Your year in school (semester, degree sought):

Your name:

Cornell MAE 4735/5735

Prelim 2

Nov 8, 2012

No calculators, books or notes allowed.

3 Problems, 90 minutes (+ up to 90 minutes extra)

How to get the highest score?

Please do these things:

- Draw **Free body diagrams** whenever force, moment, linear momentum, or angular momentum balance are used.
- Use correct **vector notation**.
- A+ Be (I) neat, (II) clear and (III) well organized.
- ◻ TIDILY REDUCE and $\boxed{\text{box in}}$ your answers (Don't leave simplifyable algebraic expressions).
- >> Make appropriate `Matlab code` clear and correct.
  You can use shortcut notation like "$T_7 = 18$" instead of, say, "`T(7) = 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).
- **Extra sheets.** 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 4: ______ /25

Problem 5: ______ /25

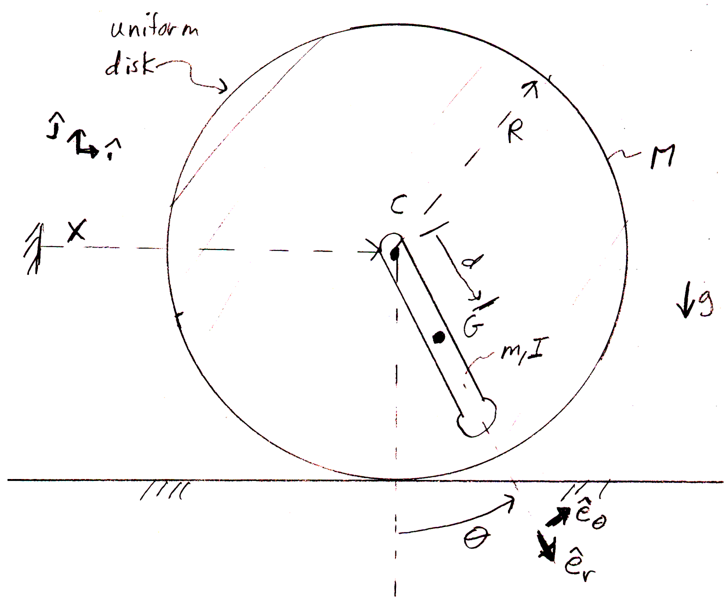
Problem 6: ______ /25

1) 2D. A uniform disk (mass M, radius r) rolls without slip on level ground. Hanging from it's center C is a pendulum (with mass m, moment of inertia I about it's COM, and distance d from C to the pendulum's COM at G). Answer all questions in terms of $x, \dot{x}, \theta, \dot{\theta}, \hat{\imath}, \hat{\jmath}, \hat{e}_r, \hat{e}_\theta, M, m, r, d$ and I, or an appropriate simplified subset of these.

(1) Write 2 scalar equations from which one could solve for $\ddot{x}$ and $\ddot{\theta}$.

(2) For small motions near $x = 0$ and $\theta = 0$ write the equations in standard vibration form, finding the components of the matrices M and K.

(3) By *any* means find just one normal mode: give the value of ω, the components of $\vec{v}$, and describe the mode in words.

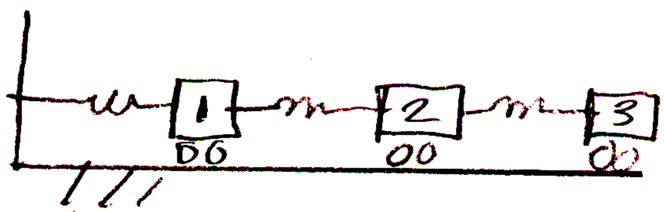


2) Consider the one-D arrangement of three unequal masses and three unequal springs shown. Write Matlab code that would

plot the deflection (from equilibrium) of the first mass as a function of time.

Pick non-trivial numerical values for all variables (that is, do not pick variables that especially simplify the problem).

- The initial deflections of the masses are given as $\vec{x}_0 = [111]'$.
- The initial velocities are zero.
- Use techniques from vibrations (i.e., not ode23 or Euler's method).
- As much as possible, have Matlab do the calculations (i.e., don't try to find normal modes by hand calculations or intuition).
- You can assume that none of the normal modes have $\omega = 0$.



3) 1D. Two *unequal* masses are connected to each other, and nothing else, by one linear spring. Find and describe as many normal modes as you can. That is, clearly give the mode shapes and frequencies in terms of m_1, m_2 and k. As always, clearly justify your results.