****On the top of every page, write the following****
—Please print clearly (for computer text recognition)—

Your netID (xyz*lmn*) & **name**	Problem number and page number of that problem

Cornell ME 2030

No calculators, books or notes allowed.

Prelim 2

Thursday April 8, 2021, 6:30 - 8 PM$^+$

3 Problems, 90 minutes (+ 90 minutes extra time)

How to get the highest score?

Please do these things:

PDF scans. Start each problem on a clean sheet. Only write on one side.
Put ***your name, *net ID, *problem number** and ***page number, starting with 1 for each problem** on the top of every side of every sheet. **At the end:**
—Scan your 3 exam problems to 3 pdf files,& check them for completeness and quality; only one (possibly multi-page) file per problem
—Filenames should be your netID-problem number (e.g., alr3-2.pdf)
—Upload each problem separately to Canvas —Check on Canvas that it has been received before leaving the exam;

- Draw **Free body diagrams** whenever force, moment, linear momentum, or angular momentum balance are used.
- $\vec{\bullet}$ 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 simplifiable algebraic expressions).
- >> Make appropriate `Matlab code` clear and correct.
You can use shortcut notation like "$\phi_7 = 2\pi$" instead of, say, "`phi(7) = 2*pi;`".
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 ($\hat{\imath}, \hat{\jmath}, \hat{e}_r, \hat{e}_\theta, \hat{\lambda}, \hat{n} \ldots$) and signs ($\pm$) with sketches, equations or words.
- $\rightarrow\!|$ **Justify** your results so a grader can distinguish an informed answer from a guess. If you quote a fact that a grader might doubt your understanding of, explain it. Especially if it is not commonly used.
- If a problem seems *poorly defined*, clearly state any reasonable assumptions (that do not oversimplify the problem).
- $\approx$ 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 (unless specifically precluded).
- **Extra sheets.** If live, Ask for more extra paper if you need it. Put your name, net ID, problem number and page number on each extra sheet, label it clearly place it in order with it's associated problem.

4) Pendulum. A uniform block (width = w, height = h, mass = m) is suspended by two massless rigid rods AB and CD with lengths L that have ideal bearings at their ends (A,B,C & D). Gravity g causes the pendulum to swing. The pendulum is released from rest (all velocities at $t = 0$ are $\vec{\mathbf{0}}$) at $\theta = \theta_0$.

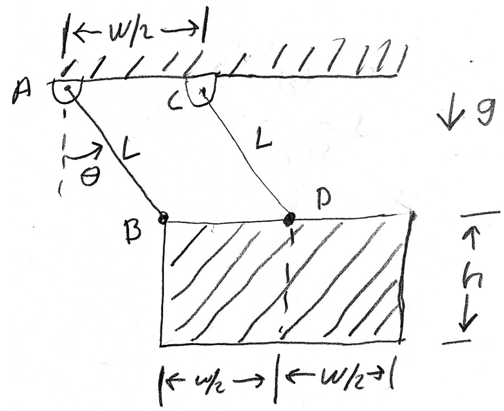
* All answers below should be in terms of some or all of w, h, m, L, g and θ_0.

* Hint: all points on the block have the same acceleration.

a) Immediately after release, find tension AB or CD (your choice)?

b) Find the equations of motion (*e.g.,* find differential equations that, if you solved them would give you the motion.)

c) Find tensions AB and CD (both of them) when the pendulum has swung down to $\theta = 0$.

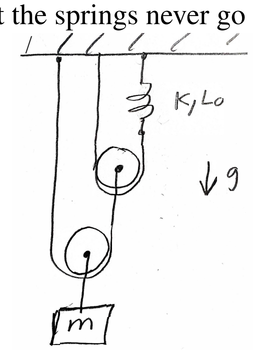


5) Mass, pulleys and spring. A mass m hangs from two ideal pulleys and ideal ropes and a spring (k, L_0). Gravity g is pulling it down. The left rope has length L_1 and the right rope has length L_2. You can neglect the radii of the pulleys, or not, your choice. Answer the questions below in terms of some or all of k, L_0, L_1, L_2, m and g.

Assuming the strings have positive tension, a possible motion of the mass is $y = y_0 + d\ \sin(\lambda t)$.

a) Find λ.

b) Find the biggest possible value of d so that the springs never go slack.



6) Vibrations. Two masses are held by three springs. Assume all springs are relaxed in the equilibrium configuration. Measure displacements relative to that equilibrium.

a) Write the governing equations in matrix form.

b) Someone claims that if $k_2 = k_1, k_3 = 4k_1$ and $m_2 = 2m_1$ that a normal mode of vibration is $[x_1, x_2]' = \sin(\lambda t)[1, -1]'$ for some appropriate λ.

Are they right?

(1 point for a correct guess, more points for convincing reasoning).