AME 101 Fall 2017
Lecture homework #2
Assigned: 9/15/2017
Due: 9/22/2017, 4:30 pm, in the drop box in OHE 430N (back room of the OHE 430 suite of offices, where the Xerox machine is located) (Note this is a different box than my personal mailbox in the same room).

FYI, some of you have been asking if is there a source of more examples and more problems for statics. A cheap text is the *Schaum's Outline Of Statics and Mechanics of Materials* (see http://www.mhprofessional.com/product.php?isbn=0070458960). (A very old book but the information is still current and relevant to this course.)

Problem #1 (25 points)

The Nusselt number (Nu) and Rayleigh number (Ra) for heat transfer between a vertical wall of height L at temperature $T_{surface}$ and a fluid at temperature T_{fluid} are defined by

$$Nu \equiv \frac{hL}{k_f}; Ra \equiv \frac{g\beta\left(T_{surface} - T_{fluid}\right)L^3}{\alpha\nu}$$

where h is the convective heat transfer coefficient (units W/m^2°C), k_f is the thermal conductivity of the fluid (=0.603 W/m°C for water), g is the acceleration of gravity, β is the thermal expansion coefficient (=2.12 x 10^{-4}/°C for water), α is the thermal diffusivity (=0.0014 cm^2/s for water) and ν is the fluid kinematic viscosity (0.010 cm^2/s for water).

(a) What are the units of Nu and Ra in the SI system?
(b) For a wall of height L = 2 ft submerged in water with $T_{surface}$ = 32°C and T_{fluid} = 27°C, what is the value of Ra?
(c) For certain conditions, Nu can be estimated by the expression $Nu = 0.10Ra^{1/3}$. For this configuration, using the value of Ra calculated in part (b), what is Nu and what is h?
(d) The formula for heat transfer rate ($\dot{Q}$, units of power, e.g. Watts) is

$$\dot{Q} = hA\left(T_{surface} - T_{fluid}\right)$$

where A is the wall area, i.e. height L x width w. For a wall of width w = 15 inches, what is the heat transfer rate $\dot{Q}$?

Problem #2 (15 points)

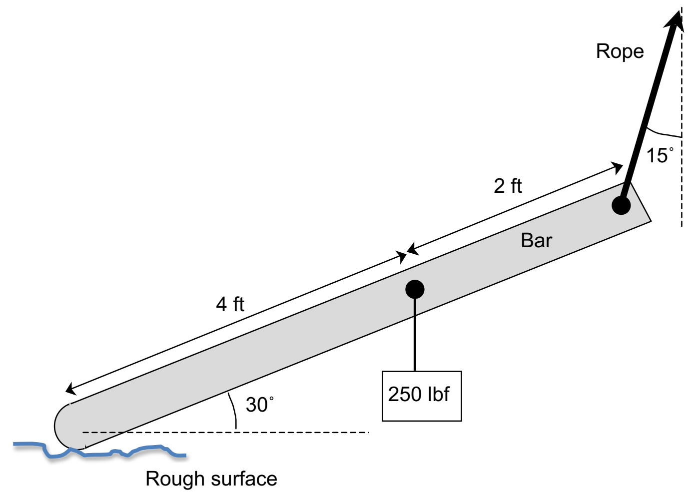
I calculated the normal stress (σ, units force/area, i.e. same as pressure) acting on a telephone pole of height h and diameter d caused by a hurricane wind of speed v in air with drag coefficient C_D, density ρ and dynamic viscosity μ (units (mass)/(length * time), for example kg / (m s)) (don't confuse this μ with the coefficient of friction already discussed) as follows:

$$\sigma = \frac{\rho v}{2C_D} - \rho g h + \sqrt{\frac{\rho^3 v^5 h}{\mu}}$$

Using "engineering scrutiny," what "obvious" mistakes can you find with this formula? There are at least 5, but list only the 4 you are most certain of.

Problem #3 (30 points)

A 6 ft long bar of negligible weight has one end resting on a rough horizontal surface (with friction) and the other end supported by a rope. A 250 lbf weight is hung on the bar as shown in the figure.



(a) What unknown forces are acting on the bar (hint: there are 3), and in what direction do they act? Assume that the surface provides enough friction to prevent the bar from sliding.
(b) Write down all equations needed to solve for these 3 unknown forces (hint: you need 3 equations since there are 3 unknown forces!)
(c) Solve these equations to find the 3 unknown forces
(d) What is the minimum coefficient of friction needed to prevent the bar from sliding?
(e) Repeat (a) - (d) if instead of a rope supporting the right side of the bar, the rope is removed, a wheel is attached to the right side of the bar and this wheel rests against a **vertical** wall.

Problem #4 (30 points)

Reanalyze the "car on a ramp" example in the lecture notes. Suppose that instead of either of the cases analyzed in class, the rear (downhill) wheels are locked and the front (uphill) wheels are free to spin. (There is no cable attached to the car.)
(a) In terms of a, b, c, θ and W, what coefficient of static friction μ_s would be required to keep the car from sliding down the ramp?
(b) What would the force parallel to the ramp at point B ($F_{x,B}$) be?
(c) Repeat parts (a) and (b) if the configuration is reversed, that is, the front wheels are locked and the rear wheels are free to spin. (For the repeat of part (b) compute $F_{x,A}$ rather than $F_{x,B}$).