Name: ____

PHYS 1210-02 Exam 3

Standards 28–44

Calculators of any type are permitted. You may bring your own 8 ½" × 11"notes sheet, which may contain information on both sides.

Enter your answer inside the box provided by each question. Include units with all quantitative answers. Do not make stray marks in the box, and do not write your answer outside the box. It is a good idea to write your answers in pencil. If the question asks for a selection from provided options, fill the circle (○) by the most correct answer.

1. My grandfather had a pedal-driven grinding wheel that he used to sharpen tools like axes, splitting wedges, and mower blades. It was a uniform stone cylinder with a radius of 20 cm. Suppose Grandpa finishes grinding with the grinding wheel and allows it to slow down and stop on its own. He leaves it while it is rotating at a speed of 72.0 revolutions per minute, and it slows to a stop in 15.0 seconds. Assume that its angular acceleration is constant as it slows.

   A. What is the initial angular speed of the grinding wheel, in radians per second?

   B. What is the angular acceleration of the grinding wheel, in radians per second per second?

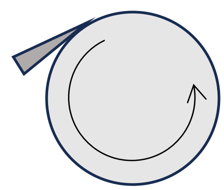
   C. How many revolutions does the grinding wheel complete as it slows to a stop?

   D. What is the average angular speed of the grinding wheel as it slows to a stop?

E. Grandpa's grinding wheel had a mass of 25.0 kilograms. What was its moment of inertia?

F. You have already determined the wheel's angular acceleration and its moment of inertia. What is the magnitude of the net torque that acted on it as it came to a stop?

Suppose that to sharpen an axe with the grinding wheel, Grandpa pressed the axe against the cylindrical rim of the wheel, which was turning at a rate of 72.0 revolutions per minute. The axe exerted a frictional force of 3.5 newtons on the wheel.



G. What torque did this apply to the grinding wheel?

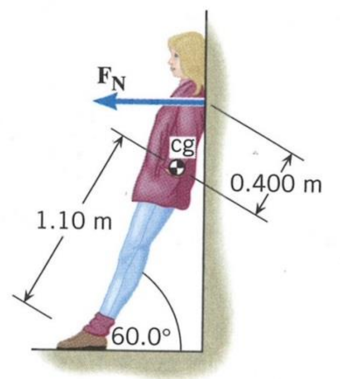
H. How much work did Grandpa have to do to maintain the wheel's speed for 36.0 revolutions?

2. While a physics teacher tries to replace a flat tire on his car with the tiny spare tire in the trunk, the spare tire begins to roll downhill without slipping. The spare tire has a mass of 13.8 kilograms, a radius of 0.210 meters, and a moment of inertia about its center of mass of 0.370 kg·m^2.

   A. When the tire is reaches a speed of 5.5 meters per second, what is its translational kinetic energy?

B. When the tire reaches a speed of 5.5 meters per second, what is its rotational kinetic energy?

3. A woman who weighs 500 N leans against a frictionless vertical wall, as the drawing shows. The distance from the bottom of her feet to her shoulders, which touch the wall, is 1.50 meters, and from the bottom of her feet to her center of gravity cg is 1.10 meters. The vector from where her feet touch the ground to where her shoulders rest against the wall is 60 degrees above horizontal.



A. What is the torque exerted by her weight about the point where her feet contact the ground? Don't forget to specify the direction and the units.

B. What is the lever arm of her weight about this axis?

C. What is the torque exerted by force $\mathbf{F}_N$ about the point where her feet contact the ground?

D. What is the lever arm of the force $\mathbf{F}_N$ about this axis?

E. What is the magnitude of the force $\mathbf{F}_N$?

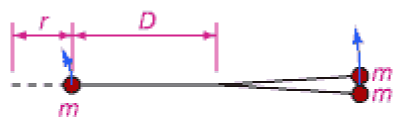
F. If the woman brings her feet closer to the wall, that is, if the angle shown becomes greater than its illustrated 60°, would the magnitude of force $\mathbf{F}_N$ increase or decrease?

○ a. increase. ○ b. decrease.

4. Argentine *gauchos* use a device known as *bolas* to hunt. The device consists of several weights at the ends of cords tied together in the middle. The gaucho throws the spinning bolas (the word appears to be self-plural, like "scissors" or "pants") at the animal, and the weights wrap around the animal's legs, immobilizing it.

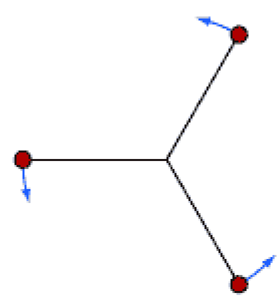
Archives of Pearson Scott Foresman, donated to the Wikimedia Foundation.

A conventional design (*boleadoras*) consists of three balls of mass *m* connected to a central knot by cords of length *D*. To throw the boleadoras, the gaucho holds one of the balls in his hand and swings it in a circle of radius *r* over his head. The other two balls move as far away from the handled ball as the cords allow, and travel in circular paths about the same center. In this configuration, the center of mass of the boleadoras is 2/3 *D* from the end with two balls, and 4/3 *D* from the end with a single ball.



A. When the boleadoras are in this configuration, what is their moment of inertia I_1 about their center of mass? Express in terms of *m* and *D*.

After the gaucho releases the boleadoras, the balls fan out into a more symmetrical configuration, with the three weights evenly distributed about the central knot.



B. What is the moment of inertia I_2 of the boleadoras about their center of mass in this new configuration?

Suppose that immediately after the gaucho releases them, the angular velocity of the spinning boleadoras in the initial configuration is ω_1.

C. What is the angular momentum of the spinning boleadoras in their initial configuration? Express in terms of m, D, and ω_1.

D. After they fan out to the more symmetrical configuration, what is the angular momentum of the spinning boleadoras? Express in terms of m, D, and ω_1.

E. After they fan out to the more symmetrical configuration, what is their angular velocity ω_2? Express in terms of m, D, and ω_1.

F. Is the rotational kinetic energy of the boleadoras conserved when they change their configuration?

○ a. Definitely, yes. ○ c. Maybe. ○ c. Absolutely not.

5. A mass m_1 on a Hooke's law spring is displaced a distance A from its equilibrium length and released, sending it into oscillation. At another time, a different mass m_2, where $m_2 > m_1$, is placed on the same spring, displaced the same distance A from equilibrium, and released. The following questions refer to the properties of the oscillation with the heavier mass m_2 as compared to the same properties of the oscillation with the lighter mass m_1.

A. How does the oscillation period compare?

○ a. The period with the heavier mass is longer than the period with the lighter mass.
○ b. The period with the heavier mass is shorter than the period with the lighter mass.
○ c. The period with the heavier mass is the same as the period with the lighter mass.

B. How does the maximum kinetic energy compare?

- ○ a. The maximum kinetic energy with the heavier mass is greater than the maximum kinetic energy with the lighter mass.
- ○ b. The maximum kinetic energy with the heavier mass is less than the maximum kinetic energy with the lighter mass.
- ○ c. The maximum kinetic energy with the heavier mass is the same as the maximum kinetic energy with the lighter mass.

C. How does the maximum speed compare?

- ○ a. The maximum speed of the heavier mass is faster than the maximum speed of the lighter mass.
- ○ b. The maximum speed of the heavier mass is slower than the maximum speed of the lighter mass.
- ○ c. The maximum speed of the heavier mass is the same as the maximum speed of the lighter mass.

D. How does the maximum net force on the mass compare?

- ○ a. The maximum force on the heavier mass is greater than the maximum force on the lighter mass.
- ○ b. The maximum force on the heavier mass is less than the maximum force on the lighter mass.
- ○ c. The maximum force on the heavier mass is the same as the maximum force on the lighter mass.

E. How does the maximum acceleration of the mass compare?

- ○ a. The maximum acceleration of the heavier mass is greater than the maximum acceleration of the lighter mass.
- ○ b. The maximum acceleration of the heavier mass is less than the maximum acceleration of the lighter mass.
- ○ c. The maximum acceleration of the heavier mass is the same as the maximum acceleration of the lighter mass

6. A simple pendulum has length $L = 0.200$ m and its bob has mass $m = 30$ g (0.030 kg). The bob is displaced from its equilibrium (straight down) position by a small angle $\theta_1 = 5.0°$ and released from rest, so that it swings back and forth.

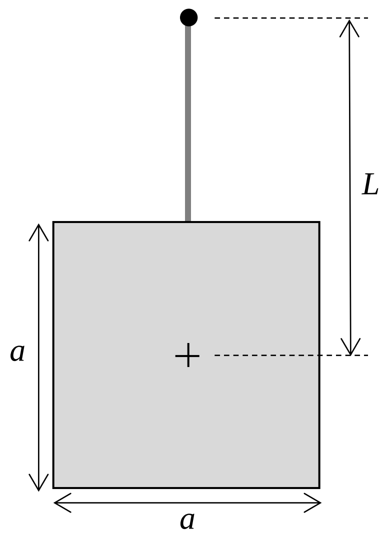
   A. What is the amplitude of its oscillation in radians?

   B. What is the angular speed of the bob at the bottom of its arc? Show your work.

   C. What is the kinetic energy of the bob at the bottom of its arc?

   D. How much time does it take for the pendulum to swing back to its point of release?

7. A particular physical pendulum consists of a bob with mass M, in the shape of a square with sides of length a. The center of mass of the bob is a distance L from the center of the pendulum's arc (the pendulum's axis). In terms of a, M, and L, write the formula for the pendulum's period of oscillation. Show your work.



8. The lowest note made by a guitar in standard tuning is E2, which has a frequency of 82.41 Hz. The guitar string is clamped at the "bridge" and the "nut;" the distance between these points is around 65.0 cm.

   A. E2 is the fundamental mode of vibration of this string. Sketch the motion of a guitar string as it vibrates in its fundamental mode.

   B. Is this wave transverse, or longitudinal?

   ○ a. transverse. ○ b. longitudinal.

   C. What is the wavelength of the wave?

   D. What is the propagation speed of the wave in the string?

   E. What is the angular frequency ω of this wave, in radians per second?

   F. What is the angular wavenumber k of this wave, in radians per meter?

   G. A typical tension of a guitar string is 65.0 newtons. What must the mass of the string be for its fundamental frequency to be 82.41 Hz at this tension?