PHYS2350 EV1 Fall 2017 Exam 3 Review Questions

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Chapter 8: Rotational Motion

1. A record spins at 10 rad/s when a break is applied, stopping it in 2s. (a) What was the angular acceleration applied by the break? (b) How many revolutions did the record undergo before it stopped?

2. A bicyclist is riding along at 7m/s when he applies his breaks, coming to a stop in 20m. The wheels of his bicycle have a radius of 20cm. (a) What was the initial angular speed of his wheels? (b) What was the angular acceleration of his wheels? (c) What angular displacement did the wheels undergo while he stopped?

3. A lever is set up such that a 100 kg mass is placed on one end, 15cm from the pivot, and the free end of the lever at the other end is 45cm from the pivot. What force has to be applied on the free end of the lever to lift the mass?

4. A meter stick is placed on a pivot such that the pivot is at the 30cm mark. A 40g mass was placed at the 0cm mark and a 70g mass was placed at the 65cm mark. (a) Could a 30g mass balance the meter stick? (b) If so, where would it need to be placed? (c) Is there a minimum/maximum mass below/above which it is impossible to balance the meter stick? (d) If so, what is that minimum/maximum mass?

5. A rod has a mass of 50g and a length of 10cm and rotates about its center. (a) What is its moment of inertia? (b) What would its moment of inertia be if it were rotating about its end?

6. In general, the equation for the moment of inertia is:

$$I = \sum mr^2$$

   i.e. it is the sum of all masses that make up an object times the distance (squared) of that mass from the rotational axis. Thinking about this conceptually, would a hollow sphere or solid sphere, each of the same mass and radius, have a larger moment of inertia? You can check the formulas to see if you're correct.

7. A 10kg disc of radius 12cm rotates at 150 rad/s. (a) How much angular momentum does it have? (b) How much kinetic energy does it have? (c) What torque would be required to stop the disc in 5s?

8. A hollow sphere, with a mass of M and a radius of R, starts at the top of a hill of height h. What is the sphere's rotational speed at the bottom of the hill? *Hint: don't forget that some*

of its potential energy is converted to translational kinetic energy; it's not all converted into rotational kinetic energy.

9. Imagine a basketball player spinning a ball on his finger. If he slaps the ball with a force of 10 N tangential to its surface, and the ball has a mass of 0.6 kg and a radius of 24 cm, what is the angular acceleration of the ball?

10. A 500g disc of radius 0.2m rotates at 15rad/s. A 5g ant happens to be on the surface of this disc, at the edge of the disc, and begins walking towards the center. When the ant reaches the center of the disc, what is the angular speed of the disc? *Hint: the ant has a non-zero moment of inertia. Treat it as a point mass, which has a moment of inertia of* mr^2.

Chapter 10: Fluids

1. An object is submerged to a depth of 10cm in a fluid with a density of 800kg/m^3. (a) What is the fluid pressure on the object? (b) What is the total pressure on the object if it's in an open container? (c) If the container it were in was closed, and all the air was sucked out of the container, what would the total pressure on the object be? *Hint: Think about this in terms of all the weight above the object in the fluid.*

2. A submarine is submerged to a depth of 1500m. If a porthole on the submarine was circular with a radius of 10cm, how much force does the water put on the porthole?

3. An object experiences a fluid pressure of P_f and a total pressure of P_{tot} at a depth of D. (a) What would the fluid pressure be at $2D$? (b) What would the total pressure be at $2D$?

4. A 100g mass occupies a volume of .0002m^3. Would this object sink or float in water?

5. A cube with a density of 1500kg/m^3 and volume of .005 m^3 is placed underwater on a scale. What would the scale read?

6. An object with a density of 750kg/m^3 floats on the surface of water. What percentage of the object is submerged in the water?

7. A boat floats on the surface of a lake, when the fisherman aboard drops an anchor from the boat into the water. Has the buoyant force on the boat increased or decreased as a result of this?

8. A fluid moves at 20m/s through a pipe with a radius of 5cm. How fast will it move through a pipe with a radius of 10cm?

9. A large tank of water is open to the air. A small hole is punctured in the side of the tank, allowing water to pour out of the tank. If the hole was punctured 2m from the top of the waterline, at what speed would the water be exiting the tank? *Hint: since the hole is very small, the waterline moves very slowly.*

10. An easy way to make a barometer (an instrument to measure ambient pressure) is to use a tube, formed in the shape of a U, filled with water. One end of the tube is to be capped, with the air in it at exactly 1×10^5Pa, normal atmospheric pressure, and the other end is open to the air at whatever the atmospheric pressure happens to be at the time. When the ambient pressure is normal atmospheric pressure, the water on each side of the U is at the

same height. (a) If a hurricane, which is a low-pressure system, passes overhead, would you expect the waterline at the open end of the U to be higher or lower than the waterline at the closed end? (b) If the difference in height between the waterlines is 5cm during the hurricane, what is the ambient pressure? *Hint: even thoug this fluid is at rest, this problem is most easily solved with Bernoulli's equation.*

Chapter 11: Oscillations & Waves

1. A spring, with a force constant of 100N/m, has a 100g mass hanging from it. If the spring's length if 10cm with the mass hanging from it, what's the natural (i.e. unstretched) length of the spring?

2. A spring, with a force constant of 20N/m, oscillates between a minimum length of 45cm and a maximum length of 55cm. What is the total energy of the mass attached to the spring?

3. A spring, with a force constant of 50N/m, oscillates with a 50g mass attached. The speed of the mass is 20m/s when the spring is stretched by 5cm. (a) What is the total energy of the mass? (b) What is the maximum speed of the mass? (c) What is the amplitude of the oscillation?

4. A 4kg mass is pressed against a spring of force constant 250N/m, compressing the spring by 10cm. When the spring is released, the mass is accelerated to some speed and free to travel along a frictionless surface (note that the mass isn't actually attached to the spring; it's just along for the ride). (a) What is the speed that the mass leaves the spring with? (b) If, shortly after leaving the spring, the mass goes up a frictionless ramp, what maximum height would the mass reach?

5. A pendulum of length $7cm$ oscillates with a maximum angle of 10^o. If the mass at the end of the pendulum is 5kg, what is the maximum speed of this mass?

6. A wave travels in some medium with a wavelength of 15cm and a frequency of 100Hz. (a) What is the speed of the wave in this medium? (b) If the wave travels into a new medium, where its speed is halved, what is its wavelength in the new medium? (c) What would its frequency be in the new medium?

7. A string is fixed at both ends and has a tension of 100 N, a mass of 100 g, and a length of 10 cm. (a) What is the speed of waves on this string? (b) What is the lowest frequency standing wave you could produce on the string? (c) What about the largest frequency?

8. The first harmonic is known as the fundamental harmonic. The fundamental wavelength for a string fixed at both ends is 200nm, and the fundamental frequency is 1015Hz. (a) What is the wavelength of the twentieth harmonic? (b) What is the frequency of the twentieth harmonic? (c) What is the speed of the wave on this string?

Chapter 12: Sound

1. A speaker has a volume of 30dB when you stand 5m from it. How loud would the speaker be when you stood 10m from it?

2. Explain the interpretation of the constant I_0 in the equation for volume,

$$\beta = (10\text{dB}) \log\left(\frac{I}{I_0}\right)$$

3. A source of sound is moving away from you at 25m/s. If the sound you hear is at 150Hz, what is the actual frequency of the sound being emitted from the source?

4. A speaker emits a sound at 100Hz. Imagine you threw the speaker into the air at a speed of 10m/s. (a) What would be the lowest frequency you'd hear from the speaker during its path through the air? (b) What would be the highest frequency you'd hear from the speaker during its path through the air? (c) At what point in the speaker's path would the frequency you head be the same as the actual frequency emitted from the speaker? Consider the speed of sound to be 350m/s.

5. Two sounds are emitted from two different speakers to produce a beat frequency of 30Hz. (a) If the frequency of one speaker was 480Hz, then what possible frequencies could the other sound be? (b) If the frequency of the known sound was increased to 490Hz, causing the beat frequency to increase to 40Hz, what must the frequency of the other sound be?

6. If a tube with one end closed had a length of 50cm, what would the third-longest harmonic wavelength be?

Chapter 13: Temperature & Kinetic Theory

1. An aluminum rod has an initial length of 10cm. When heat is applied to it, its length increases to 10.1cm. If the initial temperature of the rod was 250K, what would the final temperature of the rod be?

2. A gas inside a box has a pressure of 5×10^6Pa when at a temperature of 400K. What would the pressure of the gas in the box be if the temperature was decreased to 300K?

3. There are many types of processes one can perform on a gas, but the most important are ones in which the volume of the gas changes, known as expansions. An isothermal expansion is one that occurs at a constant temperature, and an adiabatic expansion is one that occurs with no heat exchange. Explain conceptually whether an isothermal expansion and an adiabatic expansion should occur rapidly or slowly.

4. A gas at a temperature of 300K has heat added to it until it reaches a temperature of 350K. This causes its pressure to rise to 6×10^7Pa and its volume to double. What was the pressure of the gas at 300K?

5. A gas is expanded isobarically – that is, at constant pressure – from a volume of 0.005m^3 to a volume of 0.01m3. What is the ratio of the initial to the final temperature of the gas?

6. Imagine an ideal gas, composed of N particles each with a mass of m and an rms speed of v_{rms}, is contained in a box with a volume V at a temperature T. Explain, conceptually, what factors the pressure of the gas within the box should depend on, and what the dependence should be? You don't need to be as specific as saying "the pressure should depend on x^3," but you should be able to say whether the pressure increases or decreases with x.

7. Imagine a gas of N particles at a temperature T, occupying a volume V. Common constants associated with thermodynamics are the ideal gas constant R, Boltzmann's constant k_B, and Avagadro's number N_A. What combination of variables and constants defines the thermal energy of the gas?

8. What is the rms speed of a molecular helium gas, He_2, at a temperature of 400K?

9. An atomic hydrogen gas, H, has an average kinetic energy of 3×10^{-12}J per particle. What is the temperature of the gas?