University of California at Berkeley
College of Engineering
Department of Mechanical Engineering

ME102B, Fall 2014

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Exam (November 12, 2014)
Close book, Open one formula sheet

Problem 1 (40%)

The cover of a pressure vessel is held in place by ten 1/2" UNC bolts (proof stress = 85 kpsi). The pressure is 200 Psi and effective area of the cover exposed to the pressure is 314 in^2. The ratio of stiffness of the bolt to the connected member is 1/3. Each bolt is tightened to 7500 lb initially, before the pressure is applied.

(a) Draw a diagram to illustrate safety factors of bolts by showing the important lines in the figure. Please shade the area that is safe to operate and show the definition of safety factor against yielding and safety factor against separation. Derive the equations for safety factors against yielding and against separation, respectively (10%)

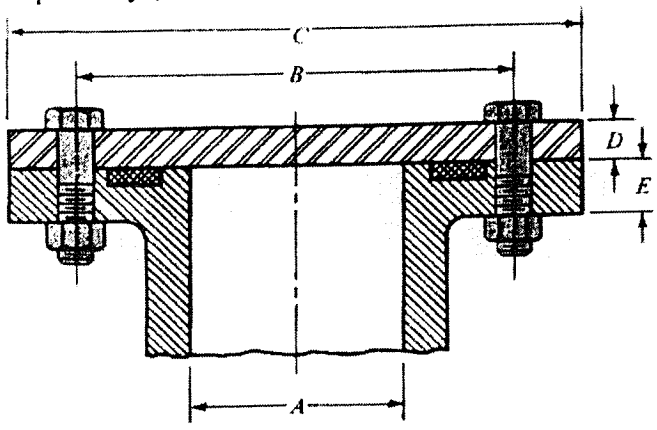
(b) Calculate the safety factor against yielding. (5%)

(c) Calculate the safety factor against separation. (5%)

(d) Under what pressure, "separation" will start to occur? (5%)

(e) Explain in less than 20 words what is happening after the separation? (5%)

(f) Please calculate the safety factor against yielding (proof stress) right before and right after separation. (10%)



Problem 2 (60%)

The 24-tooth, 2mm module, 20° pinion shown as element 2 in the figure below rotates clockwise at 1000 rpm and is driven at a power of 2000 Watts. Gears 4, 5, and 6 have 24, 36, and 144 teeth, respectively and the gear efficiency is 100 percent.

(a) Illustrate and explain the "contact ratio" and "interference" in a figure when two gears are meshing together. (5%)

(b) What is the contact ratio for gear 4 and 5? (10%)

(c) Determine if there is interference between gear 4 and 5? (5%)

(d) What is the rotational speed and direction of the arm 3? (10%)

(e) What torque can arm 3 deliver? (10%)

(f) Draw free-body diagrams of the arm 3 and Gears 2, 4, 5 respectively, and show/analyze/calculate all forces which act upon them in both figures. (20%)

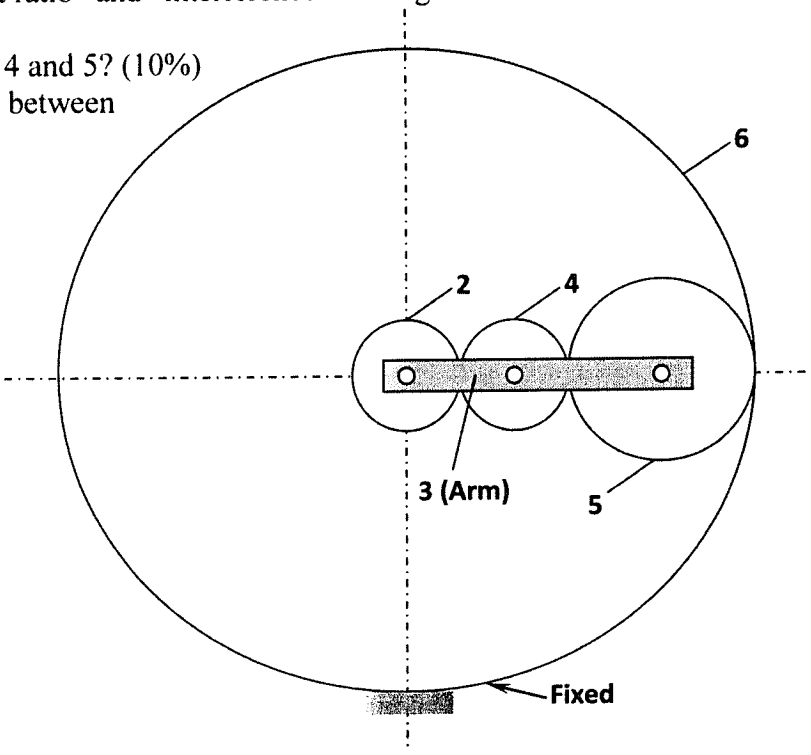


Table 8–2

Diameters and Area of Unified Screw Threads UNC and UNF*

Size Designation	Nominal Major Diameter in	Coarse Series – UNC Threads per Inch N	Coarse Series – UNC Tensile Stress Area A_t in²	Coarse Series – UNC Minor Diameter Area A_r in²	Fine Series – UNF Threads per Inch N	Fine Series – UNF Tensile Stress Area A_t in²	Fine Series – UNF Minor Diameter Area A_r in²
0	0.0600				80	0.001 80	0.001 51
1	0.0730	64	0.002 63	0.002 18	72	0.002 78	0.002 37
2	0.0860	56	0.003 70	0.003 10	64	0.003 94	0.003 39
3	0.0990	48	0.004 87	0.004 06	56	0.005 23	0.004 51
4	0.1120	40	0.006 04	0.004 96	48	0.006 61	0.005 66
5	0.1250	40	0.007 96	0.006 72	44	0.008 80	0.007 16
6	0.1380	32	0.009 09	0.007 45	40	0.010 15	0.008 74
8	0.1640	32	0.014 0	0.011 96	36	0.014 74	0.012 85
10	0.1900	24	0.017 5	0.014 50	32	0.020 0	0.017 5
12	0.2160	24	0.024 2	0.020 6	28	0.025 8	0.022 6
1/4	0.2500	20	0.031 8	0.026 9	28	0.036 4	0.032 6
5/16	0.3125	18	0.052 4	0.045 4	24	0.058 0	0.052 4
3/8	0.3750	16	0.077 5	0.067 8	24	0.087 8	0.080 9
7/16	0.4375	14	0.106 3	0.093 3	20	0.118 7	0.109 0
1/2	0.5000	13	0.141 9	0.125 7	20	0.159 9	0.148 6
9/16	0.5625	12	0.182	0.162	18	0.203	0.189
5/8	0.6250	11	0.226	0.202	18	0.256	0.240
3/4	0.7500	10	0.334	0.302	16	0.373	0.351
7/8	0.8750	9	0.462	0.419	14	0.509	0.480
1	1.0000	8	0.606	0.551	12	0.663	0.625
1 1/8	1.2500	7	0.969	0.890	12	1.073	1.024
1 1/4	1.5000	6	1.405	1.294	12	1.581	1.521

*The data are compiled from ASME B1.1-1974. The minor diameter was found from the equation $d_r = d - 1.299\,038\,p$, and the pitch diameter from $d_p = d - 0.649\,519\,p$. The mean of the pitch diameter and the minor diameter was used to compute the tensile-stress area.

Figure 8–3

(a) Square thread; (b) Acme thread.