

Name: \_\_\_\_\_

ID: \_\_\_\_\_

# Physics 202

## Final Exam

3/15/2022

Collaboration is not allowed. Allowed on your desk are: ten 8.5 x 11 inch doubled sided sheets of notes that are bound together, non-communicating graphing scientific calculator, 1 page of scratch paper, writing utensils, and the exam. You will have 110 minutes to complete this exam.

### Constants

$$k_B = 1.38 \times 10^{-23} \text{ J/K}$$

$$R = 8.31 \text{ J/mol}\cdot\text{K}$$

$$m_{\text{nitrogen}} = 4.65 \times 10^{-26} \text{ kg}$$

$$p_{\text{atm}} = 101,300 \text{ Pa}$$

$$1 \text{ cal} = 4.19 \text{ J}$$

$$1 \text{ liter} = 1 \times 10^{-3} \text{ m}^3,$$

$$c_{\text{water}} = 4190 \text{ J/kg}\cdot\text{K}$$

$$c_{\text{ice}} = 2090 \text{ J/kg}\cdot\text{K}$$

$$L_{f,\text{water}} = 3.33 \times 10^5 \text{ J/kg}$$

$$L_{v,\text{water}} = 22.6 \times 10^5 \text{ J/kg}$$

$$\sigma = 5.67 \times 10^{-8} \text{ W/m}^2\cdot\text{K}^4$$

$$\rho_{\text{air}} = 1.28 \text{ kg/m}^3$$

$$\rho_{\text{water}} = 1000 \text{ kg/m}^3$$

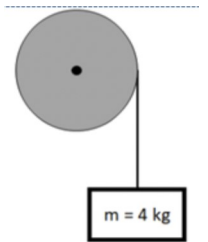
For questions 1 through 6 **fill in the square** next to all correct answers. A given problem may have more than one correct answer. Each correctly bubbled answer will receive two points. There are **9** correct answers in this section and only the first **9** filled in answers will be graded. There is no partial credit.

1. The O.H. Hinsdale Wave Research Laboratory at OSU can generate a large number of water wave types and configurations. In one experiment they send two waves traveling in opposite directions down a long channel. Both waves have the same amplitude and frequency. Which **one** of the following statements best describes the resulting phenomena?



- (a) This experiment generates a large wave pulse, consistent with the non-linear addition of wave theory.
  - (b) This experiment generates a standing wave, consistent with the linear superposition of waves theory.
  - (c) This experiment generates completely destructive wave interference everywhere in the channel, consistent with Riverton's addition of waves theory.
  - (d) This experiment generates completely constructive wave interference everywhere in the channel, consistent with the Nessian addition of waves theory.
2. Consider the sound intensity from a constant power spherical source. Which of the following statements are correct?
- (a) If you move to a distance twice as far from the source, the sound intensity will **double**.
  - (b) If you move to a distance twice as far from the source, the sound intensity will **half**.
  - (c) If you move to a distance twice as far from the source, the sound intensity will **quadruple**.
  - (d) If you move to a distance twice as far from the source, the sound intensity will be a **quarter** of what it was.
3. Consider the sound intensity level (dB) from a constant power spherical source. Which of the following statements are correct?
- (a) If the sound intensity level goes from 1 dB to 10 dB, the factor by which **sound intensity** changes is **less than 10**.
  - (b) If the sound intensity level goes from 1 dB to 10 dB, the factor by which **sound intensity** changes is **equal to 10**.
  - (c) If the sound intensity level goes from 1 dB to 10 dB, the factor by which **sound intensity** changes is **greater than 10**.

4. Which of the following situations describe a scenario where the entropy of the system decreases?
- (a) Jupiter has excess thermal energy, causing a storm more than three times the size of the Earth which radiates heat into the solar system. The system is our universe.
  - (b) A refrigerator cools a refreshing drink for after this exam. The system is the refreshing drink.
  - (c) Liquid water ( $H_2O$ ) changes phase directly from a solid (ice) to a gas (water vapor) in a process known as sublimation. The system is the  $H_2O$ .
5. Before your final exam, you have a nightmare of accurate physics. In your nightmare, a demented ice cream truck drives towards you at a high constant velocity, playing a constant tone. The truck passes you, then the truck slows down to a stop. Which of the following describe the frequency you hear compared to the frequency of the tone emitted by the truck?
- (a) While the truck is approaching you, the frequency you observe is **higher** than the emitted frequency.
  - (b) While the truck is approaching you, you observe the same frequency **that** is emitted.
  - (c) While the truck is approaching you, the frequency you observe is **lower** than the emitted frequency.
  - (d) While the truck is approaching you, the frequency you observe is **increasing**.
  - (e) While the truck is approaching you, the frequency you observe is **constant**.
  - (f) While the truck is approaching you, the frequency you observe is **decreasing**.
  - (g) After it has passed you, when the truck is slowing down, the frequency you observe is **increasing**.
  - (h) After it has passed you, when the truck is slowing down, the frequency you observe is **constant**.
  - (i) After it has passed you, when the truck is slowing down, the frequency you observe is **decreasing**.
6. A disk is able to freely rotate (negligible friction) around an axel fixed at a distance  $h$  above level ground. A light string wraps around the edge of the disk and connects to a box at the other end. The box starts from rest initially and falls downwards unraveling the string, spinning the disk. Which of the following statements are true during the time the box is falling towards the ground?

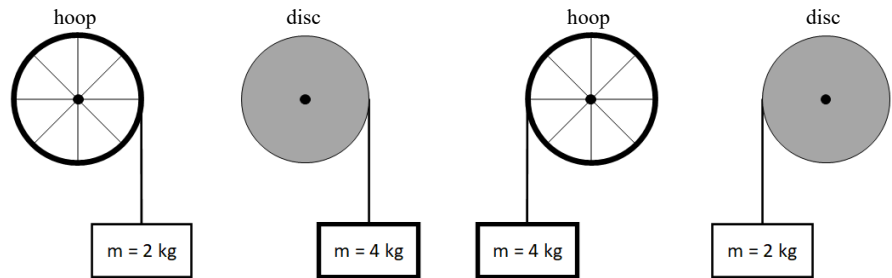


- (a) The rotational kinetic energy of the disk is **decreasing**.
- (b) The rotational kinetic energy of the disk is **increasing**.
- (c) The rotational kinetic energy of the disk is **constant**.
- (d) The angular momentum of the disk is **decreasing**.
- (e) The angular momentum of the disk is **increasing**.
- (f) The angular momentum of the disk is **constant**.

7. (5 points) Two identical hoops and two identical discs are fixed on frictionless pivots the same distance above the ground. All of the hoops/discs have the same weight and radius. Each hoop/disc has a box with a given mass hung from strings wound around them, as shown in the figure. All boxes are released from identical heights, from rest, and at the same time. What is the order in which the boxes first hit the ground? Explain using words, diagrams, equations, etc.

$$I_{disc} = \frac{1}{2}mr^2$$

$$I_{hoop} = mr^2$$



8. (8 points) An experiment involves taking an equal mass of solid aluminum and iron, both at  $100.0^{\circ}\text{C}$ , and placing them in a very well insulated and sealed container. The container holds an unknown liquid substance that has the same mass as one of the solids, and is initially at a temperature of  $20.00^{\circ}\text{C}$ . After some time it is observed that the three substances have come to an equilibrium temperature of  $48.36^{\circ}\text{C}$ .
- (a) Use related quantities sensemaking to determine if the final equilibrium temperature of  $48.36^{\circ}\text{C}$  seems reasonable. Related quantities sensemaking involves comparing the value of two or more quantities and their expected relationship.
- (b) What is the unknown liquid? Assume the temperature change for the insulated container is negligible and there are no phase changes.

**Table of Specific Heats**

Substance	Specific Heat ( $\text{J}\cdot\text{kg}^{-1}\cdot\text{K}^{-1}$ )
Ammonia (liquid)	4700
Gasoline (liquid)	2200
Ethanol (liquid)	2440
Mercury (liquid)	140
Polyethylene (solid)	2939
Aluminum (solid)	890
Granite (solid)	790
Iron (solid)	450
Glass (solid)	840

9. (7 points) On a nice spring day you find yourself relaxing under an old oak tree. You pull the end of one of the tree's branches down (negative maximum displacement) about 2 ft and let it go ( $t = 0$  s). You note that the resulting motion appears to be from a simple harmonic oscillator with a period of about 2.5 seconds. It takes the branch about 8 oscillations to decrease the amplitude by a factor of 2.



- (a) What evidence could you have to claim the branch undergoes simple harmonic motion? (be brief)
- (b) Describe the energy transfers in the branch + earth system during an entire cycle of the motion. Focus on the three most important types of energy in the system. Feel free to use a plot or diagram to illustrate how/when the energy changes forms.
- (c) What is the time constant  $\tau$  for the amplitude as a function of time during the damping of the oscillation.

10. (8 points) In order to take a nice relaxing bath after this final, you fill up a bathtub with warm water. To fill the tub, water travels at  $9 \text{ m/s}$  in a pipe under your house. The faucet (where the water exits into the tub) in your house has a diameter twice that of the pipe under your house. The water pressure in the pipe/faucet is the same everywhere.

(a) What is the height of your faucet, relative to the pipe under your house?

(b) Let's do some special cases sensemaking! If the diameter of the faucet were the same as the diameter of the pipe under your house and the pressure was the same everywhere, what would the height difference need to be? explain.

11. (6 points) A 0.850-kg box is at rest hanging vertically from a light string with a linear mass density of 0.00720 kg/meter. A traveling wave was created at the top of the string and took 0.0588 seconds to reach the bottom of the string. How long is the string? (assume tension is constant throughout the rope)



12. (6 points) A water wave was observed traveling in the negative x-direction. Two plots were created to represent this water wave. Construct an equation that represents the displacement of this traveling wave. Your equation should be a function of the variables:  $x$ , and  $t$  only.

