Last Name:_______________First Name__________________Network-ID____________
Discussion Section:________Discussion TA Name:______________________________
Exam Room______________________________Seat Number__________

This solution uses the source version of the exam, so it is NOT the actual version A. So, when you check your answers, look at the actual answers.

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 13 ***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!**

This solution uses the source version of the exam, so it is NOT the actual version A. So, when you check your answers, look at the actual answers.

Exam Grading Policy—
The exam is worth a total of xxx 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.

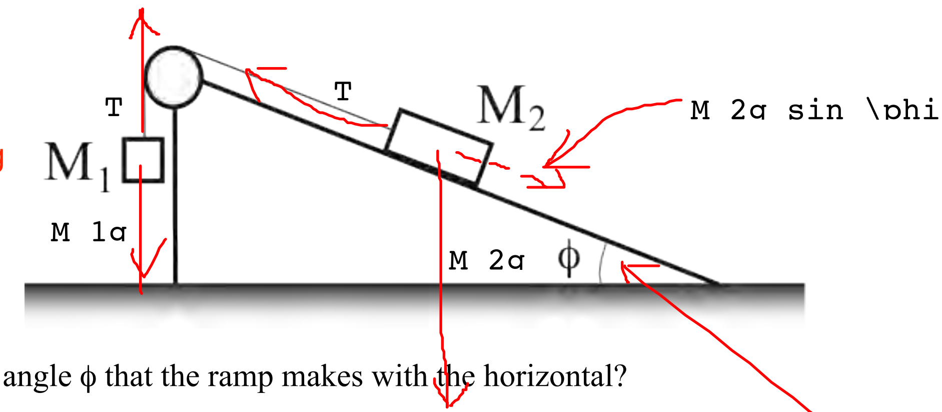
Unless told otherwise, you should assume that the acceleration of gravity near the surface of the earth is 9.8 m/s^2 *downward and ignore any effects due to air resistance.*

This solution uses the source version of the exam, so it is NOT the actual version A. So, when you check your answers, look at the actual answers.

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.

T is the tension in the string



\phi

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

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

```
Both the masses are stationary, so
T = M_1 g, T = M_2 g sin \phi.
That is,
M_1 = M_2 sin \phi.  Therefore,
sin \phi = M_1/M_2 = 1.5/3.5 = 0.42857,
so \phi = 25.376.. deg.
```

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. $T = M_2 g\sin(\phi)$
e. $T = g(M_2 + M_1)\cos(\phi)$

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.

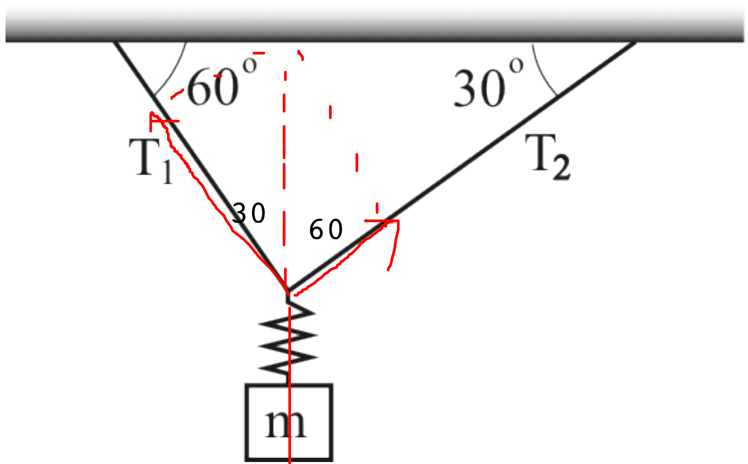
a. $a_1 = a_2$
b. $a_1 > a_2$
c. $a_1 < a_2$

~~3, 6b, 6d, 3b~~

```
You can use your own intuition: imagine the situation.
If you wish to proceed in formulas:
Write down the equations of motion.
M_1: M_1a_1 = M_1 g (downward);
M_2: M_2a_2 = M_2 g sin\phi (downward along the slope).
That is,
    a_1 = g, a_2 = g sin\phi.
Obviously, a_1 is larger than 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?

mg

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

T_1 = mg cos 30
T_2 = mg cos 60, obviously, T_1 is larger than T_2.
Or, you could use T_1 sin 30 = T_2 sin 60.

5. What is the mass of the block?

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

For a spring F = k \Delta x. Here, F = mg, \Delta x = 0.3 m and k = 100 N/m. Therefore,
m g = k \Delta x = 100 \times 0.3 = 30 (N).
Thus, m = 30/9.8 = 3 (kg).

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

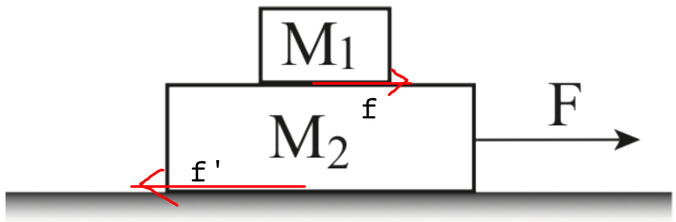
a. remain the same
b. decrease by a fact of 2 sin(60)
c. increase by a factor 2 sin(60)
d. increase by a factor of 2
e. decrease by a factor of 2

From the formulas written down in Problem 4, we know everything is proportional to m.

~~3, 3c, 3a, 6d~~

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 at 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 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

This implies a = 0, so no net force on any block.

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

Write down the equation of motion for M_1:

$M_1 a = f$.

Its acceleration is 1 m/s^2, so $M_1 a$ = 10 N, which must be the magnitude of the net force.

f is the internal force, so it does not show up.

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

The equation of motion for the two blocks combined reads

$(M_1 + M_2)\, a = F - f'$.

The net force acting on the two blocks combined is $(M_1 + M_2)\, a$ = 40 N. Since the friction between M_1 and M_2 is an `internal force,' it does not contribute to the net force, the friction f' = 50 – 40 = 10 (N).

$f' = \mu_k (M_1 + M_2) g$.

normal force from the table

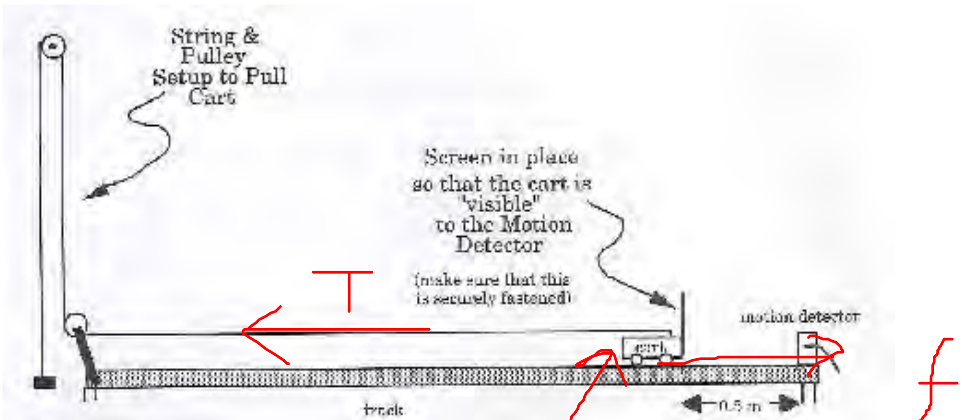
That is,

$\mu_k = 10/40g = 0.0255$ m/s^2.

~~3, 3b, 6a, 6c~~

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:

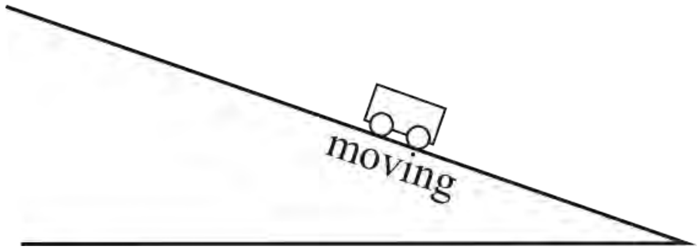
a. doubles.
b. reduces by (m+M)/m.
c. stays the same.

The magnitude of the friction force f is equal to the tension T in the string, but T has nothing to do with the mass of the cart.

~~1, 3c~~

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

This is a constant acceleration motion just as a ball thrown upward.

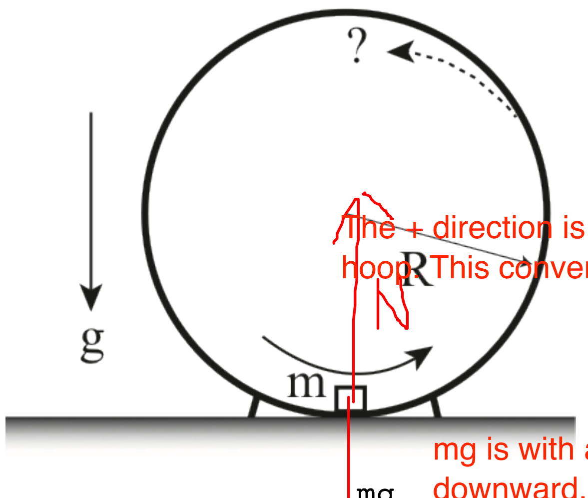
12. Referring to the figure above, assume there is no friction. The magnitude of the acceleration of the cart when traveling upwards (a_{up}) compared to that when it is going down (a_{down}) is:

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

~~**2, 3a, 3c**~~

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.



Draw all the forces.

The + direction is inward to the center of the hoop. This convention is NOT up to you.

mg is with a minus sign NOT because it is downward, but because it is OUTWARD.

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

```
The equation of motion in the radial direction is in terms
of the centripetal acceleration V^2/R (V = 1.2 m/s).
    m(V^2/R) = N – mg.
Since N = 4.5,
    m(1.2^2/R) = 4.5 – 0.3 \times 9.8
               = 1.56.
R = 0.3 \times 1.44/1.56 = 0.2769... 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.

~~2, 6e, 3a~~

```
If the block could reach the top, the equation of motion
reads
    m(V^2/R) = N + mg.
            = 1.56
            = N + 2.94
This implies N < 0.  That is,
the hoop DOES NOT push the block
inward.
```

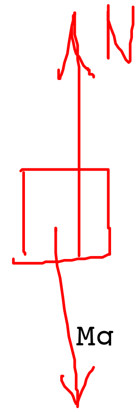
Pay attention to the explanation of the signs above.

M

Upward + convention is used.

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 the unit 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. $a/g = 0.046$
b. $a/g = -0.092$
c. $a/g = -0.0$
d. $a/g = -0.046$
e. $a/g = 0.092$

This implies that the normal force is +59g (upward).

This is Mg.

The equation of motion for the person is

$$65\ a = 59g - 65g = -6\ g.$$

Therefore, $a/g = -(6/65) = -0.0923$.

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

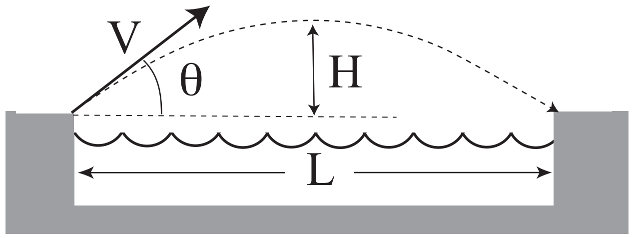
a. There is not enough information to answer the question.
b. Smaller
c. Larger

Imagine that you are coming to a halt from below, or that you start to go down from a stationary state.

~~2, 6b, 3a~~

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. 45°
b. 57°
c. 69°
d. 60°
e. 53°

```
Let the initial velocity be (V_x, V_y). Let t be the time needed
to reach the highest point.  Then, V_y - gt = 0. During this t
the ball reaches the midpoint of the moat, so V_xt = L/2.
Therefore,
tan \theta = V_y/V_x = (gt)/(L/2t) = 2gt^2/L = 4H/L = 4/3.
Therefore, \theta = 53.13 degree.
```

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?

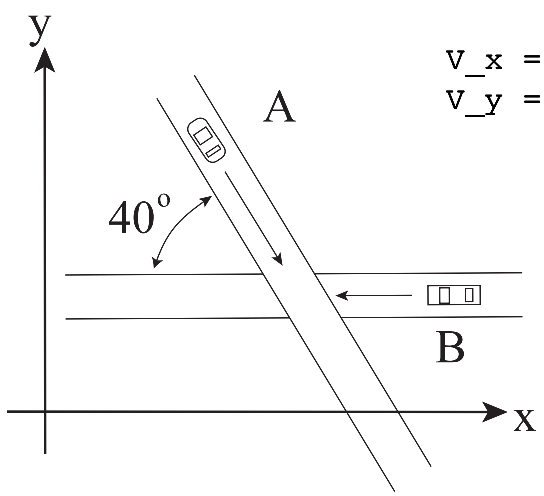
a. V' = V
b. V' = 2V
c. V' = V/2
d. $V' = 2^{1/2}V$
e. $V' = V/2^{1/2}$

```
The mass has nothing to do with the problem.
```

~~*2, 6e, 6a*~~

The following two problems concern the same situation.

Two straight highways make an angle 40° at their crossing as illustrated below. The car A is moving at 65 miles/hour, and the 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.

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V_x = V cos 40 = 49.79;
V_y = -V sin 40 = -41.78.
```

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

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

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

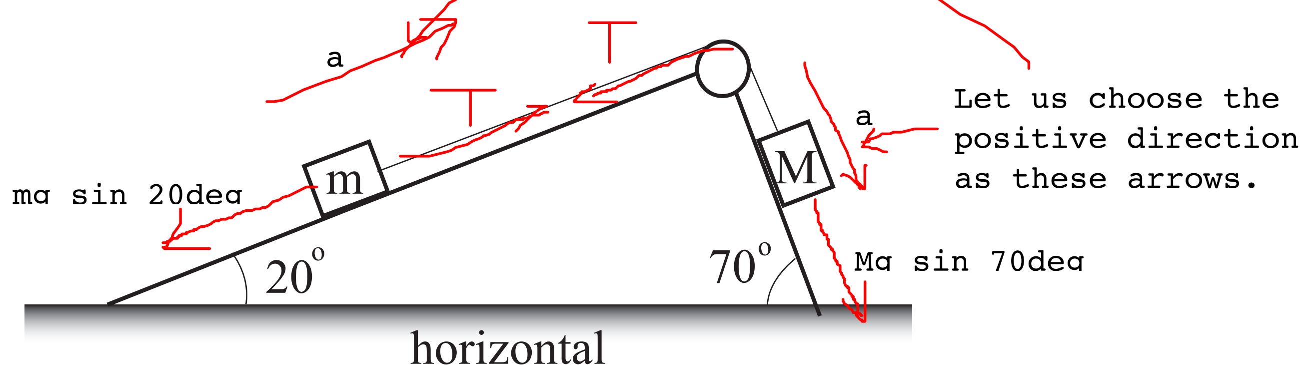
a. 87.9 miles/hour
b. 73.5 miles/hour
c. 105.0 miles/hour
d. 99.1 miles/hour
e. 68.3 miles/hour

```
The relative velocity seen from car A is
V_B – V_A = (-40, 0) – (49.79, -41.78)
       = (-89.79, -41.78).
Therefore, its magnitude is
 (89.8^2 + 41.8^2)^{1/2} = 99.05 miles/hour.
```

~~2, 3c, 6d~~

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. 2.93 m/s^2
c. 1.34 m/s^2
d. 3.32 m/s^2
e. 7.89 m/s^2

Let us set up the equations of motion:
    m: ma = T – mg sin 20 ;
    M: Ma = Mg sin 70 – T.
From these two, we get (add both!)
    (m + M) a = (M sin 70 – m sin 20)g.
If m = M, a = (sin70 – sin20)g/2 = 2.928 m/s^2.

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

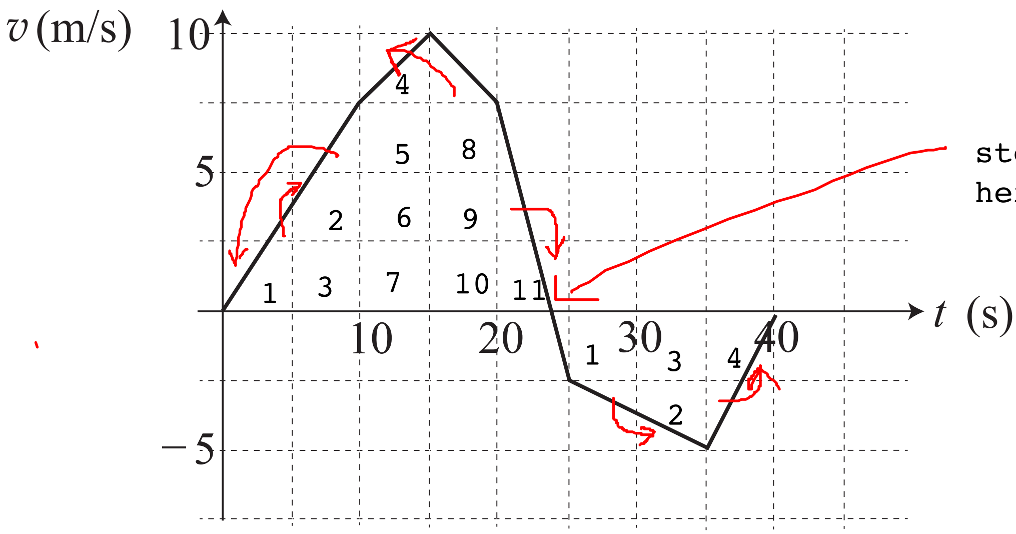
a. 8.6 m/s^2
b. 7.0 m/s^2
c. 9.8 m/s^2
d. 9.2 m/s^2
e. 6.4 m/s^2
~~2, 6b, 6d~~

Notice that still m and M move together, so they must have the same acceleration. Since M >> m, a is almost solely due to M (for M, m is nothing), so we have only to consider the sliding motion of M: its acceleration is obviously g sin 70 = 9.208 m/s^2.

Or, if you wish to use the formula
    a = (M sin 70 – m sin 20)g/(m + M)
      = [sin 70 – (m/M)sin 20]g/[1 + m/M],
but m/M is almost zero, so a goes to g sin 70.

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.



steepest around here.

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

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

The magnitude of the total force = mass times the magnitude of the accelration.

Acceleration is the slope of the graph. The steepest portion is between 20s and 25s. 10/5 = 2 m/s^2, so Fmax = 6.2 x 2 = 12.4 N.

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

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

The total displacement is the (signed) area below the graph. There are 11 positive squares and 4 negative squares, so total 7 squares. 1 square = 2.5 \times 5 = 12.5 m, so 7 squares correspond to 12.5 \times 7 = 87.5 m. Since the initial position is x = 0, the position at t = 40s is 87.5 m.

~~2, 6b, 6d~~

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
~~1, 6a~~

```
Since
    \w = 0,
    \w_0 = 780 \times 2\pi/60  = 26 \pi rad/s
and
    \a = -75 rad/s^2 (deceleration)
are given,it is a straightforward
    \w^2 = \w_0^2 + 2 \a \Delta \theta
question.  Therefore,
    \Delta \theta = \w_0^2/2\a
                  = (26 \pi)^2/150 = 4.5 \pi^2
This corresponds to \Delta \theta/2\pi rotations:
    = 4.5\pi/2 = 7.079... rotations.
```

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