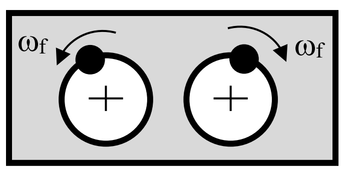
ME 328 – Machine Design
Spring 2019, Homework Set 7

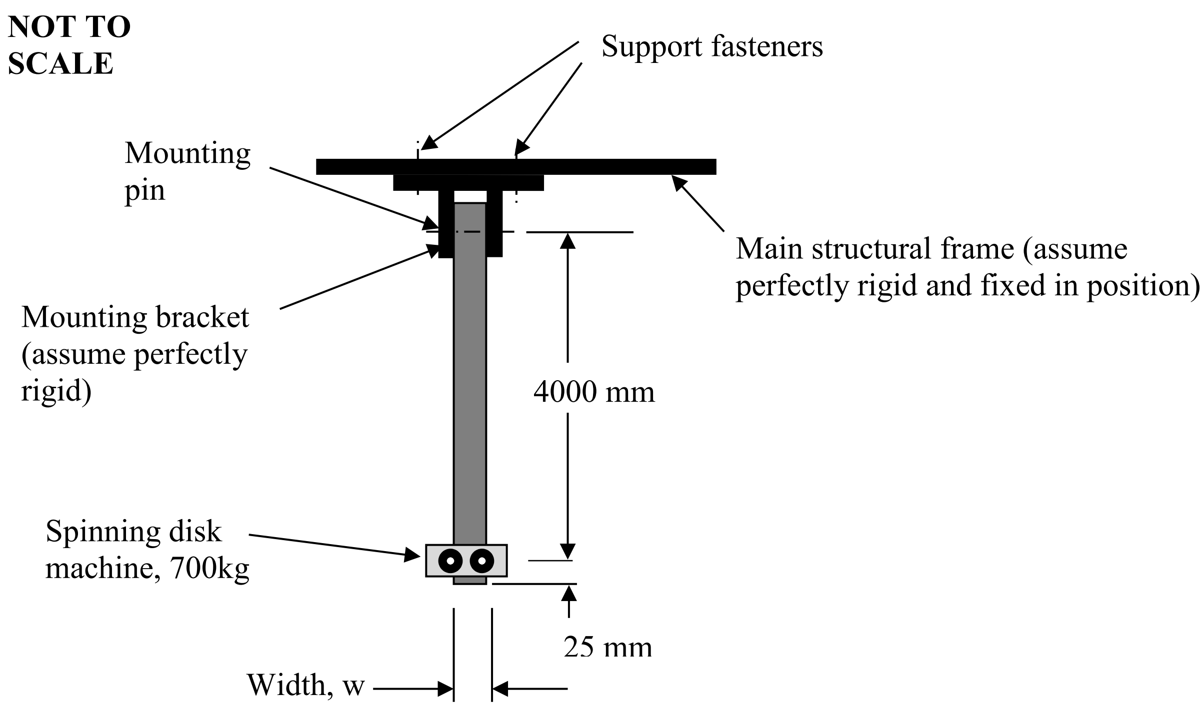
1. **Educational purpose**: *Develop an appreciation for dynamic loading that can produce vibrations within a machine and the effect this may have on stresses. **Pay particular attention to the fact that <u>more</u> material does NOT always result to <u>lower</u> stress!***

   DESIGN PROBLEM (25 pts total) A machine that has a total mass of 700kg (including 2-100kg disks), has two spinning turbine-disks rotating at a speed of ω_f in opposite directions (one disk is spinning clockwise, the other spins counterclockwise). The mass of each disk is 100kg, and the mass is eccentric (not centered on the axis of rotation). The eccentricity is 20mm in each disk. The eccentricities are "in phase" such that the horizontal component of force produced by one disk is equal and opposite to the horizontal component of force produced by the other disk; therefore, cancel out. The vertical components, however, are additive (each disk produces equal force in the same direction as the other). The spinning eccentric masses produce +/- 43.8kN vertical force at 1000RPM {P(t) = 43.8kN sin(ω_ft)}. ***This should be looking familiar – and there is no need to reinvent the wheel, so to speak.***



   The machine with the spinning turbine-disks is attached to the end of a support bar as shown below. For this problem, the disks are spinning at 1000RPM. The support bar has a thickness of 30mm and is 4000mm long made from 5052 H36 aluminum alloy (S_{ys} = 34ksi = 234MPa). Assume the bar has only 1 degree of freedom (axial) and there is only axial load in the bar. State all other assumptions you make. One assumption to make is that the bar does not buckle. For each problem, be sure to include hand-done example work (following the problem-solving standard) to check your computer-based analysis.

   a) (5 pts) On the same graph plot as a function of the width (dimension w) from zero to 50mm:
      i) the static displacement (X_0) of the bar due to P_0 only (43.8kN)
      ii) the actual (dynamic) maximum displacement (X) due to the rotating disks.
   b) (5 pts) On a separate graph, plot the transmitted force as a function of width (w) from zero to 50mm.
   c) (5 pts) The total force is the sum of the transmitted force calculated in part (b) plus the static weight of the spinning disk machine. Plot the stress in the bar due to the total force as a function of width (w) from zero to 50mm.
   d) (5 pts) For 5052 H36, what range of widths will result in a stress below the yield strength? Neglect stress concentrations created by the holes in the bar.
   e) (5 pts) Is the assumption that the spring (the 4000mm bar) has negligible mass reasonably valid? If not, how might the mass affect your conclusions?



Fatigue: Educational Purpose: The "*second law" of machine design – fatigue is enemy #1.*

2. (5 pts) Determine the 10^3 – cycle strength (S_{10^3}) for each condition in the table below. Show all your work. (Note that 10^3 – cycle strength is not modified based on real world conditions.)

3. (5 pts) Determine the 10^6 – cycle strength (modified endurance limit, S_e) for each condition in the table below. Show all your work. Use 99.9% reliability and assume room temperature.

Material	**Surface condition**	**Diameter**	**Load**
AISI 1040	Hot-rolled	0.5 inch	Axial
AISI 1040	Cold-drawn (a.k.a. as-rolled)	0.5 inch	Axial
AISI 1040	Hot-rolled, then fine-ground	0.5 inch	Axial
AISI 1040	Hot-rolled	0.5 inch	Bending*
AISI 1040	Cold-drawn	0.5 inch	Bending*
AISI 1040	Hot-rolled, then fine-ground	0.5 inch	Bending*

*rotating bending

4. 5 pts Educational purpose: *Jargon – is engineering a foreign language? Not really, but it does have its own vocabulary! The purpose of this "problem" is to broaden your engineering vocabulary.* Define or describe the following terms, use sketches if appropriate, and cite your sources (URL's are acceptable if cited): hysteresis, load cell, nacelle, fairing, pillow block, splines, trunnion, trunnion bearing.