Name: ______________________________________ Section _________ CM ___________

Exam 2

ES 204 Mechanical Systems

January 20th, 2006

Problem 1 _______ / 30

Problem 2 _______ / 30

Problem 3 _______ / 40

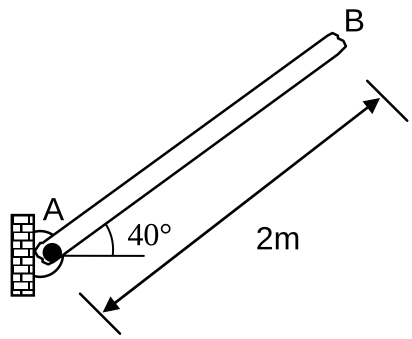
Exam score ______ / 100

Instructions:

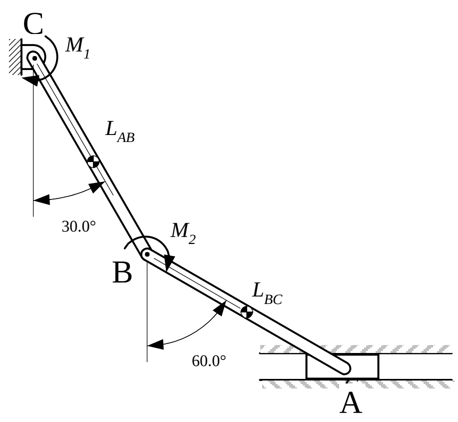
- The exam is closed-book, closed-notes, and closed-hard-drive. Laptop computers running Maple or other math software are permitted. Network connections are not allowed.
- Two 8.5”x11” help sheets with notes written on one side are permitted. Help sheets may not contain example problems.
- Show all work for credit.
- Turn in your help sheet with the exam.
- Put your section number and CM number on all pages. Put your name on this cover page only.

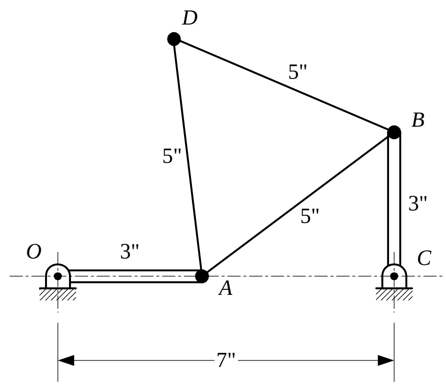
Problem 1

1a. [8 points] The uniform bar AB has an angular velocity of 4 rad/s CCW about *A*. Calculate the bar's angular momentum, ***L*** about the pin at *A*. I_G = 2 kg-m^2, and m = 6 kg.

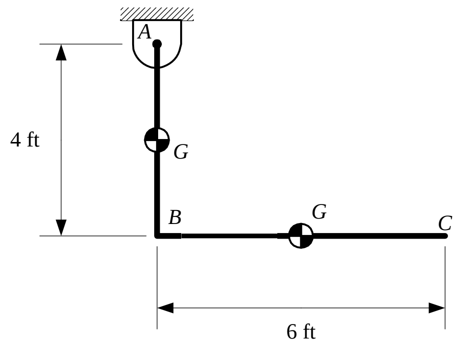


1b. [6 points] Locate the instantaneous center for each body labeled *AB*.

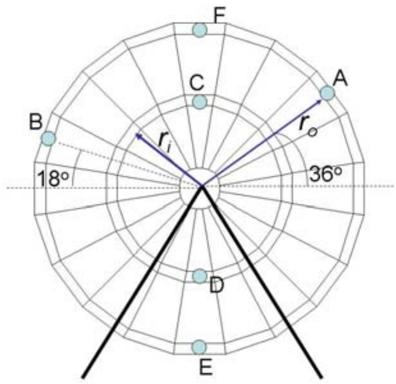


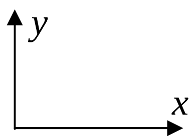


1c. [10 points] Two homogeneous slender rods *AB* and *BC* are welded perpendicular to each other at B. If the welded rods have an angular velocity of 1 rad/s CCW, determine the kinetic energy of the system using m_{AB}= 1 slug, m_{BC} = 2 slug, I_{AB} = 4/3 slug-ft^2, and I_{BC} = 6 slug-ft^2.



1d. [6 points] The ferris wheel has an outer radius r_o of 24 ft, a clockwise angular velocity of 1/2 rad/s and a counter-clockwise angular acceleration of 1/3 rad/s^2. Determine the acceleration of the passenger at *F*, directly above the hub. Express your answer in *x*-*y* coordinates.





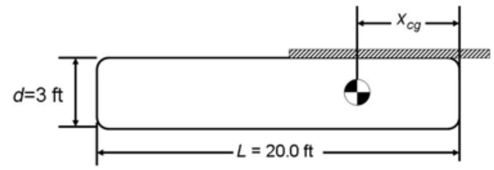
Problem 2 ‘t/LAD’ [30 points]

The trapeze / lanyard air drop (t/LAD) launch is an innovative method for airborne launch of a payload carrying rocket (shown on cover). The release sequence involves several steps. Initially, the rocket body drops freely from the carrier aircraft (Figure a)) until the 6 ft lanyard stops the vertical motion of point *A* (Figure b)). Assume point A is a free to move horizontally when the lanyard is fully extended.

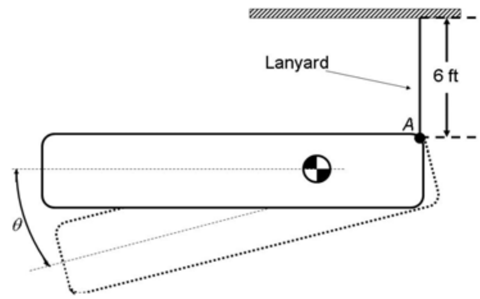
<u>Find the equations required to determine</u>: The rocket’s angular velocity immediately after the lanyard becomes taut (Figure b)).
Your solution should consist of a table of unknowns, and a numbered collection of equations.

Hint: Consider the carrier aircraft velocity to be zero (the test is done in a wind tunnel). The mass of the rocket, the rocket’s mass moment of inertia, and distance x_{cg} are all known parameters.

a)



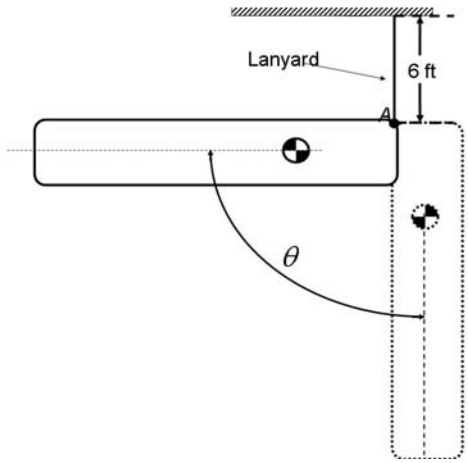
b)



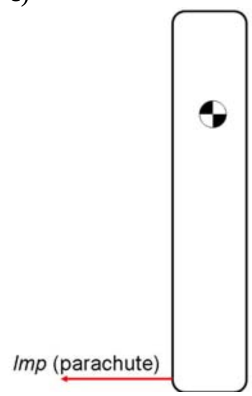
Problem 3 't/LAD' part deux [40 points]

After the lanyard is fully extended the rocket rotates to approximately 90^o. During the rotation, from horizontal to vertical, aerodynamic forces exert a clockwise moment equal to $1200\sin(\theta)$ ft-lb (Figure b)). Just after reaching vertical, the lanyard is cut, and a parachute applies an impulse (Figure c)).

b)



c)



Assume, for this problem, the angular velocity at horizontal is known and treat point A as a fixed point (pinned). The mass, mass moment of inertia and dimensions are known as in Problem 2. <u>Find the equations required to determine</u>:

(i) The rocket's angular velocity when it reaches vertical (Figure b)).
(ii) The reactions at *A* when the rocket reaches vertical (Figure b)).
(iii) The impulse required to stop the rocket's *angular* velocity at vertical. Assume the lanyard force and aerodynamic force is zero (Figure c)).

Your solution should consist of a table of unknowns/equations and a numbered collection of equations.