Your Name: _____

TA name and section time: _____

T&AM 203 Final Exam

Friday May 19, 2006, 2-4:30 PM

Draft May 15, 2006

5 problems, 25^+ points each, and 90^+ minutes.

Please follow these directions to ease grading and to maximize your score.

a) No calculators, books or notes allowed. A blank page for tentative scrap work is provided at the back. Ask for extra scrap paper if you need it. If you want to hand in extra sheets, put your name on each sheet and refer to that sheet in the problem book for the relevant problems.

b) Full credit if

↖•↗ →free body diagrams← are drawn whenever force, moment, linear momentum, or angular momentum balance are used;

$\underline{\bullet}$ correct vector notation is used, when appropriate;

↑→ any dimensions, coordinates, variables and base vectors that you add are clearly defined;

± all signs and directions are well defined with sketches and/or words;

→| reasonable justification, enough to distinguish an informed answer from a guess, is given; you clearly state any reasonable assumptions if a problem seems *poorly defined*;

• work is I.) neat,
II.) clear, and
III.) well organized;

• your answers are TIDILY REDUCED (Don't leave simplifiable algebraic expressions.);

□ your answers are boxed in; and

≫ Matlab code, if asked for, is clear and correct. To ease grading and save space, your Matlab code can use shortcut notation like "$\dot{\theta}_7$ `= 18`" instead of, say, "`theta7dot = 18`". You will be penalized, but not heavily, for minor syntax errors.

c) Substantial partial credit if your answer is in terms of well defined variables and you have not substituted in the numerical values. Substantial partial credit if you reduce the problem to a clearly defined set of equations to solve.

$$\underline{\mathbf{v}}_{\mathrm{B}} = \underline{\mathbf{v}}_{\mathrm{A}} + \underline{\boldsymbol{\omega}} \times \underline{\mathbf{r}}_{\mathrm{B/A}} + \underline{\mathbf{v}}_{rel}$$

$$\underline{\mathbf{a}}_{\mathrm{B}} = \underline{\mathbf{a}}_{\mathrm{A}} + \underline{\boldsymbol{\omega}} \times (\underline{\boldsymbol{\omega}} \times \underline{\mathbf{r}}_{\mathrm{B/A}}) + \dot{\underline{\boldsymbol{\omega}}} \times \underline{\mathbf{r}}_{\mathrm{B/A}} + 2\,\underline{\boldsymbol{\omega}} \times \underline{\mathbf{v}}_{rel} + \underline{\mathbf{a}}_{rel}$$

$$\frac{1}{\rho} = \frac{y''}{(1+y'^2)^{3/2}}$$

Problem	0:	/-125
Problem	1:	/25
Problem	2:	/25
Problem	3:	/25
Problem	4:	/25
Problem	5:	/25
TOTAL:		

0) -125 pt In order to *not* get -125 points you need to sign your name below. List here all things you know or have heard about this exam or the early final that are not listed on the course web page. Say from what source you heard or read these things.

Above is listed all I know or have heard about the questions asked above.

Signed _____

(sign clearly and legibly)

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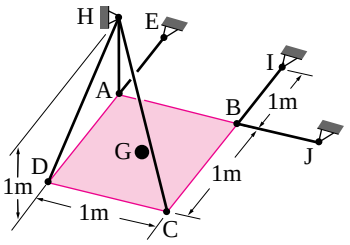
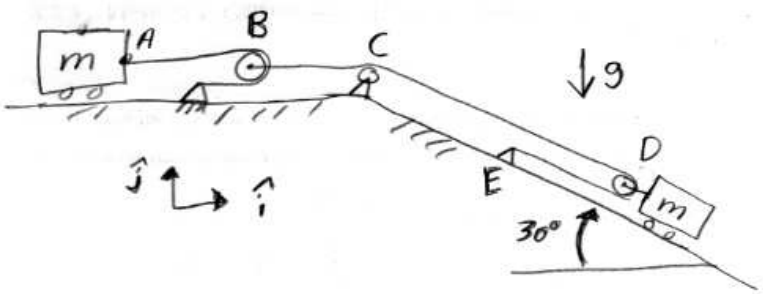
1) (25 pt) A uniform square horizontal rigid plate ABCD has weight mg and is held in place by 6 negligible-mass rods. You need not write long vector formulas if you can confidently justify your answers without them. Find the tension in bar HD.



2) (25 pt) Make the usual assumptions about pulleys and the like. The two masses both have mass m.

a) (20 pt) In terms of some or all of m and g find $\underline{\mathbf{a}}_D \cdot \hat{\mathbf{j}}$. That is, find the y component of the acceleration of point D.

b) (5 pt) Roughly speaking can you explain the answer to part (a). Hint: the answer to part (a) is a number multiplied by a symbol or symbols. That number is close to $2^{\pm n}$ where n is an integer. For example, if the answer to part (a) was $9m/g$ (it isn't) then we could say that answer was close to $2^3 m/g$ and we would have $n = 3$. Use words and/or diagrams to rationalize the appropriate value of n from part (a). That is, somehow the mechanics has in it, approximately, n factors of two. Can you identify each one of these factors. [A very good answer to this part can make up for lost points in part (a)].



3) (25 pt) A person with mass m stands still at the back of a stationary boat with mass M. Then at $t = 0$ she walks the length L of the boat over time T according to the equation

$$x_{p/b} = \frac{L(1 - \cos(\pi t/T))}{2}$$

where $x_{p/b}$ is how far she has moved relative to the boat. Then for $t > T$ she stands still in the front of the boat.

a) (5 pt) Make a plot of $x_{p/b}$ vs t (put t on the "x" axis). Label key points on the "x" and "y" axes in terms of m, M, T and L.

b) (10 pt) Make a plot of x_b vs t, labeling key points on the axis as for part (a). x_b is the absolute position of the boat relative to a fixed reference frame. Assume the boat moves frictionlessly on the water.

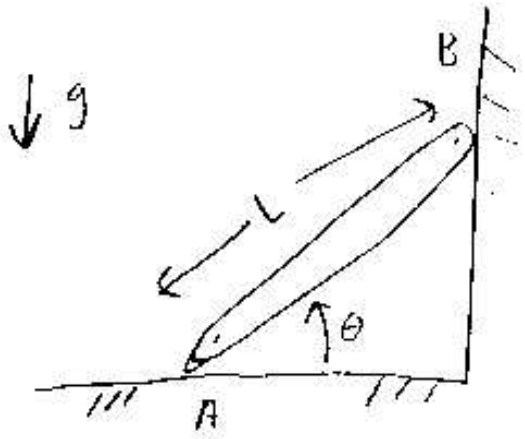
c) (5 pt) For parts (c & d) assume that the boat *has* friction with the water. The drag force is proportional to the boat speed:

$$F_{drag} = cv_b.$$

Eventually, as $t \to \infty$, the boat speed tends to zero and the system comes to rest. What is the net impulse of the force of the water on the boat? That is, evaluate $\int_0^\infty F_{drag}\, dt$ (using basic mechanics principles this is a short calculation).

d) (5 pt) What is $x_b(\infty)$? That is, after all has come to rest how far will the boat have moved? Show a plot of x_b vs t.

4) (25 pt) A uniform ladder with mass m and length L slides on a slippery floor and against a slippery wall. It is released from rest at angle θ. Immediately after release find the angular acceleration of the rod. Answer in terms of some or all of θ, g, L, m, $\hat{\mathbf{i}}$, $\hat{\mathbf{j}}$ and $\hat{\mathbf{k}}$. If you think you need I_G, I_A or I_B you can recall them or derive them or, for less credit, leave them in your final answer.



5) (25 pt) A spool (like the movie *Heat Treatment of Aluminum* shown in lecture), with outer radius R rolls without slip on a flat horizontal surface. The film is at a radius r and is being pulled with a horizontal force F. At the moment in question the velocity of the middle of the spool is $v\,\hat{\mathbf{i}}$. The mass of the spool is m and its moment of inertia about its center of mass is I_G. What is the acceleration of point A on the spool which is, at the instant in question, touching the ground. Answer in terms of some or all of m, I_G, r, R, g, v, F, $\hat{\mathbf{i}}$ and $\hat{\mathbf{j}}$.