Name: _____

PHYSICS 1050 Final Examination

University of Wyoming

4 May 2010

This test is closed-note and closed-book. No written, printed, or recorded material is permitted, with the exception of a formula sheet and two 3" × 5" cards which may bear writing on both sides.

Calculators are permitted but computers are not. No collaboration, consultation, or communication with other people (other than the administrator) is allowed by any means, including but not limited to verbal, written, or electronic methods. Sharing of materials, such as calculators, formula sheets, and notes cards, is prohibited.

If you have a question about the test, please raise your hand. If that does not get the administrator's attention, he will probably notice if you do "the wave."

Please do not open this test booklet until everyone has received a booklet and the test administrator has indicated for you to begin. While you are waiting, make sure that your name is written clearly at the top of this page, and clearly address a mailing envelope to yourself. (Include my return address.)

A

Part 1 (Exam 3): Recent Topics

Hollow Earth

1. (5 points) The Earth's core is made principally of iron, and its mass is about one-third (1/3) of the Earth's total mass. If alien invaders were to remove the Earth's core, how would your weight at the surface of the hollow Earth differ from what it is now? (Assume that the Earth's size does not change—the aliens are responsible miners.)

a. Your weight would be 1/3 of what it is now.

b. Your weight would be 2/3 of what it is now.

c. Your weight would be 4/3 of what it is now.

d. Your weight would be 1/9 of what it is now.

e. Your weight would be 4/9 of what it is now.

f. Your weight would be three times (3×) what it is now.

g. Your weight would be 3/2 of what it is now.

h. Your weight would be 9/4 of what it is now.

i. Your weight would be nine times (9×) what it is now.

Balloon and fur

2. (5 points) When a clean, dry rubber balloon is rubbed with clean, dry fur, the balloon and fur will stick together. Why?

a. Unbalanced charges in the balloon cause the opposite charges in the fur to move in opposite directions.

b. The balloon and fur attract gravitationally.

c. The balloon and fur have opposite magnetic fields.

d. The balloon and fur have opposite electric charges.

e. The balloon and fur have the same electric charge.

3. (5 points) Does the attraction between the balloon and the fur change with the distance between them?

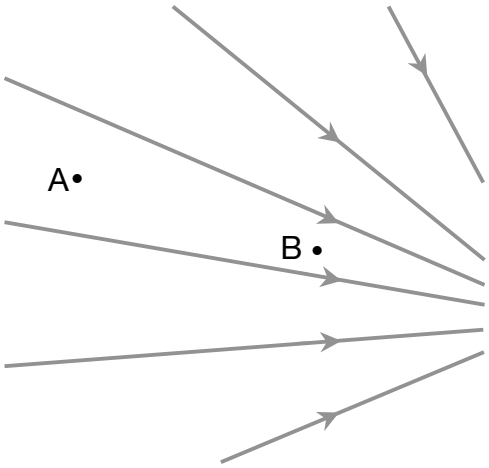
a. Yes. Their attraction is weaker when they are farther apart.

b. Yes. Their attraction is stronger when they are farther apart.

c. No.

Electric field

4. (5 points) The diagram at right shows two points, A and B, in an electric field. The field is illustrated by field lines, shown as gray lines. Arrowheads on the field lines indicate the direction of the field. At which point is the *magnitude* of the electric field *greater*?



a. At point A.

b. At point B.

c. The magnitude is the same at both positions.

d. It is impossible to tell.

5. (5 points) The electric field described in the previous problem is created by a single point charge (an infinitesimally small object with an electric charge). The diagram does not show the location of the point charge. What is the *sign* of the charge that creates the field?

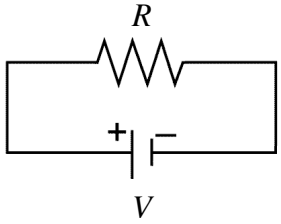
a. Positive (+).

b. Negative (–).

c. The charge could be either positive or negative.

Power in a resistor

6. (5 points) Different resistors are wired so that there are voltages across them. In which combination of resistance R and voltage V below does the resistor dissipate the most *power*?



a. $V = 5$ V, $R = 5\ \Omega$.

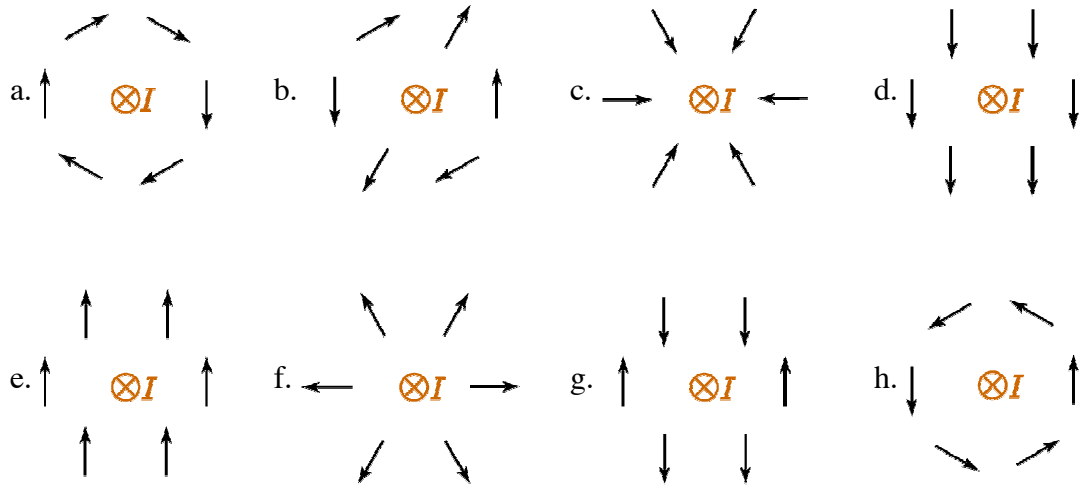
b. $V = 10$ V, $R = 10\ \Omega$.

c. $V = 5$ V, $R = 10\ \Omega$.

d. $V = 2$ V, $R = 1\ \Omega$.

Compasses and a wire

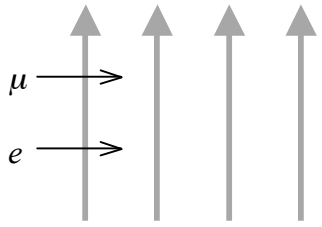
7. (5 points) An electric current flows along a straight wire into the page away from you (⊗). Six compasses are placed around the wire, in the positions shown. Their needles are free to turn. Which selection below shows how the compass needles will point? (Arrowheads indicate the north-seeking ends of the compass needles.)



Particle zoo

8. (5 points) In the mid-20th century, physicists discovered a particle now known as the *muon*. A muon's mass is about 207 times greater than an electron's mass, but a muon has exactly the same charge as an electron.

In the diagram at right, a muon (designated μ) and an electron (designated e) cross a magnetic field as shown. (The thick gray arrows represent magnetic field lines; the thin black arrows represent the particles' velocities.) Both the muon and the electron travel in the same direction with the same speed. How do the Lorentz forces on the two particles compare?



a. The Lorentz forces on both particles are *zero*.

b. The Loentz force on the *muon* is greater than the Lorentz force on the electron.

c. The Lorentz force on the *electron* is greater than the Lorentz force on the muon.

d. Both particles experience the *same* Lorentz force, which is not zero.

9. (5 points) What is the *direction* of the Lorentz force on the electron described in the previous question?

a. Up (↑). b. Down (↓). c. Left (←).

d. Right (→). e. Into the page (⊗). f. Out of the page (•).

g. The Lorentz force on the electron has no direction, because it is *zero*.

Transformer

10. (5 points) In an electrical transformer, why does alternating current in the primary circuit cause current to flow in the secondary circuit?

a. Current in the primary circuit creates an electric field in the transformer core, causing electrons in the secondary circuit to move.

b. Alternating current in the primary circuit creates a changing magnetic field in the transformer core, which induces an electric potential in the secondary circuit.

c. The primary circuit charges a battery, which powers the secondary circuit.

d. The primary circuit and the secondary circuit are wired in series, so current that flows through the primary circuit then flows through the secondary circuit.

Light and x-rays

11. (10 points) Light and x-rays are both electromagnetic waves. Which of their properties do they share in common, and which of their properties are different? For each property listed below, identify whether it is the same or different for x-rays and light.

same	different	a. frequency
same	different	b. energy
same	different	c. speed in a vacuum
same	different	d. wavelength
same	different	e. relative directions of electric field, magnetic field, and velocity

Nuclear reactions

12. (5 points) Choose the species that correctly completes this nuclear decay reaction.

$$^{14}\text{C} \rightarrow \_\_\_\_\_ + e^{-}$$

a. ^{10}N. b. ^{10}Be. c. ^{14}N. d. ^{14}B.

13. (5 points) Which nucleus listed below would be most likely to release energy by fission?

a. ^{55}Mn. b. ^{4}He. c. ^{251}Cf. d. ^{3}H.

Constructed response questions

14. (15 points) Why are surfaces of equal electric potential always and everywhere perpendicular to electric field lines?

15. (15 points) Draw a diagram of an electrical circuit. Label each component with its value: the voltage of the voltage source and the resistance of each resistor.

- The circuit must contain exactly one voltage source, with a voltage of 90 V.
- The total current of the circuit (into and out of the voltage source) must be 3 A.
- The circuit may contain up to one 30-Ω resistor and up to one 45-Ω resistor. The resistors may be used alone, together in series, or together in parallel.

16. (extra credit) In class, I sang, "Any charge to cross those lines feels a right-handed force."

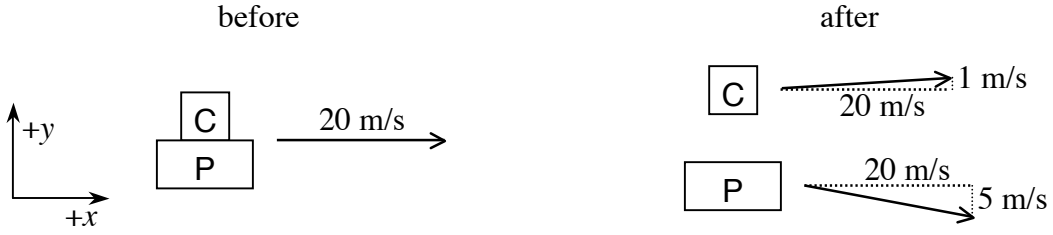
a. (3 points) What is the formula for that force?

b. (2 points) In what way is the force "right-handed?"

Part 2 (Exam 4): Comprehensive

Detachment

Two docked spacecraft, the Chiron and the Polyphemus, drift in deep space at a constant velocity of 20 m/s in the direction of the *x*-axis. After their joint mission is complete, a piston on the Polyphemus pushes with a constant force of 5,000 N against the Chiron. After 4 s of pushing, they drift apart without any further forces acting on them. As they drift apart, the Chiron's *x*-component of velocity remains 20 m/s, while its *y*-component of velocity is 1 m/s; the Polyphemus's *x*-component of velocity also remains 20 m/s, while its *y*-component of velocity is –5 m/s.



1. (5 points) In what *direction* was the *net force* that acted on the Chiron?

a. In the +*x* direction.
b. In the –*x* direction.
c. In the +*y* direction.
d. In the –*y* direction.
e. In a combination of the +*x* and +*y* directions.
f. In a combination of the +x and –y directions.

2. (5 points) What was the *magnitude* of the Chiron's *acceleration* during the push-apart? (Don't forget the units!)

_____

3. (5 points) How does the Chiron's *change* in *momentum* compare to the Polyphemus's change in momentum?

a. Their momentum changes were exactly equal.
b. Their momentum changes were exactly opposite.
c. The Chiron's momentum change had a greater magnitude.
d. The Chiron's momentum change had a smaller magnitude.

4. (5 points) How does the Chiron's *change* in *kinetic energy* compare to the Polyphemus's change in kinetic energy?

a. Their kinetic energy changes were exactly equal.
b. Their kinetic energy changes were exact negatives of each other.
c. The Chiron's kinetic energy change was greater than the Polyphemus's.
d. The Chiron's kinetic energy change was less than the Polyphemus's.

5. (5 points) What was the *power* applied to the Chiron at the final instant of the push-apart? (Don't forget the units!)

_____

Uniform circular motion

6. (5 points) When an object undergoes uniform circular motion (motion at a constant speed in a circular path), some of its properties change as it moves while other properties remain the same. Identify (by circling either "changes" or "constant") whether each of the five properties listed below changes or remains constant for an object in uniform circular motion.

changes	constant	a. magnitude of acceleration
changes	constant	b. momentum
changes	constant	c. net force
changes	constant	d. kinetic energy
changes	constant	e. angular momentum (about the path's center)

Vectors and Scalars

7. (3 points) From the choices below, select (by circling) *three* quantities that are *vectors*. (Do not select more than three! If you do, only the first three will count.)

a. Work.	b. Electric charge.	c. Time.
d. Electric field.	e. Angular momentum.	f. Velocity.
g. Force.	h. Heat.	i. Impulse.

8. (2 points) From the choices below, select (by circling) *two* quantities that are *scalars*. (Do not select more than two! If you do, only the first two will count.)

a. Work.	b. Electric charge.	c. Time.
d. Electric field.	e. Angular momentum.	f. Velocity.
g. Force.	h. Heat.	i. Impulse.

Conserved quantities

9. (5 points) Some physical quantities are conserved in all interactions, and others are not. Identify (by circling "always conserved" or "not always") whether each of the physical quantities listed below is always conserved or not.

always conserved	not always	a. angular momentum
always conserved	not always	b. momentum
always conserved	not always	c. total energy
always conserved	not always	d. entropy
always conserved	not always	e. temperature

Heat transfer

10. (5 points) A student in physics lab places a hot block of metal into an insulated container of cool water. The metal block and the water have exactly the same mass, and the metal block is completely submerged in the water. When the metal block and the water reach the same final temperature, the temperature of the metal has decreased by 60 °C and the temperature of the water has increased by 6 °C. Why was the water's increase in temperature less than the metal's decrease in temperature?

a. The metal's specific heat was greater than the water's specific heat.
b. The water's specific heat was greater than the metal's specific heat.
c. The metal released more heat than the water absorbed.
d. The water absorbed more heat than the metal released.

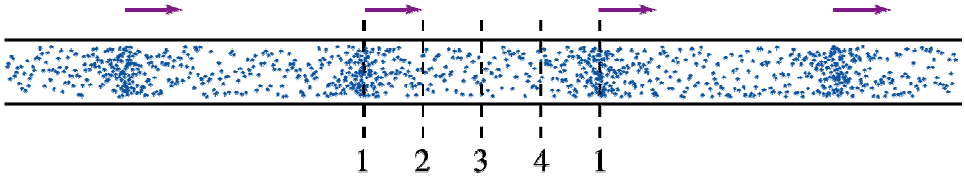
Interaction forces

11. (5 points) All forces are interactions between two objects. Match the forces listed below to the types of objects between which they act.

Force	Interacting Objects
friction	two masses
gravity	two charges
Lorentz	two nucleons
strong	two contacting surfaces
electrostatic	a charge and a magnet

Sound Waves

Longitudinal sound waves (pulses of condensations and rarefactions) travel to the right in an air-filled tube. The dots indicate the positions of the air molecules at one moment. The direction that the pulses travel is indicated by the arrows. Four evenly-spaced phases in a cycle are marked on the illustration, with the first repeated.



12. (5 points) What is the *direction* of the *net force* on the air molecules at phase 1? (Ignore the force of gravity.)

a. To the left.

b. To the right.

c. No direction : the net force is zero.

13. (5 points) At which phase is an air molecule's *acceleration* to the *left* the greatest?

a. At phase 1.

b. At phase 2.

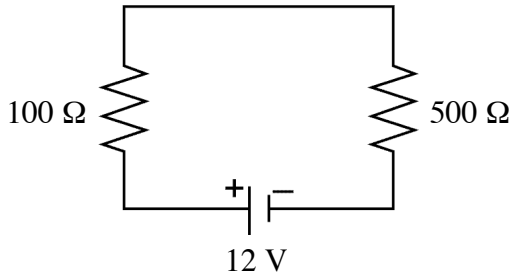
c. At phase 3.

d. At phase 4.

e. Air molecules in this wave train *never* accelerate to the left.

Circuit I

A 100-Ω resistor and a 500-Ω resistor are wired in series to a 12-V source, as shown.



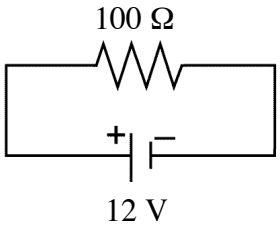
14. (2 points) Through which resistor does the greatest *current* flow?

a. The greatest current flows through the 100-Ω resistor.
b. The greatest current flows through the 500-Ω resistor.
c. The current through both resistors is the same.

15. (2 points) Across which resistor is the *voltage drop* the greatest?

a. The voltage drop across the 100-Ω resistor is the greatest.
b. The voltage drop across the 500-Ω resistor is the greatest.
c. The voltage drops are the same across both resistors.

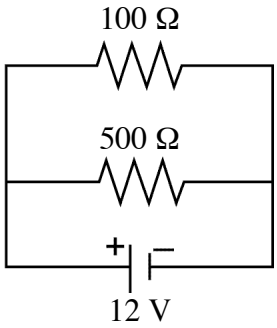
16. (1 point) How does the *total current* in the circuit above compare to the total current in the circuit to the right, which has a 12-V source and a single 100-Ω resistor?



a. The circuit with two resistors has more total current than the circuit with one resistor.
b. The circuit with one resistor has more total current than the circuit with two resistors.
c. Both circuits have the same total current.

Circuit II

A 100-Ω resistor and a 500-Ω resistor are wired in parallel to a 12-V source, as shown.



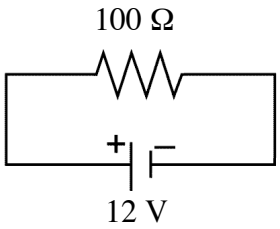
17. (2 points) Through which resistor does the greatest *current* flow?

a. The greatest current flows through the 100-Ω resistor.
b. The greatest current flows through the 500-Ω resistor.
c. The current through both resistors is the same.

18. (2 points) Across which resistor is the *voltage drop* the greatest?

a. The voltage drop across the 100-Ω resistor is the greatest.
b. The voltage drop across the 500-Ω resistor is the greatest.
c. The voltage drops are the same across both resistors.

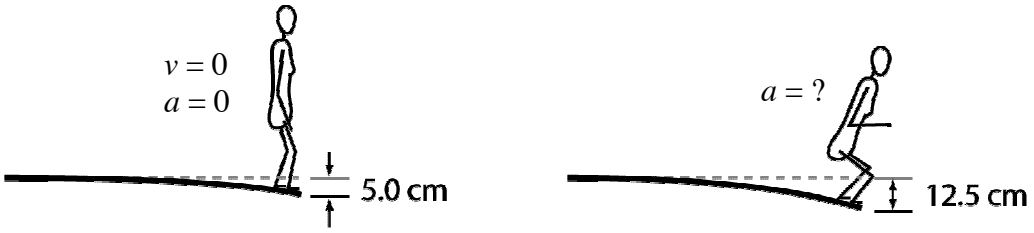
19. (1 point) How does the *total current* in the circuit above compare to the total current in the circuit to the right, which has a 12-V source and a single 100-Ω resistor?



a. The circuit with two resistors has more total current than the circuit with one resistor.
b. The circuit with one resistor has more total current than the circuit with two resistors.
c. Both circuits have the same total current.

Constructed response questions

20. When a diver stands motionless on a diving board, her weight deflects it downward 5.0 cm from its unweighted position. When she jumps and lands back on the board, it deflects downward 12.5 cm from its unweighted position.



a. (2 points) Name the forces that act on the diver in both cases.

b. (4 points) Draw a force diagram for the diver showing the forces as vector arrows pointing away from the diver's center of mass.

c. (4 points) Give formulas for all the forces that act on the diver. Use variables for the quantities in the formulas: don't substitute in the quantities' numerical values. Identify each quantity in each formula in terms of this specific situation. (For example, "λ = wavelength of the sound waves emitted by the diving board.")

d. (5 points) What is the diver's *acceleration* when the board is deflected downward 12.5 cm? (Report both magnitude and direction. Don't forget the units!)

21. Wires carrying alternating electric current emit electromagnetic waves of the same frequency as the alternating current. The conversion of energy into the electromagnetic waves is greatest when the wire is about as long as the wavelength of the electromagnetic wave. So, a radio antenna works best if it is about as long as the radio waves it transmits. On the other hand, a circuit using alternating current at frequency *f* will "leak" power if it is about the same size as electromagnetic waves with frequency *f*.

    In the United States, commercial electric power is generated and distributed at a frequency of 60 Hz.

a. (10 points) What is the *wavelength* of the electromagnetic waves emitted by power lines carrying this current? Report the wavelength in *kilometers* (1 km = 1000 m).

b. (5 points) What might this mean for distribution of electric power from one part of the United States to another? (The straight-line distance from Laramie to Salt Lake City is a little over 500 km.)

22. (5 points extra credit) When I sang, "Please allow me to introduce myself: I'm the law that tells your fate," what law was I personifying? Name it.