Your TA, Section # and Section time:

Your name:

Cornell TAM 2030

Final Exam

No calculators, books or notes allowed.

5 Problems, 150 minutes total.

May 8, 2009 (Clarifications added on 5/9/09)

Directions. To ease your TA's grading and to maximize your score, please:

- Draw **Free body diagrams** whenever force, moment, linear momentum, or angular momentum balance are used.
- Use correct **vector notation**.
- ✓+ Be (I) neat, (II) clear and (III) well organized.
- □ TIDILY REDUCE and box in your answers (Don't leave simplifiable algebraic expressions).
- >> Make appropriate `Matlab code` clear and correct.
  You can use shortcut notation like "$\dot{\theta}_7$ `= 18`" instead of, say, "`theta7dot = 18`".
  Small syntax errors will have small penalties.
- Clearly **define** any needed dimensions $(\ell, h, d, \ldots)$, coordinates $(x, y, r, \theta \ldots)$, variables $(v, m, t, \ldots)$, base vectors $(\hat{\boldsymbol{\imath}}, \hat{\boldsymbol{\jmath}}, \hat{\boldsymbol{e}}_r, \hat{\boldsymbol{e}}_\theta, \hat{\boldsymbol{\lambda}}, \hat{\boldsymbol{n}} \ldots)$ and signs $(\pm)$ with sketches, equations or words.
- **Justify** your results so a grader can distinguish an informed answer from a guess.
- If a problem seems *poorly defined*, clearly state any reasonable assumptions (that do not oversimplify the problem).
- ≈ Work for **partial credit** (from 60–100%, depending on the problem)
  - Put your answer is in terms of well defined variables even if you have not substituted in the numerical values.
  - Reduce the problem to a clearly defined set of equations to solve.
  - Provide Matlab code which would generate the desired answer (and explain the nature of the output).
- Put your name on each extra sheet, fold it in, and refer to it at the relevant problem.
  Note the last page is **blank** for your use. Ask for more extra paper if you need it.

Problem 1: ____/25

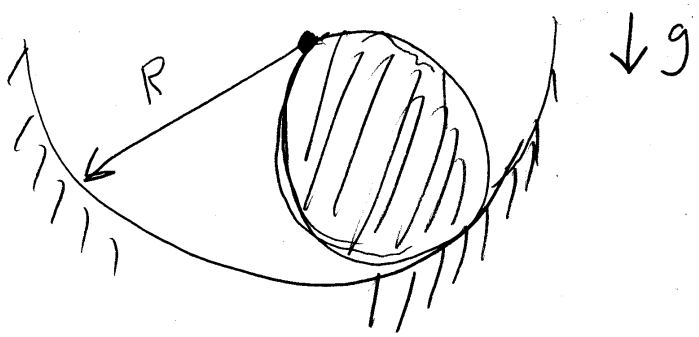
Problem 2: ____/25

Problem 3: ____/25

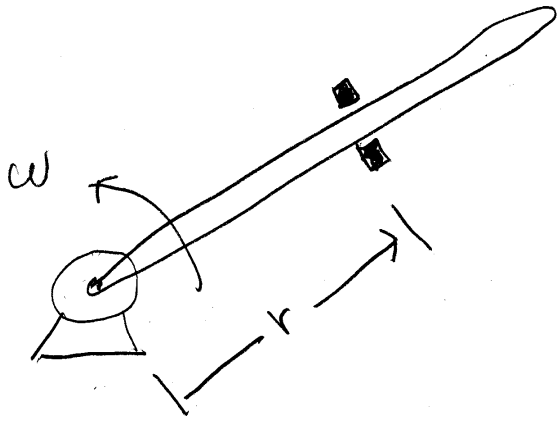
Problem 4: ____/25

Problem 5: ____/25

1) A uniform disk with mass m and diameter R rolls back and forth in a trough with radius R. Assuming small oscillations what is the period of oscillation. Answer in terms of some or all of R, g and m.



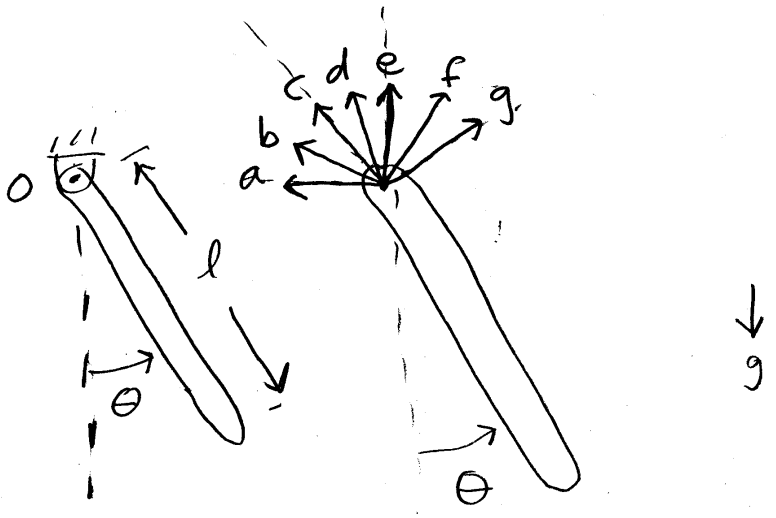
2) A small bead m slides without friction on a straight rod which is rotating at constant ω about a point on the rod. Neglect gravity. 2D. Find $\ddot{r}$ in terms of some or all of r, $\dot{r}$ and ω.



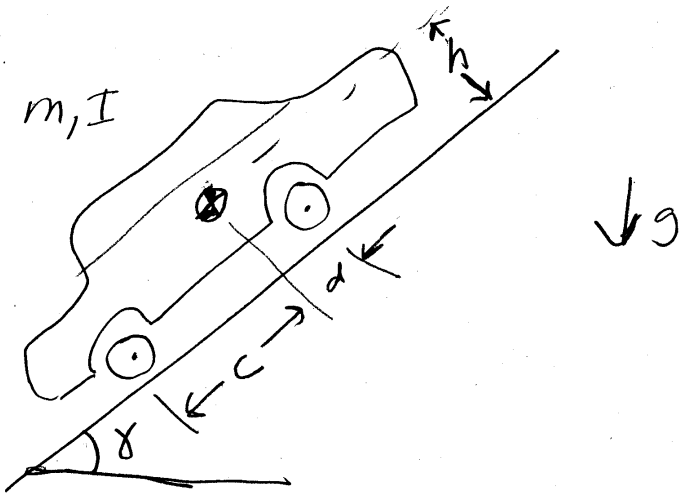
3) A uniform stick with mass m and length ℓ swings from a frictionless hinge at 0.

a) Find the equation of motion. That is, find $\ddot{\theta}$ in terms of some or all of $\theta, \dot{\theta}, \ell, m$ and g.

b) The partial free body diagram shows some conceivable reaction forces at O. With θ positive as shown, which of these, could be several or all, are you confident are in the wrong direction (a,b,c,d,e,f,g)? Justify your answer in a manner that is fully convincing.



4) A rear-wheel drive car attempts to drive uphill. Assume it does not tip over. What is the steepest slope γ it can go up without the rear wheel sliding? Answer in terms of some or all of m, c, d, h, g, μ and the moment of inertia about the center of mass I.



5) A particle m is acted on by gravity and a cubic drag force $F_D = cv^3$ that opposes its motion. Find $\ddot{x}$ in terms of some or all of $x, y, \dot{x}, \dot{y}, m, g$ and c.