

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

Section:             1 (8AM)             2 (9AM)

1	/15
2	/25
3	/15
4	/15
5	/15
6	/15
<b>/100</b>	

## PHYSICS 221 FINAL EXAM - December 2009

**Do not open this booklet until instructed. The exam will end promptly at 4:00 PM.**

**Instructions:** When you are told to begin, check that this examination booklet contains all the numbered pages from 2 through 11.

Read each problem carefully so that you are certain what it is asking. Do not panic or be discouraged if you cannot do every part of every problem. If a part of a problem depends on a previous answer you have not obtained, define a symbol for it and proceed to maximize your credit. Keep moving to finish as much as you can!

**You must show your work.** The purpose of this exam is to show how well you understood the material we have covered. You must include an adequate explanation, including correct equations where applicable, for full credit. A number with no explanation will not get credit. **Show your answer's units**, and give an adequate number of significant digits. Completely numerical solutions showing no equations are not eligible for partial credit. Do not use scratch paper. Indicate any work on the backs of the pages that you wish to be considered.

**Box your answers.**

This examination is administered under the Cadet Honor Code. All suspected violations must be reported appropriately. The seat next to you must be unoccupied. No talking is permitted during the examination, apart from questions to the instructor. You may use a scientific calculator, but may not use "advanced features", including graphing, solving, derivatives, integrals, symbolic manipulation, or equation storage capabilities. Any other electronic devices, including headphones, cell phones, PDAs, and MP3 players, may not be used during the exam in any way. You may use one two-sided page of notes you have prepared. No other notes or textbooks may be open during the exam.

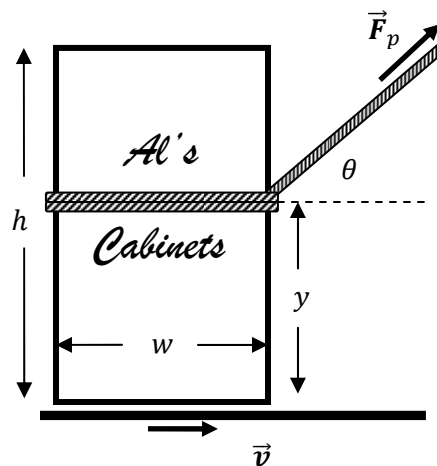
**The content of this exam must be kept confidential until everyone has taken it.**

**Problem 1: [15pt]** To start an avalanche on a mountain slope, an artillery shell is fired with an initial velocity of 330 m/s at  $53.0^\circ$  above the horizontal. It explodes on the mountainside 36.0 s after firing.

- (a) [5pt] What are the  $x$  and  $y$  coordinates of the shell where it explodes, relative to its firing point?
- (b) [5pt] What is the maximum height reached by the shell along its trajectory?
- (c) [5pt] What is the speed of the artillery shell when it strikes the mountainside?

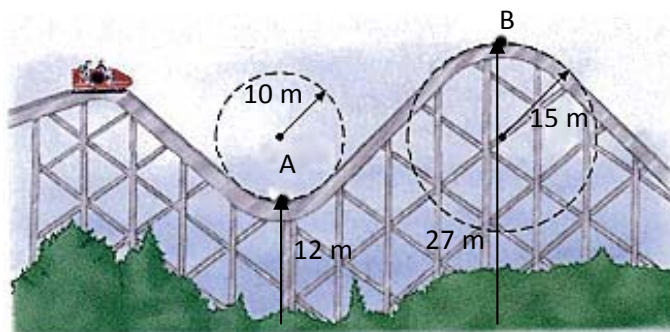
[If you don't have an answer to part (a), assume  $y = 3000$  m.]

**Problem 2: [25pt]** A rectangular cabinet of weight  $F_g = 400$  N is pulled across the floor at a constant speed  $v = 1.5$  m/s by a person applying a force  $F_p = 200$  N to a rope tied around the cabinet as shown, sloping upward at angle  $\theta$ . There is a frictional force of  $F_f = 160$  N between the cabinet and the floor.



- (a) [5pt] Draw and label a free-body diagram for the cabinet, showing all forces acting on it.
- (b) [5pt] What is the angle  $\theta$  of the rope pulling the cabinet?
- (c) [5pt] What is the coefficient of kinetic friction between the cabinet and the floor?
- (d) [5pt] What is the power exerted by the person pulling the cabinet?
- (e) [5pt] If the cabinet's center of gravity is at its center, and its height and width are  $h = 130$  cm,  $w = 44$  cm, what is the maximum height  $y$  at which it can be pulled in this manner if it is not to tip over? [When the cabinet is about to tip, the contact forces with the floor act at its front edge.]

**Problem 3: [15pt]** A roller coaster follows the track shown, where the height at point A is 12.0 m above the ground, and the height at point B is 27.0 m above the ground. The radius of curvature of the track is 10.0 m at point A and 15.0 m at point B.



- (a) [5pt] What is the greatest speed the roller coaster car can have at point B for the passengers to stay in their seats without the help of a seat belt?
- (b) [5pt] If the roller coaster has the speed at point B found in part (a), what is its speed at point A, neglecting friction and air resistance? [If you don't have an answer to part (a), assume it is 10 m/s.]
- (c) [5pt] What is the normal force of the car's seat on a 75 kg passenger at point A in this case? [If you don't have an answer to part (b), you can assume the speed is 20 m/s.]

**Problem 4: [15pt]** A uniform cylindrical turntable of radius 2.00 m and mass 31.7 kg rotates counterclockwise in a horizontal plane with an initial angular speed of  $4\pi$  rad/s. The fixed turntable bearing is frictionless. A lump of clay of mass 2.44 kg and negligible size is dropped onto the turntable from a small distance above it and immediately sticks to the turntable at a point 1.90 m to the east of the axis. [The moment of inertia of a uniform cylinder of radius  $R$  and mass  $M$  about an axis through the center is  $\frac{1}{2}MR^2$ .]

- (a) [5pt] Find the final angular speed of the clay and turntable.
- (b) [5pt] Is mechanical energy of the turntable-clay system conserved in this process? What, if any, is the change in energy?
- (c) [5pt] Is momentum conserved in this process? What, if any, is the amount of impulse on the system imparted by the bearing when the clay lands?

**Problem 5. [15pt]** A village maintains a large tank with an open top, containing water for emergencies. The water can drain from the tank through a hose of diameter 6.75 cm. The hose ends with a nozzle of diameter 2.50 cm. A rubber stopper is inserted into the nozzle. The water level in the tank is kept 7.50 m above the nozzle. [The density of water is  $1 \text{ g/cm}^3$ .]

**(a) [5pt]** Calculate the friction force exerted by the nozzle on the stopper.

**(b) [5pt]** How many kg/s of water flows from the pipe when the stopper is removed?

**(c) [5pt]** Calculate the gauge pressure of the flowing water in the hose just behind the nozzle.

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**Problem 6. [15pt]** A 0.500 kg object attached to a spring with a force constant of 8.00 N/m vibrates in simple harmonic motion with an amplitude of 10.0 cm.

**(a) [3pt]** What is the period of the oscillation?

**(b) [6pt]** Calculate the maximum value (magnitude) of its speed and acceleration?

**(c) [6pt]** Calculate the speed and acceleration when the object is 8.00 cm from the equilibrium position.