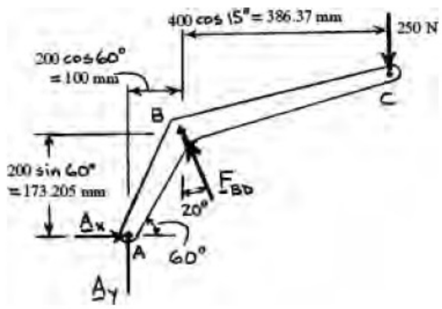
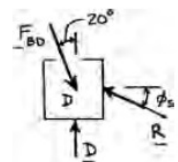
Q. No.1 The press shown in Fig. 1 is used to emboss a small seal at E. Knowing that the coefficient of static friction between the vertical guide and the embossing die D is 0.30, determine the force exerted by the die on the seal.

SOLUTION

Free body: Member ABC



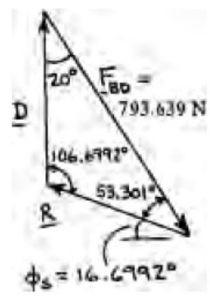
$$+\circlearrowleft \Sigma M_A = 0: \quad F_{BD}\cos 20°(100\text{ mm}) + F_{BD}\sin 20°(173.205\text{ mm})$$
$$-(250\text{ N})(100 + 386.37\text{ mm}) = 0$$
$$F_{BD} = 793.639\text{ N}$$



Free body: Die D

$$\phi_s = \tan^{-1}\mu_s$$
$$= \tan^{-1} 0.3$$
$$= 16.6992°$$

Force triangle:

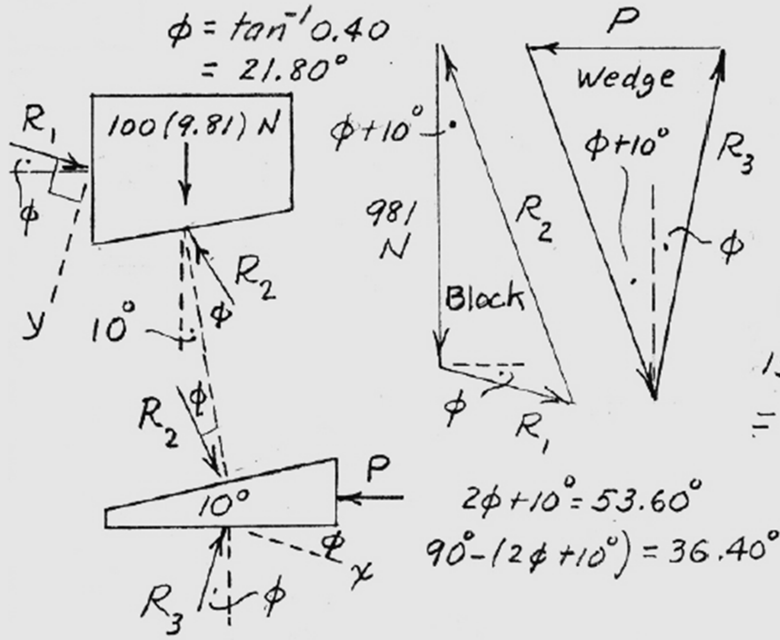


$$\frac{D}{\sin 53.301°} = \frac{793.639\text{ N}}{\sin 106.6992°}$$
$$D = 664.347\text{ N}$$

On seal: **D** = 664 N ↓ ◀

Q. No.2 The vertical position of the 100 Kg block is adjusted by the screw activated wedge shown in Fig. 2. Calculate the moment M which must be applied to the handle of the screw to raise the block. The single threaded screw has square threads with a mean diameter of 30 mm and advances 10 mm for each complete turn. The coefficient of friction for the screw treads is 0.25, and the coefficient of friction for all mating surfaces of the block and wedge is 0.40. Neglect friction at the ball at joint A.

SOLUTION:



Block: $\Sigma F_y = 0$;

$981 \cos 21.80° = R_2 \cos 53.60°$

$R_2 = 1535$ N

Wedge: $\Sigma F_x = 0$;

$1535 \cos 36.40° = P \cos 21.80°$

$P = 1331$ N

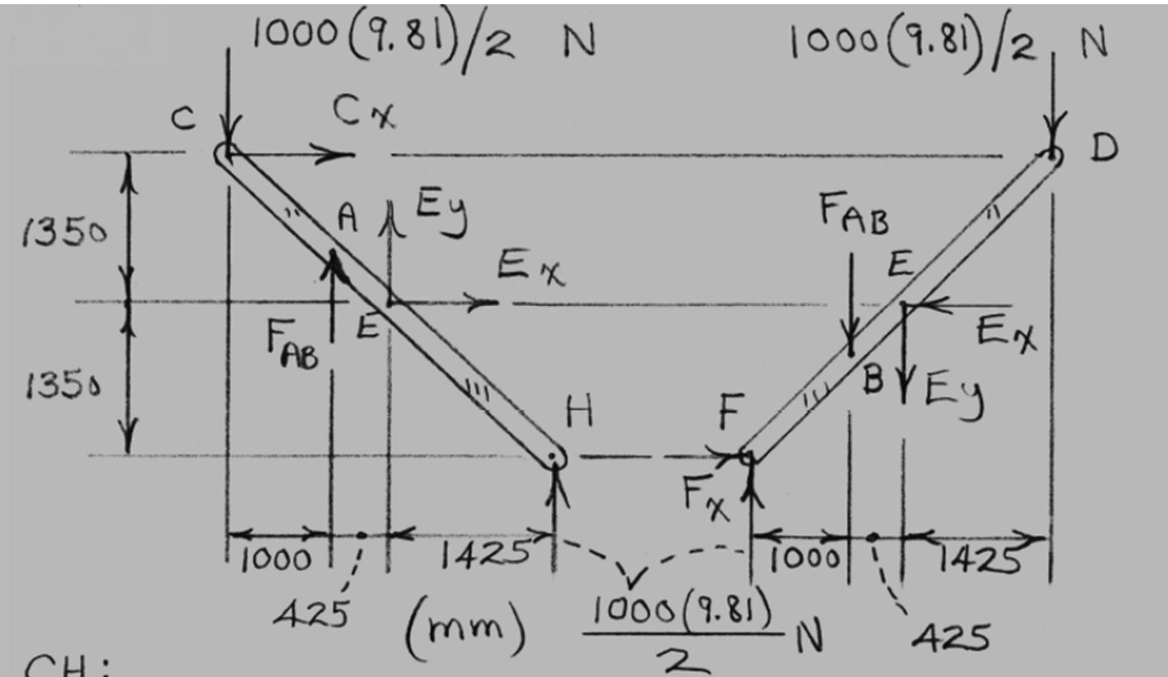
Screw: $\alpha = \tan^{-1}\frac{L}{2\pi r} = \tan^{-1}\frac{10}{2\pi(15)} = 6.06°$; $\phi = \tan^{-1}0.25 = 14.04°$

$\phi + \alpha = 20.09°$

$M = Pr\tan(\phi+\alpha) = 1331(0.015)\tan 20.09° = \underline{7.30\ N\cdot m}$

Q. No.3 The truck shown in Fig. 3 is used to deliver food to aircraft. The elevated unit has a mass of 1000 kg with center of mass at G. Determine the required force in the hydraulic cylinder AB.

SOLUTION:



CH:

$$\Sigma F_x = 0 : \quad C_x + E_x = 0 \qquad (1)$$

$$\Sigma F_y = 0 : \quad F_{AB} + E_y + \frac{1000(9.81)}{2} - \frac{1000(9.81)}{2} = 0 \qquad (2)$$

$$\circlearrowleft + \Sigma M_C = 0 : \quad F_{AB}(1000) + E_y(1425) + E_x(1350) + \frac{1000(9.81)}{2}(2850) = 0 \qquad (3)$$

DF:

$$\Sigma F_x = 0 : \quad F_x - E_x = 0 \qquad (4)$$

$\Sigma F_y = 0 :$ (Same as Eq. (2))

$$\circlearrowleft + \Sigma M_F = 0 : \quad -F_{AB}(1000) - E_y(1425) + E_x(1350) - \frac{1000(9.81)}{2}(2850) = 0 \qquad (5)$$

Solution : $F_{AB} = 32.9\ \text{kN}$

4. Find the support reactions and draw the SFD & BMD for the following structure. Given that the intensity of the UDL is ω per unit length and the point loads P are acting at the quarter points in the span BC which has an internal hinge. Also locate the max SF, BM and Point of Contra Flexure, if any.

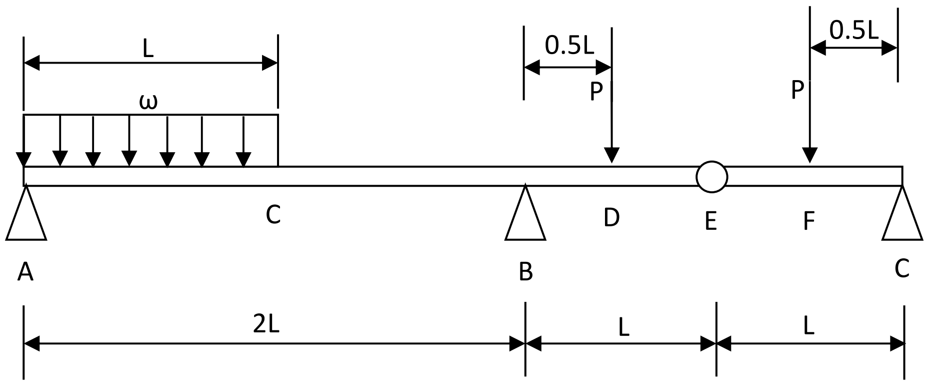
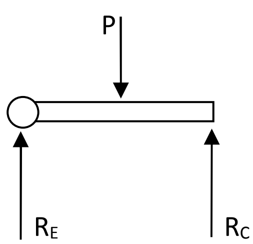


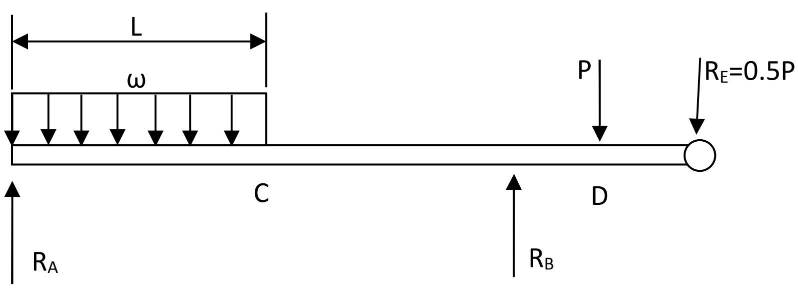
Figure 1

SOLUTION



In span EC

$R_E = R_C = 0.5P$

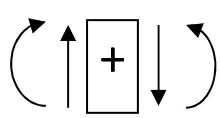


Moment about B (clockwise +ve)

$$M_B = R_A \times 2L - wL \times 1.5L + P \times 0.5L + 0.P \times L = 0; \quad R_A = 0.75wL - 0.5P$$

$$R_B = (0.5P + wL + P) - R_A = (0.5P + wL + P) - (0.75wL + 0.5P) = wL + 2P$$

Sign convention for BM and SF



x is any distance right from A

Span AC

$R_x = R_A - wx = 0.75wL - 0.5P - wx; \quad R_{x=L} = -0.25wL - 0.5P$

$M_x = R_A x - 0.5wx^2 = (0.75wL - 0.5P)x - 0.5wx^2; \quad M_{x=L} = 0.25wL^2 - 0.5PL$

Span AB

$R_x = 0.75wL - 0.5P - wL = -0.25wL - 0.5P$

$M_x = R_A x - wL(x - 0.5L)^2 = (0.75wL - 0.5P)x - wL(x - 0.5L)^2;$

$M_{x=2L} = 1.5wL^2 - PL - 2.25wL^2 = -0.75wL^2 - PL$

Span AD

$R_x = R_A - wL + R_B = 0.75wL - 0.5P - wL + 2P + 0.25wL = 1.5P$

$$\begin{aligned} M_x &= R_A x - wL(x - 0.5L)^2 + R_B(x - 2L) \\ &= (0.75wL - 0.5P)x - wL(x - 0.5L)^2 + (0.25wL + 2P)(x - 2L); \end{aligned}$$

$$\begin{aligned} M_{x=2.5L} &= (0.75wL - 0.5P)2.5L - wL(2.5L - 0.5L)^2 + (0.25wL + 2P)(2.5L - 2L) \\ &= -2wL^2 - 0.25PL \end{aligned}$$

Span AE

$R_x = R_A - wL + R_B = 0.75wL - 0.5P - wL + 0.25wL + 2P - P = 0.5P$

$$\begin{aligned} M_x &= R_A x - wL(x - 0.5L)^2 + R_B(x - 2L) - P(x - 2.5L) \\ &= (0.75wL - 0.5P)x - wL(x - 0.5L)^2 + (0.25wL + 2P)(x - 2L) - P(x - 2.5L) \end{aligned}$$

$M_{x=3L} = 2.25wL^2 - 1.5PL - 6.25wL^2 + 0.25wL^2 + 2PL - 0.5PL = -3.75wL^2$

Span EC

Here, x considered any distance right from E

When $x < 0.5L$

$R_x = 0.5P$ and $M_x = 0.5Px; \quad M_{x=0.5L} = 0.25PL$

When $x > 0.5L$

$R_x = 0.5P - P = -0.5P$ and $M_x = 0.5Px - P(x - 0.5L); \quad M_{x=L} = 0.5PL - P(0.5L) = 0$

Point of contra Flexure

In span CB, assume distance y right from C

$$\frac{0.25wL^2 - 0.5PL}{y} = \frac{-0.75wL^2 - PL}{L-y}; \quad \frac{L-y}{y} = \frac{0.75wL^2 + PL}{0.5PL - 0.25wL^2}; \quad \frac{L}{y} = \frac{2wL + 3P}{2P - wL};$$

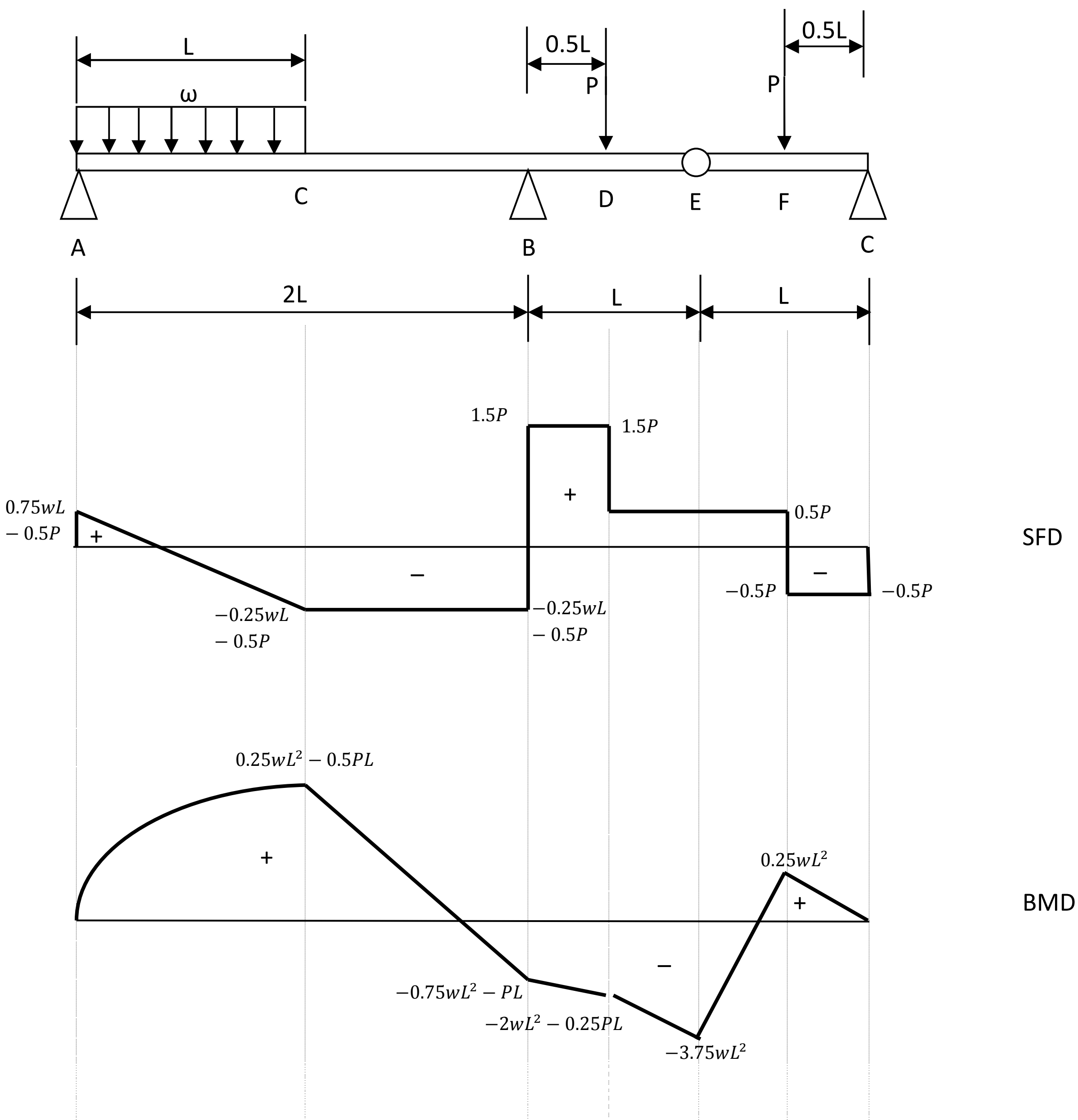
$$y = \left(\frac{2P - wL}{2wL + 3P}\right) L$$

In span In span EF, assume distance z right from E

$$-\frac{3.75wL^2}{z} = \frac{0.25PL}{\frac{L}{2} - z}; \quad \frac{L}{2z} - 1 = -\frac{0.25PL}{3.75wL^2}; \quad \frac{2z}{L} = \frac{15wL}{15wL - P}$$

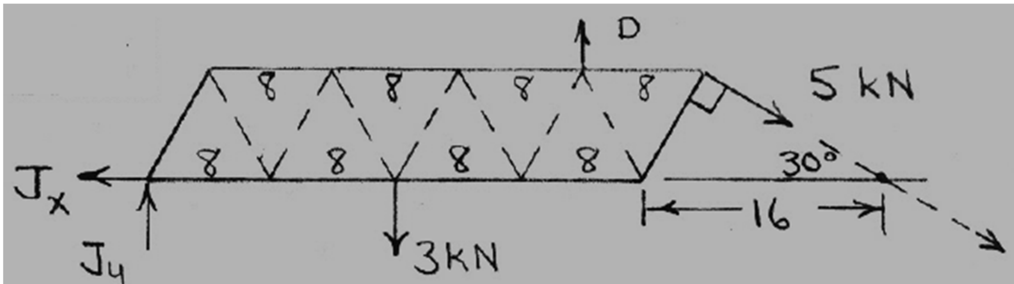
$$z = \left(\frac{15wL}{15wL - P}\right) \frac{L}{2}$$

Max SF = $1.5P$ and BM = $-3.75wL^2$



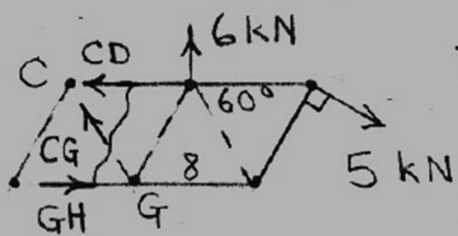
Q. No.5 Calculate the forces in members CD and CG of the loaded truss composed shown in Fig. 5 of equilateral triangles, each of side length 8 m.

SOLUTION:



$$\Sigma M_J = 0: \quad -3(16) + D(28) - (5\sin 30°)(48) = 0$$

$$D = 6 \text{ kN}$$



$$\Sigma F_y = 0: \quad CG \sin 60° + 6 - 5\sin 30° = 0$$

$$CG = -4.041 \text{ kN C}$$

$$\Sigma M_G = 0: \quad CD(8\sin 60°) + 6(4) - (5\sin 30°)(24) = 0, \quad CD = 5.20 \text{ kN T}$$