

Chapter 3.

3-1 $\cos \theta = 5/18 \Rightarrow \theta = 73.8^\circ //$

3-2 $A = \sqrt{(18)^2 - (5)^2} = 17.3 \text{ m} //$

3-3 $\tan 60^\circ = \frac{x}{6} \Rightarrow x = 10.4 \text{ in} //$

3-4 $\theta = 180 - (60 + 90) = 30^\circ //$
 $\cos 60^\circ = \frac{6}{R} \Rightarrow R = 12 \text{ in} //$

3-5 a) $\tan \theta = \frac{6}{4} \Rightarrow \theta = 56.3^\circ //$

$R = \sqrt{(6)^2 + (4)^2} = 7.2 \text{ m} //$

b) $\theta = 180 - (90 + 60) = 30^\circ //$

$\cos 30^\circ = \frac{5}{R} \Rightarrow R = 5.8 \text{ in} //$

c) $\tan \theta = \frac{5}{8} \Rightarrow \theta =$

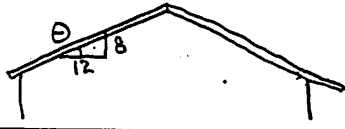
$R = \sqrt{(5)^2 + (8)^2} = 9.4 \text{ in} //$

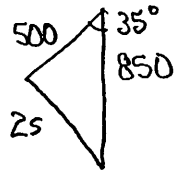
3-6 $\tan \beta = \frac{x}{y} = \frac{150}{275} \Rightarrow \beta = 28.6^\circ //$
 hypotenuse = 2s
 $2s = \sqrt{(150)^2 + (275)^2} \Rightarrow s = 156.6 \text{ mm} //$

3-7 $\tan 35^\circ = \frac{x}{16} \Rightarrow x = 11.2 \text{ in} //$
 $2s = \sqrt{(16)^2 + (11.2)^2} \Rightarrow s = 9.8 \text{ in} //$

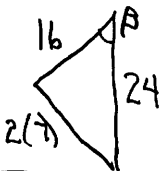
3-8 $s = 10 \Rightarrow \text{hypotenuse} = 20 \text{ in}$
 $\sin 35^\circ = \frac{x}{20} \Rightarrow x = 11.5 \text{ in} //$
 $\cos 35^\circ = \frac{y}{20} \Rightarrow y = 16.4 \text{ in} //$

3-9 $\tan \theta = \frac{8}{12} \Rightarrow \theta = 33.7^\circ //$

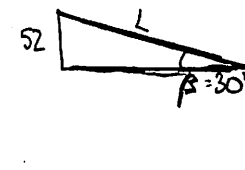


3-10 law of cosines

 $2s = \sqrt{(500)^2 + (850)^2 - 2(500)(850)\cos 35}$
 $s = 175 \text{ mm} //$

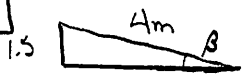
3-11 $\cos \beta = \frac{(16)^2 + (14)^2 - (24)^2}{2(16)(14)}$
 $\beta = 42.9^\circ //$



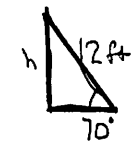
3-12 $L = \frac{52}{\sin 30}$
 $= 104 \text{ in} //$
 $104 \text{ in} \left(\frac{1 \text{ ft}}{12 \text{ in}} \right)$
 $= 8 \text{ ft } 8 \text{ in} //$



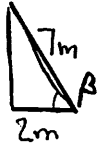
3-13 $\sin \beta = \frac{1.5}{4} \Rightarrow \beta = 22.0^\circ //$



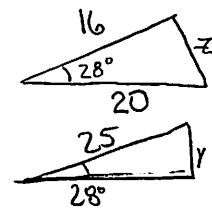
3-14 $\sin 70^\circ = \frac{h}{12}$
 $h = 11.3 \text{ ft} //$



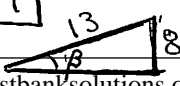
3-15 $\cos \beta = \frac{2}{7} \Rightarrow \beta = 73.4^\circ //$



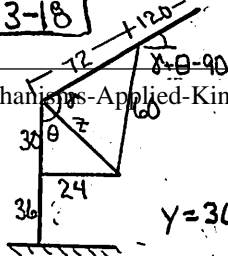
3-16 law of cosines
 $z = \sqrt{(16)^2 + (20)^2 - 2(16)(20)\cos 28}$
 $= 9.5 \text{ ft} //$
 $\sin 28^\circ = \frac{y}{25}$
 $\Rightarrow y = 11.7 \text{ ft} //$



3-17 $\sin \beta = \frac{8}{13}$
 $\Rightarrow \beta = 38.0^\circ //$

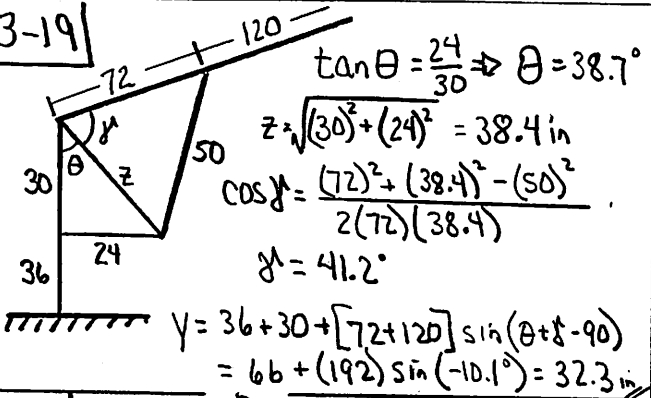


3-18 $\tan \theta = \frac{24}{30} \Rightarrow \theta = 38.7^\circ //$
 $z = \sqrt{(24)^2 + (30)^2} = 38.4 \text{ in}$
 $\cos \beta = \frac{(72)^2 + (38.4)^2 - (60)^2}{2(72)(38.4)} \Rightarrow \beta = 56.4^\circ //$
 $y = 36 + 30 + [72 + 120]\sin(38.7 + 56.4 - 90) = 83.1 //$



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 42,382
 200 SHEETS EYE-EASE 5 SQUARE
 42,383
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 42,389
 100 SHEETS EYE-EASE 5 SQUARE
 42,390
 200 SHEETS EYE-EASE 5 SQUARE
 Made in U.S.A.
 National Brand

3-19



$$\tan \theta = \frac{24}{30} \Rightarrow \theta = 38.7^\circ$$

$$z = \sqrt{(30)^2 + (24)^2} = 38.4 \text{ in}$$

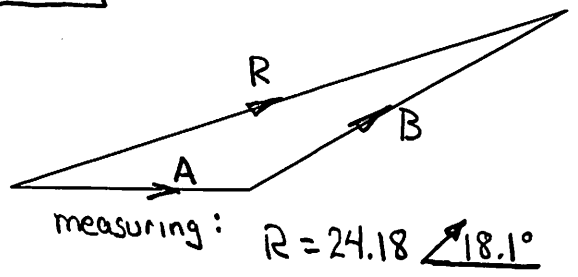
$$\cos \phi = \frac{(72)^2 + (38.4)^2 - (50)^2}{2(72)(38.4)}$$

$$\phi = 41.2^\circ$$

$$y = 36 + 30 + [72 + 120] \sin(\theta + \phi - 90)$$

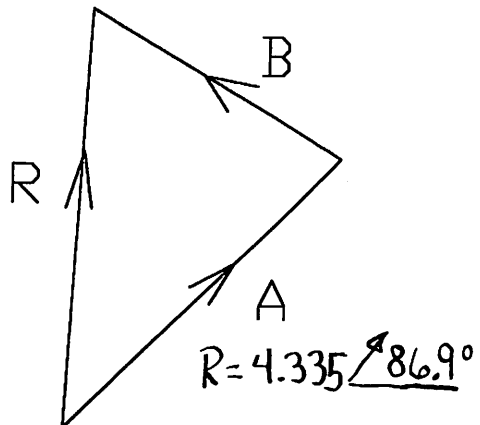
$$= 66 + (192) \sin(-10.1^\circ) = 32.3 \text{ in}$$

3-20



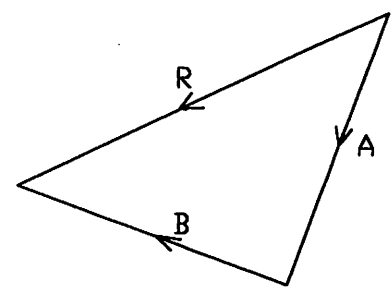
measuring: $R = 24.18 \nearrow 18.1^\circ$

3-21



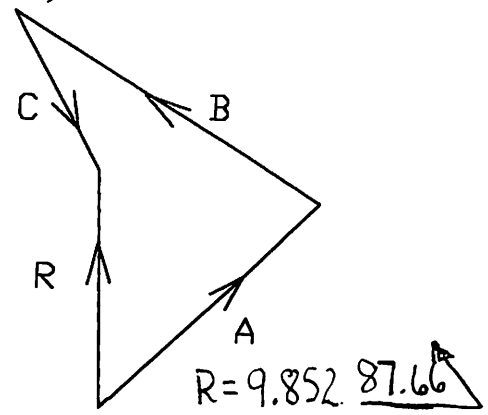
$R = 4.335 \nearrow 86.9^\circ$

3-22



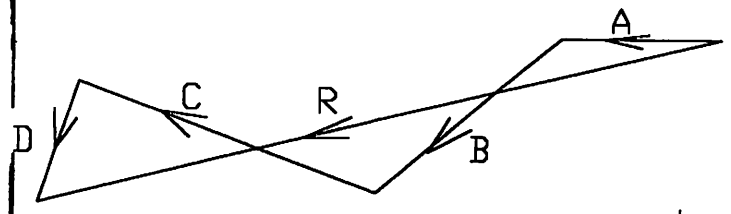
$R = 212.13 \overline{25^\circ}$

3-23



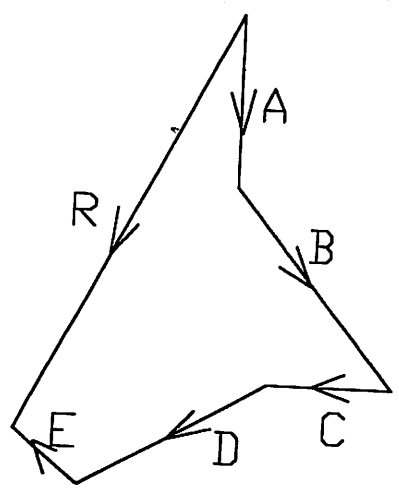
$R = 9.852 \nearrow 87.66^\circ$

3-24



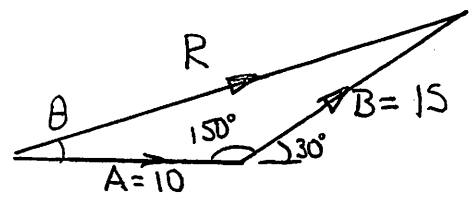
$R = 221.20 \overline{13.49^\circ}$

3-25



$R = 110.14 \overline{62.97^\circ}$

3-26



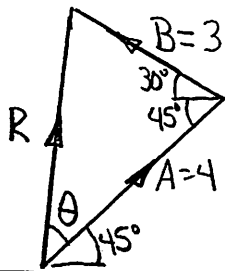
$$R = \sqrt{(10)^2 + (15)^2 - 2(10)(15)\cos 150} = 24.18$$

$$\theta = \sin^{-1}\left(\frac{15}{24.18} \sin 150\right) = 18.07^\circ$$

$R = 24.18 \nearrow 18.07^\circ$

13-782
42-381
42-389
42-392
42-399
500 SHEETS, FILLER 5 SQUARE
500 SHEETS, FILLER 5 SQUARE
100 SHEETS, FILLER 5 SQUARE
100 SHEETS, FILLER 5 SQUARE
100 SHEETS, FILLER 5 SQUARE
100 RECYCLED WHITE 5 SQUARE
200 RECYCLED WHITE 5 SQUARE
200 RECYCLED WHITE 5 SQUARE
Made in U.S.A.

3-27

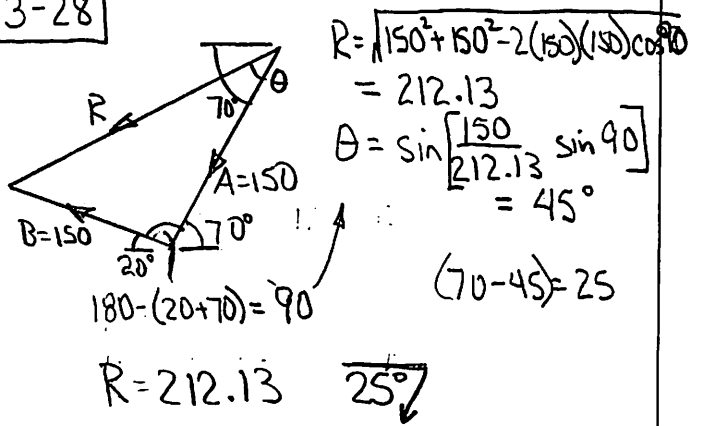


$$R = \sqrt{(4)^2 + (3)^2 - 2(4)(3)\cos 75^\circ} = 4.335$$

$$\theta = \sin^{-1}\left[\frac{3}{4.335} \sin 75^\circ\right] = 41.9^\circ$$

$$R = 4.335 \nearrow 86.9^\circ \quad (45 + 41.9) = 86.9^\circ$$

3-28



$$R = \sqrt{150^2 + 150^2 - 2(150)(150)\cos 90^\circ}$$

$$= 212.13$$

$$\theta = \sin^{-1}\left[\frac{150}{212.13} \sin 90^\circ\right]$$

$$= 45^\circ$$

$(70 - 45) = 25$

$$R = 212.13 \nearrow 25^\circ$$

3-29 $R_x = 12.5 \cos 45 - 15 \cos 30 + 7.5 \cos 60$
 $= -0.40$

$R_y = 12.5 \sin 45 + 15 \sin 30 - 7.5 \sin 60 = 9.84$



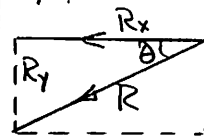
$$R = \sqrt{(-0.4)^2 + (9.84)^2} = 9.85$$

$$\theta = \tan^{-1}\left(\frac{9.84}{-0.40}\right) = 87.66^\circ$$

$$R = 9.85 \nearrow 87.67^\circ$$

3-30 $R_x = -50 - 75 \cos 40 - 100 \cos 20$
 $- 40 \cos 70 = -215.1$

$R_y = 0 - 75 \sin 40 + 100 \sin 20 - 40 \sin 70 = -51.6$



$$R = \sqrt{(-215.1)^2 + (-51.6)^2}$$

$$= 221.2$$

$$\theta = \tan^{-1}\left(\frac{51.6}{215.1}\right) = 13.4^\circ$$

$$R = 221.2 \searrow 13.4^\circ$$

3-31 $R_x = 0 + 60 \sin 40 - 30 - 50 \cos 30$
 $- 20 \sin 50 = -50.05$

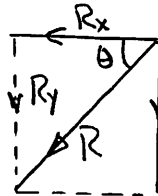
$R_y = -40 - 60 \cos 40 - 0 - 50 \sin 30 + 20 \cos 50$
 $= -98.11$

$$R = \sqrt{(-50.05)^2 + (98.11)^2}$$

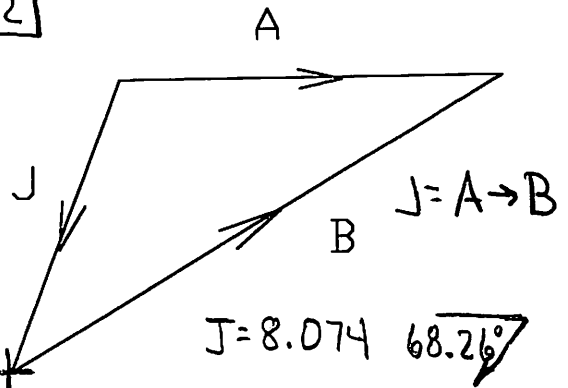
$$= 110.14$$

$$\theta = \tan^{-1}\left(\frac{98.11}{50.05}\right) = 62.97^\circ$$

$$R = 110.14 \searrow 62.97^\circ$$

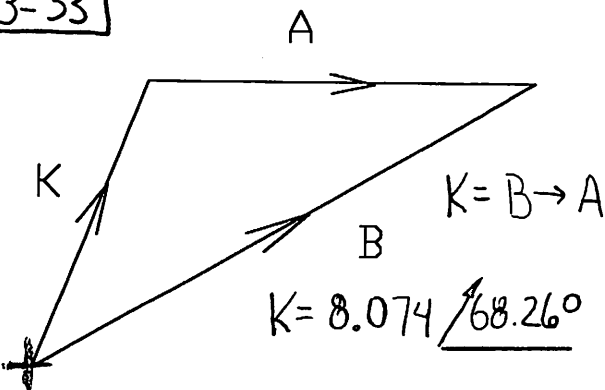


3-32



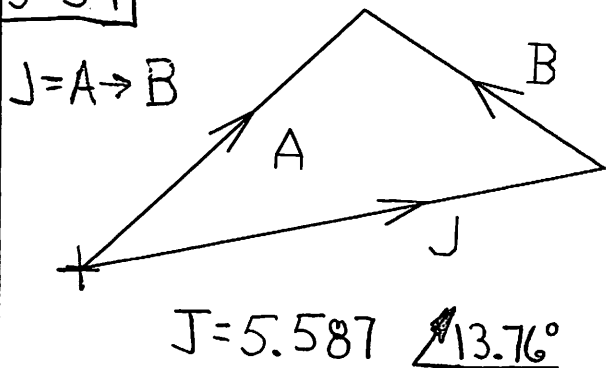
$$J = 8.074 \searrow 68.26^\circ$$

3-33



$$K = 8.074 \searrow 68.26^\circ$$

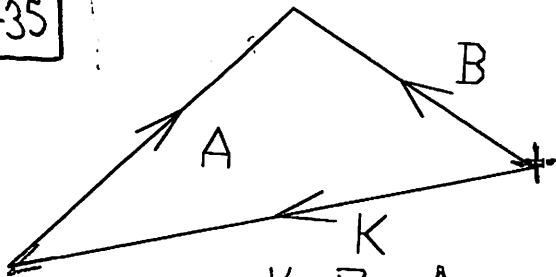
3-34



$$J = 5.587 \searrow 13.76^\circ$$

13.782
 26.564
 42.382
 58.264
 74.166
 90.050
 105.934
 121.816
 137.702
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 185.354
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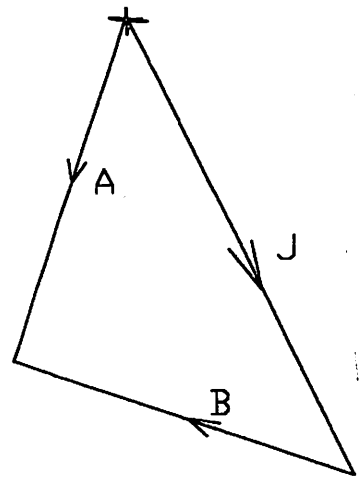
3-35



Measuring:
 $K = B \rightarrow A$
 $K = 5.587 \quad 13.76^\circ$

3-36

$J = A \rightarrow B$
 Measuring:
 $J = 212.13 \quad 65^\circ$

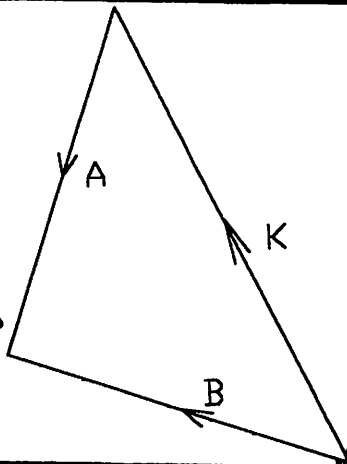


3-37

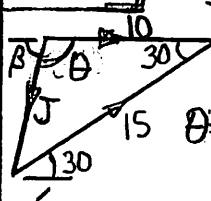
$K = B \rightarrow A$

Measuring:

$K = 212.13 \quad 65^\circ$



3-38



$J = \sqrt{10^2 + 15^2 - 2(10)(15)\cos 30}$
 $= 8.074$

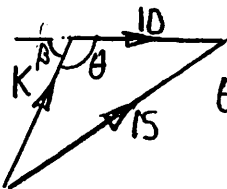
$\theta = \cos^{-1}\left(\frac{8.074^2 + 10^2 - 15^2}{2(8.074)(10)}\right) = 111.74^\circ$

$\beta = 180 - 111.74 = 68.26^\circ$

$J = 8.074 \quad 68.26^\circ$

3-39

$K = \sqrt{10^2 + 15^2 - 2(10)(15)\cos 30}$
 $= 8.074$

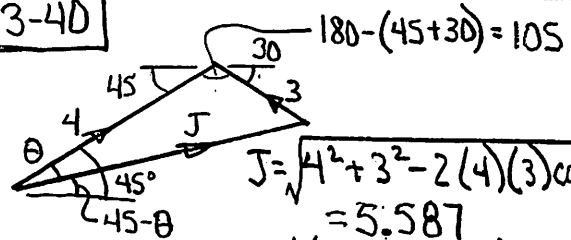


$\theta = \cos^{-1}\left(\frac{8.074^2 + 10^2 - 15^2}{2(8.074)(10)}\right)$
 $= 111.74^\circ$

$\beta = 180 - \theta = 68.26$

$K = 8.074 \quad 68.26^\circ$

3-40



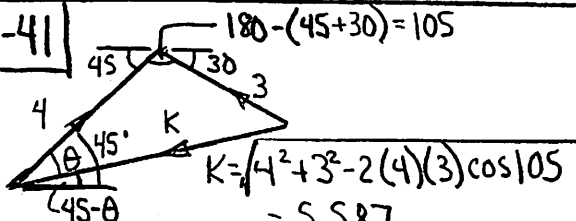
$J = \sqrt{4^2 + 3^2 - 2(4)(3)\cos 105}$
 $= 5.587$

$\theta = \sin^{-1}\left(\frac{3}{5.587} \sin 105\right) = 31.24^\circ$

$45 - \theta = 13.76^\circ$

$J = 5.587 \quad 13.76^\circ$

3-41



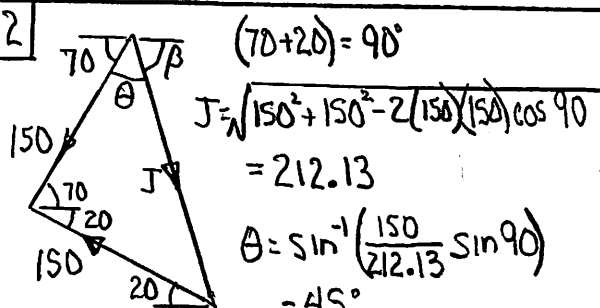
$K = \sqrt{4^2 + 3^2 - 2(4)(3)\cos 105}$
 $= 5.587$

$\theta = \sin^{-1}\left(\frac{3}{5.587} \sin 105\right) = 31.24^\circ$

$45 - \theta = 13.76^\circ$

$K = 5.587 \quad 13.76^\circ$

3-42



$J = \sqrt{150^2 + 150^2 - 2(150)(150)\cos 90}$
 $= 212.13$

$\theta = \sin^{-1}\left(\frac{150}{212.13} \sin 90\right)$
 $= 45^\circ$

$\beta = 180 - (\theta + 70) = 65^\circ$

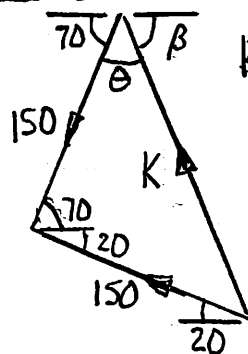
$J = 212.13 \quad 65^\circ$

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3-43

70+20=90



$$K = \sqrt{150^2 + 150^2 - 2(150)(150)\cos 90}$$

$$= 212.13$$

$$\theta = \sin^{-1}\left(\frac{150}{212.13} \sin 90\right)$$

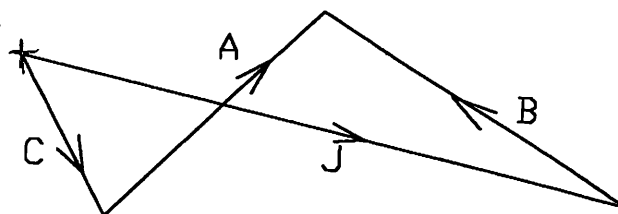
$$= 45^\circ$$

$$\beta = 180 - (\theta + 70) = 65^\circ$$

$$K = 212.13 \quad 65^\circ$$

3-44

J = C + A → B

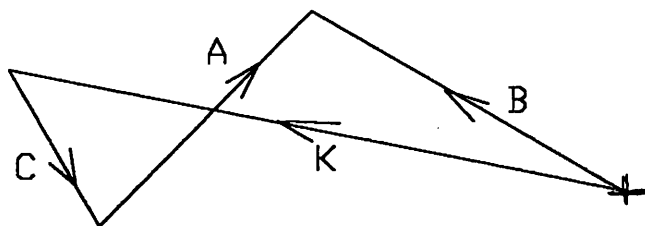


Measuring:

$$J = 26.094 \quad \sqrt{11.40^\circ}$$

3-45

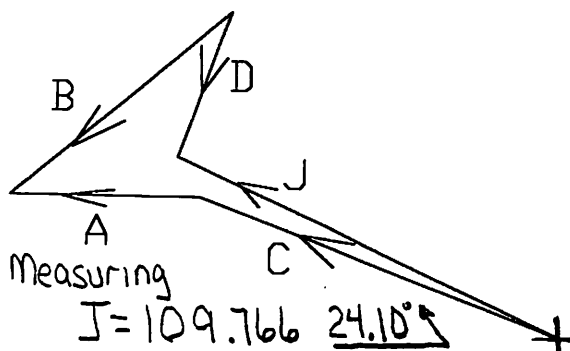
K = B → A → C



Measuring: K = 26.094 $\sqrt{11.40^\circ}$

3-46

J = C + A → B + D

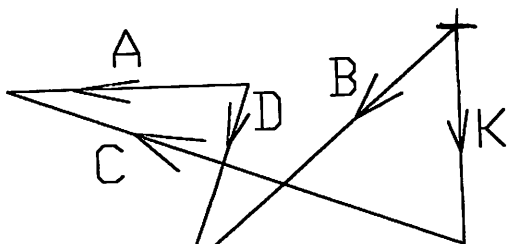


Measuring

$$J = 109.766 \quad 24.10^\circ$$

3-47

K = B → D + A → C

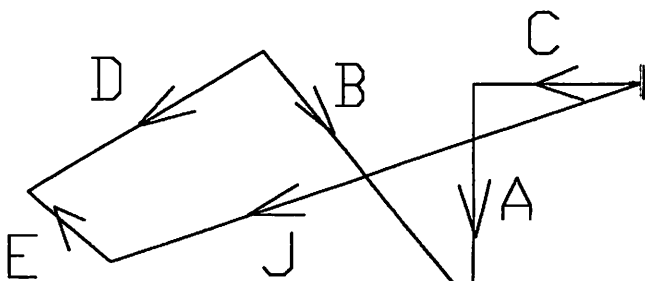


Measuring:

$$K = 44.824 \quad \sqrt{89.75^\circ}$$

3-48

J = C + A → B + D → E

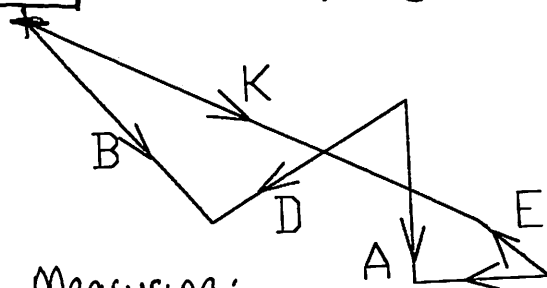


Measuring:

$$J = 101.679 \quad \sqrt{18.28^\circ}$$

3-49

K = B → D + A → C + E



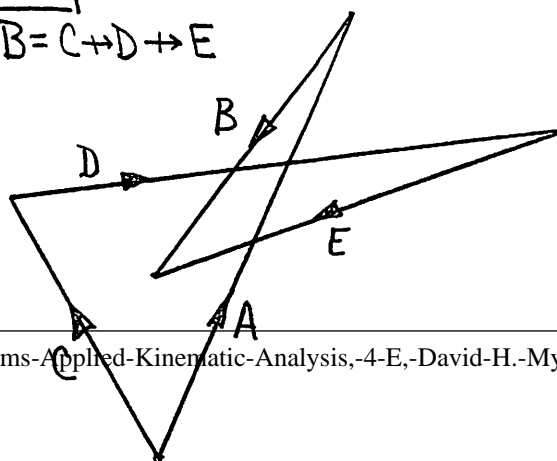
Measuring:

$$K = 107.819 \quad \sqrt{26.40^\circ}$$

3-50

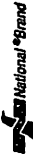
A → D + B = C → E

A → B = C + D + E

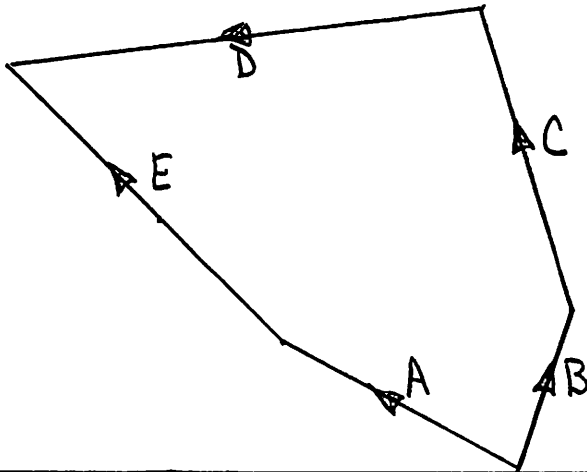


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3-51 | $A \rightarrow C \rightarrow E = D \rightarrow B$
 $A \rightarrow E = B \rightarrow C \rightarrow D$



3-52 | $J = C \rightarrow A \rightarrow B$

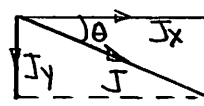
$$J_x = (7.5 \cos 60) + (12.5 \cos 45) - (-15 \cos 30) = 25.58$$

$$J_y = (-7.5 \sin 60) + (12.5 \sin 45) - (15 \sin 30) = -5.16$$

$$J = \sqrt{(25.58)^2 + (-5.16)^2} = 26.10$$

$$\theta = \tan^{-1}(5.16/25.58) = 11.40^\circ$$

$$J = 26.10 \swarrow 11.40^\circ$$



3-53 | $K = B \rightarrow A \rightarrow C$

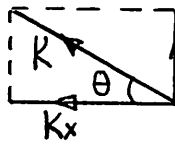
$$K_x = (-7.5 \cos 30) - (12.5 \cos 45) - (7.5 \cos 60) = -25.58$$

$$K_y = (15 \sin 30) - (12.5 \sin 45) - (-7.5 \sin 60) = 5.16$$

$$K = \sqrt{(-25.58)^2 + (5.16)^2} = 26.10$$

$$\theta = \tan^{-1}(5.16/25.58) = 11.40^\circ$$

$$K = 26.10 \searrow 11.40^\circ$$



3-54 | $J = C \rightarrow A \rightarrow B \rightarrow D$

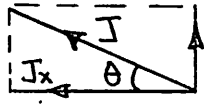
$$J_x = (-100 \cos 20) + (-50) - (-75 \cos 40) + (-40 \cos 70) = -100.2$$

$$J_y = (100 \sin 20) + (0) - (-75 \sin 40) + (-40 \sin 70) = 44.8$$

$$J = \sqrt{(-100.2)^2 + (44.8)^2} = 109.8$$

$$\theta = \tan^{-1}(44.8/109.8) = 24.1^\circ$$

$$J = 109.8 \swarrow 24.1^\circ$$



3-55 | $K = B \rightarrow D \rightarrow A \rightarrow C$

$$K_x = (-75 \cos 40) - (-40 \cos 70) + (-50) - (-100 \cos 20) = 0.20$$

$$K_y = (-75 \sin 40) - (-40 \sin 70) + (0) - (100 \sin 20) = -44.82$$

$$K = \sqrt{(0.20)^2 + (-44.82)^2} = 44.82$$

$$\theta = \tan^{-1}(44.82/0.2) = 89.7^\circ$$

$$K = 44.82 \swarrow 89.7^\circ$$



3-56 | $J = C \rightarrow A \rightarrow B \rightarrow D \rightarrow E$

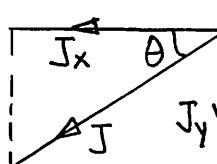
$$J_x = (-30) + (0) - (60 \sin 40) + (-50 \cos 30) - (-20 \sin 50) = -96.55$$

$$J_y = 0 + (-40) - (-60 \cos 40) + (-50 \sin 30) - (20 \cos 50) = -31.89$$

$$J = \sqrt{(-96.55)^2 + (-31.89)^2} = 101.68$$

$$\theta = \tan^{-1}(31.89/96.55) = 18.3^\circ$$

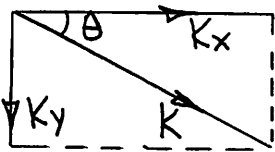
$$J = 101.68 \swarrow 18.3^\circ$$



3-57 $K = B \rightarrow D \rightarrow A \rightarrow C \rightarrow E$

$$K_x = (60 \sin 40) - (-50 \cos 30) + (0) - (-30) + (-20 \sin 50) = 96.54$$

$$K_y = (-60 \cos 40) - (-50 \sin 30) + (-40) - 0 + (20 \cos 50) = -48.11$$



$$K = \sqrt{(96.54)^2 + (-48.11)^2} = 107.86$$

$$\theta = \tan^{-1}\left(\frac{48.11}{96.54}\right) = 26.5^\circ$$

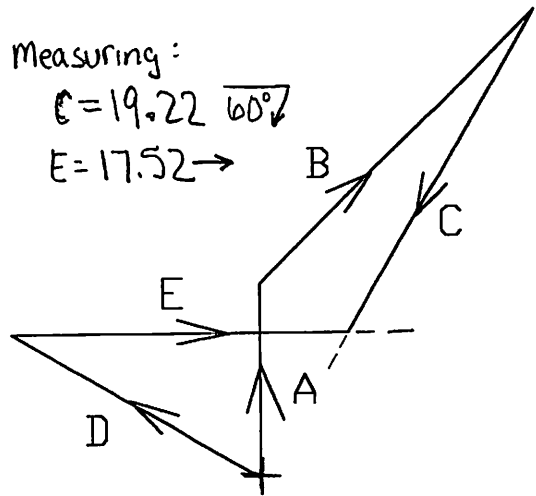
$$K = 107.86 \swarrow 26.5^\circ$$

3-58 $A \rightarrow B \rightarrow C = D \rightarrow E$

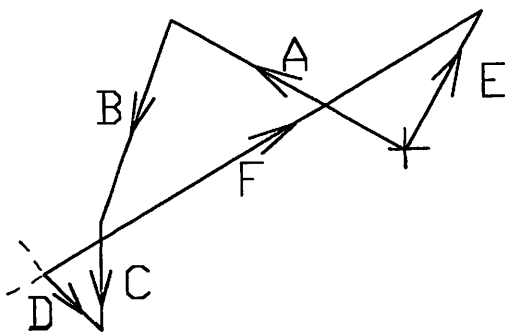
Measuring:

$$C = 19.22 \overline{60^\circ}$$

$$E = 17.52 \rightarrow$$



3-59 $A \rightarrow B \rightarrow C \rightarrow D = E \rightarrow F$



Measuring:

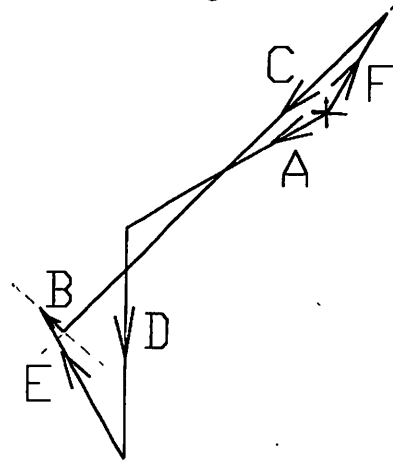
$$D = 38.12 \swarrow 45^\circ$$

$$F = 238.9 \nearrow 30^\circ$$

3-60 $A \rightarrow B \rightarrow C \rightarrow D = E \rightarrow F$

rewriting:

$$A \rightarrow D \rightarrow E \rightarrow B = F \rightarrow C$$



measuring

$$B = 8.81 \swarrow 45^\circ \quad C = 117.7 \overline{45^\circ}$$

3-61 $A \rightarrow B \rightarrow C = D \rightarrow E$

assume directions $C \nearrow E, \rightarrow$

horiz:

$$0 + (20 \cos 45) + C \cos 60 = -15 \cos 30 + E$$

vert:

$$10 + (20 \sin 45) + C \sin 60 = 15 \sin 30 + 0$$

$$C = -19.2$$

$$\text{substituting } \Rightarrow E = 17.5$$

3-62 $A \rightarrow B \rightarrow C \rightarrow D = E \rightarrow F$

horiz assume directions $D \nearrow, F \nearrow$

$$(-125 \cos 30) + (-100 \cos 70) + (0) - (-D \cos 45) = (75 \cos 60) - (F \cos 30)$$

$$D = (179.95 - F \cos 30) / \cos 45 \quad \text{--- (1)}$$

vert:

$$(125 \sin 30) + (-100 \sin 70) + (-50) - (D \sin 45) = (75 \sin 60) - (F \sin 30)$$

$$D = (F \sin 30 - 146.42) / \sin 45 \quad \text{--- (2)}$$

using (1) + (2) simultaneous

$$F = 238.9, D = -38.12$$

$$F = 238.9 \nearrow 30^\circ \quad D = 38.12 \swarrow 45^\circ$$

$$3-63 \mid A \rightarrow B \rightarrow C \rightarrow D = \rightarrow E \rightarrow F$$

assume directions $B \nwarrow$, $C \nearrow$

horiz:

$$\begin{aligned}(-60 \cos 30) - (-B \cos 45) - (C \cos 45) + 0 \\ = -(-45 \cos 60) + (30 \sin 30) \\ B = (C \cos 45 + 89.46) / \cos 45 \quad \text{--- ①}\end{aligned}$$

vert:

$$\begin{aligned}(-60 \sin 30) - (B \sin 45) - (C \sin 45) + (-60) \\ = -(45 \sin 60) + (30 \cos 30) \\ B = (-77.0 - C \sin 45) / \sin 45 \quad \text{--- ②}\end{aligned}$$

Solving ① + ② simultaneously

$$B = 8.81, C = -117.7$$

$$B = 8.81 \quad \underline{45^\circ \nwarrow} \quad C = 117.7 \quad \underline{45^\circ \nearrow}$$

13,782 500 SHEETS FULLER 5 SQUARE
42,391 50 SHEETS FULLER 5 SQUARE
42,392 100 SHEETS FULLER 5 SQUARE
42,393 200 SHEETS FULLER 5 SQUARE
42,394 500 SHEETS FULLER 5 SQUARE
42,395 200 RECYCLED WHITE 5 SQUARE
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National Brand

Answers to the Chapter 3 Case Study Questions:

Case 3-1.

1. As key 2 is pressed, rocker plate A rotates back, or clockwise in the left end-view.
2. Spring C provides resistance to rotating the rocker plate, counterclockwise in the left end view.
3. Spring B provides resistance to pressing the keys, 1 and 2.
4. As key 2 is pressed, the rocker plate A rotates back, and releases key 1. The Spring under key 1 forces key 1 into an upward position.
5. The purpose of this mechanism is to hamper two keys from being in the downward position at the same time.
6. Spring B, acting on key 1, is in compression and forcing button 1 upward.
7. Spring C is in tension, forcing rocker plate A to rotate counterclockwise in the right end view. Stop D prevents any further rotation than the position shown.
8. A cassette tape player uses similar mechanical means to prevent the play, rewind or fast forward buttons to be pressed at the same time.
9. As mentioned, pin D serves as a stop for rocker plate A. It prevents further clockwise rotation as seen from the right end view.

Case 3-2.

1. As driveshaft A turns, collar B also turns because of a keyed connection.
2. The motion of the shaft and collar is transmitted to gear C because the protrusion of link D is seated into the notch in collar B.
3. If link D were forced upward, the protrusion would come out of the notch in collar B. Nothing would be left driving gear C, so it would stop rotating.
4. Link D would dislodge from the notch if gear C would be exposed to significant resistance to rotation.
5. The tendency of link D to have upward motion must overcome the spring tension.
6. This device is intended to stop the rotation of the gear, if significant resistance is encountered.
7. Such a device is called a slip clutch.
8. This device would stop the winding mechanism if wire became jammed, thus supplying resistance on gear C.
9. To reset this device, link D must be placed under link F and aligned with the notch in collar B.
10. The spring must be in tension. Therefore, it pulls link F to the right, and link E to the left.

Case 3-3.

1. As handle A is rotated, moving threaded rod B to the left, grip C also moves to the left and slightly upward. Notice that links E and F are pivoting in the middle, thus grip C is constrained to a swinging motion.
2. As handle A is rotated, moving threaded rod B to the left, grip D moves to the right and slightly downward. Since links E and F are pivoting in the middle, grip D will have motion opposing grip C.
3. The purpose of this mechanism is to serve as a machining clamp for the workpiece.
4. The spring, G, pulling on link D would cause it to return to an upward and rightward position.
5. The purpose of spring G is, ultimately, to keep a positive contact between the threaded rod and link C.
6. Links E and F have a peculiar configuration to avoid interference with the workpiece, throughout the range of motion of the clamp.
7. Such a device could be called a machining clamp.
8. Since link C is moving in a swinging motion, the rounded end on the threaded rod, assures a consistent point contact with link C.