Your Name _____

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**ME102B, Fall 2018**   **Liwei Lin**

Exam (November 5, 2018)
Close book, Open one formula sheet (both sides)

Problem 1 (40%)

A frictionless gear train system with three spur gears is shown in the figure and the pressure angle is 20 degrees. A 10 hp (horse power) motor is applied on gear C, which is running at 900 rpm in the counterclockwise direction. Gear B has pitch diameter of 15 inch.

$$horsepower = \frac{Force\frac{\pi dn}{12}}{33000},$$ where force has the unit of lb; d is the pitch diameter (inch); and n is rpm.

(a) What is the speed and direction (clockwise or counterclockwise) of gear A? (5%)

(b) What is the output power at gear A? (5%)

(c) Draw free body diagrams of each gear to show all forces and directions. (10%)

(d) Calculate all force magnitudes in (c). (10%)

(e) If gear B is changed to be twice the diameter of the current one in the figure while maintaining the 90° angle as shown by rearranging the gear shaft locations, what are the new answers for (a), (b) and (d)? (10%)
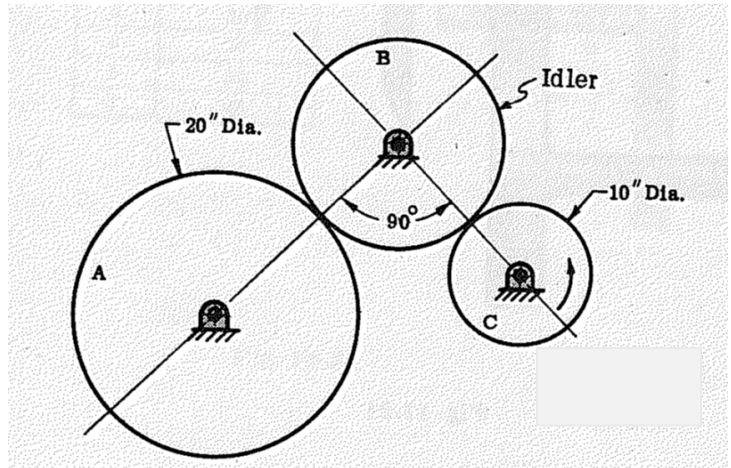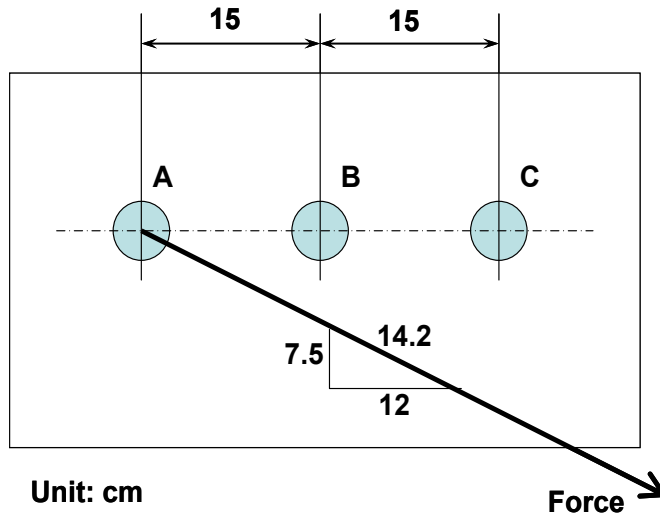
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Problem 2 (30%)
You are asked to design the following joint structure with a rivet group and consider shear failure only. The diameter of the rivets is 20 mm and the allowable shear stress is 110 MPa.
  (a) Draw the free-body diagram to analyze the bolts to show all forces and directions only without calculating the magnitude (15%)
  (b) What is the shear stress at rivet A (in terms of force "F") and the maximum allowable force one can apply in this setup? (15%)

Problem 3 (30%)

A cylindrical pressure vessel has the cross section shown in the figure. This vessel is constrained by using 10 lubricated, M20 x 1.5 bolts (coarse pitch series). The tensile stress area of these bolts is 241 mm^2 and each bolt is tightened with a preload of 33360 Newton. The joint constant C is 0.25 for these bolts. The pressure load in use varies from 0 to a maximum pressure, P_{max}. The fully corrected endurance strength for the bolt material is 124 MPa and the ultimate stress is 276 MPa. We are interested in determining the design parameters.

    (a) Please draw Goodman line and the load line for the bolts in use and mark all important points on the figure. (10%)

    (b) Illustrate the safety factor (for infinite life of the bolt) from your figure in (a) and derive/explain the equation for safety factor. (10%)

    (c) What is the maximum pressure that can be used in this pressure vessel if a safety factor of 3 is used and the effective area that the pressure is applied on the lid having a diameter of 203 mm. (10%)