Section I BASICS

CHAPTER 1 INTRODUCTION

SOLUTION (**1.1**)

Free Body: Angle Bracket (Fig. S1.1)

(**a**) $\sum M_B = 0; \quad F(20) - 15(10) - 4.8(20) = 0, \quad F = 12.3\ kN \leftarrow$ ◄

(**b**) $\sum F_x = 0: \quad R_{Bx} + 6.4 - F = 0, \quad R_{Bx} = 5.9\ kN \rightarrow$

$\sum F_y = 0: \quad R_{By} + 15 - 4.8 = 0, \quad R_{By} = 19.8\ kN \uparrow$

Thus

$$R_B = \sqrt{(5.9)^2 + (19.8)^2} = 20.7\ kN$$ ◄

and

$$\alpha = \tan^{-1} \tfrac{5.9}{20.7} = 15.9^o$$ ◄

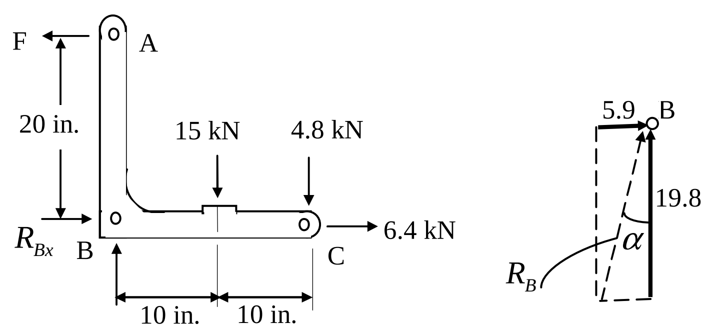


Figure S1.1

SOLUTION (**1.2**)

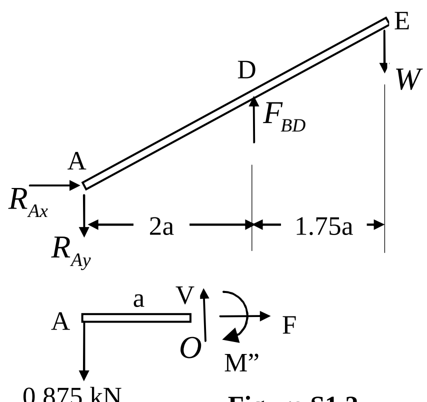


Figure S1.2

Free Body: Beam ADE (Fig. S1.2)

$\sum M_A = 0: \quad -W(3.75\alpha) + F_{BD}(2a) = 0,$

$F_{BD} = 1.875W \uparrow$

$\sum F_x = 0: \quad R_{Ax} = 0$

$\sum F_y = 0: \quad -R_{Ay} + F_{BD} - W = 0,$

$R_{Ay} = 0.875W \downarrow$ ◄

Free-Body: Entire structure (Fig. S1.2)

$\sum M_A = 0: \quad R_C(3a) - W(3.75a) = 0,$

$R_C = 1.25W \uparrow$

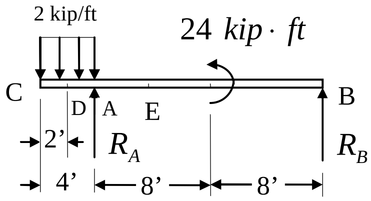
Free Body: Part AO (Fig. S1.2)

$V = 0.875W \uparrow$

$F = 0$

$M = 0.875aW$ ↻

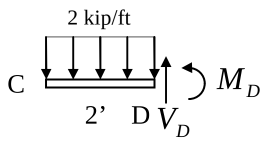
SOLUTION (**1.3**)



$\sum M_A = 0$: $R_B = 2.5\,kips \downarrow$ ◄

$\sum F_y = 0$: $R_A = 10.5\,kips \uparrow$

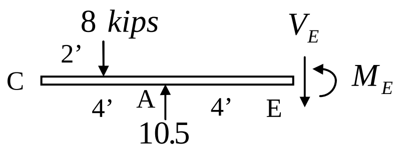
Segment CD



$M_D = \frac{1}{2}(2)(2^2) = 4\,kip \cdot ft$ ◄

$V_D = 4\,kips$

Segment CE

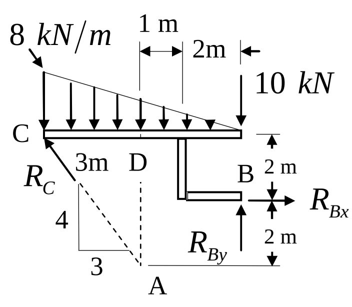


$M_E = 8(6) - 10.5(4) = 6\,kip \cdot ft$ ◄

$V_E = 2.5\,kips$

SOLUTION (**1.4**)

(**a**)



$\sum M_B = 0$: $0.8R_C(6) - 0.6R_C(2) - 24(4) = 0$

$\therefore R_C = 26.667\,kN$ ◄

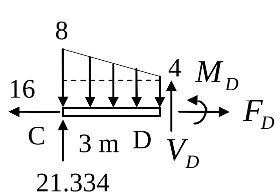
$R_{Cx} = 16\,kN, \quad R_{Cy} = 21.334\,kN$

Then

$\sum F_x = 0$: $R_{Bx} = 16\,kN$ ◄

$\sum F_y = 0$: $R_{By} = 12.66\,kN$

(**b**) Segment CD



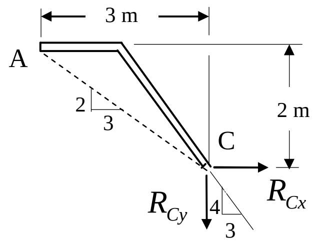
$M_D = 21.334(3) - 12(1.5) - 6(2) = 34\,kN \cdot m$

$F_D = 16\,kN$ ◄

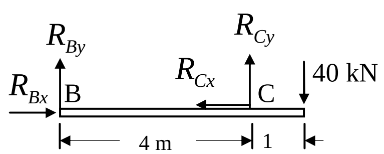
$V_D = 21.334 - 18 = 3.334\,kN$

SOLUTION (**1.5**)

(**a**)



$\sum M_A = 0$: $R_{Cx} = \frac{3}{2} R_{Cy}$

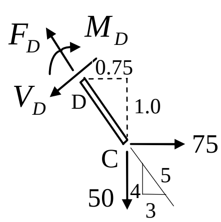


$\sum M_B = 0$: $40(5) - 4R_{Cy} = 0$ $R_{Cy} = 50\ kN \uparrow$

Then $R_{Cx} = 75\ kN \leftarrow$

$R_{By} = 10 kN \uparrow$, $R_{Bx} = 75 kN \leftarrow$

(**b**)



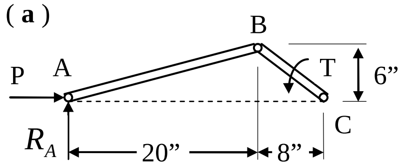
$F_D = 75(\frac{3}{5}) + 50(\frac{4}{5}) = 85\ kN$

$V_D = 75(\frac{4}{5}) - 50(\frac{3}{5}) = 30\ kN$ ◄

$M_D = 75(1) - 50(0.75) = 37.5 kN \cdot m$

SOLUTION (**1.6**)

(**a**)

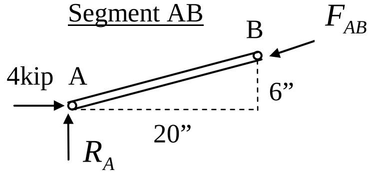


Free body entire connection

$\sum M_C = 0$: $R_A(28) - T = 0$

$T = 28 R_A$

Segment AB



$AB = \sqrt{20^2 + 6^2} = 20.88\ in.$

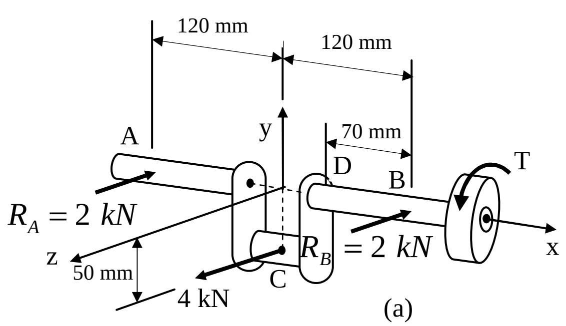
$\sum M_B = 0$: $4(6) - R_A(20) = 0$

$R_A = 1.2\ kips$ ◄

and $T = 33.6\ kip \cdot in.$

(**b**) $\sum F_x = 0$: $4 - \frac{20}{20.88} F_{AB} = 0$, $F_{AB} = 4.176\ kips$ ◄

SOLUTION (**1.7**)



(a)

Free Body: Entire Crankshaft (Fig. S1.7a)

(**a**) From symmetry: $R_A = R_B$

$\sum F_z = 0$: $R_A = R_B = 2\ kN \nearrow$

$\sum M_x = 0$: $-4(0.05) + T = 0$,

$T = 0.2\ kN \cdot m = 200\ N \cdot m$ ◄

(CONT.)

1.7 (CONT.)

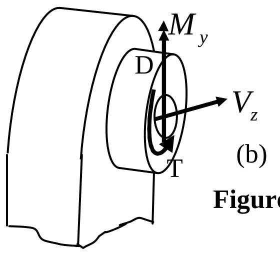


Figure S 1.7

(**b**) Cross Section at D (Fig. S1.7b)

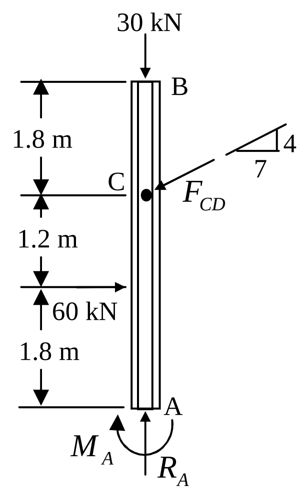
$V_z = 2\ kN \nearrow$

$T = 200\ N \cdot m \longrightarrow\!\!\to$

$M_y = 2(0.07) = 0.14\ kN \cdot m$

$= 140\ N \cdot m \uparrow$ ◄

SOLUTION (**1.8**)



Free-Body Diagram, Beam AB

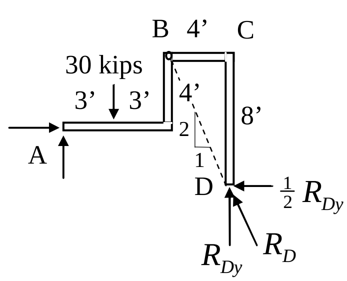
$\sum F_x = 0: \quad -\frac{7}{\sqrt{65}} F_{CD} + 60 = 0, \quad F_{CD} = 69.11\ kN$

$\sum F_y = 0: \quad R_A - \frac{4}{\sqrt{65}} F_{CD} - 30 = 0, \quad R_A = 64.3\ kN \uparrow$ ◄

$\sum M_A = 0: \quad -60(1.8) + \frac{7}{\sqrt{65}} F_{CD}(3) - M_A = 0,$

$M_A = 72\ kN \cdot m$ ↻ ◄

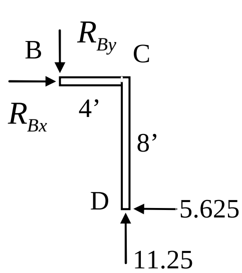
SOLUTION (**1.9**)



Free body entire frame

$\sum M_A = 0: \quad -30(3) - \frac{1}{2} R_{Dy}(4) + R_{Dy}(10) = 0$

$R_{Dy} = 11.25\, kips, \quad R_{Dx} = 5.625\, kips$ ◄



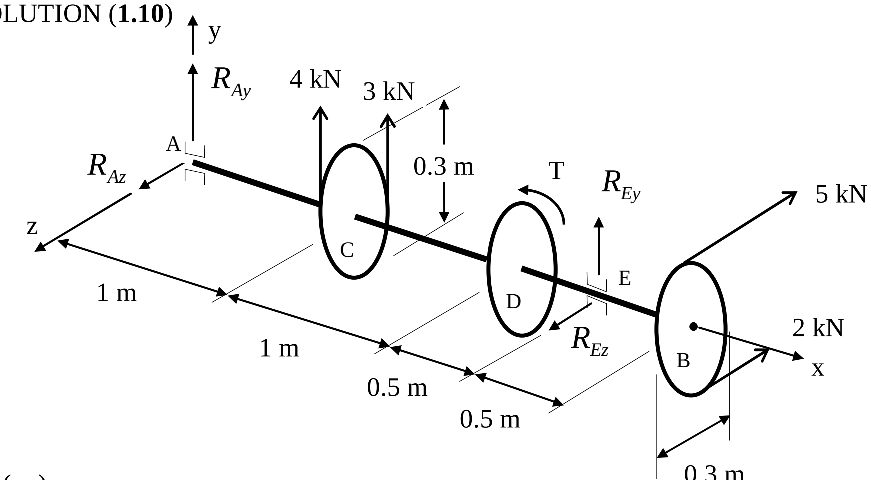
Free body BCD

$\sum F_x = 0: \quad R_{Bx} = 5.625\, kips$

$\sum F_y = 0: \quad R_{By} = 11.25\, kips$

$R_B = \sqrt{5.625^2 + 11.25^2} = 12.58\, kips$ ◄

SOLUTION (**1.10**)



(**a**)

$$\sum M_x = 0: \quad 3(0.15) - 4(0.15) + T - 5(0.15) + 2(0.15) = 0$$

or $\quad T = 0.6 \ kN \cdot m$ ◄

(**b**)

$$\sum M_z = 0: \quad (4+3)(1) + R_{Ey}(2.5) = 0, \qquad R_{Ey} = -2.8 \ kN$$

$$\sum M_y = 0: \quad -R_{Ez}(2.5) + (5+2)(3) = 0, \qquad R_{Ez} = 8.4 \ kN$$

$$\sum F_y = 0: \quad R_{Ay} + 4 + 3 + R_{Ey} = 0, \qquad R_{Ay} = -4.2 \ kN$$

$$\sum F_z = 0: \quad R_{Az} + R_{Ez} - 5 - 2 = 0, \qquad R_{Az} = -1.4 \ kN$$

Thus $\quad R_A = \sqrt{4.2^2 + 1.4^2} = 4.427 \ kN$ ◄

$$R_E = \sqrt{2.8^2 + 8.4^2} = 8.854 \ kN$$

SOLUTION (**1.11**)

(a) Free-body Diagrams, Arm BC and shaft AB

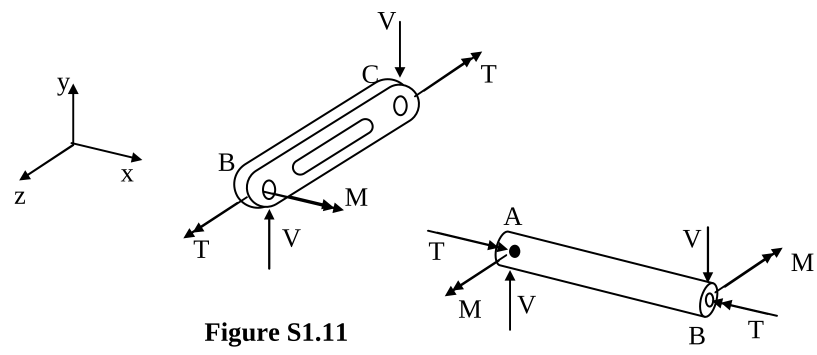


Figure S1.11

(**b**) At C:

$$V = -2 \ kN \qquad T = -50 \ N \cdot m$$

At end B of arm BC:

$$V = 2 \ kN \qquad T = 50 \ N \cdot m \qquad M = 200 \ N \cdot m$$

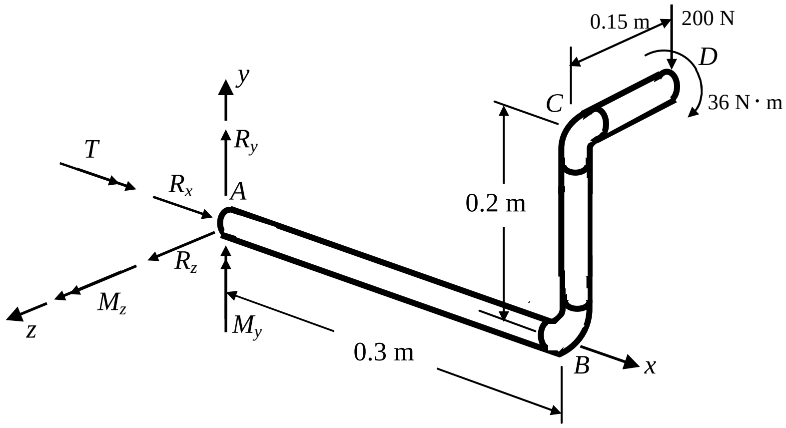
At end B of shaft AB:

$$V = -2 \ kN \qquad T = -200 \ N \cdot m \qquad M = -50 \ N \cdot m$$

At A: $\quad V = 2 \ kN \qquad T = 200 \ N \cdot m \qquad M = 300 \ N \cdot m$

SOLUTION (**1.12**)

Free Body: Entire Pipe



Reactional forces at point *A*:

$$\sum F_x = 0: \quad R_x = 0$$

$$\sum F_y = 0: \quad R_y - 200 = 0, \qquad R_y = 200 \ N$$ ◄

$$\sum F_z = 0: \quad R_z = 0$$

Moments about point *A*:

$$\sum M_x = 0: \quad T - 200(0.15) = 0, \qquad T = 30 \ N \cdot m$$

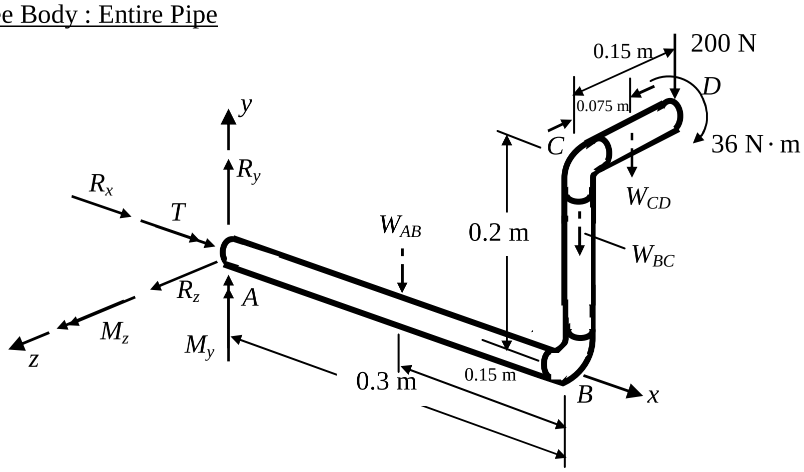
$$\sum M_y = 0: \quad M_y = 0$$ ◄

$$\sum M_z = 0: \quad M_z - 200(0.3) - 36 = 0, \qquad M_z = 96 \ N \cdot m$$

The reactions act in the directions shown on the free-body diagram.

SOLUTION (**1.13**)

Free Body : Entire Pipe



(CONT.)

1.13 (CONT.)

We have 1 lb/ft=14.5939 N/m (Table A.1).
Thus, for 3 in. or 75-mm pipe (Table A.4): 14.5939(7.58)=110.62 N/m
Total weights of each part acting at midlength are:

$$W_{AB} = 110.62(0.3) = 33.2 \ N$$
$$W_{BC} = 110.62(0.2) = 22.1 \ lb$$
$$W_{CD} = 110.62(0.15) = 16.6 \ N$$

Reactional forces at point *A*:

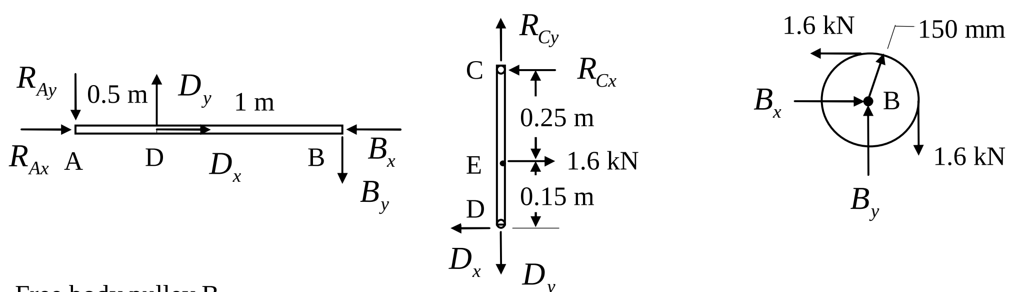
$$\sum F_x = 0: \qquad R_x = 0$$
$$\sum F_y = 0: \quad R_y - W_{AB} - W_{BC} - W_{CD} - 200 = 0, \qquad R_y = 271.9 \ N \quad ◄$$
$$\sum F_z = 0: \qquad R_z = 0$$

Moments about point *A*:

$$\sum M_x = 0: \quad T - W_{CD}(0.075) - 10(0.15) = 0, \qquad T = 2.745 \ N \cdot m$$
$$\sum M_y = 0: \qquad M_y = 0$$
$$\sum M_z = 0: \quad M_z - (200 + W_{CD} + W_{BC})(0.3) - W_{AB}(0.15) - 36 = 0$$
$$M_z = 112.6 \ N \cdot m. \quad ◄$$

SOLUTION (**1.14**)

(**a**)



Free body pulley B

$$\sum F_x = 0: \qquad B_x = 1.6 \ kN \rightarrow$$
$$\sum F_y = 0: \qquad B_y = 1.6 \ kN \uparrow$$

Free body CED

$$\sum M_D = 0: \qquad R_{Cx}(0.4) - 1.6(0.15) = 0, \qquad R_{Cx} = 0.6 \ kN \leftarrow$$
$$\sum F_x = 0: \qquad -D_x - 0.6 + 1.6 = 0, \qquad D_x = 1 \ kN \leftarrow$$
$$\sum F_y = 0: \qquad R_{Cy} = D_y$$

Free body ADB

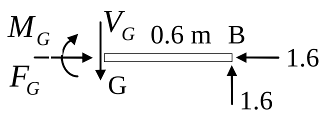
$$\sum M_A = 0: \qquad D_y(0.5) - B_y(1.5) = 0, \qquad D_y = 4.8 \ kN, \qquad R_{Cy} = 4.8 \ kN \uparrow$$
$$\sum F_x = 0: \qquad -R_{Ay} + D_y - B_y = 0, \qquad R_{Ay} = 3.2 \ kN \downarrow \quad ◄$$

(CONT.)

1.14 (CONT.)

$$\sum F_x = 0: \qquad R_{Ax} + D_x - B_x = 0, \qquad R_{Ax} = 0.6\,kN \rightarrow$$

(**b**)



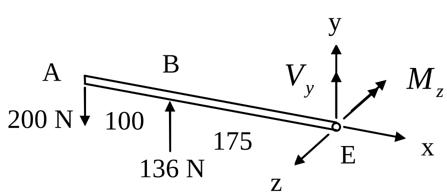
$$M_G = 1.6(0.6) = 960\ N \cdot m, \qquad V_G = 1.6\,kN$$
$$F_G = 1.6\,kN$$ ◄

SOLUTION (**1.15**)

<u>Free body entire rod</u>

$$\sum M_x = 0: \qquad R_{Dy}(0.25) - 300(0.1), \qquad R_{Dy} = 120\,N \uparrow$$
$$\left(\sum M_z\right)_C = 0: \qquad -200(0.35) + R_{By}(0.25) + (300 - 120)(0.2) = 0$$
$$R_{By} = 136\ N \uparrow$$

<u>Free body ABE</u>



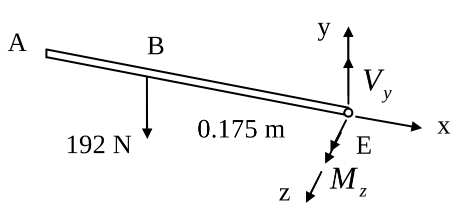
$$\left(\sum M_z\right)_E = 0: \quad -M_z + 200(0.275) - 136(0.175) = 0, \quad M_z = 31.2\,N \cdot m$$
$$\sum F_y = 0: \quad V_y = 200 - 136 = 64\,N$$ ◄

SOLUTION (**1.16**)

<u>Free body entire rod</u>:

$$\sum M_x = 0: \qquad R_{Dy}(0.25) - 400(0.1) = 0, \qquad R_{Dy} = 160N \uparrow$$
$$\left(\sum M_z\right)_C = 0: \qquad R_{By}(0.25) + (400 - 160)(0.2) = 0, \qquad R_{By} = 192 \downarrow$$

<u>Segment ABE</u>



At point E:

$$M_z = -192(0.175) = -33.6\ N \cdot m$$
$$V_y = 192\ N$$ ◄

SOLUTION (**1.17**)

Side view

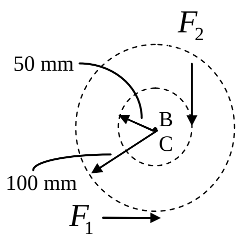


Figure (a)

Top view

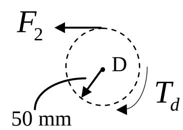


Figure (c)

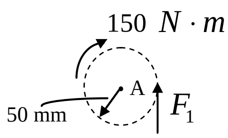


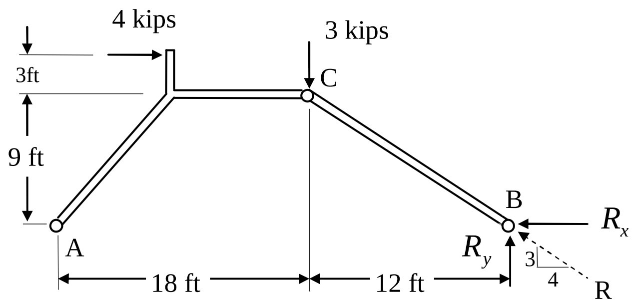
Figure (b)

Fig. (b): $\sum M_A = 0$: $\quad F_1(0.05) - 150 = 0, \quad F_1 = 3\ kN$

Fig. (a): $\sum M_B = 0$: $\quad F_1(0.1) - F_2(0.05) = 0, \quad F_2 = 6\ kN$

Fig. (c): $\sum M_D = 0$: $\quad F_2(0.05) - T_d = 0, \quad T_d = 0.3\ kN \cdot m$ ◀

SOLUTION (**1.18**)



Free body-entire frame

$$\sum M_A = 0: \quad R_y(30) - 3(18) - 4(12) = 0, \quad R_y = 3.4\ kips$$

Free body-member BC

$$\sum M_C = 0: \quad R_x(9) - R_y(12) = 0$$

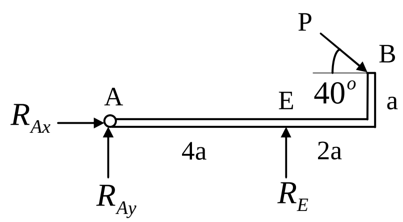
and

$$R_x = \tfrac{4}{3}(3.4) = 4.533\ kips$$

Thus

$$F_{BC} = R = \sqrt{(4.533)^2 + (3.4)^2} = 5.666\ kips$$ ◀

SOLUTION (**1.19**)



Free body-member AB

$\sum M_A = 0$:

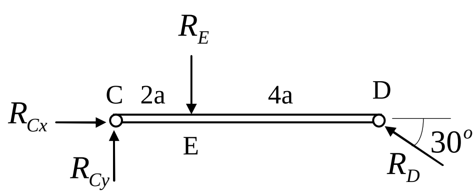
$R_E(4a) - P\cos 40^o(a) - P\sin 40^o(6a) = 0$

$\therefore\ R_E = 1.156P$

$\sum F_x = 0$: $\quad R_{Ax} = P\cos 40^o = 0.766P \leftarrow$ ◄

$\sum F_y = 0$: $\quad R_{Ay} + 1.156P - P\sin 40^o = 0, \quad R_{Ay} = 0.513P \downarrow$ ◄

Free body-member CD



$\sum M_D = 0$: $\quad R_E(4a) - R_{Cy}(6a) = 0$

$\therefore\ R_{Cy} = 0.771P \uparrow$ ◄

$\sum M_C = 0$: $\quad R_D \sin 30^o(6a) - R_E(2a) = 0, \quad R_D = 0.771P$

$\sum F_x = 0$: $\quad R_{Cx} = R_D \cos 30^o = 0.668P \rightarrow$ ◄

SOLUTION(**1.20**)

(**a**) Power= P=(pA)(L)(n/60)

$= (1.2)(2100)(0.06)(\frac{1500}{60}) = 3.78\ kW$

Power required $= \frac{P}{e} = \frac{3.78}{0.9} = 4.2\ kW$ ◄

(**b**) Use Eq.(1.15),

$T = \frac{9549 kW}{n} = \frac{9549(4.2)}{1500} = 26.74\ N \cdot m$ ◄

SOLUTION (**1.21**)

Refer to App. A.1: 65 mph=65(5280)/60=5720 fpm.

(**a**) From Eq. (1.17), the drag force equals,

$F_d = \frac{33{,}000 hp}{V} = \frac{33{,}000(18)}{5720} = 103.4\ lb$

See: Fig. P1.21:

$\sum F_x = 0: \quad F = 103.4\ lb$ ◄

It follows that

$\sum M_A = 0: \quad -Wa + F_d c + R_f L = 0$

or

$-3.2(60) + (0.1034)(25) + R_f(110) = 0$

(CONT.)

1.21 (CONT.)

Solving,

$$R_f = 1.722\ kips \quad ◄$$

and

$$\sum F_y = 0: \quad R_r - 3.2 + 1.722 = 0$$

or

$$R_r = 1.478\ kips \quad ◄$$

(**b**)

We have $V = 0, \quad F_d = 0, \quad F = 0.$ ◄

See Fig. P1.21:

$$\sum M_A = 0: \quad Wa + R_f L = 0$$

Thus

$$R_f = \tfrac{a}{L} W = \tfrac{60}{110}(3.2) = 1.745\ kips \quad ◄$$

So, $\sum F_y = 0$ gives

$$R_r = W - R_f = 3.2 - 1.745 = 1.455\ kips \quad ◄$$

SOLUTION (**1.22**)

<u>Refer to Solution of Prob. 1.21.</u> Now we have $W_t = 3.2 + 1.2 = 4.4\ kips$ and friction force $F = 103.4\ lb$ acts at point A.

(**a**) See: Fig. 1.21 (with $W = W_t$):

$$\sum M_A = -4.4(60) + (0.1034)(25) + R_f(110) = 0$$

from which

$$R_f = 2.377\ kips \quad ◄$$

and

$$R_r = 4.4 - 2.377 = 2.023\ kips \quad ◄$$

(**b**) $V = 0, \quad F_d = 0, \quad F = 0,$ as before,

$$\sum M_A = 0: \quad R_f = \tfrac{a}{L} W_t = \tfrac{60}{110}(4.4) = 2.4 kips$$

and

$$R_r = W_t - R_f = 4.2 - 2.4 = 1.8\ kips \quad ◄$$

SOLUTION (**1.23**)

(**a**) <u>Free-Body Diagram: Gears (Fig. S1.23).</u>

Applying Eq. (1.15):

$$T_{AC} = \tfrac{9550P}{n} = \tfrac{9550(35)}{500} = 668.5\ N \cdot m$$

Therefore,

$$F = \tfrac{T_A}{r_A} = \tfrac{668.5}{0.125} = 5.348\ kN \quad ◄$$

(CONT.)

1.23 (CONT.)

(**b**) $T_{DE} = Fr_D = 5,348(0.075) = 401.1\ N \cdot m$ ◄

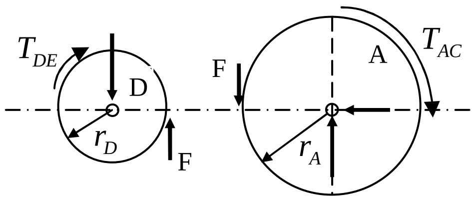


Figure S1.23

SOLUTION (**1.24**)

From Eq. (1.17), we obtain *T*=63,000 hp/n. Thus

For <u>input shaft</u>

$$T = \frac{63000(30)}{1800} = 1.05\ kip \cdot in.$$ ◄

For <u>output shaft</u>

$$T = \frac{63000(27)}{425} = 4.0\ kip \cdot in.$$ ◄

Equation (1.14) gives

$$e = \frac{27}{30} = 0.9 = 90\ \%$$ ◄

SOLUTION (**1.25**)

(**a**) Referring to Eq. (1.12):

$$\text{power output} = Fs(\tfrac{N}{60}) = 500 \times 2.5(\tfrac{150}{60})$$
$$= 3{,}125\ lb \cdot in./s$$

(**b**) Using Eq. (1.14), power transmitted by the shaft:

$$\text{power input} = 3{,}125/(0.88) = 3{,}551\ lb \cdot in./s$$

SOLUTION (**1.26**)

Equation (1.10) becomes

$$\Delta E_k = \tfrac{1}{2} I(\omega_{\max}^2 - \omega_{\min}^2) \qquad (1)$$

Here, mass moment inertia with 5 percent added:

$$I = (1.05)\tfrac{\pi}{32}(d_o^4 - d_i^4) \cdot l\rho \qquad \text{(Table A-5)}$$
$$= 1.05\tfrac{\pi}{32}(0.4^4 - 0.3^4)(0.1)(7{,}200)$$
$$= 1.299\ kg \cdot m^2$$
$$\omega_{\max} = 1200(\tfrac{1}{60}) = 20\ rps = 125.7\ rad/s$$
$$\omega_{\min} = 1100(\tfrac{1}{60}) = 18.3\ rps = 115\ rad/s$$

Equation (1) is therefore

$$\Delta E_k = \tfrac{1}{2}(1.299)(125.7^2 - 115^2)$$
$$= 1{,}673\ J$$ ◄

SOLUTION (**1.27**)

Final length of the wire:

$$L_{AC'} = \sqrt{(80)^2 + (50.4)^2} = 94.55242 \ in.$$

Initial length of the wire is

$$L_{AC} = \sqrt{(80)^2 + (50)^2} = 94.33981 \ in.$$

Hence, Eq. (1.20):

$$\varepsilon_{AC} = \tfrac{L_{AC'} - L_{AC}}{L_{AC}} = \tfrac{94.55242 - 94.33981}{94.33981}$$

$$= 0.00225 = 2250 \ \mu \quad ◄$$

SOLUTION (**1.28**)

(**a**) $\varepsilon_c = \frac{2\pi(r+\Delta r) - 2\pi r}{2\pi r} = \frac{\Delta r}{r}$

$(\varepsilon_c)_i = \frac{0.3}{150} = 2000 \ \mu$ ◄

$(\varepsilon_c)_o = \frac{0.2}{250} = 800 \ \mu$

(**b**) $\varepsilon_r = \frac{\Delta r_o - \Delta r_i}{r_o - r_i} = \frac{0.3 - 0.2}{250 - 150} = 1000 \ \mu$ ◄

SOLUTION (**1.29**)

$L_{OB} = d, \quad L_{AB} = L_{BC} = d\sqrt{2} = 1.41421d$

(**a**) $\varepsilon_{OB} = \frac{0.0012d}{d} = 1200\mu$ ◄

(**b**) $L_{AB'} = L_{CB'} = \left[d^2 + (1.0012d)^2\right]^{1/2} = 1.41506d$ ◄

$\varepsilon_{AB} = \varepsilon_{BC} = \frac{1.41506 - 1.41421}{1.41421} = 601 \ \mu$ ◄

(**c**) $CAB = \tan^{-1}\left(\frac{1.0012d}{d}\right) = 45.0344^o$

Increase in angle CAB is $45.0344 - 45 = 0.0344^o$.
Thus

$$\gamma = 0.0344\left(\tfrac{\pi}{180}\right) = 600\,\mu \quad ◄$$

SOLUTION (**1.30**)

(**a**) $\varepsilon_x = \frac{0.8 - 0.5}{250} = 1200\,\mu \qquad \varepsilon_y = \frac{-0.4 - 0}{200} = -2000 \ \mu$ ◄

(**b**) $L'_{AD} = L_{AD} + \varepsilon_x L_{AD} = L_{AD}(1 + \varepsilon_x)$

$= 250(1.0012) = 250.3\,mm$ ◄

SOLUTION (**1.31**)

$$\Delta L_{AB} = 800(10^{-6})150 = 120(10^{-3})\ mm$$
$$\Delta L_{AD} = 1000(10^{-6})200 = 200(10^{-3})\ mm$$ ◀

We have

$$L_{BD}^2 = L_{AB}^2 + L_{AD}^2$$
$$2L_{BD}\Delta L_{BD} = 2L_{AB}\Delta L_{AB} + 2L_{AD}\Delta L_{AD}$$

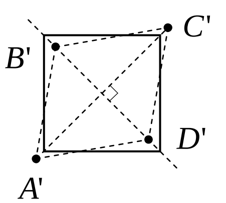
or

$$\Delta L_{BD} = \tfrac{L_{AB}}{L_{BD}}\Delta L_{AB} + \tfrac{L_{AD}}{L_{BD}}\Delta L_{AD} \qquad (1)$$
$$= \left[\tfrac{150}{250}(120) + \tfrac{200}{250}(200)\right]10^{-3} = 0.232\ mm$$ ◀

SOLUTION (**1.32**)

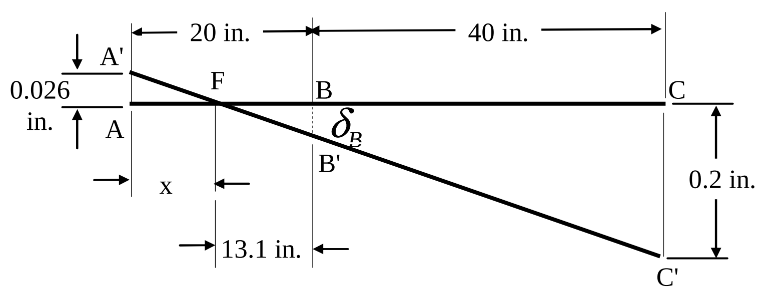
$$AC = BD = \sqrt{300^2 + 300^2} = 424.26\ mm$$
$$B'D' = 424.26 - 0.5 = 423.76 mm, \qquad A'C' = 424.26 + 0.2 = 424.46 mm$$

Geometry: $A'B' = A'D'$



$$\varepsilon_x = \varepsilon_y = \tfrac{A'D' - AD}{AD}$$
$$= \frac{\left[\left(\frac{423.76}{2}\right)^2 + \left(\frac{424.46}{2}\right)^2\right]^{1/2} - 300}{300} = -363\ \mu$$ ◀
$$\gamma_{xy} = \tfrac{\pi}{2} - \beta = \tfrac{\pi}{2} - 2\tan^{-1}\tfrac{423.76/2}{424.46/2} = 1651\ \mu$$

SOLUTION (**1.33**)



We have

$$\delta_{AD} = \varepsilon_{AD} L_{AD}$$
$$= 800\times 10^{-6}(32)$$
$$= 0.026\ in.$$

From triangles $A'AF$ and $C'CF$:

$$\tfrac{0.026}{x} = \tfrac{0.2}{60-x}, \qquad x = 6.9\ in.$$

From triangles $B'BF$ and $C'CF$:

$$\tfrac{13.1}{\delta_B} = \tfrac{53.1}{0.2}, \qquad \delta_B = 0.049\ in. = -\delta_{BE} \quad \text{(contraction)}$$

Therefore

$$\varepsilon_{BE} = \tfrac{-\delta_{BE}}{L_{BE}} = \tfrac{0.049}{40} = -1225(10^{-6})$$
$$= -1,225\ \mu$$ ◀

SOLUTION (**1.34**)

(**a**) $\varepsilon_x = \frac{0.006}{50} = 120\ \mu \qquad \varepsilon_y = \frac{-0.004}{25} = -160\ \mu$

$\gamma_{xy} = -1000 + 200 = -800\ \mu$ ◄

(**b**) $L'_{AB} = L_{AB}(1+\varepsilon_y) = 25(1-0.00016) = 24.996mm$

$L'_{AD} = L_{AD}(1+\varepsilon_x) = 50(1+0.00012) = 50.006mm$ ◄

End of Chapter 1

CHAPTER 2 MATERIALS

SOLUTION (**2.1**)

$$A_0 = \tfrac{\pi}{4}(0.5)^2 = 196.35(10^{-3})\ in.^2, \quad A_f = \tfrac{\pi}{4}(0.5-0.00024)^2 = 196.16(10^{-3})\ in.^2$$

We have $\varepsilon_a = \frac{12(10^{-3})}{8} = 1500\ \mu, \quad \varepsilon_t = \frac{0.24(10^{-3})}{0.5} = 480\ \mu$

Thus

$$S_p = \frac{P}{A_0} = \frac{4(10^3)}{196.35(10^{-3})} = 20.37\ ksi$$

$$E = \frac{S_p}{\varepsilon_a} = \frac{20.37(10^3)}{1500(10^{-6})} = 13.58(10^6)\ psi, \quad \nu = \frac{\varepsilon_t}{\varepsilon_a} = 0.32 \quad ◄$$

Also

$$\%elongation = \frac{12(10^{-3})}{8}(100) = 0.15$$

$$\%\ reduction\ in\ area = \frac{196.35-196.16}{196.35}(100) = 0.097 \quad ◄$$

SOLUTION (**2.2**)

Normal stress is

$$\sigma = \frac{P}{A} = \frac{500}{\frac{\pi}{4}(1/8)^2} = 4744\ ksi$$

This is below the yield strength of 50 ksi (Table B.1).
We have

$$\varepsilon = \frac{\delta}{L} = \frac{0.3}{18.5\times 12} = 0.001351 = 1351\ \mu$$

Hence

$$E = \frac{\sigma}{\varepsilon} = \frac{40{,}744}{135(10^{-6})} = 30\times 10^6\ \ psi \quad ◄$$

SOLUTION (**2.3**)

The cross-sectional area: $A = w_o t_o = 0.5(0.25) = 0.125\ in.^2$

(**a**) Axial strain and axial stress are

$$\varepsilon_a = \frac{0.00331}{2.5} = 0.01324 = 1324\ \mu$$

$$\sigma_a = \frac{P}{A} = \frac{4.8}{0.125} = 38.4\ ksi$$

Because $\sigma_a < S_y$ (See Table B.1), Hooke's Law is valid.

(**b**) Modulus of elasticity,

$$E = \frac{\sigma_a}{\varepsilon_a} = \frac{38{,}400}{1324(10^{-6})} = 29\times 10^6\ \ psi$$

(**c**) Decrease in the width and thickness

$$\Delta w = \nu w_o = 0.3(0.5) = 0.15\ in. \quad ◄$$

$$\Delta t = \nu t_o = 0.3(0.24) = 0.072\ in.$$
