Printed Name: _____

Section: ☐ 1 (8AM) ☐ 2 (9AM)

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Bonus	
Total	**/ 60**

PHYSICS 221 EXAM 3

November 10, 2008

Do not open this booklet until instructed. The exam will end promptly at 50 minutes after the hour.

Instructions: When you are told to begin, check that this examination booklet contains all the numbered pages from 2 through 6. The Bonus Question is extra credit, and is optional.

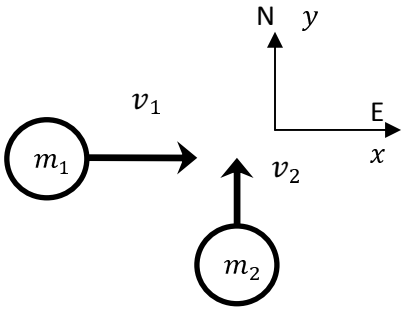
Read each problem carefully so that you are certain what it is asking. Do not panic or be discouraged if you cannot do every part of every problem. If a part of a problem depends on a previous answer you have not obtained, define a symbol for it and proceed to maximize your credit. Keep moving to finish 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 the equation sheet distributed with the exam. No other notes or textbooks may be open during the exam.

Problem 1: [18pt]



In an American football game, a fullback of mass $m_1 =$ 95 kg running east with a speed of $v_1 = 5.8$ m/s is tackled by an opponent of mass $m_2 = 125$ kg running north with a speed of $v_2 = 3.1$ m/s.

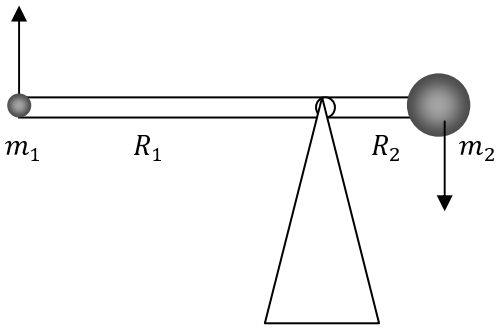
[*Note:* This is a two-dimensional problem. It cannot be solved using one-dimensional methods! Vectors are required throughout.]

(a) [6pt] Find the magnitude and direction of the total velocity of the two football players after the tackle. You can give the angle relative to east as the direction.

(b) [6pt] How much kinetic energy was lost by the two players during the collision?

(c) [6pt] Find the components F_x, F_y of the average force exerted by player 2 on player 1 during their collision, assuming it lasts for a time $\Delta t = 0.50$ s.

Problem 2: [20pt] The trebuchet shown is constructed of a light-weight rod of negligible mass pivoted as shown $R_1 = 7.50$ m and $R_2 = 0.50$ m. A mass $m_2 = 120$ kg is attached to the short end, and allowed to fall, launching mass m_1 =6.0 kg when it gets to its highest point.



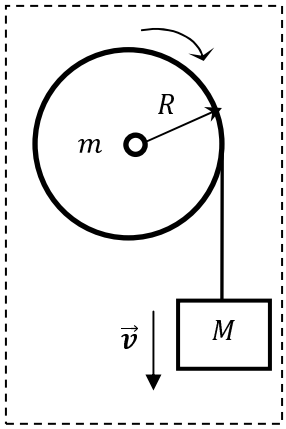
(a) [5pt] Find the moment of inertia of the masses and rod, treating the masses as point objects.

(b) [5pt] Calculate the work done by gravity on the system as it moves from the position shown to the point of launch.

(c) [5pt] What is the launch speed of mass m_1?

(d) [5pt] Find the initial angular acceleration of the trebuchet about its pivot when it is first released from the position shown.

Problem 3: [22pt] A mass M hangs from a spool of string wound around a solid uniform cylinder of mass m and radius R (with moment of inertia $I = \frac{1}{2} mR^2$). The spool is supported by a rod passing through its center. In this problem, express your results symbolically in terms of quantities labeled in the figure, as needed.



system

(a) [3pt] Three external forces act on the system consisting of the spool, hanging block, and string: two weights and a force $\vec{F}$ of the rod on the spool. (Tension is an internal force, and not included.) **Draw and label** all three forces in the correct location and direction on the figure to the right. (Put the tail of each vector where it acts.)

(b) [4pt] What is the net torque about the rod due to the external forces?

(c) [5pt] When the block is falling at speed v, what is the total angular momentum of the system about the rod supporting the spool?

(d) [5pt] Use the answers to parts (b) and (c) together with the fact that $\tau = dL/dt$ to find the acceleration $a = dv/dt$ of the block.

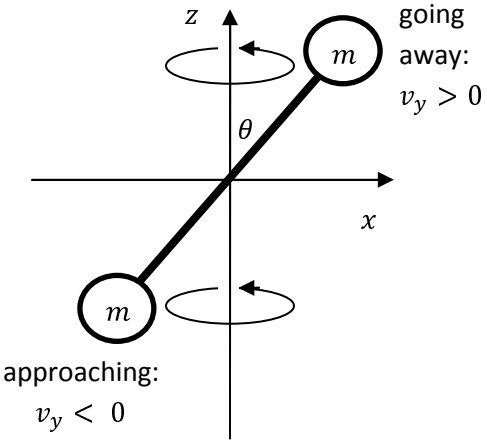
(e) [5pt] What is the total kinetic energy of the system when the block is falling at speed v?

The following problem is extra credit, and can increase your score by a maximum of 3 points. You cannot get more than 60 points on this exam via extra credit, however.

Bonus Question: [3pt] Two equal masses are attached to a tilted rod that rotates counterclockwise at a constant rate about the z axis as shown. At the time shown, both masses are in the plane of the paper. The y axis points into the page.

[2pt] The total angular momentum vector is directed

- **(a)** upward along the z axis.
- **(b)** downward along the z axis.
- **(c)** into the page ($+y$).
- **(d)** out of the page ($-y$).
- **(e)** upward to the left.
- **(f)** downward to the right.
- **(g)** nowhere – it's zero.



[1pt] Is the angular momentum vector conserved?

yes

no [Circle the correct answers. No explanation is requested.]