

PHY2048 Physics with Calculus I

Section “B”, 606223

Prof. Douglas H. Laurence

Exam 3 (Chapters 9, 10, 17)

December 4, 2018

Name: _____

Instructions:

This exam is composed of **10 multiple choice questions** and **4 free-response problems**. To receive a perfect score (100) on this exam, 3 of the 4 free-response problems must be completed. The fifth free-response problem **may not be answered for extra credit**. Each multiple choice question is worth 2.5 points, for a total of 25 points, and each free-response problem is worth 25 points, for a total of 75 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	
Total	

MULTIPLE CHOICE QUESTIONS

1. A wheel spinning at 15 rad/s has a brake applied to it, stopping the wheel in 2 revolutions. What angular acceleration did the brake apply on the wheel?
 - (a) -0.60 rad/s
 - (b) -8.95 rad/s
 - (c) -17.9 rad/s
 - (d) -56.2 rad/s

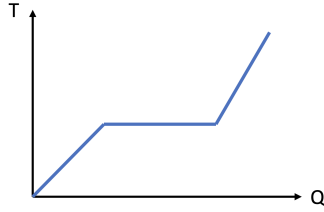
2. A hollow sphere, a solid cylinder, and a hollow cylinder are all released from rest at the top of a ramp. Which object reaches the bottom of the ramp first?
 - (a) The hollow sphere
 - (b) The solid cylinder
 - (c) The hollow cylinder
 - (d) They all reach the bottom of the ramp at the same time

3. What is the formula for the moment of inertia of a hollow cylinder rotating about an axis at its edge?
 - (a) $I = \frac{1}{2}MR^2$
 - (b) $I = MR^2$
 - (c) $I = \frac{3}{2}MR^2$
 - (d) $I = 2MR^2$

4. A meter stick is held such that it rotates at its end. If the meter stick has a mass of 100g, how much torque does gravity produce?
 - (a) 0 Nm
 - (b) 0.5 Nm
 - (c) 0.75 Nm
 - (d) 1 Nm

5. A wheel is placed at the top of an incline. What force acting on the wheel produces the torque responsible for rolling the wheel down the incline?
 - (a) Gravity
 - (b) Friction
 - (c) The normal force
 - (d) It depends on which point on the wheel you consider to be the axis

6. An ice skater with her hands pulled in towards her body is going to have a smaller moment of inertia than with her hands outstretched.
 - (a) True
 - (b) False

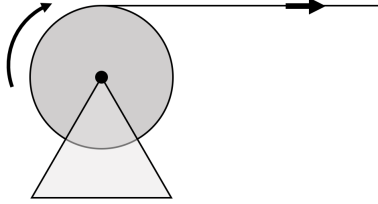


7. The above figure shows a graph of temperature versus heat added to a substance. The flat part of the graph represents the:
- Specific heat
 - Heat capacity
 - Latent heat
 - None of the above
8. A 7.5m rod expands by 1.5mm when the temperature is increased from 17°C to 67°C . What is the coefficient of linear thermal expansion for the rod?
- $3.0 \times 10^{-6} \text{ K}^{-1}$
 - $4.0 \times 10^{-6} \text{ K}^{-1}$
 - $1.2 \times 10^{-5} \text{ K}^{-1}$
 - $4.0 \times 10^{-3} \text{ K}^{-1}$
9. Placing a pot of cold water on top of a hot stove will bring the water to a boil. During this process, what mechanism of heat transfer heats up the water?
- Conduction
 - Convection
 - Radiation
 - None of the above
10. An aluminum pot, filled with water at 25°C , is placed on a stove top at 200°C . The base of the pot is circular, with a radius of 10cm and thickness of 1mm. How quickly is heat entering the water? Note that the thermal conductivity of aluminum is 217 W/mK and the thermal conductivity of water is 0.6 W/mK .
- $3.30 \times 10^3 \text{ J/s}$
 - $3.30 \times 10^5 \text{ J/s}$
 - $1.19 \times 10^6 \text{ J/s}$
 - $1.19 \times 10^7 \text{ J/s}$

FREE-RESPONSE PROBLEMS

1. A cyclist is riding her bicycle at 15 m/s when she applies the brakes, coming to a stop in 40m. Note that the radius of the bicycle's wheel is 17cm.

- a) What was the initial angular velocity of the wheel?
- b) What is the angular acceleration of the wheel during the breaking process?
- c) What is the linear acceleration of the bicycle during the breaking process?
- d) How long does it take the cyclist to stop?



2. A light string, wound tightly around a solid cylinder, is pulled with a force of 20N as shown in the figure above. The cylinder has a mass of 2.3kg and a radius of 15cm, and has a frictionless axle placed through its center to allow the cylinder to spin.

- a) What is the angular acceleration of the wheel?
- b) After the string is pulled 25cm, what is the angular velocity of the wheel?
- c) How much work was done on the wheel during the 25cm pull?

3. You want to heat 1.3kg of water, initially at 25°C , to 150°C . Note that for ice, $c = 2090 \text{ J/kgK}$, for water, $c = 4186 \text{ J/kgK}$, and for steam, $c = 2010 \text{ J/kgK}$, and that for freezing, $L = 335 \text{ kJ/kg}$, and for vaporization, $L = 2260 \text{ kJ/kg}$.

- a) Does the water undergo any phase changes during this heating process? If so, which phase change(s)?
- b) How much heat is required **only** to change the temperature of the water?
- c) How much heat is required to undergo any phase changes, if any are required?
- d) How much total heat is required to raise the temperature of the water to 150°C ?

4. A styrofoam cooler, with a width of 50cm, a height of 30cm, and a depth of 30cm, is filled with 500g of ice. The styrofoam throughout the cooler has a thickness of 2cm. Note that the thermal conductivity of styrofoam is 0.01 W/mK and the latent heat of melting for water is 335 kJ/kg. Throughout the entire problem, ignore any heat entering through the **bottom** of the cooler.

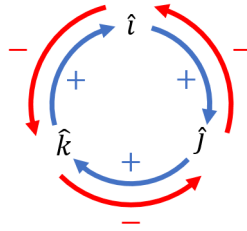
- a) If the air outside the cooler is 35°C , and the ice is at 0°C , at what rate is heat entering the cooler?
- b) How much heat would be required to melt the ice completely?
- c) How long would it take the ice to melt inside the cooler?

FORMULA SHEET

- Vectors:

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

$$|\vec{A} \times \vec{B}| = AB \sin \theta$$



- Kinematics:

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

$$\vec{v}_{av} = \frac{\Delta \vec{x}}{\Delta t}$$

$$\vec{a}_{av} = \frac{\Delta \vec{v}}{\Delta t}$$

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

$$v = v_0 + a t$$

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

- Forces:

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

$$W = m g$$

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

$$f_k = \mu_k N$$

- Work & Energy:

$$W = \vec{F} \cdot \Delta\vec{x} \quad \text{or} \quad W = \int \vec{F} \cdot d\vec{x}$$

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

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

$$W_{nc} = \Delta E$$

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

$$U_g = mgy$$

$$U_{sp} = \frac{1}{2}kx^2$$

$$K_i + U_i = K_f + U_f \quad (\text{energy conservation})$$

$$K_i + U_i + W_{nc} = K_f + U_f \quad (\text{general energy equation})$$

- Momentum & Collisions:

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

$$J = \Delta\vec{p} = \int \vec{F} dt \quad (\text{impulse})$$

$$\sum \vec{F} = \frac{d\vec{p}}{dt} \quad \text{or} \quad \sum \vec{F}_{av} = \frac{\Delta\vec{p}}{\Delta t}$$

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

$$m_1\vec{v}_{1i} + m_2\vec{v}_{2i} = (m_1 + m_2)\vec{v}_f \quad (\text{when objects stick together})$$

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