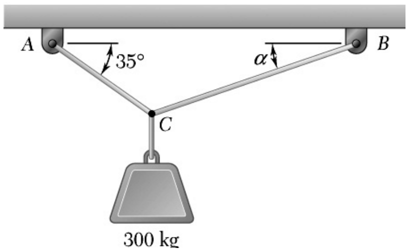
## PROBLEM 2.59

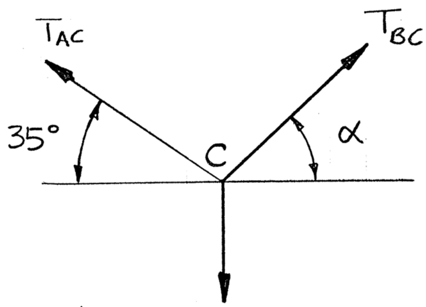



For the cables and loading of Problem 2.46, determine (*a*) the value of $\alpha$ for which the tension in cable *BC* is as small as possible, (*b*) the corresponding value of the tension.

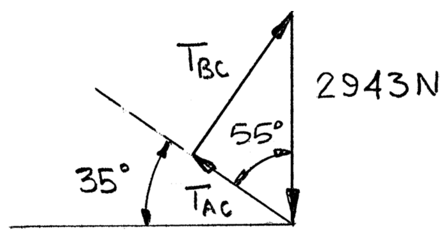
## SOLUTION

The smallest $T_{BC}$ is when $T_{BC}$ is perpendicular to the direction of $T_{AC}$

**Free-Body Diagram At C**




**Force Triangle**




(*a*) $\alpha = 55.0°$ ◀

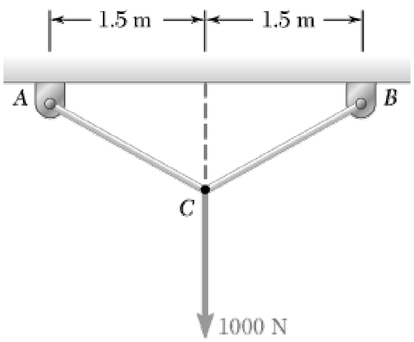
(*b*)

$$T_{BC} = (2943 \text{ N})\sin 55°$$

$$= 2410.8 \text{ N}$$

$T_{BC} = 2.41 \text{ kN}$ ◀

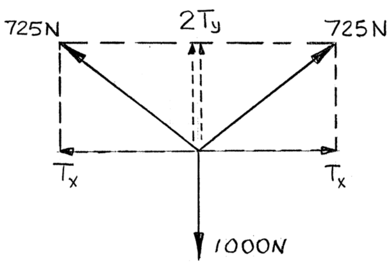
## PROBLEM 2.60




Knowing that portions *AC* and *BC* of cable *ACB* must be equal, determine the shortest length of cable which can be used to support the load shown if the tension in the cable is not to exceed 725 N.

## SOLUTION

**Free-Body Diagram:** C
(For $T = 725$ N)




$$+\uparrow \Sigma F_y = 0: \quad 2T_y - 1000\text{ N} = 0$$

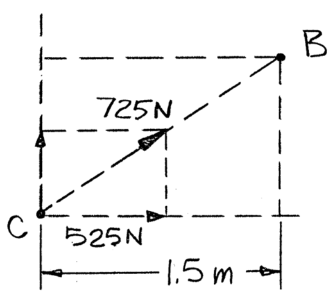
$$T_y = 500\text{ N}$$

$$T_x^2 + T_y^2 = T^2$$

$$T_x^2 + (500\text{ N})^2 = (725\text{ N})^2$$

$$T_x = 525\text{ N}$$

By similar triangles:



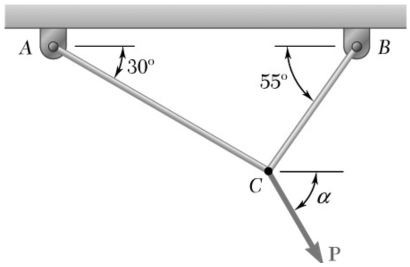

$$\frac{BC}{725} = \frac{1.5\text{ m}}{525}$$

$$\therefore \; BC = 2.07\text{ m}$$

$$L = 2(BC) = 4.14\text{ m}$$

$L = 4.14$ m ◀

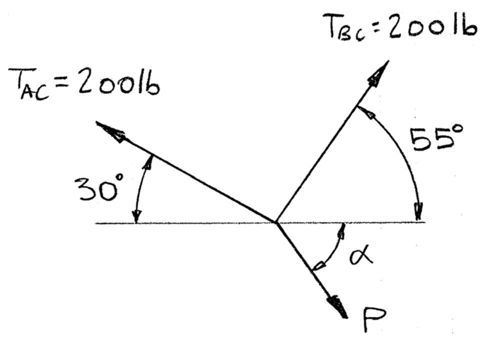
## PROBLEM 2.61



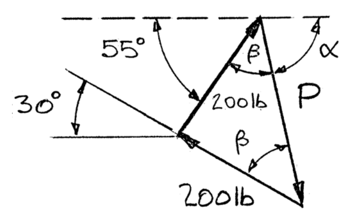

Two cables tied together at $C$ are loaded as shown. Knowing that the maximum allowable tension in each cable is 200 lb, determine (*a*) the magnitude of the largest force **P** which may be applied at $C$, (*b*) the corresponding value of $\alpha$.

## SOLUTION

**Free-Body Diagram: C**




**Force Triangle**




Force triangle is isoceles with

$$2\beta = 180° - 85°$$

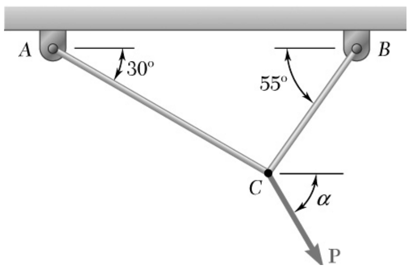
$$\beta = 47.5°$$

(*a*) $$P = 2(200 \text{ lb})\cos 47.5° = 270 \text{ lb}$$

Since $P > 0$, the solution is correct. $P = 270$ lb ◀

(*b*) $$\alpha = 180° - 55° - 47.5° = 77.5°$$ $\alpha = 77.5°$ ◀

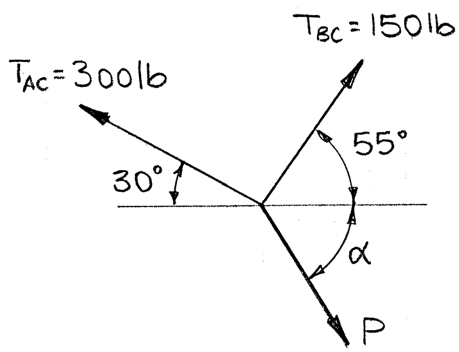
## PROBLEM 2.62



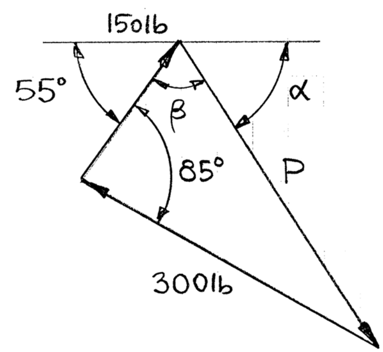

Two cables tied together at $C$ are loaded as shown. Knowing that the maximum allowable tension is 300 lb in cable $AC$ and 150 lb in cable $BC$, determine ($a$) the magnitude of the largest force **P** which may be applied at $C$, ($b$) the corresponding value of $\alpha$.

## SOLUTION

**Free-Body Diagram: C**




**Force Triangle**




($a$) Law of Cosines:

$$P^2 = (300\text{ lb})^2 + (150\text{ lb})^2 - 2(300\text{ lb})(150\text{ lb})\cos 85^\circ$$

$$P = 323.5\text{ lb}$$

Since $P > 300$ lb, our solution is correct. $P = 324\text{ lb}$ ◀

($b$) Law of Sines:

$$\frac{\sin\beta}{300} = \frac{\sin 85^\circ}{323.5^\circ}$$

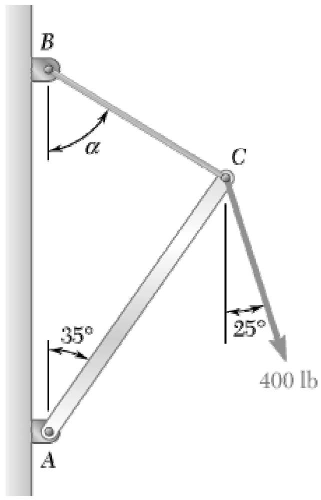
$$\sin\beta = 0.9238$$

or $$\beta = 67.49^\circ$$

$$\alpha = 180^\circ - 55^\circ - 67.49^\circ = 57.5^\circ$$

$\alpha = 57.5^\circ$ ◀

## PROBLEM 2.63

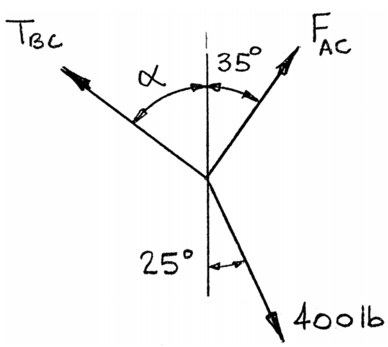



For the structure and loading of Problem 2.45, determine (*a*) the value of $\alpha$ for which the tension in cable *BC* is as small as possible, (*b*) the corresponding value of the tension.

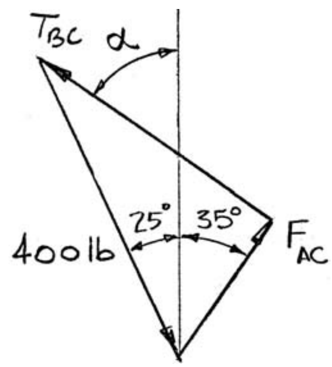
## SOLUTION

$T_{BC}$ must be perpendicular to $F_{AC}$ to be as small as possible.

**Free-Body Diagram: C**




**Force Triangle is a right triangle**

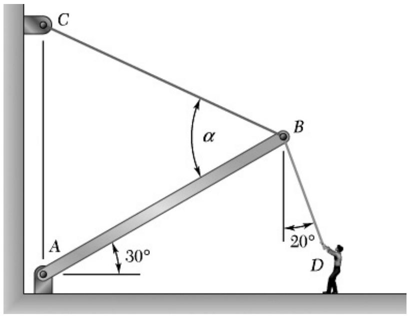



(*a*) We observe: $\alpha = 55°$ $\alpha = 55°$ ◀

(*b*) $T_{BC} = (400 \text{ lb})\sin 60°$

or $T_{BC} = 346.4 \text{ lb}$ $T_{BC} = 346 \text{ lb}$ ◀

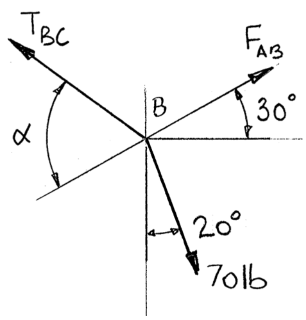
## PROBLEM 2.64

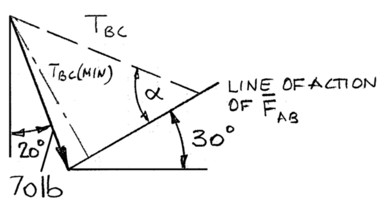



Boom *AB* is supported by cable *BC* and a hinge at *A*. Knowing that the boom exerts on pin *B* a force directed along the boom and that the tension in rope *BD* is 70 lb, determine (*a*) the value of $\alpha$ for which the tension in cable *BC* is as small as possible, (*b*) the corresponding value of the tension.

## SOLUTION

**Free-Body Diagram: B**




(*a*) Have: $\mathbf{T}_{BD} + \mathbf{F}_{AB} + \mathbf{T}_{BC} = 0$

where magnitude and direction of $\mathbf{T}_{BD}$ are known, and the direction of $\mathbf{F}_{AB}$ is known.

Then, in a force triangle:

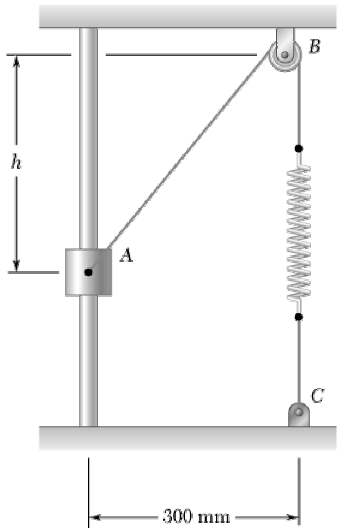
By observation, $T_{BC}$ is minimum when $\alpha = 90.0°$ ◀

(*b*) Have $T_{BC} = (70 \text{ lb})\sin(180° - 70° - 30°)$

$= 68.93 \text{ lb}$

$T_{BC} = 68.9 \text{ lb}$ ◀

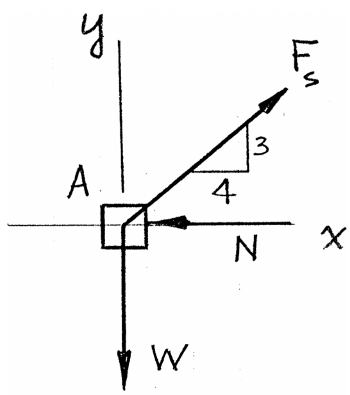
## PROBLEM 2.65




Collar $A$ shown in Figure P2.65 and P2.66 can slide on a frictionless vertical rod and is attached as shown to a spring. The constant of the spring is 660 N/m, and the spring is unstretched when $h = 300$ mm. Knowing that the system is in equilibrium when $h = 400$ mm, determine the weight of the collar.

## SOLUTION

**Free-Body Diagram: Collar A**




Have: $$F_s = k\left(L'_{AB} - L_{AB}\right)$$

where:

$$L'_{AB} = \sqrt{(0.3\text{ m})^2 + (0.4\text{ m})^2} \qquad L_{AB} = 0.3\sqrt{2}\text{ m}$$

$$= 0.5\text{ m}$$

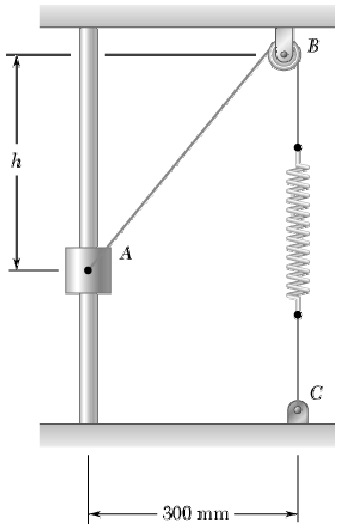
Then: $$F_s = 660\text{ N/m}\left(0.5 - 0.3\sqrt{2}\right)\text{m}$$

$$= 49.986\text{ N}$$

For the collar:

$$+\uparrow \Sigma F_y = 0: \quad -W + \frac{4}{5}(49.986\text{ N}) = 0$$

or $W = 40.0$ N ◀

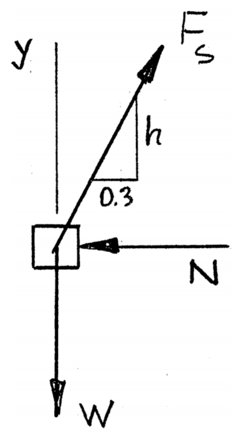



## PROBLEM 2.66

The 40-N collar $A$ can slide on a frictionless vertical rod and is attached as shown to a spring. The spring is unstretched when $h = 300$ mm. Knowing that the constant of the spring is 560 N/m, determine the value of $h$ for which the system is in equilibrium.

## SOLUTION

**Free-Body Diagram: Collar A**




$$+\uparrow \Sigma F_y = 0: \quad -W + \frac{h}{\sqrt{(0.3)^2 + h^2}} F_s = 0$$

or $$hF_s = 40\sqrt{0.09 + h^2}$$

Now.. $$F_s = k\left(L'_{AB} - L_{AB}\right)$$

where $$L'_{AB} = \sqrt{(0.3)^2 + h^2} \text{ m} \qquad L_{AB} = 0.3\sqrt{2} \text{ m}$$

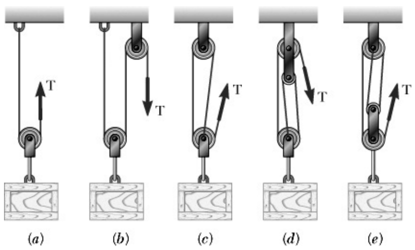
Then: $$h\left[560\left(\sqrt{0.09 + h^2} - 0.3\sqrt{2}\right)\right] = 40\sqrt{0.09 + h^2}$$

or $$(14h - 1)\sqrt{0.09 + h^2} = 4.2\sqrt{2}h \qquad h \sim \text{m}$$

Solving numerically,

$$h = 415 \text{ mm} \blacktriangleleft$$

## PROBLEM 2.67

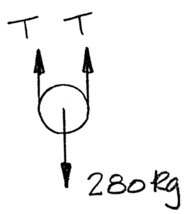



A 280-kg crate is supported by several rope-and-pulley arrangements as shown. Determine for each arrangement the tension in the rope. (*Hint:* The tension in the rope is the same on each side of a simple pulley. This can be proved by the methods of Chapter 4.)

## SOLUTION

**Free-Body Diagram of pulley**

(*a*)

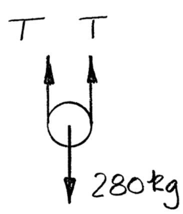



$$+\uparrow \Sigma F_y = 0: \quad 2T - (280\text{ kg})(9.81\text{ m/s}^2) = 0$$

$$T = \frac{1}{2}(2746.8\text{ N})$$

$$T = 1373\text{ N} \blacktriangleleft$$

(*b*)

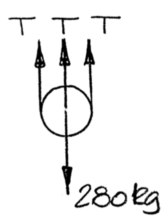



$$+\uparrow \Sigma F_y = 0: \quad 2T - (280\text{ kg})(9.81\text{ m/s}^2) = 0$$

$$T = \frac{1}{2}(2746.8\text{ N})$$

$$T = 1373\text{ N} \blacktriangleleft$$

(*c*)

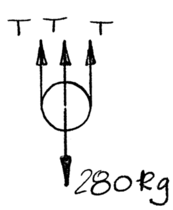



$$+\uparrow \Sigma F_y = 0: \quad 3T - (280\text{ kg})(9.81\text{ m/s}^2) = 0$$

$$T = \frac{1}{3}(2746.8\text{ N})$$

$$T = 916\text{ N} \blacktriangleleft$$

(*d*)

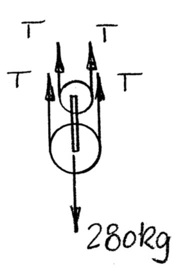



$$+\uparrow \Sigma F_y = 0: \quad 3T - (280\text{ kg})(9.81\text{ m/s}^2) = 0$$

$$T = \frac{1}{3}(2746.8\text{ N})$$

$$T = 916\text{ N} \blacktriangleleft$$

(*e*)

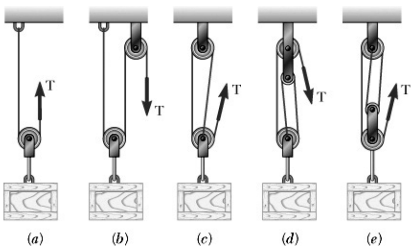



$$+\uparrow \Sigma F_y = 0: 4T - (280\text{ kg})(9.81\text{ m/s}^2) = 0$$

$$T = \frac{1}{4}(2746.8\text{ N})$$

$$T = 687\text{ N} \blacktriangleleft$$

## PROBLEM 2.68



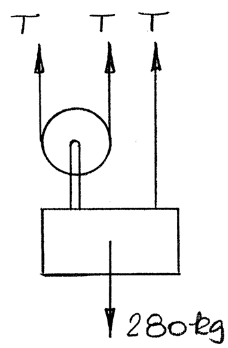

Solve parts *b* and *d* of Problem 2.67 assuming that the free end of the rope is attached to the crate.

**Problem 2.67:** A 280-kg crate is supported by several rope-and-pulley arrangements as shown. Determine for each arrangement the tension in the rope. (*Hint:* The tension in the rope is the same on each side of a simple pulley. This can be proved by the methods of Chapter 4.)

## SOLUTION

**Free-Body Diagram of pulley and crate**

(*b*)

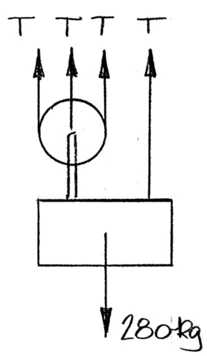



$$+\uparrow \Sigma F_y = 0: \quad 3T - (280 \text{ kg})\left(9.81 \text{ m/s}^2\right) = 0$$

$$T = \frac{1}{3}(2746.8 \text{ N})$$

$$T = 916 \text{ N} \blacktriangleleft$$

(*d*)




$$+\uparrow \Sigma F_y = 0: \quad 4T - (280 \text{ kg})\left(9.81 \text{ m/s}^2\right) = 0$$

$$T = \frac{1}{4}(2746.8 \text{ N})$$

$$T = 687 \text{ N} \blacktriangleleft$$