

Name: _____

TA: _____

The next 3 pages of this exam have 10 multiple choice questions. For these, choose the best answer of the choices given.

The remaining 5 pages contain 5 show work problems. **All work must be shown** for you to receive full credit.

The final page is an equation sheet which you may remove and use during the exam.

You have 1 hour and 48 minutes to complete this exam. Calculators are allowed, but no additional equation sheets or any other material may be used.

WRITE YOUR NAME ON EACH PAGE OF THIS EXAM!

Good luck.

Name: _____

TA: _____

Multiple Choice. Each question is worth 5 points. Choose the best answer.

1) If a certain car, going with speed v_1 , rounds a level curve with a radius R_1 , it is just on the verge of skidding. If its speed is now doubled, the radius of the tightest curve on the same road that it can round without skidding is:

- A) $2R_1$
- B) $4R_1$
- C) $R_1/2$
- D) $R_1/4$
- E) R_1

2) Two objects, one having three times the mass of the other, are dropped from rest at the same height in a vacuum on the earth. At the end of their fall, their velocities are equal because:

- A) anything falling in vacuum has constant velocity
- B) the acceleration of the larger object is three times greater than that of the smaller object
- C) the force of gravity is the same for both objects
- D) their accelerations are the same
- E) all objects reach the same terminal velocity

3) The amount of work required to stop a moving object is equal to the:

- A) velocity of the object
- B) kinetic energy of the object
- C) mass of the object times its acceleration
- D) mass of the object times its velocity
- E) square of the velocity of the object

4) A coin is placed on a horizontal phonograph turntable. Let N be the normal force exerted by the turntable on the coin, f be the frictional force exerted by the turntable on the coin, and f_s, \max be the maximum force of the static friction. The speed of the turntable is increased in small steps. If the coin does not slide, then

- A) N increases, f increases, and f_s, \max stays the same
- B) N increases, f increases, and f_s, \max increases
- C) N , f , and f_s, \max all stay the same
- D) N , f , and f_s, \max all increase
- E) f increases and both N and f_s, \max stay the same

Name: _____

TA: _____

Multiple Choice Continued. Each question is worth 5 points. Choose the best answer.

5) A disk is free to rotate on a fixed axis. A force of given magnitude F , in the plane of the disk, is to be applied. Of the following alternatives the greatest angular acceleration is obtained if the force is:

- A) applied tangentially halfway between the axis and the rim
- B) applied tangentially at the rim
- C) applied radially halfway between the axis and the rim
- D) applied radially at the rim
- E) applied at the rim but neither radially nor tangentially

6) Two identical carts travel at 1 m/s on a common surface. They collide head-on and are reported to rebound, each with a speed of 2 m/s. Then:

- A) momentum was not conserved, therefore the report must be false
- B) if some other form of energy were changed to kinetic during the collision, the report could be true
- C) if the collision were elastic, the report could be true
- D) if the surface were inclined, the report could be true
- E) if the duration of the collision were short enough, the report could be true

7) Two bodies of unequal mass, placed at rest on a frictionless surface, are acted on by equal horizontal forces for equal times. Just after these forces are removed, the body of greater mass will have:

- A) the greater speed
- B) the greater acceleration
- C) the smaller momentum
- D) the greater momentum
- E) the same momentum as the other body

8) A sphere and a cylinder of equal mass and radius are simultaneously released from rest on the same inclined plane. Then:

- A) the sphere reaches the bottom first because it has the greater inertia
- B) the cylinder reaches the bottom first because it picks up more rotational energy
- C) the sphere reaches the bottom first because it picks up more rotational energy
- D) they reach the bottom together
- E) none of the above is true

Name: _____

TA: _____

Multiple Choice Continued. Each question is worth 5 points. Choose the best answer.

9) A man, with his arms at his sides, is spinning on a light frictionless turntable. When he extends his arms:

- A) his angular velocity increases
- B) his angular velocity remains the same
- C) his rotational inertia decreases
- D) his rotational kinetic energy increases
- E) his angular momentum remains the same

10) A phonograph record is dropped onto a freely spinning turntable. Then:

- A) neither angular momentum nor mechanical energy is conserved because of the frictional forces between record and turntable
- B) the frictional force between record and turntable increases the total angular momentum
- C) the frictional force between record and turntable decreases the total angular momentum
- D) the total angular momentum remains constant
- E) the sum of the angular momentum and rotational kinetic energy remains constant

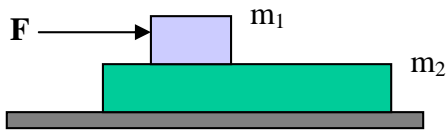
Name: _____

TA: _____

SHOW WORK PROBLEMS. ALL WORK MUST BE SHOWN TO RECEIVE ALL CREDIT. EACH QUESTION IS WORTH A TOTAL OF 30 POINTS.

1) In the figure below, mass 2 is a 50.0kg slab on a frictionless floor. Mass 1 (=15.0kg) is on top of mass 2, and the coefficients of static and kinetic friction between these two surfaces is $\mu_s=0.60$ and $\mu_k=0.40$. A force $F=150.0\text{N}$ is applied to mass 1 as shown.

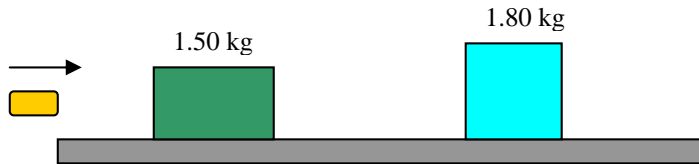
- What is the maximum force of static friction between the two boxes? (5 points)
- What is the acceleration of block 1? (15 points)
- What is the acceleration of block 2? (10 points)



Name: _____

TA: _____

- 2) A bullet of mass 2.80g is fired horizontally at two blocks at rest on a frictionless tabletop. The bullet passes through the first block, with mass 1.50kg, and embeds itself in the second, with mass 1.80 kg. As a result, the 1.50 kg block attains a speed of 0.550m/s, and the 1.80kg block (with the bullet inside) attains a speed of 1.10m/s.
- What is the speed of the bullet immediately after it emerges from the 1.50kg block? (15 points)
 - What is the original speed of the bullet? (10 points)
 - Is kinetic energy conserved in this situation? (5 points)



Name: _____

TA: _____

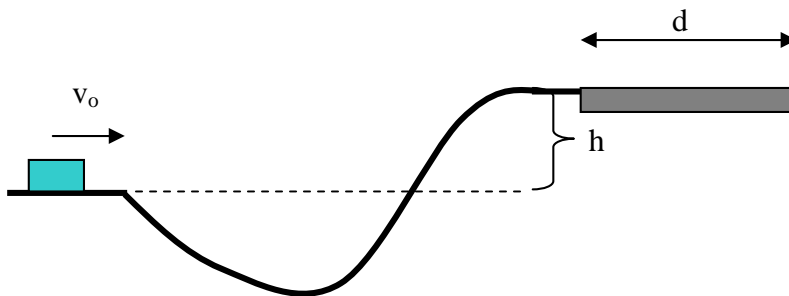
- 3) A yo-yo has a moment of inertia I (about its center of mass) , mass m , and axis radius R . A string of length L is wrapped around the axis. A person holds the end of the string, and lets go, while keeping her hand fixed. Assume the string does not slip on the axis.
- What is the linear acceleration of the yo-yo center of mass, as it falls? (15 points)
 - Using energy considerations, determine the linear speed of the yo-yo center of mass, just before it reaches the end of the string. (10 points)
 - What is the angular momentum of the yo-yo about its center of mass, right before it reaches the end of the string? Is angular momentum conserved in this problem, and why or why not? (5 points)

Name: _____

TA: _____

4) In the picture below, the block has an initial speed of $v_0 = 7.0\text{m/s}$. It slides over a frictionless surface from one level to a higher level, going through an intermediate valley. The track is frictionless until after the block reaches the higher level. There a frictional force stops the block in a distance d . The coefficient of kinetic friction μ between the block and the surface in this region is 0.5. The height difference between the two levels is 0.85m.

- What is the speed of the block just before it enters the friction region on the higher level? (15 points)
- What is the distance d ? (15 points)

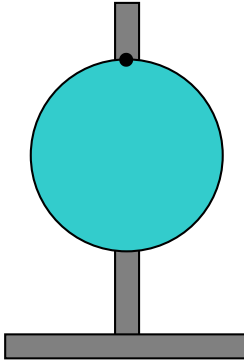


Name: _____

TA: _____

5) A uniform thin disk of mass M and radius R is suspended freely from a point on its edge as shown below. The disk is then pulled to one side and allowed to swing like a pendulum, its center of mass passing through its lowest point with a linear speed v . Neglecting friction and air resistance. The moment of inertia of a thin disk rotated about its center of mass is $I = (1/2)MR^2$.

- What is the disk's kinetic energy at its lowest position? (10 points)
- How far above the lowest position does the center of mass of the disk rise? (20 points)



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