Last Name:______________First Name________________Network-ID___________
Discussion Section:________Discussion TA Name:________________________________

Instructions—
Turn off your cell phone and put it out of sight.
Keep your calculator on your own desk. Calculators cannot be shared.
This is a closed book exam. You have ninety (90) minutes to complete it.

1. Use a #2 pencil. Do not use a mechanical pencil or pen. Darken each circle completely, but stay within the boundary. If you decide to change an answer, erase vigorously; the scanner sometimes registers incompletely erased marks as intended answers; this can adversely affect your grade. Light marks or marks extending outside the circle may be read improperly by the scanner. Be especially careful that your mark covers the **center** of its circle.

2. You may find the version of **this Exam Booklet at the top of page 2**. Mark the **version** circle in the **TEST FORM** box near the bottom right on the face of your answer sheet. **DO THIS NOW!**

3. Print your **NETWORK ID** in the designated spaces at the *right* side of the answer sheet, starting in the left most column, then **mark the corresponding circle** below each character. If there is a letter "o" in your NetID, be sure to mark the "o" circle and not the circle for the digit zero. If and only if there is a hyphen "-" in your NetID, mark the hyphen circle at the bottom of the column. When you have finished marking the circles corresponding to your NetID, check particularly that you have not marked two circles in any one of the columns.

4. Print **YOUR LAST NAME** in the designated spaces at the *left* side of the answer sheet, then mark the corresponding circle below each letter. Do the same for your **FIRST NAME INITIAL.**

5. Print your UIN# in the **STUDENT NUMBER** designated spaces and mark the corresponding circles. You need not write in or mark the circles in the SECTION box.

6. Sign your name **(DO NOT PRINT)** on the **STUDENT SIGNATURE** *line*.

7. On the **SECTION** *line*, print your **DISCUSSION SECTION**. You need not fill in the COURSE or INSTRUCTOR lines.

Before starting work, check to make sure that your test booklet is complete. You should have 11 ***numbered pages*** *plus two Formula Sheets.*

*Academic Integrity—***Giving assistance to or receiving assistance from another student or using unauthorized materials during a University Examination can be grounds for disciplinary action, up to and including dismissal from the University.**

This Exam Booklet is Version A. Mark the **A** circle in the **TEST FORM** box near the bottom right on the face of your answer sheet. **DO THIS NOW!**

Exam Grading Policy—
The exam is worth a total of **120** points, and is composed of three types of questions:

MC5: *multiple-choice-five-answer questions, each worth 6 points.*
Partial credit will be granted as follows.
(a) If you mark only one answer and it is the correct answer,
you earn **6** points.
(b) If you mark *two* answers, one of which is the correct answer,
you earn **3** points.
(c) If you mark *three* answers, one of which is the correct answer, you earn **2** points.
(d) If you mark no answers, or more than *three*, you earn 0 points.

MC3: *multiple-choice-three-answer questions, each worth 3 points.*
No partial credit.
(a) If you mark only one answer and it is the correct answer,
you earn **3** points.
(b) If you mark a wrong answer or no answers, you earn **0** points.

TF: *true-false questions, each worth 2 points.*
No partial credit.

(a) If you mark only one answer and it is the correct answer, you earn **2** points.
(b) If you mark the wrong answer or neither answer, you earn **0** points.

Unless told otherwise, you should assume that the acceleration of gravity near the surface of the earth is 9.8 $\mathrm{m/s^2}$ *downward and ignore any effects due to air resistance.*

Choose the closest number to the correct answer when a numerical answer is required.

1. Two blocks, A (mass M) and B (mass 3M), are initially at rest. A force F is applied to block A over a distance D on a horizontal frictionless surface. The same force F is applied to block B over the same distance D. Which block ends up with the larger kinetic energy?

$W = \Delta KE$

a. Block A.
b. Block B.
(c.) Both blocks end up with the same kinetic energy.

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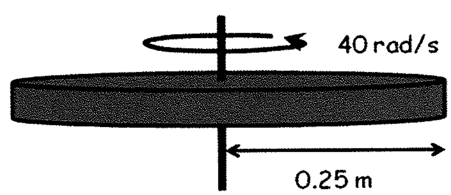
2. A car of mass 800 kg moving at 1.5 m/s collides with a stone wall and comes to rest. The collision takes 0.1 s. What is the total <u>impulse</u> delivered to the car?

a. 800 kg-m/s
(b.) 1200 kg-m/s
c. 1600 kg-m/s
d. 5333 kg-m/s
e. 8000 kg-m/s

$I = \Delta p = mv = 800\ kg \times 1.5\ m/s$
$= 1200\ kg\ m/s$

The following 2 questions concern the same physical situation:

3. A uniform solid disk of mass 5 kg and radius 0.25 m is spinning with an angular velocity of 40 rad/s around the axis at the center of mass, perpendicular to the disk. What is the magnitude of the disk's angular momentum?



a. 1.0 $kg\text{-}m^2/s$
b. 2.5 $kg\text{-}m^2/s$
(c.) 6.25 $kg\text{-}m^2/s$
d. 8.5 $kg\text{-}m^2/s$
e. 12.0 $kg\text{-}m^2/s$

$L = I\omega$
$= \frac{1}{2} MR^2 \omega$
$= \frac{1}{2}\, 5\ kg\,(0.25\ m)^2\, 40\ rad/s = 6.25\ kg\ m^2/s$

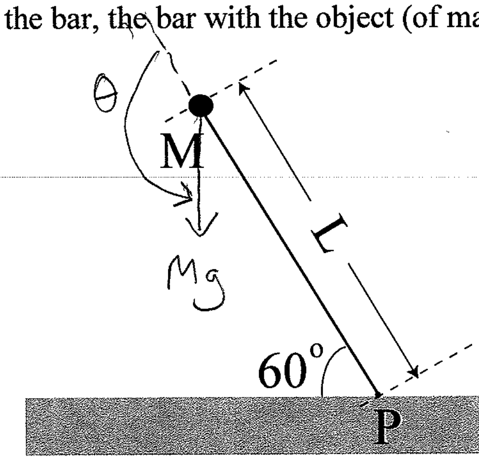
4. Suppose a frictional force is applied to the rim of the disk so that the disk experiences angular acceleration of magnitude 20 rad/s^2. What is the magnitude of the frictional force?

a. 6.25 N
(b.) 12.5 N
c. 25 N
d. 38 N
e. 50 N

$\tau = I\alpha$
$fR = \frac{1}{2} MR^2 \alpha$
$f = \frac{1}{2} MR\alpha$
$= \frac{1}{2}\, 5\ kg \times 0.25\ m \times 20\ rad/s^2$
$= 12.5\ N$

The following 2 questions concern the same physical situation:

A person is holding a bar (of length L) at an angle of 60 degrees relative to the ground as shown below. An object of mass M is attached to the end of the bar. Because the object is much heavier than the bar, we will ignore the mass of the bar in this problem. When the person lets go of the bar, the bar with the object (of mass M) starts to rotate around P.



5. What is the magnitude of the angular acceleration α of the bar around point P immediately after the person lets go of the bar?

a. $\alpha = g/4$
(b.) $\alpha = g/2L$
c. $\alpha = 3g/4L$

$\tau = I\alpha$

$Mg L \sin\theta = ML^2\alpha$

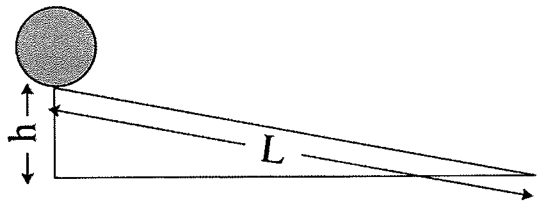
$\alpha = \frac{g}{L}\sin\theta = \frac{g}{L}\sin 150° = \frac{g}{L}\frac{1}{2}$

6. The rod continues to rotate around the pivot point P until it hits the ground. What is the direction of angular momentum just before it hits the ground?

a. To the right
b. To the left
c. Into the page
(d.) Out of the page
e. Toward the ground

The following 2 questions concern the same physical situation:

There is a slope with height h and length L = 20 m as illustrated in the figure to the right. The height of the slope is 1.0 m. A solid uniform cylinder of radius R = 0.2 m is at the top of the slope starting from rest. It rolls down the slope **without slipping**.



7. When the cylinder reaches the end of the slope, what is its center of mass speed?

a. 0.73 m/s
b. 0.92 m/s
c. 1.22 m/s
d. 1.4 m/s
(e.) 3.61 m/s

$$\frac{1}{2}mv^2 + \frac{1}{2}I\omega^2 = mgh$$
$$\frac{1}{2}mv^2 + \frac{1}{2}\frac{1}{2}mR^2\left(\frac{v}{R}\right)^2 = mgh$$
$$\frac{3}{4}v^2 = gh \Rightarrow v = \sqrt{\frac{4}{3}gh} = \sqrt{\frac{4}{3} \times 9.8\,\frac{m}{s^2} \times 1\,m}$$
$$= 3.61\ m/s$$

8. Consider the same situation except that the slope is frictionless so that the cylinder slides down without rolling. What can you say about the center of mass speed of the cylinder at the end of the slope?

(a.) It will have a larger center of mass speed compared to the rolling case.
b. It will have a smaller center of mass speed compared to the rolling case.
c. It will have the same center of mass speed as in the rolling case.

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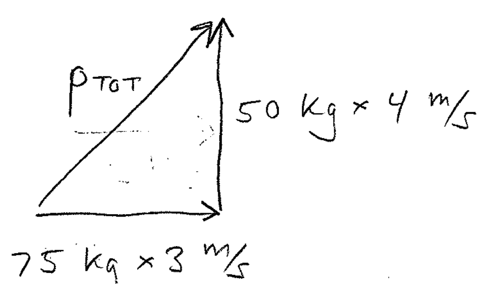
9. Two skaters are gliding across the ice. Skater A with mass 75 kg is moving at 3 m/s in the +x direction. Skater B with mass 50kg is moving at 4 m/s in the +y direction. What is the magnitude of their *total* momentum?

a. 125 kg m/s
(b.) 301 kg m/s
c. 425 kg m/s
d. 437 kg m/s
e. 602 kg m/s



$$p_{TOT} = \sqrt{(75\,kg \times 3\,m/s)^2 + (50\,kg \times 4\,m/s)^2} = 301\ kg\ m/s$$

The following two questions concern the same physical situation:

An object of mass M = 4 kg is moving horizontally at a constant speed of 6 m/s. A force of 100 N is applied in the same direction as the object's velocity over a short period of time such that the speed of the object increases to 10 m/s. Neglect all frictional forces.

10. The work done by the force is

a. 72 J
(b.) 128 J
c. 200 J
d. 256 J
e. 400 J

$$W = \Delta KE = \frac{1}{2} m v_f^2 - \frac{1}{2} m v_i^2 = \frac{1}{2} m (v_f^2 - v_i^2) = \frac{1}{2} 4\,\text{kg}\left((10\ \text{m/s})^2 - (6\ \text{m/s})^2\right) = 128\ \text{J}$$

11. What is the time period of time over which the force was applied?

a. 0.04 s
(b.) 0.16 s
c. 0.25 s

$$F\Delta t = \Delta p = M(v_f - v_i)$$
$$\Delta t = \frac{M(v_f - v_i)}{F} = \frac{4\,\text{kg}\,(10\ \text{m/s} - 6\ \text{m/s})}{100\ \text{N}} = 0.16\ \text{s}$$

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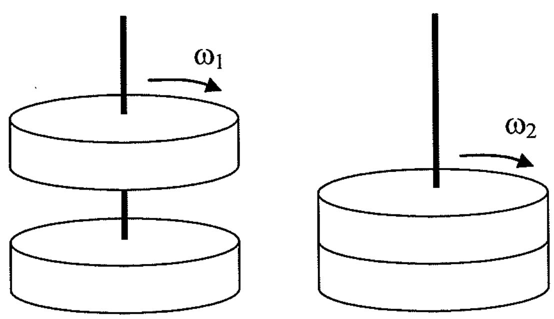
12. Two solid disks with equal mass m = 2.5 kg and equal radius R = 0.2 m both slide and rotate without friction on a vertical axis. Initially, the upper disk is rotating with angular velocity ω_1 and the lower disk is at rest. The upper disk then falls, sticks to the lower disk, after which they are observed to rotate together at angular velocity $\omega_2 = 23$ rad/s. What was the initial angular velocity of the upper disk, ω_1?

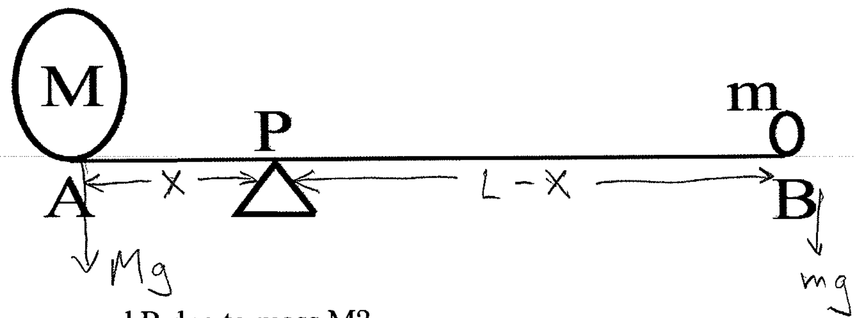


$$I_1 \omega_1 = I_2 \omega_2 \qquad I_2 = 2 I_1$$
$$\omega_1 = \frac{I_2}{I_1} \omega_2 = 2\omega_2 = 2 \times 23\ \text{rad/s} = 46\ \text{rad/s}$$

a. 4.71 rad/s
b. 28.26 rad/s
(c.) 46.00 rad/s
d. 75.35 rad/s
e. 98.90 rad/s

The following 2 questions concern the same physical situation:

There is a weightless bar of length 1m. At one end A is a mass M = 20 kg and at the other end B is a mass m = 5 kg. The bar is at rest on the pivot P. (Note: Assume + is for counterclockwise rotation.). The drawing below is not to scale.



13. What is the torque around B due to mass M?

a. + 294 Nm
(b.) + 196 Nm
c. 0 Nm
d. − 196 Nm
e. − 294 Nm

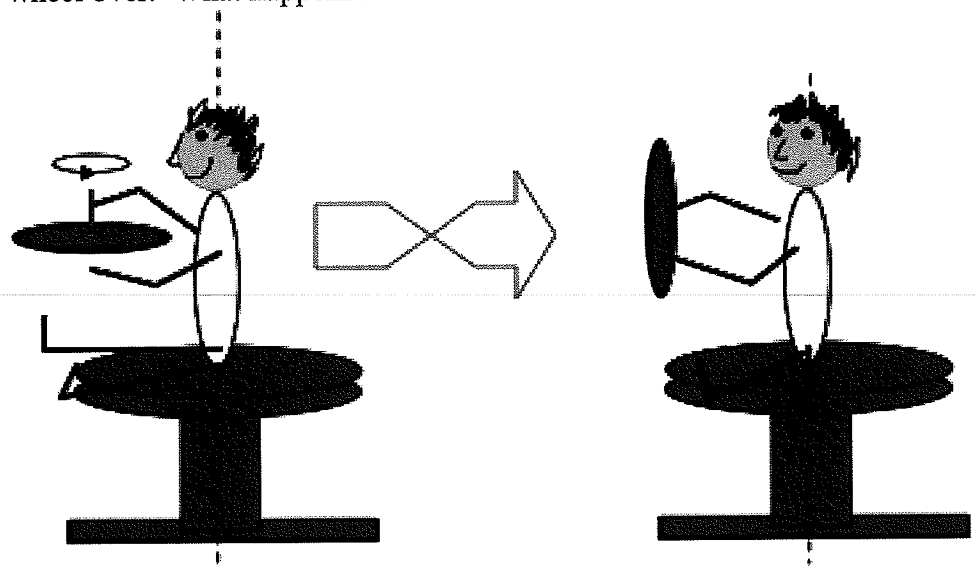
$\tau = Mg \times L$
$= 20\,kg \times 9.8\,m/s^2 \times 1\,m$
$= 196\,Nm$

14. What should be the distance between A and P to keep the system in equilibrium?

a. 0.1 m
(b.) 0.2 m
c. 0.3 m
d. 0.4 m
e. 0.5 m

$Mgx = mg(L-x)$
$(M+m)x = mL$
$x = \frac{m}{M+m}L$
$= \frac{5}{20+5} \times 1\,m = 0.2\,m$

15. A student sits on a barstool holding a bike wheel. The wheel is initially spinning counterclockwise in the horizontal plane (as viewed from above). She now turns the bike wheel over. What happens?



a. She starts to spin counterclockwise.
b. She starts to spin clockwise.
c. She does not spin.

$\uparrow = \downarrow + \uparrow$

The next two questions pertain to the following situation:

A rubber raft of mass 200 kg and speed 2 m/s in the +x direction strikes a stationary boat of mass 1000 kg. Assume that the forces exerted by the water on the boat and the raft are negligible.

16. What is their speed if the raft and the boat stick together after the collision?

a. 0.0 m/s
b. 0.18 m/s
c. 0.33 m/s
d. 1.67 m/s
e. 2.0 m/s

$$m v_i = (m + M) V$$
$$V = \frac{m}{m+M} v_i = \frac{200}{200+1000} \, 2 \, \text{m/s} = 0.33 \, \text{m/s}$$

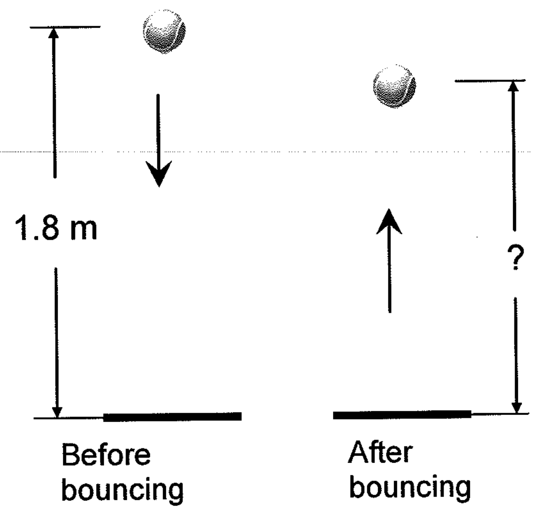
17. Suppose that instead of sticking to the boat, the raft bounces off the boat in the –x direction with speed 1.33 m/s with respect to the water. What is now the resulting speed of the boat?

a. -0.67 m/s
b. 0.0 m/s
c. 0.40 m/s
d. 0.67 m/s
e. 1.33 m/s

$$m v_i = -m v_f + M V$$
$$V = \frac{m}{M}(v_i + v_f)$$
$$= \frac{200}{1000}(2 \, \text{m/s} + 1.33 \, \text{m/s}) = 0.67 \, \text{m/s}$$

The following 2 questions concern the same physical situation:

A ball falls vertically from the initial height of 1.8 m with no initial velocity to the floor and bounces vertically up as illustrated. Take the origin of the potential energy of the ball to be that on the floor. Assume the mass of the ball is 0.14 kg and neglect air resistance.



18. During the period that the ball is falling before it hits the ground, which of the following statement is **NOT** true:

a. As the ball is falling, its potential energy is converted into kinetic energy. The total mechanical energy of the ball stays constant.

b. When the height of the ball is at 0.9 m above ground, the potential energy of the ball equals to its kinetic energy.

(c.) The kinetic energy of the ball increases linearly with time.

v increases linearly with time

$\Rightarrow KE = \frac{1}{2}mv^2$ increases quadratically with time

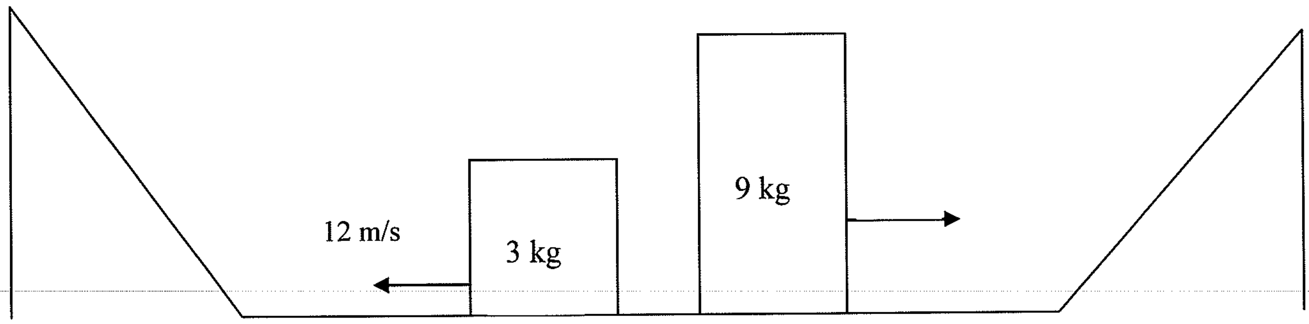
19. If 20% of mechanical energy is lost due to the bounce, what is the maximum height the ball will reach after the bounce?

a. 1.00 m
b. 1.22 m
(c.) 1.44 m
d. 1.66 m
e. 1.88 m

$mgh_f = 80\% \, mgh_i$

$h_f = 0.8\,h = 0.8 \times 1.8\,m = 1.44\,m$

The next three questions pertain to the following situation:



A block sits at rest on a horizontal surface. It suddenly explodes and breaks into two pieces as shown. A piece of mass 3 kg goes to the left and a piece of mass 9 kg goes to the right. Each block slides along the <u>frictionless</u> surface, then up a <u>frictionless</u> ramp. The speed of the 3 kg block is 12 m/s immediately after the explosion.

20. What is the speed of the 9 kg block immediately after the explosion?

a. 0 m/s
(b.) 4 m/s
c. 8 m/s
d. 12 m/s
e. 36 m/s

$m_1 v_1 = m_2 v_2$

$v_2 = \frac{m_1}{m_2} v_1 = \frac{3}{9} 12 \text{ m/s} = 4 \text{ m/s}$

21. What is the maximum height reached by the 3 kg block on the left slope?

a. 0.61 m
b. 1.22 m
c. 3.67 m
(d.) 7.35 m
e. 14.69 m

$mgh = \frac{1}{2} mv^2$

$h = \frac{1}{2} \frac{v^2}{g} = \frac{1}{2} \frac{(12 \text{ m/s})^2}{9.8 \text{ m/s}^2} = 7.35 \text{ m}$

22. Eventually the two blocks slide back and collide and stick together. In what direction do the two blocks move immediately after the collision?

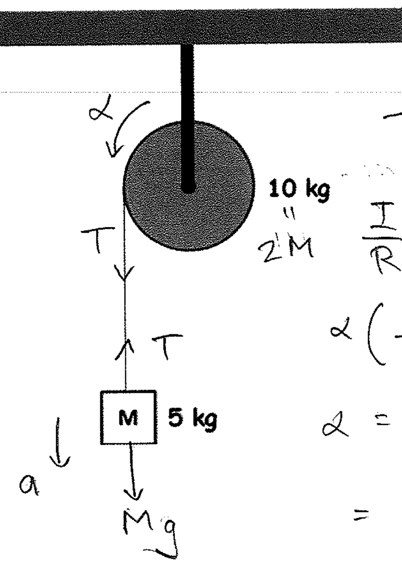
a. They move to the left.
b. They move to the right.
(c.) They do not move.

Momentum = 0

The following 2 questions concern the same physical situation:

23. A freely hanging block of mass 5 kg is attached to a massless string, which is wrapped several times around a pulley (solid cylinder) of mass 10 kg and radius 0.2 m (see diagram). There is no friction in the pulley mechanism. What is the angular acceleration of the pulley?

a. 2.9 Rad/s^2
b. 13.7 Rad/s^2
(c.) 24.5 Rad/s^2
d. 45.3 Rad/s^2
e. 66.1 Rad/s^2



$$T - Mg = -Ma = -M\alpha R$$
$$TR = I\alpha \Rightarrow T = \frac{I}{R}\alpha$$
$$\frac{I}{R}\alpha - Mg = -M\alpha R$$
$$\alpha\left(\frac{I}{R} + MR\right) = Mg$$
$$\alpha = Mg \Big/ \left(\frac{\frac{1}{2}2MR^2}{R} + MR\right)$$
$$= Mg / (2MR) = \frac{1}{2}\frac{g}{R}$$
$$= \frac{1}{2}\frac{9.8\ m/s^2}{0.2\ m}$$
$$= 24.5\ rad/s^2$$

24. What can you say about the kinetic energy of the block of mass M after it has dropped by a distance of *h*?

a. It is equal to M g h.
b. It is larger than M g h.
(c.) It is smaller than M g h.

Did you bubble in your name, exam version, and network ID?
Check to make sure you have bubbled in all your answers.