

# PHYSICS 211 FINAL EXAM

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

Recitation section number: \_\_\_\_\_

- Look up your recitation section number on the next page.
- There are eight sections worth 20 points each, and a possible 10 points extra credit.
- **You must show your reasoning to receive credit.** A numerical answer with no logic shown will be treated as no answer.
- If you run out of room, continue your work on the back of the page, or on the attached extra pages.
- Remember, show your reasoning as thoroughly as possible for partial credit, including large, clear drawings.
- You may use  $g = 10 \text{ m/s}^2$  throughout, except where indicated, to minimize arithmetic.

## TABLE OF SECTION NUMBERS

SEC	DAY	TIME	ROOM	TEACHINGASST.
M003	W	8:25-9:20A	B129E	W. Jiang
M004	W	9:30-10:25A	B129E	W. Jiang
M005	W	10:35-11:30A	B129E	W. Jiang
M006	W	11:40A-12:35P	B129E	N. Butt
M007	W	12:45-1:40P	B129E	K. Liu
M008	W	2:15-3:10P	B129E	K. Dodge
M009	W	3:45-4:40P	B129E	K. Dodge
M010	W	5:15-6:10P	B129E	K. Dodge
M011	W	8:25-9:20A	106	J. Zhang
M012	W	9:30-10:25A	106	J. Zhang
M013	W	10:35-11:30A	106	J. Zhang
M014	W	11:40A-12:35P	106	F. Serafin
M015	W	12:45-1:40P	106	F. Serafin
M016	W	2:15-3:10P	106	F. Serafin
M017	W	3:45-4:40P	106	N. Butt
M018	W	5:15-6:10P	106	N. Butt
M019	W	8:25-9:20A	LINK 101	B. Jain
M020	W	9:30-10:25A	AG 203	Q. Long
M021	W	10:35-11:30A	AG 203	Q. Long
M022	W	11:40A-12:35P	AG 203	Q. Long
M023	W	10:35-11:30A	AG 210	K. Liu
M024	W	11:40A-12:35P	AG 210	K. Liu
M025	W	9:30-10:25A	LINK 101	J. Georg

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## PAGE 1: SHORT QUESTIONS

Answer the following questions:

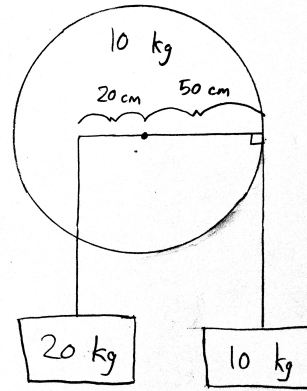
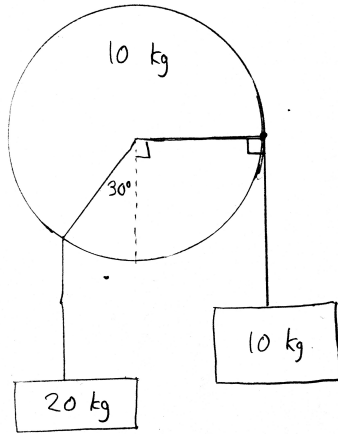
1. *Saturn has about the same value of  $g$  (the acceleration due to gravity at its surface) as the Earth, even though it has about nine times the radius. About how many times more massive than the Earth is Saturn? (5 points)*
  
  
  
  
  
  
  
  
  
  
2. *A low quality speaker system that only reproduces frequencies between 300 Hz and 1200 Hz plays two musical notes at the same time. A listener hears the following frequencies: 300 Hz, 400 Hz, 450 Hz, 500 Hz, 600 Hz, 700 Hz, 750 Hz, 800 Hz, 900 Hz, 1000 Hz, 1050 Hz, 1100 Hz, and 1200 Hz. The fundamental frequencies of both notes are below 300 Hz and thus absent. What are the two fundamental frequencies? (5 points)*
  
  
  
  
  
  
  
  
  
  
3. *Consider a person standing on a bathroom scale in a bus as it travels over hills and through valleys. If the person weighs 150 pounds, will the scale read greater than 150, less than 150, or equal to 150, when the bus;*
  - (a) *... travels over the top of a hill? (2.5 points)*
  
  - (b) *... travels through the bottom of a valley? (2.5 points)*
  
  
  
  
  
  
  
  
  
  
4. *Explain briefly why the potential energy stored in a stretched spring is  $\frac{1}{2}k\Delta x^2$ ; specifically, where does the factor of  $\frac{1}{2}$  come from? (5 points)*

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## PAGE 2: SHORT QUESTIONS

Answer the following questions:

1. For the following pictures, will the pulley shown rotate clockwise, counterclockwise, or not at all? If it will rotate, what is its angular acceleration? In both cases, the pulley is a cylinder ( $I = \frac{1}{2}mr^2$ ). (10 points)



2. A small block of mass  $M$  rests on the rightmost edge of a table. It is struck by a projectile of mass  $m$  coming from the left at speed  $v_0$ ; the projectile sticks to the block and the combination immediately falls off the table. The table has height  $h$ . The block lands a distance  $d$  from the base of the table. Which of the following would increase the distance  $d$  by a factor of two? (10 points)
  - Doubling the mass  $m$  of the projectile, while keeping everything else the same
  - Doubling the initial velocity  $v_0$  of the projectile, while keeping everything else the same
  - Doubling the height  $h$  of the table, while keeping everything else the same
  - Reducing the mass  $M$  of the block by half, while keeping everything else the same

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### QUESTION 3

A particular spring has a spring constant of  $200 \text{ N/m}$ , and is  $50 \text{ cm}$  long at equilibrium. A  $2 \text{ kg}$  mass is affixed to one end. A person holds the other end and spins the mass in a circle with an angular velocity of  $2 \text{ rad/sec}$ ; when this is done the spring stretches to some length greater than  $50 \text{ cm}$ .

**Ignore gravity** for this problem.

*a) Explain in words why the spring stretches when it is spun. (5 points)*

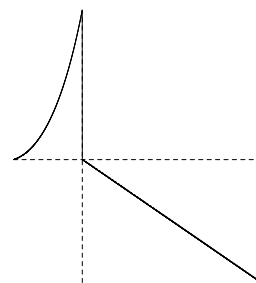
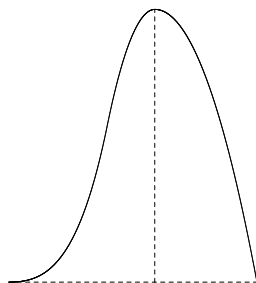
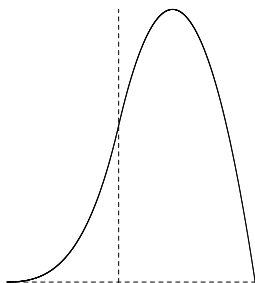
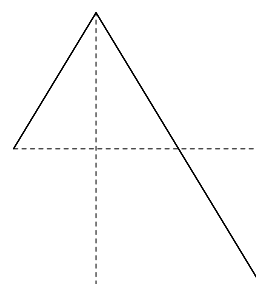
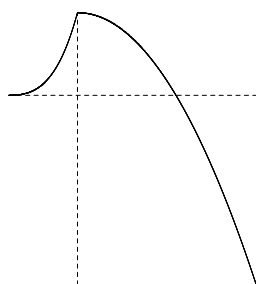
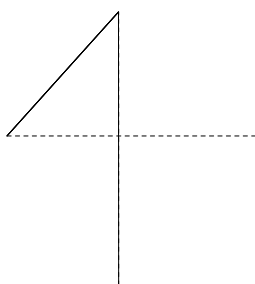
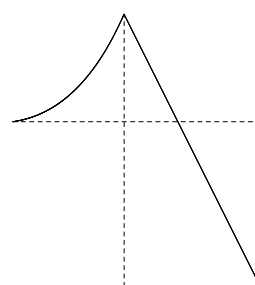
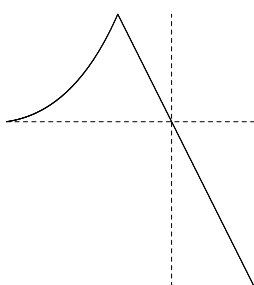
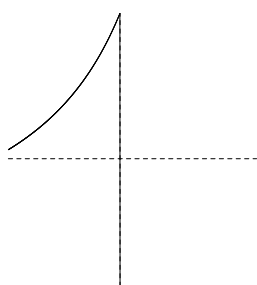
*b) What is the stretched length of the spring? (15 points)*

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## QUESTION 4

A small rocket is pointed upward and launched; half of its mass is fuel, which it consumes in 1 second. During this time, the thrust produces a constant force upward. Once the fuel is exhausted, the rocket continues until it reaches the ground again.

Here are nine possible graphs. The horizontal dotted line is the x-axis; the vertical dotted line represents the time when the fuel is exhausted. Label the correct position vs. time (7 points), velocity vs. time (7 points), and acceleration vs. time (6 points) graphs.



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## QUESTION 5

A light ball rests on a table; the coefficient of static friction between the table and the ball is  $\mu_s$ . A strong wind blows on the ball, causing it to accelerate to the side with a constant force  $F_w$ . (This force can be treated as acting on the center of the ball.) Treat the ball as a solid sphere ( $I = \frac{2}{5}mr^2$ ).

If the wind is light, the ball will roll without slipping. If the force is too large, then the ball will slide. In this problem, you will compute the required coefficient of static friction for the ball to roll without slipping, rather than slide.

*a) What two laws of physics are you going to use to solve this problem? You may write equations or words. (4 points)*

*b) Draw a force diagram for the ball on the back of this page; include all features that would be helpful to solve the problem. (4 points)*

*c) What value of  $\mu_s$  is required for the ball to roll rather than slide? Write a system of  $N$  equations and  $N$  unknowns ( $N$  will probably be two or three) that will let you solve for  $\mu_s$  in terms of  $g$  and  $F_w$ . You do **not need to solve the system** for  $\mu_s$ . (12 points)*

*Hint: Think carefully about your minus signs that relate translational and angular quantities.*

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## QUESTION 6

A pendulum with a string of length  $L$  is drawn back to an angle  $\theta$  from the vertical and released. The mass of the pendulum bob is  $m$ .

*a) In terms of  $L$ ,  $\theta$ , and  $g$ , how fast is the ball traveling when it reaches the lowest point of its swing? (10 points)*

*b) What is the tension in the string at that point? (10 points)*



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## QUESTION 7

A solid ball (moment of inertia  $I = \frac{2}{5}mr^2$ ) and a hollow ball ( $I = \frac{2}{3}mr^2$ ) roll down a hill without slipping.

- a) *Which reaches the bottom first? (3 points)*
- b) *What is the ratio of their speeds as they reach the bottom? (12 points)*
- c) *Why is this question much easier than a question like “How long does it take the ball to roll down the hill”? (In other words, what is different about the techniques you would have to use?) (5 points)*

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## PAGE 8

Two children of mass 50 kg each are playing on a merry-go-round, a large horizontal disk that can rotate around its center. It has a mass of 200 kg and is spinning about its center at 0.5 rad/sec, while the children stand on the outside rim.

*The children then walk to the center. What is the new angular velocity of the disk? (20 points)*

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