Name: ____
(2 points)

PHYSICS 1050 Test 2
University of Wyoming
30 October 2008

This test is closed-note and closed-book. No written, printed, or recorded material is permitted, with the exception of a formula sheet which may be written on above the line and one 3"×5" note card which may bear writing on both sides. Turn your note card in with your test when you are finished.

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 note cards, is prohibited.

If you have a question about the test, please raise your hand. If that does not get the administrator's attention, perhaps he will notice if you do a trick with your longboard.

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.

A

Scenario Problems

4 scenarios, 17 questions, 4 points each, 68 points total.

If choices are given, only one is correct. Please circle the correct choice. If a blank is provided, please enter your answer in the blank.

Scenario 1. Spinning chair demonstration

In a classic physics demonstration, a demonstrator spins with arms outstretched while sitting in a pivoting chair. He holds dumbbells in both hands. When the demonstrator pulls the dumb35yu9bells toward his body, he spins faster. If he eases the dumbbells back out, he spins slower again. This happens even though nothing pushes on him or on his chair.

Pretend that the chair pivots without friction. Although this is not possible, the friction in the bearings can realistically be small enough that it does not substantially affect the behavior of the system over short time periods.

1. When the demonstrator speeds up by pulling the dumbbells inward, how does his *kinetic energy* change? Consider the total kinetic energy of the demonstrator, his chair, and the dumbbells.

a. His kinetic energy *decreases* as he spins faster.

b. His kinetic energy *increases* as he spins faster.

c. His kinetic energy remains the *same* as he spins faster.

Speeding up makes kinetic energy increase. Conservation of energy does not pose a problem, because he does work to pull the dumbbells inward, and that work raises his kinetic energy.

2. When the demonstrator speeds up by pulling the dumbbells inward, how does his *total angular momentum* change? Consider this to be the total angular momentum of the demonstrator, his chair, and the dumbbells.

a. His total angular momentum *decreases* as he spins faster.

b. His total angular momentum *increases* as he spins faster.

c. His total angular momentum remains the *same* as he spins faster.

Angular momentum is conserved. The system receives no outside torques.

3. As the demonstrator pulls the dumbbells inward, what is the *sign* of the *work* he does on the dumbbells?

a. The work done by the demonstrator on the dumbbells by the demonstrator is *negative*.

b. The work done by the demonstrator on the dumbbells by the demonstrator is *zero*: he does no work on the dumbbells.

c. The work done by the demonstrator on the dumbbells is *positive*.

The applied force is in the same direction (inward) as the movement.

4. To get himself spinning in the first place, the seated demonstrator pushes against the ground with his feet. In order to obtain the maximum *torque*, where should he place his feet? The force his feet exert on the ground will be the same everywhere.

a. He should place his feet as *far* as possible from the rotation axis of the chair.

b. He should place his feet as *close* as possible to the rotation axis of the chair.

c. It *does not matter* where he puts his feet.

The longer the lever arm for the same force, the greater the torque.

Scenario 2. Paraffin athletic heating pad

One type of heating pad used by athletic trainers contains paraffin wax sealed inside it. The pad is kept in a hot water bath maintained just above the melting temperature of the wax. To use the pad, the trainer removes it (using tongs) from the hot water, wraps it in a towel, and places it on the athlete's body.

The melting/freezing temperature of paraffin wax is 55 °C. Its heat of melting (the amount of energy needed to melt the solid at its melting temperature) is 200,000 J/kg.[*]

5. Human body temperature is around 37 °C. When a heating pad is placed on an athlete's body, what is the overall *direction* of heat flow between the pad and the athlete's body?

a. Heat flows *from the athlete's body* into the pad.

b. There is *no* net flow of heat.

c. Heat flows *from the pad* into the athlete's body.

Heat flows from the object at higher temperature to the object at lower temperature.

6. After the pad and the athlete's body come to thermal equilibrium, how has the *total entropy of the universe* (including the pad and the athlete) changed?

a. The total entropy of the universe remained *constant*.

b. The total entropy of the universe has *decreased*.

c. The total entropy of the universe has *increased*.

Entropy increases in all processes that can occur. Heat transfer from the pad to the athlete is perfectly plausible.

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[*] Paraffin wax is actually a mixture of compounds, so it melts over a range of temperatures and its heat of melting depends on its composition. Here we will pretend that its composition is uniform so that we can concentrate on the physics.

7. While the heating pad and the athlete's body are in contact, how are their *temperature* changes related? Pretend that neither the athlete nor the heating pad exchange any energy with anything but each other.

a. The heating pad will change its temperature by exactly the *same amount*, and in the *same direction*, as the athlete's body.

b. The heating pad will change its temperature by exactly the *same amount*, but in the *opposite direction*, as the athlete's body.

c. The temperatures of the heating pad and the athlete's body will change by *different amounts*, but in the *same direction*.

d. The temperatures of the heating pad and the athlete's body will change by *different amounts*, and in *opposite directions*.

e. The temperature change will be *zero* for both the heating pad and the athlete's body.

The pad's temperature will drop and the athlete's temperature will rise. There is no reason to expect the changes to be opposite in magnitude.

8. While the heating pad and the athlete's body are in contact, how are their changes in *internal energy* related? Continue to pretend that neither the athlete nor the heating pad exchange any energy with anything but each other.

a. The heating pad will change its internal energy by exactly the *same amount*, and in the *same direction*, as the athlete's body.

b. The heating pad will change its internal energy by exactly the *same amount*, and in the *opposite direction*, as the athlete's body.

c. The internal energies of the heating pad and the athlete's body will change by *different amounts*, but in the *same direction*.

d. The internal energies of the heating pad and the athlete's body will change by *different amounts*, and in *opposite directions*.

e. The internal energy change will be *zero* for both the heating pad and the athlete's body.

Energy is conserved! Energy lost from the pad is gained by the athlete's body.

9. While the *heating pad* is in contact with the athlete's body, how does its amount of *internal energy* change?

a. The heating pad's internal energy remains *constant*.

b. The heating pad's internal energy *increases*.

c. The heating pad's internal energy *decreases*.

Heat flowing *from* the pad means that the pad's total energy decreases.

Scenario 3. Springs

Two springs, a "stretchy spring" and a "stiff spring," follow Hooke's law exactly. The springs are suspended from hooks, and weights are hung from the springs. When the weights on the two springs are identical, the stretchy spring stretches farther than the stiff spring.

10. Which spring has the larger Hooke's law spring constant *k*?

a. The *stretchy* spring has the larger *k*.

b. The *stiff* spring has the larger spring constant *k*.

c. Both springs have the *same* spring constant *k*.

d. There is not enough information to rank the two spring constants.

The spring constant is the stiffness of the spring. Algebraically, the distance x stretched under force F is F/k: larger k gives smaller stretch.

11. If identical masses on the two springs are allowed to oscillate in simple harmonic motion, which spring oscillates with the *longer period*?

a. The *stretchy* spring has the longer period of oscillation.

b. The *stiff* spring has the longer period of oscillation.

c. The two springs have the *same* period of oscillation.

d. There is not enough information to rank the oscillation periods of the two springs.

The stiffer the spring, the shorter its amplitude and the greater the acceleration at any position. In terms of the formula $T = 2\pi\sqrt{m/k}$, as k decreases T increases.

12. How must the *mass* of the weight on the stiff spring be changed to make its oscillation *period* the *same* as the oscillation period of the weight on the stretchy spring?

a. The mass of the weight on the stiff spring must be *increased* to match the periods.

b. The mass of the weight on the stiff spring must be *decreased* to match the periods.

c. The mass of the weight on the stiff spring *must not change*, because the periods already match.

d. There is not enough information to decide how to change the mass.

Mass slows down the frequency and lengthens the period, so the mass on the stiff spring must be increased.

13. If the two springs are initially unstretched and motionless, and then are gradually stretched to the *same final tension*, which spring has the *most work done* on it during the stretching?

a. The *stretchy* spring has the most work done on it.

b. The *stiff* spring has the most work done on it.

c. Both springs have the *same* amount of work done on them.

d. There is not enough information to compare the work done on the two springs.

The stretchy spring is stretched farther through the same range of force.

Scenario 4. 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.

14. Since the dimensions of the shower stall are not the same in all directions, different standing sound waves can be maintained in the up-and-down (vertical) direction than in the font-and back or side-to-side (horizontal) directions. Each direction will therefore have a characteristic set of standing sound waves. How do the *frequencies* of the fundamental standing waves in the vertical and horizontal directions compare?

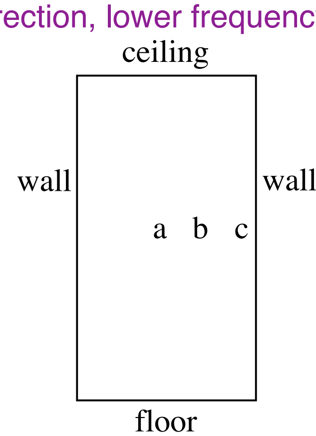
a. The fundamental waves in both the vertical and horizontal directions have the *same* frequency.

b. The fundamental wave in the *vertical* direction has a *higher* frequency than the fundamental wave in the horizontal direction.

c. The fundamental wave in the *vertical* direction has a *lower* frequency than the fundamental wave in the horizontal direction.

Fundamental has nodes at each end, so the dimensions of the stall are half the wavelength. Thus, longer wavelength in the vertical direction, lower frequency.

15. Where in the shower stall is there the *greatest side-to-side movement* of air molecules from the fundamental horizontal standing wave?



a. At the very *center* of the stall.

b. Midway between the center of the stall and the wall.

c. Right at the *wall* of the stall.

d. The location depends on the wavelength of the fundamental standing wave.

The nodes are at the edges, and the antinodes are between them. Maximum motion will be right at the center.

16. 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*.

The wavelengths of a standing wave are dictated by the dimensions of the available space, not by the speed of the wave.

17. 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*.

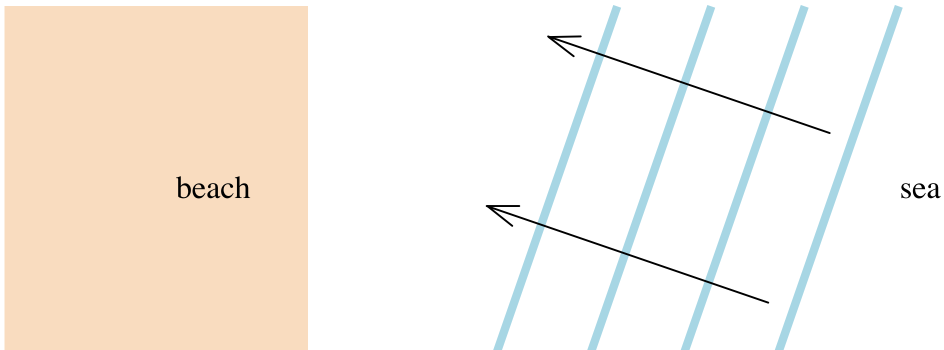
Faster speed, same wavelength means that the frequency must increase. The wave covers the same distance in a shorter time.

Short Scenario Problems

1 scenario, 5 questions, 2 points each, 10 points total.

Scenario 5. Ocean waves

Ocean waves approach the sea shore at an angle, as illustrated.



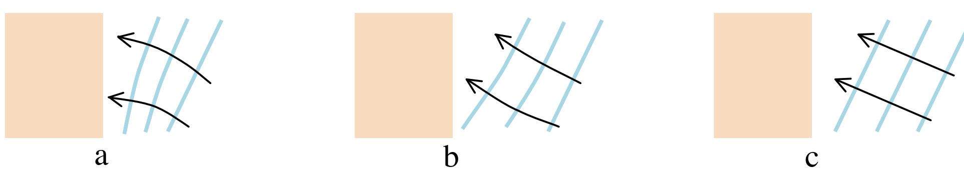
As the waves approach the shore, they undergo many changes. Describe how each of the following characteristics changes.

18. Speed:

a. Increases. b. Decreases. c. Remains constant.

Water surface waves are faster in deep water than in shallow water, because friction against the bottom slows them down.

19. Direction:



a. Waves turn toward the shore (crests become more parallel to the shore).

b. Waves turn away from the shore (crests become more angled from the shore).

c. Wave direction remains constant.

Waves turn toward the region of slower speed.

20. Amplitude:

a. Increases. b. Decreases. c. Remains constant.

Waves increase in height as they approach the shore.

21. Frequency:

a. Increases. b. Decreases. c. Remains constant.

Waves still regularly approach the shore.

22. Wavelength:

a. Lengthens. b. Shortens. c. Remains constant.

Same period and lower speed means they are not traveling as far in each cycle.

Constructed Response

2 questions, 10 points each, 20 points total.

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

23. A playground carousel has a radius of 1.5 m. If children riding on the edge of the carousel experience a centripetal acceleration of 6 m/s^2, what is their tangential *speed*?

Hint: First get a formula for the quantity you want, then enter the appropriate values.

Don't forget the units!

The equation to use is the one for centripetal acceleration:

$$a = v^2/r,$$

where a is the centripetal acceleration, v is the tangential speed, and r is the radius of the circular path. Here you know the acceleration a and the radius r; you want to find the tangential speed v. So, solve the formula for v.

$$v^2 = ar$$

$$v = \sqrt{ar}$$

Now we plug in the values: $a = 6\ m/s^2$ and $r = 1.5$ m, so

$$v = \sqrt{(6\ m/s^2)(1.5\ m)} = \sqrt{9\ m^2/s^2}$$

$$v = 3\ m/s$$

24. When a mass on a Hooke's law spring oscillates in simple harmonic motion, its position, speed, and acceleration are continuously changing. One of the characteristics of this motion is that the object's speed is greatest when its acceleration is zero. Explain why this is necessary: why the acceleration *must* be zero when speed is greatest. (Explain why speed and acceleration are related in this way: don't just identify the position in the cycle where this occurs.)

The force on an object oscillating on a spring is always directed toward the center of the oscillation, and is either right in the direction of the object's velocity or in the opposite direction from its velocity. If force and velocity are in the same direction, the speed increases; if force and velocity are in opposite directions, the speed decreases.

If the object's speed is increasing, it cannot be at its fastest, because it will soon be faster. If its speed is decreasing, it cannot be at its fastest, because it recently was faster. It can only be at its fastest when its acceleration is zero.

For an oscillating object, this is at the equilibrium position. The object speeds up approaching the equilibrium position, it at its fastest at the equilibrium position, and then slows down as it departs from the equilibrium position.

Extra credit

25. (5 points) In class, when I sang

"So we find different rules
Even though our world's the same.
I see straight shootin', and side with Newton,
While paths are curved in your rotating reference frame,"

I was describing the effect of a "fictitious" force that exists in a rotating frame of reference. Name that force.

The Coriolis force.