PHYSICS 131 EXAM 3 10 April 2001

INSTRUCTIONS: Write your name on the front of the blue exam booklet. The exam is closed book, and you may have only a pen/pencil and a calculator (no stored equations or programs and no graphing). Show all of your work in the blue book. For problems II−V, an answer alone is worth very little credit, even if it is correct − so show how you get it.

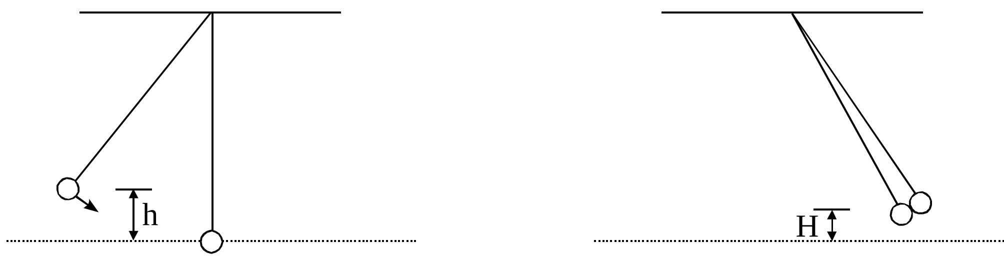
Suggestions: Draw a diagram when possible, circle or box your final answers, and cross out parts which you do not want us to consider.

In all problems neglect the effects of air resistance.

I. *Multiple Choice Questions* (4 points each).

1. Two identical masses are hung on strings of the same length. One mass is released from a height h above its free−hanging position and strikes the second, very sticky mass. The two masses stick together and move off. They rise to a maximum height H given by

(a) $3h/4$ (b) $h/4$ (c) $h/2$ (d) h (e) None of these



2. The spherical Death Star (a large hollow spacestation) is far from any planet and spins about its (vertical) axis. If it has a radius of 5.10 km, how fast does it need to spin in order that someone on its equator feels an artificial gravity of 9.8 m/s^2?

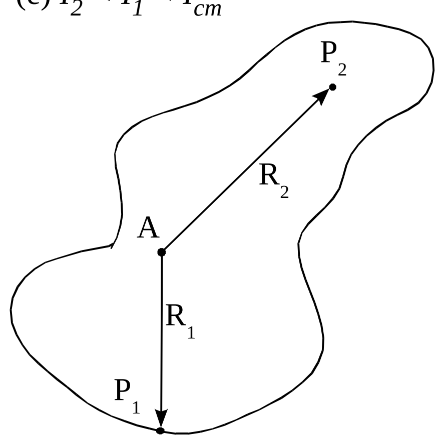
(a) 4.4×10^{-2} rad/s (b) 7.0×10^{-3} rad/s (c) 0.28 rad/s

(d) −0.22 rad/s (e) 1.3×10^{3} rad/s

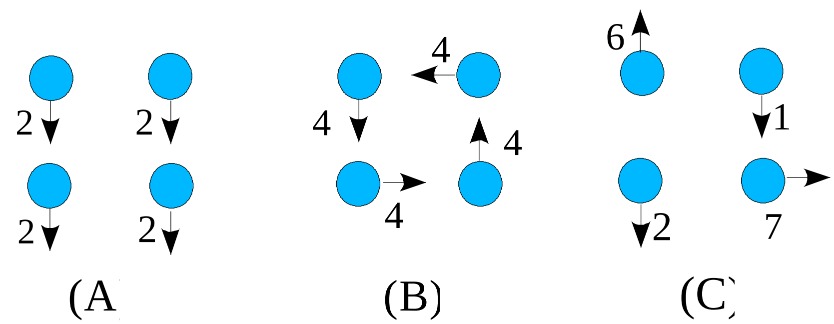
3. In the figure, $R_2 > R_1$, and A is the center−of−mass. The moment of inertia about an axis through P_1 is I_1, the moment of inertia about an axis through P_2 is I_2, and the moment of inertia about and axis through A is I_{cm}. The relationship among these moments is

(a) $I_1 = I_2 > I_{cm}$ (b) $I_1 = I_2 < I_{cm}$ (c) $I_1 > I_2 > I_{cm}$

(d) $I_2 > I_1 > I_{cm}$ (e) $I_2 < I_1 < I_{cm}$



4. Consider the following three configurations of identical masses moving with the velocities of the size (in m/s) and direction shown. Order the configurations according to their (linear) momentum, from <u>least</u> momentum to <u>most</u>.



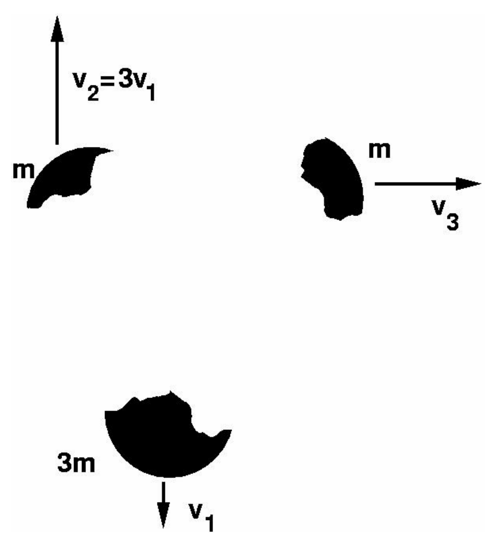
(a) A, B, C (b) A, C, B (c) B, A, C

(d) B, C, A (e) C, A, B (f) C, B, A

5. The figure below shows the behavior of a projectile just after it has broken up into three pieces. What was the speed of the projectile the instant before it broke up?

(a) v_3 (b) $v_3/5$ (c) $v_3/4$

(d) $5v_3$ (e) $(v_1+v_2+v_3)/5$



II. A propeller on a turboprop aircraft has a moment of inertia of 30 kg m^2. When the engine is started, the propeller goes from rest to 300 revolutions per minute in 3 seconds.

(a) Find the angular velocity of the propeller at 3 seconds in radians/s .

(b) Find the average angular acceleration α.

(c) Find the average torque applied to the propeller by the engine. Ignore air resistance.

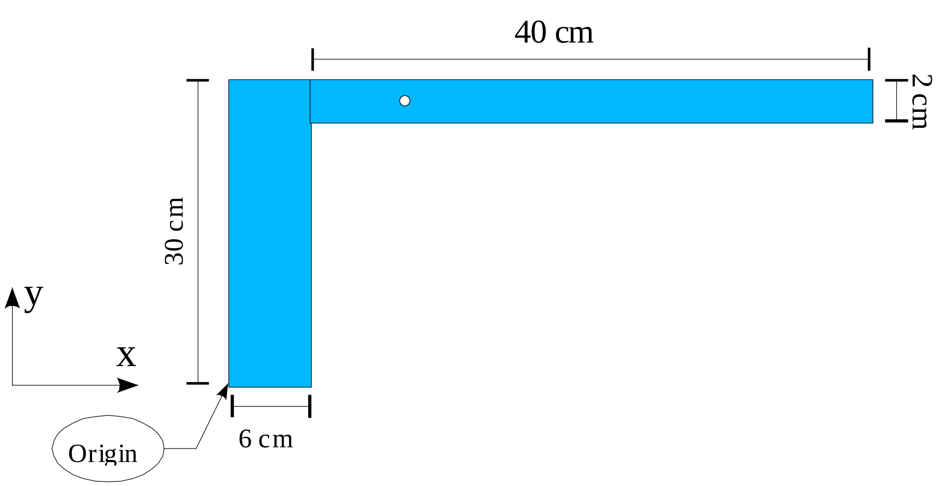
(d) How many revolutions does the propeller make during the first 3 seconds of its motion?

(e) How much work is done by the engine during the first 3 seconds?

III. A carpenter's square is an L−shaped piece of metal of constant mass density ρ. The shorter arm has length of 3 cm and width of 6 cm. The longer arm is of length 40 cm and width of 2 cm.

(a) Find the position of the center−of−mass of this square, using the bottom left−hand corner of the square as the origin of your coordinates. (Hint: the value of ρ should drop out of your final answer.)

(b) A small hole is drilled through the square as shown in the diagram at the position (x=x_{cm}, y=29 cm) and the square is hung from a nail through that hole in the configuration shown below (*i.e.*, the bottom of the page is down). Is this position a stable, unstable or neutral equilibrium position? Why?



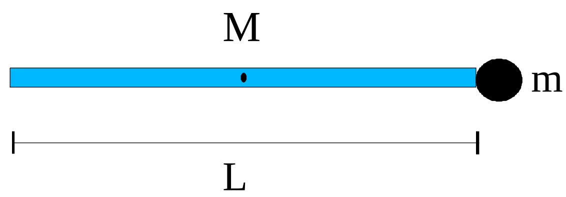
IV. A rod of length L and mass M is held to the wall on a frictionless pivot through the rod's center−of−mass. A small weight of mass m is then stuck on the end of the rod while the rod is horizontal and the rod begins to swing. Note that the moment of inertia of a rod through its center of mass is $I=(1/12)ML^2$. You can ignore the radius of the added weight.

(a) What is the gravitational torque on the system?

(b) What is the moment of inertia of this system?

(c) What is the angular acceleration, α, of the system at the beginning of its swing?

(d) What is the angular velocity, ω, at the bottom of its swing (when the rod is vertical)?



V. Consider an elastic collision between a car of mass M and another of mass m. Assume that they are moving towards each other, each with the same initial velocity V, and that $M > m$.

(a) Find the final velocity U of the car with larger mass (M), and v, the final velocity of the car with smaller mass (m). *(Please be sure to write clearly so that we can tell* M *apart from* m, *and* U *apart from* V *when grading!)*

For parts (b) − (d) (but not for (a)!) use the following numerical values: M=3000 kg, m=1000 kg and V=5 m/s:

(b) Calculate the *change* in momentum of each of the cars (take care of the signs!). Is momentum conserved? Why?

(c) Consider the forces exerted by each car on the other during the collision. Which car (if any) exterts more force on the other?

(d) Given that it's sudden acceleration/deceleration that causes injury, and taking into account your answer to part (c), is it safer to be in a lead−shielded sport utility vehicle (M) or a VW Beetle (m)? Why?