Physics P221
Final Exam

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Student Name_____ **Student ID**_____

Each part of each problem is worth 6 points. **Show your work for all problems.** You may consult five sheets of personal notes and you may use the appendices in our HR&W text.

1. A flying saucer drops onto a merry-go-round. Prior to contact both are spinning about the same vertical axis. After contact they rotate together. If the moments of inertia and original angular velocities are as given in the table, what is the magnitude of their final angular velocity (neglect any external torques)?

Merry-go-round	**Flying saucer**
Rotational Inertia = 20,000 kg m^2	Rotational Inertia = 30,000 kg m^2
Velocity = 8.0 rad / s **clockwise**	Velocity = 2.0 rad / s **counterclockwise**

A) 2.0 rad / s
B) 1.0 rad / s
C) .75 rad / s
D) .50 rad / s
E) .25 rad / s

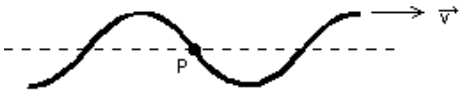
2. An object dropped from a stationary balloon hits the ground in 12.0 s. If its acceleration is 9.80 m / s^2, the height of the balloon is:

A) 29.4 m
B) 53.8 m
C) 118 m
D) 353 m
E) 706 m

3. If the earth had 3 times its present radius and the same average density, its mass would be 27 times greater. In terms of g = 9.8 m / s^2, what would be the acceleration of an object dropped near the surface of this triple-sized earth?

A) 1 / 3 g
B) 1 g
C) 3 g
D) 9 g
E) 27 g

4. The transverse wave shown is traveling from left to right in a string. The direction of the instantaneous velocity of the string at point P for the time pictured below is most accurately described as:



A) ↑

B) ↓

C) →

D) ↗

E) no direction since v = 0.

5. A meter stick is pivoted at a distance *a* from its center and it swings as a physical pendulum from this point. Of the following values for *a* below, which gives the shortest period of oscillation? (The rotational enertia of a uniform stick of length ℓ and mass M about its center of mass is $I_{CM} = \frac{M\ell^2}{12}$.) SHOW WORK FOR PARTIAL CREDIT.

A) $a = \ell/\sqrt{8}$

B) $a = \ell/\sqrt{10}$

C) $a = \ell/\sqrt{12}$

D) $a = \ell/\sqrt{14}$

E) $a = \ell/4$

6. A small solid steel ball floats in a large container that is about half full of mercury. Assume that steel is denser than water. When the remainder of the container is filled with water,

A) The ball sinks to the bottom of the container

B) The mercury floats on the water.

C) The ball sinks slightly.

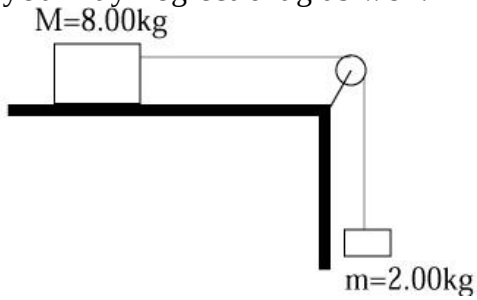
D) The ball rises slightly.

E) The ball remains stationary.

7. For a given medium, the frequency of a wave is:

A) independent of wavelength
B) inversely proportional to wavelength
C) proportional to wavelength
D) proportional to the amplitude
E) inversely proportional to the amplitude

8. Two blocks (one of mass 2.00 kg and the other of mass 8.00 kg) are connected together by a massless string that passes over a massless pulley as shown in the figure below. The blocks start from rest, the 8.00 kg block slides without friction along the table, and you may neglect drag as well.



A) After the 2.00 kg block has moved down by 0.500 m, what is the speed of the 8.00 kg block?

B) At that same point in time (i.e. when each block has traveled 0.5 m) what is the tension in the string?

9. While playing pool, Dave hits two balls simultaneously with the cue ball in an **elastic** collision. All three balls have the same mass. Before the collision the cue ball has a speed of 6.0 m/s. Afterwards, the cue ball continues in the same direction with 1/3 of its original speed. The two other balls recoil symmetrically through an angle θ, as shown in the figure.

A) Prove that the other two balls have the same speed after the collision.

B) Find the speed of either of the two balls after the collision.

C) Find θ.

10. To answer this question you may need to use some of the following information about aluminum (Al):

Density	$r = 2.70\times10^{3}$ kg/m^3	Molecular weight	$W = 26.98$ g/mol
Specific heat	$c_p = 900$ J/kgK	Coeff. of linear expansion	$a = 23\times10^{-6}$ K^{-1}
Thermal conductivity	$k = 235$ W/m·K	Melting point	$T_m = 660.4$ °C

A 100 W electrical heater is used to raise the temperature of an Al rod from 25.0 °C to 150.0 °C in a period of 1.41 minutes. Assume that all the energy emitted by the heater goes into the Al rod and that the rod's temperature is uniform at all times.

A) The Al rod was 17.00 cm long when its temperature was 25.0 °C. What is its length at 150.0 °C?

B) What is the heat capacity of the Al rod?

C) Assuming that the rod has a circular cross-section, what is its radius?

D) If, during heating, a 1.5 °C temperature gradient develops across the length of the rod, at what rate would thermal energy flow along the rod?

11. A violinist plays a note of 150.0 Hz on his violin. Recall that the speed of sound in air is 343 m / s at 20 °C (the temperature of the concert hall)

A) What is the wavelength (in air) of the sound produced by the violin?

B) The standing wave on the violin string is described by

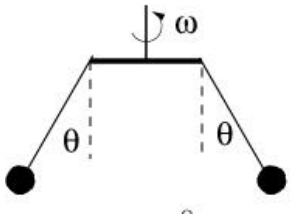
$$y(x,t) = 2.00\text{mm}\,\sin\left(\frac{p\,x}{0.4\text{m}}\right)\cos\left(300p\,t\,\text{sec}^{-1}\right)$$

What is the maximum transverse speed of the string at $x = 0.20$ m?

C) Assuming the string producing the 150.0 Hz note is under a tension of 105 N, is 40.0 cm long (between its rigid supports), and has one antinode in this mode, what is the linear density of this string?

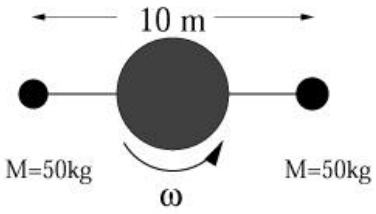
D) A microphone on the violin is used to drive a speaker placed 2.50 m directly above the position of the violin. The speaker produces the same frequency wave and it is in phase with the original sound. Find the closest distance a listener could stand to the violin to hear a minimum in sound intensity due to interference between the waves from the speaker and the violin. (Assume that the listener's ear is at the same height above the floor as the violin and treat both the violin and the speaker as point sources.)

12. In a certain circus act two trapeze artists (each of mass 50.0 kg) hang from a horizontal platform that rotates at a constant rate of 10.16 revolutions per minute. The situation at the time of interest is shown below schematically (with the performers separated by 10.0 m and represented as small black circles due to Prof. Baxter's limited artistic skills)



$\theta = 30^{\circ}$

Side view



Top view

A) Neglecting the mass of the ropes and platform, what is the tension in the upper cable that suspends the platform?

B) What is the tension in either of the 5 m long ropes that support the performers?

C) What is the kinetic energy of the system (again neglecting any mass but that of the two performers)?

Score

1-7	(42)	_____
8	(12)	_____
9	(18)	_____
10	(24)	_____
11	(24)	_____
12	(18)	_____
Total	(138)	_____