PROBLEM 1-EXERCISE 6-73

The compound beam is pin-supported at C and supported by a roller A and B. There is a hinge (pin) at D. Determine the reactions at the supports. Neglect the thickness of the beam.

SOLUTION 1-EXERCISE 6-73

Equation of Equilibrium: from FBD of (a)

\[ \sum M_D = 0 \quad 4 \cos 30^\circ \times (12 + 8) + A_y \times (6) = 0 \quad A_y = 9.595 \text{kip} \]

\[ \sum F_y = 0 \quad D_y + 9.595 - 4 \cos 30^\circ - 8 = 0 \quad D_y = 1.869 \text{kip} \]

\[ \sum F_x = 0 \quad D_x + 9.595 - 4 \sin 30^\circ = 0 \quad D_x = 2.00 \text{kip} \]
From FBD of (b):

\[ \sum M_c = 0 \quad 1.869(24) + 15 + 12(0.8) - B_y(16) = 0 \quad B_y = 8.541 \text{kip} \]

\[ \sum F_y = 0 \quad C_y + 8.541 - 1.869 - 12(0.8) = 0 \quad C_y = 2.93 \text{kip} \]

\[ \sum F_x = 0 \quad C_x - 2.00 - 12(0.6) = 0 \quad C_x = 9.2 \text{kip} \]

\[ \leftrightarrow \text{Ans} \]

**PROBLEM 1-EXERCISE 6-91**

Determine the horizontal and vertical components of force which the pin at A, B and C exert on member ABC of the frame.
SOLUTION 1-EXERCISE 6-91

FBD:

\[ \sum M_E = 0; \quad -A_y (3.5) + 400(2) + 300(3.5) + 300(1.5) = 0 \]
\[ A_y = 657 \text{ N} \quad \text{ANS} \]

FBD of member CD:

\[ \sum M_D = 0; \quad -C_y (3.5) + 400(2) = 0 \quad C_y = 229 \text{ N} \quad \text{ANS} \]
FBD of member ABC:

\[ \sum M_B = 0; \quad C_x = 0 \]
\[ \sum F_x = 0; \quad F_{BD} = F_{BE} \]
\[ \sum F_y = 0; \quad 657.1 - 229 - 2 \frac{5}{\sqrt{74}} F_{BD} = 0 \]
\[ F_{BD} = F_{BE} = 368.7 \text{ N} \]
\[ B_x = 0 \leftarrow \text{Ans.} \]
\[ B_y = \frac{5}{\sqrt{74}} (368.7)(2) = 429 \text{ N} \leftarrow \text{Ans.} \]

**PROBLEM 1-EXTRA PRACTICE 6-76**

The three-hinged arch support the loads \( F_1 = 8kN \) and \( F_2 = 5kN \). Determine the horizontal and vertical components at the pin supports A and B. Take \( h = 2m \).
SOLUTION 1-EXTRA PRACTICE 6-76

Member AC:

\[
\sum M_A = 0 \implies -8(4) + C_y(8) + C_x(7) = 0
\]
\[
\sum F_x = 0 \implies 8 - A_x - C_x = 0
\]
\[
\sum F_y = 0 \implies -A_y + C_y = 0 \implies C_y = A_y
\]

Member BC:
\[ \sum M_B = 0 \quad 5(2) + C_y(6) - C_x(9) = 0 \]
\[ \sum F_x = 0 \quad C_x - B_x = 0 \]
\[ \sum F_y = 0 \quad -C_y + B_y - 5 = 0 \]

Solving the above equations we have:

\[ A_x = 5.6141 = 5.61 \text{kN} \]
\[ A_y = 1.9122 = 1.91 \text{kN} \]
\[ C_x = 2.3859 = 2.39 \text{kN} \]
\[ C_y = 1.9122 = 1.91 \text{kN} \]
\[ B_x = 2.3859 = 2.39 \text{kN} \]
\[ B_y = 6.9122 = 6.91 \text{kN} \]

**PROBLEM 1-EXTRA PRACTICE 6-89**

Determine the horizontal and vertical components of force at each pin. The suspended cylinder has a weight of 80 lb.
SOLUTION 1-EXTRA PRACTICE 6-89

\[ \sum M_B = 0 \quad F_{CD} \left(\frac{2}{\sqrt{13}}\right)(3) - 80(4) = 0 \quad F_{CD} = 192.3 \text{lb} \]  
\[ C_x = D_x = \frac{3}{\sqrt{13}} (192.3) = 160 \text{lb} \]  
\[ C_y = D_y = \frac{2}{\sqrt{13}} (192.3) = 107 \text{lb} \]  
\[ \sum F_y = 0 \quad -B_y + \frac{2}{\sqrt{13}} (192.3) - 80 = 0 \quad B_y = 26.7 \text{lb} \]
PROBLEM 1-EXERCISE 6-101

If a force $P=6\text{ lb}$ is applied perpendicular to the handle of the mechanism, determine the magnitude of force $F$ for equilibrium. The members are pin-connected at A, B, C and D.

SOLUTION 1-EXERCISE 6-101

FBD of dismembered machine:
\[
\sum M_A = 0 : F_{BC} (4) - 6(25) = 0 \rightarrow F_{BC} = 37.5 lb
\]
\[
\sum F_x = 0 : - A_x + 6 = 0 \rightarrow A_x = 6 lb
\]
\[
\sum F_y = 0 : - A_y + 37.5 = 0 \rightarrow A_y = 37.5 lb
\]
\[
\sum M_D = 0 : -5(6) - 37.5(9) + (39)(F) = 0 \rightarrow F = 9.42 lb \leftarrow \text{Ans.}
\]

**PROBLEM 1-EXERCISE 6-120**

Determine the required force \( P \) that must be applied at the blade of the pruning shears so that the blade exerts a normal force of 20 lb on the twig at \( E \).

**SOLUTION 1-EXERCISE 6-120**

**FBD**
\[ \sum M_D = 0; \quad -P(5.5) - A_x (0.5) + 20(1) = 0 \]
\[ 5.5P + 0.5A_x = 0 \]
\[ \sum F_x = 0; \quad D_x = A_x \]
\[ \sum F_y = 0; \quad D_y - A_y - 20 = 0 \]

\[ \sum M_B = 0; \quad A_y (0.75) + A_x (0.5) - 4.75P = 0 \]
\[ \sum F_x = 0; \quad A_x - \frac{3}{\sqrt{3}} F_{CB} = 0 \]
\[ \sum F_y = 0; \quad A_y + P - F_{CB} \frac{2}{\sqrt{13}} = 0 \]

Solving:
\[ A_x = 13.3 \text{ lb}, \quad A_y = 6.46 \text{ lb} \]
\[ D_x = 13.3 \text{ lb}, \quad D_y = 28.9 \text{ lb} \]
\[ P = 2.42 \text{ lb} \quad \leftarrow \text{Ans.} \]
\[ F_{CB} = 16.0 \text{ lb} \]
### PROBLEM 1-EXTRA PRACTICE 6-113

A man having a weight of 175 lb attempts to lift himself using one of the two methods shown. Determine the total force he must exerts on bar AB in each case and the normal reaction he exerts on the platform at C. Neglect the weight of the platform.

![Diagram](image)

### SOLUTION 1-EXTRA PRACTICE 6-113

**A) FBD**

<table>
<thead>
<tr>
<th>Component</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>87.51 lb</td>
<td>87.51 lb</td>
</tr>
<tr>
<td>F/2</td>
<td>F/2</td>
</tr>
</tbody>
</table>

**Bar:**

\[ \sum F_y = 0; \quad 2\left(\frac{F}{2}\right) - 2(87.5) = 0 \quad F = 175 \text{ lb} \quad \text{ANS} \]

**Man:**

\[ \sum F_y = 0; \quad N_c - 175 - 2(87.5) = 0 \quad N_c = 350 \text{ lb} \quad \text{ANS} \]
B) **FBD**

![FBD Diagram](image_url)

**Bar:**

\[ \sum F_y = 0; \quad 2(43.75) - 2(F) = 0 \quad F = 87.5 \text{ lb} \quad \text{ANS} \]

**Man:**

\[ \sum F_y = 0; \quad N_c - 175 - 2(43.75) = 0 \quad N_c = 87.5 \text{ lb} \quad \text{ANS} \]

**PROBLEM 1-EXTRA PRACTICE 6-117**

The tractor boom supports the uniform mass of 500 kg in the bucket which has a center of mass at G. Determine the force in each hydraulic cylinder AB and CD and the resultant force at pins E and F. The load is supported equally on each side of the tractor by similar mechanism.
**SOLUTION 1-EXTRA PRACTICE 6-117**

From the bucket FBD:

\[
\sum M_E = 0 \quad 2452.5(0.1) - F_{AB}(0.25) = 0 \quad F_{AB} = 981N
\]

\[
\sum F_x = 0 \quad -E_x + 981 = 0 \quad E_x = 981N
\]

\[
\sum F_y = 0 \quad E_y - 2452.5 = 0 \quad E_y = 2452.5N
\]

\[
F_E = \sqrt{(981)^2 + (2452.5)^2} = 2.64kN
\]

(a) The Bucket FBD

(b) The Tractor Boom FBD

From the tractor boom FBD:

\[
\sum M_F = 0 \quad 2452.5(2.8) - F_{CD}(\cos 12.2^\circ)(0.7) + F_{CD}(\sin 12.2^\circ)(1.25) = 0
\]

\[
F_{CD} = 16349N = 16.3kN
\]

\[
\sum F_x = 0 \quad F_x - 16349 \sin 12.2^\circ = 0 \quad F_x = 3455N
\]

\[
\sum F_y = 0 \quad -F_y - 2452.5 + 16349 \cos 12.2^\circ = 0 \quad F_y = 13527N
\]

\[
F_F = \sqrt{(3455)^2 + (13527)^2} = 14.0kN
\]
PROBLEM 3:

Model the ladder rung as a simply supported (pin supported) beam and assume that the 750-N load exerted by the person’s shoe is uniformly distributed. Determine the internal forces and moment at A.

SOLUTION 3

Free-body diagram of the entire beam:

\[ \sum F_y = 0 : \]
\[ B + C - 750 = 0 \]
\[ \sum M_{pt,B} = 0 : \]
\[ 0.375C - (0.25)(750) = 0 \]
Solving: \( B = 250\text{N} \), \( C = 500\text{N} \)

The distributed load is:

\[ \omega = \frac{(750\text{N})}{0.1\text{m}} = 7500 \frac{N}{m} \]

From the equilibrium equations:

\[ \sum F_x = 0 : \]
\[ P_A = 0 \]
\[ \sum F_y = 0 : \]
\[ 250 - V_A - 0.05(7500) = 0 \]

\[ \sum M_{right-end} = 0 : \]
\[ M_A = (250)(0.25) + (0.05)(7500)(0.025) = 0 \]

Therefore, the internal forces at A are:

\[ P_A = 0, \quad V_A = -125 \text{ N}, \quad M_A = 53.1 \text{ N-m} \]

**PROBLEM 4-EXERCISE 7-5**

The shaft is supported by a journal bearing at A and a thrust bearing at B. Determine the normal force, shear force, and moment at a section passing through

(a) Point C, which is just to the right of the bearing at A.
(b) Point D, which is just to the left of the 3000-lb force.

**SOLUTION 4-EXERCISE 7-5**

\[ \sum M_y = 0 \]

\[ -A_y(14) + 2500(20) + 900(8) + 3000(2) = 0 \]

\[ A_y = 4514 \text{ lb} \]

\[ \sum F_x = 0 \quad B_x = 0 \]

\[ \sum F_y = 0 \quad B_y + 4514 - 2500 - 900 - 3000 = 0 \quad B_y = 1886 \text{ lb} \]
PROBLEM 4-EXERCISE 7-19

Determine the normal force, shear force, and moment at a section passing through point C. Take $P = 8kN$
**SOLUTION 4-EXERCISE 7-19**

\[ \sum M_A = 0 \quad -T(0.6) + 8(2.25) = 0 \quad T = 30kN \]
\[ \sum F_x = 0 \quad A_x = 30kN \]
\[ \sum F_y = 0 \quad A_y = 8kN \]

\[ \sum M_C = 0 \quad 8(0.75) - M_C = 0 \quad M_C = 6kN.m \]
\[ \sum F_x = 0 \quad N_C = -30kN \]
\[ \sum F_y = 0 \quad V_C + 8 = 0 \quad V_C = -8kN \]

**PROBLEM 4-EXTRA PRACTICE 7-13**

Determine the internal normal force, shear force, and moment acting at point C, and point D, which is acted just to the right of the roller support at B.
SOLUTION 4-EXTRA PRACTICE 7-13

Support Reactions: From FBD (a):

\[ \sum M_A = 0 \quad B_y (8) + 800(2) - 2400(4) - 800(10) = 0 \quad B_y = 2000 \text{lb} \]

\[ \sum F_x = 0 \quad N_D = 0 \]

\[ \sum F_y = 0 \quad V_D - 800 = 0 \quad V_D = 800 \text{lb} \]

Internal Forces: Applying the equations of equilibrium to segment ED (FBD (b)), we have:

\[ \sum M_D = 0 \quad -800(2) - M_D = 0 \quad M_D = -1600 \text{lb}. \text{ft} \]
Applying the equations of equilibrium to segment EC (FBD(c)), we have:

\[\sum M_C = 0 \quad -M_C + 2000(4) - 1200(2) - 800(6) = 0 \quad M_C = 800\text{lb-ft}\]

\[\sum F_x = 0 \quad N_C = 0 \quad \text{Ans}\]

\[\sum F_y = 0 \quad V_C + 2000 - 1200 - 800 = 0 \quad V_C = 0 \]

**PROBLEM 4-EXTRA PRACTICE 7-29**

Determine the internal force, shear force, and the moment at point C and D.

**SOLUTION 4-EXTRA PRACTICE 7-29**

Support Reactions:

From FBD (a):

\[\sum M_A = 0 \quad B_y (6 + 6\cos 45^\circ) - 12(3 + 6\cos 45^\circ) = 0 \quad B_y = 8.485\text{kN}\]

\[\sum F_x = 0 \quad A_x = 0 \quad \text{Ans}\]

\[\sum F_y = 0 \quad A_y + 8.485 - 12.0 = 0 \quad A_y = 3.515\text{kN}\]
From FBD (b):
\[ \sum M_C = 0 \quad M_C - 3.515 \cos 45^\circ (2) = 0 \quad M_C = 4.97kN.m \]
\[ \sum F_x = 0 \quad 3.515 \sin 45^\circ - N_C = 0 \quad N_C = 2.49kN \]
\[ \sum F_y = 0 \quad 3.515 \cos 45^\circ (2) - V_C = 0 \quad V_C = 2.49kN \]

\[ \sum M_D = 0 \quad 8.485(3) - 6(1.5) - M_D = 0 \quad M_D = 16.5kN.m \]
\[ \sum F_x = 0 \quad N_D = 0 \]
\[ \sum F_y = 0 \quad V_D + 8.485 - 6 = 0 \quad V_D = -2.49kN \]
PROBLEM 4-EXTRA PRACTICE 7-41

Determine the x, y, z components of force and moment at point C in the pipe assembly. Neglect the weight of the pipe. Take \( F_1 = (350\hat{i} - 400\hat{j})\text{lb} \) and \( F_2 = (-300\hat{j} + 150\hat{k})\text{lb} \)

SOLUTION 4-EXTRA PRACTICE 7-41

Free Body Diagram: The support reactions need not be computed.
**Internal Forces:** Applying the equations of equilibrium to segment BC. We have:

\[ \sum F_x = 0; \quad N_C + 350 = 0 \quad N_C = -350lb \]  
\[ \sum F_y = 0; \quad (V_C)_y - 400 - 300 = 0 \quad (V_C)_y = 700lb \]  
\[ \sum F_z = 0; \quad (V_C)_z + 150 = 0 \quad (V_C)_z = -150lb \]  
\[ \sum M_x = 0; \quad (M_C)_x + 400(3) = 0 \quad (M_C)_x = -1200lb.ft = -1.2kip.ft \]  
\[ \sum M_y = 0; \quad (M_C)_y + 350(3) - 150(2) = 0 \quad (M_C)_y = -750lb.ft \]  
\[ \sum M_z = 0; \quad (M_C)_z - 300(2) - 400(2) = 0 \quad (M_C)_z = 1400lb.ft = 1.4kip.ft \]