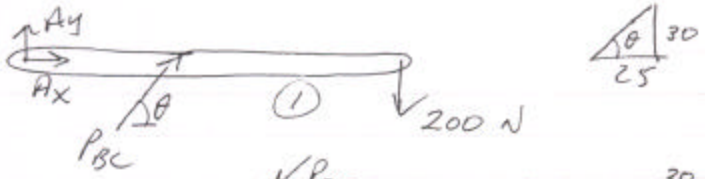
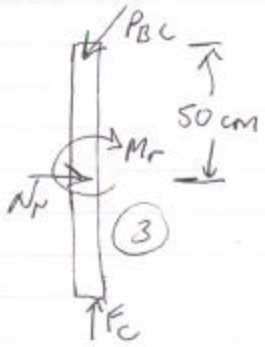
Solutions to Exam 2B, 24-261, Fall 2001



$\tan\theta = \frac{30}{25}$

$\theta = 50.2°$



① $\Sigma M|_{A_z} = -200(145) + P_{BC}\sin\theta(45) = 0$

$P_{BC} = \frac{200(145)}{45\sin\theta} = 839\ N$

③ $\Sigma F_y = -P_{BC}\sin\theta + F_c = 0 \Rightarrow \boxed{F_c = 644\ N}$

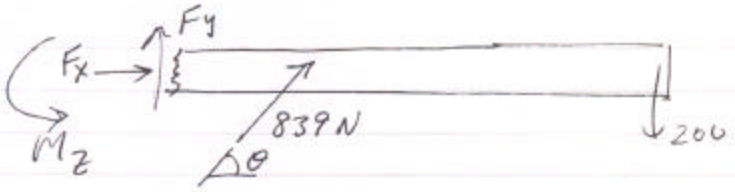
$\Sigma M|_{guide_z} = P_{BC}\cos\theta\,(50) - M_r = 0$

$\boxed{M_r = 26{,}900\ N\text{-}cm = 269\ N\text{-}m}$

$\Sigma F_x = -P_{BC}\cos\theta + N_f = 0 \Rightarrow \boxed{N_f = 537\ N}$

Crushing force is 644N

Guide + ram interact with a normal force of 537N & a moment of 269 N-m

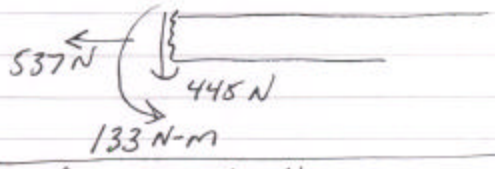


$\Sigma F_x = F_x + 839\cos\theta = 0 \Rightarrow \boxed{F_x = -537\ N}$

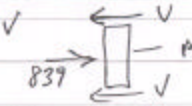
$\Sigma F_y = F_y + 839\sin\theta - 200 = 0 \Rightarrow \boxed{F_y = -445\ N}$

$\Sigma m|_{cut_z} = M_z + 839\sin\theta\,(15) - 200(115) = 0$

$M_z = 13{,}300\ N\text{-}cm = \boxed{133\ N\text{-}m = M_z}$



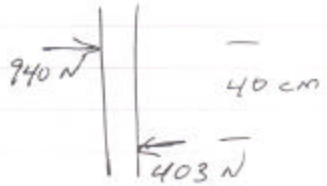
Shear force V

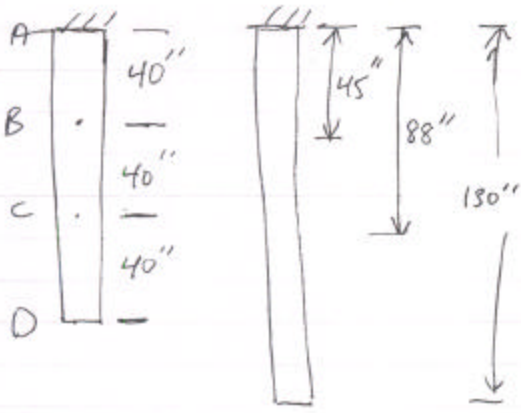


$V = \frac{839}{2}$

$\tau = \frac{V}{A} = \frac{839}{2\left(\frac{\pi}{4}(.006)^2\right)} = 10.9\ MPa$

Guide could be viewed as applying two forces to ram





$v_A = 0$

$v_B = 45 - 40 = 5''$

$v_C = 88 - 80 = 8''$

$v_D = 130 - 120 = 10''$

Find stretches

$\delta_{AB} = v_B - v_A = 5''$; $\delta_{BC} = v_C - v_B = 3''$; $\delta_{CD} = 10'' - 8'' = 2''$

Find internal forces

$$\delta = \frac{PL}{EA} \Rightarrow P = \frac{EA\delta}{L}$$

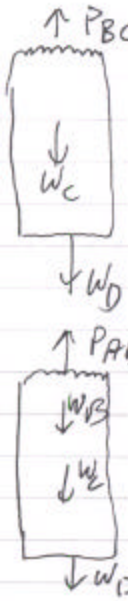
$$P_{AB} = \frac{300(1.5)(5)}{40} = 56.25\ lb$$

$$P_{BC} = \frac{300(1.5)(3)}{40} = 33.75\ lb$$

$$P_{CD} = \frac{300(1.5)(2)}{40} = 22.5\ lb$$

Find weights from equilibrium

$W_D = P_{CD} = 22.5\ lb$



$\Sigma F_y = P_{BC} - W_C - W_D = 0$

$P_{BC} = W_C + W_D \Rightarrow W_C = P_{BC} - W_D$

$W_C = 33.75 - 22.5 = 11.25\ lb$

$\Sigma F_y = P_{AB} - W_B - W_C - W_D = 0$

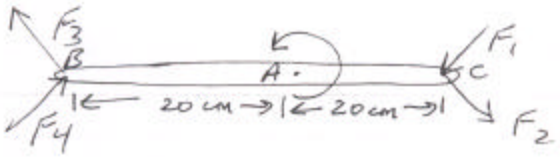
$W_B = P_{AB} - W_C - W_D$

$W_B = 56.25 - 11.25 - 22.5 = 22.5$

$W_B = 22.5\ lb,\ W_C = 11.25\ lb,\ W_D = 22.5\ lb$

between B & C, internal force is P_{BC}

$$\sigma_{BC} = \frac{P_{BC}}{A} = \frac{33.75}{1.5} = 22.5\ psi$$



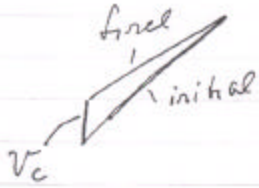
$$\Sigma M_{A_z} = M_A - (F_1 + F_2 + F_3 + F_4)(\cos 25^\circ)(20) = 0$$

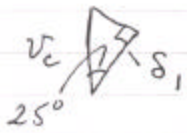
Consider motions, bar rotates by a small angle $\Rightarrow$ ends move up & down

If angle is α $\Rightarrow$ $v_B = (20\text{ cm})\,\alpha$ down

$v_C = (20\text{ cm})\,\alpha$ up

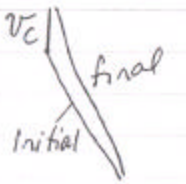
Relate displacements to stretches





$\delta_1 = v_C \cos 25^\circ$

spring 1 contracts



$\delta_2 = v_C \cos 25^\circ$

spring 2 extends

$F_1 = k_1 \delta_1 = (35) v_c \cos 25^\circ = (35)(20)\alpha \cos 25^\circ$

$F_2 = k_2 \delta_2 = (25) v_c \cos 25^\circ = (25)(20)\alpha \cos 25^\circ$

similar for $\delta_3 = v_B \cos 25^\circ$, $\delta_4 = v_B \cos 25^\circ$
(extends, contracts)

$F_3 = k_3 \delta_3 = 25 v_B \cos 25^\circ = (25)(20)\alpha \cos 25^\circ$

$F_4 = k_4 \delta_4 = 35 v_B \cos 25^\circ = (35)(20)\alpha \cos 25^\circ$

$M_A = (F_1 + F_2 + F_3 + F_4)(\cos 25^\circ)(20)$

$M_A = [35 + 25 + 35 + 25)(20)(20)\alpha \cos^2 25^\circ$

$$\alpha = \frac{2000}{(120)(20)^2 \cos^2 25^\circ}$$

$\alpha = 0.051$ rad

$\boxed{\alpha = 2.91^\circ}$