PHY2053 General Physics I

Section 584771

Prof. Douglas H. Laurence

Exam 2 (Chapters 7 – 11)

March 27, 2018

Name: ______________________________

Instructions:

This exam is composed of **10 multiple choice questions** and **5 free-response problems**. To receive a perfect score (100) on this exam, 4 of the 5 free-response problems must be completed. The fifth free-response problem **may <u>not</u> be answered for extra credit**. Each multiple choice question is worth 2 points, for a total of 20 points, and each free-response problem is worth 20 points, for a total of 80 points. This means that your exam will be scored out of 100 total points, which will be presented in the rubric below. **Please do not write in the rubric below; it is for grading purposes only.**

Only scientific calculators are allowed – do not use any graphing or programmable calculators.

For multiple choice questions, no work must be shown to justify your answer and no partial credit will be given for any work. However, for the free response questions, **work must be shown to justify your answers.** The clearer the logic and presentation of your work, the easier it will be for the instructor to follow your logic and assign partial credit accordingly.

The exam begins on the next page. **The formula sheet is attached to the end of the exam.**

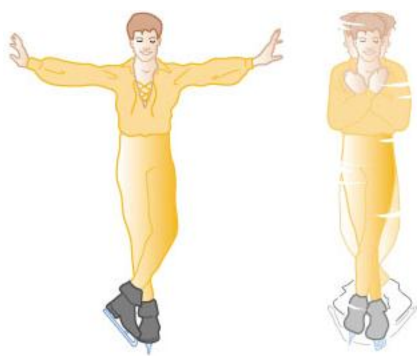
Exam Grade:

Multiple Choice	
Problem 1	
Problem 2	
Problem 3	
Problem 4	
Problem 5	
Total	

MULTIPLE CHOICE QUESTIONS

1. The condition for energy conservation is that:
   (a) There must only be conservative forces acting on a system
   (b) There must only be non-conservative forces acting on a system
   (c) The work due to all conservative forces must be zero
   (d) The work due to all non-conservative forces must be zero

2. Gravity causes the Moon to orbit the Earth at a constant speed of about 1 km/s. If the orbit has a radius of 385,000 km, how much work is done on the Moon by gravity every orbit?
   (a) 0 J
   (b) 100J
   (c) 200J
   (d) 300J



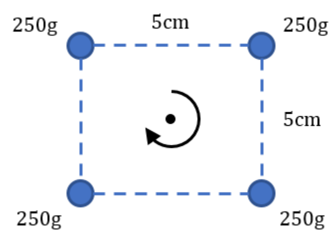
3. A spinning figure skater has his arms stretched outward. If he pulls his arms towards his sides, as shown in the figure above, which of the following statements is true?
   (a) His moment of inertia increases
   (b) His moment of inertia remains the same
   (c) His moment of inertia decreases
   (d) None of the above

4. On a dry, horizontal road, if you press the accelerator pedal in your car too hard while at rest, you will spin the wheels of your car, causing your car to skid forward (sometimes referred to as "peeling out"). If the radius of the car's wheel is R, how does the translational velocity of the wheel relate to its angular velocity?
   (a) $v > R\omega$
   (b) $v = R\omega$
   (c) $v < R\omega$
   (d) No general relationship exists

5. The condition for momentum conservation is that:
   (a) The net internal force must be zero
   (b) The net external force must be zero
   (c) The net force must be zero
   (d) The initial momentum must equal the final momentum

6. A 3000lb car, moving at 25mph to the east, collides with a 5000lb truck, moving at 10mph to the west. If the car and truck collide such that their wreckage moves as one lump of metal, in which direction will the wreckage move?

   (a) North
   (b) East
   (c) South
   (d) West



7. Four 250g masses are arranged in a square, with a 5cm side length, as shown in the figure above. What is the moment of inertia of these masses, if they rotate about an axis through the center of the square?

   (a) 0.00063 kgm^2
   (b) 0.00125 kgm^2
   (c) 0.00200 kgm^2
   (d) 0.00250 kgm^2

8. A cylinder rolls without slipping down an incline. The force responsible for causing the rotation of the cylinder is:

   (a) Gravity
   (b) The normal force
   (c) Static friction
   (d) Kinetic friction

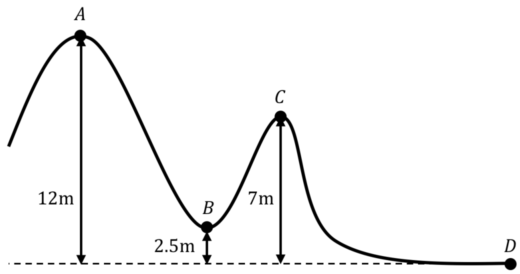
9. A box is pushed along a path of some length, causing friction to do work on the box. If the box were pushed along a path with a greater length, then:

   (a) Friction would do less work, because it is conservative
   (b) Friction would do less work, because it is non-conservative
   (c) Friction would do more work, because it is conservative
   (d) Friction would do more work, because it is non-conservative

10. A 350g meter-stick is balanced with a fulcrum placed at the 70cm mark. The moment of inertia of this meter stick is:

   (a) 0.029 kgm^2
   (b) 0.043 kgm^2
   (c) 0.057 kgm^2
   (d) 0.117 kgm^2

FREE-RESPONSE PROBLEMS



1. Consider the roller coaster shown in the figure above. People ride the coaster in a 600kg cart that can carry 500kg of passengers. Unless stated otherwise, assume that the cart moves along the track without friction.

a) If the cart drops from A at rest, what is its speed at B?

b) What would the speed of the cart be at C?

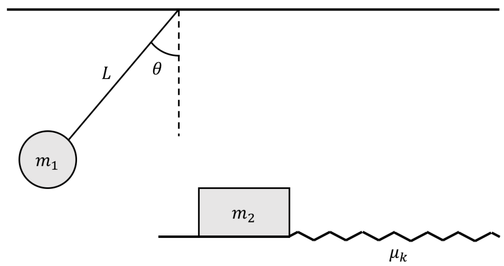
c) If the cart needed to arrive at D at rest, and there was some sort of braking mechanism between C and D, how much work would the brakes need to do on the cart so that the cart arrives at D at rest?

2. A 1700kg car moving at 15 m/s hits a 2500kg truck moving at 10 m/s in the same direction.

   a) If the collision was elastic, what would the final speed and direction of the car be?

   b) What would the final speed and direction of the truck be?

   c) If, instead, the bumpers of the car and the truck are tangled by the collision, so they can't be separated, what is the speed and direction of the car/truck wreckage?



3. A pendulum of length $L = 22$cm, with a mass $m_1 = 0.85$kg attached at the end, is released from an angle of $\theta = 25^o$ measured from the vertical axis, as shown in the above figure. The pendulum hits a block of wood, of mass $m_2 = 1.65$kg, which then slides along a horizontal surface with a coefficient of kinetic friction of $\mu_k = 0.3$ until coming to rest once again.

a) At what speed does the pendulum's mass hits the block of wood?

b) If the pendulum collides elastically with the block of wood, what speed does the block of wood begin moving at once it's hit by the pendulum?

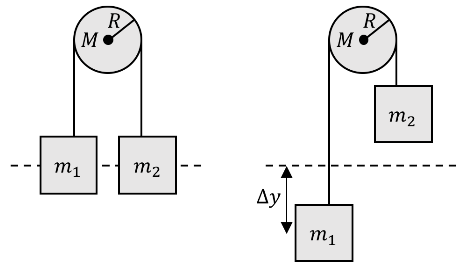
c) What is the distance traveled by the block of wood along the horizontal surface before it comes to rest again?

4. Consider a solid wheel rotating about an axis through its center, with a mass of 12kg and a radius of 45cm. Starting from rest, the wheel is accelerated to a rotational speed of 18.5 rad/s in 4.7s.

a) What torque is required to accelerate the wheel?

b) How much kinetic energy is gained by the wheel during this time?

c) A brake is applied to the wheel, stopping it in 2 revolutions. How much work is done by this brake during the stopping of the wheel?



5. Consider two masses, $m_1 = 2.5$kg and $m_2 = 1.3$kg, attached to the ends of a light rope wrapped around a solid cylinder of mass $M = 0.5$kg and radius $R = 13.5$cm, as shown in the figure above. m_1 and m_2 are released from rest and allowed to move such that m_1 drops a distance $\Delta y = 75$cm. As the cylinder rotates, friction does -2J of work per revolution.

a) How much work, total, is done on the cylinder due to friction?

b) What is the final speed of m_1?

c) What is the final angular speed of the cylinder?

FORMULA SHEET

- Constants:

$$g = 9.8\text{m/s}^2$$

- Vectors:

$$\begin{aligned}\vec{A} \cdot \vec{B} &= AB\cos\theta \\ &= A_x B_x + A_y B_y + A_z B_z \\ \left|\vec{A} \times \vec{B}\right| &= AB\sin\theta\end{aligned}$$

- Kinematics:

$$\Delta x = v_0 t + \frac{1}{2}at^2$$

$$v = v_0 + at$$

$$v^2 = v_0^2 + 2a\Delta x$$

- Forces:

$$\sum \vec{F} = m\vec{a}$$

$$W = mg$$

$$f_{s,max} = \mu_s N$$

$$f_k = \mu_k N$$

- Work & Energy:

$$W = \vec{F} \cdot \Delta\vec{x}$$

$$W_{tot} = \Delta K$$

$$W_{cons} = -\Delta U$$

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

$$U_g = mgy$$

$$K_i + U_i + W_{nc} = K_f + U_f$$

- Momentum & Collisions:

$$\vec{p} = m\vec{v}$$

$$\sum \vec{F} = \frac{\Delta\vec{p}}{\Delta t}$$

$$m_1\vec{v}_{1i} + m_2\vec{v}_{2i} = m_1\vec{v}_{1f} + m_2\vec{v}_{2f}$$

$$\vec{v}_{1i} - \vec{v}_{2i} = \vec{v}_{2f} - \vec{v}_{1f}$$

- Rotational Mechanics

$$\Delta\theta = \omega_0 t + \frac{1}{2}\alpha t^2$$

$$\omega = \omega_0 + \alpha t$$

$$\omega^2 = \omega_0^2 + 2\alpha\Delta\theta$$

$$s = r\theta$$

$$v = r\omega$$

$$a = r\alpha$$

$$\tau = rF\sin\theta$$

$$\sum \tau = I\alpha \quad \text{or} \quad \sum \tau = \frac{\Delta L}{\Delta t}$$

$$K_{rot} = \frac{1}{2}I\omega^2$$

$$L = I\omega \quad \text{or} \quad L = rp$$

$$I_{new} = I_{cm} + md^2$$