AME 101, Fall 2018
Midterm exam #1 review
10/16/18

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 2017 (the problems should look familiar) (average score was 89/100!!!)

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) (25 points)

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

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

(a) (8 points) What are the units of the friction factor f in SI units?

(b) (17 points) For a fluid with density ρ = 62.4 lbm/ft^3, velocity v = 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 in SI units?

Problem #2 (scrutiny) (30 points)

I calculated the power production from a new type of steam turbine as

$$Power = \left(\frac{v_{out}^2}{2} - \frac{v_{in}^2}{2}\right) + \dot{m}C_P\left(T_{out} + T_{in}\right) + \frac{\dot{m}}{\rho}\left(P_{out} - P_{in}\right) - \frac{\dot{m}}{\mu}\left(Nd\right)^2 + 1$$

where T_{in}, P_{in} and v_{in} are the temperature, pressure and velocity of the steam going into the turbine, T_{out}, P_{out} and v_{out} are the temperature, pressure and velocity of the steam leaving the turbine, C_p is the heat capacity of the steam (units Joules/kg°C), $\dot{m}$ the mass flow rate of steam through the turbine (units kg/s), ρ the steam density (kg/m^3), μ the coefficient of dynamic friction in the rotating shaft, N the rotation rate of the shaft (units 1/s) and d the shaft diameter.

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

Problem #3 (statics) (45 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) (15 points) For this case, solve these equations to find all the forces (in units of lbf) acting on the ladder.

d) (5 points) Based on your answer to 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 to prevent the ladder from sliding increase, decrease or remain the same? You don't have to re-solve the problem (but you can if you want), just state your answer and explain why. **No credit without explanation**.