Solutions Manual

SOLUTIONS TO CHAPTER 2 PROBLEMS

S.2.1 By inspection:

a. Translation parallel to BA.

b. Translation parallel to BD, clockwise rotation.

c. No translation, possible clockwise rotation.

d. The force F at C may be resolved into two components as shown in Fig. S.2.1(a). The force system is then equivalent to a force parallel to AD of $2F - F\cos 45^\circ = 1.293F$ and a force of $0.707F$ parallel to AB both acting at the centre of the block together with an anticlockwise torque as shown in Fig. S.2.1(b). The resultant of the two forces then acts at an angle α to the direction of AD given by

$$\tan\alpha = \frac{0.707F}{1.293F} = 0.547$$

which gives

$$\alpha = 28.7^\circ$$

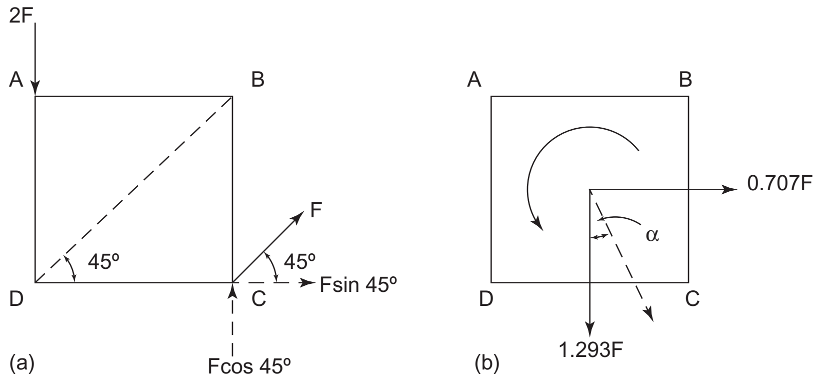

FIGURE S.2.1

S.2.2 **a.** Vectors representing the 10 and 15 kN forces are drawn to a suitable scale as shown in Fig. S.2.2. Parallel vectors AC and BC are then drawn to intersect at C. The resultant is the vector OC which is 21.8 kN at an angle of 23.4° to the 15 kN force.

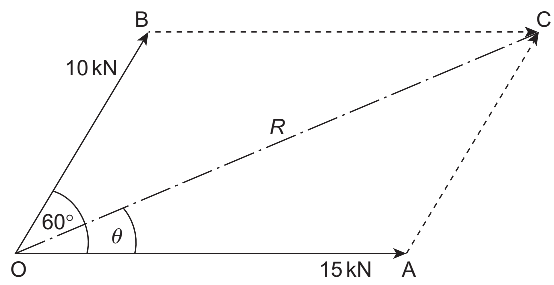

FIGURE S.2.2

b. From Eq. (2.1) and Fig. S.2.2

$$R^2 = 15^2 + 10^2 + 2 \times 15 \times 10 \cos 60^\circ$$

which gives

$$R = 21.8 \text{ kN}$$

Also, from Eq. (2.2)

$$\tan \theta = \frac{10 \sin 60^\circ}{15 + 10 \cos 60^\circ}$$

so that

$$\theta = 23.4^\circ.$$

S.2.3 **a.** The vectors do not have to be drawn in any particular order. Fig. S.2.3 shows the vector diagram with the vector representing the 10 kN force drawn first.

The resultants R is then equal to 8.6 kN and makes an angle of 23.9° to the negative direction of the 10 kN force.

b. Resolving forces in the positive x direction

$$F_x = 10 + 8 \cos 60^\circ - 12 \cos 30^\circ - 20 \cos 55^\circ = -7.9 \text{ kN}$$

Then, resolving forces in the positive y direction

$$F_y = 8 \cos 30^\circ + 12 \cos 60^\circ - 20 \cos 35^\circ = -3.5 \text{ kN}$$

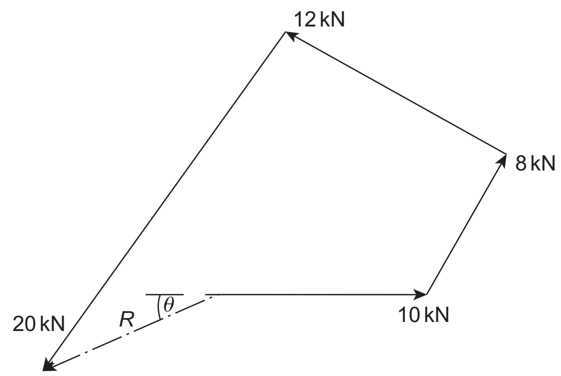

FIGURE S.2.3

The resultant R is given by

$$R^2 = (-7.9)^2 + (-3.5)^2$$

so that

$$R = 8.6 \text{ kN}$$

Also

$$\tan\theta = \frac{3.5}{7.9}$$

which gives

$$\theta = 23.9^\circ.$$

S.2.4 Referring to Fig. S.2.4 the resultant vertical force F_V is given by

$$F_V = 10 + 8 + 3 = 21 \text{ kN}$$

Taking moments about the centre of the cylinder

$$F_V\ \bar{x} = 10 \times 1.25 + 8 \times 0.75 - 3 \times 1.0$$

so that

$$21\bar{x} = 15.5$$

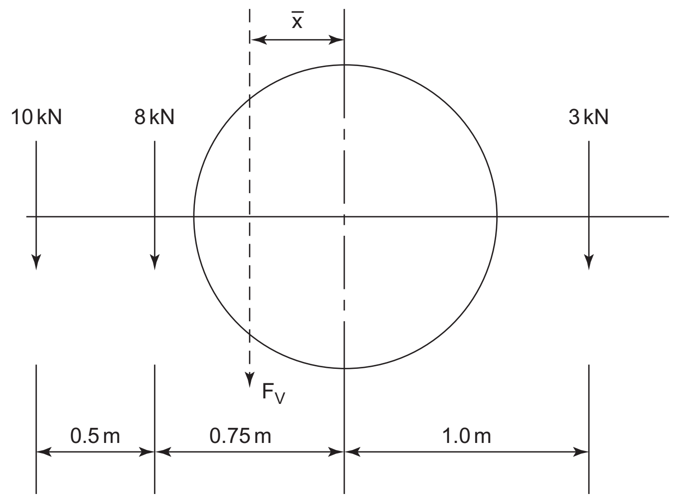

FIGURE S.2.4

which gives

$$\bar{x} = 0.738 \text{ m}$$

The force system is then equivalent to a vertically downward force of 21 kN acting through the centre of the cylinder together with a torque $T = 21 \times 0.738 = 15.5$ kNm (anticlockwise).

Alternatively, and more directly

$$T = 10 \times 1.25 + 8 \times 0.75 - 3 \times 1.0 = 15.5 \text{ kNm (anticlockwise)}$$

The bending moment at the built in end is given by

$$M = 21 \times 2.5 = 52.5 \text{ kNm}$$

S.2.5 Initially the forces are resolved into vertical and horizontal components as shown in Fig. S.2.5.

Then

$$R_x = 69.3 + 35.4 - 20.0 = 84.7 \text{ kN}$$

Now taking moments about the x axis

$$R_x\bar{y} = 35.4 \times 0.5 - 20.0 \times 1.25 + 69.3 \times 1.6$$

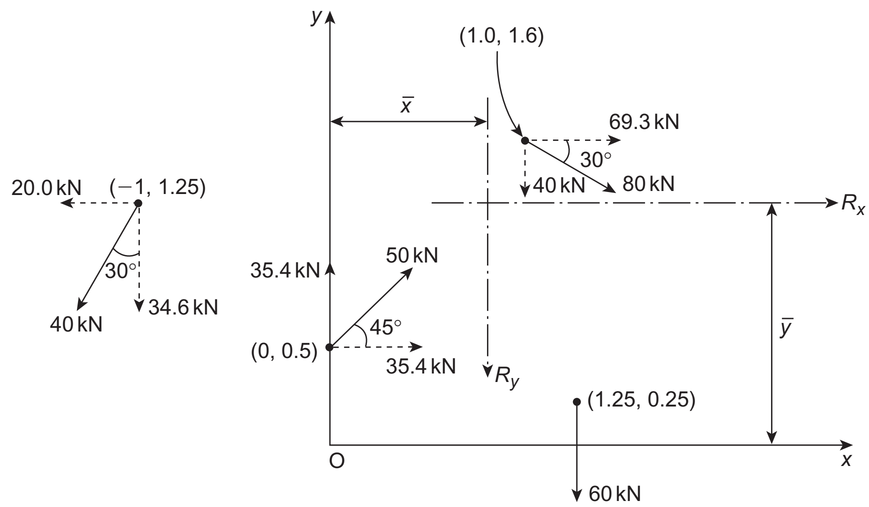

FIGURE S.2.5

which gives

$$\bar{y} = 1.22 \text{ m}$$

Also, from Fig. S.2.5

$$R_y = 60 + 40 + 34.6 - 35.4 = 99.2 \text{ kN}$$

Now taking moments about the y axis

$$R_y\bar{x} = 40.0 \times 1.0 + 60.0 \times 1.25 - 34.6 \times 1.0$$

so that

$$\bar{x} = 0.81 \text{ m}$$

The resultant R is then given by

$$R^2 = 99.2^2 + 84.7^2$$

from which

$$R = 130.4 \text{ kN}$$

Finally

$$\theta = \tan^{-1}\frac{99.2}{84.7} = 49.5^\circ.$$

S.2.6 **a.** In Fig. S.2.6(a) the inclined loads have been resolved into vertical and horizontal components. The vertical loads will generate vertical reactions at the supports A and B while the horizontal components of the loads will produce a horizontal reaction at A only since B is a roller support.

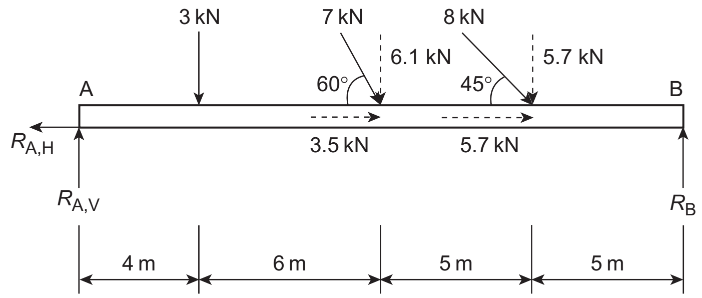

FIGURE S.2.6(a)

Taking moments about B

$$R_{A,V} \times 20 - 3 \times 16 - 6.1 \times 10 - 5.7 \times 5 = 0$$

which gives

$$R_{A,V} = 6.9 \text{ kN}$$

Now resolving vertically

$$R_{B,V} + R_{A,V} - 3 - 6.1 - 5.7 = 0$$

so that

$$R_{B,V} = 7.9 \text{ kN}$$

Finally, resolving horizontally

$$R_{A,H} - 3.5 - 5.7 = 0$$

so that

$$R_{A,H} = 9.2 \text{ kN}$$

Note that all reactions are positive in sign so that their directions are those indicated in Fig. S.2.6(a).

b. The loads on the cantilever beam will produce a vertical reaction and a moment reaction at A as shown in Fig. S.2.6(b).

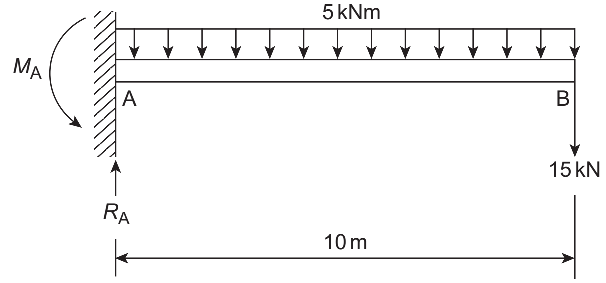

FIGURE S.2.6(b)

Resolving vertically

$$R_A - 15 - 5 \times 10 = 0$$

which gives

$$R_A = 65 \text{ kN}$$

Taking moments about A

$$M_A - 15 \times 10 - 5 \times 10 \times 5 = 0$$

from which

$$M_A = 400 \text{ kN m}$$

Again the signs of the reactions are positive so that they are in the directions shown.

c. In Fig. S.2.6(c) there are horizontal and vertical reactions at A and a vertical reaction at B.

By inspection (or by resolving horizontally)

$$R_{A,H} = 20 \text{ kN}$$

Taking moments about A

$$R_B \times 8 + 20 \times 5 - 5 \times 2 \times 9 - 15 \times 6 - 10 \times 2 = 0$$

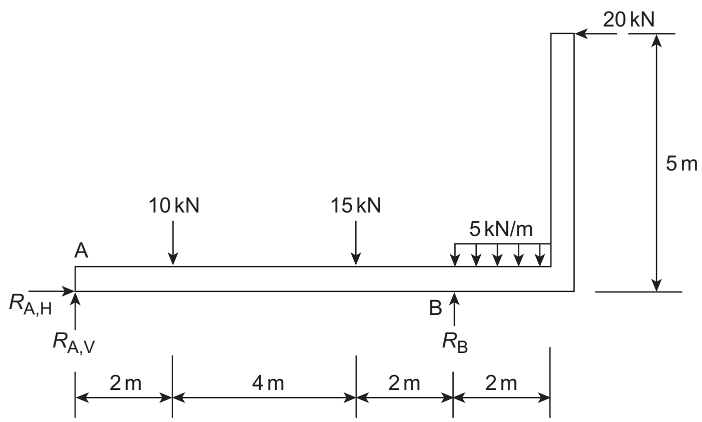

FIGURE S.2.6(c)

which gives

$$R_B = 12.5 \text{ kN}$$

Finally, resolving vertically

$$R_{A,V} + R_B - 10 - 15 - 5 \times 2 = 0$$

so that

$$R_{A,V} = 22.5 \text{ kN}.$$

d. The loading on the beam will produce vertical reactions only at the supports as shown in Fig. S.2.6(d).

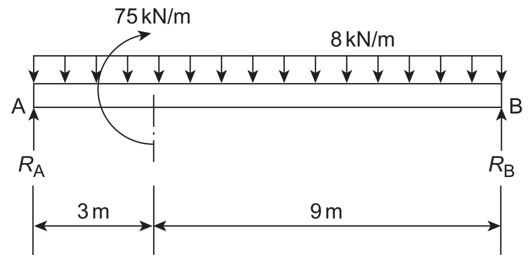

FIGURE S.2.6(d)

Taking moments about B

$$R_A \times 12 + 75 - 8 \times 12 \times 6 = 0$$

Hence

$$R_A = 41.8 \text{ kN}$$

Now resolving vertically

$$R_B + R_A - 8 \times 12 = 0$$

so that

$$R_B = 54.2 \text{ kN}.$$

S.2.7 **a.** The loading on the truss shown in Fig. P.2.7(a) produces only vertical reactions at the support points A and B; suppose these reactions are R_A and R_B respectively and that they act vertically upwards. Then, taking moments about B

$$R_A \times 10 - 5 \times 16 - 10 \times 14 - 15 \times 12 - 15 \times 10 - 5 \times 8 + 5 \times 4 = 0$$

which gives

$$R_A = 57 \text{ kN} \quad \text{(upwards)}$$

Now resolving vertically

$$R_B + R_A - 5 - 10 - 15 - 15 - 5 - 5 = 0$$

from which

$$R_B = -2 \text{ kN} \quad \text{(downwards).}$$

b. The angle of the truss is $\tan^{-1}(4/10) = 21.8°$. The loads on the rafters are symmetrically arranged and may be replaced by single loads as shown in Fig. S.2.7.

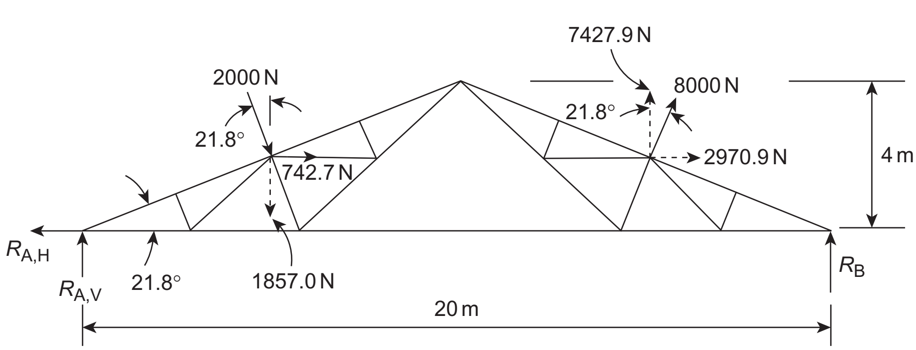

FIGURE S.2.7

These, in turn, may be resolved into horizontal and vertical components and will produce vertical reactions at A and B and a horizontal reaction at A.

Taking moments about B

$$R_{A,V} \times 20 + 742.7 \times 2 - 1857.0 \times 15 + 2970.9 \times 2 + 7427.9 \times 5 = 0$$

which gives

$$R_{A,V} = -835.6 \text{ N} \quad \text{(downwards)}.$$

Now resolving vertically

$$R_B + R_{A,V} - 1857.0 + 7427.9 = 0$$

from which

$$R_B = -4735.3 \text{ N} \quad \text{(downwards)}.$$

Finally, resolving horizontally

$$R_{A,H} - 742.7 - 2970.9 = 0$$

so that

$$R_{A,H} = 3713.6 \text{ N}.$$