Name: ____

PHYS 1210-02 Exam 3

Standards 29–45

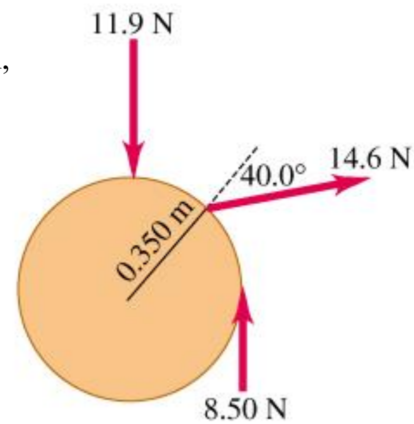
Calculators of any type are permitted. You may bring your own 8 ½" × 11"notes sheet, which may contain information on both sides, and a pool noodle. Each question is worth one point unless otherwise indicated.

Enter your answer to a free response question inside the box provided for the question. Include units with all quantitative answers. Do not make stray marks in the box, and do not write your answer outside the box. **Answers written outside the box will not be credited**. Show your work in the space provided with the question. It is a good idea to write your answers in pencil.

If the question asks for a single selection from provided options, **fill** the circle (○) by the most correct answer. If the question asks you to select all appropriate options, **fill** the squares (☐) by all correct options. Do not check, mark an "X," circle, or otherwise indicate your choices. If you want to revoke a choice, fully erase the mark.

Questions

1. Three forces are applied to a wheel of radius 0.350 m, as shown in the figure. One force is perpendicular to the rim, one is tangent to it, and the third one makes a 40° angle with the radius.



   A. What is the magnitude of the net torque on the wheel due to these three forces about an axis perpendicular to the wheel and passing through its center?

   B. What is the direction of the net torque on the wheel? (Tell me the direction of the torque vector, not "clockwise" or "counterclockwise.")

C. If the other two forces are kept the same, what magnitude would the force at 40° from the radius need to have to prevent the wheel from turning?

2. A playground merry-go-round has radius 2.30 m and moment of inertia 2400 kg·m^2 about a vertical axle through its center, and it turns with negligible friction. A child applies a 20.0 N force tangentially to the edge of the merry-go-round for 23.0 s.

A. If the merry-go-round was initially at rest, what is its angular speed after this push?

B. If the merry-go-round was initially at rest, through how many radians did it rotate during the push?

C. How much work does the child do on the merry-go-round?

3. Under some circumstances, a star can collapse into an extremely dense object made mostly of close-packed neutrons and consequently called a *neutron star*. The density of a neutron star is roughly 10^{14} times as great as that of ordinary solid matter. Suppose we represent the star as a uniform, solid, rigid sphere, both before and after the collapse. Before collapse, the star completed one rotation every 34 days. The star's initial radius was 7.0×10^{5} km (comparable to our sun); its final radius is 9.0 km. Assume that its mass of 2.0×10^{30} kg does not change during the collapse.

A. What is the initial moment of inertia of the star, before its collapse?

B. What is the final moment of inertia of the star, after its collapse?

C. What is the initial rotational kinetic energy of the star, before its collapse?

D. What is the initial angular momentum of the star, before its collapse?

E. What is the final angular momentum of the star, after its collapse?

F. Stars do not have uniform density: their central cores are much denser than their outer envelopes. Knowing that, is the moment of inertia you calculated in part A too *small*, or too *large*?

○ a. Too small. ○ b. Too large.

G. Knowing that a star's density increases toward the center, is the angular momentum you calculated in part D too *small*, or too *large*?

○ a. Too small. ○ b. Too large.

4. A glider of mass 0.400 kg is placed on a frictionless, horizontal air track. One end of a horizontal spring is attached to the glider, and the other end is attached to the end of the track. When released, the glider oscillates in simple harmonic motion with amplitude 2.0 cm and frequency 2.25 Hz.

A. What is the period of the oscillation, in seconds?

B. What is the angular frequency of the motion, in radians per second?

C. What is the force constant k of the spring, in newtons per meter?

D. What is the maximum speed of the glider, in meters per second?

E. What is the total mechanical energy of the oscillator?

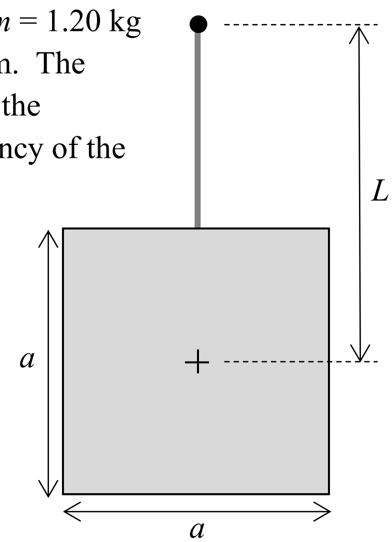
5. A simple pendulum consisting of a bob of mass m attached to a string of length L swings with a period T.

A. If the bob's mass is doubled, what will the pendulum's new period be? Express in terms of T.

B. If the length of the string is doubled, what will the pendulum's new period be? Express in terms of T.

C. If the pendulum is brought to the moon where the gravitational acceleration is about $g/6$, approximately what will its period be? Express in terms of T.

6. A physical pendulum is composed of a bob with mass $m = 1.20$ kg in the shape of a square with sides of length $a = 12.0$ cm. The center of mass of the bob is a distance $L = 9.0$ cm from the pendulum's axis. What is the natural oscillation frequency of the pendulum?



7. When the oscillation of the particles in a medium is parallel to the direction of the wave's motion, what type of wave is this?

   ○ a. transverse wave ○ b. longitudinal wave

8. One difference between the frequency *f* and the angular frequency ω is that *f* is measured in cycles per second or hertz (abbreviated Hz) whereas the units for ω are

   ○ a. meters per second ○ b. meters per radian

   ○ c. seconds per cycle ○ d. radians per second

9. What is the simplest relationship between the angular wavenumber *k* and just *one* of the other kinematic variables period *T*, wavelength λ, amplitude *A*, and frequency *f*?

10. A certain transverse wave is described by

$$y(x,t) = B\cos\left[2\pi\left(\frac{x}{L} - \frac{t}{\tau}\right)\right],$$

where $B = 6.10$ mm, $L = 27.0$ cm, and $\tau = 4.00\times10^{-2}$ s.

A. What is the wave's *amplitude*?

B. What is the wave's *wavelength*?

C. What is the wave's *frequency*?

D. What is the wave's *speed of propagation*?

E. What is the wave's *direction of propagation*?

○ a. $+x$ direction ○ b. $-x$ direction

11. With what tension must a rope with length 2.80 m and mass 0.150 kg be stretched for transverse waves of frequency 35.0 Hz to have a wavelength of 0.800 m?

12. A small source of sound waves emits uniformly in all directions. The total power output of the source is P. By what factor must P increase if the sound intensity level at a distance of 20.0 m from the source is to increase 7.00 dB?

13. A police car responding to a call travels east at 40.0 m/s with its siren emitting sound at a frequency of 1.20×10^3 Hz. The driver of an oncoming car traveling west toward the police car at 20.0 m/s hears the siren. The speed of sound is 342 m/s. What is the frequency of the sound that the driver of the approaching car hears?