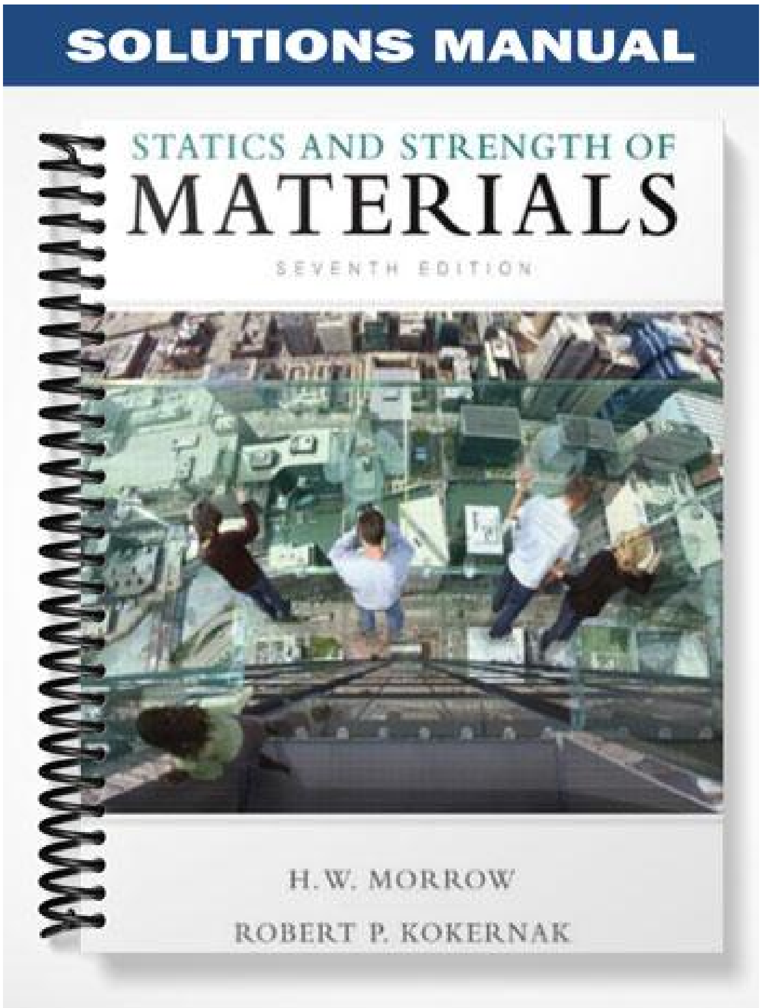
SOLUTIONS MANUAL
STATICS AND STRENGTH OF
MATERIALS
SEVENTH EDITION
H.W. MORROW
ROBERT P. KOKERNAK

Instructor's Solutions Manual
to accompany

Statics and Strength of Materials

Seventh Edition

H.W. Morrow
Robert P. Kokernak

PEARSON
Prentice Hall

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Contents

1 Basic Concepts

1. (a) 17.9 in. (25.40 mm)/1 in. = 455 mm = 0.455 m <
(b) 6.4 ft (304.8 mm)/1 ft = 1951 mm = 1.951 m <
(c) 13.8 in. (25.40 mm)/1 in. = 351 mm = 0.351 m <
(d) 95.2 ft (304.8 mm)/1 ft = 29.0×10^3 mm = 29.0 m <

2. (a) 10.2 m (39.37 in.)/1 m = 402 in. = 33.5 ft <
(b) 45.0 m (39.37 in.)/1 m = 1772 in. = 147.6 ft <
(c) 204 mm (39.37 in.)/1000 mm = 8.03 in. = 0.669 ft <
(d) 4600 mm (39.37 in.)/1000 mm = 181.1 in. = 15.09 ft <

3. 1 hr = 3600 s
1 mi = 5280 ft
$\frac{60\text{ mi}}{\text{hr}} \times \frac{1\text{ hr}}{3600\text{ s}} \times \frac{5280\text{ ft}}{1\text{ mi}} = 88.0\ \frac{\text{ft}}{\text{s}}$ <

4. (a) $60\text{ W} \times \frac{1\text{ hp}}{745.7\text{ W}} = 0.0805\text{ hp}$ <

(b) $210\text{ hp} \times \frac{745.7\text{ W}}{1\text{ hp}} = 156\,597\text{ W}$ <

5. (a) 23.5 lb (4.448 N)/1 lb = 104.5 N = 0.1405 kN <
(b) 5.8 kips (4448 N)/1 kip = 25.8×10^3 N = 25.8 kN <
(c) 250 lb (4.448 N)/1 lb = 1112 N = 1.112 kN <
(d) 15.9 kips (4448 N)/1 kip = 70.7×10^3 N = 70.7 kN <

6. (a) 52.9 N (0.2248 lb)/1 N = 11.89 lb = 0.01189 kip <
(b) 6.85 kN (224.8 lb)/1 kN = 1540 lb = 1.540 kips <

7. (a) 250 kg × 9.81 m/s^2 = 2450 N = 2.45 kN <
(b) 4.5 Mg: 4.5×10^3 kg × 9.81 m/s^2 = 44.1×10^3 N = 44.1 kN <
(c) 375 × 9.81 m/s^2 = 3680 N = 3.68 kN <
(d) 25.0 Mg: 25×10^3 kg × 9.81 m/s^2 = 245×10^3 N = 245 kN <
(e) 140.0 kg: 140 kg × 9.81 m/s^2 = 1373 N = 1.373 kN <

8. (a) 2000 N/9.81 m/s^2 = 204 kg <
(b) 3.50 kN: 3500 N/9.81 m/s^2 = 357 kg <
(c) 1200 N/9.81 m/s^2 = 122.3 kg <
(d) 4.40 kN: 4400 N/9.81 m/s^2 = 449 kg <

9. (a) 62.428 lb/ft^3(1 ft/0.3048)^3 × (4.448 N/lb) = 9810 N/m^3 = 9.81 kN/m^3 <
(b) $62.428\frac{\text{lb}}{\text{ft}^3} \times \frac{1\text{ ft}^3}{1728\text{ in}^3} \times \frac{231\text{ in}^3}{\text{gal}} \times 55\text{ gal} = 459\text{ lb}$ <

10. 150(10 in. × 22 in.) × (1 ft^2/144 $in.^2$) = 229 lb/ft <
(229 lb/ft)(1 ft/0.3048 m)(4.448 N/lb) = 3344 N/m = 3.34 kN/m <
(3344 N/m)(1 kg/9.81 N) = 341 kg/m <

11. (1 lb/$in.^2$)(4.448 N/lb) × (1 in./0.02540 m)^2 = 6894 N/m^2 = 6.89 kPa(kN/m^2) <
[(6894 N/m^2)/(1 lb/$in.^2$)] × (14.7 lb/$in.^2$) = 101 340 Pa = 101.3 kPa(kN/m^2) <

12. $250\ \text{MN/m}^2 = 250 \times 10^6\ \text{N/m}^2$
$(250 \times 10^6\ \text{N/m}^2)(1\ \text{lb}/4.448\ \text{N}) \times (1\ \text{m}/39.37\ \text{in.})^2 = 36.3 \times 10^3\ \text{lb/in.}^2$ (psi) <
$= 36.3\ \text{kips/in.}^2$ (ksi) <
$55\ \text{MN/m}^2 = 55 \times 10^6\ \text{N/m}^2$
$(55 \times 10^6\ \text{N/m}^2)(1\ \text{lb}/4.448\ \text{N}) \times (1\ \text{m}/39.37\ \text{in.})^2$ <
$= 7.98 \times 10^3\ \text{lb/in.}^2$ (psi) $= 7.98\ \text{kips/in.}^2$ (ksi) <

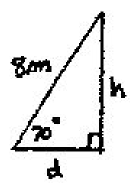
13. $43{,}560\ \text{ft}^2(0.3049\ \text{m/ft})^2 = 4050\ \text{m}^2$ <

14. $400\ \text{MN/m}^2 = 400 \times 10^6\ \text{N/m}^2$
$400 \times 10^6\ \text{N/m}^2(1\ \text{lb}/4.448\ \text{N}) \times (1\ \text{m}/39.37\ \text{in.})^2 = 58.0 \times 10^3\ \text{lb/in.}^2$ (psi) <
$= 58.0\ \text{kips/in.}^2$ (ksi) <
$70 \times 10^6\ \text{N/m}^2(1\ \text{lb}/4.448\ \text{N}) \times (1\ \text{m}/39.37\ \text{in.})^2 =$
$10.15 \times 10^3\ \text{lb/in.}^2$ (psi) <
$= 10.15\ \text{kips/in.}^2$ (ksi) <

15. (a) $c^2 = (475)^2 + (950)^2$
$c = 1062$ mm <
$\theta = \arctan(475/950) = 26.6°$
$\sin 26.6° = 0.447$ <
$\cos 26.6° = 0.894$ <

(b) $c^2 = 8^2 + 6^2$, $c = 10$ ft
$\sin\theta = (6/10) = 0.6$ <
$\cos\theta = (8/10) = 0.8$ <

16. (a) $\frac{d}{8\ \text{m}} = \cos 70° = 0.3420$
$d = 8\ \text{m} \times 0.3420 = 2.74$ m <
(b) $\frac{h}{8\ \text{m}} = \sin 70° = 0.9397$
$h = 8\ \text{m} \times 0.9397 = 7.52$ m <



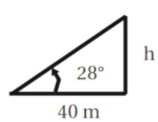
CHECK: $d^2 + h^2 = (8\ \text{m})^2$?

17. $\theta_1 = 45°$, $\theta_2 = 35°$, $d = 300$ mm
Eliminating b from the two Eq. (a) of Prob. 1.16, we have
$(c + d)/\tan\theta_1 = d/\tan\theta_2$
$c = d(\tan\theta_1 - \tan\theta_2)/\tan\theta_2 = 300(\tan 45° - \tan 35°)/\tan 35°$
$c = 128.4$ m <

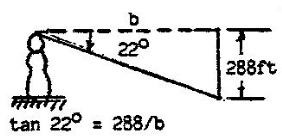
From Eq. (a), we have
$b = (c + d)/\tan\theta_1$
$= (128.4 + 300)/\tan 45° = 428$ m <

18. $b = 10$ ft $= 120$ in.
$h = 5$ ft 8 in. $= 68$ in.
$\tan\theta = h/b = 68/120$; $\theta = 29.5°$ <

19. $\tan 28° = h/40$
$h = 40 \tan 28°$
$h = 21.3$ m <

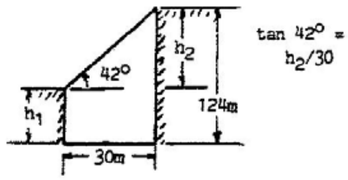


20.



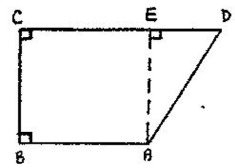
tan 22° = 288/*b*
b = 288/tan 22° = 712.8 = 713 ft <

21.



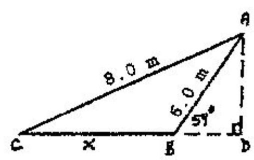
h_2 = 30 tan 42° = 27.0 m <
$h_1 = 124 - h_2$ = 124 – 27.0 = 97.0 m <

22. Distance *AE* = *BC* = 200 ft
Distance *ED* = 340 ft – 225 ft = 115 ft
Then for triangle *AED*:
$(AD)^2 = (200\text{ ft})^2 + (115\text{ ft})^2$
AD = Road frontage = 230.7 ft <



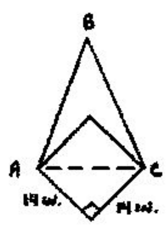
23. In triangle *ABD*:
$\frac{AD}{6.0\text{ m}}$ = sin 54° or *AD* = 4.854 m

$\frac{BD}{6.0\text{ m}}$ = cos 54° or *BD* = 3.527 m

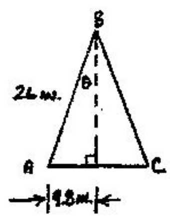


In triangle *ACD*:
$(CD)^2 + (4.854\text{ m})^2 = (8.0\text{ m})^2$
CD = 6.359 m
Then: *x* = *BC* = *CD* – *BD*
x = 6.539 m – 3.527 m
x = 2.832 m <

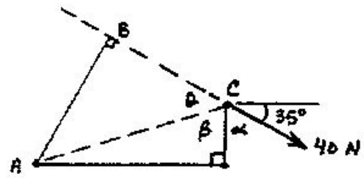
24. $(AC)^2 = (14\text{ in.})^2 + (14\text{ in.})^2$
AC = 19.8 in.
$AB = BC = \frac{1}{2}$(80 in. – 2 × 14 in.)
AB = *BC* = 26 in.



sin θ = $\frac{9.8\text{ in.}}{26\text{ in.}}$ = 0.3769
θ = 22.14°
Angle *ABC* = 2θ = 44.3° <



25. Using bracket dimensions:



$(AC)^2 = (2.5\text{ m})^2 + (0.6\text{ m})^2$

$AC = 2.57$ m

$\tan\beta = \frac{2.5\text{ m}}{0.6\text{ m}} = 4.1667\beta = 76.5°$

$\alpha = 90° - 35° = 55°$

$\theta = 180° - \alpha - \beta = 48.5°$

In triangle *ABC*:

$\frac{AB}{AC} = \sin\theta$ $\qquad \frac{AB}{2.57\text{ m}} = \sin 48.5°$

$AB = 1.93$ m <

26. (a) In triangle *ECG*, let angle *CEG* = θ. Then:

$\frac{CG}{EG} - \tan\theta = \frac{16\text{ ft}}{(8\text{ ft} + 8\text{ ft})} = 1.0000$

So: $\theta = 45°$

Similarly, the following angles are equal to θ:

BAH, *BGH*, *DGF*, *ABH*, *GBH*, *BCG*, *FDG*, *EDF*, and *DCG*.

(b) In triangle *DEF*, $\frac{DF}{EF} = \tan 95° = 1.000$

so $DF = BH = 8$ ft

and $(DE)^2 = (8\text{ ft})^2 + (8\text{ ft})^2$

or $DE = 11.31\text{ ft} = DG = BG = AB$

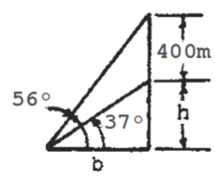
Since angle $CDG = 90°$,

then $CD = DG = CB = BG = 11.31$ ft

Total lineal feet:

(6 @ 8 ft) + (6 @ 11.31 ft) + (1 @ 16 ft) = 132 ft <

27. From the Fig.



$\tan 37° = h/b$ (a)

$\tan 56° = (400 + h)/b$ (b)

Eliminating b beween

Eqs. (a) and (b), we have

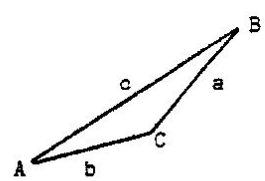
$h/\tan 37° = (400 + h)/\tan 56°$

or $h(\tan 56° - \tan 37°) = 400 \tan 37°$

$h = 400 \tan 37°/(\tan 56° - \tan 37°)$

$h = 413.5 = 414$ m

28. (a) For Fig.



$a = 7$ in., $B = 40°$, $C = 30°$

$A = 180° - B - C = 110°$

From Fig. and law of sines

$b/\sin 40° = c/\sin 30° = 7/\sin 110°$

$b = 7 \sin 40°/\sin 110° = 4.79$ in. <

$c = 7 \sin 30°/\sin 110° = 3.72$ in. <

(b) $a = 3$ m, $b = 6$ m, $C = 48°$

From Fig. and law of cosines

$c^2 = (6)^2 + (3)^2 - 2(6)(3)\cos 48°$

$c = 4.57$ m <

From Fig. and law of sines

$\sin A/3 = \sin 48°/4.57$

$\sin A = 0.4878$; $A = 29.2°$ <

$B = 180° - A - C$; $B = 102.8°$ <

(c) $a = 8$ ft, $b = 7$ ft, $A = 60°$

From Fig. and law of sines

$\sin B/7 = \sin 60°/8$

$\sin B = 0.7578$; $B = 49.3°$ <

$C = 180° - A - B$; $C = 70.7°$ <

From Fig. and law of cosines

$c^2 = (7)^2 + (8)^2 - 2(7)(8) \cos 70.7°$

$c = 8.72$ ft <

(d) $a = 4$ m, $b = 7$ m, $c = 9$ m

From Fig. and law of cosines

$(9)^2 = (7)^2 + (4)^2 - 2(7)(4) \cos C$

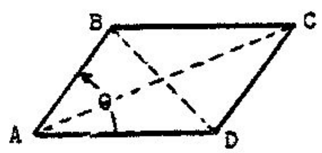
$\cos C = -0.2857$; $C = 106.6°$ <

& $(4)^2 = (7)^2 + (9)^2 - 2(7)(9) \cos A$

$\cos A = 0.9048$; $A = 25.2°$ <

$B = 180° - A - C$; $B = 48.2°$ <

29.



(a) 8 in., 12.5 in., 65°

From Fig. and law of cosines

$(AC)^2 = (8)^2 + (12.5)^2 - 2(8)(12.5) \times \cos(180° - 65°)$; $AC = 17.46$ in. <

$(BD)^2 = (8)^2 + (12.5)^2 - 2(8)(12.5) \times \cos 65°$; $BD = 11.65$ in. <

(b) 550 mm, 320 mm, 55°

From Fig. and law of cosines

$(AC)^2 = (550)^2 + (320)^2 - 2(550)(320) \times \cos(180° - 55°)$; $AC = 779$ mm <

$(BD)^2 = (550)^2 + (320)^2 - 2(550)(320) \times \cos 55°$; $BD = 451$ mm <

(c) 10.3 ft, 12.5 ft, 45°

From Fig. and law of cosines

$(AC)^2 = (10.3)^2 + (12.5)^2 - 2(10.3)(12.5)\ \cos(180° - 45°)$ $AC = 21.1$ ft <

$(BD)^2 = (10.3)^2 + (12.5)^2 - 2(10.3)(12.5) \cos 45°$ $BD = 8.96$ ft <

(d) 5 m, 12 m, 125°

From Fig. and law of cosines

$(AC)^2 = (5)^2 + (12)^2 - 2(5)(12) \times \cos(180° - 125°)$; $AC = 10.01$ m <

$(BD)^2 = (5)^2 + (12)^2 - 2(5)(12) \times \cos 125°$; $BD = 15.42$ m <

30. From Fig. and the law of cosines

$(AB)^2 = (5)^2 + (8)^2 - 2(5)(8) \cos 40°$

$AB = 5.26$ ft <

From Fig. and law of sines

$\sin A/8 = \sin 40°/5.26$

$\sin A = 0.9768$

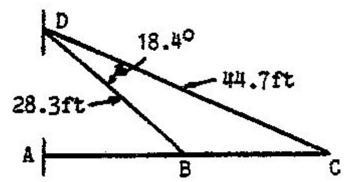
$A = 180° - 77.6° = 102.4°$

$\theta = A - 90° = 102.4° - 90° = +12.4°$ <

31. From Fig. and law of cosines

$(BC)^2 = (28.3)^2 + (44.7)^2 - 2(28.3)(44.7) \cos 18.4°$

$BC = 19.96$ ft <



From Fig. and law of sines

$\sin\angle BCD/28.3 = \sin\angle DBC/44.7 = \sin 18.4°/19.96$

$\sin\angle BCD = 0.4475$; $\angle BCD = 26.6°$ <

$\sin\angle DBC = 0.7068$

$\angle DBC = 180° - 44.98° = 135.0°$ <

$\angle DBA = 180° - 135.0° = 45°$ <

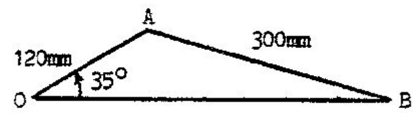
$AD = AB \tan\angle ABD = AC \tan \angle BCD$

$AB \tan 45° = (AB + 19.96) \tan 26.6°$

$AB = 20.02$ ft

$AC = 19.96 + 20.02 = 40.0$ ft <

32. $OA = 120$ mm, $AB = 300$ mm



From the law of sines

$\sin 35°/300 = \sin A/OB = \sin B/120$

$\sin B = (120/300) \sin 35°$

Angle $B = 13.26°$

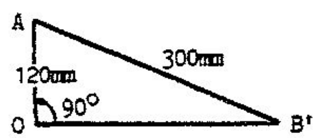
Angle $A = 180° - 13.26° - 35°$

$= 131.7°$

$OB = 300 \sin A/\sin 35°$

$= 300 \sin 131.7°/\sin 35°$

$OB = 390$ mm <

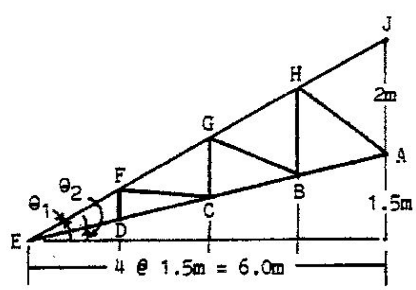


$(120)^2 + (OB')^2 = (300)^2$

$OB' = 275$ mm <

Distance moved $= OB - OB' = 390 - 275 = 115.0$ mm <

33. Fig. (1)



(a) From Fig. (1)

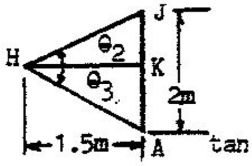
$\tan \theta_1 = 1.5/6$; $\theta_1 = 14.04°$

$\tan \theta_2 = (2 + 1.5)/6$; $\theta_2 = 30.26°$

and $\angle GCB = 90° - \theta_2 = 75.96°$

$= 76.0°$ <

(b) From Fig. (2)



$JK = 1.5 \tan \theta_2 = 0.875$ m

$KA = 2 - JK = 1.125$ m

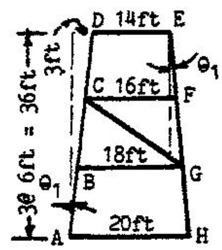
$\tan \theta_3 = 1.125/1.5$

$\theta_3 = 36.87°$

$\angle AHJ = \theta_1 + \theta_2 = 67.1°$ <

Fig. (2)

34. From the Fig.



$\tan \theta_1 = 3/36$

$\theta_1 = 4.76°$

$\angle BAH = 90° - \theta_1 = 85.2°$ <

$(AD)^2 = (3)^2 + (36)^2$

$AD = 36.12$

$BC = AD/3 = 12.04$ ft

$\angle BAH = \angle CBG$

From Fig. and law of cosines

$(CG)^2 = (18)^2 + (12.04)^2 - 2(18)(12.04) \cos 85.2°$

$CG = 20.81$ ft

From the figure of the tower and the law of sines

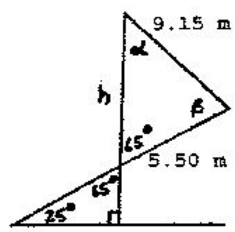
$$\frac{\sin \angle BCG}{18} = \frac{\sin 85.2°}{20.81}$$

$\sin\angle BCG = 0.8615$

$\angle BCG = 59.5°$ <

$\angle DEF = 90 + \theta_1 = 94.8°$ <

35. (a) Law of sines:



$$\frac{9.15 \text{ m}}{\sin 65°} = \frac{5.50 \text{ m}}{\sin \alpha}$$

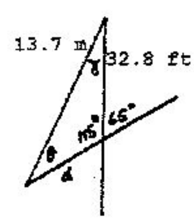
$\alpha = 33.0°$

$\beta = 180° - 65° - \alpha = 82.0°$

So $\dfrac{9.15 \text{ m}}{\sin 65°} = \dfrac{h}{\sin 82.0°}$

$h = 10.0$ m <

(b) Law of sines:



$$\frac{13.7 \text{ m}}{\sin 115°} = \frac{10.0 \text{ m}}{\sin \theta}$$

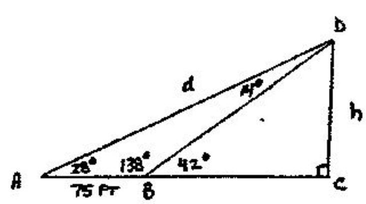
$\theta = 41.4°$

$\gamma = 180° - 115° - \theta = 23.6°$

$$\frac{13.7 \text{ m}}{\sin 115°} = \frac{d}{\sin 23.6°}$$

$d = 6.05$ m <

36. In triangle *ABD*, law of sines yields:



$$\frac{d}{\sin 138°} = \frac{75 \text{ ft}}{\sin 14°}$$

$d = 207.4$ ft

In right triangle *ACD*:

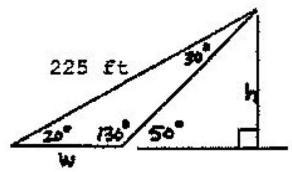
$\dfrac{h}{207.4 \text{ ft}} = \sin 28° = 0.4695$

$h = 97.4$ ft, tree will hit house <

37. (a) Law of sines:

$\frac{225 \text{ ft}}{\sin 130°} = \frac{W}{\sin 30°}$

$W = 146.9$ ft <



(b) $h = (225 \text{ ft})\sin 20° = 77.0$ ft

$V = \frac{1}{2}(146.9 \text{ ft})(77.0 \text{ ft})(\frac{5280 \text{ ft}}{8})$

$= 3{,}732{,}729 \text{ ft}^3$

$V = \frac{1 \text{ cu. yd.}}{27 \text{ ft}^3} \times 3{,}732{,}729 \text{ ft}^3$

$V = 138{,}249$ cu. yds. <

(c) No. of truckloads = $\frac{138{,}249 \text{ cu. yds.}}{20 \text{ cu. yds./truck}}$

= 6,912 truckloads <

38. From law of cosines:

$R^2 = (18)^2 + (32)^2 - 2(18)(32) \cos 41.5°$

$R = 22.0$ ft <

From law of sines:

$\frac{18 \text{ ft}}{\sin B} = \frac{22.0 \text{ ft}}{\sin 41.5°}$

$\sin B = 0.5421$

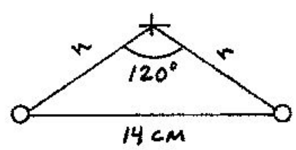
$B = 32.8°$ <

39. From law of cosines:

$(14)^2 = r^2 + r^2 - 2(r)(r) \cos 120°$

$r = 8.08$ cm

$d = 2r = 16.2$ cm <



40. $D = \begin{vmatrix} -15 & 21 \\ -2 & 3 \end{vmatrix} = -15(3) - 21(-2)$

$= -3$

$Dx = \begin{vmatrix} 12 & 21 \\ 17 & 3 \end{vmatrix} = 12(3) - (21)(17)$

$= -321$

$Dy = \begin{vmatrix} -15 & 12 \\ -2 & 17 \end{vmatrix} = -15(17) - (12)(-2)$

$= -231$

Dividing Dx and Dy by D, we have

$x = \frac{-321}{-3} = 107, \quad y = \frac{-231}{-3} = 77$ <

41. $D = \begin{vmatrix} 19 & -20 \\ 20 & -21 \end{vmatrix} = 19(-21) - (-20)(20) = 1$

$Du = \begin{vmatrix} -22 & -20 \\ -23 & -21 \end{vmatrix} = (-22)(-21) - (-20)(-23) = 2$

$Dv = \begin{vmatrix} 19 & -22 \\ 20 & -23 \end{vmatrix} = 19(-23) - (-22)(20) = 3$

Dividing *Du* and *Dv* by *D*, we have

$u = \frac{2}{1} = 2, \quad v = \frac{3}{1} = 3$ <

42. $D = \begin{vmatrix} 5 & -3 \\ 3 & -5 \end{vmatrix} = 5(-5) - (-3)(3)$

$= -16$

$Dm = \begin{vmatrix} 9 & -3 \\ -9 & -5 \end{vmatrix} = 9(-5) - (-3)(-9) = -72$

$Dn = \begin{vmatrix} 5 & 9 \\ 3 & -9 \end{vmatrix} = 5(-9) - 9(3) = -72$

Dividing *Dm* and *Dn* by *D*, we have

$m = \frac{-72}{-16} = 4.5, \quad n = \frac{-72}{-16} = 4.5$ <

43. $D = \begin{vmatrix} 2 & 2 \\ 1 & -1 \end{vmatrix} = (2)(-1) - (1)(2) = -4$

$DA = \begin{vmatrix} 3 & 2 \\ -0.9 & -1 \end{vmatrix} = (3)(-1) - (-0.9)(2) = -1.2$

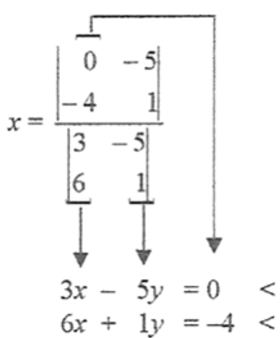
$DB = \begin{vmatrix} 2 & 3 \\ 1 & -0.9 \end{vmatrix} = (2)(-0.9) - (1)(3) = -4.8$

Then:

$A = \frac{DA}{D} = \frac{-1.2}{-4} = 0.3$ <

$B = \frac{DB}{D} = \frac{-4.8}{-4} = 1.2$ <

44.



45. $-7x + 10y = 10$ <

$9x - 5y = -5$ <

$x = \frac{\begin{vmatrix} 10 & 10 \\ -5 & -5 \end{vmatrix}}{\begin{vmatrix} -7 & 10 \\ 9 & -5 \end{vmatrix}} = \frac{(-50)-(-50)}{(35)-(90)} = \frac{0}{-55} = 0$ <

$y = \frac{\begin{vmatrix} -7 & 10 \\ 9 & -5 \end{vmatrix}}{\begin{vmatrix} -7 & 10 \\ 9 & -5 \end{vmatrix}} = \frac{(35)-(90)}{(35)-(90)} = \frac{-55}{-55} = +1$ <

Equation set is valid.

46. $\$10.10 = F + 12r$ <

$\$13.95 = F + 19r$ <

$$F = \frac{\begin{vmatrix} 10.10 & 12 \\ 13.95 & 19 \end{vmatrix}}{\begin{vmatrix} 1 & 12 \\ 1 & 19 \end{vmatrix}} = \frac{(191.90) - (167.40)}{(19) - (12)}$$

$F = \$3.50$ <

$$r = \frac{\begin{vmatrix} 1 & 10.10 \\ 1 & 13.95 \end{vmatrix}}{\begin{vmatrix} 1 & 12 \\ 1 & 19 \end{vmatrix}} = \frac{(13.95) - (10.10)}{(19) - (12)}$$

$r = \$0.55$/lb <

47. C = Cost of one 2 × 4

P = Cost of one 2 × 6

$350C + 200P = \$1077.50$ <

$140C + 125P = \$527.75$ <

$$C = \frac{\begin{vmatrix} 1077.50 & 200 \\ 527.75 & 125 \end{vmatrix}}{\begin{vmatrix} 350 & 200 \\ 140 & 125 \end{vmatrix}} = \frac{29{,}137.50}{15{,}750}$$

$C = \$1.85$ <

$$P = \frac{\begin{vmatrix} 350 & 1077.50 \\ 140 & 527.75 \end{vmatrix}}{15{,}750} = \frac{33{,}862.50}{15{,}750}$$

$P = \$2.15$ <

48. (1st column)

$$D = \begin{vmatrix} 2 & 3 & -2 \\ 1 & 1 & 1 \\ -1 & -3 & 2 \end{vmatrix} = 2[1(2) - 1(-3)] - 1[3(2) - (-2)(-3)] + (-1)[3(1) - (-2)(1)] = 5$$

(2nd row)

$$Dx = \begin{vmatrix} -7 & 3 & -2 \\ 2 & 1 & 1 \\ 5 & -3 & 2 \end{vmatrix} = -2[3(2) - (-2)(-3)] + 1[(-7)(2) - (-2)(5)] - 1[(-7)(-3) - (3)(5)]$$

$= -10$

(1st column)

$$Dy = \begin{vmatrix} 2 & -7 & -2 \\ 1 & 2 & 1 \\ -1 & 5 & 2 \end{vmatrix} = 2[2(2) - 1(5)] - 1[(-7)(2) - (-2)(5)] + (-1)[(-7)(1) - (-2)(2)] = 5$$

(1st column)

$$Dz = \begin{vmatrix} 2 & 3 & -7 \\ 1 & 1 & 2 \\ -1 & -3 & 5 \end{vmatrix} = 2[1(5) - 2(-3)] - 1[3(5) - (-7)(-3)] + (-1)[3(2) - (-7)(1)] = 15$$

Dividing Dx, Dy, & Dz by D, we have

$x = \frac{-10}{5} = -2, y = \frac{5}{5} = 1, z = \frac{15}{5} = 3$ <

49. $D = \begin{vmatrix} 1 & 3 & 2 \\ -2 & -2 & 3 \\ -1 & 1 & 1 \end{vmatrix} \begin{matrix} 1 & 3 \\ -2 & -3 \\ -1 & 1 \end{matrix}$ = +(1)(–2)(1) + (3)(3)(–1) + (2)(–2)(1) – (2)(–2)(–1)

–(1)(3)(1) – (3)(–2)(1) = –16

$$DP = \left|\begin{array}{ccc|cc} 2 & 3 & 2 & 2 & 3 \\ 1 & -2 & 3 & 1 & -2 \\ -1 & 1 & 1 & -1 & 1 \end{array}\right. = +(2)(-2)(1) + (3)(3)(-1) + (2)(1)(1) - (2)(-2)(-1)$$

$$-(2)(3)(1) - (3)(1)(1) = -24$$

$$DQ = \left|\begin{array}{ccc|cc} 1 & 2 & 2 & 1 & 2 \\ -2 & 1 & 3 & -2 & 1 \\ -1 & -1 & 1 & -1 & -1 \end{array}\right. = +(1)(1)(1) + (2)(3)(-1) + (2)(-2)(-1) - (2)(1)(-1)$$

$$-(1)(3)(-1) - (2)(-2)(1) = 8$$

$$DR = \left|\begin{array}{ccc|cc} 1 & 3 & 2 & 1 & 3 \\ -2 & -2 & 1 & -2 & -2 \\ -1 & 1 & -1 & -1 & 1 \end{array}\right. = +(1)(-2)(-1) + (3)(1)(-1) + (2)(-2)(1) - (2)(-2)(-1)$$

$$-(1)(1)(1) - (3)(-2)(-1) = -16$$

Dividing *DP*, *DQ*, & *DR* by *D*, we have $P = \frac{-24}{-16} = 1.5$,
$Q = \frac{8}{-16} = -0.5, R = \frac{-16}{-16} = 1$ <

50. $$D = \left|\begin{array}{ccc|cc} 0 & 1 & 2 & 0 & 1 \\ -2 & 2 & -1 & -2 & 2 \\ 3 & -1 & 1 & 3 & -1 \end{array}\right. = +(0)(2)(1) + (1)(-1)(3) + (2)(-2)(-1) - (2)(2)(3)$$

$$-(0)(-1)(-1) - (1)(-2)(1) = -9$$

$$Dx = \left|\begin{array}{ccc|cc} 1 & 1 & 2 & 1 & 1 \\ 3 & 2 & -1 & 3 & 2 \\ 2 & -1 & 1 & 2 & -1 \end{array}\right. = +(1)(2)(1) + (1)(-1)(2) + (2)(3)(-1) - (2)(2)(2)$$

$$-(1)(-1)(-1) - (1)(3)(1) = -18$$

$$Dy = \left|\begin{array}{ccc|cc} 0 & 1 & 2 & 0 & 1 \\ -2 & 3 & -1 & -2 & 3 \\ 3 & 2 & 1 & 3 & 2 \end{array}\right. = +(0)(3)(1) + (1)(-1)(3) + (2)(-2)(2) - (2)(3)(3)$$

$$-(0)(-1)(2) - (1)(-2)(1) = -27$$

$$Dz = \left|\begin{array}{ccc|cc} 0 & 1 & 1 & 0 & 1 \\ -2 & 2 & 3 & -2 & 2 \\ 3 & -1 & 2 & 3 & -1 \end{array}\right. = +(0)(2)(2) + (1)(3)(3) + (1)(-2)(-1) - (1)(2)(3)$$

$$-(0)(3)(-1) - (1)(-2)(2) = 9$$

Dividing *Dx*, *Dy*, & *Dz* by *D*, we have
$x = \frac{-18}{-9} = 2, y = \frac{-27}{-9} = 3, z = \frac{9}{-9} = -1$ <

51. $$D = \left|\begin{array}{ccc|cc} 2 & 3 & 2 & 2 & 3 \\ 2 & 1 & -4 & 2 & 1 \\ 1 & 2 & 1 & 1 & 2 \end{array}\right. = +(2)(1)(1) + (3)(-4)(1) + (2)(2)(2) - (2)(1)(1)$$

$$-(2)(-4)(2) - (3)(2)(1) = 6$$

$$DA = \left|\begin{matrix}3 & 3 & 2\\ 4 & 1 & -4\\ 2 & 2 & 1\end{matrix}\right|\begin{matrix}3 & 3\\ 4 & 1\\ 2 & 2\end{matrix} = +(3)(1)(1) + (3)(-4)(2) + (2)(4)(2) - (2)(1)(2)$$

$$-(3)(-4)(2) - (3)(4)(1) = 3$$

$$DB = \left|\begin{matrix}2 & 3 & 2\\ 2 & 4 & -4\\ 1 & 2 & 1\end{matrix}\right|\begin{matrix}2 & 3\\ 2 & 4\\ 1 & 2\end{matrix} = +(2)(4)(1) + (3)(-4)(1) + (2)(2)(2) - (2)(4)(1)$$

$$-(2)(-4)(2) - (3)(2)(1) = 6$$

$$DC = \left|\begin{matrix}2 & 3 & 3\\ 2 & 1 & 4\\ 1 & 2 & 2\end{matrix}\right|\begin{matrix}2 & 3\\ 2 & 1\\ 1 & 2\end{matrix} = +(2)(1)(2) + (3)(4)(1) + (3)(2)(2) - (3)(1)(1)$$

$$-(2)(4)(2) - (3)(2)(2) = -3$$

Dividing *DA*, *DB*, & *DC* by *D*, we have
$A = \frac{3}{6} = 0.5,\ B = \frac{6}{6} = 1,\ C = \frac{-3}{6} = -0.5$ <

52. *L* = Lightest casting weight
M = Middle casting weight
H = Heaviest casting weight

$L + M + H = 1867$ <
$H - L = 395$ <
$2L = M + H - 427$ <

Aligning equations:

$L + M + H = 1867$ <
$-L + H = 395$ <
$2L - M - H = -427$ <

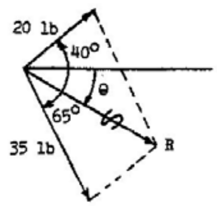
$$L = \frac{\begin{vmatrix}1867 & 1 & 1\\ 395 & 0 & 1\\ -427 & -1 & -1\end{vmatrix}}{\begin{vmatrix}1 & 1 & 1\\ -1 & 0 & 1\\ 2 & -1 & -1\end{vmatrix}} = \frac{1440}{3} = 480 \text{ lb}$$ <

$$M = \frac{\begin{vmatrix}1 & 1867 & 1\\ -1 & 395 & 1\\ 2 & -427 & -1\end{vmatrix}}{\begin{vmatrix}1 & 1 & 1\\ -1 & 0 & 1\\ 2 & -1 & -1\end{vmatrix}} = \frac{1536}{3} = 512 \text{ lb}$$ <

$$H = \frac{\begin{vmatrix}1 & 1 & 1867\\ -1 & 0 & 395\\ 2 & -1 & -427\end{vmatrix}}{\begin{vmatrix}1 & 1 & 1\\ -1 & 0 & 1\\ 2 & -1 & -1\end{vmatrix}} = \frac{2625}{3} = 875 \text{ lb}$$ <

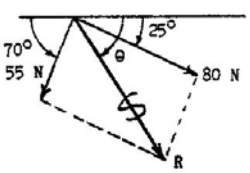
2 Resultant of Concurrent Forces in a Plane

1.



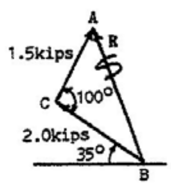
R = 36 lb @ –32° <

2.



R = 100 N @ –58° <

3. $R^2 = (2.0)^2 + (1.5)^2 - 2(2.0)(1.5) \cos 100°$
R = 2.70 kips



$(\sin B/1.5) = (\sin 100°/2.70)$

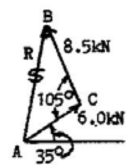
B = 33.2°
$\theta = 35 + B = 68.2°$

R = 2.70 kN @ 111.8° <

4. $R^2 = (6.0)^2 + (8.5)^2 - 2(6.0)(8.5) \cos 105°$
R = 11.60 kN

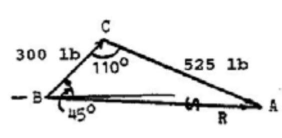
$(\sin A/8.5) = (\sin 105°/11.60)$ A = 45.1°
$\theta = 35° + A = 80.1°$

R = 11.60 kN @ 80.1° <



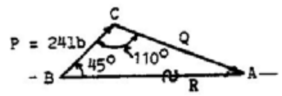
5. $R^2 = (300)^2 + (525)^2 - 2(300)(525) \cos 110°$
R = 688.0 lb

$(\sin B/525) = (\sin 110°/688.0)$
B = 45.81° $\theta = B - 45° = 0.81°$
R = 688 lb @ –0.81° <



6. $A = 180° - 45° - 110° = 25°$

$(R/\sin 110°) = (Q/\sin 45°) = (24/\sin 25°)$



$R = 53.4$ kN <

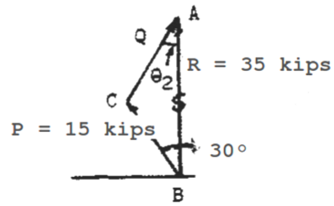
$Q = 40.2$ kN <

7. $Q^2 = (15)^2 + (35)^2 - 2(15)(35)\cos 30°$

$Q = 23.3$ kips <

$(\sin \theta_2)/15 = (\sin 30°)/23.3$

$\theta_2 = 18.8°$ <

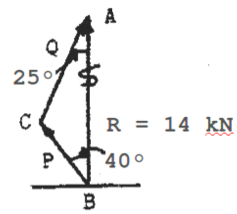


8. $C = 180° - 25° - 40° = 115°$

$Q/\sin 40° = P/\sin 25° = 14/\sin 115°$

$Q = 9.93$ kN <

$P = 6.53$ kN <



9. $(R')^2 = (800)^2 + (600)^2 - 2(800)(600)\cos 120°$

$R' = 1216.6$ N

$\frac{1216.6\text{ N}}{\sin 120°} = \frac{600\text{ N}}{\sin \theta} \rightarrow \theta = 25.3°$

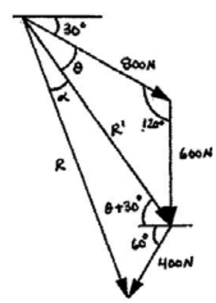
$(R)^2 = (1216.6)^2 + (400)^2 - 2(1216.6)(400)\cos(60° + 55.3°)$

$R = 1434$ N

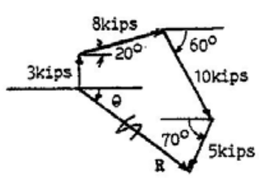
$\frac{1434\text{ N}}{\sin 115.3°} = \frac{400\text{ N}}{\sin \alpha} \rightarrow \alpha = 14.6°$

$R = 1434$ N @ $(30° + \theta + \alpha)$

$R = 1434$ N @ $-69.9°$ <

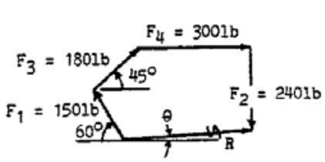


10.



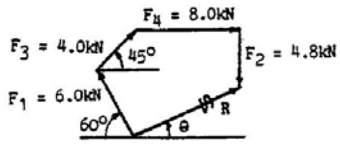
$R = 13$ kips @ $-35°$ <

11.



$R = 355$ lb @ $3°$ <

12.



R = 8.5 kN @ 22° <

13. Direction: right or up is +

$P_{||} = P \cos\theta$, $P_{\perp} = P \sin\theta$

(a) 35 kN @ 30°:
+ 30.3 kN, +17.5 kN <

(b) 35 kN @ 60°:
+ 17.5 kN, +30.3 kN <

14. Direction: right or up is +

$P_{||} = P \cos\theta$, $P_{\perp} = P \sin\theta$

(a) 2000 lb @ 45°:
+ 1414 lb, +1414 lb <

(b) 2000 lb @ 75°:
+ 518 lb, +1932 lb <

15. Direction: right or up is +

$F_x = F \cos\theta$, $F_y = F \sin\theta$

(a) –22.9 kN, ← –16.06 kN ↓ <

(b) +1449 lb, → +388 lb ↑ <

(c) –2.64 kips, ← +9.85 kips ↑ <

(d) –289 N, ← –345 N ↓ <

16. Direction: right or up is +

$F_{x'} = F \cos\theta', F_{y'} = F \sin\theta'$

(a) 28 kN @ 170°:
–27.6 kN, +4.86 kN <

(b) 1500 lb @ –30°:
+1299 lb, –750 lb <

(c) 10.2 kips @ 60°:
+5.10 kips, +8.83 kips <

(d) 450 N @ –135°:
–448 N, –39.2 N <

17. Perpendicular component:

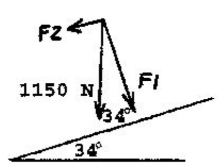
$\frac{F1}{1150\ \text{N}} = \cos 34° = 0.8290$

$F1$ = 953.4 N <

Parallel component:

$\frac{F2}{1150\ \text{N}} = \sin 34° = 0.5592$

$F2$ = 643.1 N <



18. $\tan \alpha = \frac{14 \text{ in.}}{26 \text{ in.}} = 0.53846$

$\alpha = 28.3°$

$\tan \beta = \frac{(14 \text{ in.} + 38 \text{ in.})}{26 \text{ in.}} = 2.0000$

$\beta = 63.4°$

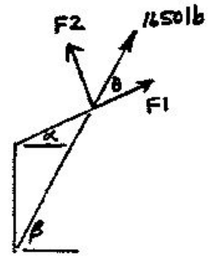
$\theta = \beta - \alpha = 35.1°$

Parallel component:

$F1 = 1650 \text{ lb} \times \cos 35.1° = 1350 \text{ lb}$ <

Perpendicular component:

$F2 = 1650 \text{ lb} \times \sin 35.1° = 948.8 \text{ lb}$ <



19. $R_x = \sum F_x = 3.4 \cos 130° + 4.8 \cos 243°$

$R_x = -4.365$ kips

$R_y = \sum F_y = 3.4 \sin 130° + 4.8 \sin 243°$

$R_y = -1.672$ kips

$R^2 = (-4.365)^2 + (-1.672)^2$

$R = 4.67$ kip <

$\tan \theta = \frac{-1.672}{-4.365} = 0.38305$

$\theta = 20.96° \sim 21.0°$ in 3rd quadrant

or $\theta = 201°$ <

20. $R_x = \sum F_x$

$R_x = 12.5 \cos 30° + 11.5 \cos 105° = 7.85$ kN

$R_y = \sum F_y = 12.5 \sin 30° + 11.5 \sin 105° = 17.36$ kN

$R^2 = (7.85)^2 + (17.36)^2 = 362.9$

$R = 19.05$ kN <

$\theta = \arctan (17.36/7.85)$

$\theta = +65.7°$ <

21. $\sum F_x = 2.15 \cos 115°$

$R_x = -0.909$ kN

$\sum F_y = 2.15 \sin 115° + 3.46 \sin (-90°)$

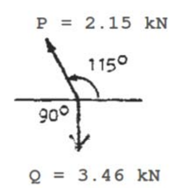
$R_y = -1.511$ kN

$R^2 = (-0.909)^2 + (-1.511)^2$

$R = 1.76$ kN <

$\theta_1 = \arctan (-1.511/-0.909) = 59.0°$

$\theta = -180° + 59° = -121°$ <



22. $\sum F_x = -4.73 - 3.81(3/\sqrt{13})$

$R_x = -7.900$ kips

$\sum F_y = 3.81(2/\sqrt{13}) - 3.65$

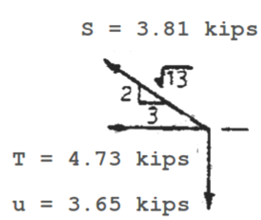
$R_y = -1.537$ kips

$R^2 = (-7.900)^2 + (-1.537)^2$

$R = 8.05$ kips <

$\theta_1 = \arctan (-1.537/-7.900) = 11.0°$

$\theta = -180° + 11.0° = -169°$ <



23. $R_x = \sum F_x = 0$

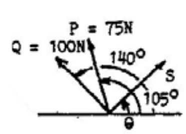
$\sum F_x = S_x + 100 \cos 105° + 75 \cos 140° = 0$

$S_x = 83.3$ N

$R_y = \sum F_y = 500$

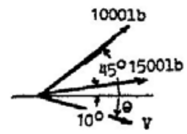
$\sum F_y = S_y + 100 \sin 105° + 75 \sin 140° = 500$, $S_y = 355.2$ N

$S^2 = (83.3)^2 + (355.2)^2$; $S = 365$ N <



$\theta = \arctan(355.2/83.3) = +76.8°$ <

24. $R_x = \sum F_x = 4800$



$\sum F_x = V_x + 1500 \cos 10° + 1000 \cos 45°$
$V_x = 2616$ lb
$R_y = \sum F_y = 0$
$\sum F_y = 1000 \sin 45° + 1500 \sin 10° + V_y = 0$
$V_y = -967.6$ lb
$V^2 = (2616)^2 + (967.6)^2$
$V = 2790$ lb <
$\theta = \arctan(-967.6/2616) = -20.3°$ <

25. Solve Prob. 2.1 by components.
$R_x = \sum F_x = 20 \cos 40° + 35 \cos -65° = 30.1$ lb
$R_y = \sum F_y = 20 \sin 40° + 35 \sin -65° = -18.87$ lb
$R^2 = (30.1)^2 + (18.87)^2$
$R = 35.5$ lb <
$\theta = \arctan(-18.87/30.1) = -32.1°$ <

26. Solve Prob. 2.2 by components.
$R_x = \sum F_x = 80 \cos -25° + 55 \cos -110° = 53.7$ N
$R_y = \sum F_y = 80 \sin -25° + 55 \sin -110° = -85.5$ N
$R^2 = (53.7)^2 + (85.5)^2$
$R = 101.0$ N <
$\theta = \arctan(-85.5/53.7) = -57.9°$ <

27. Solve Prob. 2.3 by components.
$R_x = \sum F_x = 1.5 \cos 65° + 2.0 \cos 145° = -1.004$ kips
$R_y = \sum F_y = 1.5 \sin 65° + 2.0 \sin 145° = 2.51$ kips
$R^2 = (1.004)^2 + (2.70)^2$
$R = 2.70$ kips <
$\theta_1 = \arctan(2.51/-1.004) = -68.2°$
$\theta = 180° - 68.2° = +111.8°$ <

28. Solve Prob. 2.4 by components.
$R_x = \sum F_x = 6.0 \cos 35° + 8.5 \cos 110° = 2.01$ kN
$R_y = \sum F_y = 6.0 \sin 35° + 8.5 \sin 110° = 11.43$ kN
$R^2 = (2.01)^2 + (11.43)^2$
$R = 11.61$ kN <
$\theta = \arctan(11.43/2.01) = +80.0°$ <

29. Solve Prob. 2.9 by components.
$R_x = \sum F_x = 30 \cos 135° + 25 \cos -160° + 20 \cos -120° = -54.7$ kN
$R_y = \sum F_y = 20 + 30 \sin 135° + 25 \sin -160° + 20 \sin -120° = 15.34$ kN
$R^2 = (54.7)^2 + (15.34)^2$
$R = 56.8$ kN <
$\theta_1 = \arctan(15.34/-54.7) = -15.7°$
$\theta = 180° - 15.7° = 164.3°$ <

30. Solve Prob. 2.10 by components.
$R_x = \sum F_x = 8 \cos 20° + 10 \cos -60° + 5 \cos 110° = 10.81$ kips
$R_y = \sum F_y = 3 + 8 \sin 20° + 10 \sin -60° + 5 \sin -110° = -7.62$ kips
$R^2 = (10.81)^2 + (7.62)^2$

$R = 13.23$ kips <
$\theta = \arctan(-7.62/10.81) = -35.2°$ <

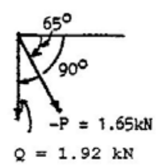
31. Solve Prob. 2.11 by components.
$R_x = \sum F_x = 300 + 180\cos 45° + 150\cos 120° = 352$ lb
$R_y = \sum F_y = 180\sin 45° + 150\sin 120° + 240\sin -90° = 17.18$ lb
$R^2 = (352)^2 + (17.18)^2$
$R = 352$ lb <
$\theta = \arctan(17.18/352) = +2.79°$ <

32. Solve Prob. 2.12 by components.
$R_x = \sum F_x = 8.0 + 4.0\cos 45° + 6.0\cos 120° = 7.83$ kips
$R_y = \sum F_y = 4.0\sin 45° + 6.0\sin 120° + 4.8\sin -90° = 3.22$ kips
$R^2 = (7.83)^2 + (3.22)^2$
$R = 8.47$ kips <
$\theta = \arctan(3.22/7.83) = +22.4°$ <

33. Find $F_1 - F_2$ Prob. 2.19 by comp.
$R_x = \sum F_x = 3.0\cos 65° + 2.5\cos 140° = -0.647$ kips
$R_y = \sum F_y = 3.0\sin 65° + 2.5\sin 140° = 4.33$ kips
$R^2 = (0.647)^2 + (4.33)^2$
$R = 4.37$ kips
$\theta_1 = \arctan(4.33/-0.647) = -81.6°$ <
$\theta = 180° - 81.6° = +98.4°$ <

34. Find $P - Q$ Prob. 2.20 by comp.
$R_x = \sum F_x = 11.5\cos 105° + 12.5\cos -150° = -13.80$ kN
$R_y = \sum F_y = 11.5\sin 105° + 12.5\sin -150° = 4.86$ kN
$R^2 = (13.80)^2 + (4.86)^2$
$R = 14.63$ kN <
$\theta_1 = \arctan(4.86/-13.80) = -19.4°$
$\theta = 180° - 19.4° = +160.6°$ <

35. $\sum F_x = 1.65\cos -65° + 1.92\cos -90° = 0.697$ kN
$\sum F_y = 1.65\sin -65° + 1.92\sin -90° = -3.415$ kN
$Q = 1.92$ kN
$R^2 = (0.697)^2 + (3.415)^2$; $R = 3.49$ kN <
$\theta = \arctan(-3.415/0.697) = -78.5°$ <



36. $\sum F_x = 4.5\cos 180° + 3.6(-3/13) = -7.50$ kips
$\sum F_y = 3.5\sin 90° + 3.6(2/13) = 5.50$ kips
$R^2 = (7.50)^2 + (5.50)^2$; $R = 9.30$ kips <
$\theta_1 = \arctan(5.50/-7.50) = -36.3°$
$\theta = 180° - 36.3° = 143.7°$ <