Online Instructor's Solutions Manual
to accompany

Applied Mechanics for Engineering Technology

Keith M. Walker
Affiliation

PEARSON
Prentice Hall

Upper Saddle River, New Jersey
Columbus, Ohio

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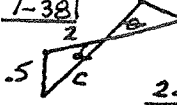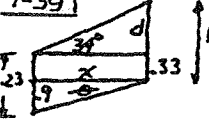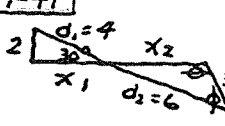
1-1	$24 + 8x - 12x = 8x$
	$8x - 12x - 8x = -24$
	$x = 2$
1-2	$12 + 6x + 3 = 27$
	$6x = 27 - 12 - 3$
	$x = 2$
1-3	$28 = \frac{3}{4}x + \frac{5}{12}x$
	$= \frac{9}{12}x + \frac{5}{12}x$
	$= \frac{14}{12}x$
	$\frac{28 \times 12}{14} = x$
	$x = 24$
1-4	① $\times 5$ $10x + 40y = 100$
	② $x - 2$ $-10x + 6y = -20$
	$46y = 80$
	$y = 1.74$
1-5	① $\times 8$ $176x + 24y = 968$
	② $\times 3$ $39x - 24y = 168$
	$215x + 0 = 1136$
	$x = 5.28$
1-6	$x = \frac{+2 \pm \sqrt{4 - (4)(13)(-8)}}{(2)(13)}$
	$= \frac{+2 \pm 20.5}{26}$
	$= 0.865 \text{ or } -0.712$
1-7	$(3x)x + \frac{5}{x}(x) = 8(x)$
	$3x^2 - 8x + 5 = 0$
	$x = \frac{-(-8) \pm \sqrt{(-8)^2 - (4)(3)(5)}}{6}$
	$x = \frac{+8 \pm \sqrt{64 - 60}}{6}$
	$x = 1.67 \text{ or } 1$
1-8	$a = 35°$ opposite angle
	$b = 180 - 35 - 90 = 55°$
	$c = 180 - 55 = 125°$
1-9	$a = 80°$ opposite angle
	$b = 180 - 80 = 100°$
	$c = 100°$ opposite angle
1-10	$a = 90 - 40 = 50°$
	$b = 15°$ opposite angle
	$c = 180 - 50 - 15 = 115°$
	$d = 180 - 115 = 65°$
	$e = 65°$ opposite angle
1-11	$\frac{21}{7} = \frac{ED}{5}$ $ED = \frac{21}{7} \times 5 = 15 \text{ in.}$
1-12	$\frac{CE}{8} = \frac{12.5}{5}$ $CE = \frac{12.5 \times 8}{5} = 20 \text{ m}$
1-13	$A = 20 \sin 38° = 12.3 \text{ m}$
1-14	$\cos \theta = \frac{4}{10}$ $\theta = 66.4°$
1-15	$\tan \theta = \frac{6}{A}$ $A = 16.5 \text{ ft}$
1-16	$\tan 70° = \frac{y}{4}$ $y = 11 \text{ m}$

1-17	$R = 5 \text{ in}$ $\theta = 36.9°$
	$R = 13 \text{ in}$ $\theta = 67.4°$
	$R = 17$ $\theta = 28.1°$
1-18	$\tan 20 = \frac{A}{6}$ $A = 2.18 \text{ in}$
	$\tan 40 = \frac{A}{4}$ $A = 3.36 \text{ ft}$
	$\tan 55 = \frac{20}{A}$ $A = 14 \text{ in.}$
1-19	$\sin \theta = \frac{25}{40}$ $\theta = 38.7°$
1-20	$\tan 65 = \frac{y}{4}$ $y = 8.58 \text{ mm}$
1-21	$\sin \theta = \frac{33}{72}$ $\theta = 27.3°$
1-22	$c^2 = 15^2 + 42^2 - 2(15)(42)\cos 120$
	$c = 51.2 \text{ cm}$
1-23	$c^2 = 15^2 + 25^2 - 2(15)(25)\cos 65$
	$c = 23.1 \text{ ft}$
1-24	$(5.5)^2 = 3^2 + 4^2 - 2(3)(4)\cos \theta$
	$\theta = 77.36° (2^{nd} \text{ quadrant})$
	or $\theta = 102.6°$
1-25	$(CB)^2 = 55^2 + 90^2 - 2(55)(90)\cos 25$
	$CB = 46.2 \text{ in.}$
1-26	$d^2 = 6^2 + 8^2 - 2(6)(8)\cos 130$
	$d = 12.7 \text{ m}$
1-27	$(CD)^2 = (.25)^2 + (.4)^2 - 2(.25)(4)\cos 16°$
	$CD = 0.174 \text{ m}$
1-28	$\frac{A}{\sin 120} = \frac{50}{\sin 20}$ $A = 127 \text{ in.}$
1-29	$\frac{AC}{\sin 73} = \frac{640}{\sin 42}$ $AC = 913 \text{ ft}$
	$\frac{AD}{\sin 65} = \frac{640}{\sin 42}$ $AD = 865 \text{ ft}$
1-30	$\frac{d}{\sin 40} = \frac{14}{\sin 105}$ $d = 9.32 \text{ m}$
1-31	$\cos \theta = \frac{14}{48}$ $\theta = 73°$
1-32	$\frac{6}{\sin 70} = \frac{x}{\sin 40}$
	$x = 4.1 \text{ ft}$
1-33	$\tan \theta = \frac{1}{10}$ $\theta = 5.7°$
	included angle $= 11.4°$
1-34	$\cos 50 = \frac{y}{10}$ $y = 6.43 \text{ in.}$
	$h = 10 - 6.43 = 3.57 \text{ in.}$
1-35	$x = 3.3 \cos 55 = 1.9 \text{ in.}$
	$y = 3.3 \sin 55 = 2.7 \text{ in.}$
1-36	Corner Width $= 1.875 / \cos 30 = 2.17 \text{ in.}$

1

1-37
$$d^2 = (3.75)^2 + (3.75)^2 - 2(3.75)^2 \cos 120$$
$$d = 6.49 \text{ cm}$$
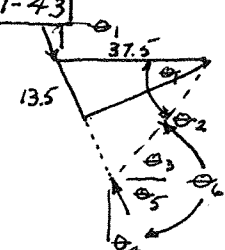
1-38
$$c^2 = .5^2 + 2^2 - 2(.5)(2) \cos 105$$
$$c = 2.18 \text{ m}$$
$$\frac{2.18}{\sin 105} = \frac{.5}{\sin d} \qquad d = 12.8° \qquad \therefore \theta = 12.8°$$

1-39
$$x^2 = 20^2 - .9^2$$
$$x = 19.979$$
$$\tan 34° = \frac{d}{19.979}$$
$$d = 13.476$$
$$h = 13.476 + .33 = 13.867 \text{ m}$$

1-40
① $(BD)^2 = 3^2 + 2^2 - 2(3)(2) \cos 120$
$$BD = 4.36 \text{ m}$$
② $(BD)^2 = 3^2 + 2^2 - 2(3)(2) \cos 50$
$$BD = 2.29$$
A drops $4.36 - 2.29 = 2.07 \text{ m}$

1-41
$$x_1 = \frac{2}{\tan 30} = 3.47 \qquad d_1 = \frac{2}{\sin 30} = 4$$
$$\frac{6}{\sin \theta} = \frac{3.25}{\sin 30} \qquad \therefore \theta = 112.7°$$
$$\phi = 37.3°$$
$$\frac{x_2}{\sin 37.3} = \frac{3.25}{\sin 30} \qquad x_2 = 3.94$$
$$\text{horiz. dist.} = 3.47 + 3.94 = 7.41 \text{ m.}$$

1-42
$$\frac{6}{\sin 105} = \frac{2.5}{\sin \theta} \qquad \theta = 23.7°$$
$$\phi = 180 - 23.7 - 105 = 51.3°$$
$$\frac{d}{\sin 51.3} = \frac{6}{\sin 105} \qquad d = 4.85 \text{ m}$$
$$x = 2.5 \sin 51.3 = 1.95 \text{ m}$$

1-43
$$\sin \theta = \frac{13.5}{37.5}$$
$$\theta_1 = 21.1°$$
$$\therefore \theta_2 = 42.2°$$
$$\theta_3 = 42.2°$$
$$\theta_4 = 21.1°$$
$$\theta_5 = 90 - 21.1 = 68.9°$$
$$\theta_6 = 68.9 + 42.2 = 111.1°$$

R1-1
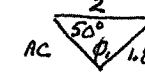$$x = 15 \cos 25 = 13.6 \text{ m}$$
$$y = 15 \sin 25 = 6.34 \text{ m}$$

R1-2
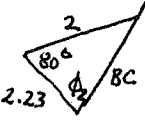$$\cos 18 = \frac{4.5}{B} \qquad B = 4.73 \text{ m}$$
$$\tan 18 = \frac{A}{4.5} \qquad A = 1.46 \text{ m}$$

R1-3
$$9^2 = 6^2 + 5^2 - 2(6)(5) \cos \theta$$
$$\theta = 70.5$$
$$\text{or } \theta = 109.5° \ (2^{nd} \text{ quadrant})$$

R1-4
$$\frac{3.5}{\sin \phi} = \frac{2.8}{\sin 40} \qquad \phi = 53.5°$$
$$\theta = 180 - 40 - 53.5 = 86.5°$$

R1-5
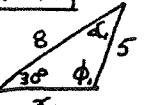$$(160)^2 = (120)^2 + (85)^2 - 2(120)(85) \cos \theta$$
$$\theta = 101°$$

R1-6
$$\frac{5}{\sin 40} = \frac{3}{\sin \theta} \qquad \theta = 22.69°$$
$$\phi = 180 - 22.69 - 40 = 117.3°$$
$$\frac{R}{\sin 117.3} = \frac{5}{\sin 40} \qquad R = 6.91 \text{ m}$$
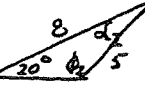
R1-7
original triangle ABC
$$\frac{2}{\sin \phi_1} = \frac{1.8}{\sin 50} \qquad \phi_1 = 58.3°$$
$$180 - 50 - 58.3 = 71.7°$$
$$\frac{AC}{\sin 71.7} = \frac{1.8}{\sin 50} \qquad AC = 2.23$$
final triangle ABC
$$(BC)^2 = 2^2 + 2.23^2 - 2 \times 2.23 \cos 80°$$
$$BC = 2.72$$
$$\frac{2}{\sin \phi_2} = \frac{2.72}{\sin 80} \qquad \phi_2 = 46.4°$$
$$\theta = 71.7 - 46.4 = 25.3°$$

R1-8
$$(AC)^2 = .5^2 + .2^2 - 2(.2)(.5) \cos 6°$$
$$AC = 0.302$$
$$\frac{.302}{\sin 6°} = \frac{.5}{\sin \theta} \qquad \theta = 170°$$
$$\phi = 360 - 170 - 80 - 70 = 40°$$
$$(CB')^2 = (.2)^2 + (.302)^2 - 2(.2)(.302) \cos 40$$
$$CB' = 0.197 \text{ m}$$

R1-9
$$(AB)^2 = (20)^2 + (60)^2 - 2(20)(60) \cos 115$$
$$AB = 70.81$$
$$\frac{20}{\sin \phi} = \frac{70.81}{\sin 115} \qquad \phi = 14.8°$$

R1-10
$$\frac{8}{\sin \phi_1} = \frac{5}{\sin 30} \qquad \phi_1 = 126.87°$$
$$\therefore d_1 = 23.13°$$
$$\frac{x_1}{\sin 23.13} = \frac{5}{\sin 30} \qquad x_1 = 3.928$$
$$\frac{8}{\sin \phi_2} = \frac{5}{\sin 20} \qquad \phi_2 = 146.82°$$
$$\therefore d_2 = 13.18°$$
$$\frac{x_2}{\sin 13.18} = \frac{5}{\sin 20} \qquad x_2 = 3.333$$
$$\text{horiz. dist. of C} = 3.928 - 3.333 = 0.595 \text{ m}$$
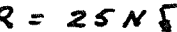
R1-11
$$(40)^2 = (35)^2 + (45)^2 - 2(35)(45) \cos \theta$$
$$\theta = 58.4°$$

R1-12	

$AC^2 = 4^2 + 5^2 - 2 \times 4 \times 5 \cos 143.1$

$AC = 8.54$

$h = 5 \sin 36.9 = 3$

$\cos \theta = \frac{3}{4} \quad \theta = 60°$

$(AC')^2 = 4^2 + 5^2 - 2 \times 4 \times 5 \cos 60$

$AC' = 4.58$

$\Delta AC = 3.96 \text{ in}$

2-1 $\quad R = 42.7 \text{ lb} \quad \angle \frac{8}{3}$

2-2 $\quad 60.2 \text{ lb} \quad 126 \text{ lb } 71.6 \quad 1060 \text{ lb } 32.6$

2-3 $\quad R = 80.8 \text{ lb } 21.8 \quad R = 5391 \text{ lb } 68.2$
$R = 7210 \text{ lb } 33.7$

2-4 $\quad R = 15.2 \text{ kN} \quad 23.2°$
$R = 10.2 \text{ MN } 78.7$
$R = 25 \text{ N } 36.9$

2-5 $\quad R = 632 \text{ N} \quad 3$

2-6 $\quad R = 17 \text{ lb} \quad \frac{15}{8}$
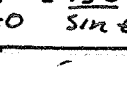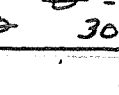
2-7 $\quad \tan \theta = \frac{250}{1500} \quad \theta = 9.5°$
$\therefore R = 1.5 \text{ kN } 29.5°$

2-8 $\quad R = \sqrt{(1.5)^2 + 4^2} = 4.27$
$\tan \theta = \frac{4}{1.5} \quad \theta = 69.4°$
$69.4 + 12 = 81.4°$
$R = 4.27 \text{ kN } 81.4°$

2-9 $\quad R = \sqrt{30^2 + 20^2} \quad \tan^{-1} \frac{30}{20} = 56.3°$
$= 36.1 \text{ lb } 76.3°$
$56.3 + 20 = 76.3°$

2-10 $\quad R^2 = 120^2 + 250^2 - 2(120)(250) \cos 122$
$R = 300 \text{ N } 80$
$\frac{330}{\sin 122} = \frac{250}{\sin \theta} \quad \theta = 40°$
$40 + 40 = 80°$

2-11 $\quad R^2 = 30^2 + 40^2 - 2(30)(40) \cos 130$
$R = 63.6 \text{ kN } 38.8°$
$\frac{\sin \phi}{40} = \frac{\sin 50}{63.5} \quad \phi = 28.8°$

2-12 $\quad R^2 = 20^2 + 15^2 - 2(20)(15) \cos 100$
$R = 27 \text{ lb } 61.8°$
$\frac{27}{\sin 100} = \frac{20}{\sin \theta} \quad \theta = 46.8°$
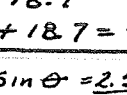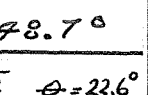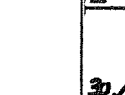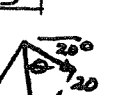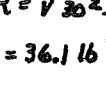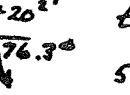$46.8 + 15 = 61.8°$

2-13 $\quad R^2 = (6.5)^2 + (8)^2 - 2(6.5)(8) \cos 151.6°$
$R^2 = 197.7$
$R = 14.1 \text{ kN } 39.5°$
$\frac{6.5}{\sin \phi} = \frac{14.1}{\sin 151.6} \quad \phi = 12.7°$
$21.8 + 12.7 = 34.5°$

2-14 $\quad R^2 = 400^2 + 150^2 - 2(400)(150) \cos 40$
$R = 301 \text{ lb } 48.7$
$\frac{301}{\sin 40} = \frac{150}{\sin \theta} \quad \theta = 18.7°$
$30 + 18.7 = 48.7°$

2-15
$\sin \theta = \frac{2.5}{6.5} \quad \theta = 22.6°$

100 lb $22.6°$
R 134.8
100 lb $22.6°$

$\frac{R}{\sin 134.8} = \frac{100}{\sin 22.6}$
$R = 185 \text{ lb}$

$\frac{R}{\sin 157.4} = \frac{100}{\sin 11.3}$
$R = 196 \text{ lb } 11.3$

2-16
$\tan \theta = \frac{3}{4} \quad \theta = 36.9°$
$180 - 55 - 36.9 = 88.1°$
$R = 5 \text{ kips } 88.1°$

2-17
$P_x = 25 \sin 20 = 8.55 \text{ lb} \leftarrow$
$P_y = 25 \cos 20 = 23.5 \text{ lb} \downarrow$
$P_x = 2 \cos 50 = 1.29 \text{ kips} \rightarrow$
$P_y = 2 \sin 50 = 1.53 \text{ kips} \uparrow$
$P_x = 20 \cos 30 = 17.3 \text{ lb} \leftarrow$
$P_y = 20 \sin 30 = 10 \text{ lb} \uparrow$

2-18
$F_x = \frac{8}{17} \times 85 = 40 \text{ N} \rightarrow$
$F_y = \frac{15}{17} \times 85 = 75 \text{ N} \uparrow$
$F_x = .707 \times 40 = 28.3 \text{ kN} \leftarrow$
$F_y = .707 \times 40 = 28.3 \text{ kN} \downarrow$
$F_x = \frac{4}{5} \times 120 = 96 \text{ N} \rightarrow$
$F_y = \frac{3}{5} \times 120 = 72 \text{ N} \uparrow$
$F_x = \frac{12}{13} \times 52 = 48 \text{ kN} \leftarrow$
$F_y = \frac{5}{13} \times 52 = 20 \text{ kN} \downarrow$
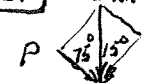
2-19
$F_y = 30 \text{ lb} \uparrow \quad F_x = 52 \text{ lb} \rightarrow$
$F_y = 75.2 \text{ kips} \downarrow \quad F_x = 27.4 \text{ kips} \leftarrow$
$v_y = 400 \text{ ft/sec} \uparrow \quad v_x = 300 \text{ ft/sec} \rightarrow$
$v_y = 16 \text{ mph} \downarrow \quad v_x = 30 \text{ mph} \leftarrow$

2-20
$F_x = 200 \cos 38 = 158 \text{ lb} \leftarrow$
$F_y = 200 \sin 38 = 123 \text{ lb} \uparrow$
$F_x = 28 \sin 25 = 11.8 \text{ ft/sec} \leftarrow$
$F_y = 28 \cos 25 = 25.4 \text{ ft/sec} \downarrow$
$F_x = 190 \sin 63 = 169 \text{ lb} \rightarrow$
$F_y = 190 \cos 63 = 86.3 \text{ lb} \uparrow$
$F_x = 860 \cos 20.5 = 806 \text{ lb} \rightarrow$
$F_y = 860 \sin 20.5 = 301 \text{ lb} \downarrow$

2-21
$F_x = 1.8 \cos 80 = 0.313 \text{ kN} \rightarrow$
$F_y = 1.8 \sin 80 = 1.77 \text{ kN} \downarrow$

2-22
$A_x = 637.6 \cos 45 = 451 \text{ N} \rightarrow$
$A_y = 451 \text{ N} \downarrow$

2-23	$P_y = 100 \sin 40 = 64.3 N$ ↖20°
	$P_x = 100 \cos 40 = 76.6 N$ ∠20°
	$Q_y = 12 \cos 10 = 11.8 kN$ ↘70°
	$Q_x = 12 \sin 10 = 2.1 kN$ ∠20°
	$R_y = 40 \sin 16.8 = 11.6 N$ ↓70°
	$R_x = 40 \cos 16.8 = 38.3 N$ ∠20°

2-24

5 kN

P

$\cos 75 = \dfrac{P}{5}$

$P = 1.29 kN$

2-25 $F_x = 20 \sin 30 = 10 lb$ ↗15°

2-26 $P_y = 80 \sin 32 = 42.4 N$ ↘70°
$P_x = 80 \cos 32 = 67.8 N$ ↗20°

2-27 120° 25 $\cos 12° = \dfrac{F}{25}$
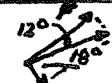180° $F = 24.5 lb$ ∠30°

2-28 $P_x = 400 \cos 10°$
$= 394 N$ ∠10°
$P_y = 400 \sin 10°$
$= 69.5 N$ ↖10°

2-29 $R_y = \dfrac{4}{5} \times 50 + \dfrac{5}{13} \times 52 = 60 N$ ↑
$R_x = \dfrac{12}{13} \times 52 - \dfrac{3}{5} \times 50 = 18 N$ →
$R = 62.6 N$ ∠73.10

2-30 $R_y = \dfrac{3}{5} \times 50 + \dfrac{1}{4.12} \times 100 = 54.3 lb$ ↑
$R_x = \dfrac{4}{5} \times 50 + 65 - 25 - \dfrac{4}{4.12} \times 100 = 17 lb$ ←
$R = 56.9 lb$ ↖72.6°

2-31 $R_x = \dfrac{15}{17}(204) - 160 \sin 15 + 70 \cos 65$
$= 168.2$
$R_y = \dfrac{8}{17}(204) - 160 \cos 15 - 70 \sin 65$
$= -73.9$
$R = 184 N$ ↘23.7°

2-32 $R_x = 90 \sin 75 - 70 \cos 10 - \dfrac{5}{13} \times 104$
$= -22$
$R_y = +80 + 90 \cos 75 + 70 \sin 10 + \dfrac{12}{13} \times 104$
$= +211.5$
$R = 213 lb$ ↖84.1°

2-33 $R_x = 4 \sin 20 + 2 - 3 \cos 30 - 5 \sin 15$
$= -0.524$
$R_y = 4 \cos 20 - 3 \sin 30 + 5 \cos 15$
$= +7.09$
$R = 7.11 kN$ ↖85.8°

2-34 $R_x = -1200 \cos 20 - 700 \sin 35$
$= -1530$
$R_y = 1200 \sin 20 - 700 \cos 35 - 800$
$= -963.4$
$R = 1810 lb$ ↙57.8°

2-35 $R_x = \dfrac{12}{13} \times 52 - 20 - \dfrac{3}{5}(30) - 40 \cos 80$
$= +3.054$
$R_y = \dfrac{5}{13}(52) + \dfrac{4}{5}(30) - 40 \sin 80$
$= 4.608$
$R = 5.53 kN$ ∠56.5°

2-36 $R_x = 70 \cos 25 + 150 \sin 30 + 200 \cos 70$
$= 206.8$
$R_y = 70 \sin 25 + 150 \cos 30 + 200 \sin 70$
$= 87.6$
$R = 225 lb$ ∠23°

2-37 $R_x = -40 \sin 20 - 20 \cos 40 + \dfrac{12}{13}(39)$
$= +6.99$
$R_y = 40 \cos 20 - 20 \sin 40 - \dfrac{5}{13} \times 39$
$= 9.73$
$R = 12 lb$ ∠54.3°

R2-1 $R = 65 N$ ↖12/5
$R = 8.54 kN$ ↗3/8 $R = 102 N$ ↗8/15

R2-2 $\tan \theta = \dfrac{6}{3}$ $\theta = 63.4°$
$180 - 30 - 63.4 = 86.6°$
$R = 6.7 Kips$ ↘86.6°

R2-3 $R_x = -180 \cos 45 - 300 \cos 10$
$= -422.7$
$R_y = 180 \sin 45 + 300 \sin 10$
$= +179.4$
$R = 459 N$ ↖23°

R2-4	$F_x = 80 \sin 15 = 20.7 lb$ ←
	$F_y = 80 \cos 15 = 77.3 lb$ ↓
	$v_x = 19 \cos 37 = 15.2 ft/se$ ←
	$v_y = 19 \sin 37 = 11.4 ft/sec$ ↑
	$F_x = 2 \cos 48 = 1.34 lb$ →
	$F_y = 2 \sin 48 = 1.49 lb$ ↓
	$F_x = 420 \cos 21.8 = 390 lb$ ←
	$F_y = 420 \sin 21.8 = 156 lb$ ↓

R2-5	$v_x = 6 \cos 55 = 3.44 m/s$ ←
	$v_y = 6 \sin 55 = 4.91 m/s$ ↓
	$S_x = 18 \sin 10 = 3.13 m$ →
	$S_y = 18 \cos 10 = 17.7 m$ ↑
	$a_x = \dfrac{15}{17}(68) = 60 m/s^2$ ←
	$a_y = \dfrac{8}{17}(68) = 32 m/s^2$ ↑
	$P_x = \dfrac{2}{3.605}(65) = 36.1 N$ →
	$P_y = \dfrac{3}{3.605}(65) = 54.1 N$ ↑

R2-6 initial $F_x = 3 \cos 6 = 2.98 kN$ ∠40°
Final $F_x = 3 \cos 15 = 2.9 kN$ ∠40°

4

R2-1	$F_x = -400\cos10 + 150\cos50 + 200\sin15$ $\quad = -245.7$ $F_y = +300 + 400\sin10 + 150\sin50 - 200\cos15$ $\quad = +291.2$ $R = 381\ N \nearrow 49.8°$
R2-8	$R_x = 120 - \frac{12}{13}(26) - \frac{8}{17}(170)$ $\quad = +16$ $R_y = -90 - \frac{5}{13}(26) + \frac{15}{17}(170)$ $\quad = +50$ $R = 52.5\ N \nearrow 72.3°$
3-1	$M_A = -12 \times 2 - 9 \times 1 - 24 \times 2 + 10 \times 4$ $\qquad + 30 \times 3 - 16 \times 3$ $M_A = 1\ lb\text{-}ft \circlearrowright$
3-2	$M_A = -48 \times 2 + 36 \times 1 - 20 \times 4 + 15 \times 3$ $M_A = 95\ N \cdot m \circlearrowright$
3-3	$M_A = +(60)(20) + (36)(32)$ $M_A = 2350\ lb\text{-}in \circlearrowright$
3-4	$M_A = -5.66(.5) - 3(.5) - 5.2(.3) - 4(.4)$ $M_A = 7.49\ Nm \circlearrowright$
3-5	$M_A = -160(7) + 400(10) - 800(2)$ $M_A = 1280\ lb\text{-}ft \circlearrowright$
3-6	$M_A = -800(5\sin38)$ $\quad = 2460\ N \cdot m \circlearrowright$
3-7	$M_A = 850(6.3\sin30) = 26,800\ lb\text{-}in \circlearrowright$
3-8	$M_C = 1800 \times 2.3 = 4140\ N \cdot m \circlearrowright$ $M_B = (1800)(1.7) = 3060\ N \cdot m \circlearrowright$
3-9	$M_A = 360(24) - 150(18) = 5940\ lb\text{-}in \circlearrowright$
3-10	$M_P = -36(15) + 15(8) = 420\ lb\text{-}in \circlearrowright$
3-11	$M_A = F \times d$ $500 = P\cos28(1.8) \qquad P = 315\ N \searrow 75°$
3-12	$M_A = 200(3) + 360(6) - 150(4)$ $\quad = 2160\ Nm \circlearrowright$
3-13	$M_A = 90(.1) - 120(.24)$ $\quad = 19.8\ N \cdot m \circlearrowright$
3-14	$M_A = -60(3) + 240(1) + 200(0) + 80(0)$ $\quad = 60\ kN \cdot m \circlearrowright$
3-15	$M_A = (1200\cos20)1 - (1200\sin20)9.5 + (600)4.5$ $\qquad + (160)1.5 + (120)6$ $\quad = 889\ lb\text{-}ft \circlearrowright$
3-16	$M_B = (500\sin15)(2\cos25)$ $\qquad + (500\cos15)(2\sin25)$ $\quad = 643\ N \cdot m \circlearrowright$ $643 = F \times .8\cos25$ $F = 887\ N$

3-17	$M_A = -4000(8) - 1500(68)$ $\quad = -134,000\ lb\text{-}in$ $\quad = 11.2\ Kip\text{-}ft \circlearrowright$ $M_B = 4000(38) - 1500(22)$ $\quad = 119,000\ lb\text{-}in$ $\quad = 9.92\ Kip\text{-}ft \circlearrowright$
3-18	moment about wheels = hitch load × 2 $\qquad = 45 \times 2$ $\qquad = 90\ N \cdot m$ moment about wheels = dolly load × 1.5 $\qquad 90 = $ dolly load × 1.5 $\qquad$ dolly load = 60 N
3-19	Top Arm $\quad M_B = (30\cos21.1)(34)$ $\qquad = 952\ lb\text{-}in \circlearrowright$ Bottom Arm $\quad M_C = (30\cos21.1)(32.77)$ $\qquad = 917\ lb\text{-}in \circlearrowright$ $\therefore$ greater moment in upper arm
3-20	$M_A = M_B = 8(2) = 16\ N \cdot m \circlearrowright$
3-21	$M_A = 1.294(.3) - 2(.5)$ $\quad = 0.612\ kN \cdot m \circlearrowright$
3-22	$M_A = -10(4\cos10) + 8(6)$ $\quad = 8.6\ lb\text{-}ft \circlearrowright$
3-23	$M_A = -80(2) - 60(4.2) = -412$ $\quad = 412\ lb\text{-}ft \circlearrowright$
3-24	$M_A = 30 \times .376$ $\quad = 11.3\ N \cdot m \circlearrowright$
3-25	$M_A = 10(8) - 25(15)$ $\quad = 280\ lb\text{-}in \circlearrowright$
3-26	$500(4) = F \times .15$ $\qquad F = 13,300$ $\therefore A = 13,300 \rightarrow$ $\quad B = 13,300 \leftarrow$
3-27	$M = 20 \times 8$ $\quad = 160$
3-28	$6 \times 3 = F(4)$ $\quad F = 4.5\ N$
3-29	$0.4(8) = F(.25)$ $\quad F = 12.8\ kN$
3-30	$4(2000) = F(300)$ $\quad F = 26.7\ N$
3-31	$4(2000) = 50\ F$ $\quad F = 160\ N$

R3-1

$$M_A = -24(4) + 10(0) - 30(1) + 16(3)$$
$$\quad - 6(1) - 8(2) + 8(1)$$
$$= 92 \; N\cdot m \;\circlearrowright$$

R3-2

$$M_A = 1200(15\cos 18) = 17{,}120 \; lb\text{-}ft \;\circlearrowright$$
$$17{,}120 = B(8\sin 20)$$
$$B = 6260 \; lb \;\underline{\diagup 38°}$$

R3-3

140

140

.15   .65

$$M_A = 140 \times .15$$
$$= 21 \; N\cdot m \;\circlearrowright$$

$$M_A = 140 \times .65$$
$$= 91 \; N\cdot m \;\circlearrowright$$

R3-4

$$M_A = -10(1.5) - 30(1)$$
$$= 45 \; N\cdot m \;\circlearrowright$$
$$M_B = -10(1.5) - 30(1)$$
$$= 45 \; N\cdot m \;\circlearrowright$$

R3-5

15   B   8   10   12
15   12   12

$$15(8) = F(10)$$
$$F = 12 \; lb$$

4-1

B_y B_x C
A 5   1
.8m   .1m   .7m

4-2

3'   3'
A   2   1   1   2   C
90 lb

4-3

15 mm   10   60 mm   50N
4   3
AB C_x C_y

4-4

2m B_x 3m
T   1   1   12
B_y 5
50kN

4-5

200N   B
45°
200°   450
R_1 R_2

4-6

6m   4m
A_x
A_y 1   2   3m
E   600N

4-7

B_x B_y
2 Kips
5'
E_x
3'   2' E_y

4-8

2m   4m C_y
2m C_x
1m $\tfrac{4}{5}$-BD
$\tfrac{3}{5}$ BD
15°
T

4-9

A_x
2'
80 lb
8'
B_x 5'
B_y

4-10

C_x $B_y = AB\sin 70$ 700 N
.2m
C_y $B_x = AB\cos 70$
3m   4m

4-11

C
1.5m   3kN
E_x
E_y 5m

4-12

A_y
A_x 10'   5   12   B
2'   3   4   D
6'   3
E

4-13

1.7   0.6 C_y
0.3
7   C_y
3   BD
1800 N

4-14

900
E_x 1   5   9
E_y 21   6
8   10   12   H

E_y E_x
5.33
3
6.67   2.67
BD C_x
2   1 C_y

4-15

AD
31
11
500 lb
B_x 6
14
B_y
20   11

4-16

10   T   EL
31   7
11   8
AD G_x
G_y
10

4-17

G_y K_y K_x
G_x 9
HJ   7
B_x 29
B_y 10   71

4-18

B_y B_x $3/4$ C_x C_y $1/2$ 100 B 8

B_x $1/4$ 4 6 G B_y 3 4 DE

100 C_y DE 4 3 C_x H $8\frac{1}{2}$ $6\frac{1}{2}$ 6

4-24

A_x $3m$ $5.33m$ C_y B_x B_y C_x A_y

2 2 2 E_x E_y $300 N$ B_x B_y B 15 G 5.33 2.67

4-19

$780 N$ 5 12 13 C_y C_x $780 N$ $3m$ $2m$ B

4-20

A_y 6 A_x 8 T T 11 10 7 C 5 12

4-21

4 4 12 5 B_y $T = 30$ 6 B_x 7 3 4 30 30

4-22

$1200 \, lb$ D_y D_x 1200 1.5 2.5 1.5 A_x 1200 A_y $3'$ $5'$ $3'$

1200 1200 D_x $2.5'$ D_y $5.5'$ G_x $8'$ $4'$ G_y

4-23

1.5 1.5 1 P 1.67 2 2 C_x C_y 400 A_x 200 A_y

C_y C_x $2m$ $3m$ E

4-25

T_A T_A T_A

$\Sigma F_y = 0$

$3 T_A = 60$

$T_A = 20 \, lb$

$60 \, lb$

4-26

$T \; T \; T \; T$

$\Sigma F_y = 0$

$5 T = 200$

$T = 40 \, lb$

$200 \, lb$

4-27

$2 T_A$ T_A T_A

$\Sigma F_y = 0$

$4 T_A = 240$

$T_A = 60 \, lb$

240

T_B $2 T_B$

$\Sigma F_y = 0$

$3 T_B = 240$

$T_B = 80 \, lb$

240

4-28

$2 T_B$ T_B T_B

$\Sigma F_y = 0$

$4 T_B = 300$

$T_B = 75 \, kg$

300

4-29

T_A T_A T_A T_A T_A

$\Sigma F_y = 0$

$5 T_A = 200$

$T_A = 40 \, lb$

$200 \, lb$

Top Pulley

T_B

$\Sigma F_y = 0$

$T_B = 4 T_A = 4 \times 40$

$T_B = 160 \, lb$

$T_A \; 2 T_A \; T_A$

4-30

$6T = 60$

$T = 10\ kN$

4-31

$4T_1 = 60$

$T_1 = 15\ Kg$

$T_2 = 45\ Kg$

$T = 75\ Kg$

$= 736\ N$

4-32

$5T_1 = 400$

$T_1 = 80\ lb$

$T_2 = 2 \times 80$

$= 160\ lb$

$T_3 = 4T_1\ or\ 2T_2$

$T_3 = 320\ lb$

4-33

$2T_1 = 40$

$T_1 = 20$

$T = 3 \times 10$

$T = 30\ kN$

4-34

FBD of C

$\Sigma F_y = 0$

$\frac{3}{5}AC = 600$

$AC = 1000\ N\ T$

$\Sigma F_x = 0$

$\frac{4}{5} \times 1000 = BC$

$BC = 800\ N\ C$

4-35

FBD of B

$\Sigma F_y = 0$

$\frac{8}{17}AB = 160$

$AB = 340\ lb\ C$

$\Sigma F_x = 0$

$\frac{15}{17} \times 340 = BC$

$BC = 300\ lb\ C$

4-36

FBD of B

$\Sigma F_x = 0$

$\frac{4}{5}BC = 100$

$BC = 125\ lb\ T$

$\Sigma F_y = 0$

$AB = \frac{3}{5} \times 125$

$AB = 75\ lb\ T$

FBD of C

$\Sigma F_y = 0$

$\frac{8}{17}CE = \frac{3}{5} \times 125$

$CE = 160\ lb\ T$

$\Sigma F_x = 0$

$CD = \frac{4}{5}(125) + \frac{15}{17}(160)$

$CD = 241\ lb\ T$

4-37

FBD of B

$\Sigma F_y = 0$

$\frac{4}{5}AB - \frac{15}{17}(680) = 0$

$AB = 750\ N\ T$

$\Sigma F_x = 0$

$BC = \frac{8}{17}(680) + \frac{3}{5}(750)$

$BC = 770\ N\ C$

4-38

FBD of B

$\Sigma F_x = 0$

$\frac{5}{13}BD = \frac{4}{5}(100)$

$BD = 208\ lb\ T$

FBD of D

$\Sigma F_x = 0$

$\frac{15}{17}DE = \frac{5}{13}(208)$

$DE = 90.7\ lb\ T$

$\Sigma F_y = 0$

$DF = \frac{8}{17}(90.7) + \frac{12}{13}(208)$

$DF = 234\ lb\ T$

FBD of F

$\Sigma F_y = 0$

$3T = 234$

$T = 78.2\ lb$

FBD of G

ΣF_y

$W = 156\ lb$

4-39

FBD of B

$\Sigma F_x = 0$

$\frac{15}{17}BC = 4000$

$BC = 4530\ lb\ T$

$\Sigma F_y = 0$

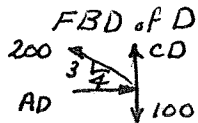$BD + 2000 = \frac{8}{17}(4530)$

$BD = 130\ lb\ T$

4-40

FBD of A

$\Sigma F_y = 0$

$AC \sin 50 + AB \sin 20 + 3 \sin 15 = 3$

$AC = 2.9 - .446\ AB \cdots ①$

$\Sigma F_x = 0$

$3 \cos 15 = AB \cos 20 - AC \cos 50$

Subst. ①

$AB = 1.59\ kN\ C$

$\therefore AC = 2.19\ kN\ C$

4-41

FBD of D

$\Sigma F_x = 0$

$AD = \frac{4}{5}(200)$

$= 160\ lb$

200 → $\frac{3}{4}$ CD

AD ↘ ↓100

4-42

FBD of B

$\frac{490.5}{\sin 30} = \frac{AB}{\sin 110}$

$AB = 922\ N\ T$

AB ↖ 50° 20° → BC ↘ ↓490.5 N

30° 110° AB 40° 490.5
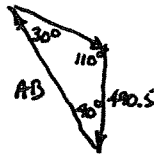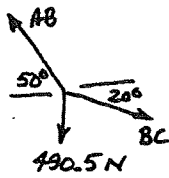
$\frac{490.5}{\sin 30} = \frac{BC}{\sin 40}$

$BC = 631\ N\ T$

FBD of C

BC ↙ 10° 60° CD ↗ ↓E

CD 30° E 80° 70° 631 N
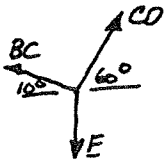
$\frac{631}{\sin 30} = \frac{CD}{\sin 70}$

$CD = 1190\ N\ T$

$\frac{E}{\sin 80} = \frac{631}{\sin 30}$

$E = 1242\ N$

$= 126\ kg$

4-43

FBD of B
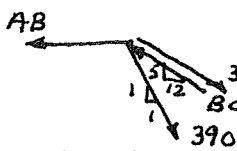
$\Sigma F_y = 0$

$\frac{5}{13}BC = \frac{5}{13}(390) + .707(390)$

$BC = 1107\ N$

AB ↖ 5 12 1 Bc 390 1 ↓390
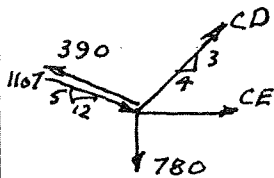
FBD of C

$\Sigma F_y = 0$

$\frac{5}{13}(390) + \frac{3}{5}CD = \frac{5}{13}(1107) + 780$

$CD = 1760\ N\ T$

390 ← 1107 ↖ 5 12 CD ↗ 3 4 → CE ↓780

4-44

A=30 ↗ 20° 70° 80° B=30 → 10° P ↙ θ

$\frac{P}{\sin 80} = \frac{30}{\sin 50}$

$P = 38.6$

P 50° 30 P θ 50° 80° 30

4-45

$\Sigma F_x = 0$
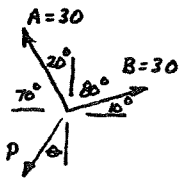
FBD Top roller
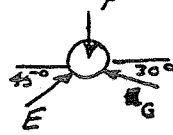
$E\cos 45 = G\cos 30$

$E = 1.225\ G\ ----①$

$\Sigma F_y = 0$

$E\sin 45 + G\sin 30 = 50$

subst ①

$G = 36.6$

$E = 44.8$

45° 30° E ↙ ↘ G

FBD middle roller

$\Sigma F_x = 0$

$C = 44.8\cos 45$

$= 31.7\ lb$

50 ↓ 44.8 ↘ C ← ↓D

FBD left roller
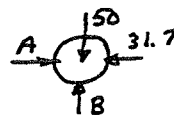
$\Sigma F_x = 0$

$A = 31.7\ lb$ →

$\Sigma F_y = 0$

$B = 50\ lb$ ↑

↓50 A → 31.7 ↑B

4-46

FBD of E

$\frac{CE}{\sin 15} = \frac{2}{\sin 105}$

$CE = 0.536\ kN\ T$

CE ↖ 30° 75° DE ↗ ↓2kN

60° CE 105 2 15° DE
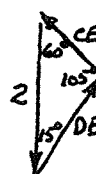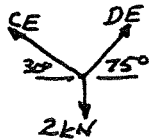
$\frac{DE}{\sin 60} = \frac{2}{\sin 105}$

$DE = 1.79\ kN\ T$

FBD of D
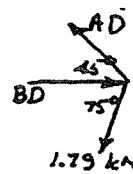
$\Sigma F_y = 0$

$1.79\sin 75 = AD\sin 45$

$AD = 2.45\ kN\ T$

AD ↗ 45° BD ← 75° ↓1.79 kN

$\Sigma F_x = 0$

$BD = 2.45\cos 45 + 1.79\cos 75$

$BD = 2.2\ kN\ C$

4-47

$\tan\theta = \frac{.25}{15}$ $\theta = 1°$

FBD of A

& $\sin\theta \approx \tan\theta$

T ← θ ↓10 θ → T P

$\Sigma F_y = 0$

$2(T\sin 1°) = 10$

$T = 300\ lb$

4-48

FBD of pulley
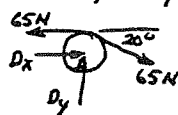
$\Sigma F_y = 0$

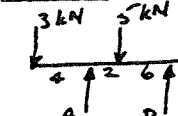$D_y = 65\sin 20 = 22.2\ N$

$\Sigma F_x = 0$

$D_x + 65\cos 20 = 65$

$D_x = 3.9\ N$

65N ← 20° ↘ 65N Dx ↓Dy

3.9 ← ↓ 75° 22.2 ↓ 50
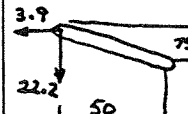
$M_B = 3.9(.075) + 22.2(.050)$

$M_B = 1.4\ N\cdot m$ ↻

4-49

$\Sigma M_A = 0$

$5(2) + 4(9) = 3(4) + B(8)$
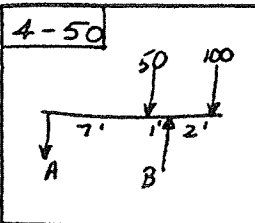
$B = 4.25\ kN$ ↑

$\Sigma F_y = 0$

$4.25 + A = 3 + 5 + 4$

$A = 7.75\ kN$ ↑

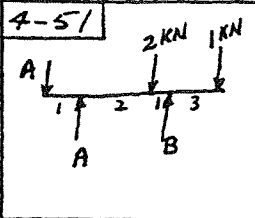3kN 5kN 4kN ↑ ↑ ↑ 4 2 6 1 A B

4-50

$\Sigma M_A = 0$
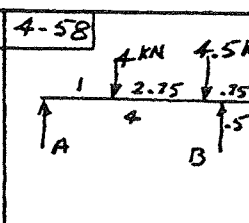
$8B = 50(7) + 100(10)$

$B = 169 \text{ lb} \uparrow$

$\Sigma F_y = 0$

$A + 50 + 100 = 169$

$A = 19 \text{ lb} \downarrow$

4-51

$\Sigma M_A = 0$

$.8(1) + 4B = 2(3) + 1(7)$

$B = 3.05 \text{ kN} \uparrow$

$\Sigma F_y = 0$

$A + 2 + 1 = 0.8 + 3.05$

$A = 0.85 \text{ kN} \downarrow$

4-52

$\Sigma M_B = 0$

$4A = 10 \times 6 + 9 \times 12$

$A = 42 \text{ kN} \uparrow$

$\Sigma M_A = 0$

$4B = 2 \times 10 + 12 \times 5$

$B = 20 \text{ kN} \downarrow$

4-53

$\Sigma M_A = 0$

$800(.5) + 900(3.5)$

$+ 200(5) = B(4.5)$

$B = 1.01 \text{ kN} \uparrow$

$\Sigma F_y = 0$

$800 + 900 + 200 = 1010 + A$

$A = 890 N = 0.89 \text{ kN} \uparrow$

4-54

$\Sigma M_A = 0$

$8B = 36(5.5) + 36(9)$

$B = 65.2 \text{ kN} \uparrow$

$\Sigma M_B = 0$

$8A + 36(1) = 36(2.5)$

$A = 6.8 \text{ kN} \uparrow$

4-55

$\Sigma M_A = 0$

$22B = 2700(4) + 5400(10)$

$B = 2950 N \uparrow$

$\Sigma M_B = 0$

$22A = 5400(12) + 2700(18)$

$A = 5150 N \uparrow$

4-56

$\Sigma M_A = 0$

$14B = 22.5(2) + 165(8.5)$

$+ 15(12)$

$B = 116 \text{ kN} \uparrow$

$\Sigma F_y = 0$

$A + 116 = 22.5 + 165 + 15$

$A = 86.5 \text{ kN} \uparrow$

4-57

$\Sigma M_A = 0$

$2700(1) + 5400(2.5) = 6B$

$B = 2.7 \text{ kN} \uparrow$

$\Sigma M_B = 0$

$6A = 5400(3.5) + 2700(1.5)$
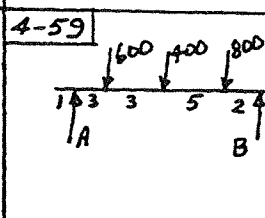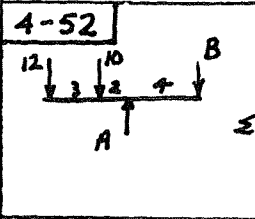
$A = 5.4 \text{ kN} \uparrow$

4-58

$\Sigma M_A = 0$

$4B = 4(1) + 4.5(3.75)$

$B = 5.22 \text{ kN} \uparrow$

$\Sigma F_y = 0$

$A + 5.22 = 4 + 4.5$
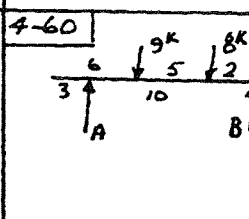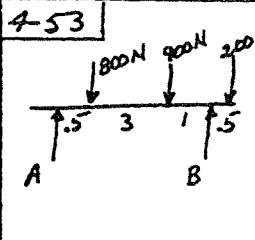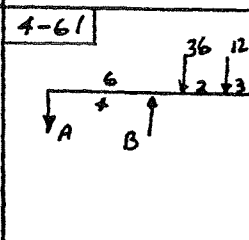
$A = 3.28 \text{ kN} \uparrow$

4-59

$\Sigma M_B = 0$

$13A = 800(2) + 400(7) + 600(10)$

$A = 800 \text{ lb} \uparrow$

$\Sigma M_A = 0$

$13B = 600(3) + 400(6) + 800(11)$

$B = 1000 \text{ lb} \uparrow$

4-60

$\Sigma M_A = 0$

$10B = 9(3) + 8(8)$

$B = 9.1 \text{ kips} \uparrow$

$\Sigma F_y = 0$
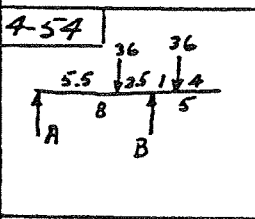
$A = 17 - 9.1$

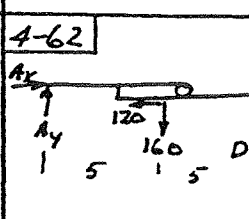$A = 7.9 \text{ kips} \uparrow$

4-61

$\Sigma M_A = 0$

$4B = 30(5) + 12(8) + 14(11)$

$B = 100 \text{ kN} \uparrow$

$\Sigma F_y = 0$

$A + 30 + 12 + 14 = 100$
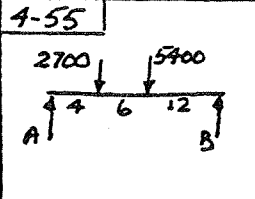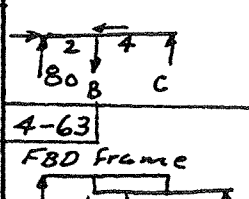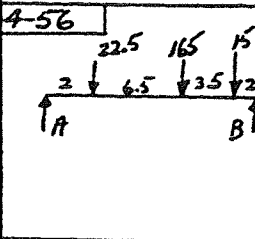
$A = 44 \text{ kN} \downarrow$

4-62

$\Sigma M_D = 0$

$A_y(10) = 5(160)$

$A_y = 80 \text{ lb}$

$\Sigma M_C = 0$

$4B = 80(6)$

$B = 120 \text{ lb} \ T$

4-63

FBD frame

$\Sigma M_D = 0$

$50(11) = A(20)$

$A = 27.5 \text{ lb}$

FBD of AC

$\Sigma M_C = 0$

$5 BE = 12(27.5)$

$BE = 66 \text{ lb} \ T$

4-64

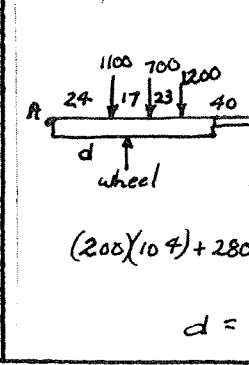$\Sigma F_y = 0$

$wheel + 200 = 3000$

$wheel = 2800 \text{ lb}$

$\Sigma M_A = 0$

$(200)(104) + 2800d = (1100)(24) + 700(41)$
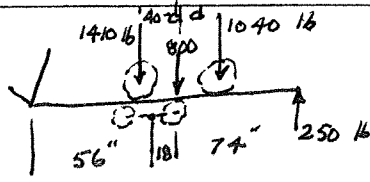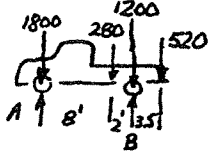
$+ 1200(64)$

$d = 39.7 \text{ in.}$

4-65

$\Sigma M_A = 0$

$(800)(18)+1040d = 1410(40-d)+250(92)$

$$d = 26.5"$$

4-66
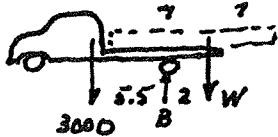

$\Sigma M_A = 0$

$10B = (280)8+(1200)10+(520)13.5$

$$B = 2130 \text{ lb}\uparrow$$

$\Sigma M_B = 0$

$10A+(520)3.5 = (280)2+(1800)10$

$$A = 1670 \text{ lb}\uparrow$$

4-67

$\Sigma M_B = 0$
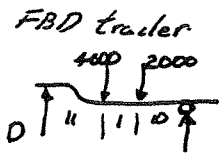
$3000 \times 5.5 = W \times 2$

$W = 8250 \text{ lb}$

$\dfrac{8250}{800} = 10.3$

wheels lift @ 11

4-68

FBD trailer
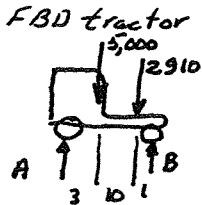

$\Sigma M_D = 0$

$22C = 4000(11)+2000(12)$

$C = 3090 \text{ lb}\uparrow$

$\Sigma F_y = 0$

$D+3090 = 6000$

$$D = 2910 \text{ lb}\uparrow$$

FBD tractor

$\Sigma M_A = 0$

$15B = 5000(3)+2910(13)$

$$B = 3520 \text{ lb}\uparrow$$

$\Sigma F_y = 0$

$A+3520 = 5000+2910$

$$A = 4390 \text{ lb}$$

4-69

FBD of BD
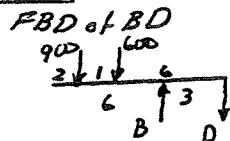
$\Sigma M_D = 0$

$3B = 600(6)+900(7)$

$$B = 3300 \text{ lb}\uparrow$$

FBD frame
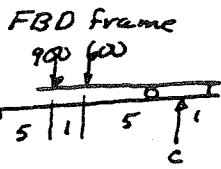
$\Sigma M_A = 0$

$11C = 900(5)+600(6)$

$$C = 736 \text{ lb}\uparrow$$

4-70
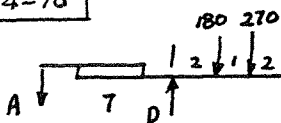
$\Sigma M_D = 0$

$7A = 180(2)+270(3)$

$$A = 167 \text{ lb}\downarrow$$

$\Sigma M_B = 0$

$3C = 167(2)$

$$C = 111 \text{ lb}\uparrow$$

4-71
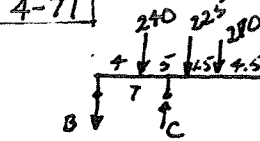
$\Sigma M_B = 0$

$7C = 240(4)+225(9)+270(10.5)$

$C = 831 \text{ lb}$

$\Sigma F_y = 0$

$831 = 240+225+270+B$

$$B = 96 \text{ lb}\downarrow$$

$\Sigma M_A = 0$

$20D+96(3) = 831(10)$

$$D = 401 \text{ lb}\uparrow$$
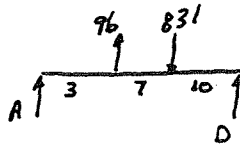
$\Sigma F_y = 0$

$A+401+96 = 831$

$$A = 334 \text{ lb}\uparrow$$

4-72
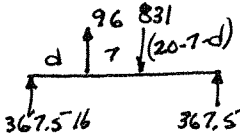
from 4-71 $\quad A+D = 334+401 = 735$

$\therefore A=D = 367.5 \text{ lb}$

$\Sigma M_A = 0$

$96d+367.5(20) = 831(d+7)$

$$d = 2.09 \text{ ft}$$

4-73

FBD of frame

$\Sigma M_A = 0$

$6D = 3(3.2)$

$D = 1.6 \text{ kN}\uparrow$

FBD of BD
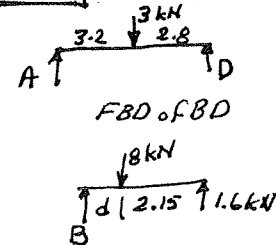
$\Sigma M_B = 0$

$8d = 1.6(2.15+d)$

$$d = 0.538 \text{ m}$$

4-74
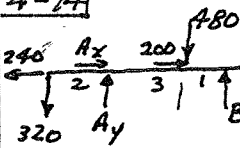
$\Sigma F_x = 0$

$A_x+200 = 240$

$A_x = 40N \rightarrow$

$\Sigma M_A = 0$

$320(2)+B(4) = 480(3)$

$$B = 200 \text{ N}\uparrow$$

$\Sigma F_y = 0$

$A_y+200 = 480+320$

$$A_y = 600N \uparrow$$

4-75
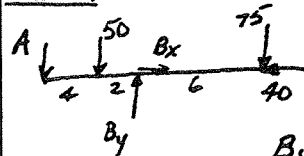
$\Sigma M_B = 0$

$6A+50(2) = 75(6)$

$A = 58.3 \text{ kN}\downarrow$

$\Sigma F_y = 0$

$B_y = 58.3+50+75$

$$B_y = 183 \text{ kN}\uparrow$$

$\Sigma F_y = 0$

$$B_x = 40 \text{ kN} \rightarrow$$

4-76

$\Sigma M_A = 0$
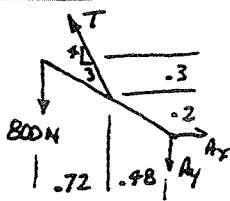
$800(1.2) + \frac{3}{5}T(.2) = \frac{4}{5}T(.48)$

$T = 3640 \, N$

$\Sigma F_x = 0$

$A_x = \frac{3}{5}(3640)$

$\quad = 2180 \, N \rightarrow$

$\Sigma F_y = 0$

$A_y + 800 = \frac{4}{5}(3640)$

$A_y = 2110 \, N \downarrow$

4-77
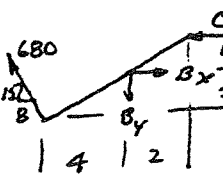
$\Sigma F_y = 0$

$B_y = \frac{15}{17}(680) = 600 \, N \downarrow$

$\Sigma M_B = 0$

$C(1) = \frac{15}{17}(680)(4) + \frac{8}{17}(680)(2)$

$C = 3040 \, N \leftarrow$

$\Sigma F_x = 0$

$B_x = 3040 + \frac{8}{17}(680)$

$B_x = 3360 \, N \rightarrow$

4-78
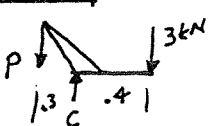
$\Sigma M_C = 0$

$P(.3) = 3(.4)$

$P = 4 \, kN \downarrow$

FBD of A
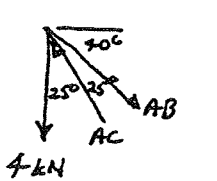
$\dfrac{AC}{\sin 130} = \dfrac{4}{\sin 25}$

$AC = 7.25 \, kN \, C$

$\dfrac{AB}{\sin 25} = \dfrac{4}{\sin 25}$

$AB = 4 \, kN \, T$

4-79

FBD of A

$\dfrac{AB}{\sin 112.6} = \dfrac{1500}{\sin 28.7}$

$AB = 2890 \, lb \, C$

$\quad \& \quad DE = 2890 \, lb \, C$
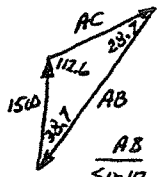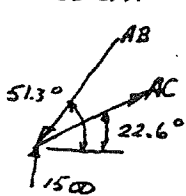
$\dfrac{AC}{\sin 38.7} = \dfrac{1500}{\sin 28.7}$

$AC = 1950 \, lb \, T$

$CE = 1950 \, lb \, T$

4-80
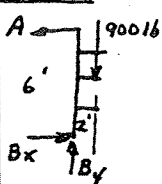
$\Sigma F_y = 0$

$B_y = 900 \, lb \uparrow$

$\Sigma M_B = 0$

$A(6) = 900(2)$

$A = 300 \, lb \rightarrow$

$\Sigma F_x = 0$

$B_x = 300 \, lb \rightarrow$

4-81
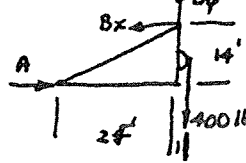
$\Sigma F_y = 0$

$B_y = 400 \, lb \uparrow$

$\Sigma M_B = 0$

$A(14) = 400(1)$

$A = 28.6 \, lb \rightarrow$

$\Sigma F_x = 0$

$B_x = 28.6 \, lb \leftarrow$

4-82

FBD of frame
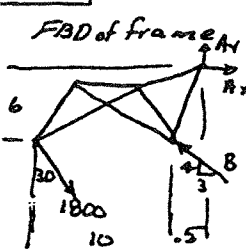
$\Sigma M_A = 0$

$\frac{3}{5}B(6) + \frac{4}{5}B(5) = 1800 \sin 30(6)$

$\qquad\qquad + 1800 \cos 30(10.5)$

$B = 5440 \, lb$

$\Sigma F_x = 0$

$500 + A_x = \frac{3}{5}(5440)$

$A_x = 2370 \, lb \rightarrow$

$\Sigma F_y = 0$

$A_y + \frac{4}{5}(5440) = 1800 \cos 30$

$A_y = -2790$

$A_y = 2790 \, lb \downarrow$

4-83
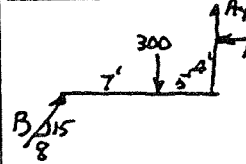
$\Sigma M_A = 0$

$\frac{15}{17}B(12) = 300(5) + \frac{8}{17}B(4)$

$B = 172 \, lb$

$\Sigma F_x = 0$

$A_x = \frac{8}{17}(172) = 81.1 \, lb \leftarrow$

$\Sigma F_y = 0$

$A_y + \frac{15}{17}(172) = 300$

$A_y = 148 \, lb \uparrow$

4-84
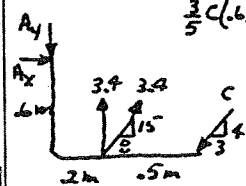
$\Sigma M_A = 0$

$\frac{3}{5}C(.6) + \frac{4}{5}C(.7) = 3.4(2) + \frac{15}{17}(3.4)(2) + \frac{8}{17}(3.4)(.6)$

$C = 2.43 \, kN$

$\Sigma F_x = 0$

$A_x + \frac{8}{17}(3.4) = \frac{3}{5}(2.43)$

$A_x = -0.139 = .139 \, kN$

$\Sigma F_y = 0$

$A_y + \frac{4}{5}(2.43) = 3.4 + \frac{15}{17}(3.4)$

$A_y = 4.45 \, kN \downarrow$

4-85
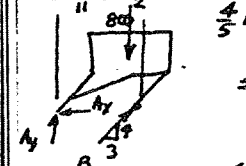
$\Sigma M_A = 0$

$\frac{4}{5}B(13) = 800(11)$

$B = 846 \, lb$

$\Sigma M_B = 0$

$A_y(13) = 800(2)$

$A_y = 123 \, lb \uparrow$

$\Sigma F_x = 0$

$A_x = \frac{3}{5} \times 846 = 508 \, lb \leftarrow$

4-86
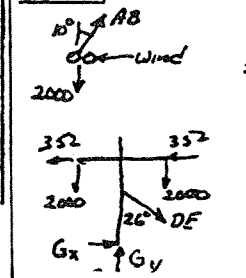
$\Sigma F_y = 0$

$AB \cos 10 = 2000$

$AB = 2030 \, lb \, T$

$\Sigma F_x = 0$

Wind force $= 2030 \sin 10$

$\qquad\qquad = 352 \, lb \leftarrow$

$\Sigma M_G = 0$

$2(352)(137) + 2000(22)$

$\quad = 2000(22) + DE \sin 26(123)$

$DE = 1790 \, lb \, T$

12

R4-1

R4-2

R4-3

R4-4

$\Sigma F_y = 0$

$7T_1 = 700$

$T_1 = 100 kg = 981 N$

$\therefore T_2 = 1960 N$

$\Sigma F_y = 0$

$T_3 + 100 = 200$

$T_3 = 100 kg = 981 N$

R4-5

R4-6

FBD of B

$\Sigma F_y = 0$

$27 T = 6000$

$T = 222 N$

R4-7

FBD of B

$\Sigma F_x = 0$

$\frac{4}{5} BC = 800$

$BC = 1000 N$ C

$\Sigma F_y = 0$

$AB = \frac{3}{5}(1000) = 600 N$ T

FBD of C

$\Sigma F_y = 0$

$\frac{5}{13} DC = \frac{3}{5}(1000)$

$DC = 1560 N$ C

$\Sigma F_x = 0$

$CE = \frac{4}{5}(1000) + \frac{12}{13}(1560)$

$CE = 2240 N$ C

R4-8

FBD of D

$\Sigma F_x = 0$

$\frac{12}{13} DE = \frac{3}{5}(100)$

$DE = 65 \; lb$ C

$\Sigma F_y = 0$

$DB = 100 + \frac{4}{5}(100) + \frac{5}{13}(65)$

$DB = 205 \; lb$ T

FBD of B

$\Sigma F_y = 0$

$\frac{12}{13} AB = 205$

$AB = 222 \; lb$ T

$\Sigma F_x = 0$

$BC = \frac{5}{13}(222)$

$BC = 85.4 \; lb$ T

R4-9

Position A

$\Sigma F_x = 0$

$\frac{4}{5} AB = \frac{12}{13} CB$

$AB = 1.154 CB \cdots ①$

$\Sigma F_y = 0$

$\frac{5}{13} CB + \frac{3}{5} AB = 600$

Subst ① $CB = 557 \; lb$ T

Position B

$\Sigma F_x = 0$

$\frac{4}{5} AB = \frac{12}{25.9} CB$

$AB = 0.578 CB \cdots ①$

$\Sigma F_y = 0$

$\frac{23}{25.9} CB = \frac{3}{5} AB + 600$

Subst ① $CB = 1110 \; lb$ T

R4-10

FBD of E

$\Sigma F_y = 0$

$2(T_1 \sin 60) = 2$

$T_1 = 1.155 kN$

FBD of B

$\Sigma F_x = 0$

$1.155 \cos 40 = T \cos 25$

$T = 0.973 kN$

R4-11

$\Sigma M_B = 0$

$300(4) + 800(7) + 300(11)$

$+ 600(12) = 14 A$

$A = 1240 \; lb$ ↑

$\Sigma F_y = 0$

$1236 + B = 600 + 300 + 800 + 300$

$B = 764 \; lb$ ↑

13

R4-12

FBD Frame

$\Sigma M_A = 0$
$E(5.5) = 4(4)$
$E = 2.91 \ kN$

FBD of BE

$\Sigma M_B = 0$
$DC(2) + 4(3) = 2.91(4.5)$
$DC = 0.55 \ kN \ T$

R4-13

FBD of G
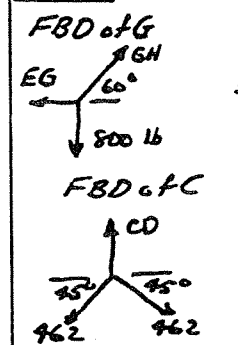
$\Sigma F_y = 0$
$GH \sin 60 = 800$
$GH = 924 \ lb$
$\Sigma F_x = 0$
$EG = 924 \cos 60 = 462 \ lb \ T$

FBD of C

$\Sigma F_y = 0$
$CD = 2(462 \sin 45)$
$CD = 653 \ lb \ T$
$\therefore \ P = 653 \ lb \ \downarrow$

R4-14
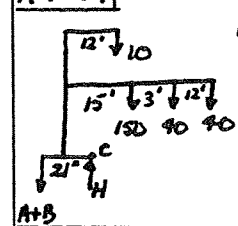
$\Sigma M_C = 0$
$(A+B)\left(\frac{21}{12}\right) = 10(11) + 150(14)$
$\qquad + 40(17) + 40(29)$
$A+B = 2314$
$\therefore A = B = 1160 \ lb \ T$

5-1

FBD of B
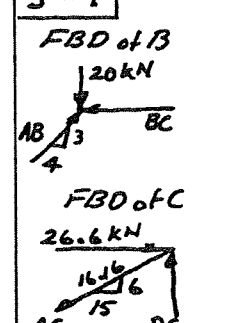
$\Sigma F_y = 0$
$\frac{3}{5} AB = 20$
$AB = 33.3 \ kN \ C$
$\Sigma F_x = 0$
$BC = \frac{4}{5}(33.3) = 26.6 \ kN \ C$

FBD of C

$\Sigma F_x = 0$
$\frac{15}{16.16} AC = 26.6$
$AC = 28.6 \ kN \ T$

5-2

FBD of B
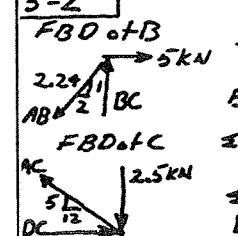
$\Sigma F_x = 0$
$\frac{2}{2.24} AB = 5$
$AB = 5.6 \ kN \ T$
$\Sigma F_y = 0$
$BC = \frac{1}{2.24}(5.6) = 2.5 \ kN \ C$

FBD of C

$\Sigma F_y = 0$
$\frac{5}{13} AC = 2.5 \quad AC = 6.5 \ kN \ T$
$\Sigma F_x = 0$
$DC = \frac{12}{13}(6.5) = 6 \ kN \ C$

5-3

FBD of A
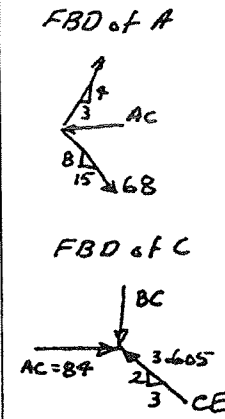
$\Sigma F_y = 0$
$\frac{8}{17}(68) = \frac{4}{5} AB$
$AB = 40 \ kN \ T$
$\Sigma F_x = 0$
$AC = \frac{15}{17}(68) + \frac{3}{5}(40)$
$AC = 84 \ kN \ C$

FBD of C

$\Sigma F_x = 0$
$\frac{3}{3.605} CE = 84$
$CE = 101 \ kN \ C$
$\Sigma F_y = 0$
$BC = \frac{2}{3.605}(101) = 56 \ kN \ C$

5-4
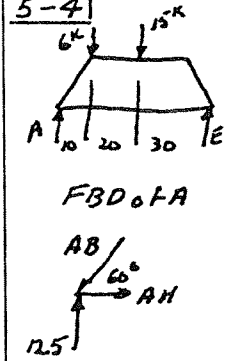
$\Sigma M_A = 0$
$60E = 6(10) + 15(30)$
$E = 8.5 \ kips \ \uparrow$
$\Sigma F_y = 0$
$A = 21 - 8.5 = 12.5 \ kips \ \uparrow$

FBD of A

$\Sigma F_y = 0$
$AB \sin 60 = 12.5$
$AB = 14.4 \ kips \ C$
$\Sigma F_x = 0$
$AH = 14.4 \cos 60$
$AH = 7.21 \ kips \ T$

FBD of B
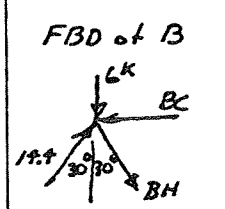
$\Sigma F_y = 0$
$BH \cos 30 + 6 = 14.4 \cos 30$
$BH = 7.51 \ kips \ T$
$\Sigma F_x = 0$
$BC = 14.4 \sin 30 + 7.51 \sin 30$
$BC = 11^K \ C$

FBD of H

$\Sigma F_y = 0$
$CH = 7.51 \ kips \ C$

5-5

FBD of Frame
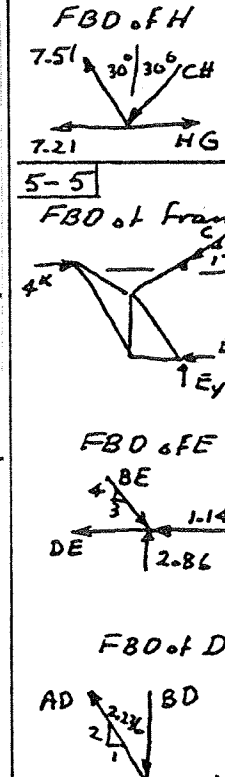
$\Sigma M_C = 0$
$14 E_x = 4(4)$
$E_x = 1.14 \ kips$
$\Sigma F_x = 0$
$C_x = 4 - 1.14$
$C_x = 2.86 \ kips$
$\Sigma F_y = 0$
$E_y = 2.86 \ kips$

FBD of E

$\Sigma F_y = 0$
$\frac{4}{5} BE = 2.86$
$BE = 3.57 \ kips$
$\Sigma F_x = 0$
$DE = \frac{3}{5}(3.57) - 1.14$
$DE = 1 \ kip$

FBD of D

$\Sigma F_x = 0$
$\frac{1}{2.236} AD = 1$
$AD = 2.24 \ kips \ T$
$\Sigma F_y = 0$
$BD = 2 \ kips \ C$

5-6

FBD frame

2.5m

A_x

A_y A

DB/3.16

20kN

$\Sigma M_A = 0$
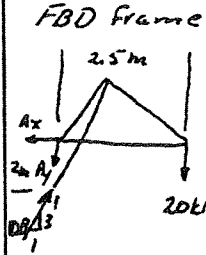
$\frac{1}{3.16} DB(2) = 20(2.5)$

$DB = 79 \, kN \; C$

$\Sigma F_y = 0$

$A_y + 20 = \frac{3}{3.16}(79)$

$A_y = 55 \, kN \downarrow$

$\Sigma F_x = 0$

$A_x = \frac{1}{3.16}(79) = 25 \, kN \leftarrow$

FBD of A

AB

25 A

AC

55
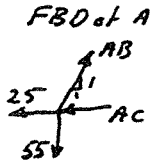
$\Sigma F_y = 0$

$0.707 AB = 55$

$AB = 77.8 \, kN \; T$

$\Sigma F_x = 0$

$AC + 25 = .707(77.8)$

$AC = 30 \, kN \quad C$

FBD of C

BC

2 3.6
3

30kN

20kN

$\Sigma F_x = 0$

$\frac{3}{3.6} BC = 30$

$BC = 36 \, kN \; T$

5-7

FBD of frame

B_x

B_y AE 2
2.5   6

20kN
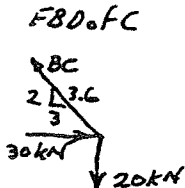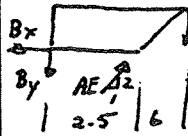
$\Sigma M_B = 0$

$\frac{2}{2.236} AE(2.5) = 20(8.5)$

$AE = 76 \, kN \; C$

$\Sigma F_x = 0$

$B_x = \frac{1}{2.236}(76) = 34 \, kN \leftarrow$

$\Sigma F_y = 0$

$B_y + 20 = \frac{2}{2.236}(76)$

$B_y = 48 \, kN \downarrow$

FBD of D

CD

ED 5
12
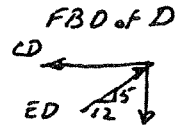
$\Sigma F_y = 0$

$\frac{5}{13} ED = 20 \quad ED = 52 \, kN \; C$

$\Sigma F_x = 0$

$CD = \frac{12}{13}(52) = 48 \, kN \; T$

FBD of C

48

CB 1
1   CE
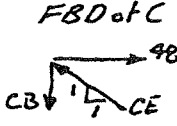
$\Sigma F_x = 0$

$.707 CE = 48 \quad CE = 67.8 \, kN \; C$

$\Sigma F_y = 0$

$CB = .707(67.8) = 48 \, kN \; T$

FBD of B

34   48 BE

48

$\Sigma F_x = 0$

$BE = 34 \, kN \quad T$

5-8

FBD of D

CD

ED 4 12
3   5   650

$\Sigma F_y = 0$
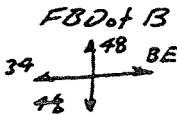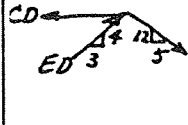
$\frac{12}{13}(650) = \frac{4}{5} ED$

$ED = 750 \, lb \; C$

$\Sigma F_x = 0$

$CD = \frac{3}{5}(750) + \frac{5}{13}(650)$

$CD = 700 \, lb T$

FBD of C

700

CB 2
1
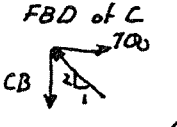
$\Sigma F_x = 0$

$\frac{1}{2.236} CE = 700 \quad CE = 1570 \, lb \; C$

$\Sigma F_y = 0$

$CB = \frac{2}{2.236}(1570) = 1400 \, lb \; T$

FBD frame

650

9 AB/14 3 1

$\Sigma M_G = 0$
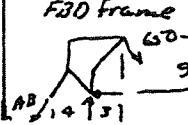
$\frac{5}{5.385} AB(4) = 200(9) + 60(3)$

$AB = 1090 \, lb \; T$

5-8 cont.

FBD of B

1400

BE

55
2   2
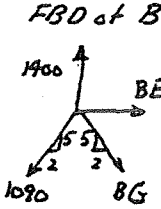
1090   BG

$\Sigma F_y = 0$

$\frac{5}{5.385} BG + \frac{5}{5.385}(1090) = 1400$

$BG = 418 \, lb \; T$

$\Sigma F_x = 0$

$BE + \frac{2}{5.385}(418) = \frac{2}{5.385}(1090)$

$BE = 250 \, lb \; T$

5-9

Joint C	$BC = 3.33 \, kips \; T$	$DC = 2.66 \, kips \; C$
Joint B	$AB = 2.66 \, kips \; T$	$BD = 2 \, kips \; C$
Joint D	$AD = 11.4 \, kips \; T$	$ED = 13.3 \, kips \; C$
Joint E	$AE = 3.33 \, kips \; T$	$FE = 16 \, kips \; C$
Joint F	$AF = 0$	

5-10

BK

BC 3 3 CD
4   4

$\Sigma F_y = 0$

$\frac{3}{5}(BC) + \frac{3}{5} CD = 8 \quad but \; BC = CD$

$CD = BC = 6.67 \, kN \; C$

6.67

2 3
4

AB   8 BE
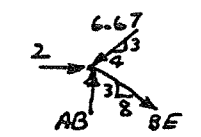
$\Sigma F_x = 0$

$\frac{8}{8.54} BE + 2 = \frac{4}{5}(6.67)$

$BE = 3.55 \, kN \; T$
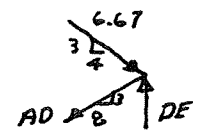
$\Sigma F_y = 0$

$AB = \frac{3}{5}(6.67) + \frac{3}{8.54}(3.55)$

$AB = 5.25 \, kN \; C$

6.67

3
4

AD 8 DE

$\Sigma F_x = 0$

$\frac{8}{8.54} AD = \frac{4}{5}(6.67) \quad AD = 5.69 \, kN \; T$

$\Sigma F_y = 0$

$DE = \frac{3}{5}(6.67) + \frac{3}{8.54}(5.69) = 6 \, kN \; C$

5-11

FBD of frame

A_x A_y 13'   3 kips
6'

E
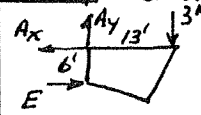
$\Sigma F_y = 0$

$A_y = 3 \, kips$

$\Sigma M_E = 0$

$6 A_x = 3(13)$

$A_x = 6.5 \, kips$

FBD of A

6.5 kips   3 kips
AB

AE

$\Sigma F_y = 0$

$AB = 6.5 \, kips \; T$

FBD of C

BC   3 kips

DC 12
5
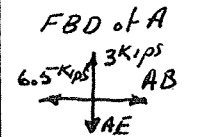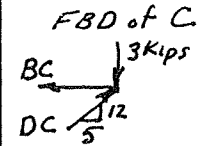
$\Sigma F_y = 0$

$\frac{12}{13} DC = 3$

$DC = 3.25 \, kips \; C$

$\Sigma F_x = 0$

$BC = \frac{5}{13}(3.25)$

$BC = 1.25 \, kips \; T$

FBD of B

6.5 kips   1.25 kips

ED 3
4   BD
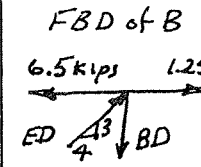
$\Sigma F_x = 0$

$\frac{4}{5} EB + 1.25 = 6.5$

$EB = 6.56 \, kips \; C$

$\Sigma F_y = 0$

$BD = \frac{3}{5}(6.56)$

$BD = 3.94 \, kips \; T$

5-12

DE CF

1000 lb

AD
CD
1570

$\Sigma F_y = 0$

$DE = CF = 1570 \text{ lb } C$

$\Sigma F_y = 0$

$AD = 1570 \text{ lb } C$

$\Sigma F_x = 0$

$CD = (2)\dfrac{3}{3.14}(1570) = 3000 \text{ lb } T$

5-13   Joint B $AB = 0$ $BD = 4 \text{ kps } C$

Joint A $AD = 3.75 \text{ Kips } C$ $AC = 2.25 \text{ Kips } T$

Joint D $CD = 3 \text{ Kips } T$ $DG = 6.25 \text{ Kips } C$

Joint C $CG = 3.75 \text{ Kips } C$ $CE = 4.5 \text{ Kips } T$

5-14   FBD of E

600 lb
CE
DE

$\Sigma F_y = 0$

$\dfrac{5}{13} DE = 600$

$DE = 1560 \text{ lb } C$

FBD of D

CD   BD   1560 lb

$\Sigma F_x = 0$

$0.707 CD = \dfrac{12}{13}(1560)$

$CD = 2037$

$\Sigma F_y = 0$

$BD = .707(2037) + \dfrac{5}{13}(1560)$

$BD = 2040 \text{ lb } T$

FBD of Frame

B   Ay   600
7'   5'

$\Sigma M_B = 0$

$7 A_y = 600(12)$

$A_y = 1029 \text{ lb}$

FBD of A

AB   1029
CA

$\Sigma F_y = 0$

$\dfrac{5}{13} CA = 1029$

$CA = 2670 \text{ lb } T$

5-15

Joint C $CE = 0$

Joint D $AD = 450 \text{ lb } T$

Joint A $AB = 649 \text{ lb } T$ $AC = 810 \text{ lb } C$

5-16

AB   AG
2K

$\Sigma F_y = 0$

$\dfrac{5}{13} AB = 2$ $AB = 5.2 \text{ kips } T$

$\Sigma F_x = 0$

$AG = \dfrac{12}{13}(5.2) = 4.8 \text{ Kips } C$

BG

AG   GE
= 4.8

$\Sigma F_y = 0$ $BG = 0$

$\Sigma F_x = 0$ $GE = 4.8 \text{ Kips}$

BC
5.2   BE = 0

$BC = 5.2 \text{ Kips } T$

Dy   Dx
9
16   E
2K

$\Sigma M_0 = 0$

$9E = 2(16)$

$E = 3.56 \text{ Kips}$

CE   DE
5   3.56
4

$\Sigma F_x = 0$

$\dfrac{4}{6.4} CE + 3.56 = 4.8$

$CE = 1.99 \text{ Kips } T$

4.8

5-17   FBD of frame

Ax   Ay
4
D

2 3 Kips

FBD of D

AD
D   DC

FBD of A

3 Kips
1.5 Kips   AB
1
2

$\Sigma F_y = 0$

$A_y = 3 \text{ Kips}$

$\Sigma M_D = 0$

$4 A_x = 3(2)$

$A_x = 1.5 \text{ Kips}$

$\Sigma F_y = 0$

$AD = 0$

$\Sigma F_y = 0$

$\dfrac{1}{2.236} AC = 3 \text{ Kips}$

$AC = 6.71 \text{ Kips } T$

5-18

Joint E $BE = 50 \text{ kN } T$ $ED = 56 \text{ kN } C$

Joints D & B $BD = 0$ $BC = 0$ $AB = 50 \text{ kN } T$

$DC = 56 \text{ kN } C$

Joint C $AC = 0$

5-19

Joint D $CD = 46.6 \text{ kN } T$ $ED = 45 \text{ kN } C$

Joint C $CE = BE = BG = AG = 0$

$AB = BC = 46.6 \text{ kN } T$

$HG = GE = 45 \text{ kN } C$

Joint H $AH = 0$

5-20   FBD of B $BE = 0$

FBD of E $CE = 0$

FBD of C

3kN
BC   CD
3   1   2

$\Sigma F_x = 0$

$\dfrac{2}{2.236} CD = \dfrac{3}{5} BC$

$CD = 0.671 BC \cdots \cdots ①$

$\Sigma F_y = 0$

$\dfrac{4}{5} BC + \dfrac{1}{2.236} CD = 3 \text{ subst. } ①$

$BC = 2.73 \text{ kN } C$ $CD = 1.83 \text{ kN } C$

FBD of B $AB = 2.73 \text{ kN } C$

FBD of A

2.73
4   AE
3   5
12

$\Sigma F_x = 0$

$\dfrac{12}{13} AE = \dfrac{3}{5}(2.73)$

$AE = 1.77 \text{ kN } T$

FBD of E $ED = 1.77 \text{ kN } T$

5-21   All internal members including CG have zero load

Dy
15   Dx
20
40   E

$\Sigma M_E = 0$

$20 D_x = 15(40)$

$D_x = 30 \text{ Kips } \rightarrow$

$\Sigma F_y = 0$ $D_y = 15 \text{ Kips } \uparrow$

FBD of D

CD   15 k
1   30 k
4
DE

$\Sigma F_x = 0$

$\dfrac{4}{4.12} CD = 30$

$CD = 30.9 \text{ Kips } T$

$\therefore BC = 30.9 \text{ Kips } T$

5-22

FBD of G

AG ↑ → GE
GN ↓

$\Sigma F_x = 0$

$GE = 0$

FBD of D

CD (15, 8)

ED → 30 kN
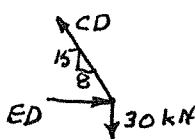
$\Sigma F_y = 0$

$\frac{15}{17} CD = 30$

$CD = 34\ kN\ T$

FBC of C

(2, 15, 8) BC, CE, 34
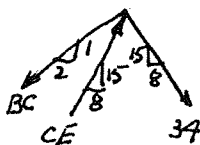
$\Sigma F_y = 0$

$\frac{15}{17}(34) + \frac{1}{2.235} BC = \frac{15}{17} CE$

$BC = 1.9676 CE - 66.9 \cdots ①$

$\Sigma F_x = 0$

$\frac{2}{2.235} BC = \frac{8}{17} CE + \frac{8}{17}(34)$

$BC = 0.5427 CE + 17.84 ②$

Equating ① & ②

$CE = 58.7\ kN\ C$

5-23

4 ↑ 6 → 5/D

$\Sigma M_A = 0$

$D(8) = 4(4) + 6(5)$

$D = 5.75\ kN$

A_x ← , A_y ↓

4 | 4

FBD of D

CD (5,3,4) BD, 5.75
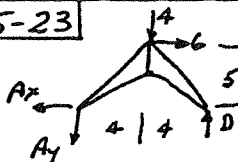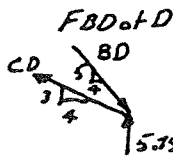
$\Sigma F_x = 0$

$\frac{4}{5} CD = \frac{4}{6.4} BD$

$CD = 0.781 BD \cdots ①$

$\Sigma F_y = 0$

$\frac{5}{6.4} BD = \frac{3}{5} CD + 5.75$

Subst ① $BD = 18.5\ kN\ C$

$CD = 14.4\ kN\ T$

FBD of C

BC ↑, AC (4,3,4) 14.4
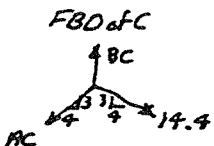
$\Sigma F_x = 0$

$AC = CD = 14.4\ kN\ T$

$\Sigma F_y = 0$

$BC = 2\left(\frac{3}{5}(14.4)\right) = 17.3\ kN\ T$

5-24

FBD of D
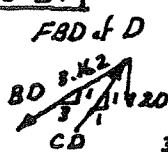
$\Sigma F_x = 0$

$\frac{3}{3.162} BD = .707 CD$

$BD = .745 CD \cdots ①$

BD (8,1,2) 20, CD

$\Sigma F_y = 0$

$\frac{1}{3.162} BD + 20 = .707 CD$

Subst ①

$CD = 42.4\ kN\ C$

FBD of C

AC (8,15,1) 42.4, BC
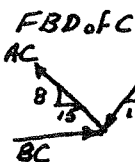
$\Sigma F_y = 0$

$\frac{8}{17} AC = .707 \times 42.4$

$AC = 63.8\ kN\ T$

5-25

A, C_x, C_y

8, 4/5200

$\Sigma M_C = 6$
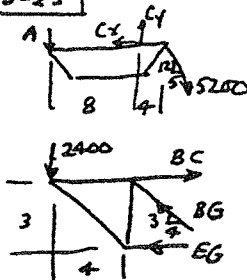
$8A = \frac{12}{13}(5200)(4)$

$A = 2400\ N$ ↓

2400 ↓, BC →

3, BG (3,4) EG

$\Sigma M_G = 0$

$EG(3) = 2400(4)$

$EG = 3200\ N\ C$

$\Sigma F_y = 0$

$\frac{3}{5} BG = 2400$

$BG = 4000\ N\ C$

$\Sigma F_x = 0$

$BC = \frac{4}{5}(4000) + 3200 = 6400\ N\ T$

5-26

5.2 kN

BD, 4m (5,12), CD (3,4), 3m, CE
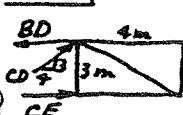
$\Sigma F_y = 0$

$\frac{3}{5} CD = 2$ $CD = 3.33\ kN\ C$

$\Sigma M_D = 0$

$3 CE = 24$ $CE = 2.67\ kN\ C$

$\Sigma F_x = 0$

$BD + 8 = 2.67 + \frac{4}{5}(3.33)$

$BD = 0.537\ kN\ T$

5-27

1k

BC →, BE (3,5), DE ←, (5,3), 3, 2k
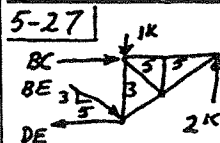
$\Sigma M_E = 0$

$BC(3) = 2(10)$

$BC = 6.67\ kips\ C$

$\Sigma F_y = 0$

$\frac{3}{5.83} BE + 1 = 2$

$BE = 1.94\ kips\ C$

$\Sigma F_x = 0$

$DE = \frac{5}{5.83}(1.94) + 6.67$

$DE = 8.33\ kips\ T$

FBD of D   ∴ $BD = 0$

5-28

G_y ↑, G_x →, 2k

A ↑, 18', 5k, 5'
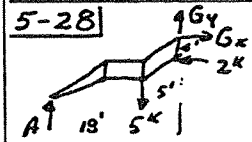
$M_G = 0$

$2(4) + 23A = 5(5)$

$A = 0.739\ kips$

6', BD, CD, 5', CE (12,5)

5', 6', .739 ↓

$\Sigma F_y = 0$
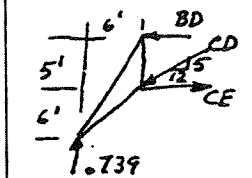
$\frac{5}{13} CD = 0.739$ $CD = 1.92\ kips\ C$

$\Sigma M_C = 0$

$0.739(6) = 5 BD$ $BD = 0.887\ kips\ C$

$\Sigma F_x = 0$

$CE = 0.887 + \frac{12}{13}(1.92) = 2.66\ kips\ T$

5-29

FBD of right half

6 | 1

BC (4,3), 20 kN, 4

BG ↓, GH ↓
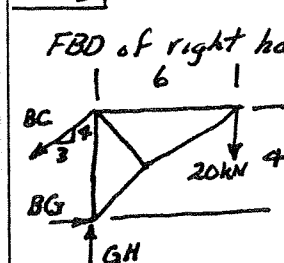
$\Sigma M_G = 0$

$\frac{3}{5} BC \times 4 = 20 \times 6$

$BC = 50\ kN\ T$

$\Sigma F_x = 0$

$BG = \frac{3}{5} \times 50$

$BG = 30\ kN\ C$

5-30   FBD frame - $\Sigma M_H = 0$ $A = 9.17\,kN$↑

$\Sigma M_B = 0$
$9.17(6) = EG(4)$
$EG = 13.7\,kN\ T$

5-31   FBD frame $\Sigma M_A = 0$ $G = 5.29\,kips$

$\Sigma M_D = 0$
$\frac{3}{5}CE(14) + \frac{4}{5}CE(2) = 5.29(3)$
$CE = 1.59\,kips\ T$
$\Sigma F_y = 0$
$\frac{3}{5}CD = \frac{4}{5}(1.59) + 5.29$
$CD = 10.9\,kips\ T$

5-32

$\Sigma M_C = 0$
$\frac{4}{5}BD(3) = 6(3)$
$BD = 7.5\,kN\ T$
$\Sigma F_y = 0$
$\frac{2}{2.24}CE = 6 + \frac{3}{5}(7.5)$
$CE = 11.8\,kN\ C$

$\Sigma F_x = 0$
$\frac{4}{5}(7.5) = CD + \frac{1}{2.24}(11.76)$
$CD = 0.75\,kN\ C$
$\Sigma M_E = 0$
$\frac{2}{2.24}DG(4) = 6(5)$
$DG = 8.4\,kN\ T$
$\Sigma F_x = 0$
$\frac{1}{2.24}(8.4) + \frac{1}{2.24}ED = \frac{1}{2.24}(11.76)$
$ED = 3.36\,kN\ C$

5-33

$\Sigma M_B = 0$
$10\,JH = 2(10)$
$JH = 2\,kips \cdot T$
$\Sigma M_H = 0$
$\frac{2}{2.24}BC(15) + 1(10) = 2(20)$
$BC = 2.24\,kips\ C$
$\Sigma F_x = 0$
$JH + .707\,BH = \frac{2}{2.24}(2.24)$
$BH = 0$

5-34   FBD frame $\Sigma M_H = 0$ $A = 20.4\,kN$↑

$\Sigma M_D = 0$
$15(3.46) + CE\sin 60(4) = 20.4(4)$
$CE = 8.57\,kN\ C$
$\Sigma M_E = 0$
$15(3.46) + DG\sin 60(8) = 20.4(8)$
$DG = 32.1\,kN\ T$
$\Sigma F_x = 0$
$DE + 32.1\cos 60 = 8.57\cos 60 + 15$
$DE = 3.22\,kN\ T$

5-35

$\Sigma M_E = 0$
$\frac{12}{13}CB(2.5) = 2(6)$
$CB = 5.2\,kN\ C$
$\Sigma F_x = 0$
$\frac{5}{13}(5.2) + \frac{3.75}{4.8}(BE) = 2 + 3$
$BE = 3.84\,kN\ C$

FBD of G $BG = 0$

5-36   FBD of frame

$\Sigma F_x = 0$ $B_x = 1000\,lb$
$\Sigma M_H = 0$
$1000(19.5) + 4B_y = 600(8) + 800(15.5) + 200(8)$
$B_y = -175\,lb↑ = +175\,lb↓$

FBD top half $\Sigma M_D = 0$
$\frac{15}{17}CE(8) = 1000(4)$ $CE = 567\,lb\ T$
$\Sigma F_x = 0$
$\frac{8}{17}ED + 800 = 1000 + \frac{8}{17}(567)$
$ED = 992\,lb\ T$
$\Sigma F_y = 0$
$DG = 175 + \frac{15}{17}(992) + \frac{15}{17}(567)$
$DG = 1550\,lb\ C$

5-37   FBD of frame $\Sigma M_A = 0$ $H = 7.875\,kN$↑

FBD of right half $\Sigma M_C = 0$
$\frac{4}{5}BD \times 4 + 7.875 \times 4 = 5 \times 7$
$BD = 1.69\,kN\ T$
$\Sigma M_D = 0$
$\frac{2}{2.236}CE \times 3 = 5 \times 3$ $CE = 5.59\,kN\ C$
$\Sigma F_x = 0$
$CD = 4.25\,kN\ T$

5-38

$\Sigma M_C = 0$
$5BD = 24(2)$ $BD = 9.6\,kN\ T$
$\Sigma M_D = 0$
$\frac{2}{2.24}CE(5) = 24(7)$
$CE = 37.6\,kN\ C$

$\Sigma F_x = 0$
$\frac{3}{5}ED = \frac{1}{2.24}(37.6) + 10$
$ED = 44.7\,kN\ C$

5-39

$\Sigma M_G = 0$
$.707\,CD(4) = 40(5)$
$CD = 70.7\,kN\ T$
$\Sigma F_x = 0$
$\frac{2}{2.24}JG = .707\,HG + .707(70.7)$
$JG = .792\,HG + 56 \cdots\cdots ①$
$\Sigma F_y = 0$
$\frac{1}{2.24}JG + 40 = .707\,HG + .707(70.7)$
Subst. ①
$HG = 40.6\,kN\ T$
$JG = 88.2\,kN\ C$

18

5-40

FBD frame $\Sigma M_A = 0$ $E = 3.69 \, Kips \uparrow$

$\Sigma M_G = 0$

$CD(6.67) + 2(8) = 3.69(8.67)$

$\qquad CD = 2.4 \, Kips \; C$

$\Sigma F_y = 0$

$3.69 + \frac{12}{13} CG + \frac{5}{13}(2.4) = \frac{12}{13}(2)$

$CG = -3 = 3 \, Kips \; C$

5-41

FBD frame $\Sigma M_D = 0$ $A = 70 \, Kips \uparrow$

$\Sigma M_G = 0$

$\frac{25}{25.18} BC(33) + 30(25) + 30(50)$

$\qquad = 70(75)$

$\qquad BC = 91.6 \, Kips \; C$

$\Sigma F_y = 0$

$70 + \frac{6}{7.81} BG = \frac{3}{25.18}(91.6) + 30 + 30$

$\qquad BG = 1.19 \, Kips \; C$

5-42

FBD frame $\Sigma M_p = 0$ $A = 3.5 \, kN \uparrow$

$\Sigma M_E = 0$

$BKH + 2(6.75) = 3.5(9)$

$\qquad KH = 2.25 \, kN \; T$

$\Sigma M_H = 0$

$\frac{9}{12.04} DE(8) + 2(2.75) = 3.5(6)$

$\qquad\qquad + \frac{8}{12.04} DE(3)$

$\qquad DE = 3.39 \, kN \; C$

$\Sigma F_x = 0$

$\frac{9}{12.04}(3.39) = \frac{3}{8.57} JE + 2.25$

$\qquad JE = 6.81 \, kN \; T$

$\angle M = MN = 0$

5-43

$\Sigma M_D = 0$

$C_x(4) = 5(6)$

$\qquad C_x = 7.5 \, Kips$

$\Sigma F_y = 0$

$D_y = 5 \, Kips \uparrow \; on \; DC$

$\Sigma F_x = 0$

$D_x = 7.5 \, Kips \rightarrow \; on \; DC$

$\qquad B_x = 7.5 \, Kips \leftarrow \; on \; BC$

5-44

$\Sigma M_B = 0$

$D_y(1.7) = \frac{15}{17}(34)(2.7)$

$\qquad D_y = 47.6 \, kN$

$\Sigma M_A = 0$

$2.5 G + \frac{8}{17}(34)(.3) = \frac{15}{17}(34)(.5)$

$\qquad G = 4.08 \, kN$

$\Sigma M_c = 0$

$(47.6)(.5) = (4.08)(1) + 1.2 D_x$

$\qquad D_x = 16.5 \, kN$

5-45

$\Sigma M_c = 0$

$4B = 60(5) + 32(7)$

$\qquad B = 131 \, lb$

$\Sigma F_y = 0 \quad C_y = 60 \, lb \uparrow$

$\Sigma F_x = 0$

$C_x + 32 = 131 \quad C_x = 99 \, lb \leftarrow$

5-46

$\Sigma M_c = 0$

$B_y(12) = 100(20)$

$\qquad B_y = 167 \, lb \uparrow$

$B_x = \frac{6}{5}(167) = 200 \, lb \leftarrow$

$\Sigma F_x = 0$

$C_x = 200 + 100 = 300 \, lb \rightarrow$

$\Sigma F_y = 0$

$C_y = 167 - 100 = 67 \, lb \downarrow$

5-47

$\Sigma M_B = 0$

$4 D_y = 1200(10)$

$\qquad D_y = 3000 \, lb$

$\therefore D_x = 3000 \, lb$

$C_x = C_y = 3000 \, lb$

$\Sigma F_x = 0 \quad B_x = 3000 \, lb$

$\Sigma F_y = 0 \quad B_y = 4200 \, lb$

5-48

$50 \, kN \quad \Sigma F_x = 0$

$\qquad D_x = 40 \, kN$

$\Sigma M_E = 0$

$40(8) = \frac{12}{17.69} AC(13)$

$\qquad AC = 36.3 \, kN \; T$

5-49

$\Sigma M_D = 0$

$\frac{4}{5} E(10) + \frac{3}{5} E(4) = 500(24)$

$\qquad E = 1157 \, lb$

$\Sigma M_B = 0$

$\frac{3}{5} AC(28) + 500(14) = \frac{3}{5}(1157)(14)$

$\qquad AC = 160 \, lb \; T$

$\Sigma F_y = 0$

$B_y = \frac{3}{5}(1157) + 500 + \frac{3}{5}(160)$

$\qquad B_y = 1290 \, lb$

$\Sigma F_x = 0$

$B_x + \frac{4}{5}(160) = \frac{4}{5}(1157)$

$\qquad B_x = 795 \, lb$

5-50

$\Sigma M_c = 0$

$3.3 D_x = 10.2(40)$

$\qquad D_x = 124 \, N$

$\Sigma M_A = 0$

$7 G = 40(3)$

$\qquad G = 17.1 \, N$

$\Sigma M_E = 0$

$124(1.5) + 17.1(2) = D_y(2)$

$\qquad D_y = 110 \, N$

5-51

$\Sigma M_B = 0$

$6T + T\sin 30(2) = 4.2(10)$

$\qquad T = 6 \, Kips$

$\Sigma F_y = 0$

$B_y + 6\sin 30 = 4.2$

$\qquad B_y = 1.2 \, Kips \uparrow$

$\Sigma F_x = 0$

$B_x = 6 + 6\cos 30 = 11.2 \, Kips$

$\therefore B = 11.3 \, Kips \; \angle 6.1°$

5-52

$\Sigma M_C = 0$

$C_x \quad \frac{7}{7.616} BD \times .6 + \frac{3}{7.616} BD \times .3$

$= 1800 \times 2.3$

$BD = 6180 N \; C$

$\Sigma F_y = 0$

$C_y + 1800 = \frac{7}{7.616} \times 6180$

$C_y = 3880 N$

$\Sigma F_x = 0$

$C_x = 2440 N$

5-57 cont.

$\Sigma M_A = 0$

$CB \sin 30 (22.5) + CB \cos 30 (12) + 96.2(16) = 275(30)$

$CB = 310 \; lb \; C$

$\Sigma F_x = 0$

$P = 310 \cos 30 = 268 lb$

5-53

$\Sigma M_D = 0$

$2E_y = 800 \times .2$

$E_y = 80 N$

$\Sigma F_y = 0 \quad C_y = 880N$

$\Sigma M_E = 0$

$C_x .7 + 800 \times 2 = 880 \times 1 + 800 \times 1.2 + 800 \times 1.4$

$C_x = 1940 N$

5-58

FBD of AC $\quad A_y = C_y = 375 \; lb$

$\Sigma M_B = 0$

$15E = 750(6.25)$

$E = 312.5 \; lb$

$\Sigma F_y = 0 \quad D_y = 375 \; lb$

$\Sigma M_A = 0$

$5 D_x + 5(375) = 312.5(10)$

$D_x = 250 \; lb$

$\Sigma F_x = 0$

$A_x + 250 = 312.5$

$A_x = 62.5 \; lb$

5-54

$\Sigma M_G = 0$

$400(450) + .707 DE(200) + .707 DE(150) = 400 \sin 40 (450) + 400 \cos 40 (500)$

$DE = 359 N \; T$

5-59

$\Sigma M_A = 0$

$4C_y + \frac{1}{2.24}(981)(3) = 981(3)$

$C_y = 407 N$

$\Sigma M_E = 0$

$4 C_x + \frac{2}{2.24}(981)(5) = \frac{1}{2.24}(981)(5) + 407(4) + 981(5)$

$C_x = 1090 N$

5-55

$\Sigma F_y = 0 \quad C_y = 3.5 KN$

$\Sigma M_C = 0$

$400 B_x = 3.5(250)$

$B_x = 2.19 KN \therefore A_x = 2.19 KN$

$\Sigma F_x = 0 \quad C_x = 2.19 KN$

$\Sigma F_x = 0 \quad E_x = 2.19 KN$

$\Sigma M_D = 0$

$200 E_y = 250(3.5)$

$E_y = 4.37 KN$

$\Sigma F_y = 0 \quad D = 4.37 + 3.5 = 7.87 KN$

5-56

$\Sigma M_A = 0$

$2T + 2(.707T) = 5P + 40(2.5)$ eqn ①

$\Sigma F_y = 0 \quad P = 200 - T$

Subst. into ①

$T = 131 \; lb$

5-60

$\Sigma M_A = 0$

$\frac{3}{5} C(3) = 3(5) \quad C = 8.33 KN$

$\Sigma F_y = 0$

$A_y = \frac{4}{5}(8.33) = \underline{6.67 KN}$

$\Sigma F_x = 0$

$A_x + 3 = \frac{3}{5}(8.33) \quad \underline{A_x = 2 KN}$

$\Sigma M_B = 0$

$8P = 8.33(5) \quad \underline{P = 5.21 KN}$

$\Sigma F_y = 0$

$B_y + 5.21 = \frac{4}{5}(8.33), \quad \underline{B_y = 1.46 KN}$

$\Sigma F_x = 0$

$\therefore B_x = \frac{3}{5}(8.33) = \underline{5 KN}$

5-57

$\Sigma M_E = 0$

$\frac{15}{17} DG(10) = \frac{3}{5}(200)(18)$

$DG = 245 \; lb$

$\Sigma F_y = 0$

$\frac{4}{5}(200) + \frac{8}{17}(245) = E_y$

$E_y = 275 \; lb$

$\Sigma F_x = 0$

$E_x + \frac{3}{5}(200) = \frac{15}{17}(245)$

$E_x = 96.2 \; lb$

5-61

$\Sigma M_B = 0$

$\frac{4}{5} G(4.67) = 20(4)$

$G = 21.4 KN$

$\Sigma F_x = 0$

$B_x = \frac{4}{5}(21.4) = 17.1 KN$

$\Sigma F_y = 0$

$B_y + \frac{3}{5}(21.4) = 20$

$B_y = 7.15 KN$

$\Sigma M_C = 0$

$4P = 17.13(2) + 7.15(2)$

$P = 12.1 KN$

5-62

$\Sigma M_B = 0$

$2.33(.707E) = 30(4)$

$E = 72.84\ kN$

$\Sigma F_y = 0$

$.707(72.84) = 30 + By$

$By = 21.5\ kN$

$\Sigma F_x = 0$

$Bx = .707(72.84) = 51.5\ kN$

$\Sigma M_C = 0$

$3P = 72.84(1.88)$

$P = 45.6\ kN$

5-63

$\Sigma M_A = 0$

$33H = 900 \times 11$

$H = 300\ lb$

$\Sigma M_E = 0$

$900 \times 8 + \frac{21}{21.59}AG \times 9 + \frac{5}{21.59}AG \times 18 = 300 \times 30$

$AG = 139\ lb$

$\Sigma F_x = 0 \quad E_x = 135\ lb$

$\Sigma F_y = 0 \quad E_y = 632\ lb$

$\Sigma M_c = 0$

$\frac{3}{7.31}BD \times 2.67 + \frac{6.67}{7.31}BD \times 1 = 632 \times 3 + 135 \times 8$

$BD = 1490\ lb\ C$

5-64

$\Sigma M_A = 0$

$48 By = 160(14) + 120(4)$

$By = 680\ lb$

$\Sigma F_x = 0$

$.707D = 680$

$D = 962\ lb$

$\Sigma M_B = 0$

$7.07(962) = 7P$

$P = 971\ lb$

5-65

$\Sigma M_B = 0$

$\frac{11}{32.9}AD \times 6 + \frac{31}{32.9}AD \times 11 = 500 \times 31$

$AD = 1253\ lb$

$\Sigma M_G = 0$

$\frac{10}{12.2}EL \times 15 = (1180 \times 10) + 419 \times 8$

$EL = 1230\ lb$

$\Sigma F_y = 0$

$Gy + \frac{7}{12.2} \times 1230 = 1180$

$Gy = 473\ lb$

$\Sigma F_x = 0$

$Gx + 419 = \frac{10}{12.2} \times 1230$

$Gx = 591\ lb$

5-66

$\Sigma M_D = 0$

$10T = 50(20) + 5P \cdots \textcircled{1}$

$\Sigma M_A = 0$

$5P = (T + \frac{3}{5}T)4 + \frac{4}{5}T(3)$

$5P = 8.8T \cdots \textcircled{2}$

Equating

$T = 1833\ lb$

$P = 1467\ lb$

5-67 FBD of cylinder

$\Sigma F_x = 0$

$.707CD = 5$

$CD = 7.07\ lb$

ΣM_E

$torque = (5)(\frac{1}{2}) + 5(1\frac{1}{4})$

$= 8.75\ lb\text{-}in$

5-68

FBD of pivot handle

$\Sigma M_B = 0$

$19A = 300(69)$

$A = 1089\ N$

$\Sigma F_x = 0$

$B_x = 1089\ N$

$\Sigma F_x = 0$

$P = 1089\ N$

$\Sigma M_C = 0$

$50D = 1089(3) + 1089(45)$

$D = 1045\ N$

$\Sigma F_y = 0$

$C = 1045\ N$

5-69

$\Sigma M_B = 0$

$13GH + \frac{4}{5}DE(\frac{1}{4}) = \frac{3}{5}DE(3)$

$GH = 0.123DE \cdots \textcircled{1}$

$\Sigma M_C = 0$

$GH(12.5) + 100(8.5) = \frac{3}{5}DE(6.5)$

Subst. ①

$GH = 44.3\ lb$

5-70

$\Sigma M_C = 0$

$D_x(3) + \frac{3}{2}D_x(6) = 150(30)$

$D_x = 375\ lb$

$\therefore D_y = 562\ lb$

$\Sigma F_x = 0$

$EH = 750\ lb$

5-71

$AB = CD$

$\Sigma F_y = 0$

$2(\frac{3}{2.24}AB) + 390 + 1600 = 6000$

$AB = CD = 2.25\ kN\ T$

5-72

$\Sigma M_E = 0$

$8(6) = \frac{12}{13} AB(5)$

$AB = 10.4 \text{ kN } T$

$\Sigma F_x = 0$

$\frac{5}{13}(10.4) + 8 = E_x$

$E_x = 12 \text{ kN}$

$\Sigma F_y = 0$

$E_y = \frac{12}{13}(10.4) = 9.6 \text{ kN}$

$\Sigma M_C = 0$

$\frac{10}{10.03} BD(4.18) + \frac{.833}{10.03} BD(10)$

$+ 9.6(5) = 12(12)$

$BD = 19.2 \text{ kN } T$

5-73

$\Sigma M_D = 0$

$\frac{2}{2.24} BE(40) = 200(95)$

$BE = 532 \text{ N } C$

$\Sigma F_y = 0$

$D_y = \frac{1}{2.24}(532) = 238 \text{ N}$

$\Sigma F_x = 0$

$D_x + 200 = \frac{2}{2.24}(532)$

$D_x = 275 \text{ N}$

$\Sigma M_C = 0$

$P(160) + \frac{2}{2.24}(532)(50)$

$= \frac{1}{2.24}(532)(120)$

$P = 29.7 \text{ N} \downarrow$

$\Sigma F_x = 0$

$C_x = \frac{2}{2.24}(532) = 475 \text{ N} \rightarrow$

$\Sigma F_y = 0$

$C_y + 29.7 = \frac{1}{2.24}(532)$

$C_y = 208 \text{ N} \downarrow$

5-74

$\Sigma M_A = 0$

$\frac{4}{5} BC(2) = 1000(1.5)$

$BC = 937 \text{ lb } T$

$\Sigma F_y = 0$

$A_y = 1000 - \frac{3}{5}(937) = 438 \text{ lb} \uparrow$

$\Sigma F_x = 0$

$A_x = \frac{4}{5}(937) = 750 \text{ lb} \leftarrow$

$\Sigma M_F = 0$

$7.7 D = 937(19.2)$

$D = 2340 \text{ lb } T$

$\Sigma M_G = 0$

$\frac{1}{2.24} E(5) + 1000(3.5) = \frac{2}{2.24} E(3.75)$

$E = 8510 \text{ lb } C$

5-75

$\Sigma M_D = 0$

$4A = 300(3)$

$A = 225 \text{ lb}$

$\Sigma F_x = 0 \quad H_x = 0$

$\Sigma M_E = 0$

$4 H_y = 300(1)$

$H_y = 75 \text{ lb}$

$\Sigma M_C = 0$

$\frac{1.5}{1.62} BG(.67) + \frac{.67}{1.62} BG(.5)$

$= 225(2) + 75(2)$

$BG = 734 \text{ lb } C$

5-76

$\Sigma M_D = 0$

$\frac{5}{13} B(95) + \frac{3}{5} AC(40) = 800(20)$

$+ \frac{5}{13} B(55)$

$AC = 667 - 0.642 B \cdots (1)$

$\Sigma M_H = 0$

$\frac{12}{13} B(120) + \frac{5}{13} B(50) + \frac{3}{5} AC(25) = \frac{4}{5} AC(60)$

$AC = 3.94 B \cdots (2)$

Equating

$B = 146 \text{ N}$

$AC = 573 \text{ N } T$

5-77

$\Sigma M_B = 0$

$2.5 A + 9.63(6) = 37.8(30)$

$A = 430 \text{ lb}$

$\Sigma F_x = 0$

$B_x = 9.63 \text{ lb}$

$\Sigma F_y = 0$

$B_y + 37.8 = 430$

$B_y = 392 \text{ lb}$

5-78 & 5-79

Slope of AC

$\sin \theta = \frac{1.125}{1.5}$

$\theta = 48.6°$

$\Sigma M_D = 0$

$AC \sin 48.6(1) + AC \cos 48.6(.75)$

$= 30 \sin 21.1(22.75) + 30 \cos 21.1(25.25)$

$AC = 765 \text{ lb } C$

$\Sigma F_y = 0$

$D_y + 30 \cos 21.1 = 765 \sin 48.6$

$D_y = 576 \text{ lb}$

$\Sigma F_x = 0$

$D_x = 765 \cos 48.6 - 30 \sin 21.1 = 495 \text{ lb}$

$\Sigma M_B = 0$

$E \sin 30(.25) + E \cos 30(3.5)$

$= 765 \sin 21.1(1\frac{1}{2}) + 765 \cos 21.1(1\frac{3}{4})$

$E = 527 \text{ lb}$

$\Sigma F_y = 0$

$B_y = 527 \cos 30 + 765 \cos 21.1$

$B_y = 1170 \text{ lb}$

$\Sigma F_x = 0$

$B_x = 527 \sin 30 + 765 \sin 21.1$

$B_x = 539 \text{ lb}$

22