Last Name:______________First Name_________________Network-ID____________
Discussion Section:________Discussion TA Name:______________________________

*Instructions—*
**Turn off your cell phone and put it away.**
**Calculators may not be shared. Please keep your calculator 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. **This Exam Booklet is Version A**. Mark the **A** circle in the **TEST FORM** box at the bottom of the front side of your answer sheet.

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* 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.**

*Exam Grading Policy—*
The exam is worth a total of 114 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.

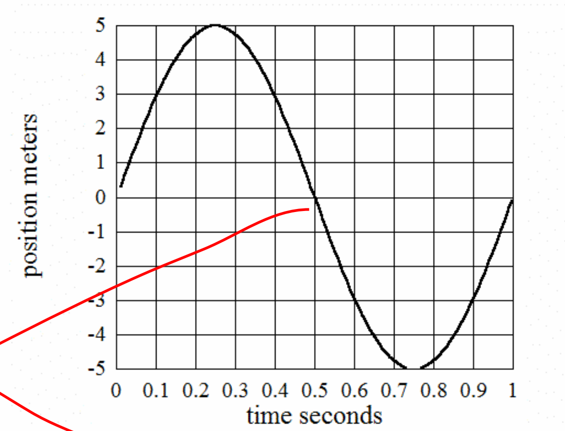
**MC2:** *multiple-choice-two-answer questions, each worth 2 points.*
**No partial credit.**

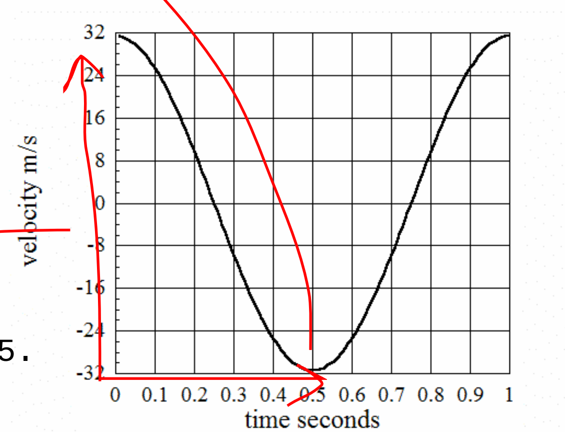
(a) If you mark only one answer and it is the correct answer, you earn **2** points.
(b) If you mark the wrong answer or neither answer, you earn **0** points.

*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.*

***The following 3 questions concern the same physical situation:***

The position vs time and velocity vs time diagrams for a block on a surface are shown at right.




1. What is the instantaneous velocity at t = 0.5 seconds?

a. 31.4 m/s
b. □31.4 m/s
c. 0 m/s
d. 5 m/s
e. □5 m/s

2. What is the average velocity between t = 0 and t = 0.5 seconds?

a. 31.4 m/s
b. □31.4 m/s
c. 0 m/s
d. 5 m/s
e. □5 m/s

3. What is the average acceleration between t = 0 and t = 0.5?

a. 126 m/s$^2$
b. □126 m/s$^2$
c. 0 m/s$^2$
d. 31.4 m/s$^2$
e. □31.4 m/s$^2$

close to -64/0.5.

4. A man riding in an elevator measures his weight to be 750N. His mass is 90kg. If the y direction is up, then the y component of the acceleration of the elevator is

a. 9.8 m/s$^2$
b. □9.8 m/s$^2$
c. 0 m/s$^2$
d. 1.5 m/s$^2$
e. □1.5 m/s$^2$

M (g + a) = 750, so g + a = 8.33 m/s^2.
That is a = -1.5 m/s^2.

What is this question about?

5. A diver is in free fall from the moment she leaves a diving board until she hits the water 3m below. She steps very, very slowly off the end of the board, so that her initial velocity is zero when she steps off the board. Her speed when she hits the water is

a. 9.2 m/s
b. 7.7 m/s
c. 6.6 m/s
d. 3.0 m/s
e. 2.2 m/s

Use v^2 = v_0^2 + 2 a \Delta y, where v_0 = 0, a = -g = -9.8, and \Delta y = -3 (upward +)
v^2 = 2 x 9.8 x 3 , so v = 7.668 m/s.
[If you know conservation of energy, the decrease of the potential energy mgh must be her final kinetic energy (1/2) mv^2, so v^2 = 2gh, or v = \sqrt{2gh} = 7.668.]

6. At the moment a car enters an intersection it is moving at 10m/s. Because the driver sees the light turning yellow, she is accelerating forward at a constant $2m/s^2$. It takes her 1.2s to cross the intersection. How wide is the intersection?

a. 5.1 m
b. 7.9 m
c. 11.7 m
d. 12.9 m
e. 13.4 m

x = x_0 + v_0 t + (1/2) a t^2, where x_0 = 0, v_0 = 10, and a = 2, t = 1.2, so
x = 12 + 1.2^2 = 13.4 m

What are the key points?

***The following two problems concern similar physical situations.***

7. A train is braking from an initial speed of 100 m/s. The train is braking hard, so the wheels are sliding over the rails. The coefficient of kinetic friction between the rail cars and the rails is $\mu_k = 0.1$. How long will it take the train to stop?

a. 10 s
b. 23 s
c. 37 s
d. 43 s
e. 102 s

Let M be the mass of the train. Then, the normal force to support the train is Mg, so the kinetic friction force is \mu_kMg. The Newton's second law says Ma = - \mu_kMg.
Therefore, a = - \mu_k g .
v = v_0 + at = 0, so t = 100/\mu_kg = 102.0 s.

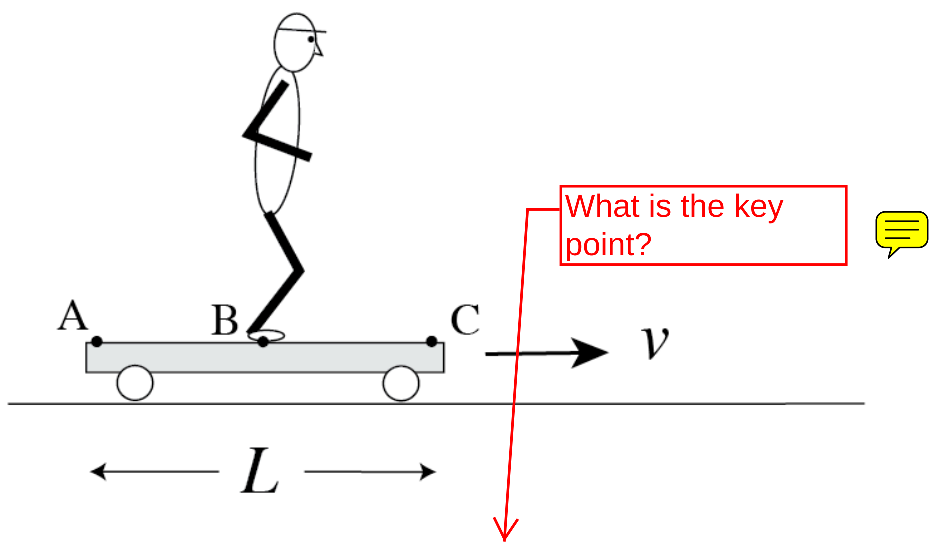
8. A train with 10 identical cars is moving forward and applies its brakes. Suppose the brakes fail on all but the first (leading) car. How does the magnitude of the force exerted by the first car on the second car $F_{1-2}$ compare to the force exerted by the 9th car on the 10th car $F_{9-10}$?

a. $F_{1-2} = F_{9-10}$
b. $F_{1-2} = 9 F_{9-10}$
c. $F_{1-2} = 10 F_{9-10}$

The first car must supply the needed force for all the remaining 9 cars. The 9th car has only to supply the force needed by the 10th car. All the accelerations of the cars are the same, so b must be the answer.

***The following 2 questions concern related physical situations:***

Bob is standing on the floor of a cart that is moving horizontally at a constant speed $v = 3$ m/s. Ignore air resistance. The length of the cart $L = 2$ m and he is at the center point B of the cart.




9. Bob jumps straight up relative to the coordinate system of the moving cart with an initial speed of 4m/s. What is the maximum distance between his foot and the cart floor? You may assume that his feet and other body parts move rigidly together.

a. 0.35 m
b. 0.57 m
c. 0.64 m
d. 0.82 m
e. 0.97 m

```
v^2 = v_0^2 - 2 g h, so 4^2 = 2gh,
or h = 0.816 m.
```

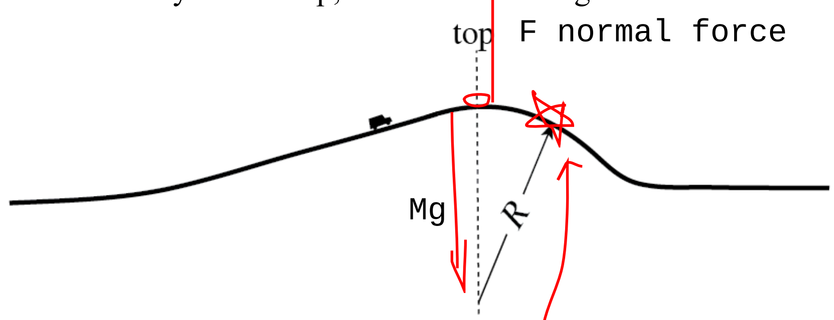
10. When he lands on the cart floor, near which point does he land?

a. A
b. B
c. C

```
The horizontal speed must be intact.
```

***The following 3 questions concern the same physical situation:***

Suppose you are driving over a hill at constant speed v. The hill is roughly circular very close to and beyond the top, as shown in the figure.




Thus, this is a circular motion problem. What are the key points?

11. If your mass is M, what relation does the magnitude of your apparent weight (i.e., the normal force F exerted on you by the car seat) have to the gravitational force on you as you drive over the top of the hill?

a. $F = Mg + Mv^2/R$
b. $F = Mg$
c. $F = Mg - Mv^2/R$

The centripetal acceleration obeys

M v^2/R = Mg - F.

Therefore, F = Mg - Mv^2/R.

12. The car has not jumped off the ground at the top (the highest point) of the hill. Is it possible for the car to jump off the road subsequently before it reaches the foot of the hill? You may assume that the speed of the car is constant.

a. Yes.
b. No.

If F is zero or negative, the car \`takes' off.
Say, at the \`star' in the above figure, Mg must be replaced by Mg sin some angle < Mg, so F is easier to be negative.

13. If the speed of your car is 65 miles per hour, your car takes off the ground at the top (the highest point) of the hill. This does not happen if the speed of your car is 60 miles per hour. What can you say about the radius of the hill R? (1 mile = 1.6 km)

a. R is approximately 100 m.
b. R is approximately 80 m.
c. R is approximately 60 m.

According to the above formula, the critical R is (R smaller than this is needed to take off the ground)

R = v^2/g.

For 65 miles/hr R = 28.8^2/9.8 = 85.1 m,
For 60 miles/hr R = 26.7^2/9.8 = 72.6 m.
That is, between 85 m and 73 m.

***The following 2 questions concern the same physical situation***

Audio CD players read the data on the disc at a constant linear speed and thus must vary the disc's rotational speed as the reading position moves from the inner edge to the outer edge. The radius of the innermost track is 25 mm and the rotational speed of the disk when the innermost track is read is 8 turns per second.

What is this question about?

14. What is the required angular speed of the disk when the outermost track, whose radius is 58 mm, is read at the same rate as the innermost track?

a. 18.7 rad/s
b. 21.7 rad/s
c. 24.7 rad/s
d. 28.7 rad/s
e. 35.7 rad/s

```
inner 25 mm 16\pi rad/s
outer 58 mm to have the same linear speed (tangential
     speed) 16 \pi 25/58 = 21.66 rad/s.
```

What is this question about?

15. You decide to stop listening to the music when the rotational speed is 40 rad/s, and the disk stops after 11 complete revolutions. What is the magnitude of the average angular acceleration?

a. 7.60 rad/s$^2$
b. 9.70 rad/s$^2$
c. 11.6 rad/s$^2$
d. 13.0 rad/s$^2$
e. 15.6 rad/s$^2$

```
Use omega^2 = omega_0^2 + 2 \a  Delta theta.
Here, omega = 0 (eventually stops), omega_0 =
40 rad/s, Delta theta = 11 x 2\pi.
Therefore,
     \a = -40^2/44\pi = 11.57 rad/s^2.
```

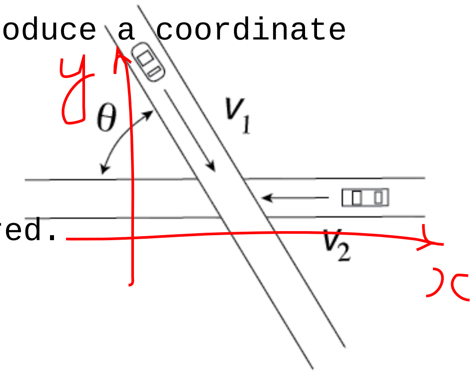
What is the essential point of the question?

16. Two cars are approaching a crossing as shown in the figure. The speed $v_1$ of the car 1 is 15m/s and the speed $v_2$ of the second car is 25 m/s. The angle  between the two roads is 54 degrees. What is the relative speed of the two cars?

The easiest way is to introduce a coordinate system and write the velocities in vectors:

I choose the coordinate system in the figure in red.

a. 28.2 m/s
b. 32.5 m/s
c. 34.1 m/s
d. 35.9 m/s
e. 40.0 m/s




```
v_1 = 15(cos 54, -sin 54)
     = (8.817, -12.14),
v_2 = (-25, 0).
Therefore, the relative velocity is
v_1 - v_2 = (33.817, 12.14), so the relative speed is its magnitude:
     |v_1 - v_2| =\sqrt{33.817^2 + 12.14^2} = 35.93 m/s
```

17. If all the external forces on an object sum to zero, then which of the following is true?

a. The object must stand still (cannot be moving).
b. The object will have a constant velocity.
c. It is possible that the object may accelerate.

Newton's second law tells us that acceleration is zero.
That is, the velocity does not change.

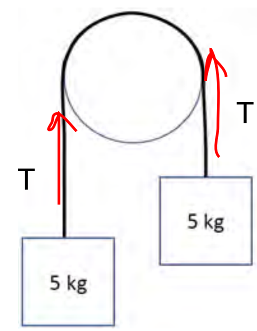
[Actually, the total momentum is constant.]

18. Two wooden blocks are hooked together and sit on a flat surface with friction. Which of the following statements regarding the forces exerted by each block on the other through the hooks is true?

a. If one block is pulling the other, then the pulling block exerts a greater force.
b. The forces are zero if the blocks are not moving.
c. The forces are equal in magnitude and opposite in direction.

This is just Newton's third law.

19. The figure to the right represents a frictionless, massless pulley with two 5kg blocks hanging from a massless string. The only forces acting on the blocks are gravity and the tension of the string. The total tension in the string is



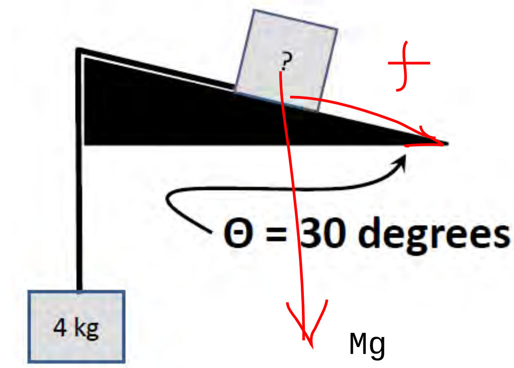

a. approximately 49 N.
b. approximately 99 N.
c. approximately 198 N.
d. zero, because the masses are not moving.
e. None of the above.

T = Mg, or 5g = 49 N.

20. To the right is a diagram of a 4 kg weight hanging from a massless string. The weight is connected to a mass sitting on an inclined plane. There is no friction between the string and the inclined plane. The coefficient of static friction between the mass and the inclined plane is 0.35. What is the <u>minimum</u> mass of the block such that there is no movement of the mass up the inclined plane?

What are the key points of this question?

a. 3 kg
b. 5 kg
c. 8 kg
d. 10 kg
e. 13kg




In the case of minimum mass, friction force f points in the direction in the figure, whose magnitude is the max possible value \mu Mg cos 30.

normal force

The total force along the inclined surface on `?' is

$$4g - f - Mg \sin 30 = 4g - Mg (\mu \cos 30 + \sin 30).$$

Therefore,

$$M = 4/(\mu \cos 30 + \sin 30) = 4.98 \text{ kg}.$$

What is the principle we need?

21. A car is pulling a trailer that has a mass of 5000 kg. The trailer is connected to the car with a rope. The driver knows that the rope will break if a tension of 10000 N is applied. What is the largest possible acceleration of the car without breaking the rope? Assume no frictional forces on the trailer.

a. 0.05 $m/s^2$
b. 0.2 $m/s^2$
c. 2 $m/s^2$
d. 20 $m/s^2$
e. 50 $m/s^2$

T = Ma, where M is the mass of the trailer.
T cannot be larger than 10,000 N.

$$T = Ma < 10000,$$

so

$$a < 10000/5000 = 2 \text{ m/s}^2.$$

***The following 3 questions concern the same physical situation:***

22. A block of wood is pulled on a flat surface with a horizontal force $F_1$ at steady velocity of $V_1$. There is friction between the block and the surface. Now another block of wood (identical) is added on top of the original block. With what force, $F_2$, must one pull so that the stacked blocks travel at a constant velocity?

a. $F_2 = F_1$
b. $F_2 = 2F_1$
c. $F_2 = F_1/2$
d. One cannot tell without knowing the value of the frictional coefficient of kinetic friction.
e. One cannot pull a block at constant velocity on the surface with a constant force; it will always accelerate.

The normal force doubles, so the friction force also doubles.

23. Is it possible to pull the original block at a constant velocity $V_2$, which is different than $V_1$, on the same surface with the force $F_1$ of the above problem?

a. Yes.
b. No.

Because the friction force is independent of V.

It is a good occasion to review Disk 4 summary (Discussion Problems p43)

24. Assume that the coefficient of static friction is larger than the coefficient of kinetic friction. Also assume that the block is pulled with the original force $F_1$, and is traveling at the original velocity $V_1$. The force $F_1$ is removed, and the block comes to rest. If one again applies the same force $F_1$ to the standing block, then

a. The block moves.
b. The block does not move.

F_1 is \mu_k Mg, which is definitely smaller than the max possible static friction force \mu_s Mg that is needed to initiate motion.

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