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Exam 3 Reference Sheet – ME 338 – Spring 2025

Equations:

$V = \pi d n$	$w = \gamma b t$
$F_c = \dfrac{wV^2}{g}$	$F_i = \dfrac{T}{d}\dfrac{\exp(f\phi)+1}{\exp(f\phi)-1}$
$F_1 = F_c + F_i\dfrac{2\exp(f\phi)}{\exp(f\phi)+1}$	$F_2 = F_c + F_i\dfrac{2}{\exp(f\phi)+1}$
$H = (F_1 - F_2)V$	$n_{fs} = H_a/(H_{\mathrm{nom}}K_s)$
$(F_1)_a = bF_aC_pC_v$	$f' = \dfrac{1}{\phi}\ln\dfrac{(F_1)_a - F_c}{F_2 - F_c}$
$\dfrac{P_1}{P_2} = e^{f\phi}$	$T = (P_1 - P_2)\dfrac{D}{2}$
$p = \dfrac{P}{br} = \dfrac{2P}{bD}$	$p_a = \dfrac{2P_1}{bD}$
Uniform Wear: $pr = constant = p_a\frac{d}{2}$ $F = \frac{\pi p_a d(D-d)}{2}$ $T = \frac{Ff(D+d)}{4}$	
$C_s = \dfrac{\omega_2 - \omega_1}{\omega}$	$\omega = \dfrac{\omega_2 + \omega_1}{2}$
$E_2 - E_1 = C_sI\omega^2$	$I = \dfrac{1}{2}m(R^2 + r^2) = \rho t J$
$\sigma_t = \rho\omega^2\left(\dfrac{3+\nu}{8}\right)\left(r_i^2 + r_o^2 + \dfrac{r_i^2r_o^2}{r^2} - \dfrac{1+3\nu}{3+\nu}r^2\right)$	$\sigma_r = \rho\omega^2\left(\dfrac{3+\nu}{8}\right)\left(r_i^2 + r_o^2 - \dfrac{r_i^2r_o^2}{r^2} - r^2\right)$
$T_R = \dfrac{Fd_m}{2}\left(\dfrac{l+\pi f d_m}{\pi d_m - fl}\right)$	$T_L = \dfrac{Fd_m}{2}\left(\dfrac{\pi f d_m - l}{\pi d_m + fl}\right)$

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$f > \tan\ \lambda$	$T_c = \frac{F f_c d_c}{2}$
Often, $T_{total} = T_R + T_c$	$\left.\begin{array}{ll} \sigma_x = \frac{6F}{\pi d_r n_t p} & \tau_{xy} = 0 \\ \sigma_y = -\frac{4F}{\pi d_r^2} & \lvert\tau_{yz}\rvert = \frac{16T}{\pi d_r^3} \\ \sigma_z = 0 & \lvert\tau_{xz}\rvert = \frac{4T}{\pi d_r^2 n_t p} \end{array}\right\}$
$\sigma_B = -\frac{F}{\pi d_m n_t p/2} = -\frac{2F}{\pi d_m n_t p}$	$\sigma' = \frac{S_y}{n}$
$\sigma' = \frac{1}{\sqrt{2}}\left[\left(\sigma_x - \sigma_y\right)^2 + \left(\sigma_y - \sigma_z\right)^2 + (\sigma_z - \sigma_x)^2 + 6\left(\tau_{xy}^2 + \tau_{yz}^2 + \tau_{zx}^2\right)\right]^{1/2}$	
$\left(\frac{F}{A}\right)_{\text{crit}} = S_y - \left(\frac{S_y}{2\pi}\frac{l}{k}\right)^2 \frac{1}{CE}$	For solid circular beam: $k = d/4$
$\tau = \frac{F}{0.707hl} = \frac{1.414F}{hl}$	$C = \frac{D}{d}$
$K_B = \frac{4C+2}{4C-3}$	$\tau = K_B \frac{8FD}{\pi d^3}$
$y = \frac{8FD^3N}{d^4G}\left(1 + \frac{1}{2C^2}\right) \approx \frac{8FD^3N}{d^4G}$	$k \approx \frac{d^4G}{8D^3N}$
$L_0 = \frac{F_s}{k} + L_s$	$L_0 < 2.63\frac{D}{\alpha}$
$S_{ut} = \frac{A}{d^m}$	$\tau_{all} = S_{sy}$

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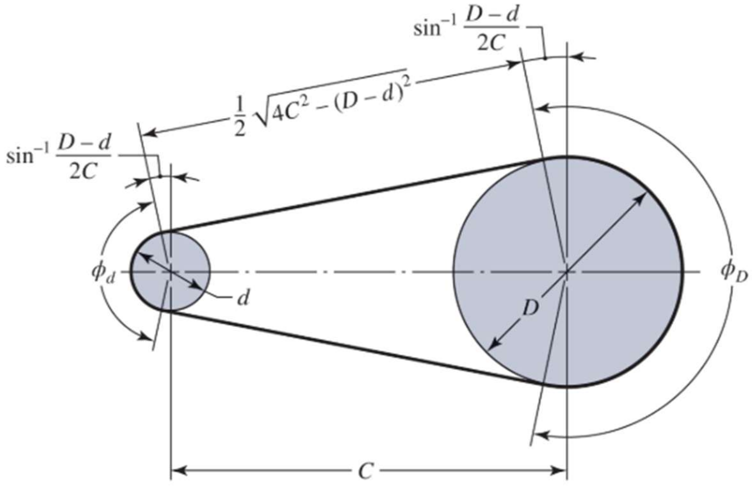
Graphs/Figures/Tables:



$$\phi_d = \pi - 2\sin^{-1}\frac{D-d}{2C}$$

$$\phi_D = \pi + 2\sin^{-1}\frac{D-d}{2C}$$

$$L = \sqrt{4C^2-(D-d)^2} + \tfrac{1}{2}(D\phi_D + d\phi_d)$$

(a)

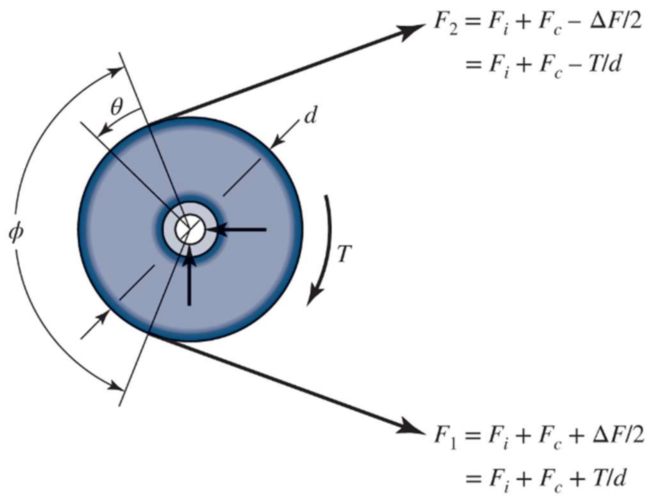


Table 17–2 Properties of Some Flat- and Round-Belt Materials.

Diameter $= d$, thickness $= t$, width $= w$

Material	Specification	Size, in	Minimum Pulley Diameter, in	Allowable Tension per Unit Width at 600 ft/min, lbf/in	Specific Weight, lbf/in^3	Coefficient of Friction
Leather	1 ply	$t = \frac{11}{64}$	3	30	0.035–0.045	0.4
		$t = \frac{13}{64}$	$3\frac{1}{2}$	33	0.035–0.045	0.4
	2 ply	$t = \frac{18}{64}$	$4\frac{1}{2}$	41	0.035–0.045	0.4
		$t = \frac{20}{64}$	6[a]	50	0.035–0.045	0.4
		$t = \frac{23}{64}$	9[a]	60	0.035–0.045	0.4
Polyamide[b]	F–0[c]	$t = 0.03$	0.60	10	0.035	0.5
	F–1[c]	$t = 0.05$	1.0	35	0.035	0.5
	F–2[c]	$t = 0.07$	2.4	60	0.051	0.5
	A–2[c]	$t = 0.11$	2.4	60	0.037	0.8
	A–3[c]	$t = 0.13$	4.3	100	0.042	0.8
	A–4[c]	$t = 0.20$	9.5	175	0.039	0.8
	A–5[c]	$t = 0.25$	13.5	275	0.039	0.8

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Table 17–4 Pulley Correction Factor C_p for Flat Belts

	Small-Pulley Diameter, in					
Material	**1.6 to 4**	**4.5 to 8**	**9 to 12.5**	**14, 16**	**18 to 31.5**	**Over 31.5**
Leather	0.5	0.6	0.7	0.8	0.9	1.0
Polyamide, F–0	0.95	1.0	1.0	1.0	1.0	1.0
F–1	0.70	0.92	0.95	1.0	1.0	1.0
F–2	0.73	0.86	0.96	1.0	1.0	1.0
A–2	0.73	0.86	0.96	1.0	1.0	1.0
A–3	–	0.70	0.87	0.94	0.96	1.0
A–4	–	–	0.71	0.80	0.85	0.92
A–5	–	–	–	0.72	0.77	0.91

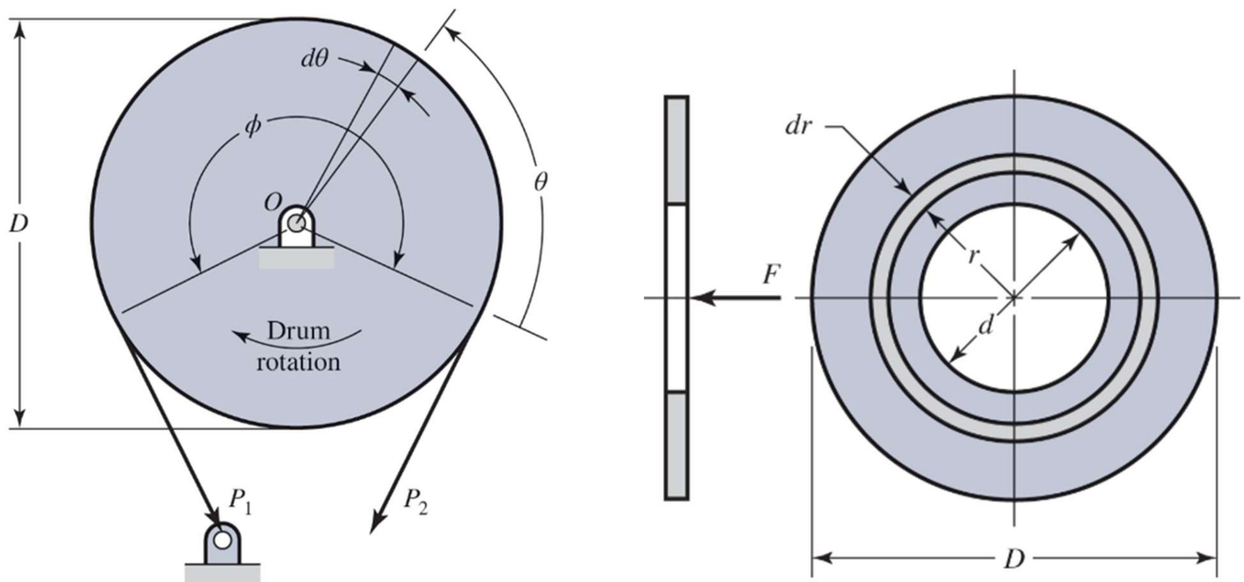

Table A–5 Physical Constants of Materials

	Modulus of Elasticity E		Modulus of Rigidity G			Unit Weight w		
Material	**Mpsi**	**GPa**	**Mpsi**	**GPa**	**Poisson's Ratio ν**	**lbf/in^3**	**lbf/ft^3**	**kN/m^3**
Aluminum (all alloys)	10.4	71.7	3.9	26.9	0.333	0.098	169	26.6
Beryllium copper	18.0	124.0	7.0	48.3	0.285	0.297	513	80.6
Brass	15.4	106.0	5.82	40.1	0.324	0.309	534	83.8
Carbon steel	30.0	207.0	11.5	79.3	0.292	0.282	487	76.5
Cast iron (gray)	14.5	100.0	6.0	41.4	0.211	0.260	450	70.6
Copper	17.2	119.0	6.49	44.7	0.326	0.322	556	87.3
Douglas fir	1.6	11.0	0.6	4.1	0.33	0.016	28	4.3
Glass	6.7	46.2	2.7	18.6	0.245	0.094	162	25.4

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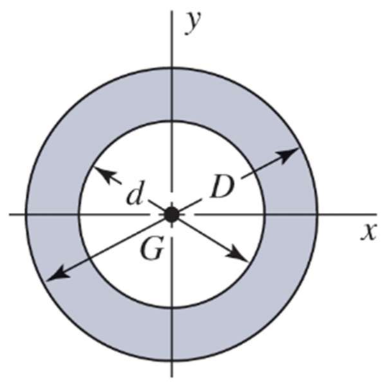
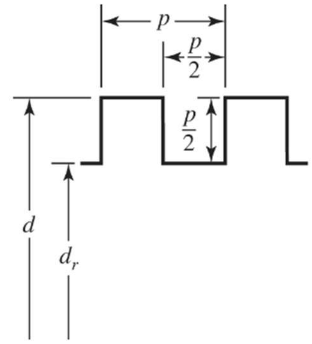
Hollow circle



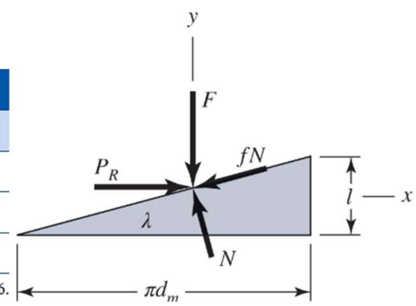


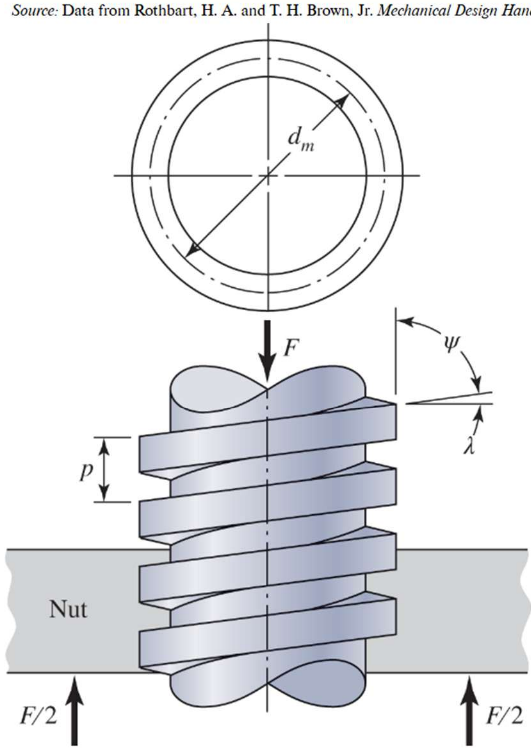
$$A = \frac{\pi}{4}\left(D^2 - d^2\right) \qquad I_x = I_y = \frac{\pi}{64}\left(D^4 - d^4\right) \qquad I_{xy} = 0 \qquad J_G = \frac{\pi}{32}\left(D^4 - d^4\right)$$

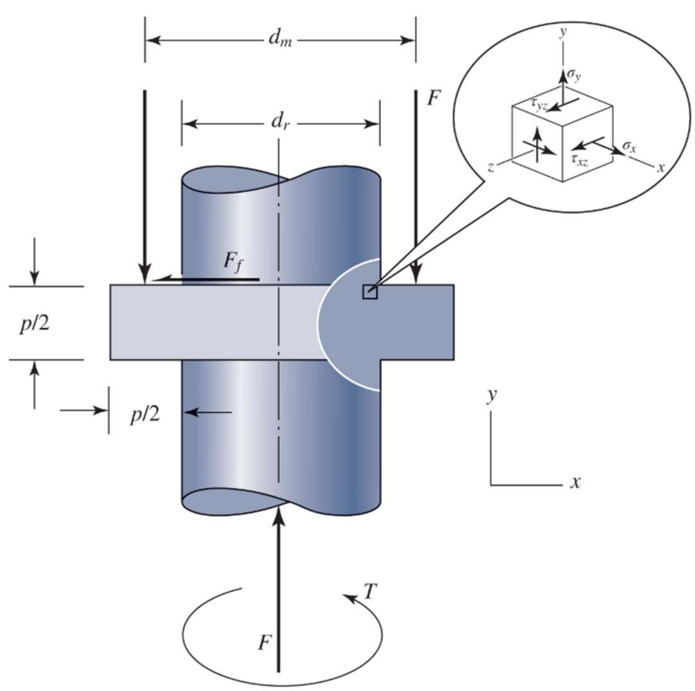
Table 8–5 Coefficients of Friction *f* for Threaded Pairs

	Nut Material			
Screw Material	**Steel**	**Bronze**	**Brass**	**Cast Iron**
Steel, dry	0.15–0.25	0.15–0.23	0.15–0.19	0.15–0.25
Steel, machine oil	0.11–0.17	0.10–0.16	0.10–0.15	0.11–0.17
Bronze	0.08–0.12	0.04–0.06	–	0.06–0.09

Source: Data from Rothbart, H. A. and T. H. Brown, Jr. *Mechanical Design Handbook*. 2nd ed. New York: McGraw Hill, 2006.







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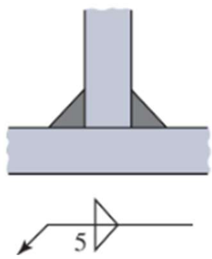

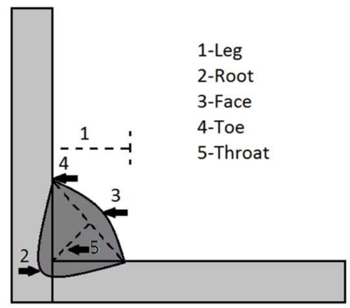

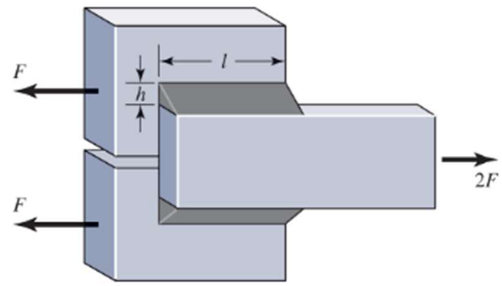

Figure 9–11 Parallel fillet welds.

Table 9–4 Stresses Permitted by the AISC Code for Weld Metal

Type of Loading	Type of Weld	Permissible Stress	n^*
Tension	Butt	$0.60S_y$	1.67
Bearing	Butt	$0.90S_y$	1.11
Bending	Butt	$0.60–0.66S_y$	1.52–1.67
Simple compression	Butt	$0.60S_y$	1.67
Shear	Butt or fillet	$0.30S_{ut}^{\dagger}$	

*The factor of safety n has been computed by using the distortion-energy theory.

†Shear stress on base metal should not exceed $0.40S_y$ of base metal.

Table 9–6 Allowable Steady Loads and Minimum Fillet Weld Sizes

Schedule A: Allowable Load for Various Sizes of Fillet Welds							
Strength Level of Weld Metal (EXX)							
	60*	70*	80	90*	100	110*	120
Allowable shear stress on throat, ksi (1000 psi) of fillet weld or partial penetration groove weld							
$\tau =$	18.0	21.0	24.0	27.0	30.0	33.0	36.0
Allowable Unit Force on Fillet Weld, kip/linear in							
$^{\dagger}f =$	$12.73h$	$14.85h$	$16.97h$	$19.09h$	$21.21h$	$23.33h$	$25.45h$

*Fillet welds actually tested by the joint AISC-AWS Task Committee.

$^{\dagger}f = 0.707h\,\tau_{\text{all}}$.

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Table A–20 Deterministic ASTM Minimum Tensile and Yield Strengths for Some Hot-Rolled (HR) and Cold-Drawn (CD) Steels

1	2	3	4	5	6	7	8
UNS No.	SAE and/or AISI No.	Processing	Tensile Strength, MPa (kpsi)	Yield Strength, MPa (kpsi)	Elongation in 2 in, %	Reduction in Area, %	Brinell Hardness
G10060	1006	HR	300 (43)	170 (24)	30	55	86
		CD	330 (48)	280 (41)	20	45	95
G10100	1010	HR	320 (47)	180 (26)	28	50	95
		CD	370 (53)	300 (44)	20	40	105
G10150	1015	HR	340 (50)	190 (27.5)	28	50	101
		CD	390 (56)	320 (47)	18	40	111
G10180	1018	HR	400 (58)	220 (32)	25	50	116
		CD	440 (64)	370 (54)	15	40	126
G10200	1020	HR	380 (55)	210 (30)	25	50	111
		CD	470 (68)	390 (57)	15	40	131

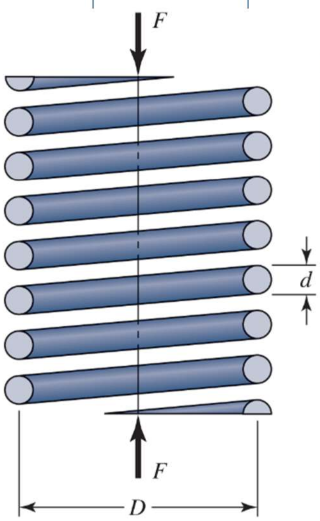

Table 10–5 Mechanical Properties of Some Spring Wires

Material	Elastic Limit, Percent of S_{ut}		Diameter d, in	E		G	
	Tension	Torsion		Mpsi	GPa	Mpsi	GPa
Music wire A228	65–75	45–60	<0.032	29.5	203.4	12.0	82.7
			0.033–0.063	29.0	200	11.85	81.7
			0.064–0.125	28.5	196.5	11.75	81.0
			>0.125	28.0	193	11.6	80.0
HD spring A227	60–70	45–55	<0.032	28.8	198.6	11.7	80.7
			0.033–0.063	28.7	197.9	11.6	80.0
			0.064–0.125	28.6	197.2	11.5	79.3
			>0.125	28.5	196.5	11.4	78.6

Table 10–4 Constants A and m of $S_{ut} = A/d^m$ for Estimating Minimum Tensile Strength of Common Spring Wires

Material	ASTM No.	Exponent m	Diameter, in	A, kpsi · in^m	Diameter, mm	A, MPa · mm^m	Relative Cost of Wire
Music wire[*]	A228	0.145	0.004–0.256	201	0.10–6.5	2211	2.6
OQ&T wire[†]	A229	0.187	0.020–0.500	147	0.5–12.7	1855	1.3
Hard-drawn wire[‡]	A227	0.190	0.028–0.500	140	0.7–12.7	1783	1.0
Chrome-vanadium wire[§]	A232	0.168	0.032–0.437	169	0.8–11.1	2005	3.1
Chrome-silicon wire[‖]	A401	0.108	0.063–0.375	202	1.6–9.5	1974	4.0
302 Stainless wire[#]	A313	0.146	0.013–0.10	169	0.3–2.5	1867	7.6–11
		0.263	0.10–0.20	128	2.5–5	2065	
		0.478	0.20–0.40	90	5–10	2911	
Phosphor-bronze wire[**]	B159	0	0.004–0.022	145	0.1–0.6	1000	8.0
		0.028	0.022–0.075	121	0.6–2	913	
		0.064	0.075–0.30	110	2–7.5	932	