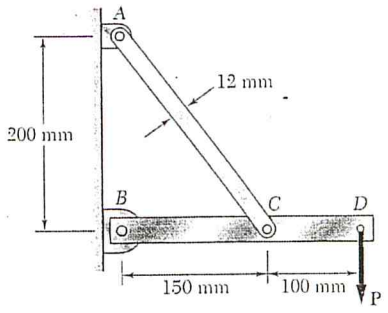
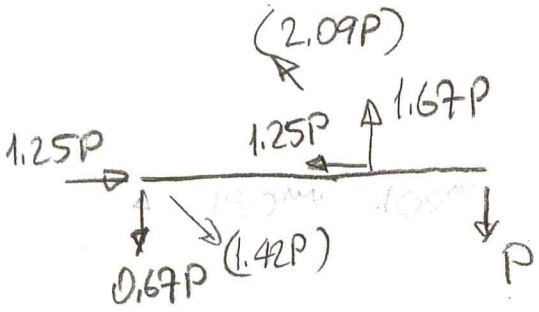
METU Civil Engineering Department	CE 224 Mechanics of Materials Summer 2014	Quiz #1
Name: SOLUTION		**Signature:**

Member AC has a 6x12mm uniform rectangular cross section and the maximum normal stress allowed on this member is 150 MPa. Member AC is connected to a support at A and to a rigid member BCD at C by 10 mm diameter pins. Member BCD is connected to the support at B by an 8 mm diameter pin. All of the pins are made of steel with a maximum allowable shearing stress of 60 MPa.

Determine the largest load **P** that can safely be applied at D without exceeding given the stress limits.

Please show all your calculations clearly!





Tension in AC

$$\frac{2.09P}{6\times(12-10)} = 150\,MPa \Rightarrow P = 861\,N$$

Pins @ A & C

$$\frac{2.09P}{\pi\times\frac{10^2}{4}} = 60\,MPa \Rightarrow P = 2254\,N$$

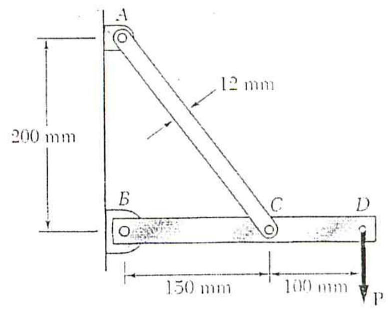
PIN @ B

$$\frac{1.42P}{\pi\times\frac{8^2}{4}} = 60\,MPa \Rightarrow P = 2124\,N$$

$\therefore P_{max} = 861\,N$

METU Civil Engineering Department	CE 224 Mechanics of Materials Summer 2014	Quiz #1
Name: SOLUTION	**Signature:**	**Time: 20 mins**

Member AC has a 6x12mm uniform rectangular cross section and the maximum normal stress allowed on this member is 150 MPa. Member AC is connected to a support at A and to a rigid member BCD at C by 10 mm diameter pins. Member BCD is connected to the support at B by an 8 mm diameter pin. All of the pins are made of steel with a maximum allowable shearing stress of 60 MPa. All pins are in single shear.



Determine the largest load **P** that can safely be applied at D without exceeding given the stress limits.

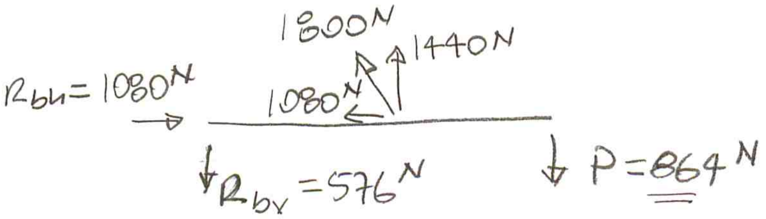
Please show all your calculations clearly!

$(F_{AC})_{max} = 150^{MPa} \times (6^{mm} \times (12^{mm} - 10^{m})) = 1800^{N}$

$(F_{AC})_{max} = 60^{MPa} \times (\pi \times \frac{10^2}{4}) = 4712^{N}$

$\Rightarrow (F_{AC})_{max} = 1800^{N}$

$(F_B)_{max} = 60^{MPa} \times (\pi \times 8^2/4) = 3016^{N}$



$(F_{AC}) = (F_{AC})_{max}$

$R_b = \sqrt{576^2 + 1080^2} = 1224^{N} < (F_B)_{max}$ ✓

$\therefore P_{max} = 864\ N$

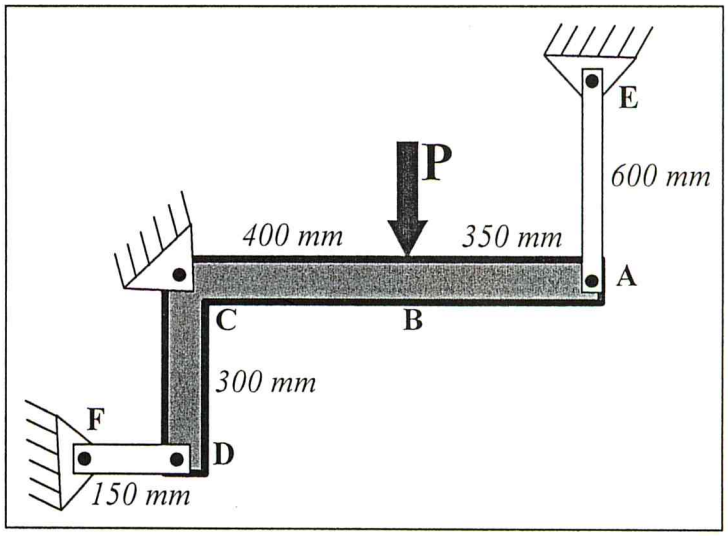
METU Civil Engineering Department	CE 224 Mechanics of Materials Summer 2014	Quiz #2
Name: SOLUTION	**Signature:**	**Time: 20 mins**

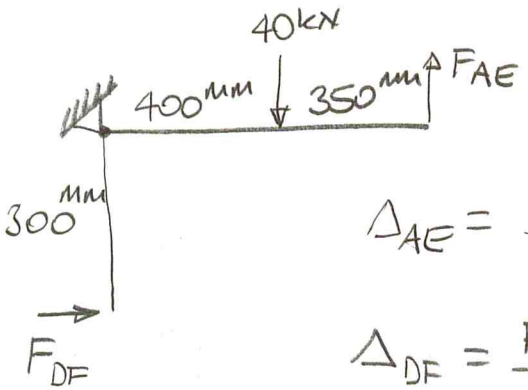
Rigid bar ABCD is pinned at point C and supported by rods AE and DF.
A concentrated load P=40 kN is applied at point B.
Determine:

i. Force in rod AE
ii. Force in rod DF
iii. Vertical displacement at point A

Please show all your calculations clearly!

Rod AE: A=70 mm^2 E=200 GPa
Rod DF: A=625 mm^2 E=100 GPa



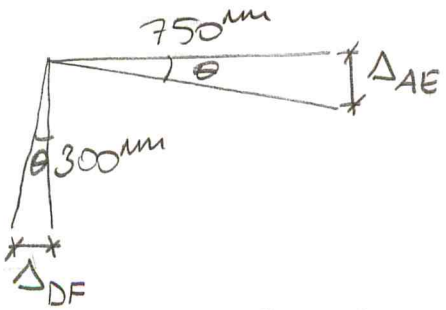


$F_{AE} \times 750^{mm} + F_{DF} \times 300^{mm} = 40^{kN} \times 400^{mm}$ (1)

$$\Delta_{AE} = \frac{F_{AE} \times 600^{mm}}{70^{mm^2} \times 200\,GPa} = 0.043 F_{AE}$$ (1)

$$\Delta_{DF} = \frac{F_{DF} \times 150^{mm}}{625^{mm^2} \times 100\,GPa} = 0.0024 F_{DF}$$ (1)

Compatibility condition:



$$\frac{\Delta_{DF}}{300^{mm}} = \frac{\Delta_{AE}}{750^{mm}}$$ (4)

$$\frac{0.0024 F_{DF}}{300^{mm}} = \frac{0.043 F_{AE}}{750^{mm}}$$

$$F_{DF} = 7.17 F_{AE}$$

$$\Rightarrow (F_{AE})(750^{mm}) + (7.17 F_{AE})(300^{mm}) = 40^{kN} \times 400^{mm}$$

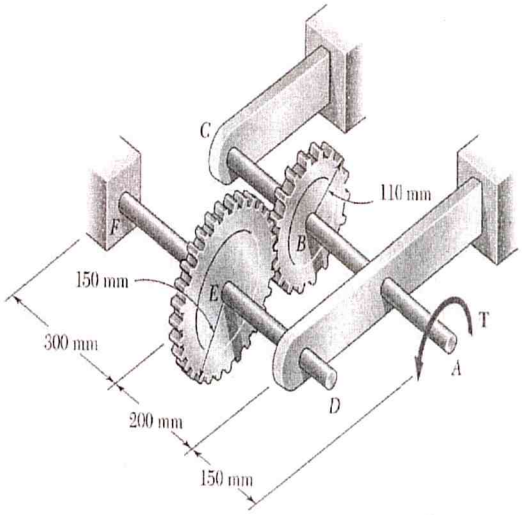
$F_{AE} = 5.5^{kN}$ (1) $\quad F_{DF} = 39.5^{kN}$ (1)

$\Delta_{AE} = 0.043 \times 5.5 = 0.24^{mm}$ (1)

$\Delta_{DF} = 0.0024 \times 39.5 = 0.09^{mm}$

METU Civil Engineering Department	CE 224 Mechanics of Materials Summer 2014	Quiz #3
Name: SOLUTION	**Signature:**	**Time: 30 mins**

Two shafts, each of 22 mm diameter, are connected by the gears shown. The shafts are made of a material that has a shear modulus of G=77 GPa. The rotation of shaft DF is fixed at point F. Determine the total rotation of point A when a torque of 130 N-m is applied at this point.



Please show all your calculations clearly!

$$\tau = \frac{T \cdot r}{J} \qquad \phi = \frac{T \cdot L}{J \cdot G} \qquad J_{circle} = \frac{\pi}{2} \cdot r^4$$

$T_{AB} = 130\ N\text{-}m$

$T_{EF} = \frac{130^{N\text{-}m}}{110^{mm}} * 150^{mm} = 177.3\ N\text{-}m$

$J = \frac{\pi}{2} \times 11^4 = 23000\ mm^4$

$\theta_{A/B} = \frac{130,000 * 350}{23,000 \times 77,000} = 0,026\ rad = 1.47\ deg.$

$\theta_{E/F} = \frac{177,300 \times 300}{23,000 \times 77,000} = 0,03\ rad = 1,72\ deg.$

$\Rightarrow \theta_A = 1,72^\circ * \frac{150^{mm}}{110^{mm}} + 1,47^\circ$

$= 2.34^\circ + 1.47^\circ \quad (0.04\ rad)$

$\theta_A = 3.81^\circ \ (0,066\ rad)$