ME 383 1/8/2012

HOMEWORK NOT COLLECTED
QUIZES ON THURSDAY'S

HOMEWORK DUE THURSDAY'S :

- PROBLEMS ON WEBSITE
- SPOON TEST : 1ST/2ND CHOICE
- READ F.S. APPENDIX ONLINE OR IN BOOK (ULLMAN)

* KEY POINTS OF COURSE :

- FIND FORCES EXTERNAL TO ASSEMBLY (SCENARIO'S)
- ESTIMATE DESIGN FACTOR OF SAFTEY
- FIND FORCES ON PARTS
- DETERMINE CRITICAL LOCATIONS
- DETERMINE MATERIAL PROPERTIES AND GEOMETRY AT CRITICAL LOCATIONS
- FIND STRESS / STRAIN AT C.L.
- APPLY FAILURE THEORY AND CALCULATE F.S.
- COMPARE DESIGN F.S. TO CALCULATED
- DETERMINE WHAT TO DO NEXT
- APPLY ~~or~~ ALL OF ABOVE TO MACHINE COMPONENTS

ALL TOPICS FOR EXAMS
EXAM 1 THROUGH STATIC FAILURE THEORIES

* FAILURES FOR HELICOPTER PARTS:

WEAR
DUCTILE RUPTURE
⋮

ME 382 1/8/2012

"CLASSICAL"

$FS = FS_{MATERIAL} \cdot FS_{STRESS} \cdot FS_{GEO} \cdot FS_{FAILURE\ THEORY} \cdot FS_{RELIABILITY}$

$FS_{MATERIAL}$ ↓

1.0 (KNOWN)
1.1 (HANDBOOK VALUES)
1.2 (NOT KNOWN)

FS_{STRESS} → 1.0 – 1.1 (LOAD WELL DEFINED)
1.2 - 1.3 (AVERAGE)
1.4 (??)

FS_{GEO} → 1.0 (AVE)
1.1 (DIM NOT CLOSELY HELD)

$FS_{FAILURE\ THEORY}$ → 1.0 - 1.1 (GOOD)
1.2 (EXTENSION)

FS_{REL} → <90% FS = 1
91-98% FS = 1.2 - 1.3
≥99% FS = 1.4 - ??

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TEAM MEETING: 10:00 AM MONDAY

* READING NOTES: CHAPTER 1:

- UNILATER TOLERANCE: VARIATION LIMITED TO ONLY ONE DIRECTION

IE. $1.005^{+0.004}_{-0.000}$ IN

- GAP DIMENTIONS NEAR LIMITS ARE RARE, SO A STATISTICAL MEASURE IS GENERALLY USED. FOR A NORMAL DISTRIBUTION:

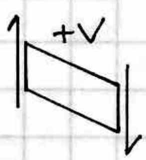
$$\boxed{\bar{w} = \sqrt{\sum t^2}}$$

A MONTE CARLO COMPUTER SIMULATION WOULD BE A BETTER FIT.

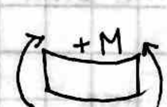
* ME 383 REVIEW NOTES:

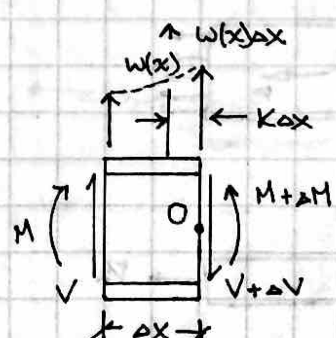
SHEAR AND MOMENT DIAGRAMS:

- POSITIVE SHEAR ROTATES BEAM SLICE CLOCKWISE, VICE-VERSA FOR NEGATIVE



- POSITIVE MOMENT MAKES BEAM "SMILE", AND VICE-VERSA





$\Sigma F_y = 0;$

$\cancel{V} + w(x)dx - (\cancel{V} + \Delta V) = 0$

$\Delta V = w(x)dx$

- RELATIONSHIPS:

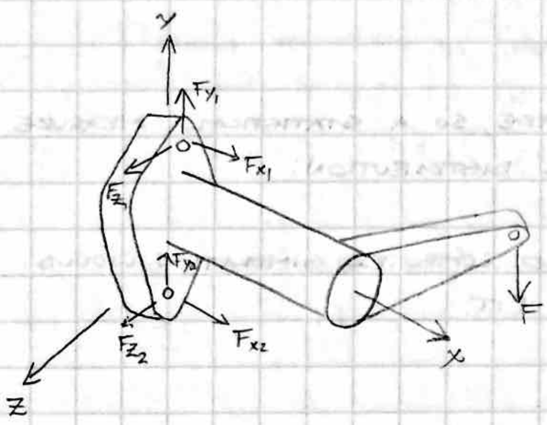
$\frac{dV}{dx} = w(x) \rightarrow V = \int w(x)dx$

$\frac{dM}{dx} = V \rightarrow M = \int V(x)dx$

1/9/2013

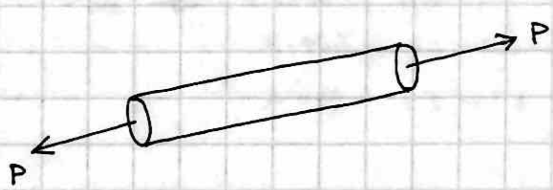
WHEN CONSTRUCTING SHEAR/MOMENT DIAGRAMS:

1. FBD BEAM. LABEL ALL REACTIONS, IF CANTILIEVER THEN REACTION MOMENT
2. CONSTRUCT V DIAGRAM
3. LOCATE KEY POINTS ON V DIAGRAM; PAYING CLOSE ATTENTION TO WHERE $V=0$ IE: BENDING MOMENT ZERO
4. CONSTRUCT M DIAGRAM



$\sum F_x = 0 = F_{x1} + F_{x2}$
$\sum F_y = 0 = F_{y1} + F_{y2} - F$
$\sum F_z = 0 = F_{z1} + F_{z2}$
$\sum M_x = 0 = -10F + 2.5F_{z1} - 2.5F_{z2}$
$\sum M_y = 0$
$\sum M_z = 0 = -12F - 2.5F_{x1} + 2.5F_{x2}$

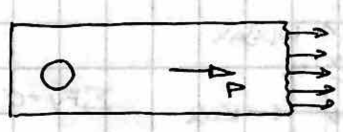
LECTURE NOTES:



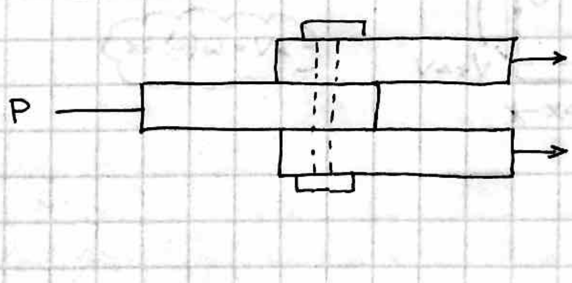
UNIAXIAL:

$\sigma = \frac{P}{A}$

→ S_y : YIELD
S_u : ULTIMATE
S_e : ENDURANCE LIMIT

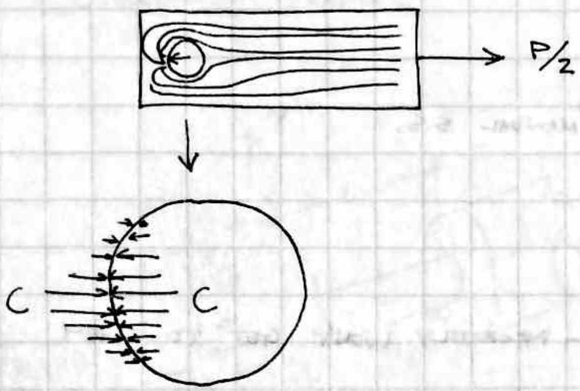


MATERIALS PROPERTIES CHANGE IN TENSION VS. COMPRESSION

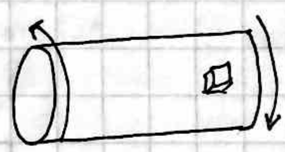


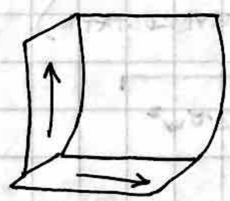
$\tau = \frac{P/2}{A}$

1/10/2013

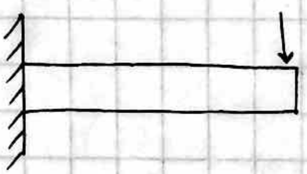


"INORDER TO GET FROM TENSION TO COMPRESSION YOU HAVE TO GO THROUGH SHEAR"





GEAR SHOWN FAILED IN BENDING



$$\sigma = \frac{Mc}{I}$$

$$\tau = \frac{VQ}{Ib}$$ ← GENERALLY NOT SIGNIFICANT

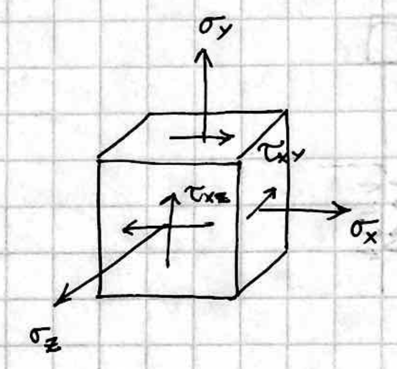
1/14/2013 TEAM MEETING NOTES:

- GOOGLE DOCS

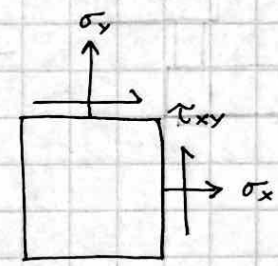
* QUIZ ON THURSDAY
- 2 PROBLEMS
- 1 STATE OF STRESS, 1 EQUILIBRIUM

MOHR'S CIRCLE / MANUAL S.S.

* HW: STIFFNESS / DEFLECTION PROBLEMS — PROBABLY WON'T GET TO THEM IN LECTURE



IF PLANAR

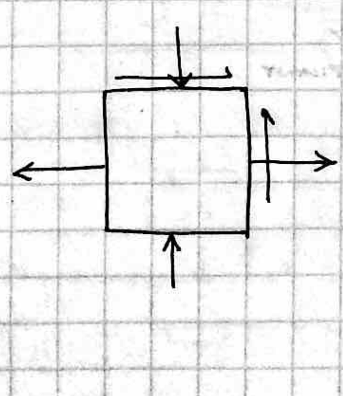


$$\sigma_{AVE} = \frac{\sigma_x + \sigma_y}{2} \quad \text{(HYDROSTATIC)}$$

$$\tau = \pm \sqrt{\frac{\sigma_x - \sigma_y}{2} + 2\tau_{xy}^2}$$

$$\tan 2\phi_p = \frac{2\tau_{xy}}{\sigma_x - \sigma_y}$$

$$\sigma_{1,2} = \frac{\sigma_x + \sigma_y}{2} \pm \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + 2\tau_{xy}^2}$$



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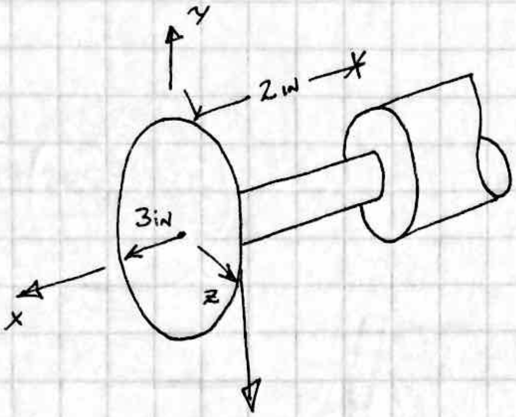
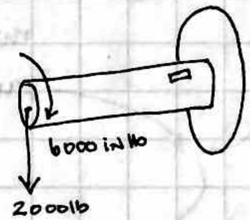
* EQUILLIBRIUM EXAMPLE:



"VISUALIZE AS FLUID FLOWING"

- STRESS CONCENTRATIONS:
  RIGHT-ANGLES ARE BAD

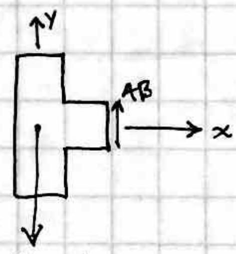
LOADS:
- BENDING, TORSIONAL
- COULD REDRAW AS $\longrightarrow$



$A = 0.78 \text{ IN}^2$

$I = 0.049 \text{ IN}^4$

$J = 0.098 \text{ IN}^4$



$\sum F_x = 0$

$\sum F_y = 0 = -2000 + F_{y_{AB}}$

$\sum M_z = 0 = 2 \cdot (F_y)_{AB} + (M_z)_{AB}$

$(M_z)_{AB} = 4000 \text{ lb} \cdot \text{in}$

$(F_y)_{AB} = 2000 \text{ lb}$

$T = M_x = 6000 \text{ in} \cdot \text{lb}$

$\sigma_x = \frac{Mc}{I} = \cancel{40.8}\ 40.8 \text{ Kpsi}$

$\tau_{xy} = \frac{Tr}{J} = 30.6 \text{ Kpsi}$

$\sigma_y = 0;$

$\sigma_z = 0$

$\sigma_{P1} = \cancel{32.71}\ \ 57.17$

$\sigma_{P2} = -\cancel{28.63}\ \ -16.38$

$\tau_{MAX} = \cancel{30.68}\ \ 36.77$

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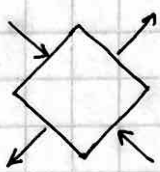
DUCTILE:

τ_{MAX}

BRITTLE

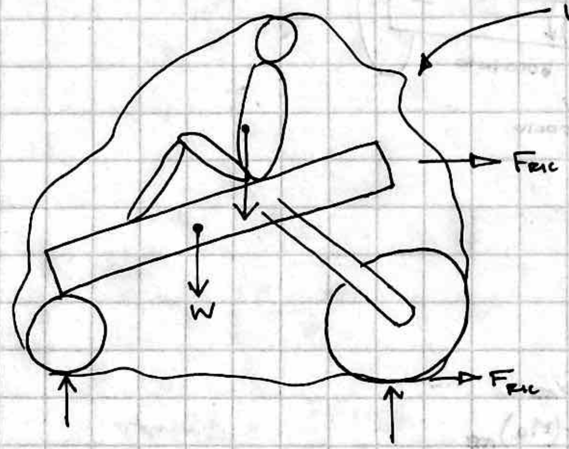


$\sigma = \tau_{MAX}$

BIKE SWING ARM EXAMPLE

MUST GO THROUGH THE ENVELOPE

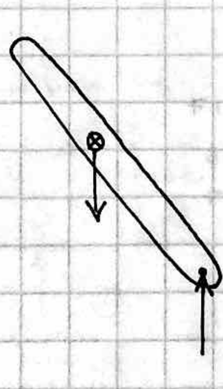
"WHAT ARE THE EXTERNAL FORCES ACTING ON BLOB?"



"REPLACE THE OBJECT WITH THE BLOB"

*KNOW FBD'S ...

-SWINGARM:



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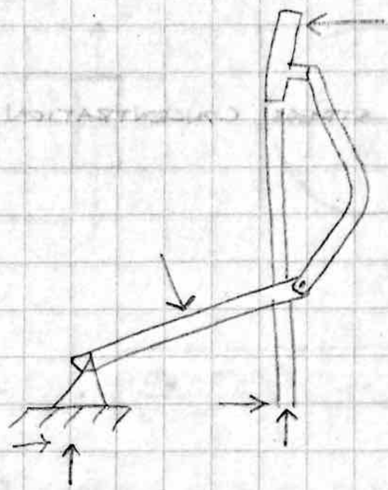
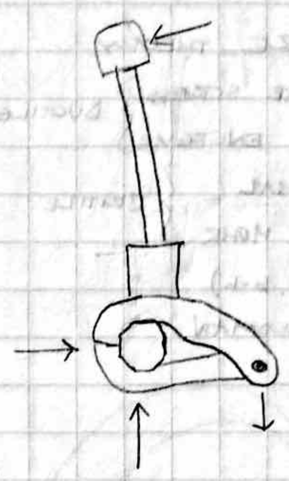
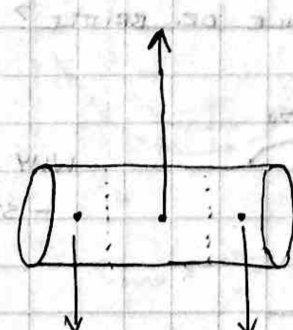
LAB ASSIGNMENT #1 (2)

- ON SYLLABUS, 1 PAGE WRITE UP

1/17/2013







SURVIVABILITY – BETTER DEFINITION

1/22/2013

- HW: 5.1 a, d, e
  5.4 b, d
  5.19 a, c, e
  5.36

NEW MATERIAL:

STATIC FAILURE THEORY

- MAX SHEAR STRESS } DUCTILE
- DISTORSION ENERGY } DUCTILE
- MAX NORMAL } BRITTLE
- MODIFIED MOHR } BRITTLE

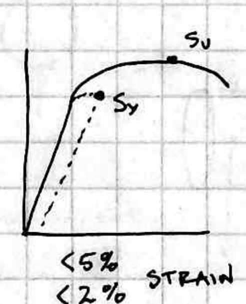
FATIGUE (TABLE 6-6)

- MODIFIED GOODMAN

* STRESS CONCENTRATION FACTORS

NOTES:

- [redacted] DUCTILE OR BRITTLE?



WHY MAKE SOMETHING BRITTLE?

- STRENGTH (HARDENING)

FAILURE IS EXPECTED TO OCCUR WHEN [redacted]

$F.S. = n = \frac{S_y}{\sigma}$ $\rightarrow S_y = F.S.\,\sigma$

$\quad\quad\rightarrow \sigma = \frac{S_y}{F.S.}$

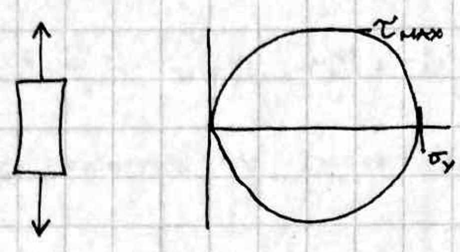
1/22/2013

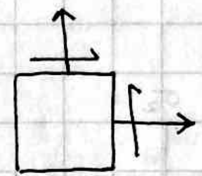
MAX SHEAR STRESS (DUCTILE)

- FAILURE PREDICTED TO OCCUR WHEN YIELDING OCCURS TO DUE MAX SHEAR EXCEEDING $S_y/2 \cdot F.S$

S_{ty} (S_y), S_{tu}, S_{cu}, S_e

$= S_{cy}$





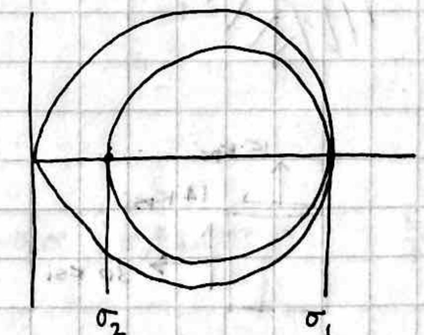
40,000 psi

$$\tau_{MAX} \le \frac{40{,}000 \text{ psi}}{2 \cdot 4} \le 5{,}000 \text{ psi}$$

$$\tau_{MAX} = \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2}$$

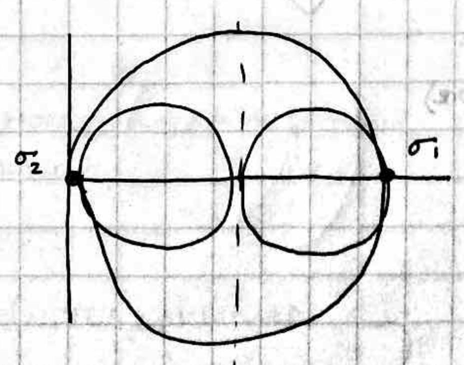
3 CASES: $\sigma_1 > \sigma_2 > 0$

1.)



$$\tau_{MAX} = \frac{\sigma_1}{2}$$

2.) $\sigma_1 > 0 > \sigma_2$



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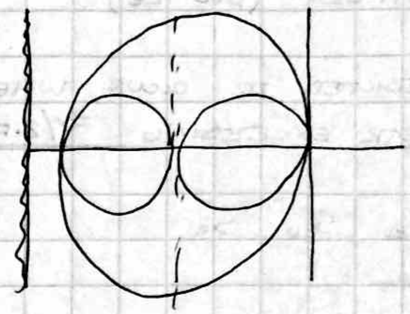
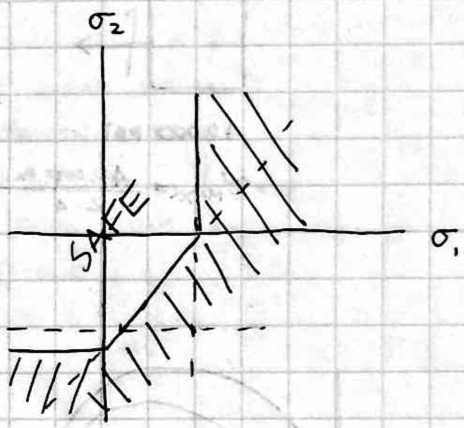
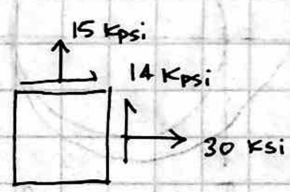
$\sigma_1 < \sigma_2 < 0$







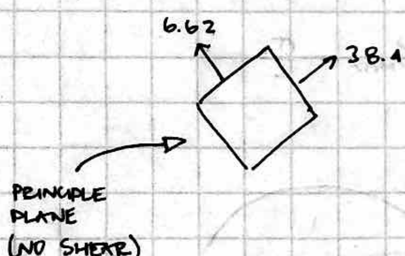
$S_y = 57$ ksi

F.S. = ?

$\sigma_1 = 38.4$ ksi

$\sigma_2 = 6.62$ ksi

$\sigma_3 = 0$



$\tau_{MAX} = \frac{S_y}{2 \cdot F.S} \rightarrow F.S. = \frac{S_y}{2 \cdot \tau_{MAX}}$

F.S = 1.5

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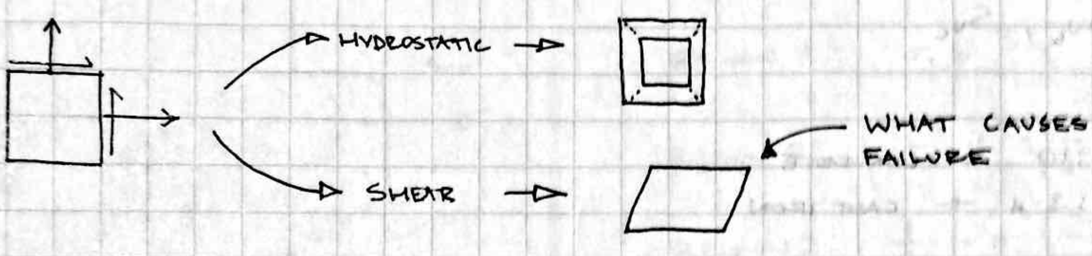
* DISTORTION ENERGY THEORY (VON-MISES, OCTAHEDRAL)



$$\sigma_{HYDRO} = \frac{1}{3}(\sigma_1 + \sigma_2 + \sigma_3)$$

$$\sigma_{DISTORSION} = \frac{1}{3}\left((\sigma_1-\sigma_2)^2 + (\sigma_2-\sigma_3)^2 + (\sigma_1-\sigma_3)^2\right)^{1/2}$$

*FAILURE PREDICTED TO OCCUR WHEN $\sigma_{DIS} \geq \frac{S_y}{F.S.}$ *

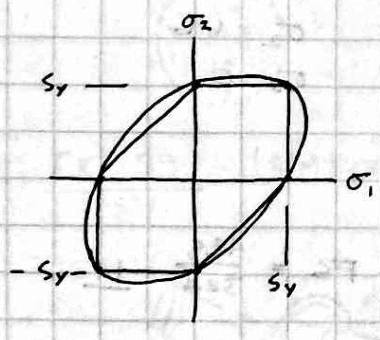
- UNIAXIAL CONDITION:

$$\sigma_2 = \sigma_3 = 0 \Rightarrow \sigma_{DIST} = \frac{1}{3}(S_y^2 + S_y^2)^{1/2} = \frac{\sqrt{2}}{3} S_y$$

$$= \frac{1}{\sqrt{2}}\left((\sigma_1-\sigma_2)^2 + (\sigma_2-\sigma_3)^2 + (\sigma_1-\sigma_2)^2\right)^{1/2}$$

- FOR PLANE STRESS:

$$(\sigma_1^2 - \sigma_1\sigma_2 + \sigma_2^2)^{1/2} \geq \frac{S_y}{F.S.} \quad \text{OR} \quad (\sigma_x^2 - \sigma_x\sigma_y + \sigma_y^2 + 3\tau_{xy}^2)^{1/2} \geq \frac{S_y}{F.S.}$$



FOR EXAMPLE:

$$\frac{1}{\sqrt{2}}\left(38.4^2 + 6.6^2 + (38.4 - 6.62)^2\right)^{1/2} \geq \frac{57}{F.S.}$$

F.S. = 1.6

* MAX SHEAR IS MORE CONSERVATIVE THAN DISTORTION ENERGY

* QUIZ ON THURSDAY
- FAILURE THEORIES PRESENT TODAY (NOTES ALLOWED)
- STRESS AT A POINT
- EQUILLIBRIUM.

1/24/2013

* BRITTLE FAILURE THEORIES

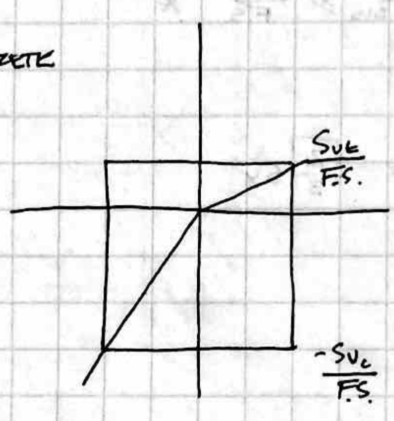
S_{u_t} , S_{u_c}

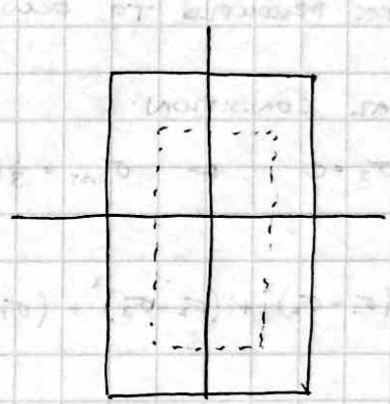
1:10 → CONCRETE

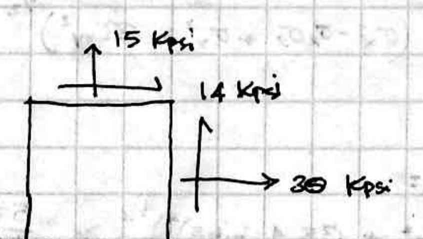
1: 3-4 → CAST IRON

- MAXIMUM NORMAL

CONCRETE







ASTM 40

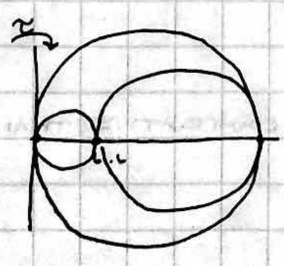
S_{u_t} = 42.5 Kpsi

S_{u_c} = 140 Kpsi

$\sigma_1 = 38.4$

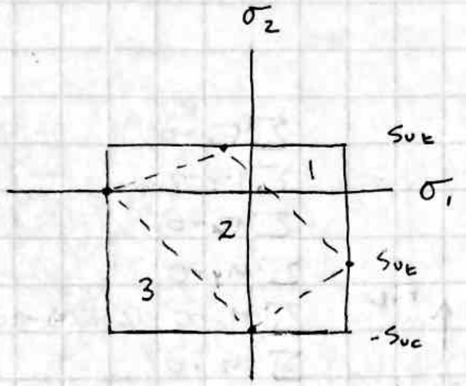
$\sigma_2 = 6.6$

$\sigma_3 = 0$



$\sigma_1 = \frac{S_{ut}}{FS}$ → $FS = \frac{42.5}{38.4} = \underline{1.1}$

1/24/2013



MODIFIED MOHR THEORY:

REGION 1 : $\sigma_1 \geq \dfrac{S_{ut}}{F.S.}$

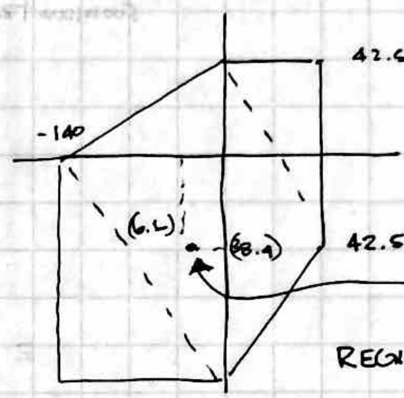
REGION 3 : $\sigma_3 \leq \dfrac{-S_{uc}}{F.S.}$

REGION 2 : $\dfrac{1}{FS} = \sigma_1 \left(\dfrac{S_{uc} - S_{ut}}{S_{uc} S_{ut}} \right) - \dfrac{\sigma_3}{S_{uc}}$

$\sigma_x = -30$ $\quad \sigma_1 = 0$

$\sigma_y = -15$ $\quad \sigma_2 \; -6.6$

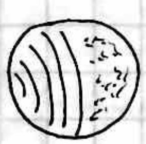
$\tau_{xy} = 14$ $\quad \sigma_3 = -38.4$



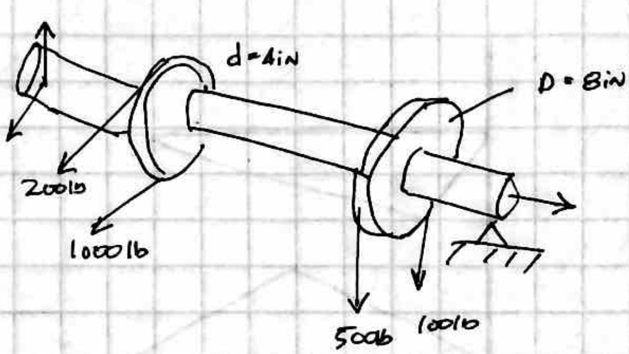
F.S. = 6 (EQ. 2)

REGION II

1/29/2013:



EX. 3.9 (SIMILAR TO ~~THE~~ PROBLEM ON EXAM)

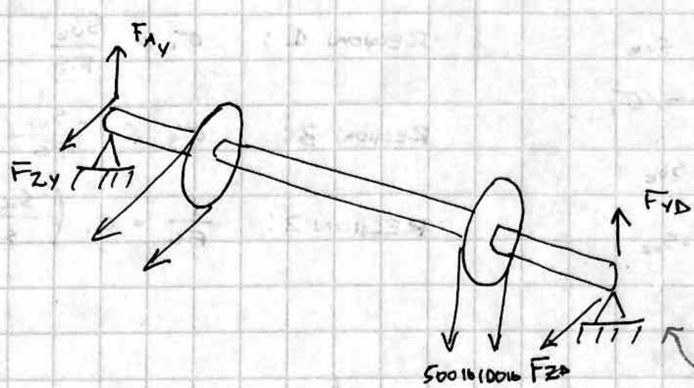


A.) $S_y = 81$ Kpsi
F.S. = ?

B.) CAST IRON
$S_{ut} = 30$ Kpsi
$S_{uc} = 100$ Kpsi

1|29|2018

EX. 3.9 CONT.



$\sum F_x = 0;$

$\sum F_y = 0;$

$\sum F_z = 0;$

$\sum M_y = 0$

$\sum M_x = 0 \quad (200)(2) - (1000)(6) + (500)(4) - (100)(4)$

$\sum M_z = 0$

WORK PROBLEM WITHOUT THIS SUPPORT FOR TEST

$F_{yA} = 200lb$

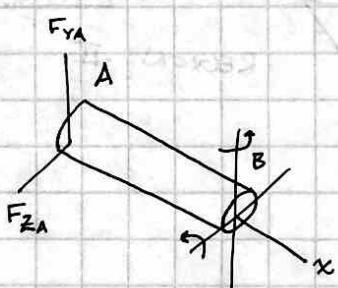
$F_{yD} = 400lb$

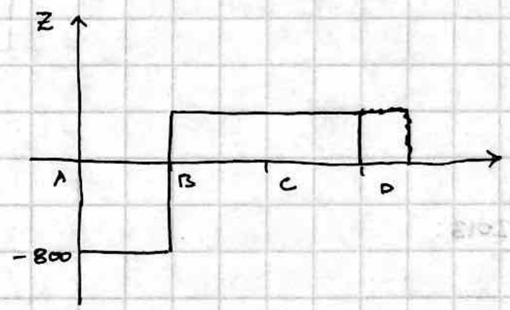
$F_{zA} = -800lb$

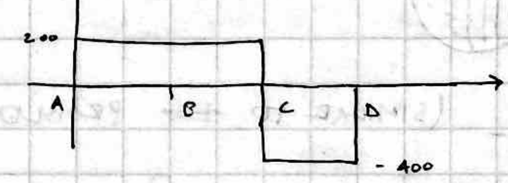
$F_{zD} = -400lb$

* ASSUMPTIONS:

- NO EXTERNAL FORCES CAUSING FORCES IN X-DIR. SO $\sum F_x = 0$







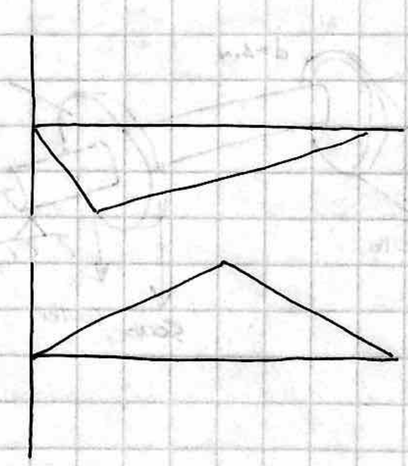
$M_B = \sqrt{8000^2 + 2000^2} = 8250 \text{ inlb}$

$M_c = 5600 \text{ inlb}$

$\tau_{TB} = \frac{Tr}{J} = 2414 \text{ psi}$

$\sigma = \frac{Mc}{I} = 24890 \text{ psi}$

$\tau_{BEND} = 603 \text{ psi}$ (TRANSVERSE



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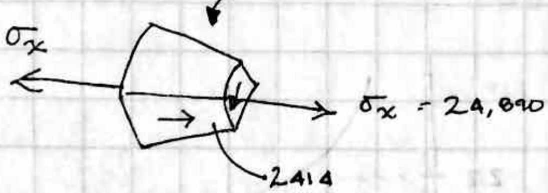
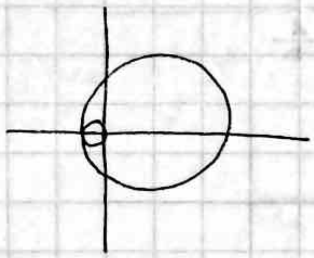
ON BOTTOM OF SHAFT (x-z PLANE)

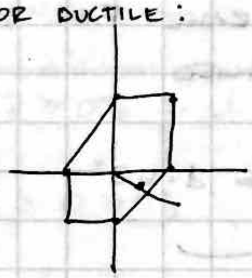


$\sigma_1 = 25,120$ psi
$\sigma_2 = -235$ psi



APPLY A FAILURE THEORY

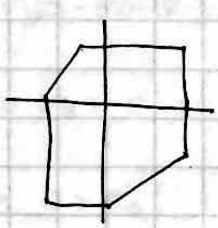
- FOR DUCTILE:



$$F.S. = 3.2$$

$$= \frac{81,000}{25,120} = 3.2$$

- FOR BRITTLE:



$$F.S. = 1.2$$

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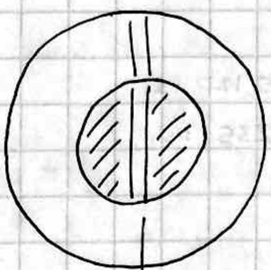
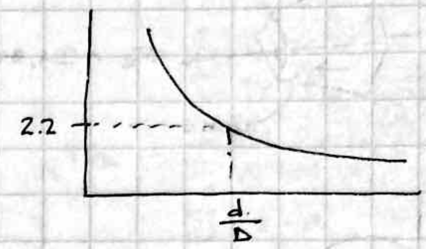
* NEW MATERIAL: STRESS CONCENTRATIONS



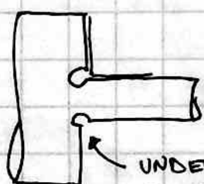
$d_{pin} = 0.15in$

$d_{shaft} = 1.5in$



$K_c = 2.2$

$\sigma_{BENDING} * K_c$



UNDERCUT TO RELIEVE STRESS CONCENTRATIONS

* FIND DIAMETER TO RAISE F.S. TO 3.2 AFTER K APPLIED

$$\underbrace{\frac{30000}{3.2 * K_t} = \frac{24890\, d/2}{\frac{\pi}{64} d^4}}_{\text{CHANGES ITERATIVELY}} \rightarrow d = 6.3"$$

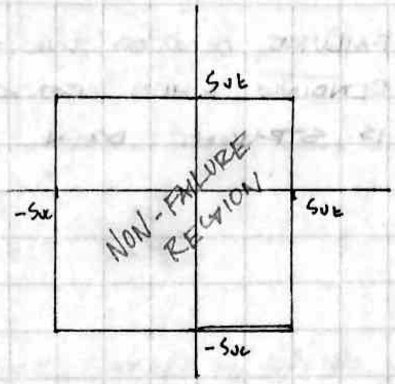
* READ FATIGUE

* READING NOTES: FAILURE THEORY - BRITTLE MATERIALS

- MAXIMUM NORMAL:

$\sigma_1 \geq S_{ut}$ OR $\sigma_3 \leq -S_{uc}$ WILL PREDICT FAILURE

WITH $\sigma_1 \geq \sigma_2 \geq \sigma_3$



DESIGN EQUATIONS:

$$\boxed{\sigma_A = \frac{S_{ut}}{n} \qquad \sigma_B = -\frac{S_{uc}}{n}}$$

- BRITTLE-COULOMB-MOHR:

3 CASES:

$\sigma_A \geq \sigma_B \geq 0$	$\rightarrow \sigma_A = \frac{S_{ut}}{n}$
$\sigma_A \geq 0 \geq \sigma_B$	$\rightarrow \frac{\sigma_A}{S_{ut}} - \frac{\sigma_B}{S_{uc}} = \frac{1}{n}$
$0 \geq \sigma_A \geq \sigma_B$	$\rightarrow \sigma_B = \frac{-S_{uc}}{n}$

- MODIFIED-MOHR:

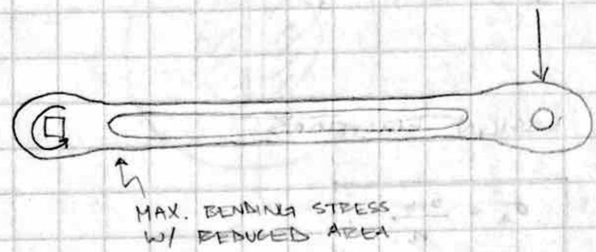
$\sigma_A \geq \sigma_B \geq 0 \rightarrow \sigma_A = \frac{S_{ut}}{n}$

$\sigma_A \geq 0 \geq \sigma_B \rightarrow$

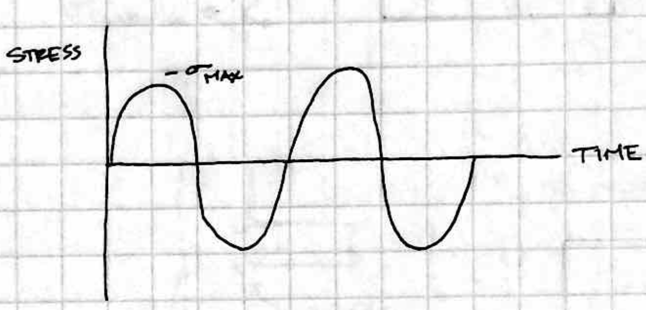
* 1/31/2013

- CHAPTER 6 SPREAD OUT TO 2 WEEKS

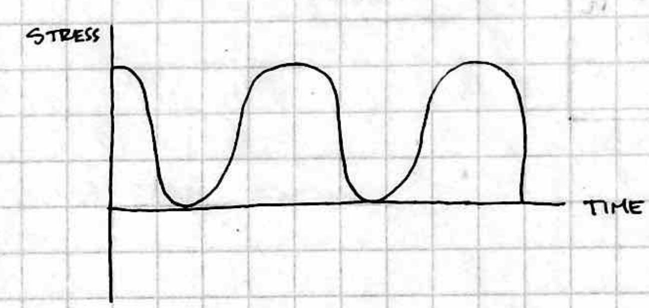
* CHAPTER 6 IS HARDEST CHAPTER *
- KNOW WELL



FAILURE OCCURED DUE TO BENDING WHEN CRANK ARM IS STRAIGHT DOWN.

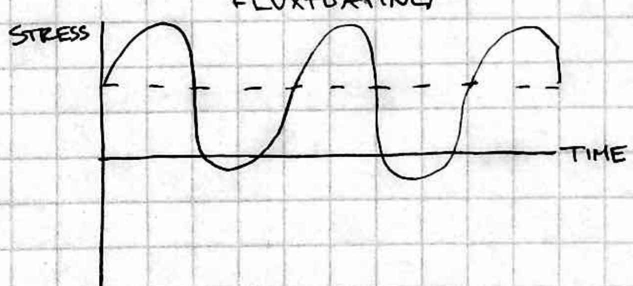


FULLY - REVERSED



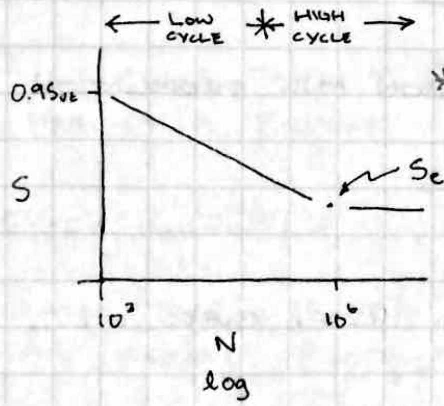
UNI-DIRECTIONAL
RELEASED

FLUXTUATING



1/31/2013:

* ENDURANCE LIMIT: STRESS FOR INFINITE LIFE, NOT ALL METALS POSSESS ONE



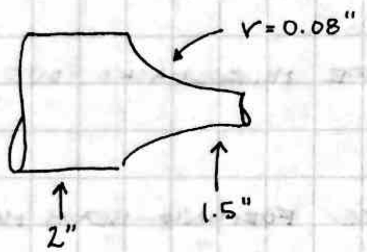
* WILL BE ON EXAMS! *

$$\underbrace{\begin{aligned} S_e' &= 0.504 S_e \\ S_e &= S_e' K_a K_b K_c K_d K_f \end{aligned}}_{\text{NOT ON EXAM!}}$$

- FAILURE IS PREDICTED TO OCCUR (UNIAXIAL LOADING, FULLY REVERSED, INFINITE LIFE) WHEN:

$$\frac{\sigma}{K_f'} =$$

- SURFACE CORRECTION FACTOR



$S_{ut} = 100$
$S_y = 84$

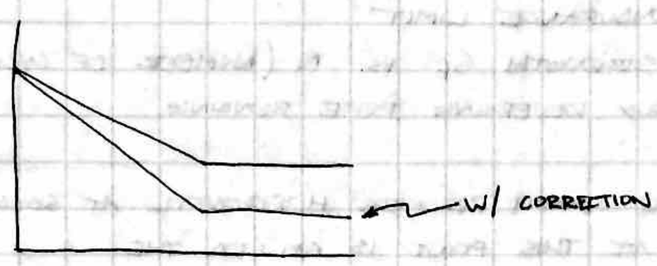
SURF $K_a = a S_{ut}^{b} = K_a = 0.785$

SIZE $K_b = \left(\frac{d}{0.3}\right)^{-0.107} = K_b = 0.84$

LOAD K_c

RELIABILITY FACTOR USUALLY INCLUDED IN

W/ CORRECTION:



* CHAPTER 6 READING NOTES:

- FATIGUE FAILURE: FAILURE DUE TO STRESS BEING LOADED REPEATEDLY A LARGE NUMBER OF TIMES

FATIGUE FAILURE IS DUE TO CRACK FORMATION AND PROPOGATION, AND IS INFLUENCED BY:
- RAPID CHANGES IN X-SECTIONAL AREA'S
- ELLEMENTS THAT ROLL OR SLIDE
- COMPOSITION OF MATERIAL ITSELF
- CARELESSNESS OF LOCATION OF STAMP MARKS, BURRS, ETC...
- TEMPERATURE
- CORROSIVE ENVIRONMENT

CRACKS WILL GROW ALONG PLANES NORMAL TO THE MAXIMUM TENSILE STRESS

- STAGES OF FATIGUE FAILURE:

  - STAGE 1: INITIATION OF ONE OR MORE MICROCRACKS DUE TO PLASTIC DEFORMATION.

  - STAGE 2: MICROCRACKS → MACROCRACKS FORMING BEACH MARKS

  - STAGE 3: OCCURS DURING FINAL STRESS CYCLE WHEN REMAINING MATERIAL CANNOT SUPPORT LOAD. RESULTS IN SUDDEN FAST, FRACTURE.

METHODS FOR ANALYZING FATIGUE FAILURE IN ANALYSIS AND DESIGN:

- FATIGUE STRENGTH AND ENDURANCE LIMIT
  - GRAPH OF FATIGUE STRENGTH S_f VS. N (NUMBER OF CYCLES), LOADING IS SINUSOIDALLY REVERSING PURE BENDING.

  - FOR SOME MATERIALS, THE GRAPH BECOMES HORIZONTAL AT SOME POINT, THE STRENGTH AT THIS POINT IS CALLED THE ENDURANCE LIMIT.

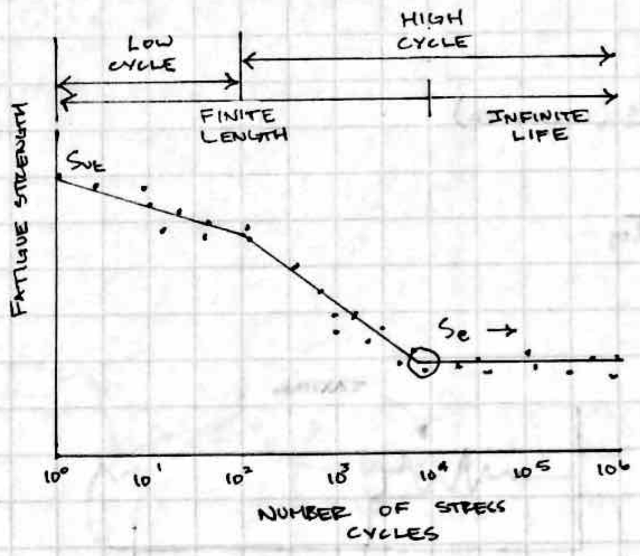
* 3 MAJOR FATIGUE LIFE METHOD'S:

- GOAL IS TO PREDICT WHEN (IN NUMBER OF CYCLES), A PART WILL FAIL UNDER A GIVEN LOADING.

- LOW-CYCLE FATIGUE (LESS THAN 10^3 CYCLES)
- HIGH-CYCLE FATIGUE (MORE THAN 10^3 CYCLES)

STRESS-LIFE METHOD:

VARYING AMOUNTS OF STRESS APPLIED TO MATERIAL IN ROTATION UNTIL FAILURE. PLOTED ON A SEMILOG SCALE

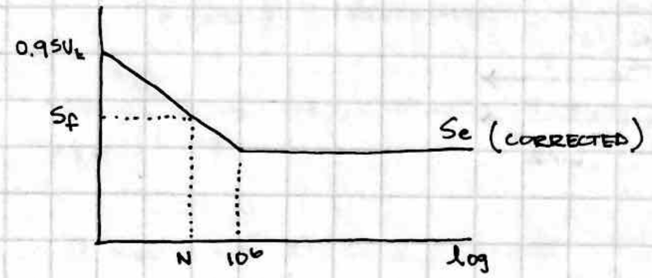


* NON-FERROUS MATERIALS HAVE NO ENDURANCE LIMIT *

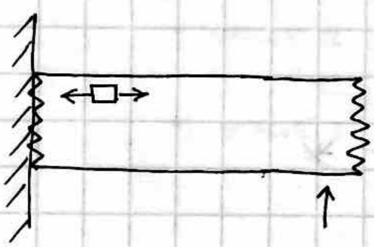
2/5/2013

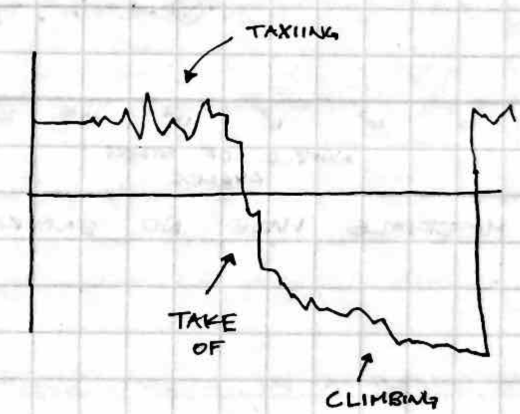
EXAM:

1 EQ.
1 STRESS AT A POINT
1 WILL IT FAIL?
- 4 FAILURE THEORIES. 2 BRITTLE, 2 DUCTILE

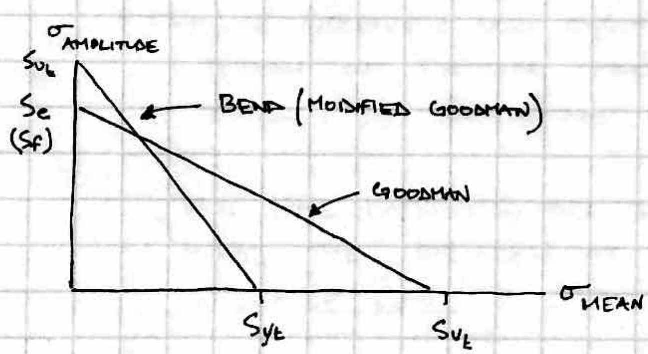


AIR PLANE:





"GOODMAN"

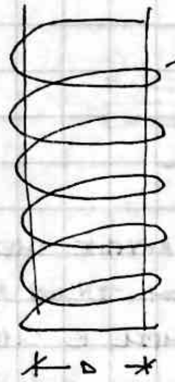


$$\underbrace{\frac{\sigma_A}{S_e} + \frac{\sigma_M}{S_{ut}}}_{} = 1$$

↳ F.S. GOES IN HERE

2/5/2013

SPRINGS:



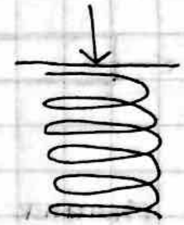
d = WIRE DIAMETER

N = # OF COILS

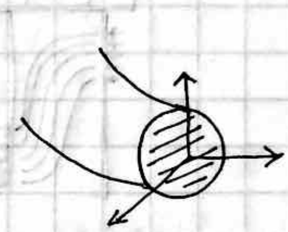
D = COIL DIAMETER

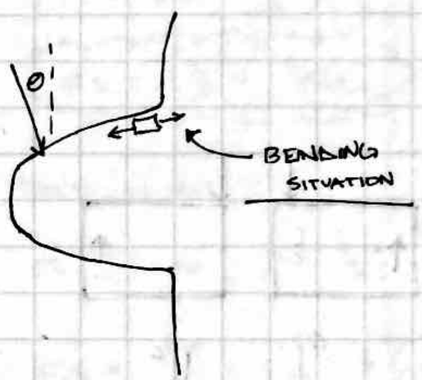
FREE LENGTH

FBD →



GEAR:





"ALMOST ANYTIME YOU HAVE ONE PART TOUCHING ANOTHER YOU HAVE A NORMAL FORCE"

2/12/2013

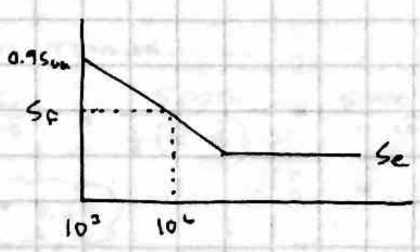
* ALL ASSIGNMENTS ON BB NOW *

- KNOW HOW TO DO ALL PROBLEMS ASSIGNED, LIKELY TO BE ON 2ND TEST.

* FATIGUE REVIEW:

$S_e' = S_e K \ldots\ldots$

$\frac{\sigma_a}{K_f} \geq \frac{S_e}{F.S.}$

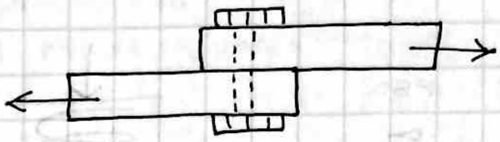


$a = \frac{(0.9S_{ut})^2}{S_e}$, $b = -\frac{1}{3}\log\left(\frac{0.9S_{ut}}{S_e}\right)$

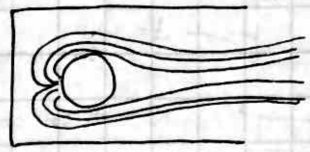
* ALL WILL BE ON EXAM *

2|12|2013

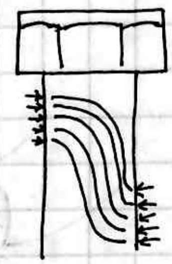
* FASTENERS



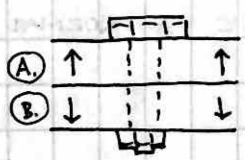
FASTENER IN SHEAR

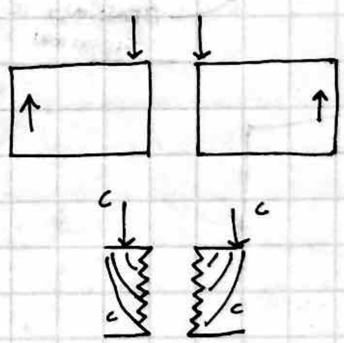


"FORCE FLOW": ANYTIME THERE IS A CHANGE FROM TENSION TO COMPRESSION THERE IS SHEAR



FASTENER IN TENSION:





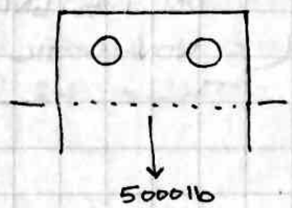
"WHAT'S THE FACTOR OF SAFTEY?"

→ TEST QUESTION

2/12/2013

EX. 8-67

1040 HOT ROLLED



5/16 x 18 UNC
SAE GRADE 8

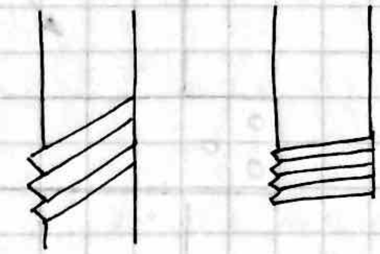


TABLE 8.6

$S_y = 130$ Kips

$S_{sy} = 0.577 S_y = 75$ Kpsi

SHEAR YIELD

(1.) BOLT SHEAR:

$$\tau \leq \frac{S_{sy}}{F.S.} \rightarrow F.S = \frac{S_{ys}}{\tau} = \frac{5000}{2\pi\left(\frac{5/16}{2}\right)^2} = 32.6 \text{ Kpsi}$$

$$F.S. = 2.3 = 75/32.6$$

(2.) BOLT CRUSH:

$$\sigma = \frac{F}{A} \rightarrow \sigma \leq \frac{S_{ys}}{FS} \rightarrow \sigma = \frac{2500}{(5/16)(1/4)} = 32 \text{ Kpsi}$$

$$F.S. = \frac{S_{ys}}{\sigma} = \frac{130}{32} = 4.06$$

FASTENERS RARELY CRUSH

(3.) PARENT MATERIAL CRUSH:

$$FS = \frac{S_{yp}}{\sigma} =$$

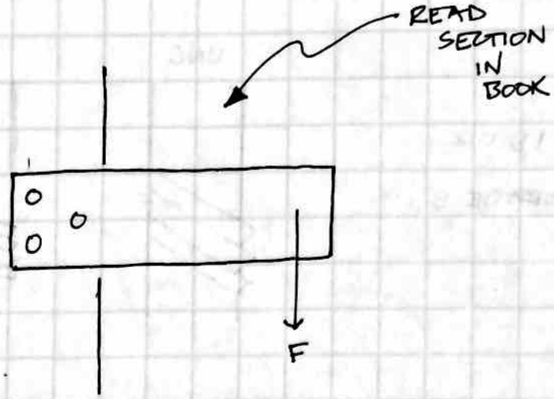
* EXPECT TO FAIL BY PARENT CRUSH *

(4.) PARENT TENSION:

$$\sigma \leq \frac{S_y}{FS} = \frac{5000}{\frac{1}{4}\left(\frac{12}{8} - \frac{5}{8}\right)} = \frac{5000}{0.44} = 11.4 \text{ Kpsi}$$

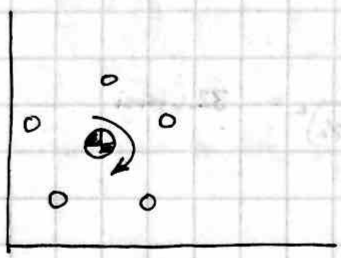
$$FS = 3.68$$

2/12/2013



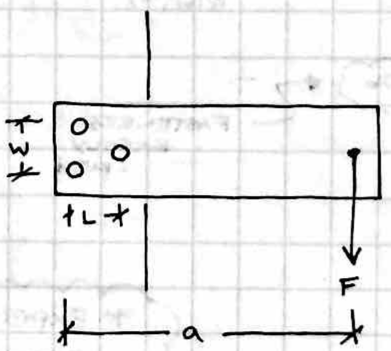
* QUIZ ON THURSDAY ON FASTENERS, POSS. NON-STATIC LOAD *

2/14/2013



(1.) $$\bar{x} = \frac{A_1 x_1 + A_2 x_2 + \ldots A_N x_n}{\sum_i^N A}$$

(2.) MOVE LOAD TO CENTROID

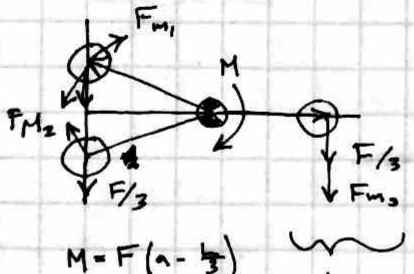


$$\bar{x} = \frac{A_1(0) + A_2(0) + A_3(L)}{A_1 + A_2 + A_3}$$

$$= \frac{L}{3}$$

$$\bar{y} = \bar{y} = \frac{A_1 \frac{W}{2} - A_2 \frac{W}{2} + A_3(0)}{A_1 + A_2 + A_3}$$

$$= 0$$



$$M = F\left(a - \frac{L}{3}\right)$$

$$M = F_{m_1} r_1 + F_{m_2} r_2 + F_{m_3} r_3$$

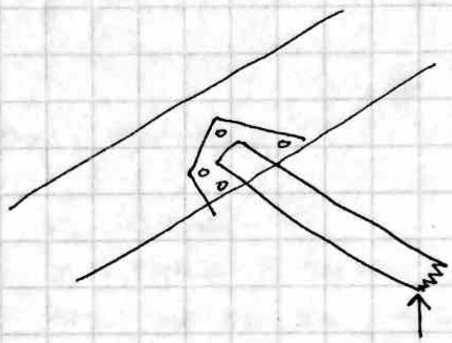
$$F_{m_n} = \frac{M r_n}{\sum_{i=1}^{N} r_i^2}$$

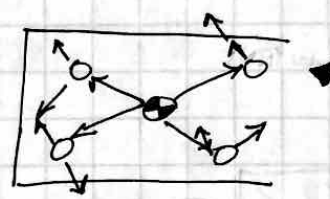
CRITICAL FASTENER

2/14/2013

4. FOR MOST CRITICAL FASTENER, EVALUATE:

1. SHEAR FASTENER
2. CRUSH FASTENER
3. ~~SHEAR~~ PARENT MATERIAL CRUSH





* LOOK AT FASTENERS IN TENSION *

*"WHEN IN DOUBT MAKE IT STOUT OUT OF THINGS YOU KNOW ABOUT" *

* WEAR:

$$\frac{\delta}{t} = \frac{K}{H} * P * V$$

δ = WEAR
t = TIME (s)
K = WEAR COEFFICIENTS
H = SURFACE HARDNESS
P = SURFACE PRESSURE
V = SLIDING VELOCITY

MICROSCOPIC SPOT WELDS IN BETWEEN SURFACES

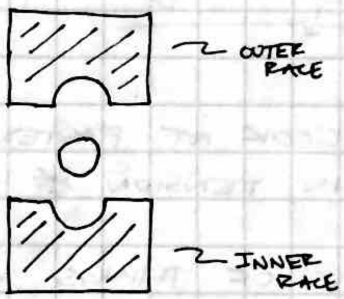
2/19/2013

* ROLLING ELEMENT
  - BALL
  - ROLLER
  - TAPERED ROLLER

* HYDRODYNAMIC

* SLIDING ELEMENT

- ROLLING ELEMENT

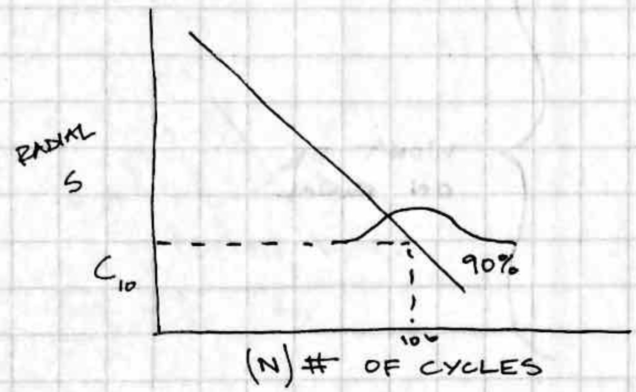


SINTERED BRONZE (SELF LUBRICATING)

TWO NUMBERS TO BE CONCERNED WITH

C_0	C_{10}
↑	↑
STATIC	DYNAMIC

2/21/2013



$$L = L_{10}\left(\frac{C_{10}}{F_R}\right)^a$$

$L_{10} = 10^6$

$a = 3$ (BALL BEARING)

$a = \frac{10}{3} = 3.33$ (ROLLER)

$L = \mathcal{L}\, n\, (60)$

hr, rpm, m/hr

BEARING EXAMPLE:

$F_R = 5.5$ KN

$\mathcal{L} = 5000$ H @ 300 RPM

SPEC AN 02 BB, 90% RELIABILITY

ANOTHER EXAMPLE

25mm bore, $F_r = 5500$ N

- HOW LONG WILL IT LAST?

$$L = 10^6\left(\frac{14{,}000}{5500}\right)^3 \rightarrow 16.5 \times 10^6 \text{ REV}$$

* RADIAL + AXIAL LOAD:

$$F_e = XVF_R + YF_a$$

EQ. RADIAL LOAD (F_e), ROTATION (V)

$V = 1$ (INNER RACE ROTATES)

$V = 1.2$ (OUTER RACE ROTATES)

1. $\frac{F_a}{VF_r}$
2. TABLE 11-1 → PICK INITIAL X & Y VALUES
3. COMPUTE $F_e = XVF_r + YF_a$
4. FIND B LOAD FACTOR

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(5.) COMPUTE $F_c = F_e a_f$

(6.) PICK BRG. FROM 11.2

(7.) $\frac{F_a}{C_o}$

(8.) TABLE 11.1

WON'T BE ON FINAL

EX.

$F_a = 1.5 \text{ KN}$
$F_r = 1.2 \text{ KN}$

40 hr/WEEK, 15 YEARS, 1800 RPM
90% RELIABILITY, BALL 02
$L = 3.24 \times 10^9$ REV
- INNER RING ROTATES, $V = 1.0$

$$\boxed{\begin{array}{l} X = 0.56 \\ Y = 1.63 \end{array}}$$

$$F_e = 0.56 * 1 * 1.2 + 1.63 * 1.5$$
$$= 3.07$$

$$F_e' = 3.07 + 1.2$$

$$C_{10} = F_e' \left(\frac{L}{L_{10}}\right)^{1/3}$$

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$$C_{10} = F_{af}\left(\frac{\chi_D n_D 60}{\chi_R n_r 60}\right)^{1/a}, \quad L_{10} = L_R n_R 60 \left(\frac{C_{10}}{F_{af}}\right)^a$$

C_{10} x_o, θ, b

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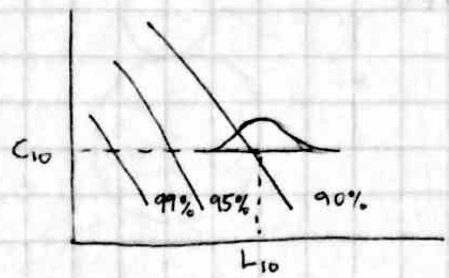


$$C_{10} = F_{Af}\left(\frac{x_D}{x_D + (\theta - x_D)(1-R_D)^{1/b}}\right)^{1/a}$$

EX.

$F_D = 413$ lb
$a_f = 1.2$
$\mathcal{L} = 30{,}000$ hr @ 300 RPM
$R_D = 99\%$

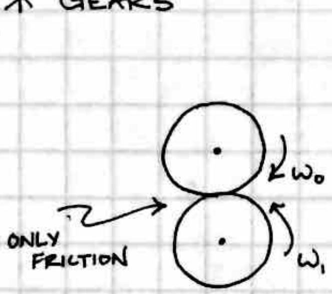
$\rightarrow$ $L_D = 30000$

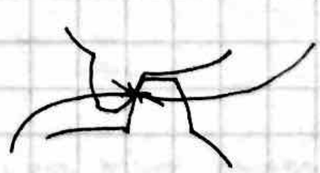
$L_D = 540 \times 10^6$ REV

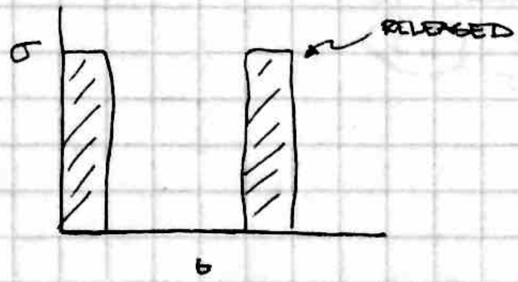
$x_D = 540 = \frac{540\times10^6}{1\times10^6} = \left(\frac{L_D}{L_{10}}\right)$

$$= 413 \times 1.2\left(\frac{540}{0.2 + (4.459 - 0.02)(1-0.99)^{1/1.483}}\right)^{1/3}$$

* GEARS







* IDELERS ARE FULLY REVERSED *

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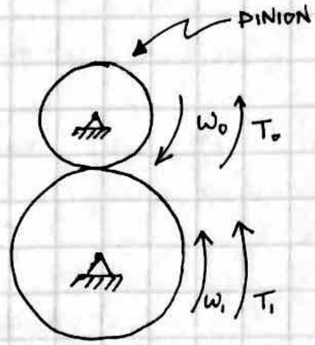
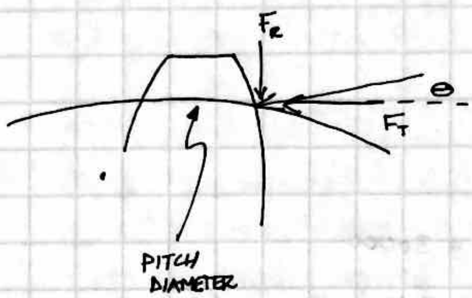


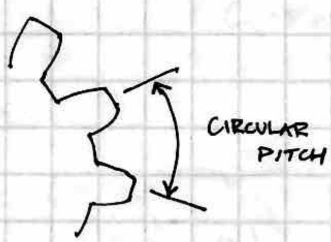
$$P = \omega T = Fv$$



$$\omega_o = \omega_1\left(\frac{r_1}{r_o}\right)$$

DIAMETRICAL PITCH $\underline{P} = \frac{\#\text{ TEETH}}{\text{PITCH DIAM}}$

$$\frac{r_1}{r_o} = \frac{d_{P_1}}{d_{P_0}} = \frac{N_1}{N_0} \quad \rightarrow \quad \omega_o = \omega_1\left(\frac{N_1}{N_0}\right)$$



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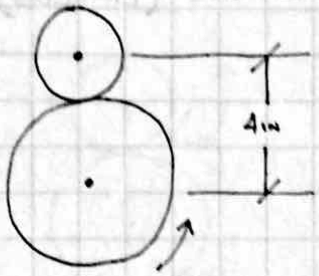


$\underline{P} = 6\text{in}$

$\omega_p = \omega_g\left(\frac{r_g}{r_p}\right)$

$r_g + r_p = 4\ ,\quad r_p = 1$
$r_G = 3$

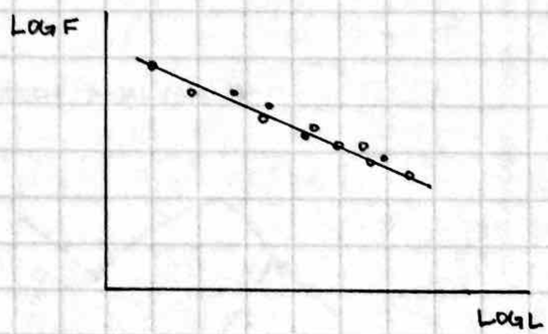
$N_g = P r_g 2 = 36$

$N_p = 12$

* QUIZ ON 2 BEARING EQUATIONS

* READING NOTES: BEARINGS

- RATING LIFE: # OF REVOLUTIONS (OR HOURS) AT A CONSTANT SPEED THAT 90% WILL ACHIEVE OR EXCEED BEFORE FAILURE. REFERED TO AS L_{10} LIFE



$F L^{1/a} = \text{CONST}$

$a = 3$ FOR BB

$a = 10/3$ FOR ROLLER

- CATALOG LOAD: RADIAL LOAD THAT CAUSES 10 % OF A GROUP OF BEARINGS TO FAIL. REFERED TO AS C_{10}. OR BASIC DYNAMIC LOAD RATING.
  → REFERENCE VALUE (NOT USUALLY ACHIEVED BY THE BEARING)

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$F_1 L_1^{1/a} = F_2 L_2^{1/a}$ → LOAD RATING (CATALOG)

AND LIFE RATING INSERTED:

$F_R L_R^{1/a} = F_D L_D^{1/a}$

- R: RATED
- D: DESIRED

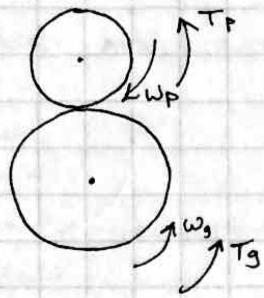
- LIFE EXPRESSED IN HOURS AT A GIVEN SPEED

$$\boxed{L = 60 \mathcal{L} n}$$

$\mathcal{L}$ = HOURS
n = REV/MIN

$$\boxed{C_{10} = F_R = F_D \left(\frac{L_D}{L_R}\right)^{1/a} = F_D \left(\frac{\mathcal{L}_D n_D 60}{\mathcal{L}_R n_R 60}\right)^{1/a}}$$

2/28/2013



$$\left.\begin{matrix} T_g = r_g W_t \\ T_p = r_p W_t \end{matrix}\right\} \rightarrow \frac{T_g}{T_p} = \frac{r_g}{r_p} = \frac{N_g}{N_p}$$

OF TEETH

$$P_{IN} = T_g \omega_g = \frac{T_p N_g}{N_p} \omega_p \frac{N_p}{N_g} = P_{OUT}$$

$\eta = 0.98$

$\rightarrow \boxed{P_{OUT} = \eta P_{IN}}$

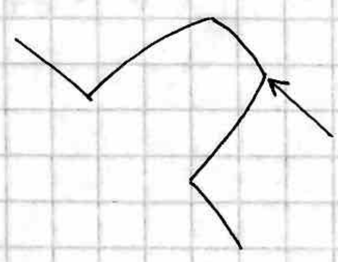
* EXAMPLE *

$N_g = 30$
$N_p = 20$
$P = 6$
$T_p = 144$ in.lb
$\omega_p = 1800$ RPM

$T_g = ?$
$\omega_g = ?$

$$HP = \frac{W_t V}{33{,}300} \leftarrow W_t r$$

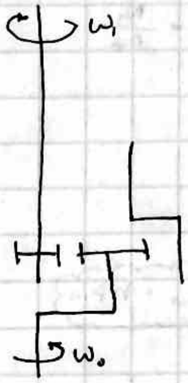
* GEAR TEETH ANALYSIS *



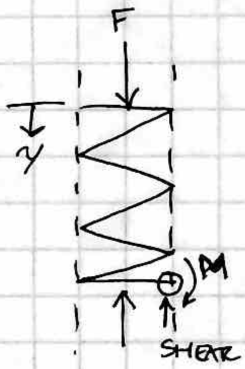
ASSUMPTIONS:

- LOAD AT TIP
- BEAM BENDING

$$\frac{N_r}{N_s}\omega_R = \left(1+\frac{N_R}{N_s}\right)\omega_A - \omega_s$$



* KNOW STRESS STATES IN SPRINGS, BEVEL WASHERS *



$$\boxed{\tau_{MAX} = K_s \frac{8FD}{\pi d^3}}$$

$$K_s = \frac{2c+1}{2c}$$

$$y = \frac{8FD^3 N_a}{d^4 G}$$ ← # OF ACTIVE COILS

SPEC SPRINGS:

- MIN WORKING LENGTH
- FREE LENGTH
- SOLID LENGTH
- $N_t * d$

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SPRINGS

* TABLES GIVEN ON EXAM *

N_T = SQUARED AND GROUND

$N_a = 5$

$OD = 31.3\,mm$

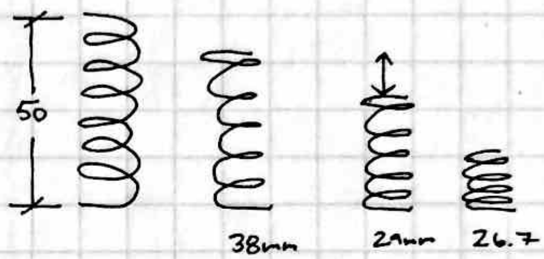
$d = 3.82\,mm$

$L_0 = 50\,mm$ ← FREELENGTH

$L_{MAX} = 38\,mm$

$L_{MIN} = 29\,mm$

$L_s = N_T d$



$$K = \frac{d^4 G}{8D^3 N_a} = 20.3\ kN/M = 116\ lb/M$$

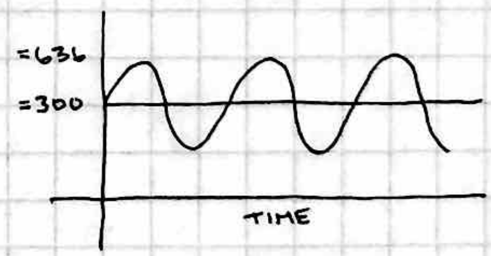
YIELD AT SOLID:

$$\tau_{MAX} = K \frac{8FD}{\pi d^3}$$

$$K_v,\ K_B = \frac{4c + 2}{4c - 3} = 1.19$$

$$\tau_{MAX} = 705\ MPa$$

$$FS = \frac{800}{705} = 1.13$$



ME 383 FINAL NOTES:

* CHAPTER 14 * HELICAL AND SPUR GEARS *

BENDING STRESS IN GEARS → LEWIS BENDING EQUATION:

$$\sigma = \frac{Mc}{I} = \frac{6W^t l}{Ft^2}$$