Name: ____

PHYS 1110 Exam 3

Standards 31–46

Calculators of any type are permitted. A formula sheet is provided. There is not enough room on this test paper to work out your answers: using scratch paper is recommended and encouraged.

Enter your answer inside the box provided by each question. 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 (○) or square (☐) by the most correct answer. If the options for a question are preceded by circles, then mark only the one best answer. If the options are preceded by squares, select all correct answers.

1. A dynamics cart on a frictionless track overtakes and collides with another cart. The first cart has a mass of 250. g and an initial speed of 2.00 m/s. The second cart has a mass of 500. g and an initial speed of 0.50 m/s (in the same direction). What are the velocities of the two carts after the *elastic* collision?

   A. Final velocity of the 250-g cart [ ]

   B. Final velocity of the 500-g cart [ ]

2. Which of the following statements are true about an *elastic* collision? Mark all the statements that are true; leave unmarked all statements that are not true.

   ☐ a. Total kinetic energy is the same before and after the collision.

   ☐ b. Total momentum is the same before and after the collision.

   ☐ c. The relative speeds are the same before and after the collision.

   ☐ d. The objects have the same velocity before and after the collision.

   ☐ e. The velocity of the center of mass is the same before and after the collision.

3. In a class exercise, we found that a simple pendulum with a period of 2.0 seconds needs to be just about 1 meter long. How long would a simple pendulum need to be to have a period of one *minute*? [ ]

4. Which of the following statements are true about a totally inelastic collision? Mark all the statements that are true; leave unmarked all statements that are not true.

 ☐ a. Total kinetic energy is the same before and after the collision.

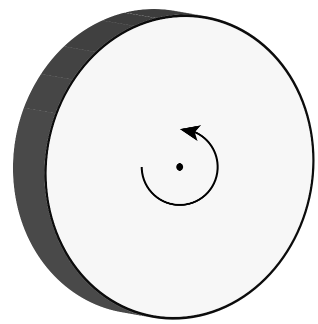
 ☐ b. Total momentum is the same before and after the collision.

 ☐ c. The relative speeds are the same before and after the collision.

 ☐ d. The objects have the same velocity before and after the collision.

 ☐ e. The velocity of the center of mass is the same before and after the collision.

5. My grandfather had a pedal-driven grinding stone that he used to sharpen tools like axes, splitting wedges, and mower blades. The grindstone was a solid stone cylinder of radius 20 cm and mass 25 kg with an axle through its center.



 A. What is the moment of inertia of the grinding stone? Don't forget the units.

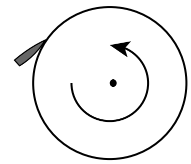
 B. If the stone rotates at a rate of 50.0 revolutions per minute, what is its angular speed in radians per second?

 C. What is the kinetic energy of the stone when it rotates at 50.0 rev/min?

 D. What constant angular acceleration would bring the stone from rest to an operating speed of 50.0 rev/min in 12.0 seconds?

 E. What constant torque would be required to bring the stone from rest to an operating speed of 50.0 rev/min in 12.0 seconds?

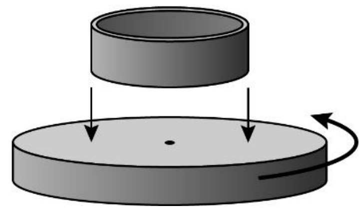
F. To sharpen a tool, my grandfather pressed the blade against the rim of the rotating grindstone, creating a tangential force on the stone of 15.0 N for 40.0 s. How much work, in joules, was required to maintain the rotation of the wheel at 50.0 rev/min during that time?



6. In an undergraduate physics laboratory experiment, a cylindrical rotor with moment of inertia $I_1 = 0.0144\ \text{kg}\cdot\text{m}^2$ rotates without power on a low-friction bearing at an angular speed of 12.0 rad/s.

A. What is the angular momentum of the spinning rotor?

As the rotor spins, a thick iron ring with moment of inertia $I_2 = 0.0096\ \text{kg}\cdot\text{m}^2$ is gently placed on top of it, with the principal axes of the rotor and ring aligned. The ring is not spinning initially, but it slips briefly until it catches and then rotates with the rotor.



B. What is true about this interaction between the ring and the spinning rotor? Mark all the statements that are true; leave unmarked all statements that are not true.

☐ a. The angular velocity of the rotor is the same after placing the ring as before.

☐ b. The total kinetic energy of the ring and rotor is the same after placing the ring as before.

☐ c. The total angular momentum of the rotor and ring is the same after placing the ring as before.

☐ d. The ring applies zero torque to the rotor when it is placed atop the rotor.

C. What is the final rotational speed of the rotor and ring together?

7. A 0.250-kg weight hanging from a spring oscillates up and down with a period of 1.50 seconds. The maximum speed of the weight in its oscillation is 0.5 meters per second.

   A. What is the amplitude of the oscillation?

   B. What is the spring constant of the spring?

   C. At what position in the oscillation is the weight's kinetic energy the highest?

      ○ a. At the top and bottom

      ○ b. At the middle

      ○ c. Same at both positions.

   D. What is the maximum kinetic energy of the weight in its oscillation?

   E. At what position in the oscillation is the potential energy of the spring the highest?

      ○ a. At the top and bottom

      ○ b. At the middle

      ○ c. Same at both positions.

   F. What is the maximum potential energy of the spring during the oscillation?

   G. At what position in the oscillation is the total mechanical energy of the system the highest?

      ○ a. At the top and bottom

      ○ b. At the middle

      ○ c. Same at both positions.

8. Kepler's third law of planetary motion, the *equal area law*, states that the area swept out by an imaginary line segment connecting the Sun and an orbiting planet is the same for all time intervals of equal duration. Which fundamental principle of physics is responsible for this law? (Chose one.)

   ○ a. Total angular momentum is conserved in all processes.

   ○ b. Entropy increases in all spontaneous processes.

   ○ c. Total energy is conserved in all processes.

   ○ d. Total momentum is conserved in all processes.

9. The Bosendorfer Model 290 Imperial grand piano has keys lower than the lowest note on a traditional grand piano, down to the note C_0, at a frequency of 16.3516 cycles per second. The length of the string corresponding to this note is about 2.10 meters, and the tension in the string is about 600 newtons.

   A. With a length of the string of 2.10 meters, the wavelength of the fundamental vibration of the string is 4.20 meters. What is the speed of this wave in the string?

   [ ]

   B. What is the mass of the string between the clamps at its ends? (There has to be some extra at the ends; tell what the mass is in its 2.10-meter length.)

   [ ]

   C. A piano makes a note by striking the side of a metal wire under tension with a felt hammer. What kind of wave does this produce?

      ○ a. A longitudinal wave.

      ○ b. A transverse wave.

      ○ c. A wave that is both longitudinal and transverse.

10. A violinist tunes to an oboe playing concert A at 440 cycles per second. The violinist can tell that her pitch is off, because she hears beats at about 3 cycles per second. She tightens her string a little and the beat frequency changes to 4 cycles per second. For her violin to play the same pitch as the oboe, what should she do?

    ○ a. She should tighten the string further.

    ○ b. She should loosen the string.

    ○ c. She doesn't yet have enough information to know which way to adjust the tension.

11. As a gentle prank, a student tosses a lit firecracker at his physics instructor. The firecracker explodes at a distance of r_1 from the instructor's ear. The student's ear is a distance of r_2 = 1.80 meters from the exploding firecracker.

A. The sound intensity (watts per square meter) at the instructor's ear is I_1. What is the sound intensity I_2 at the student's ear? Express in terms of I_1, r_1, and r_2.

B. The student's distance from the firecracker r_2 = 1.80 meters. He experiences a decibel level of 110 dB from the explosion. The instructor's distance from the explosion is r_1 = 0.30 meters. What is the decibel level at the instructor's ear?

12. The engineer of Train A, traveling at 38.0 meters per second, sees Train B approaching on a parallel track. She sounds Train A's whistle, which produces a tone with a frequency of 550 Hz. The speed of sound in air is 342 m/s.

A. How does the speed of Train A affect the frequency of the tone Train B's engineer hears?

- ○ a. The faster Train A travels, the lower the frequency that Train B's engineer hears.
- ○ b. The faster Train A travels, the higher the frequency that Train B's engineer hears.
- ○ c. Train A's speed does not affect the frequency that Train B's engineer hears.

B. How does the speed of Train B affect the frequency of the tone that its engineer hears?

- ○ a. The faster Train B travels, the lower the frequency that Train B's engineer hears.
- ○ b. The faster Train B travels, the higher the frequency that Train B's engineer hears.
- ○ c. Train B's speed does not affect the frequency that Train B's engineer hears.

C. The engineer in Train B hears the whistle at a frequency of 651.3 Hz. At what speed is Train B traveling?