AME 101, Fall 2017
Midterm exam #1 review
10/17/17

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 2016 (the problems should look familiar) (average score was 92.3/100!!!)

Instructions:

80 minutes allowed. The exam is open book *to the extent of the printed version of the course lecture notes, your own notes, homework assignments and solutions, the optional Wickert textbook only.* Calculators are allowed, but no other electronic devices. Write your answers on the exam sheet; if you mess up or need more space, use the back sides of the pages and write "SEE BACK" or something to let the graders know to look for more work.

Problem #1 (units) (20 points)

A quantity called BMEP is often used to quantify the performance of internal combustion engines. Its definition is

$$BMEP = \frac{2\left(Power\right)}{VN}$$

where "Power" is the engine power, V the displacement volume (units length^3) and N is the rotation rate (units 1/time).

(a) (10 points) What are the units of BMEP in the SI system?
(b) (10 points) If P = 200 horsepower, V = 350 in^3 and N = 3600/min, what is BMEP in SI units?

Problem #2 (units) (30 points)

I calculated the net power output (in Watts) for a new type of automotive engine as follows:

$$Power = \left(P_{ex} - P_{in}\right) - \dot{m}_f Q_R + \dot{m}_f C_P \left(T_{ex} + T_{in}^2\right) + \left[FMEP\right] N^2 V_d + 7 \text{ Watts}$$

where P_{ex} = exhaust pressure (units N/m^2), P_{in} = intake pressure (units N/m^2), $\dot{m}_f$ = mass flow rate of fuel (units kg/sec), Q_R = fuel heating value (units Joules/kg), C_P = heat capacity (units J/kg°C), T_{ex} = exhaust temperature (units K), T_{in} = intake temperature (units K), FMEP = Friction Mean Effective Pressure (units of pressure, e.g. N/m^2, a measure of friction losses), N = engine rotation rate (units 1/s), and V_d = engine displacement (units of volume, e.g. m^3).

Using "engineering scrutiny," what "obvious" mistakes can you find with this formula? There are at least 7, but list **only the 4** of which you are most certain.

Problem #3 (statics) (50 points total)

A 6 ft long bar of negligible weight has one end resting on a rough 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) (10 points) 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) (20 points) Write down all equations needed to solve for these 3 unknown forces (hint: you need 3 equations since there are 3 unknown forces!)
(c) (15 points) Solve these equations to find the 3 unknown forces
(d) (5 points) What is the minimum coefficient of friction needed to prevent the bar from sliding?