Last Name:______________ First Name________________ Network-ID___________
Discussion Section:________ Discussion TA Name:___________________________
Exam Room_____________________________ Seat Number__________

Instructions—

Turn off your cell phone and put it away.
Calculators cannot be shared. Please keep yours on your own desk.
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 a pen. Fill in completely (until there is no white space visible) the circle for each intended input – both on the identification side of your answer sheet and on the side on which you mark your answers. 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.

2. Print your last name in the **YOUR LAST NAME** boxes on your answer sheet and print the first letter of your first name in the **FIRST NAME INI** box. Mark (as described above) the corresponding circle below each of these letters.

3. Print your NetID in the **NETWORK ID** boxes, and then mark the corresponding circle below each of the letters or numerals. Note that there are different circles for the letter "I" and the numeral "1" and for the letter "O" and the numeral "0". **Do not** mark the hyphen circle at the bottom of any of these columns.

4. 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 middle of your answer sheet. **DO THIS NOW!**

5. Stop **now** and double-check that you have bubbled-in all the information requested in 2 through 4 above and that your marks meet the criteria in 1 above. Check that you do not have more than one circle marked in any of the columns.

6. Do **not** write in or mark any of the circles in the STUDENT NUMBER or SECTION boxes.

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

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

Before starting work, check to make sure that your test booklet is complete. You should have 14 ***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 middle of your answer sheet. **DO THIS NOW!**

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

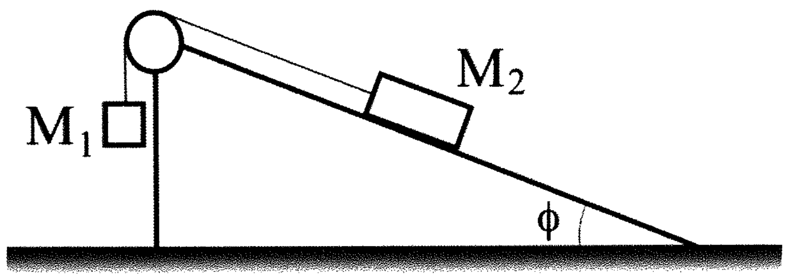
MC5: *multiple-choice-five-answer questions, each worth 6 points.*
Partial credit will be granted as follows.
(a) If you mark only one answer and it is the correct answer,
you earn **6** points.
(b) If you mark *two* answers, one of which is the correct answer,
you earn **3** points.
(c) If you mark *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.

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

The next three questions refer to the following situation.

A block of mass $M_1 = 1.5$ kg hangs vertically off the rope connected over an ideal pulley to another block of mass $M_2 = 3.5$ kg that rests on a frictionless ramp. The system of blocks is initially at rest.



1. What is the angle ϕ that the ramp makes with the horizontal?

a. 15.2°
b. 18.5°
c. 22.3°
(d.) 25.4°
e. 32.8°

$T = M_1 g$

$T = M_2 g \sin\phi$

$M_1 g = M_2 g \sin\phi$

$\sin\phi = M_1/M_2 = 1.5/3.5 = 0.428 \Rightarrow \phi = 25.38°$

2. Which expression describes tension T in the rope?

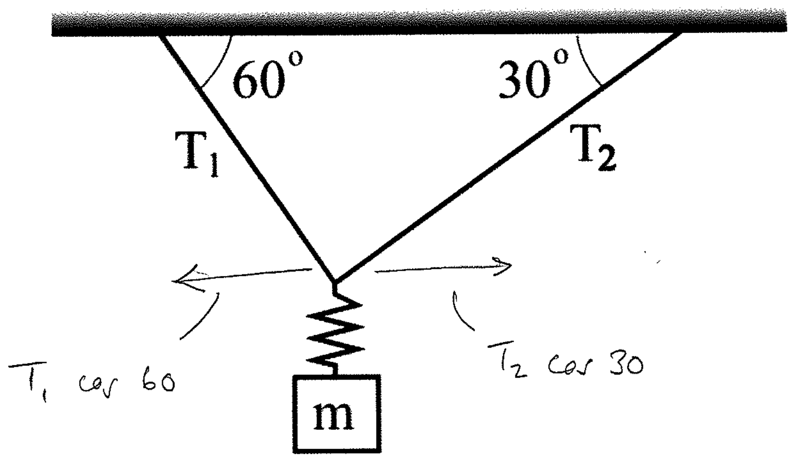
a. $T = g(M_2 - M_1)\sin(\phi)$
b. $T = M_2 g\cos(\phi)$
c. $T = gM_1M_2/(M_1 + M_2)$
d. $T = g(M_2 + M_1)\cos(\phi)$
(e.) $T = M_2 g\sin(\phi)$

3. Now, the rope is cut and the blocks start to move. If a_1 is the magnitude of the acceleration of M_1, and a_2 is the magnitude of the acceleration of M_2, how do the magnitudes of the blocks' acceleration compare? Neglect air resistance.

a. $a_1 = a_2$
(b.) $a_1 > a_2$
c. $a_1 < a_2$

The next three questions refer to the following situation.

Two ideal ropes are connected to one end of the ideal spring as shown in the figure. A block of mass m is attached to the other end of the spring. The system is in equilibrium; the spring extends 0.3 m from its equilibrium length. The spring constant k = 100 N/m.



4. How do the tensions in the ropes compare?

$T_1 \cos 60 = T_2 \cos 30$

a. $T_1 > T_2$
b. $T_1 = T_2$
c. $T_1 < T_2$

5. What is the mass of the block?

$F = kx \Rightarrow m = \frac{kx}{g} = \frac{100\ N/m \times 0.3\ m}{9.8\ m/s^2} = 3.06\ kg$ ($F = mg$)

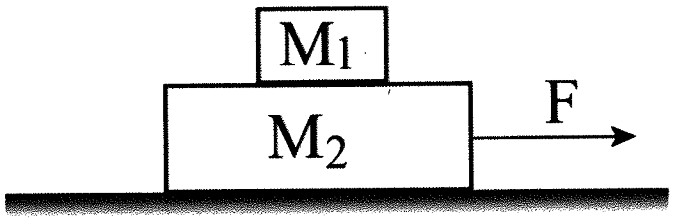
a. 2 kg
b. 3 kg
c. 1 kg

6. How would the tension in rope 1 change if the mass were doubled? You may ignore the mass of the spring.

a. remain the same
b. decrease by a fact of 2 sin(60)
c. increase by a factor of 2
d. increase by a factor 2 sin(60)
e. decrease by a factor of 2

The following three questions refer to the following situation.

A block of mass $M_1 = 10$ kg is placed on top of a larger block of mass $M_2 = 30$ kg. The second block is placed on the surface of a horizontal table and is subject to a horizontal force F. Friction acts between the two blocks and between the lower block and the table.



7. Initially, the magnitude of the horizontal force is F = 10 N. The system of two blocks remains at rest. What is the magnitude of the net force on the block of mass M_1?

a. 10N
(b.) 0 N
c. larger than 10N

$F_1 = M_1 a \quad a = 0 \Rightarrow F = 0$

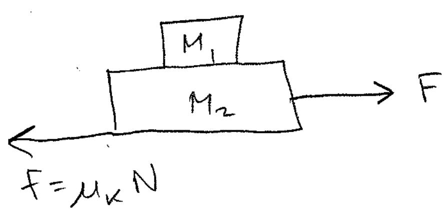
8. The magnitude of the horizontal force F is increased to 50 N, and the system of two blocks is observed to move together with a constant acceleration of 1 m/s^2. What is the magnitude of the net force on the block of mass M_1?

(a.) 10 N
b. Not enough information to tell
c. 30 N
d. 0 N
e. 40 N

$F_1 = M_1 a$
$= 10\ kg \times 1\ m/s^2$
$= 10\ N$

9. With F = 50 N and a constant acceleration of 1 m/s^2, what is the coefficient of kinetic friction between the block of mass M_2 and the table?

a. 0.05
b. 0.012
(c.) 0.026
d. 0.045
e. 0.032



$F - \mu_K N = (M_1 + M_2) a$

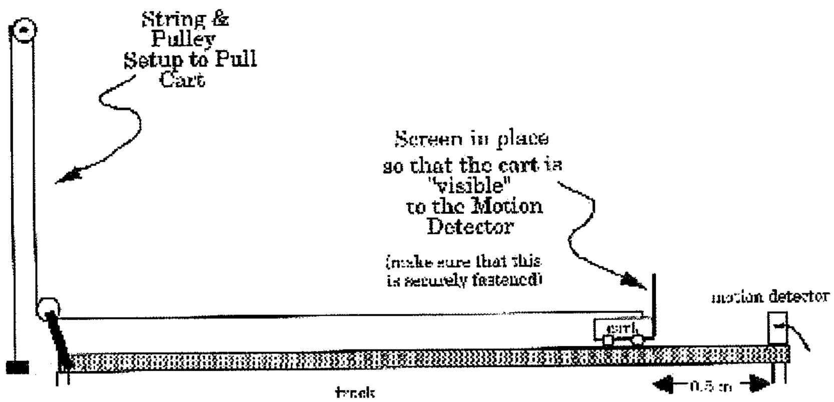
$F - \mu_K (M_1 + M_2) g = (M_1 + M_2) a$

$\mu_K = \frac{F}{(M_1 + M_2) g} - \frac{a}{g} = \frac{50\ N}{(10+30)\ kg \times 9.8\ m/s^2} - \frac{1}{9.8}$

$= 0.0255$

The following question refers to the situation shown in the figure:

A cart of mass M is on a plane with friction, pulled by a block of mass m, hanging over a pulley. Assume the cart is not moving (due to friction).

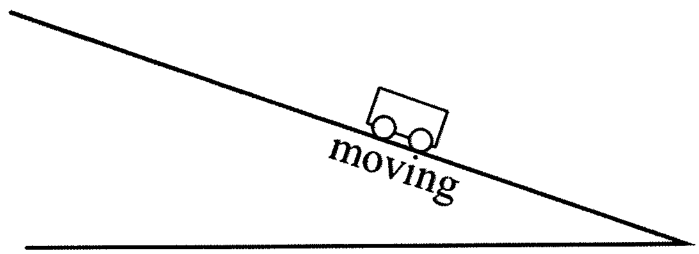


10. Suppose you double the mass of the cart but the cart is still not moving. The friction force on the cart approximately:

a. stays the same.
b. reduces by (m+M)/m.
c. doubles.

The following two questions refer to the situation shown in the figure.

You give a cart a quick push upward at the bottom of a ramp as shown in the figure.



11. There is no friction. When the cart reaches the top, and briefly stops, its velocity and acceleration are:

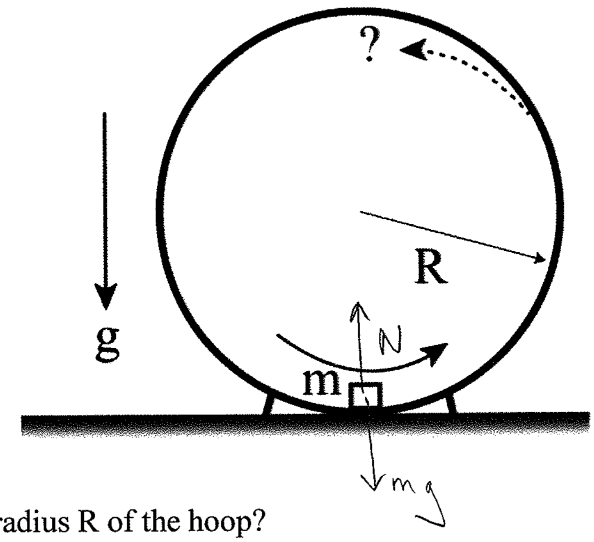
a. v = 0; a = upward along the slope
b. v = 0; a = 0
c. v = 0; a = downward along the slope

12. Referring to the figure above, assume there is no friction. The magnitude of the acceleration of the cart when traveling upwards (a_{up}) compared to that when it is going down (a_{down}) is:

a. $a_{up} > a_{down}$
b. $a_{up} < a_{down}$
c. $a_{up} = a_{down}$

The following two questions refer to the same physical situation shown in the figure:

There is a vertical hoop of radius R fixed to the ground. A small block of mass m = 0.3 kg is sliding along the inside surface of the hoop without friction as illustrated below. At the lowest point of the hoop, the block has a speed of 1.2 m/s along the hoop and the normal force on it is 4.5 N from the hoop.



13. What is the radius R of the hoop?

a. 0.12 m
b. 0.31 m
c. 0.22 m
d. 0.19 m
(e.) 0.28 m

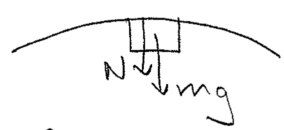
$$N - mg = m\frac{v^2}{R}$$

$$R = \frac{mv^2}{N - mg} = \frac{0.3\ kg \times (1.2\ m/s)^2}{4.5\ N - 0.3\ kg \times 9.8\ m/s^2}$$

$$= 0.277\ m$$

14. Suppose the angular speed of the block is maintained as it climbs up the hoop (i.e., assume the tangential speed of the block remains constant and equal to 1.2 m/s). Can the block reach the top of the hoop without falling?

(a.) No.
b. Yes.
c. There is not enough information to answer this question.



$$N + mg = m\frac{v^2}{R}$$ Is $N > 0$?

$$N = m\frac{v^2}{R} - mg = 0.3\ kg\left(\frac{(1.2\ m/s)^2}{0.277\ m} - 9.8\ m/s^2\right) < 0$$

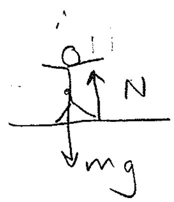
So no, N is not positive

The following two problems concern the same physical situation.

A person of mass 65 kg is on a scale in an elevator. The scale reads 59 kg when the elevator accelerates.

15. What is the acceleration a of the elevator (in units of $g = 9.8\ m/s^2$), the acceleration due to gravity? Our sign convention is that the upward direction is the positive direction.

(a) $a/g = -0.092$
b. $a/g = 0.046$
c. $a/g = -0.0$
d. $a/g = -0.046$
e. $a/g = 0.092$



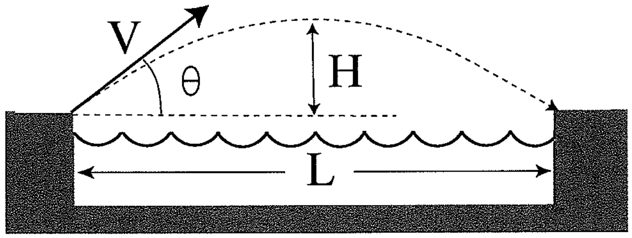
$$N - mg = ma$$
$$\frac{N}{mg} - 1 = \frac{a}{g}$$
$$\frac{a}{g} = \frac{N}{mg} - 1$$
$$= \frac{59\ kg \times g}{65\ kg \times g} - 1 = -0.092$$

16. Later, the elevator reaches a constant speed. Is this speed larger or smaller than the speed before the acceleration?

a. Smaller
(b.) There is not enough information to answer the question.
c. Larger

The following two problems concern the same physical situation.

Judy kicks a ball across a moat of width L. The ball is kicked from the ground with an initial angle θ with the horizontal as illustrated below.



17. The height of the highest point from the ground (above the mid point of the moat) is H = L/3. What is the angle θ? [Hint: Pay attention to the time t required for the ball to reach the highest point. Notice that $2H = gt^2$ and $V \sin\theta = gt$.]

a. 53°
b. 57°
c. 69°
d. 60°
e. 45°

$H = L/3 = \frac{1}{2} g t^2 \Rightarrow t = \sqrt{\frac{2L}{3g}}$

$V_y = V_{oy} - gt \Rightarrow V_{oy} = gt$ (V_y = 0 at top; $V_{oy} = V_0 \sin\theta$)

$x: \frac{L}{2} = V_0 \cos\theta \times t \Rightarrow V_0 \cos\theta = \frac{L}{2t}$

$\frac{V_0 \sin\theta}{V_0 \cos\theta} = \tan\theta = \frac{gt}{L/2t} = \frac{2gt^2}{L} = \frac{2g}{L}\frac{2L}{3g} = 4/3$

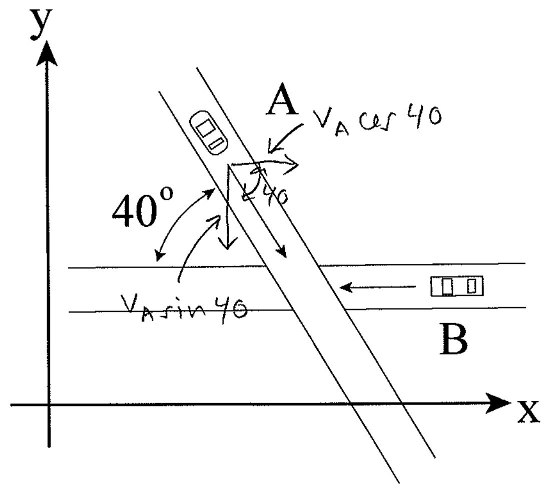
$\tan^{-1}\frac{4}{3} = 53.1°$

18. If the mass of the ball is doubled, what is the minimum required initial speed V' of the ball to cross the moat with the same angle θ?

a. $V' = V/2^{1/2}$
b. $V' = 2V$
c. $V' = V/2$
d. $V' = 2^{1/2}V$
e. $V' = V$

The following two problems concern the same situation.

Two straight highways make an angle 40° at their crossing as illustrated below. Car A is moving at 65 miles/hour, and car B at 40 miles/hour in the direction of the arrows, respectively. The xy-coordinate system is designated in the figure. The x-axis is parallel to the highway on which car B is running.



19. What is the velocity vector of car A in components with respect to the designated coordinate system?

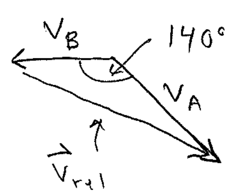
$x: V_A \cos 40 = 65 \text{ mph} \times \cos 40 = 49.8 \text{ mph}$

$y: -V_A \sin 40 = -65 \text{ mph} \times \sin 40 = -41.8 \text{ mph}$

a. (–49.8, –41.8) miles/hour
b. (49.8, –37.5) miles/hour
ⓒ (49.8, –41.8) miles/hour

20. What is the relative speed of the two cars?

$\vec{V}_{rel} = \vec{V}_A - \vec{V}_B =$



a. 87.9 miles/hour
b. 73.5 miles/hour
c. 105.0 miles/hour
ⓓ 99.1 miles/hour
e. 68.3 miles/hour

Law of cosines:

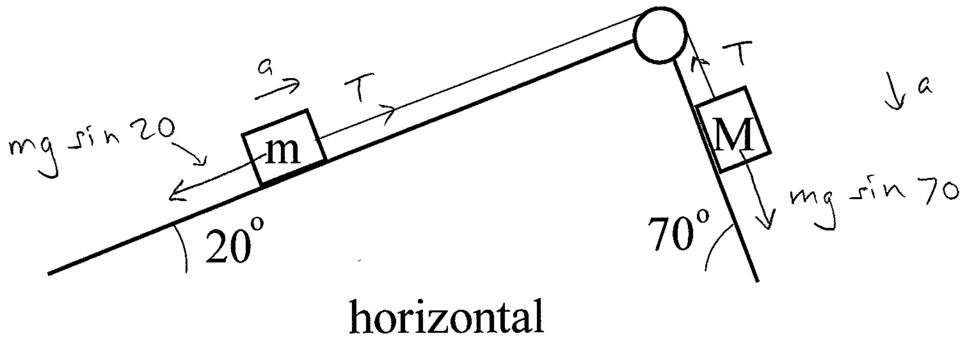
$V_{rel}^2 = V_A^2 + V_B^2 - 2 V_A V_B \cos 140°$

$= (65)^2 + (40)^2 - 2 \cdot 65 \cdot 40 \cos 140°$

$\Rightarrow V_{rel} = 99.04 \text{ mph}$

The following two problems concern the same physical situation.

Blocks of mass M and m are on the frictionless slopes as illustrated below. The two blocks are connected with a massless string through a massless and frictionless pulley.



21. Suppose m = M. What is the magnitude of the acceleration of the blocks?

a. 5.72 m/s^2
b. 1.34 m/s^2
(c.) 2.93 m/s^2
d. 3.32 m/s^2
e. 7.89 m/s^2

$T - mg \sin 70 = -ma$
$-[T - mg \sin 20 = ma]$
$mg(\sin 20 - \sin 70) = -2ma$
$a = g(\sin 70 - \sin 20)/2 = 2.93\ m/s^2$
$g = 9.8\ m/s^2$

22. Suppose M is much larger than m. What is the magnitude of the acceleration of the block of mass m?

a. 8.6 m/s^2
b. 7.0 m/s^2
c. 9.8 m/s^2
d. 6.4 m/s^2
(e.) 9.2 m/s^2

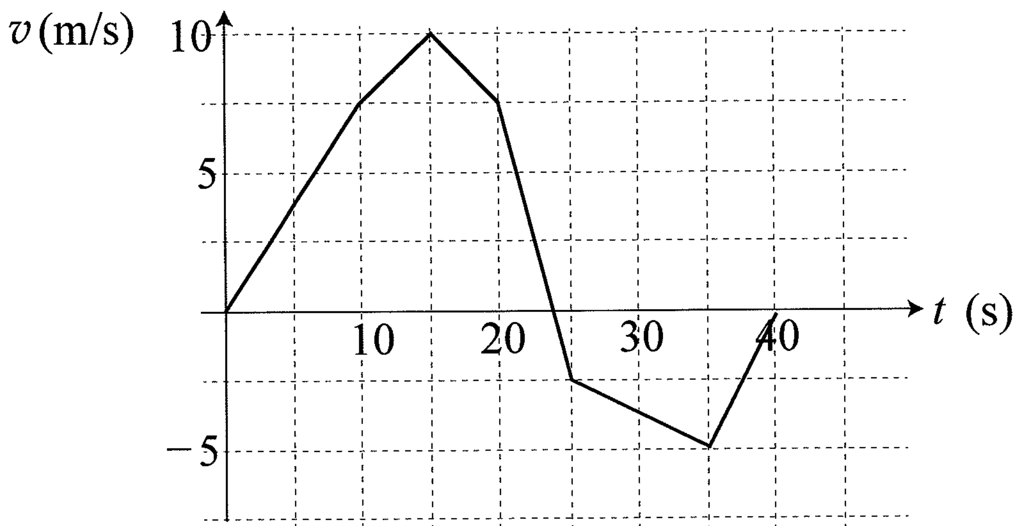
If M >> m, then a is just acceleration of M with T = 0:

$-Mg \sin 70 = -Ma$

$a = g \sin 70 = 9.21\ m/s^2$

The following two problems concern the same physical situation.

A cart of mass 6.2 kg is moving along the x-axis. Its initial position is x = 0 (m). Its velocity (x-velocity) as a function of time is graphed below.



23. What is the maximum of the magnitude of the total force acting on the cart between 0 s and 30 s?

Between 20 and 25 sec:

$a = \frac{v_f - v_i}{t} = \frac{-2.5 - 7.5 \text{ m/s}}{5 \text{ s}} = -2 \text{ m/s}^2$

$|F| = m|a| = 6.2 \text{ kg} \times 2 \text{ m/s}^2 = 12.4 \text{ N}$

a. 3.1 N
b. 24.8 N
c. 18.6 N
d. 6.2 N
(e.) 12.4 N

24. What is the x-coordinate of the cart at time 40 s? [Hint. Count the squares.]

No. of squares = 3 + 6 + ~2 − 3 − 1 ≈ 7

Each square = 2.5 m/s × 5 sec = 12.5 m

7 × 12.5 m = 87.5 m

a. 74.0 m
b. 69.0 m
c. 54.5 m
d. 91.5 m
(e.) 87.5 m

The following problem is by itself.

25. When a movie is over, the rotational speed of a DVD disk is 780 rpm. The disk rotation is stopped with the angular deceleration of $\alpha = 75$ rad/s^2. How many revolutions does the disk make before coming to a complete stop?

a. about 7 rotations
b. about 8 rotations
c. about 6 rotations
d. about 4 rotations
e. about 5 rotations

$$\omega_f^2 = \omega_0^2 - 2\alpha\Delta\theta$$

$\omega_f = 0$

$$\Rightarrow \Delta\theta = \frac{\omega_0^2}{2\alpha} = \frac{(780 \text{ rpm})^2}{2 \times 75 \text{ rad/s}^2}$$

$$= 4{,}056 \frac{\text{rev}^2}{\text{min}^2} \times \frac{\text{s}^2}{\text{rad}}$$

$$= 4{,}056 \frac{\text{rev}^2}{(60 \text{ sec})^2} \frac{\text{s}^2}{1 \text{ rev}/2\pi}$$

$$= 7.08 \text{ rev}$$

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