MET 301: Homework #1
Due on 9/12 Fall 2013

NOTE: Tables of material Properties such as modulus of elasticity (E) and coefficient of thermal expansion (α) of engineering materials are attached at the end.

5. In Fig. 1-45, find the drop of the 500-lb weight.
Ans. $\delta = 0.0128$ in.

Solution:
$P_{al} = 1000+500 = 1500$ lb
$P_{br} = 500$ lb

Total elongation

$$\delta = \delta_{al} + \delta_{br} = \frac{P_{al}L_{al}}{A_{al}E_{al}} + \frac{P_{br}L_{br}}{A_{br}E_{br}}$$

$$= \frac{1500\times 30}{\left(\frac{\pi}{4}\right)\times\left(\frac{3}{4}\right)^2\times 10\times 10^6} + \frac{500\times 24}{\left(\frac{\pi}{4}\right)\times\left(\frac{5}{8}\right)^2\times 15\times 10^6}$$

$$= 0.01019 + 0.0026 = 0.0128\ inch$$

= **0.0128 inch**

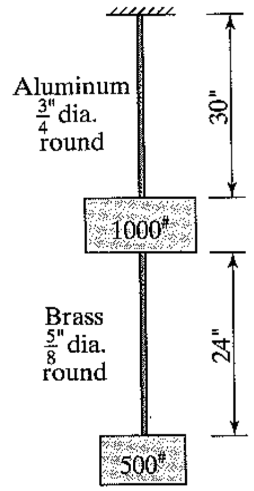
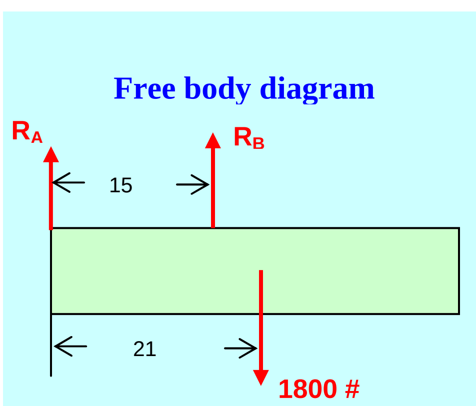
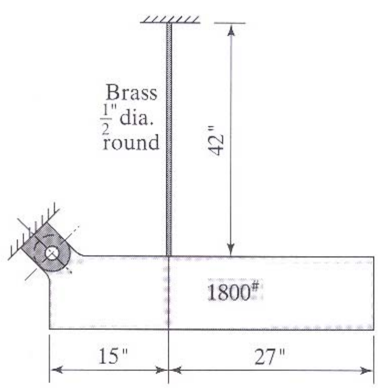


Figure 1-45 Problem 5.

3. The bottom member in Fig. 1-43 is of uniform cross section and can be assumed to be rigid. Its hinge is frictionless. Find the number of degrees of rotation of the lower member.
Ans. $\varphi = 0.137°$.





Equating moment around the hinge to zero:

$\Sigma M_A = 0$: $-R_B*15 + 1800*21 = 0$

$$R_B = \frac{1800\times 21}{15} = 2520\ lb$$

$\Sigma F_Y = 0$: $R_A + R_B = 1800$, $R_A = 1800 - R_B = 1800-2520 = -720\ lb$ (downward)

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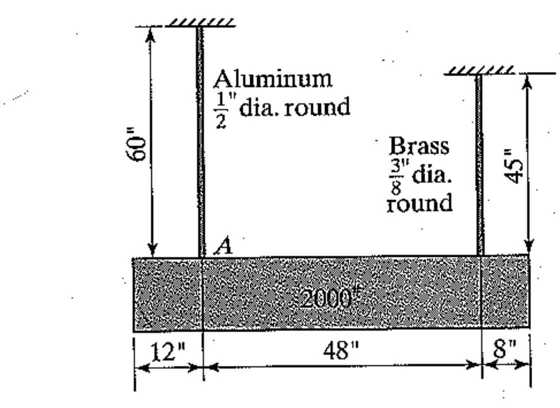
Check: $\Sigma M_B = 0$: 1800*6-720*15 = 0 CORRECT!

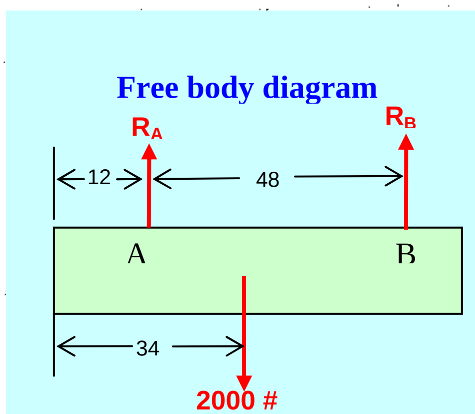
Elongation of the hanger: $\delta = \dfrac{PL}{AE} = \dfrac{2520 \times 42}{\left(\dfrac{\pi}{4}\right) \times 0.5^2 \times 15 \times 10^6} = 0.0359\ inch$

The bar will rotate in an arc around the hinge.

The rotational angle $\theta = \dfrac{0.0359}{15}\ rad = \dfrac{0.0359}{15} \times \dfrac{180}{\pi}\ \deg\ =$ **0.137°**

7. In Fig. 1-47 the lower member is of uniform cross section and can be assumed to be rigid. Find the change in elevation of the left end because of the stretch of the rods.
Ans. Drop = 0.0352 in.





Taking moment around A: $\Sigma M_A = 0$: $-R_B$*48 + 2000*22 = 0; R_B = 2000*22/48 = 917 lb

Summation of vertical forces $\Sigma F_y = 0$: R_A = 2000-917 = 1083 lb

Check moment around B: $\Sigma M_B = 0$: R_A*48 - 2000*26 = 0;
R_A = 2000*26/48 = 1083 lb

Elongation of rod A: $\delta_A = \dfrac{PL}{AE} = \dfrac{1083 \times 60}{\left(\dfrac{\pi}{4}\right) \times 0.5^2 \times 10 \times 10^6} = 0.0331\ inch$

Elongation of rod B: $\delta_B = \dfrac{PL}{AE} = \dfrac{917 \times 45}{\left(\dfrac{\pi}{4}\right) \times 0.375^2 \times 15 \times 10^6} = 0.0249\ inch$

Angle of the lower member $\theta = (0.0331 - 0.0249)/48 = 0.000171$ rad

Drop of the left edge = 0.0249+0.000171*60 = **0.0352 inch**

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8. The members in Fig. 1-48 have a neat fit at the time of assembly. Find the force caused by an increase in temperature of 50°C. Supports are immovable.
Ans. P = 101,402 N.

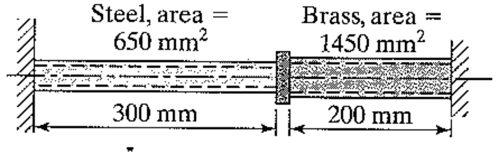

Figure 1-48 Problem 8.

Solution

From Table 2-3,

Coefficient of linear expansion for steel is 0.000 0117
and for brass is 0.000 0184 /°C

Total expansion of length of the two rods due to 50°C temp rise
= 300x0.000 0117*50+200*0.000 0184*50
= 0.1755+0.184= 0.3595 mm

Because of the rigid support, the rods cannot expand, and both the member will see the same force 'P' enough to compress the two members to fit within the two rigid walls.

Thus the shortening due to force P will be:

$$\delta = \delta_{st} + \delta_{br} =$$

$$= \frac{P \times 300}{650 \times 206{,}900} + \frac{P \times 200}{1450 \times 103{,}400}$$

$$= 0.000002231P + 0.000001334P = 0.000003565P\ mm$$

If we now equate the shortening with the lengthening due to temperature rise, we can solve the value of P. Thus,

0.000003565P = 0.3595

P = 0.3595/.000003565 = **100,850 N**

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11. In Fig. 1-51 the outer bars are symmetrically placed with respect to the center bar. The top member is rigid and located symmetrically on the supports. Find the load carried by each of the supports. Modulus for the bars is 2,000,000 psi.
Ans. Center, 5161.4 lb; outer, 2419.3 lb.

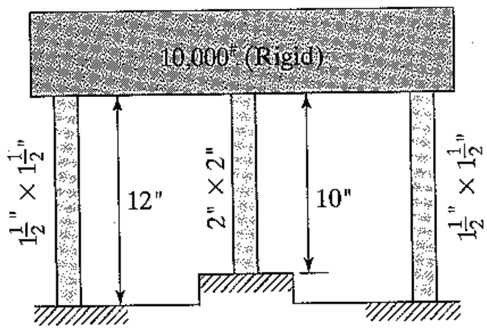

Figure 1-51 Problem 11.

Let, F_o =Force in each outer bar
F_c =Force in center bar

The deformation of the outer bar will be,

$$\delta_o = \frac{F_o \times 12}{(1.5\times1.5)\times2\times10^6}$$

The deformation of the center bar will be,

$$\delta_c = \frac{F_c \times 10}{(2\times2)\times2\times10^6}$$

Due to symmetry, the deformation in the outer and center bars will be equal, so:

$$\delta_o = \delta_c$$

$$\frac{F_o \times 12}{(1.5\times1.5)\times2\times10^6} = \frac{F_c \times 10}{(2\times2)\times2\times10^6}$$

$$F_o = F_c \times \frac{10\times(1.5\times1.5)\times2\times10^6}{12\times(2\times2)\times2\times10^6}$$

$$F_o = 0.46875F_c \quad \cdots\cdots\cdots(1)$$

Also from equilibrium of force:

$2F_o + F_c = 10,000$ ………….(2)

Using (1) into (2) : $2\text{x}0.46875F_c + F_c = 10,000$
$1.9375\ F_c = 10,000$
F_c = **5,161.3 lb**

F_o = 0.46875x5161.3 = **2,419.4 lb**