

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) $\tan \theta = \frac{6}{4} \Rightarrow \theta = 56.3^\circ //$
 $R = \sqrt{(6)^2 + (4)^2} = 7.2 \text{ m} //$

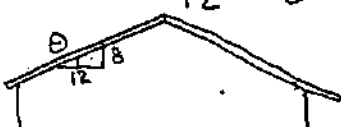
3-6 $\tan \beta = \frac{x}{y} = \frac{150}{275} \Rightarrow \beta = 28.6^\circ //$
 hypotenuse = 2s
 $2s = \sqrt{(150)^2 + (275)^2} \Rightarrow s = 156.6 \text{ mm} //$

b) $\theta = 180 - (90 + 60) = 30^\circ //$
 $\cos 30^\circ = \frac{5}{R} \Rightarrow R = 5.8 \text{ in} //$
 c) $\tan \theta = \frac{5}{8} \Rightarrow \theta =$
 $R = \sqrt{(5)^2 + (8)^2} = 9.4 \text{ in} //$

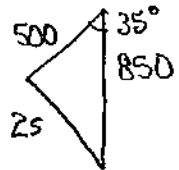
3-7 $\tan 35^\circ = \frac{x}{16} \Rightarrow x = 11.2 \text{ in} //$
 $2s = \sqrt{(16)^2 + (11.2)^2} \Rightarrow s = 9.8 \text{ m} //$

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

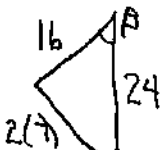
3-9 $\tan \theta = \frac{\theta}{12} \Rightarrow \theta = 33.7^\circ //$



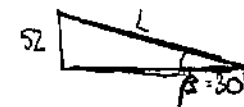
3-10 500 35° law of cosines
 850
 $2s$
 $2s = \sqrt{(500)^2 + (850)^2 - 2(500)(850)\cos 35}$
 $s = 175 \text{ mm} //$



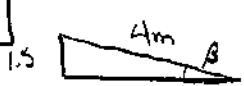
3-11 $\cos \beta = \frac{(16)^2 + (14)^2 - (24)^2}{2(16)(14)}$
 $A = 42.9^\circ //$



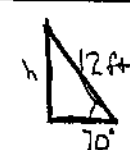
3-12 52 L
 $\beta = 30^\circ$
 $L = 52 / \sin 30$
 $= 104 \text{ in} //$
 $104 \text{ in} (1 \text{ ft} / 12 \text{ in})$
 $= 8 \text{ ft } 8 \text{ in} //$




3-13 1.5 4 m β
 $\sin \beta = 1.5/4 \Rightarrow \beta = 22.0^\circ //$



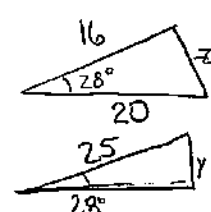
3-14 12 ft h 70°
 $\sin 70^\circ = \frac{h}{12}$
 $h = 11.3 \text{ ft} //$




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



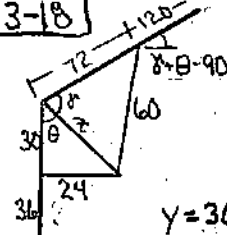
3-16 16 20 28° law of cosines
 $z = \sqrt{(16)^2 + (20)^2 - 2(16)(20)\cos 28}$
 $= 9.5 \text{ ft} //$
 $\sin 28^\circ = \frac{y}{25}$
 $\Rightarrow y = 11.7 \text{ ft} //$



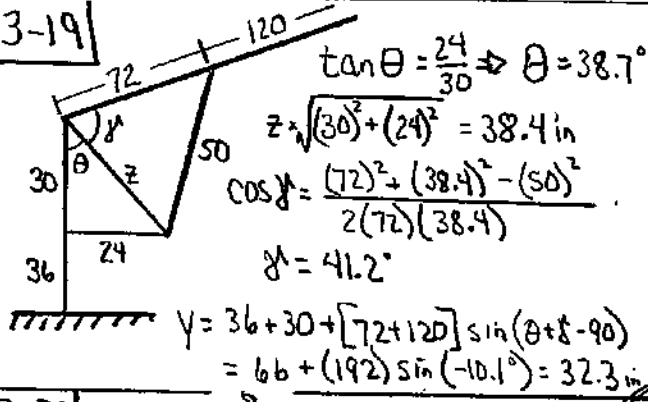
3-17 13 8 β
 $\sin \beta = 8/13 \Rightarrow \beta = 38.0^\circ //$



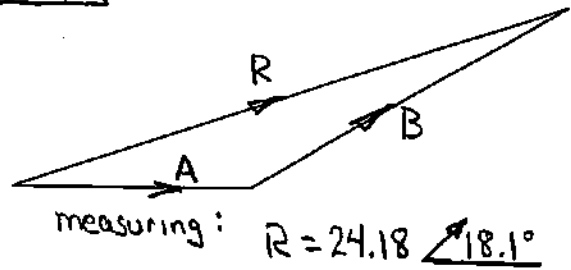
3-18 72 120 30° 60 8 $\theta = 90$
 $\tan \theta = 24/30 \Rightarrow \theta = 38.7^\circ //$
 $z = \sqrt{(24)^2 + (30)^2} = 38.4 \text{ m}$
 $\cos \beta = \frac{(72)^2 + (38.4)^2 - (60)^2}{2(72)(38.4)} \Rightarrow \beta = 56.4^\circ //$
 $y = 36 + 30 + [72 + 120] \sin(38.7 + 56.4 - 90) = 83.1 //$



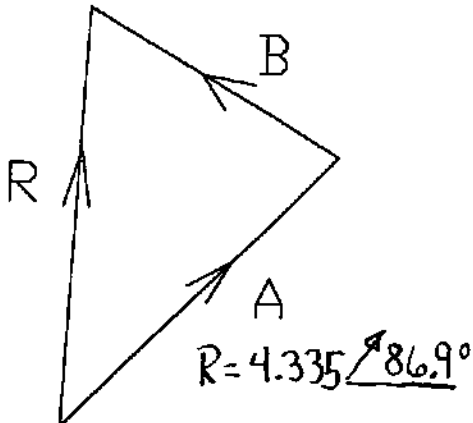
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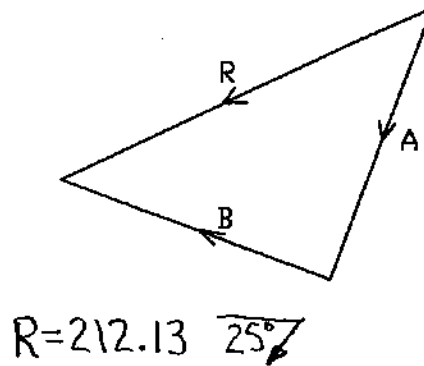
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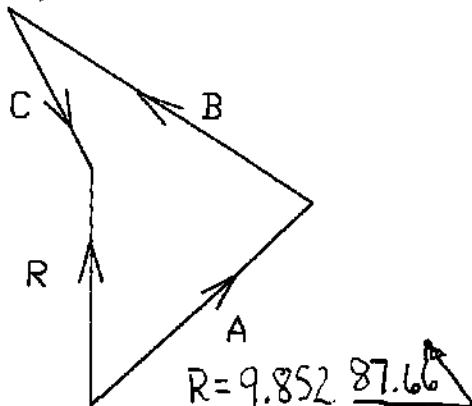
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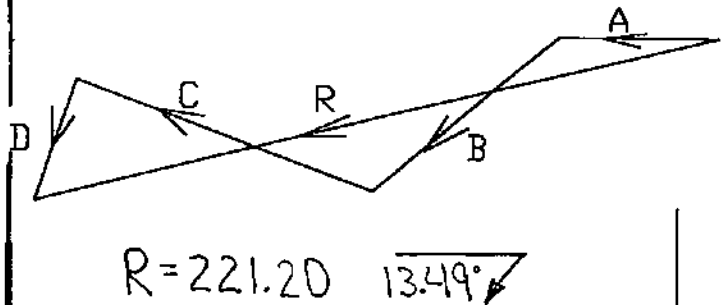
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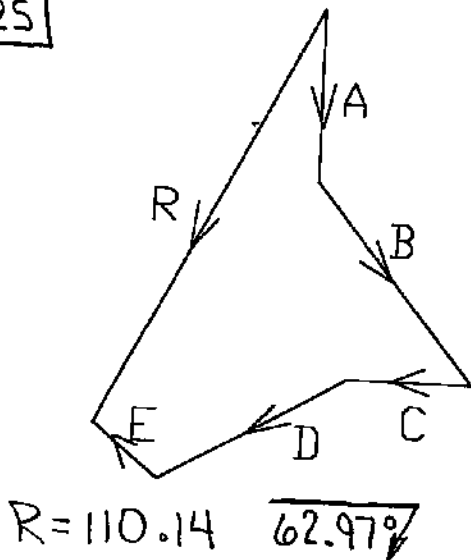
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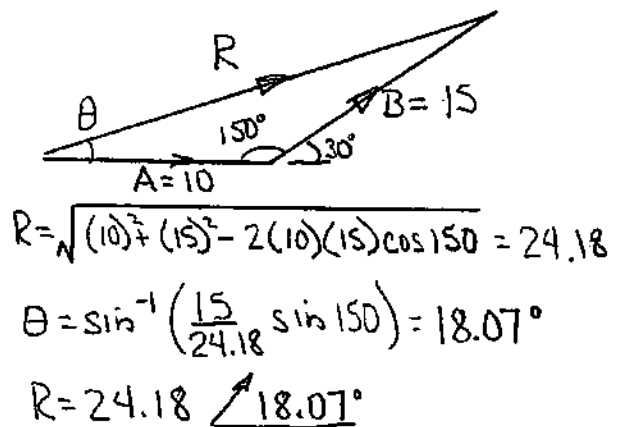
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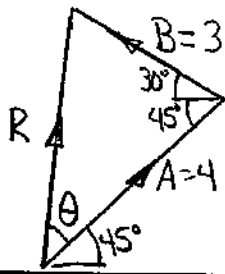
3-25



3-26



3-27

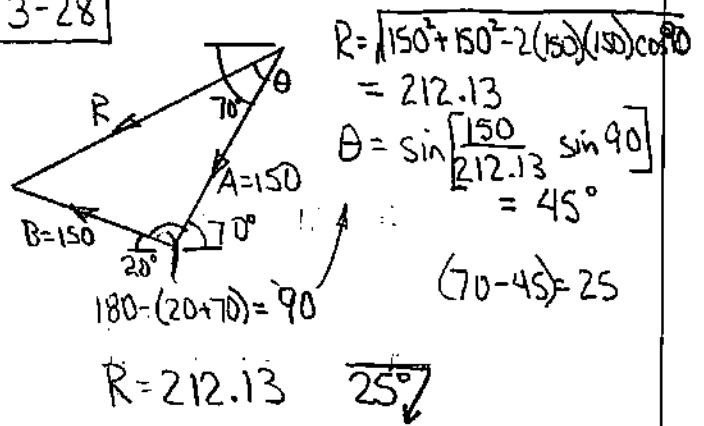


$$R = \sqrt{(4)^2 + (3)^2 - 2(4)(3)\cos 75^\circ} = 4.335$$

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

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

3-28



$$R = \sqrt{150^2 + 150^2 - 2(150)(150)\cos 50^\circ}$$

$$= 212.13$$

$$\theta = \sin^{-1} \left[\frac{150}{212.13} \sin 50^\circ \right]$$

$$= 45^\circ$$

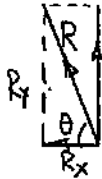
$$(70 - 45) = 25$$

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

$$3-29 \quad R_x = 12.5 \cos 45^\circ - 15 \cos 30^\circ + 7.5 \cos 60^\circ$$

$$= -0.40$$

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



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

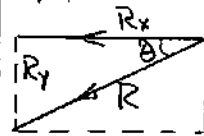
$$\theta = \tan^{-1} \left(\frac{9.84}{0.40} \right) = 87.66^\circ$$

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

$$3-30 \quad R_x = -50 - 75 \cos 40^\circ - 100 \cos 20^\circ$$

$$- 40 \cos 70^\circ = -215.1$$

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



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

$$= 221.2$$

$$\theta = \tan^{-1} \frac{51.6}{215.1} = 13.4^\circ$$

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

$$3-31 \quad R_x = 0 + 60 \sin 40^\circ - 30 - 50 \cos 30^\circ$$

$$- 20 \sin 50^\circ = -50.05$$

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

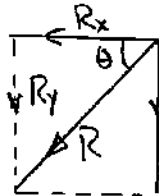
$$= -98.11$$

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

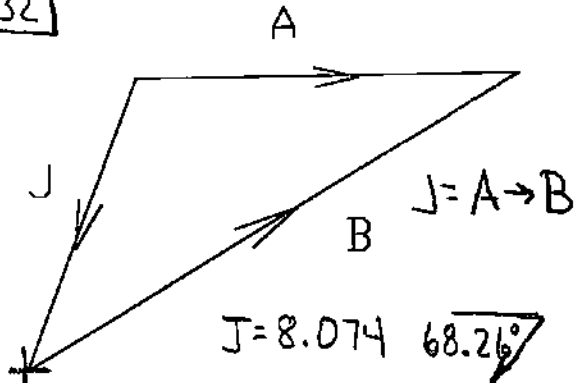
$$= 110.14$$

$$\theta = \tan^{-1} \frac{98.11}{50.05} = 62.97^\circ$$

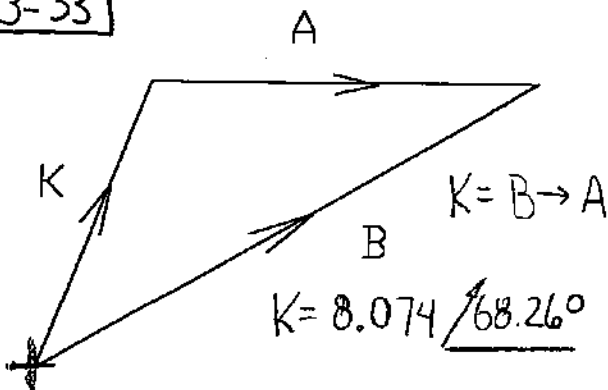
$$R = 110.14 \swarrow 62.97^\circ$$



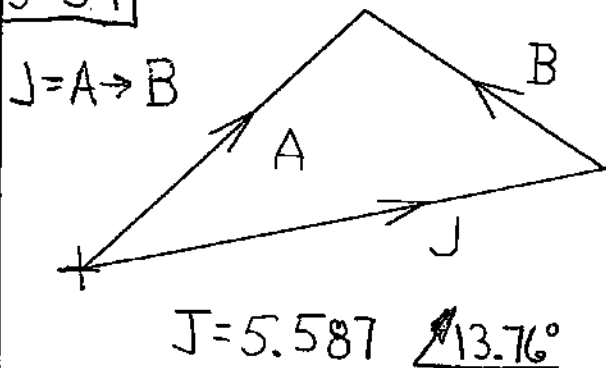
3-32



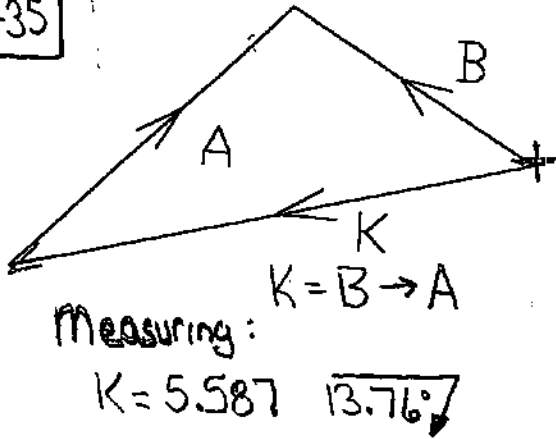
3-33



3-34



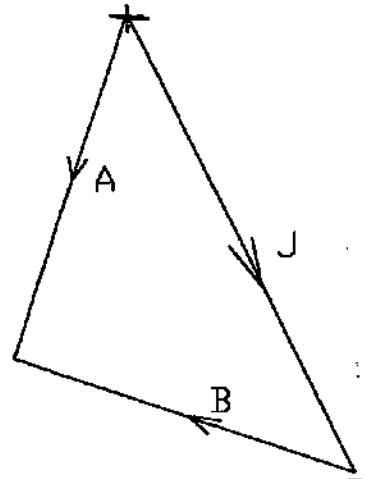
3-35



3-36

$$J = A \rightarrow B$$

Measuring:
 $J = 212.13 \quad 65^\circ$

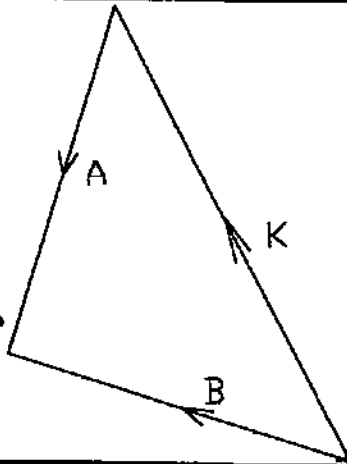


3-37

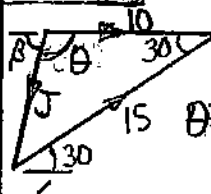
$$K = B \rightarrow A$$

Measuring:

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



3-38



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

$$= 8.074$$

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

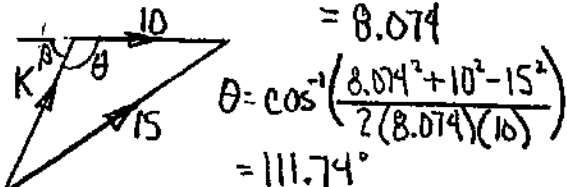
$$\beta = 180 - 111.74 = 68.26^\circ$$

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

3-39

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

$$= 8.074$$



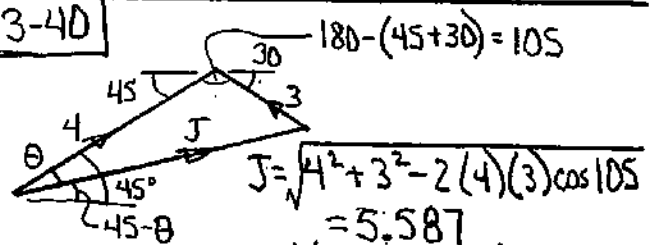
$$\theta = \cos^{-1}\left(\frac{8.074^2 + 10^2 - 15^2}{2(8.074)(10)}\right)$$

$$= 111.74^\circ$$

$$\beta = 180 - \theta = 68.26$$

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

3-40



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

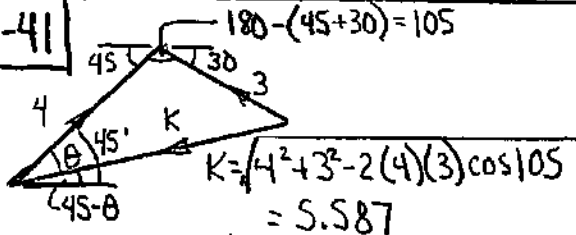
$$= 5.587$$

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

$$45 - \theta = 13.76^\circ$$

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

3-41



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

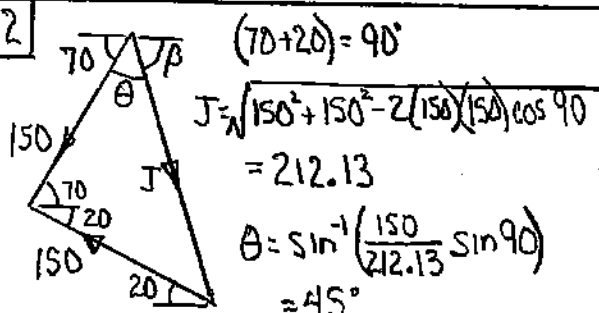
$$= 5.587$$

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

$$45 - \theta = 13.76^\circ$$

$$K = 5.587 \quad 13.76^\circ$$

3-42



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

$$= 212.13$$

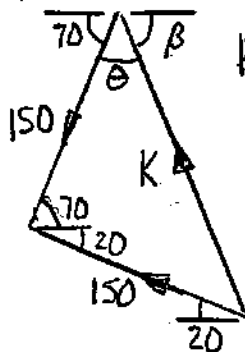
$$\theta = \sin^{-1}\left(\frac{150}{212.13} \sin 90\right)$$

$$= 45^\circ$$

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

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

3-43



$70+20=90$

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

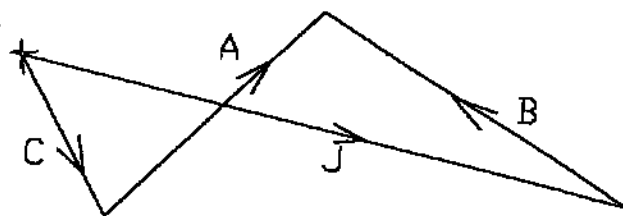
$\theta = \sin^{-1}\left(\frac{150}{212.13} \sin 90\right)$
 $= 45^\circ$

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

$K = 212.13 \quad 65^\circ$

3-44

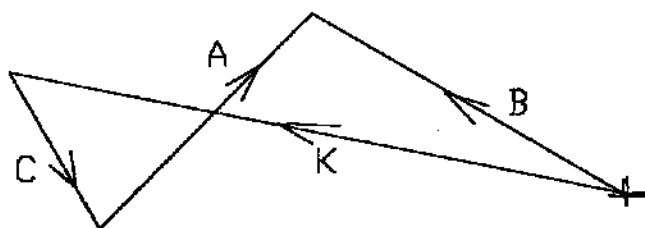
$J = C + A \rightarrow B$



Measuring:
 $J = 26.094 \quad 11.40^\circ$

3-45

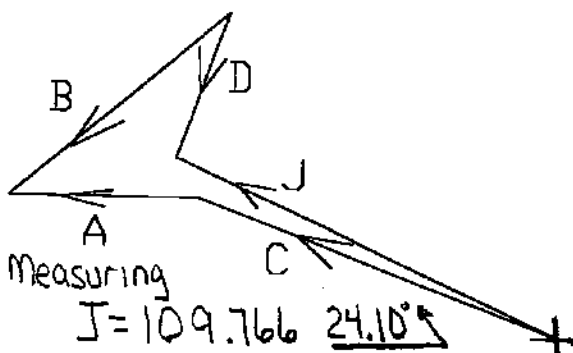
$K = B \rightarrow A \rightarrow C$



Measuring: $K = 26.094 \quad 11.40^\circ$

3-46

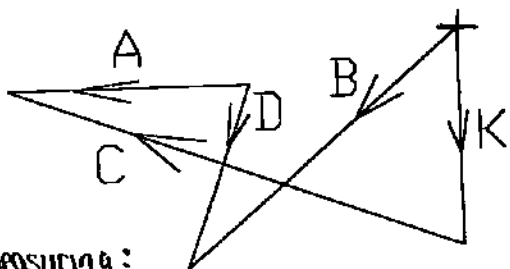
$J = C + A \rightarrow B + D$



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

3-47

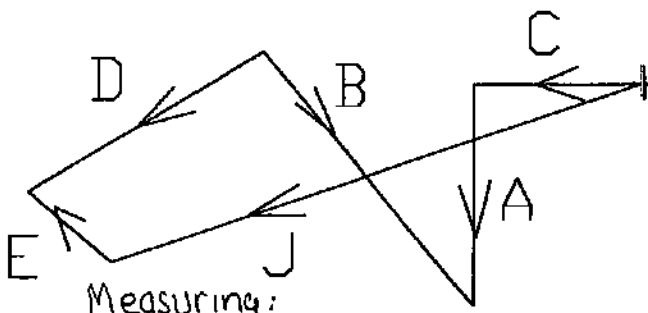
$K = B \rightarrow D + A \rightarrow C$



Measuring:
 $K = 44.824 \quad 89.75^\circ$

3-48

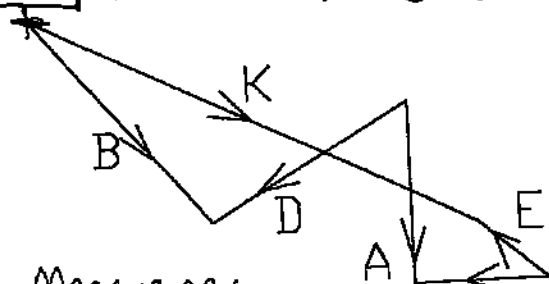
$J = C + A \rightarrow B + D \rightarrow E$



Measuring:
 $J = 101.679 \quad 18.28^\circ$

3-49

$K = B \rightarrow D + A \rightarrow C + E$

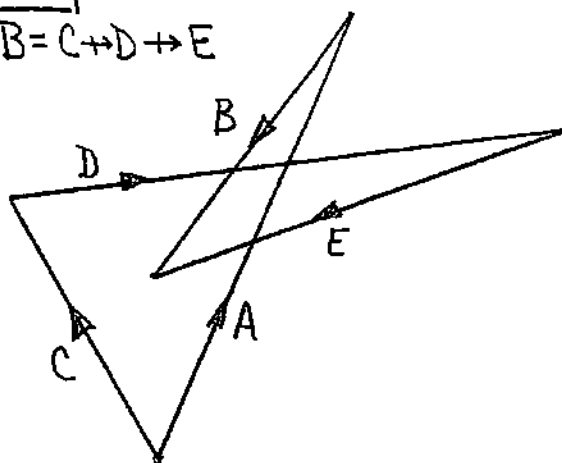


Measuring:
 $K = 107.869 \quad 26.49^\circ$

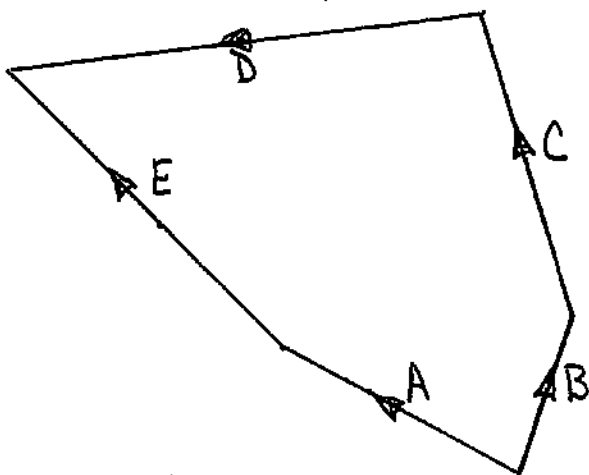
3-50

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

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



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



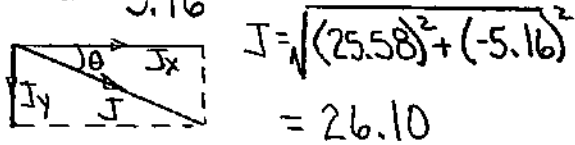
3-52 | $J = C + A \rightarrow B$

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

$$= 25.58$$

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

$$= -5.16$$



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

$$= 26.10$$

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

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

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

$$K_x = (75 \cos 30) - (12.5 \cos 45) - (7.5 \cos 60)$$

$$= -25.58$$

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

$$= 5.16$$

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

$$= 26.10$$

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

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

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

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

$$+ (-40 \cos 70) = -100.2$$

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

$$+ (-40 \sin 70) = 44.8$$

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

$$= 109.8$$

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

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

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

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

$$- (-100 \cos 20) = 0.20$$

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

$$- (100 \sin 20) = -44.82$$

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

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

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

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

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

$$- (-20 \sin 50) = -96.55$$

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

$$- (20 \cos 50) = -31.89$$

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

$$= 101.68$$

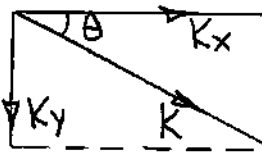
$$\theta = \tan^{-1}(31.89/96.55) = 18.3^\circ$$

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

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

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

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



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

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

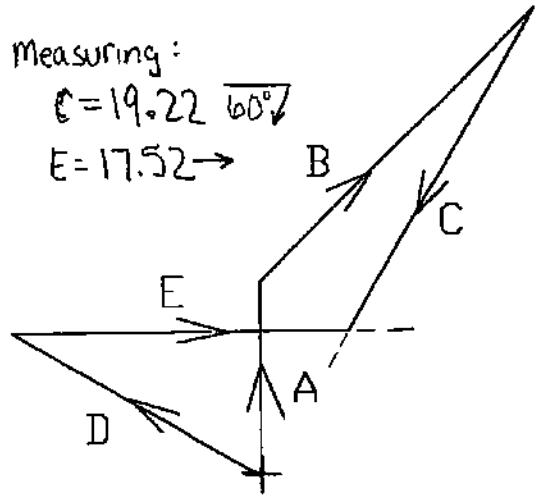
$$K = 107.86 \angle 26.5^\circ$$

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

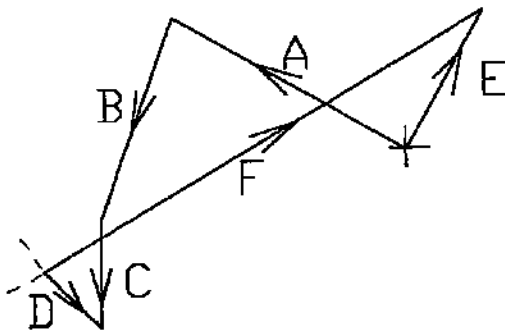
measuring:

$$C = 19.22 \angle 60^\circ$$

$$E = 17.52 \rightarrow$$



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



Measuring:

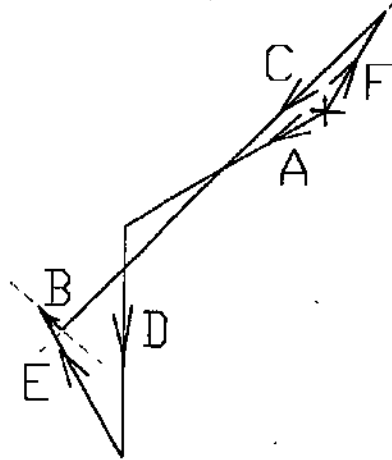
$$D = 38.12 \angle 45^\circ$$

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

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

rewriting:

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



measuring

$$B = 8.81 \angle 45^\circ \quad C = 117.7 \angle 45^\circ$$

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:

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

$$C = -19.2$$

substituting $\Rightarrow E = 17.5$

$$C = 19.22 \angle 60^\circ \quad E = 17.52 \rightarrow$$

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

$$F = 23.89, \quad D = -38.12$$

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

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

assume directions $B \nwarrow, C \nearrow$

horiz:

$$(-60 \cos 30) - (-B \cos 45) - (C \cos 45) + 0$$

$$= -(-45 \cos 60) + (30 \sin 30)$$

$$B = (C \cos 45 + 89.46) / \cos 45 \quad \text{--- ①}$$

vert:

$$(-60 \sin 30) - (B \sin 45) - (C \sin 45) + (-60)$$

$$= -(45 \sin 60) + (30 \cos 30)$$

$$B = (-77.0 - C \sin 45) / \sin 45 \quad \text{--- ②}$$

Solving ① + ② simultaneously

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

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

12, 18, 24, 30, 36, 42, 48, 54, 60, 66, 72, 78, 84, 90, 96, 102, 108, 114, 120
100 SHEETS FULLER SQUARE
100 SHEETS FULLER 45° SQUARE
100 SHEETS FULLER 60° SQUARE
100 SHEETS FULLER 30° SQUARE
100 SHEETS FULLER 45° SQUARE
100 SHEETS FULLER 60° SQUARE
100 SHEETS FULLER 30° SQUARE
100 SHEETS FULLER 45° SQUARE
100 SHEETS FULLER 60° SQUARE
100 SHEETS FULLER 30° SQUARE
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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.