FORM A

ESM 2204 Spring 2005
MECHANICS OF DEFORMABLE BODIES
Test 1

NAME
(print legibly) Grade Key
last first initial

PLEDGE (signature): On my honor I have neither given nor received unauthorized aid on this test.

Ron Kriz

INSTRUCTIONS:
Closed book, closed notes, 8.5" x 11" formula (only) sheet.

- There are 6 questions on this exam - check for completeness.
- Please be sure to mark you Form letter on the op-scan form.
- Part I (50%) consists of 5 multiple-choice problems (each problem is worth equal credit).
- Part II (50%) consists of one work-out problem. Please complete all work in the space provided.

Turn in your results in the following order:
Test questions (signed)
Formula sheet

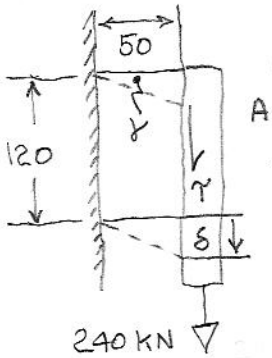
CHECK FOR COMPLETENESS

100 cm = 1 m
1000 mm = 1 m
$10^6 mm^2 = 1 m^2$

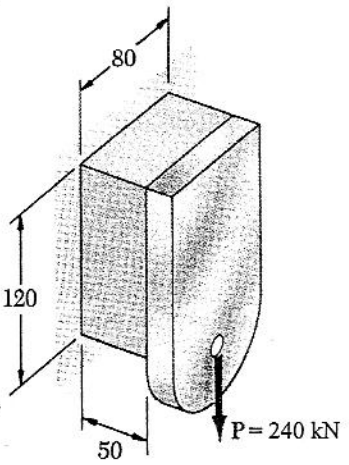
MULTIPLE CHOICE PROBLEMS (10 Points each)

1. The plastic block shown is bonded to a rigid support and to a rigid vertical plate to which a 240-kN load **P** is applied. Knowing that for the plastic used $G = 1050$ MPa, what is the deflection of the plate?

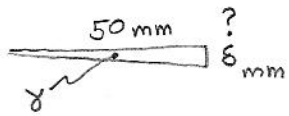
(a) 3.05 mm
(b) 6.10 mm
(c) 13.72 mm
(d) 6.86 mm
(e) 1.190 mm ✓



Area = 80(120)
$A = 9600\ mm^2$
$\tau = P/A$
$\tau = \frac{240 \times 10^3\ N}{0.0096\ m^2}$ [=] Pa
$\tau = 25\ MPa$



Dimensions in mm



Small angles

$\gamma_{rad} \approx \sin\gamma = \delta/50$

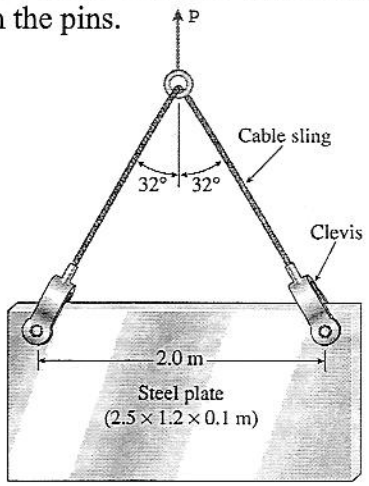
$\tau = G\gamma$; $\frac{240 \times 10^3}{0.0096} = 1050 \times 10^6 \gamma$; $\gamma = \frac{240 \times 10^3}{0.0096(1050)10^6}$

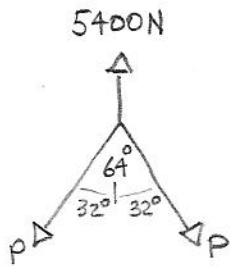
$\gamma = 0.0238$

$\delta = \gamma(50) = \frac{240(50)}{9.6(1050)}$; $\delta = 1.19\ mm$

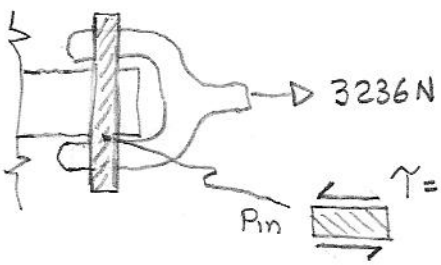
2. A steel plate weighing 5400 N is hoisted by a sling that has a clevis at each end. The pins through the clevises are 18mm diameter. Determine the average shear stress in the pins.

(a) 8.80 MPa
(b) 10.61 MPa
(c) 6.26 MPa ✓
(d) 5.31 MPa
(e) 12.51 MPa





$\uparrow + \sum F = 0 = +5400 - 2P\cos 32°$
(0.8480)
$P = 3183\ N$



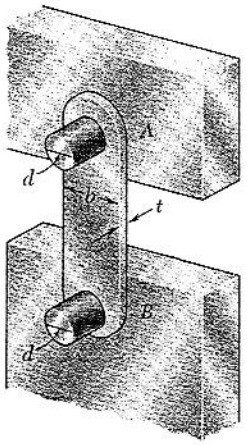
$\tau = \frac{3183/2\ N}{\pi(0.018m)^2/4}$; $A = \pi r^2$, $A = \pi d^2/4$

$\tau = \frac{2(3183)}{\pi(0.018)^2} = 6.25\ MPa = \tau$

0.25" = 1/4"

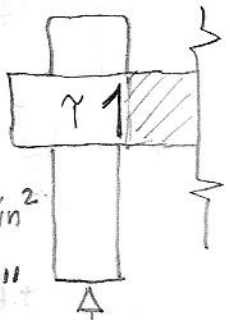
3. Link *AB*, of width $b = 2$ in. and thickness $t =$ ⊙ in., is used to support the end of a horizontal beam. Knowing that the average normal stress in the link is -20 ksi and the average shearing stress in each of the two pins is 12 ksi, determine the average bearing stress in the link.

(a) 20.0 ksi
(b) 40.7 ksi
(c) 2.8 ksi
(d) 38.8 ksi
(e) 27.5 ksi



Normal $P/A_{b.t} = \sigma = P/2"(1/4") = 20{,}000\ lb/in^2$

$P = 10{,}000$ lb



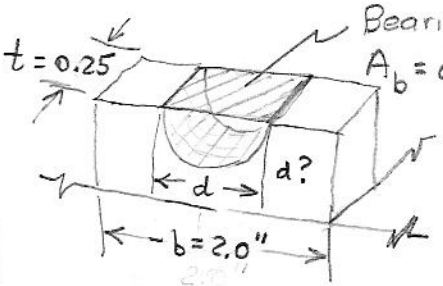
Shear

$P/\pi d^2/4 = \tau = 12{,}000\ lb/in^2$

$\frac{10{,}000(4)}{\pi d^2} = 12{,}000,\ d = 1.03"$

σ -20,000 lb/in²

$\sigma_b = P/A_b$

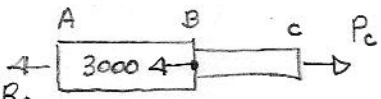


Bearing

$\sigma_b = P/d.t = \frac{10{,}000}{1.03(0.25)}$; $\sigma_b = 38.8\ lb/in^2$

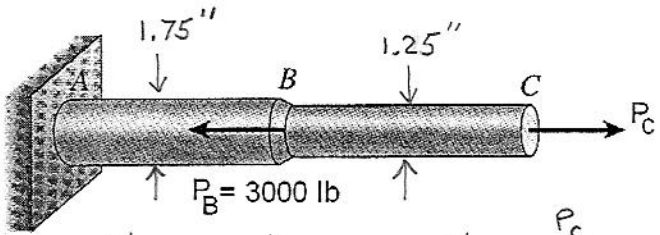
4. A metal bar ABC is loaded as shown. Part AB has a diameter of 1.75 in. and part BC has a diameter of 1.25 in. If the normal stress in part AB is 5000 psi, what is the normal stress in part BC?

(a) 12.24 ksi
(b) 9.80 ksi
(c) 4.91 ksi
(d) 2.44 ksi
(e) 7.78 ksi



$\pm\sum F = 0 = -R_A - 3000 + P_C$

$R_A = P_C - 3000$ lb



$\sigma_{AB} = 5000\ lb/in^2$

$5000 = \frac{P_C - 3000}{\pi(1.75")^2/4}$

$\sigma_{BC} = \frac{P_C}{\pi(1.25")^2/4}$

$P_C = 5000\ \pi/4\ (1.75)^2 + 3000 = 15026$ lb

$\sigma_{BC} = \frac{\pi/4\ 5000\ (1.75)^2 + 3000}{\pi/4\ (1.25)^2}$

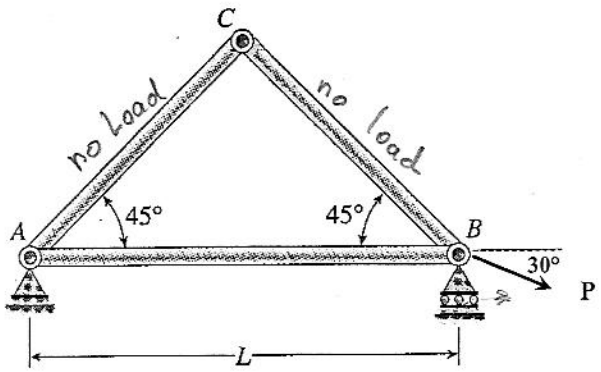
$\sigma_{BC} = 12{,}244\ lb/in^2$

$\sigma_{BC} = 12.24$ ksi

$10^6\ mm^2 = 1\ m^2$

5. The three-bar truss ABC shown in the figure has a span L = 3m and is constructed of steel pipes having cross-sectional area A = 3540 mm^2 and modulus of elasticity E = 200 GPa. A load P acts at joint B as shown. What is the maximum permissible load P_{max} if the displacement of joint B is limited to 1.0 mm?

(a) 273 kN
(b) 236 kN
(c) 118 kN
(d) 572 kN
(e) 558 kN



$\delta = \frac{PL}{AE}$

R_A ← | → $(P\cos 30^\circ)$

$(P\sqrt{3}/2)$

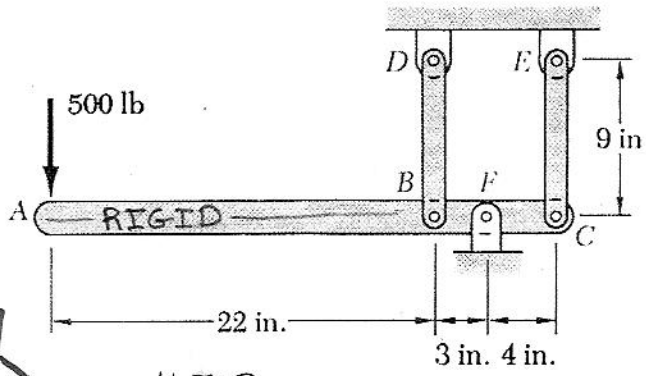
$$0.001m = \delta = \frac{(0.86603P)L}{AE}$$

$$0.001 = \frac{0.86603\ P\ 3}{\frac{3.54\times10^3}{10^6}(200)\ 10^{\cancel{6}3}}$$

$$\frac{1\times\cancel{10^{-3}}\cdot\cancel{10^{6}}^{3}(3.54)(200)}{0.86603\ (3)} = P = 272\times10^3\ lb$$

WORK OUT PROBLEM (50 Points) (0.0214)

6. Each of the rods *BD* and *CE* is made of brass ($E = 15\text{x}10^6$ psi) and has a cross-sectional area of 0.35 in^2. Determine the deflection of end *A* of the rigid member *ABC* caused by the 500-lb. load.



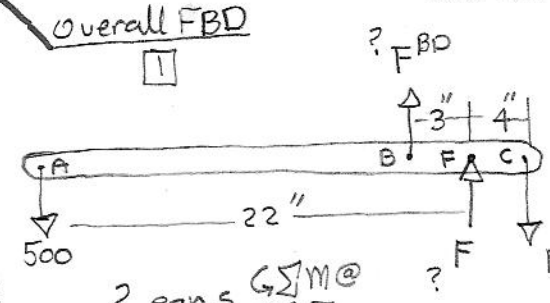
$\circlearrowleft +\sum M_{@F} = 0 = +25(500) - 3F^{BD} - 4F^{CE}$ (1)

eliminates, F unknown

2 | 20

Overall FBD

1



2 eqn.s $\circlearrowleft \sum M_{@F}$, $\uparrow \sum F$

3 unknowns ∴ need 3rd eqn. (F^{BD}, F^{CE}, F)

10 | 4

Subst. F^{BD}

$4F^{BD} = 3F^{CE}$ (2)

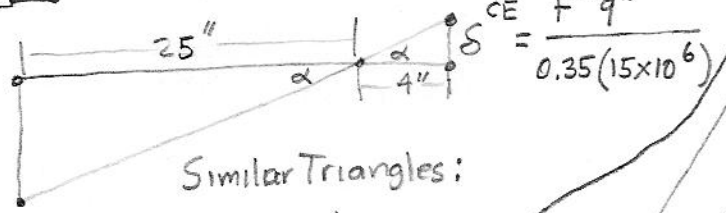
(1) $0 = 12500 - 3\left(\frac{3}{4}F^{CE}\right) - 4F^{CE}$

Solve F^{CE}

$0 = 50{,}000 - 9F^{CE} - 16F^{CE}$

$F^{CE} = 2{,}000\text{lb}$

5 | 10



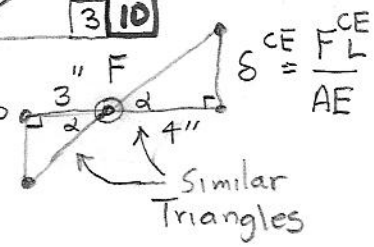
Similar Triangles:

$\frac{\delta_A}{25} = \frac{\delta^{CE}}{4''} = \frac{\frac{2\times10^{3}(9)}{0.35(15)10^{6}}}{4}$

$\delta_A = \frac{25}{4} \cdot \frac{2(3)}{0.35(5)} \cdot 10^{-3}$

$\delta_A = 0.0214\text{ in.}$

3 | 10



$\frac{F^{BP}L}{AE} = \delta$

$\frac{F^{BD}L}{AE} = \frac{F^{CE}L}{AE}$ ← $\frac{\delta^{BD}}{3''} = \frac{\delta^{CE}}{4''}$

$\frac{F^{BD}}{3} = \frac{F^{CE}}{4}$ (2)

To-all: Here are some statistics from my class.

Number of students 93:
On the MC portion (Part I) of the test: average was 3.55/5.00
- 17 got 5 questions correct
- 22 got 4 questions correct
- 52 got 2 to 3 questions correct
- 6 got 1 question correct
- 2 got no questions correct

On the sixth problem (Part II):
- 14 got 100%
- the remaining results were mixed
(overall there was a close correlation between doing well on Part I and Part II, no big surprises)

Combined Part I and II: average 74.8%
(not bi-modal, reasonable looking distribution)
- 25 were above 90%
- 36 were between 70% and 89%
- 32 were at 60% or below

With out curving the average was 74.8%, hence I told my class that I reserve the right to curve at the end of the class (after the 4th test) when I get the whole picture.
I am open to a common way of scaling, but I had to be decisive since I have to hand the tests back tomorrow AM.
I look forward to Scott's recommendation. -- r.d. kriz