Your lab TA name, and Lab Section day: Y

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Cornell ENGRD 1170 Quiz 2

No calculators, books or notes allowed. Dec 3, 2009

50 minutes total. No notes. No calculators. No text messaging.

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

- Draw **Free body diagrams** whenever you use balance of forces or balance of moments.
- 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 "θ_7 = `18`" instead of, say, "`theta7= 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 ($\hat{\imath}, \hat{\jmath}, \hat{e}_r, \hat{e}_\theta, \hat{\lambda}, \hat{n} \ldots$) 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.

44

1a) A car with mass m has motor, gears and wheels such that the forward force the wheels can supply is

$$F_w = F_0 - c'v$$

where F_0 and c' are constants and v is the speed of the car. Also acting on the car is air drag following the law

$$F_d = \frac{1}{2} c_d \rho A v^2$$

where c_d is the drag coefficient of the car, ρ is the density of air and A is the frontal area of the car. Answer all of the following questions in terms of some or all of the constants given above.

1a) Just when the car starts what is its forward acceleration a_{start}?

$$\frac{dv}{dt} = \frac{F_0}{m} - \frac{c'v}{m} - \frac{C_d \rho A v^2}{2m} \quad \text{close to } v = 0 \quad \boxed{\frac{dv}{dt} = \frac{F_0}{m}}$$

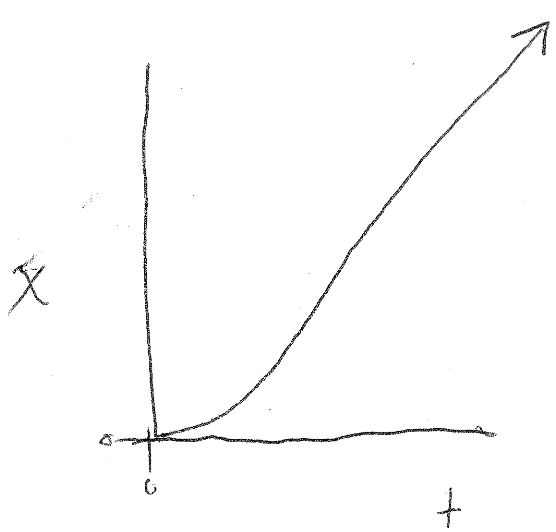
1b) What is the top speed v_{top} the car can reach on level ground?

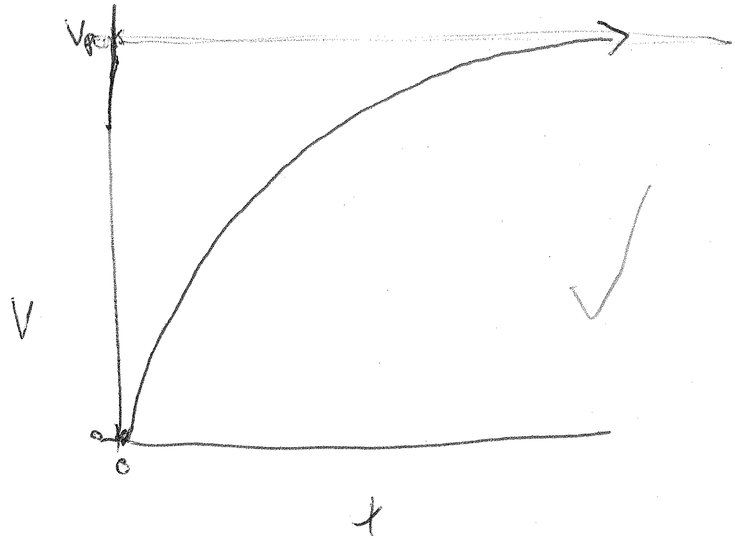
$$V_{peak} \quad \frac{c' - \sqrt{(c')^2 - 4(-\frac{1}{2}) C_d \rho A \cdot F_0)}}{-(C_d \rho A)} = \boxed{\frac{\sqrt{(c')^2 + 2 C_d \rho A F_0} - c'}{C_d \rho A}}$$

1c) As the car goes faster and faster, when its speed is v (for some $v < v_{top}$) what is its acceleration a? (Answer in terms of the constants given as well as the speed v).

$$a = \frac{dv}{dt} = \frac{F_0}{m} - \frac{c'v}{m} - \left(\left(\frac{1}{2}\right) C_d \rho A v^2 \left(\frac{1}{m}\right)\right)$$

1d) Make a plot of v vs t and of x vs t for the car given that it starts at $x = 0$ and $v = 0$. The plots don't need to be quantitatively accurate, but just need to have the right general shapes (curved the right way with well labeled asymptotes).





1) A. $F_\omega - F_d$

$$m\frac{dv}{dt}v = F_0 v - c' v^2 - \frac{1}{2} C_d \rho A v^3$$

$$m\frac{dv}{dt} = F_0 - c v - \frac{1}{2} C_d \rho A v^2$$

when $\frac{dv}{dt} = 0$ $\rightarrow$ $m = 0$

must be larger than $-b$

$$V_{peak} = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} = \frac{-c' - \sqrt{(c')^2 + 4(\frac{1}{2} C\rho A \cdot F_0)}}{(C_d \rho A)}$$

+

10/10

A

2) a) Assume you could change nothing but the gear box in the car from the previous problem (e.g., same motor, same wheels, same total mass, same air, same shape car). If you picked just the right dissipation-free gear box, how fast could you make the top speed of the car? Answer in terms of some or all of m, F_0, c', ρ, A and c_d?

you can make it go:

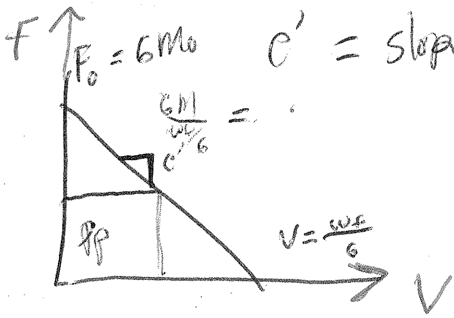
$F_0 = 6 m_0$ $\quad \int \frac{4 P_p}{F_0} - \frac{1}{2} C_d \rho A v^2 = \int \frac{dv}{dt}$

X

b) Why not just equip cars with such a gear and no others? That is, why isn't that particular gear box not the best for all purposes? Be as specific as you can be.

If there was only one gear that output peak power/speed there wouldn't be enough torque in the system to start the car in the first place. X Some gears allow for most torque (1st gear in a car) & others have less of a reduction as to allow a higher V_f. Diff. G's allow for the same P_p but are specialized for torque or velocity ✓

$P_p = \frac{M_0 \omega_f}{4}$ $F_0 = G M_0$ $F_0 - c'V$



$c' = \text{slope} = G^2 \frac{m_0}{\omega_f}$

$= \frac{F_0 V_f}{4}$

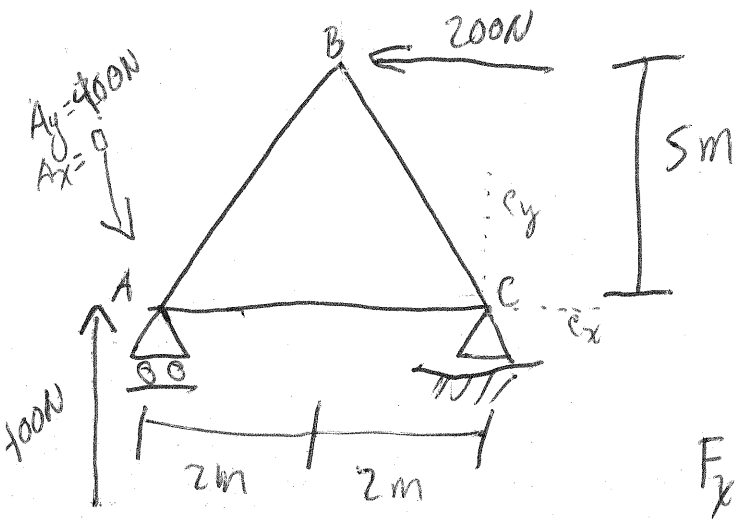
$= \frac{G M_0 V_f}{4}$

3/8

— with alot of acceleration

1/2

3) Draw any 3 bar truss that you like. Apply any non-zero load that you like. Carefully calculate the tension in any bar that you like. Your problem and solution need to be so clear that your work can be quickly evaluated and graded. You may use numbers or symbols (your choice) to define lengths, angles and loads. Draw big and clear.



rotation

$\sum M_C = 0$

$A_y \; 400N \cdot 4m + -200N\,5m + B_y 2m = 0$

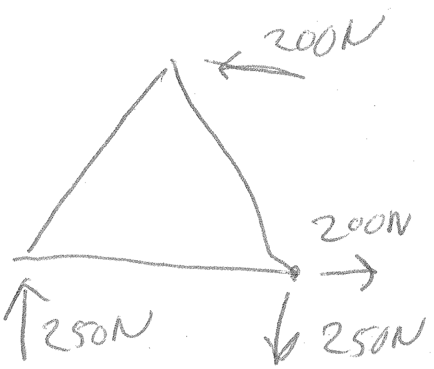
$\boxed{B_y} = \frac{1000Nm - 1600Nm}{2m} = \boxed{-200N}$

$F_x = B_x + A_x + C_x = 200N + 0 + C_x = 0$

$\boxed{C_x = -200N}$

$F_y = 0 = A_y + B_y + C_y = 400N - 200N + C_y = 0$

$\boxed{C_y = -200N}$



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4) A glass of water, not totally full, is on a scale. You slowly put a finger into the water without touching the glass. When you put your finger in the water does the reading on the scale go up (how much?), down (how much?) or stay the same. Your answer must include convincing reasoning. Define and variables you need (e.g., density of water, density of finger, volume of water in the glass, area of the bottom of the glass, etc).

The reading stays the same

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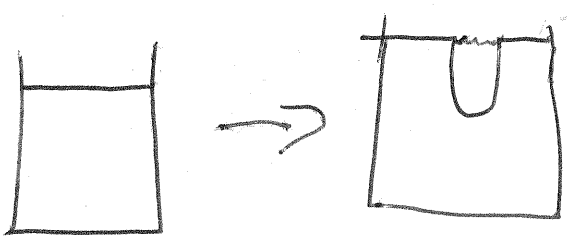

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The weight of the water does not change, and by incerting a finger (Suppoted from above! so so F_{down}) only displaces the Fingers worth of water volume.

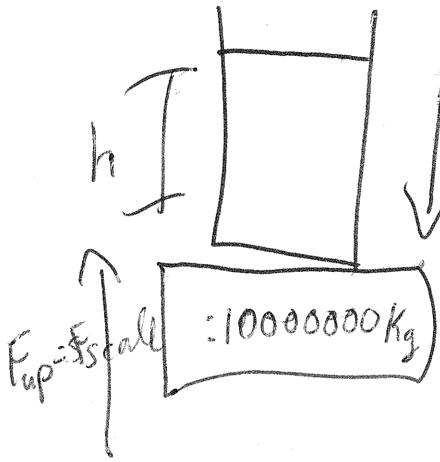
density of H2O

$$mg = \rho V_w g$$

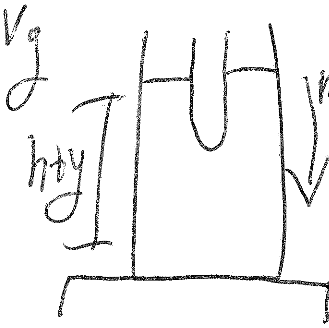
volume water, accel gravity

volume finger

$$mg = \rho (V_w - V_f) g + \rho V_f g$$



$mg = \rho V g$



$mg = \rho V g + \rho V g$

5) Two parallel plates with areas A are separated a distance h from each other with a viscous fluid in between with viscosity μ. The bottom plate is fixed and the top one is dragged in its plane with speed v. What is the force needed to drag the plate? Assume the plates are very small, that h is much smaller than that and that v is small (Kirby lecture).

μ = viscosity $\left(\frac{?}{s}\right)$ = flow rate

$$V = \frac{h}{\mu}$$

$$\sigma = (\mu)(\text{modulus})$$

$$\boxed{F = \frac{h}{\mu} \cdot \text{modulus}}$$

X

0/10

6) Comment critically on any one point from Professor Zellman Warhaft's lecture about Engineering and society. Explain it clearly as if to someone who did not see the lecture (e.g., Prof. Ruina who did not see the lecture). Answer the best you can in no more than 5 minutes.

There are ~~so~~ many topics in Engineering that are controversial. Examples are, bio research that allows us to clone or make glow in the dark pigs, but also things like ~~solar~~ wind power. Generally for ~~solar~~ wind power, the best wind is ~~also~~ in the most open/ hmm secluded areas ... namely those that ecofriendly people also want to protect & keep human influence out of. (ie windmills on tops of mtns).

Proff. Warhaft advises that the progress we can make will never please everyone - some will fear how fast tech progresses while others always want more improvements.

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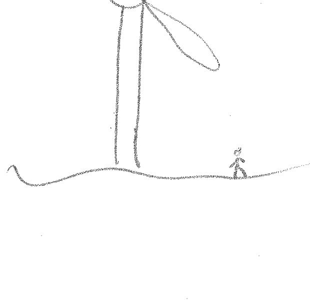

7) Describe an experiment to measure the Young's modulus E of a given material. How would you load what shape of material? What would you measure? Write a formula for E in terms of the quantities you would measure. Draw clear sketches with all quantities clearly defined by the sketch or in words.

Blocks/slabs are easy to measure because they have easily difinded dimensions & can be supported well. ✓

An ~~The~~ Equation ~~the~~ ~~yongs~~ with E in it is

deformation $= \frac{1}{4}\frac{T l^3}{h^3 w E}$ when a ~~b~~ bar is supported at two ends by roller supports and loaded with masses $(m \cdot a_{grav}) = T$. By measuring the dimensions & deformation of the bar at the center, E can be calculated

A set up may look like

9/10

8) Write Matlab commands that would draw a round circle.

```
function circle
t=0:.01:pi;
x=cos(t);
y=sin(t);
r=(x^2);
v=(y^2);
plot(t,r);
hold on;
plot(t,v);
axis equal;
end
```

2*

3/10

9) Circle all of the things on the following list that can be purchased from McMaster Carr: Clock, ~~spring~~, ~~valve~~, solder, drill bit, scissors, pulley, bicycle, tricycle, tweezers, magnifying glass, scale, coat hook, office chair, toilet plunger, the Swedish National flag, and a USB flash drive.

parts for these ... almost a whole bike

3/10