AME 101, Fall 2016
Midterm exam #1 review
10/18/16

The material on the exam may include the material up through and including Chapter 4 (Statics) but not Chapter 5 (materials and stresses). The material through Chapter 4 includes:

- Units
  - Base and derived
  - USCS and SI
  - $g_c = \frac{32.174 \text{ lbm - ft}}{\text{lbf - sec}^2} = 1$ in USCS units – useful if you have lbm and lbf, you can eliminate both this way
  - $g_c = 1$ in SI units (not needed since we use separate units, kg and N, for mass and force)
- Scrutiny
  - Smoke test – units
  - Function tests
  - Performance test
- Statics
  - Forces – vectors
  - Moments of forces
  - Static equilibrium – in 2D, a free body has 3 degrees of freedom (translation in x and y, rotation about axis orthogonal to x-y plane), so need 3 equations

    $$\sum_{i=1}^{n} F_{x,i} = 0; \sum_{i=1}^{n} F_{y,i} = 0; \sum_{i=1}^{n} M_i = 0$$

    Can also use $\sum_{i=1}^{n} F_{x,i} = 0; \sum_{i=1}^{n} M_{i,A} = 0; \sum_{j=1}^{n} M_{j,B} = 0$

    or $\sum_{i=1}^{n} M_{i,A} = 0; \sum_{j=1}^{n} M_{j,B} = 0; \sum_{j=1}^{n} M_{j,C} = 0$

    The choice of the points A, B and C is arbitrary – pick for convenience
  - Types of boundary conditions – ropes/cables, rollers, pinned joints, fixed support, contact friction

First midterm from 2015 (the problems should look familiar)
(average score was 80.7/100)

Instructions:

80 minutes allowed. The exam is open book *to the extent of your own notes, homeworks and solutions, the optional Wickert textbook and the posted lecture notes only.* Calculators are allowed. Laptop computers are not allowed. Write your answers on the exam sheet; if you mess up or need more space, use the back sides of the pages.

Problem #1 (units) (15 points)

Water has a heat capacity (also called specific heat) of $1.00\frac{calorie}{gram^{\circ}C}$. What is the heat capacity of water in units of $\frac{BTU}{lbm^{\circ}F}$?

Problem #2 (units) (30 points)

The friction factor (f) for flow of a fluid with density ρ (units mass/volume), velocity U, in a pipe of length L and inside diameter d, resulting in a pressure drop ΔP, is defined as

$$f \equiv \frac{\Delta P}{\frac{\rho U^2}{2}\frac{L}{d}}$$

(a) (10 points) What are the units of the friction factor f ?

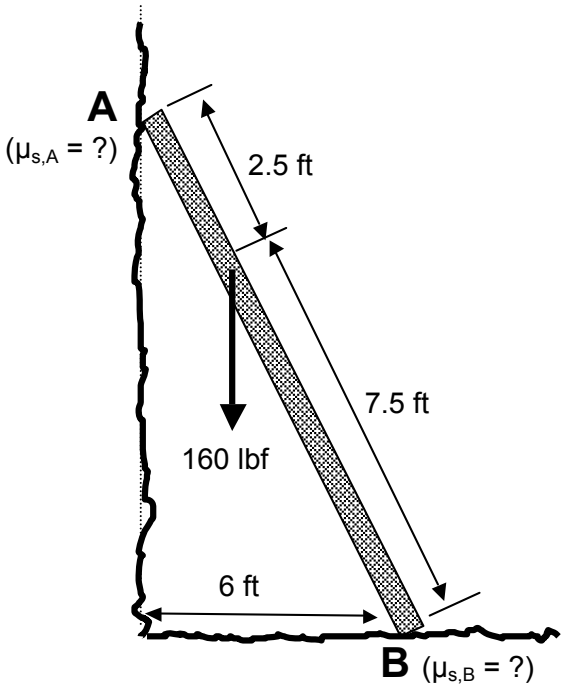
(b) (20 points) For a fluid with density ρ = 62.4 lbm/ft^3, velocity U = 1 m/s, flowing in a pipe of length L = 20 ft and diameter d = 1 inch, resulting in a pressure drop ΔP = 17.39 lbf/in^2, what is the friction factor f?

Problem #3 (statics) (55 points total)

A 160 lbf individual stands 7.5 ft up a 10 foot long ladder whose base rests 6 ft away from the wall as shown in the figure. The ladder rests against a wall at point A and ground at point B. The coefficients of static friction (μ_s) will be different at points A and B for different parts of this problem. The ladder itself has negligible weight.

a) (5 points) Draw **on the figure at right** all the forces acting on the ladder. How many unknown forces are there? List them.

b) (15 points) For the case where there is friction at point B ($\mu_{s,B} \neq 0$), but no friction at point A ($\mu_{s,A} = 0$), write down a complete set of



equations (i.e. as many equations as unknowns) needed to find the unknown forces.

c) (10 points) For this case, solve these equations to find all the forces acting on the ladder.

d) (10 points) For the case of part (c) ($\mu_{s,A} = 0$), what is the minimum coefficient of static friction at point B ($\mu_{s,B}$) required to prevent the ladder from sliding?

e) (5 points) If the weight on the ladder were increased from 160 lbf to 320 lbf, would the minimum coefficient of static friction required at point B increase, decrease or remain the same? You don't have to re-solve the problem, just state your answer and explain why. **No credit without explanation**.

f) (10 points) Suppose instead of having $\mu_{s,B} \neq 0$ and $\mu_{s,A} = 0$ as already analyzed, you had $\mu_{s,A} \neq 0$ and $\mu_{s,B} = 0$. Could you prevent the ladder from sliding in this case? Why or why not? **No credit without explanation.**