# PHY 2060 Fall 2005 — Exam 2

Instructions: Attempt all ten questions, each of which carries a maximum of 10 points. Write your solution below each question, continuing on the back page of the exam or additional paper if necessary. You will receive credit only for knowledge and understanding that you demonstrate in your written solutions. To maximize your score, you should briefly explain your reasoning and show all working. Give all final answers in terms of variables defined in the problem (and possibly also g, the acceleration due to gravity). Please try to write neatly!

During this exam, you may use a single formula sheet. You are not permitted to consult any other books, notes, or papers, to use calculators or any other electronic device, or to communicate with anyone other than the proctor. In accordance with the UF Honor Code, by turning in this exam to be graded, you affirm the following pledge: *On my honor, I have neither given nor received unauthorized aid in doing this assignment.*

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1. A plate of uniform thickness t and density ρ has the shape of a circle of radius r containing a square hole with sides of length l (where $2l < r$). One corner of the hole is located at the center of the circular plate. Find the position of plate's center of mass. Express your answer using the coordinate system shown in the figure.
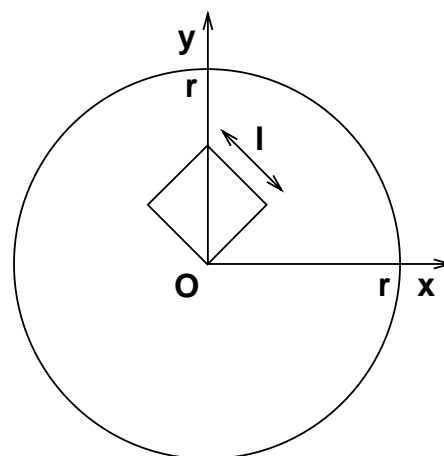

2. A shell of mass M is fired from a gun with a muzzle velocity v_0 at an angle ϕ_0 above the horizontal ground. At the top of the trajectory, the shell explodes into two fragments. After the explosion, one fragment of mass m exactly retraces its trajectory back to the gun. Assuming level terrain and neglecting drag, how far from the gun does the second fragment hit the ground?

3. A golf club consists of a shaft of mass m and length l attached to a head of mass M and linear dimensions much smaller than l. Treating the shaft as a thin, uniform rod, find an approximate expression for the rotational inertia of the club when it is rotating about a point a distance l beyond the end of the handle (representing a pivot point between a player's shoulders).
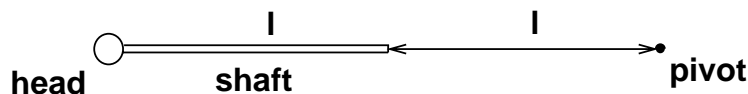
4. A window cleaner of mass m stands at the left end of a platform of length L and mass M, which is suspended by four vertical cables, two of which are attached a distance d in from each end (see figure). The mass of the cables is negligible.

(a) Find the tension in each of the left cables and in each of the right cables.

(b) What is the largest value of m/M for which the platform is stable in the horizontal position shown?
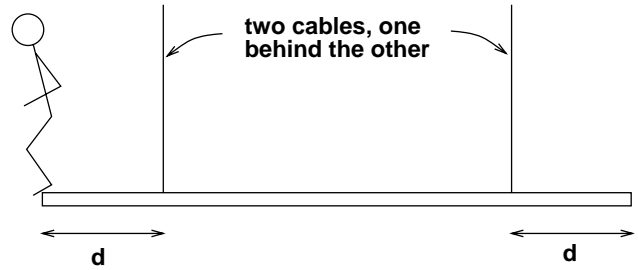
5. A uniform stick of mass m and length l is pivoted at one end. It is held horizontally and released.

(a) Find the angular momentum of the stick immediately after it is released.

(b) What is the magnitude of the force $\mathbf{F}_0$ exerted by the pivot on the stick immediately after the latter is released.
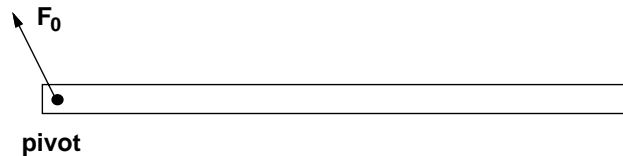
6. A plate of uniform thickness t and density ρ has a shape in the xy plane corresponding to the region that lies both below the curve $y = 4x - x^2$ and above the curve $y = x^2 - 4x$. Find the position of the center of mass. (You should be able to perform all the necessary mathematical steps to obtain a final numerical answer.)

7. A single-engine airplane is traveling in a horizontal, circular orbit. The engine has a propeller, which can be approximated as a uniform rod of mass $20\,\mathrm{kg}$ and length $2\,\mathrm{m}$, spinning at $3,000\,\mathrm{rev/min}$. For the purposes of this question, ignore all other rotating components in the engine.

(a) What is the magnitude of the horizontal component of the airplane's angular momentum?

(b) How much torque must the air exert on the airplane in order that the plane can complete two revolutions of its orbit per minute? Hint: Consider the change in the airplane's angular momentum vector.

8. A uniform solid block lies flat on a solid surface (see figure). The block has mass m, width w, height h, and depth (into the page) d. The block is subject to a force of magnitude F, directed parallel to the positive x axis, and applied to the block at its top edge.

(a) Suppose that a chock is placed behind the block (at point C in the figure) to stop it sliding. Find the minimum force F that will cause the block to tip over.

(b) Now suppose that the chock is removed. Given that the coefficient of static friction between the block and the surface is μ_s, what is the minimum height h (for given w and d) for which it is possible to tip over the box?
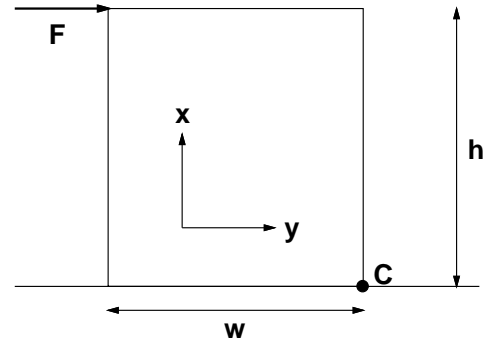
Assume that any rotation takes place around an axis that points in/out of the page.

9. Four carts are spaced out as shown in the figure along a straight track that permits the carts to move (without friction) in only one dimension. The carts have masses $m_1 = m_2 = m_4 = m$ and $m_3 = 2m$. Carts 1, 3, and 4 are initially stationary, while cart 2 is initially moving towards cart 3 at speed v. Find the final velocity of each cart, assuming that collisions involving cart 1 and/or cart 4 are totally inelastic, while collisions involving only carts 2 and 3 are elastic.

10. A uniform cylinder of mass M and radius R can roll on an inclined plane that makes an angle θ with the horizontal. An ideal string has one end firmly attached to the surface of the cylinder. The string is partly wrapped around the cylinder, then it runs over a massless, frictionless pulley and a bucket of mass m is hung on the other end, as shown in the figure.

(a) Assuming that the cylinder rolls without slipping, find the acceleration (magnitude and direction) of the bucket.

(b) For what angle θ would the cylinder roll without slipping even if the slope was frictionless? Which direction (up or down the slope) would the cylinder roll in this special case?