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PHYSICS 1050 Final Examination
University of Wyoming
9 December 2008

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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 cue sheets, 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 detonate a nuclear weapon.

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 on your note card.

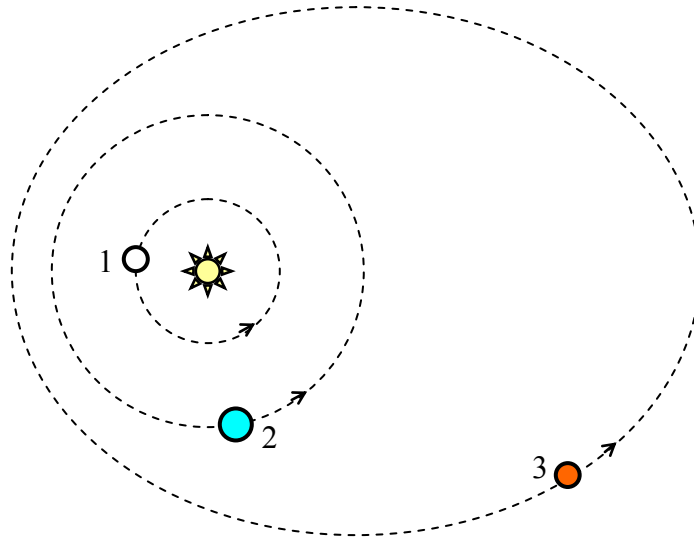
Part 1 (Exam 3): Recent Topics

Scenario Problems

13 problems, 7 points each.

Scenario 1: Planetary orbits

A star has three orbiting planets. The two inner planets (1 and 2) have perfectly circular orbits, with the star at the center of the orbits. The orbit of the outer planet (3) is elliptical. All of the planets orbit the star in a counterclockwise direction. Compared to the mass of the star, the masses of the planets are very small. Consequently, the only force acting on any of the planets is their gravitational attraction to the star.



1. Which is true about the speed of the *outer planet* (3) as it orbits the star?
 - a. Its speed remains constant.
 - b. Its speed is greatest when it is nearest to the star.
 - c. Its speed is greatest when it is farthest from the star.

2. Which is true about the angular momentum of the *outer planet* (3) as it orbits the star?
 - a. Its angular momentum remains constant.
 - b. Its angular momentum is greatest when it is nearest to the star.
 - c. Its angular momentum is greatest when it is farthest from the star.

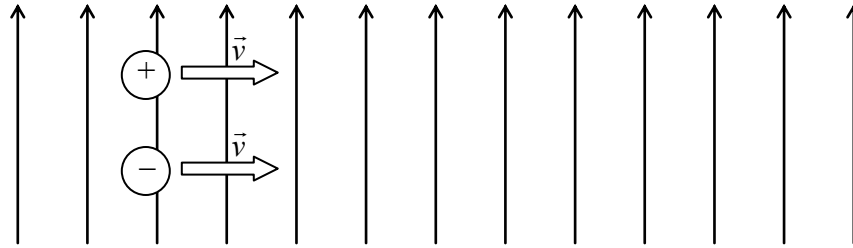
3. The middle planet (2) is twice as far from the star as the innermost planet (1). How does the gravitational attraction between the star and the middle planet (2) compare to the gravitational attraction between the star and the innermost planet (1)?
- The middle planet (2) is attracted to the star with four times ($4\times$) the force as the innermost planet (1).
 - The middle planet (2) is attracted to the star with two times ($2\times$) the force as the innermost planet (1).
 - The middle planet (2) is attracted to the star with exactly the same magnitude force as the innermost planet (1).
 - The middle planet (2) is attracted to the star with one-half ($1/2$) the force as the innermost planet(1).
 - The middle planet (2) is attracted to the star with one-fourth ($1/4$) the force as the innermost planet (1).
 - More information is needed to answer this question.

Scenario 2: Moving charges

Two objects with opposite electric charges $+Q$ and $-Q$ travel through space with the same velocity \vec{v} . At one particular instant, the distance between their centers is d .

4. What is the nature of the electric interaction between the objects?
- The objects attract each other.
 - The objects repel each other.
 - There is no electric interaction between the objects.
 - More information is needed to answer this question.
5. Does the force of electric interaction between the two objects depend on their velocity v ?
- Yes.
 - No.
 - More information is needed to answer this question.

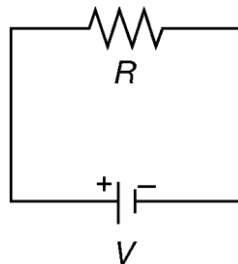
The two charged objects move through space with velocity \vec{v} as before, but now they are moving through a magnetic field \vec{B} whose field lines are perpendicular to \vec{v} , as shown.



6. What is the direction of the force from the magnetic field on the object with charge $-Q$?
- a. Up. \uparrow
 - b. Down. \downarrow
 - c. Left. \leftarrow
 - d. Right. \rightarrow
 - e. Toward you. \odot
 - f. Away from you. \otimes
 - g. The force is zero.
 - h. More information is needed to answer this question.

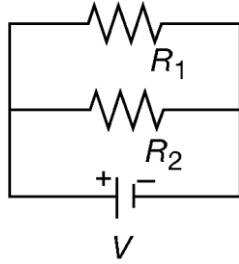
Scenario 3: Circuits

A very simple circuit consists of a voltage source providing voltage V , a resistor with resistance R , and wires connecting the two. A schematic drawing of the circuit is shown below.



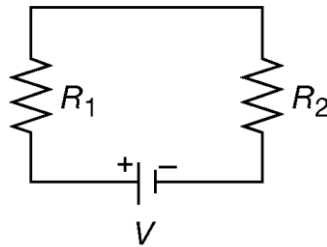
7. The battery voltage V is 1.5 V and the resistance R is 1000 Ω . What is the *current* I through the resistor?

A circuit consists of two resistors connected in parallel to a voltage source.



8. The battery voltage V is 12 V, and the resistances are $R_1 = 40 \Omega$ and $R_2 = 60 \Omega$. What is the total current from the battery through the circuit?

Two resistors are connected to a battery in series.



9. The battery voltage V is 18 V, and the resistances are $R_1 = 500 \Omega$ and $R_2 = 100 \Omega$. What is the voltage drop V_1 across resistor 1?

Scenario 5: Magnetic fields

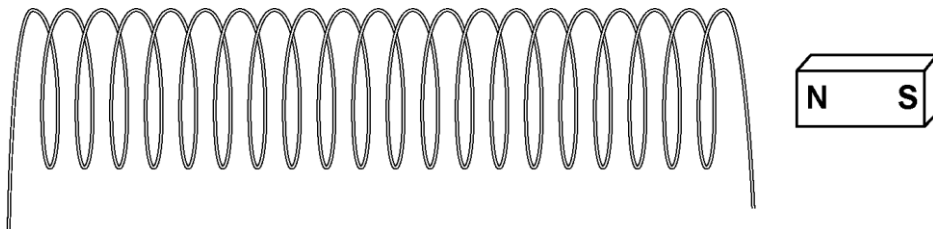
An electric current flows through a long, straight wire away from you (into the page).

$\otimes I$

10. What is the *direction* of the magnetic field in the region of space *to the left* of the wire?

- a. Up. \uparrow b. Down. \downarrow c. Left. \leftarrow
d. Right. \rightarrow e. Toward you. \odot f. Away from you. \otimes

The straight wire is bent into a helical coil with many loops (a solenoid). A bar magnet is placed next to one end of the solenoid as shown.



11. Under which one of the following circumstances will an electric potential be induced around the solenoid?

- a. When the magnet is held in place as shown.
b. When the magnet moves toward the coil. \leftarrow
c. When the magnet revolves about its horizontal axis. \curvearrowright

Scenario 6: Radioactivity

12. How much of a radioactive isotope remains after four half-lives?

- a. All of it.
b. $1/2$.
c. $1/4$.
d. $1/8$.
e. $1/16$.
f. None of it.

13. When a nucleus of Platinum-188 (^{188}Pt) decays by emitting an alpha particle, what is the resulting daughter nucleus?

- a. Gold-188 (^{188}Au).
- b. Platinum-189 (^{189}Pt).
- c. Iridium-187 (^{187}Ir).
- d. Osmium-184 (^{184}Os).
- e. Iridium-188 (^{188}Ir).
- f. Osmium-186 (^{186}Os).

Constructed Response Problems

2 problems, 12 points each.

14. An AC transformer steps voltage down from the transmission pole at 550 V (primary) to a house at 110 V (secondary). If a person in the house operates a 1100-W hair dryer, how much *current* must flow through the primary circuit of the transformer?

Be sure your answer is expressed in the proper units.

15. Using field lines, draw the electric field created by a single point positive charge. Describe your drawing in writing. Your description should explain

- the meaning of the spacing between adjacent field lines,
- the direction of the arrows on the field lines, and
- why the field takes the shape it does.

Extra Credit

One question, 5 points.

16. In my last physics song of the semester, I sang:

“The magnetic lines curl right around,
While the current’s flowing straight down the wire.”

This described one of the right-hand-rules used in this unit. Explain the rule in your own words, including under what circumstances it applies, what it allows you to determine, and how to apply it.

Part 2 (Exam 4): Cumulative

Scenario Problems

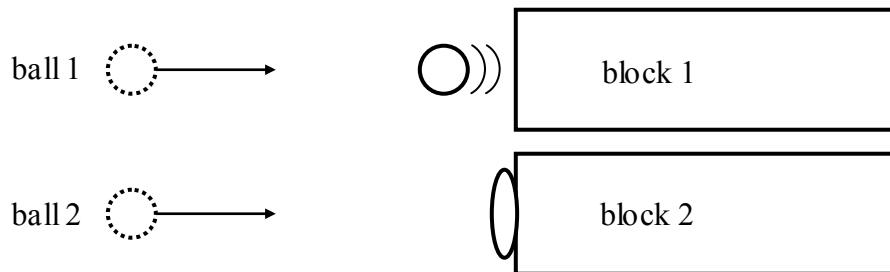
13 questions, 7 points each.

Scenario 1. Elastic and inelastic collisions

A perfectly elastic ball of mass m (ball 1) moves through space at velocity v until it collides with a motionless, very massive block (block 1) of mass M , where $M > m$. When it collides, the ball rebounds in a perfectly elastic collision. After the collision, the block moves in the direction that ball 1 was initially moving.

Another perfectly *inelastic* ball (ball 2), of the same size, mass m , and initial velocity v as the elastic ball, collides with another motionless block (block 2) of mass M . This ball, however, sticks to the block in a perfectly *inelastic* collision. After the collision, the ball and block move together in the direction that ball 2 was initially moving.

In both cases, the balls and blocks float freely in space and receive no forces other than those of the collision.



1. In which collision was momentum conserved? In other words, in which collision was (momentum of ball) + (momentum of block) the same before, during, and after the collision?
 - a. Momentum was conserved only in the *elastic* collision between ball 1 and block 1.
 - b. Momentum was conserved only in the *inelastic* collision between ball 2 and block 2.
 - c. Momentum was conserved in *both* collisions.
 - d. Momentum was *not* conserved in either collision.

2. Which ball had the most *work* done on it during the collision? (The work done is *negative* for both balls, so you need to select the one whose work has the *greatest absolute value*.)

- a. Ball 1 had the most work done on it.
- b. Ball 2 had the most work done on it.
- c. Both balls had exactly the *same* amount of work done on them.

Scenario 2: Singing in the shower

Some people like to sing in the shower. They find that their voices sound fuller than in other environments.

A particular shower stall is 2.5 m high (vertical) and 1.0 m wide and deep (horizontal). Its three walls, its ceiling, and its floor are constructed of rigid tile, and its door is rigid glass. When a singer sings in the shower, some of the sounds produced are maintained as standing sound waves in the air inside the stall. Since all of the interior surfaces of the stall are rigid, the standing waves do not move the air that is immediately adjacent to any surface.

3. Increasing the humidity of air increases the speed of sound in the air. As the shower runs and the air within the shower stall becomes *more humid*, how do the *wavelengths* of the standing sound waves within it change? The dimensions of the shower stall remain constant.

- a. The standing waves' wavelengths become *shorter*.
- b. The standing waves' wavelengths do not change.
- c. The standing waves' wavelengths become *longer*.

4. Increasing the humidity of air increases the speed of sound in the air. As the shower runs and the air within the shower stall becomes *more humid*, how do the *frequencies* of the standing sound waves within it change? The dimensions of the shower stall remain constant.

- a. The standing waves' frequencies become *lower*.
- b. The standing waves' frequencies do not change.
- c. The standing waves' frequencies become *higher*.

Scenario 3: Joule experiment

In the classic experiment that now bears his name, James P. Joule linked a falling weight to a paddle inside an insulated vat of water. The falling weight powered the paddle, which churned the water. Joule calculated the amount of work done on the water from the speed and height change of the weight, and measured the temperature of the water before and after dropping the weight.

5. After the experiment, was the water warmer or cooler than before?
 - a. The water was *warmer* afterwards.
 - b. The water was *cooler* afterwards.
 - c. The water's temperature did *not change*.
 - d. More information is needed to answer this question.

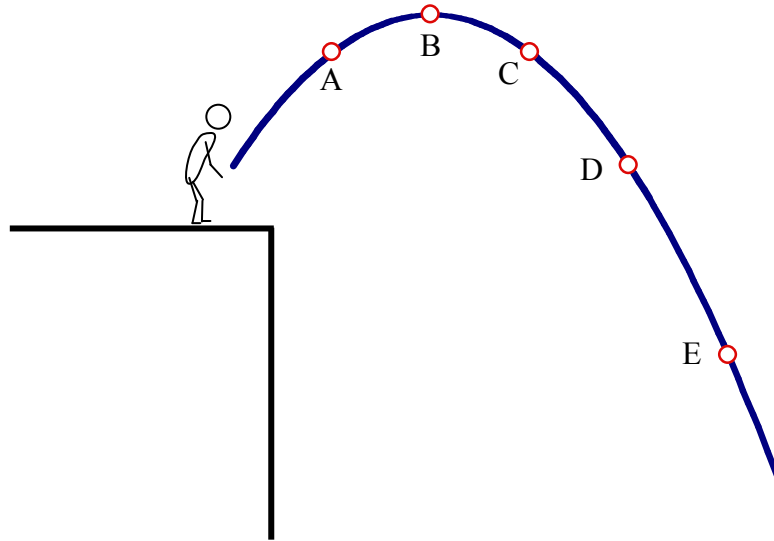
6. After the experiment, was the entropy of the universe greater or less than before?
 - a. The entropy of the universe was *greater* afterwards.
 - b. The entropy of the universe was *less* afterwards.
 - c. The entropy of the universe did *not change*.
 - d. More information is needed to answer this question.

7. If the apparatus had been filled with a mixture of ice and water at 0 °C instead of with water, which of the following statements would be true?
 - a. The ice/water mixture would have had a *higher temperature* after the experiment.
 - b. The ice/water mixture would have had a *lower temperature* after the experiment.
 - c. The ice/water mixture would have had a *higher internal energy U* after the experiment.
 - d. The ice/water mixture would have had a *lower internal energy U* after the experiment.
 - e. More information is needed to answer this question.

Scenario 4: Falling rock

A young man with nothing better to do stands at the edge of a cliff and throws a rock into the air. The rock follows an arcing path as shown. The positions of the rock at five equal time intervals are indicated on the diagram below.

For this scenario, assume that the upward (\uparrow) direction is positive. Also assume that air resistance (drag) does not significantly affect the motion of the rock.



8. At which point does the rock have the greatest magnitude of *acceleration*?
- a. A b. B. c. C. d. D. e. E.
- f. The rock's acceleration is the same at all points on the trajectory.
9. At which point is the *sign* of the *work* done by gravity on the rock *negative*?
- a. A. b. B. c. C, D, and E.
- d. The sign of the work done is negative at *all* points on the trajectory.
- e. The sign of the work done is *not* negative at any point on the trajectory.

Scenario 5. Graphs of motion

The following questions explore the information that can be obtained from acceleration-time, velocity-time, and position-time graphs.

10. What physical quantity is given by the *area* under an *acceleration*-time plot?
- The *position* x of the object.
 - The *velocity* v of the object.
 - The *acceleration* a of the object.
 - The *change in position* Δx of the object.
 - The *change in velocity* Δv of the object.
11. What physical quantity is given by the *curvature* of a *position*-time plot?
- The *position* x of the object.
 - The *velocity* v of the object.
 - The *acceleration* a of the object.
 - The *change in position* Δx of the object.
 - The *change in velocity* Δv of the object.

Scenario 6: Carousel

Two children ride on a park carousel. Both have the same mass. One rides at the outer edge and the other stands at the center, over the carousel's axis of rotation.

12. If only one child rode the carousel, in which case would the carousel be easier to push? In other words, would the carousel's rotational frequency increase more quickly with the child standing over the axis of the carousel or with the child riding at the outer edge?
- The carousel would be easier to push with the child at the *axis* of the carousel.
 - The carousel would be easier to push with the child at the *edge* of the carousel.
 - Where the child stands has *no effect* on the acceleration of the carousel.

Scenario 7: Electromagnetic waves

Light waves and radio waves are types of electromagnetic waves, but they have different wavelengths. In vacuum, light wavelengths are in the range of $400\text{--}700 \times 10^{-9}$ m, while radio wavelengths are roughly in the range of 0.5–1000 m.

13. Which type of electromagnetic wave has the *higher* energy?
- Radio waves.
 - Light waves.
 - More information is needed to answer this question.

Constructed Response Problems

2 problems, 12 points each.

Please provide complete answers to each question. Show all work so that partial credit can be assigned.

14. Answer one, and only one, of the following questions. You may choose either one you wish. Clearly indicate which one you are answering.
- What are the similarities between an electrical ac transformer and a mechanical simple machine?
 - Compare and contrast the electric force and the gravitational force. Identify all similarities and differences between the two interactions.

15. When railroad tracks end, fixtures are often installed to prevent trains from running off the end. At commuter rail stations, these stop-fixtures are often platforms clamped to the tracks with spring bumpers mounted on them. We hope that no train will ever collide with the fixture, but if one does, the spring should be long enough and strong enough to *not* compress all the way—otherwise the fixture, and probably the train, will be damaged.

You are designing a stop- fixture for a commuter rail station. The fixture must allow 1.5 m of travel in the spring before it is fully compressed. If a 450-ton (1 ton = 1000 kg) commuter train runs into the stop- fixture at 2.0 m/s, the spring alone must fully stop the train in the travel distance.

What must the spring constant k of the spring be? Be sure your answer includes the correct units.

Extra credit

One question, 5 points.

16. (5 points) The movie clip shown depicts a situation in which the laws of physics are violated. What is wrong, and what would happen in the clip if the laws of physics were followed?

Bonus extra credit

One question, 5 points.

17. (5 points) Which physics song is *my* favorite?