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

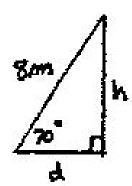
14. $400\ \text{MN/m}^2 = 400 \times 10^6\ \text{N/m}^2$
$400 \times 10^6\ \text{N/m}^2(1\ \text{lb}/4.448\ \text{N}) \times (1\ \text{m}/39.37\ \text{in.})^2 = 58.0 \times 10^3\ \text{lb/in.}^2$ (psi) <
$= 58.0\ \text{kips/in.}^2$ (ksi) <
$70 \times 10^6\ \text{N/m}^2(1\ \text{lb}/4.448\ \text{N}) \times (1\ \text{m}/39.37\ \text{in.})^2 =$
$10.15 \times 10^3\ \text{lb/in.}^2$ (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) $\dfrac{d}{8\ \text{m}} = \cos 70° = 0.3420$
$d = 8\ \text{m} \times 0.3420 = 2.74$ m <
(b) $\dfrac{h}{8\ \text{m}} = \sin 70° = 0.9397$
$h = 8\ \text{m} \times 0.9397 = 7.52$ m <

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

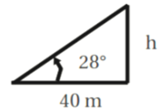


17. $\theta_1 = 45°$, $\theta_2 = 35°$, $d = 300$ mm
Eliminating b from the two Eq. (a) of Prob. 1.16, we have
$(c + d)/\tan\theta_1 = d/\tan\theta_2$
$c = d(\tan\theta_1 - \tan\theta_2)/\tan\theta_2 = 300(\tan 45° - \tan 35°)/\tan 35°$
$c = 128.4$ m <

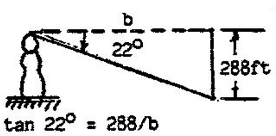
From Eq. (a), we have
$b = (c + d)/\tan\theta_1$
$= (128.4 + 300)/\tan 45° = 428$ m <

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 <

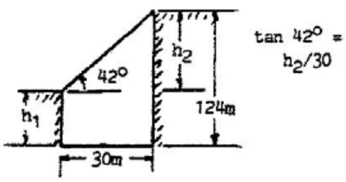


20.



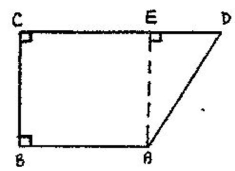
tan 22° = 288/b
b = 288/tan 22° = 712.8 = 713 ft <

21.



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

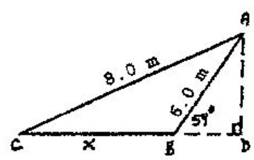
22. Distance AE = BC = 200 ft
Distance ED = 340 ft – 225 ft = 115 ft
Then for triangle AED:
$(AD)^2 = (200 \text{ ft})^2 + (115 \text{ ft})^2$
AD = Road frontage = 230.7 ft <



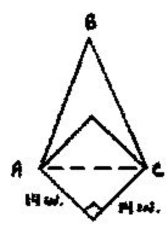
23. In triangle ABD:
$\frac{AD}{6.0 \text{ m}}$ = sin 54° or AD = 4.854 m

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

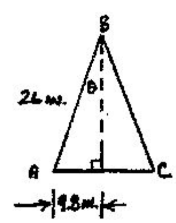
In triangle ACD:
$(CD)^2 + (4.854 \text{ m})^2 = (8.0 \text{ m})^2$
CD = 6.359 m
Then: $x = BC = CD - BD$
x = 6.539 m – 3.527 m
x = 2.832 m <



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

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

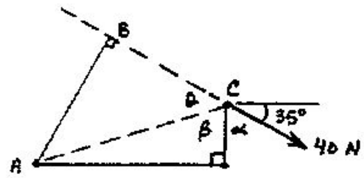
$\alpha = 90° - 35° = 55°$

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

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: θ = 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

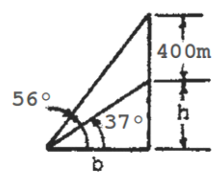
Total lineal feet:

(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., $B = 40°$, $C = 30°$

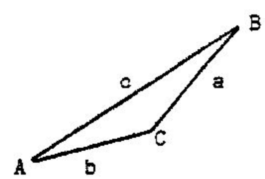
$A = 180° - B - C = 110°$

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

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

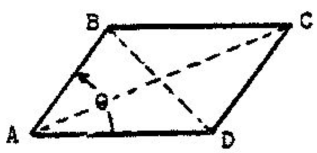
$\cos C = -0.2857$; $C = 106.6°$ <

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

$\cos A = 0.9048$; $A = 25.2°$ <

$B = 180° - A - C$; $B = 48.2°$ <

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

$\sin A/8 = \sin 40°/5.26$

$\sin A = 0.9768$

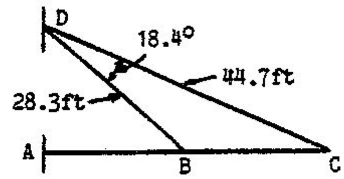
$A = 180° - 77.6° = 102.4°$

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

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

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

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

$\sin\angle DBC = 0.7068$

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

$\angle DBA = 180° - 135.0° = 45°$ <

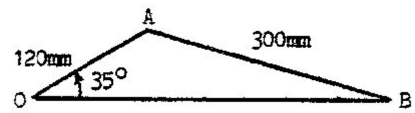
$AD = AB \tan\angle ABD = AC \tan \angle BCD$

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

$AB = 20.02$ 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 $B = 13.26°$

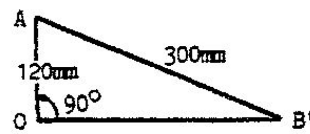
Angle $A = 180° - 13.26° - 35°$

$= 131.7°$

$OB = 300 \sin A/\sin 35°$

$= 300 \sin 131.7°/\sin 35°$

$OB = 390$ mm <

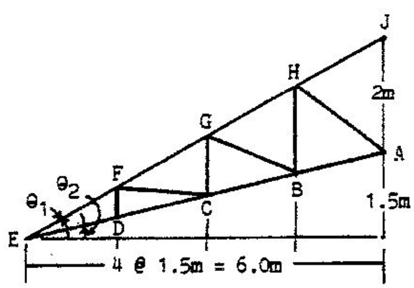


$(120)^2 + (OB')^2 = (300)^2$

$OB' = 275$ 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)

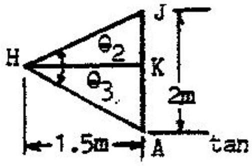
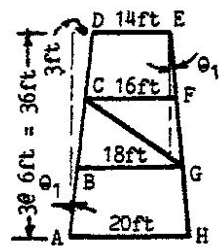


Fig. (2)

$JK = 1.5 \tan \theta_2 = 0.875$ m
$KA = 2 - JK = 1.125$ m
$\tan \theta_3 = 1.125/1.5$
$\theta_3 = 36.87°$
$\angle AHJ = \theta_1 + \theta_2 = 67.1°$ <

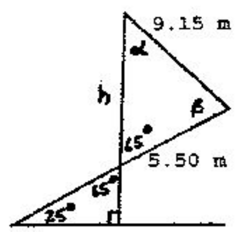
34. From the Fig.



$\tan \theta_1 = 3/36$
$\theta_1 = 4.76°$
$\angle BAH = 90° - \theta_1 = 85.2°$ <
$(AD)^2 = (3)^2 + (36)^2$
$AD = 36.12$
$BC = AD/3 = 12.04$ 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

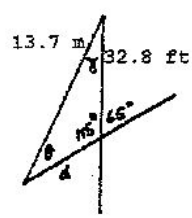
From the figure of the tower and the law of sines
$$\frac{\sin \angle BCG}{18} = \frac{\sin 85.2°}{20.81}$$
$\sin\angle BCG = 0.8615$
$\angle BCG = 59.5°$ <
$\angle DEF = 90 + \theta_1 = 94.8°$ <

35. (a) Law of sines:



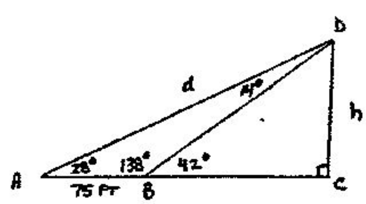
$$\frac{9.15 \text{ m}}{\sin 65°} = \frac{5.50 \text{ m}}{\sin \alpha}$$
$\alpha = 33.0°$
$\beta = 180° - 65° - \alpha = 82.0°$
So $\frac{9.15 \text{ m}}{\sin 65°} = \frac{h}{\sin 82.0°}$
$h = 10.0$ m <

(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:

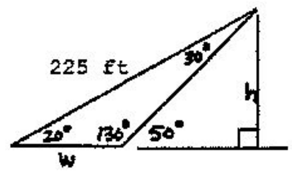


$$\frac{d}{\sin 138°} = \frac{75 \text{ ft}}{\sin 14°}$$
$d = 207.4$ ft
In right triangle *ACD*:
$$\frac{h}{207.4 \text{ ft}} = \sin 28° = 0.4695$$
$h = 97.4$ ft, tree will hit house <

37. (a) Law of sines:

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

W = 146.9 ft <



(b) h = (225 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

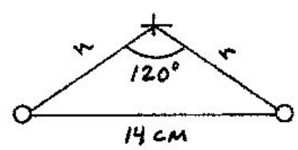
B = 32.8° <

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

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

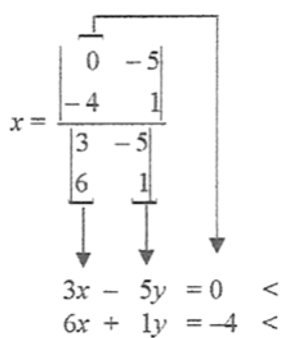
$DB = \begin{vmatrix} 2 & 3 \\ 1 & -0.9 \end{vmatrix} = (2)(-0.9) - (1)(3) = -4.8$

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

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

$$DP = \begin{vmatrix} 2 & 3 & 2 \\ 1 & -2 & 3 \\ -1 & 1 & 1 \end{vmatrix} \begin{matrix} 2 & 3 \\ 1 & -2 \\ -1 & 1 \end{matrix} = +(2)(-2)(1) + (3)(3)(-1) + (2)(1)(1) - (2)(-2)(-1)$$

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

$$DQ = \begin{vmatrix} 1 & 2 & 2 \\ -2 & 1 & 3 \\ -1 & -1 & 1 \end{vmatrix} \begin{matrix} 1 & 2 \\ -2 & 1 \\ -1 & -1 \end{matrix} = +(1)(1)(1) + (2)(3)(-1) + (2)(-2)(-1) - (2)(1)(-1)$$

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

$$DR = \begin{vmatrix} 1 & 3 & 2 \\ -2 & -2 & 1 \\ -1 & 1 & -1 \end{vmatrix} \begin{matrix} 1 & 3 \\ -2 & -2 \\ -1 & 1 \end{matrix} = +(1)(-2)(-1) + (3)(1)(-1) + (2)(-2)(1) - (2)(-2)(-1)$$

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

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. $$D = \begin{vmatrix} 0 & 1 & 2 \\ -2 & 2 & -1 \\ 3 & -1 & 1 \end{vmatrix} \begin{matrix} 0 & 1 \\ -2 & 2 \\ 3 & -1 \end{matrix} = +(0)(2)(1) + (1)(-1)(3) + (2)(-2)(-1) - (2)(2)(3)$$

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

$$Dx = \begin{vmatrix} 1 & 1 & 2 \\ 3 & 2 & -1 \\ 2 & -1 & 1 \end{vmatrix} \begin{matrix} 1 & 1 \\ 3 & 2 \\ 2 & -1 \end{matrix} = +(1)(2)(1) + (1)(-1)(2) + (2)(3)(-1) - (2)(2)(2)$$

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

$$Dy = \begin{vmatrix} 0 & 1 & 2 \\ -2 & 3 & -1 \\ 3 & 2 & 1 \end{vmatrix} \begin{matrix} 0 & 1 \\ -2 & 3 \\ 3 & 2 \end{matrix} = +(0)(3)(1) + (1)(-1)(3) + (2)(-2)(2) - (2)(3)(3)$$

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

$$Dz = \begin{vmatrix} 0 & 1 & 1 \\ -2 & 2 & 3 \\ 3 & -1 & 2 \end{vmatrix} \begin{matrix} 0 & 1 \\ -2 & 2 \\ 3 & -1 \end{matrix} = +(0)(2)(2) + (1)(3)(3) + (1)(-2)(-1) - (1)(2)(3)$$

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

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

51. $$D = \begin{vmatrix} 2 & 3 & 2 \\ 2 & 1 & -4 \\ 1 & 2 & 1 \end{vmatrix} \begin{matrix} 2 & 3 \\ 2 & 1 \\ 1 & 2 \end{matrix} = +(2)(1)(1) + (3)(-4)(1) + (2)(2)(2) - (2)(1)(1)$$

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

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

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

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

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

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

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

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:

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

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

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

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