sphere.	<input checked="" type="radio"/> B. zero.	C. less in magnitude than the field outside the sphere (but not zero).	D. unable to be determined from the information given.	E. 42
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12. Imagine that you are basking in the sun next to cool, clear lake, celebrating your summer vacation and having a much deserved and relaxing break. You look down into the water of the lake and see a fish. If you can see the fish, then you know that

<input checked="" type="radio"/> A. the fish can see you.	B. the fish cannot see you.	C. the fish may or may not be able to see you – it depends on some other factor.	D. you're not sure whether or not that wretched fish can see you, but you're bitter that you're wasting a perfectly good relaxing moment of your summer vacation thinking about physics.	E. soon you will wake up from your little dream and you'll realize that you're really living a nightmare: Taking a PHSX 2020 final exam.
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Situation I: The life of an electron

A. [10 pts.] Imagine that you shine some light on an unknown metal and electrons are detected coming off the metal. If the electrons have a deBroglie wavelength of 1.50 nm when you shine light of 650 nm on this metal, what is the binding energy of the metal?

$$KE = \frac{hc}{\lambda} - BE$$

$$\lambda = \frac{h}{mv} \Rightarrow v = \frac{h}{m\lambda}$$

$$BE = \frac{hc}{\lambda} - KE = \frac{hc}{\lambda} - \frac{1}{2}mv^2$$

$$= \frac{hc}{\lambda} - \frac{1}{2}m \left(\frac{h}{m\lambda} \right)^2$$

$$= \frac{1240 \text{ eV}\cdot\text{nm}}{650 \text{ nm}} - \frac{1}{2} \frac{(6.63 \times 10^{-34} \text{ J}\cdot\text{s})^2}{(1.5 \times 10^{-9} \text{ m})^2} \left(\frac{1.6 \times 10^{-19} \text{ C}}{9.11 \times 10^{-31} \text{ kg}} \right)^2$$

$$= 1.91 - \cancel{1.67} \text{ eV} = 1.24 \text{ eV}$$

$$= 1.98 \times 10^{-19} \text{ J}$$

B. [10 pts.] The electrons emitted in the previous problem (with a deBroglie wavelength of 1.50 nm) must be stopped! In order to do this, you have two parallel plates with a constant electric field between them measuring 0.500 V/m. What is the minimum distance required to bring these electrons to rest in between these parallel plates?

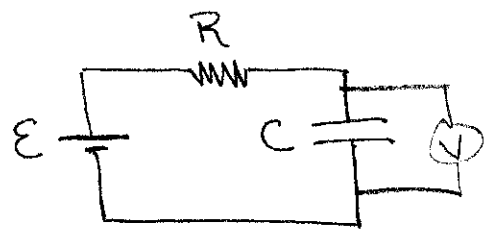
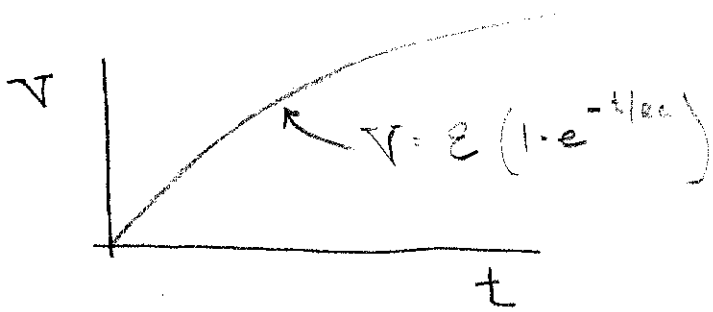
$$KE = \frac{1}{2}mv^2 = q\Delta V = qEd$$

$$\frac{1}{2}mv^2 = qEd \rightarrow d = \frac{\frac{1}{2}mv^2}{qE} = \frac{1}{2} \frac{9.11 \times 10^{-31} \text{ kg} \cdot v^2}{(1.6 \times 10^{-19} \text{ C})(0.5 \text{ V/m})}$$

$$= 1.34 \text{ m}$$

C. The parallel plates that you use in the previous problem are given their own charge by connecting them, as a capacitor, to a circuit that is shown below.

- [5 pts.] If the charge on the capacitor is initially zero, show on the 'voltage versus time' graph how the voltage across this capacitor would change once the switch has been connect to allow current to flow in the circuit.
- [5 pts.] Show on the circuit diagram where/how you would connect a voltmeter to measure the voltage describe in your graph.



Situation II: *The life of a photon*

- A. [10 pts.] Remember that light from Situation I with a wavelength of 650 nm? In order to obtain this particular wavelength, you used a diffraction grating. How many lines (i.e., the scratches imbedded on this grating) per centimeter are on this particular diffraction grating if the first order of this 650 nm wavelength is viewed at an angle of 25.0° from the normal?

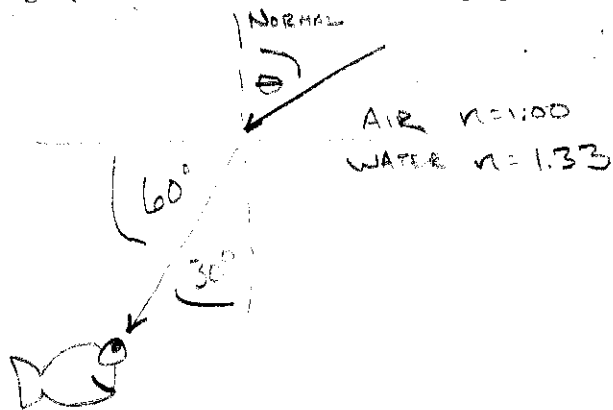
$$d \sin \theta = m \lambda$$

$$d = \frac{m \lambda}{\sin \theta} = \frac{1 (650 \times 10^{-7} \text{ m})}{\sin 25^\circ} = \frac{650 \times 10^{-7} \text{ cm}}{\sin 25^\circ}$$

$$d = 1.54 \times 10^{-4} \text{ cm}$$

$$\frac{1}{d} = \boxed{6500 \frac{\text{grooves}}{\text{cm}}}$$

- B. [10 pts.] Remember that fish that you were looking at in multiple choice question #12? You are shining your red laser pointer so that the red light (with a wavelength of 650 nm ... hey, what a coincidence!) hits the fish. From the fish's perspective, the laser beam is coming down through the water at an angle of 60.0° below the surface of the water. At what angle (as measured from the "normal", perpendicular to the surface of the water) does your laser beam point in air?



$$n_1 \sin \theta_1 = n_2 \sin \theta_2$$

$$\sin \theta_1 = \frac{1.33}{1.00} \sin 30^\circ$$

$$\theta_1 = \boxed{41.7^\circ}$$

- C. [10 pts.] You turn around and come face-to-face with ... yourself! You (a very handsome individual standing at 1.50 m tall) are looking at "you" in a converging mirror that is 2.00 m away. Your image is right-side-up and appears to be twice as tall as you are in reality. What is the focal length of this mirror?

$$d_o = 2.00 \text{ m}$$

$$h_o = 1.50 \text{ m}$$

$$m = 2 = -\frac{d_i}{d_o} = -\frac{d_i}{2.00 \text{ m}}$$

$$d_i = -4.00 \text{ m} \text{ (virtual)}$$

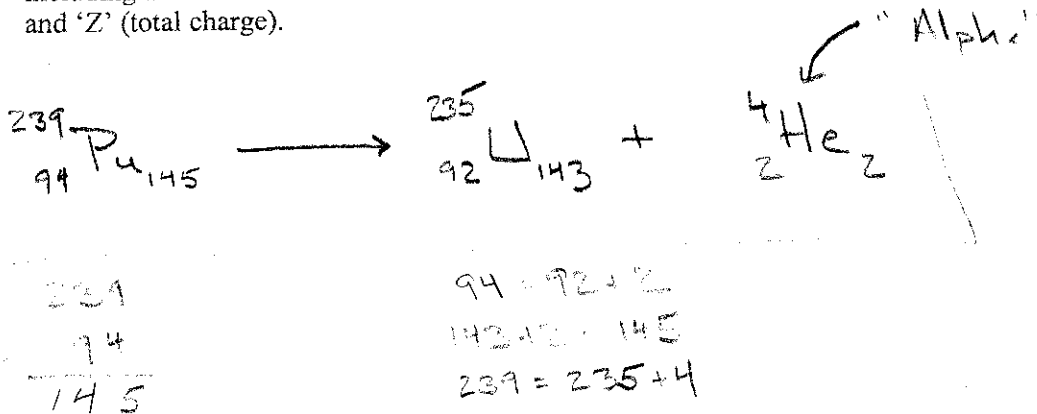
$$\frac{1}{f} = \frac{1}{d_i} + \frac{1}{d_o} = \frac{1}{-4 \text{ m}} + \frac{1}{2 \text{ m}}$$

$$\frac{1}{f} = .25 \text{ m}^{-1} \quad f > 0, \text{ so converging}$$

$$f = \boxed{+4.00 \text{ m}}$$

Situation III: The life of an alpha particle

A. [10 pts.] A Plutonium nucleus ('Pu', A = 239, Z = 94) alpha decays into Uranium. Write the equation for this reaction, including all of the above-mentioned nuclei and any other products and their values for 'A' (total number of nucleons) and 'Z' (total charge).



B. [10 pts.] Calculate the energy released from above reaction. Some atomic masses that might be useful to you are listed.

Helium-4	4.002603 u
Plutonium-239	239.052157 u
Uranium-235	235.043924 u
Uranium-238	238.050784 u
Hydrogen-1	1.007825 u

$$\Delta mc^2 = (239.052157 - 235.043924 - 4.002603) \times \left(931.5 \frac{\text{MeV}}{c^2}\right) c^2$$

$$= \boxed{5.24 \text{ MeV}} = \underline{\underline{8.38 \times 10^{-13}}}$$

C. [10 pts.] Let's say your alpha particle (Z = 2), with a mass of 6.68×10^{-27} kg, is traveling through a magnetic field. If the velocity of this alpha particle is 4.00×10^5 m/s, what is the minimum magnetic field required for this alpha particle to navigate a circular path whose radius is 1.99×10^{-4} m? (Round your answer to 3 significant figures for full credit.)

$$F = ma$$

$$qvB = m \frac{v^2}{r}$$

$$B = \frac{mv}{qr} = \frac{(6.68 \times 10^{-27} \text{ kg})(4 \times 10^5 \frac{\text{m}}{\text{s}})}{2(1.6 \times 10^{-19} \text{ C})(1.99 \times 10^{-4} \text{ m})}$$

$$\boxed{B = 42.0 \text{ T}}$$