$$2rr'' + 2r'^2 = -ab^2\cos(b\theta)\,\theta'^2 \qquad r'' = \frac{-ab^2\cos(b\theta)\,\theta'^2 - 2r'^2}{2r}$$

$v_r = r'$ $\qquad v_r = 0\ \frac{\text{m}}{\text{s}}$

$v_\theta = r\theta'$ $\qquad v_\theta = 12\ \frac{\text{ft}}{\text{s}}$

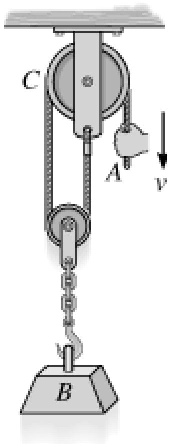
$a_r = r'' - r\theta'^2$ $\qquad a_r = -216\ \frac{\text{ft}}{\text{s}^2}$

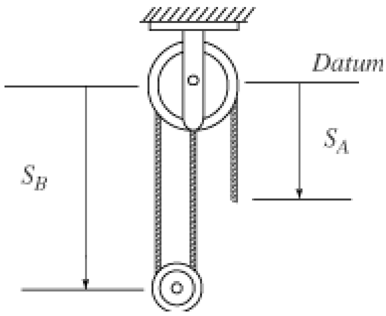
$a_\theta = 2r'\theta'$ $\qquad a_\theta = 0\ \frac{\text{ft}}{\text{s}^2}$

***Problem 12-172**

If the end of the cable at *A* is pulled down with speed *v*, determine the speed at which block *B* rises.

Given: $v = 2\ \frac{\text{m}}{\text{s}}$





Solution:

$v_A = v$

$L = 2s_B + s_A$

$0 = 2v_B + v_A$

$v_B = \frac{-v_A}{2}$

$v_B = -1\ \frac{\text{m}}{\text{s}}$

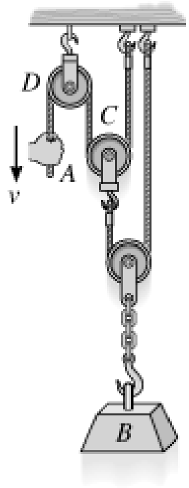
Problem 12-173

If the end of the cable at *A* is pulled down with speed *v*, determine the speed at which block *B* rises.

Given:

$v = 2\ \frac{\text{m}}{\text{s}}$

Solution:



$v_A = v$

$L_1 = s_A + 2s_C$

$0 = v_A + 2v_C \qquad v_C = \frac{-v_A}{2}$

$L_2 = (s_B - s_C) + s_B \quad 0 = 2v_B - v_C$

$v_B = \frac{v_C}{2} \qquad v_B = -0.5\ \frac{\text{m}}{\text{s}}$

Problem 12-174

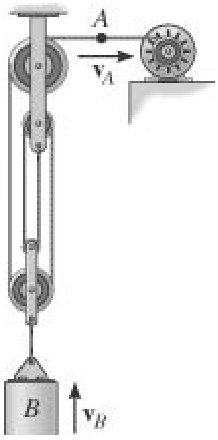
Determine the constant speed at which the cable at *A* must be drawn in by the motor in order to hoist the load at *B* a distance *d* in a time *t*.

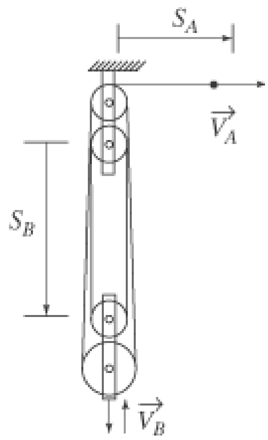
Given:

$d = 15\ \text{ft}$

$t = 5\ \text{s}$

Solution:





$L = 4s_B + s_A$

$0 = 4v_B + v_A$

$v_A = -4v_B$

$v_A = -4\left(\frac{-d}{t}\right)$

$v_A = 12\frac{\text{ft}}{\text{s}}$

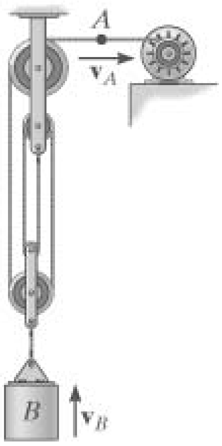
Problem 12-175

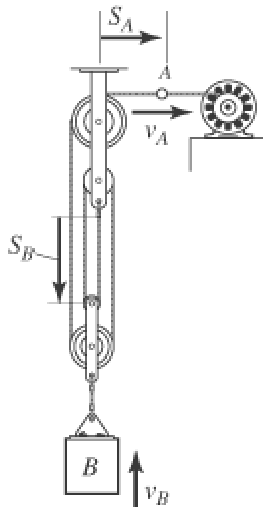
Determine the time needed for the load at *B* to attain speed *v*, starting from rest, if the cable is drawn into the motor with acceleration *a*.

Given:

$v = -8\ \frac{\text{m}}{\text{s}}$

$a = 0.2\ \frac{\text{m}}{\text{s}^2}$





Solution:

$v_B = v$

$L = 4s_B + s_A$

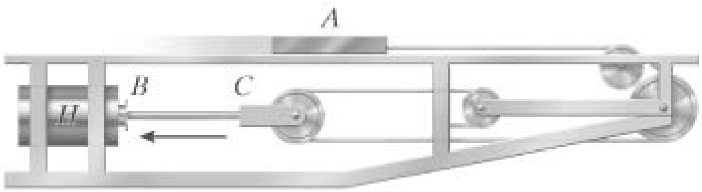
$0 = 4v_B + v_A$

$v_B = \frac{-v_A}{4} = \frac{-1}{4}a\,t$

$t = \frac{-4v_B}{a}$ $\quad t = 160\ \text{s}$

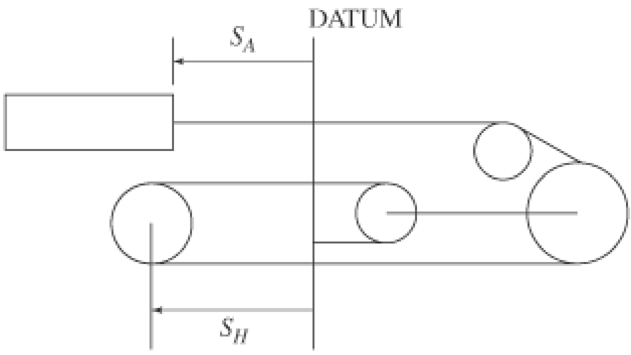
***Problem 12–176**

If the hydraulic cylinder at H draws rod BC in by a distance d, determine how far the slider at A moves.



Given:

$d = 8\ \text{in}$



Solution:

$\Delta s_H = d$

$L = s_A + 2s_H \qquad 0 = \Delta s_A + 2\Delta s_H$

$\Delta s_A = -2\Delta s_H \qquad \Delta s_A = -16\,\text{in}$

Problem 12-177

The crate is being lifted up the inclined plane using the motor M and the rope and pulley arrangement shown. Determine the speed at which the cable must be taken up by the motor in order to move the crate up the plane with constant speed v.

Given:

$v = 4\ \frac{\text{ft}}{\text{s}}$

Solution:

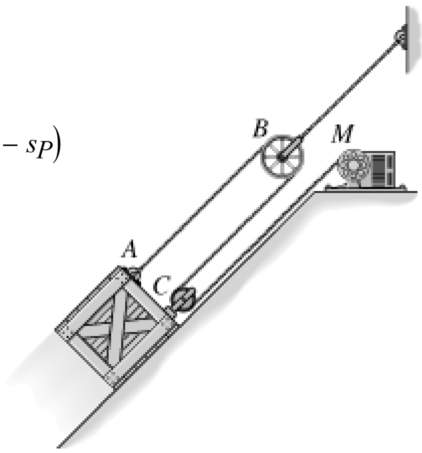
$$v_A = v$$

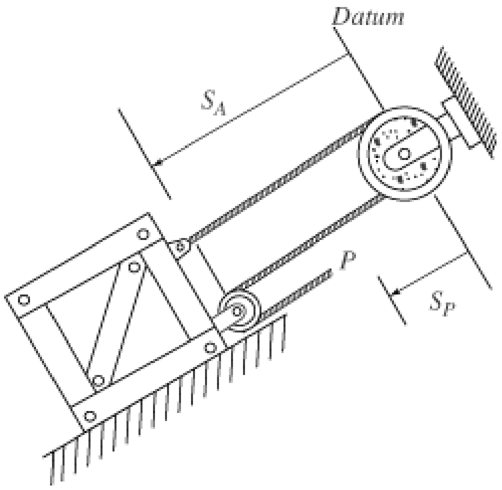
$$L = 2s_A + (s_A - s_P)$$

$$0 = 3v_A - v_P$$

$$v_P = 3v_A$$

$$v_P = 12\,\frac{\text{ft}}{\text{s}}$$





Problem 12-178

Determine the displacement of the block at *B* if *A* is pulled down a distance *d*.

Given:

$$d = 4\ \text{ft}$$

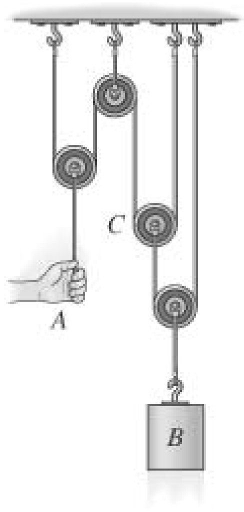
Solution:

$$\Delta s_A = d$$

$$L_1 = 2s_A + 2s_C \qquad L_2 = (s_B - s_C) + s_B$$

$$0 = 2\Delta s_A + 2\Delta s_C \qquad 0 = 2\Delta s_B - \Delta s_C$$

$$\Delta s_C = -\Delta s_A \qquad \Delta s_B = \frac{\Delta s_C}{2} \qquad \Delta s_B = -2\ \text{ft}$$

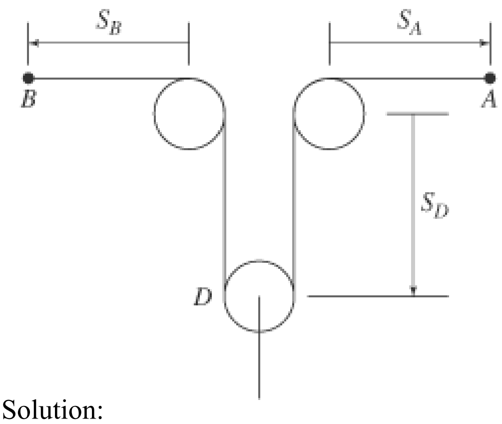


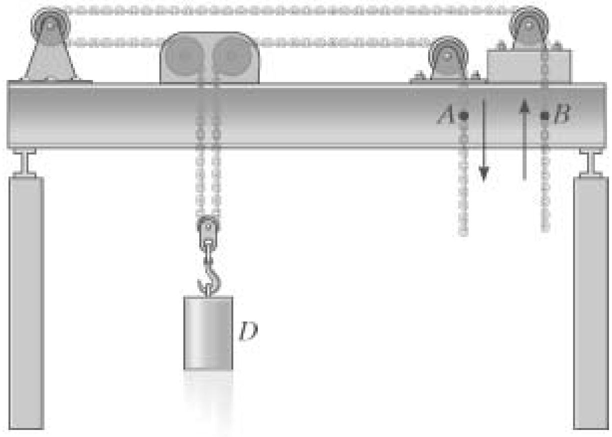
Problem 12–179

The hoist is used to lift the load at *D*. If the end A of the chain is travelling downward at v_A and the end *B* is travelling upward at v_B, determine the velocity of the load at *D*.

Given:

$$v_A = 5\,\frac{\text{ft}}{\text{s}} \qquad v_B = 2\,\frac{\text{ft}}{\text{s}}$$





Solution:

$L = s_B + s_A + 2s_D \qquad 0 = -v_B + v_A + 2v_D$

$v_D = \dfrac{v_B - v_A}{2} \qquad v_D = -1.5\,\dfrac{\text{ft}}{\text{s}}$ Positive means down, Negative means up

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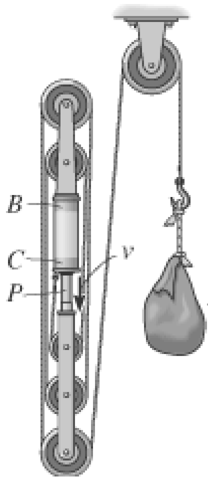
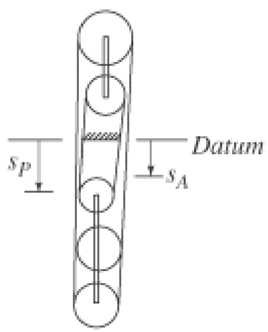
***Problem 12-180**

The pulley arrangement shown is designed for hoisting materials. If *BC remains fixed* while the plunger *P* is pushed downward with speed *v*, determine the speed of the load at *A*.





Given:

$v = 4\,\dfrac{\text{ft}}{\text{s}}$

Solution:

$v_P = v$

$L = 6s_P + s_A \qquad 0 = 6v_P + v_A$

$v_A = -6v_P \qquad v_A = -24\,\dfrac{\text{ft}}{\text{s}}$

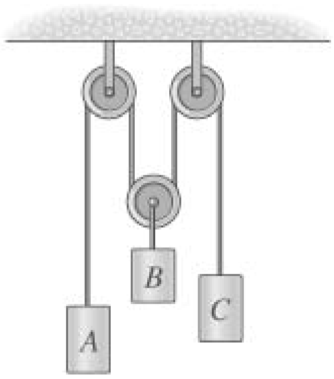
Problem 12-181

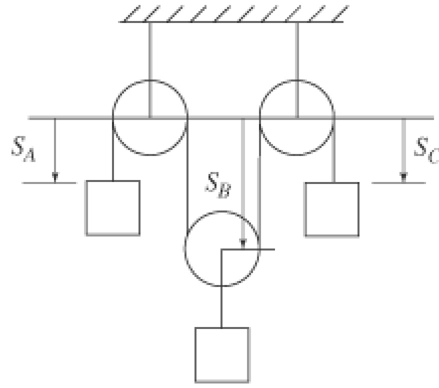
If block *A* is moving downward with speed v_A while *C* is moving up at speed v_C, determine the speed of block *B*.

Given:

$v_A = 4\,\dfrac{\text{ft}}{\text{s}}$

$$v_C = -2\ \frac{\text{ft}}{\text{s}}$$





Solution:

$$S_A + 2S_B + S_C = L$$

Taking time derivative:

$$v_A + 2v_B + v_C = 0$$

$$v_B = \frac{-(v_C + v_A)}{2}$$

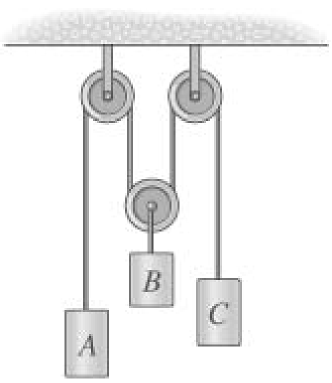
$$v_B = -1\ \frac{\text{ft}}{\text{s}}$$ Positive means down, negative means up.

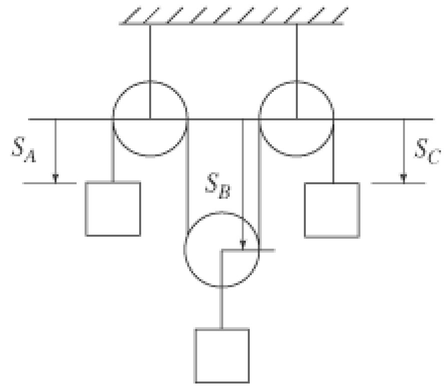
Problem 12-182

If block A is moving downward at speed v_A while block C is moving down at speed v_C, determine the relative velocity of block B with respect to C.

Given:

$$v_A = 6\ \frac{\text{ft}}{\text{s}} \qquad v_C = 18\ \frac{\text{ft}}{\text{s}}$$





Solution:

$$S_A + 2S_B + S_C = L$$

Taking time derivative

$$v_A + 2v_B + v_C = 0$$

$$v_B = \frac{-(v_A + v_C)}{2} \qquad v_B = -12\ \frac{\text{ft}}{\text{s}}$$

$$v_{BC} = v_B - v_C \qquad v_{BC} = -30\ \frac{\text{ft}}{\text{s}}$$ Positive means down, negative means up

---

Problem 12–183

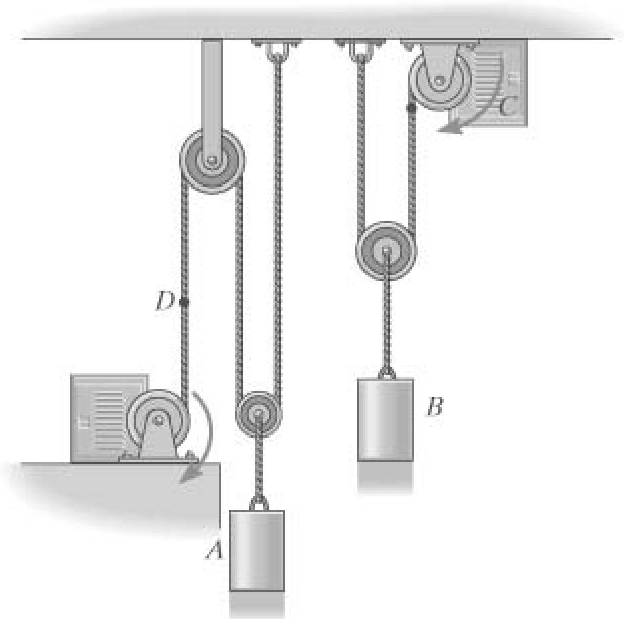
The motor draws in the cable at C with a constant velocity v_C. The motor draws in the cable at D with a constant acceleration of a_D. If $v_D = 0$ when $t = 0$, determine (a) the time needed for block A to rise a distance h, and (b) the relative velocity of block A with respect to block B when this occurs.

Given:

$v_C = -4 \ \frac{\text{m}}{\text{s}}$

$a_D = 8 \ \frac{\text{m}}{\text{s}^2}$

$h = 3 \ \text{m}$



Solution:

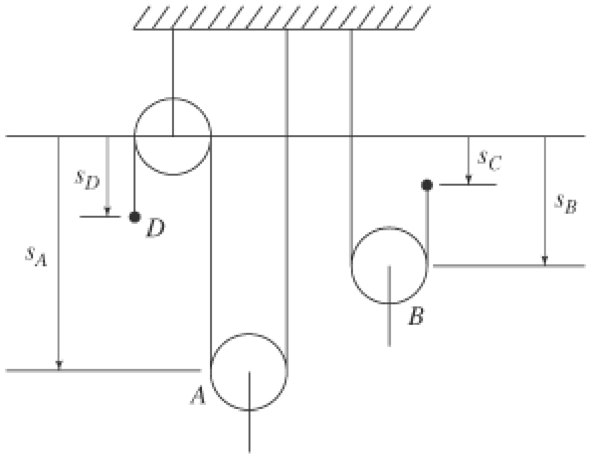
$L_1 = s_D + 2s_A$

$0 = v_D + 2v_A$

$0 = a_D + 2a_A$

$L_2 = s_B + (s_B - s_C)$

$0 = 2v_B - v_C \qquad 0 = 2a_B - a_C$



$a_A = \frac{-a_D}{2}$

$v_A = a_A t$

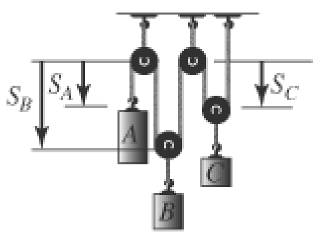
$s_A = -h = a_A\left(\frac{t^2}{2}\right)$

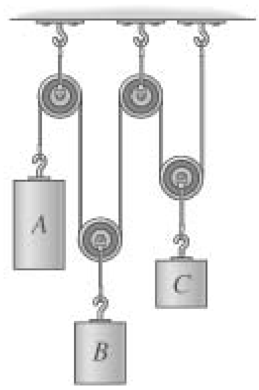
$t = \sqrt{\frac{-2h}{a_A}} \qquad t = 1.225 \ \text{s}$

$v_A = a_A t \qquad v_B = \frac{1}{2}v_C \qquad v_{AB} = v_A - v_B \qquad v_{AB} = -2.90 \ \frac{\text{m}}{\text{s}}$

***Problem 12-184**

If block A of the pulley system is moving downward with speed v_A while block C is moving up at v_C determine the speed of block B.





Given:

$v_A = 4 \ \frac{\text{ft}}{\text{s}}$

$v_C = -2 \ \frac{\text{ft}}{\text{s}}$

Solution:

$$S_A + 2S_B + 2S_C = L$$

$$v_A + 2v_B + 2v_C = 0 \qquad v_B = \frac{-2v_C - v_A}{2} \qquad v_B = 0\ \frac{\text{m}}{\text{s}}$$

Problem 12–185

If the point A on the cable is moving upwards at v_A, determine the speed of block B.

Given: $v_A = -14\ \frac{\text{m}}{\text{s}}$

Solution:

$$L_1 = (s_D - s_A) + (s_D - s_E)$$

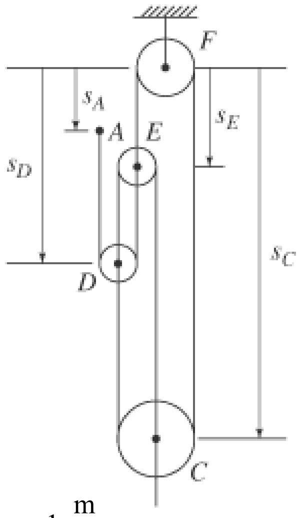
$$0 = 2v_D - v_A - v_E$$

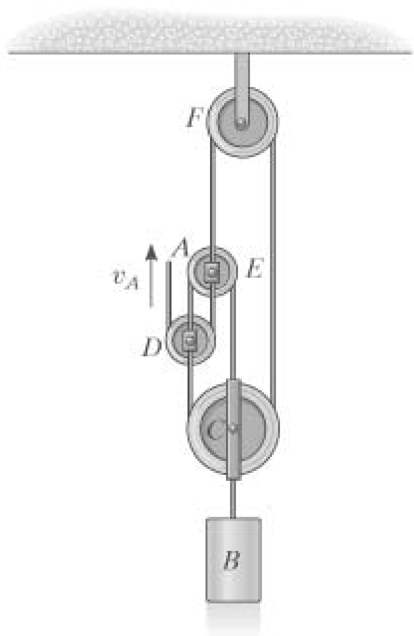
$$L_2 = (s_D - s_E) + (s_C - s_E)$$

$$0 = v_D + v_C - 2v_E$$

$$L_3 = (s_C - s_D) + s_C + s_E$$

$$0 = 2v_C - v_D + v_E$$





Guesses

$$v_C = 1\ \frac{\text{m}}{\text{s}} \qquad v_D = 1\ \frac{\text{m}}{\text{s}} \qquad v_E = 1\ \frac{\text{m}}{\text{s}}$$

Given

$$0 = 2v_D - v_A - v_E$$

$$0 = v_D + v_C - 2v_E$$

$$0 = 2v_C - v_D + v_E$$

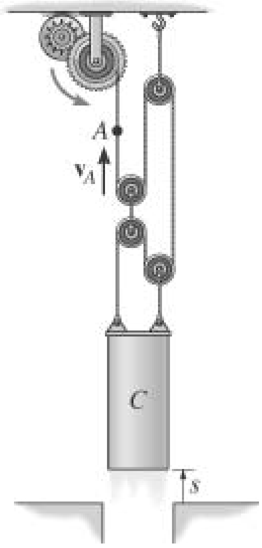
$$\begin{pmatrix} v_C \\ v_D \\ v_E \end{pmatrix} = \text{Find}(v_C, v_D, v_E) \qquad \begin{pmatrix} v_C \\ v_D \\ v_E \end{pmatrix} = \begin{pmatrix} -2 \\ -10 \\ -6 \end{pmatrix} \frac{\text{m}}{\text{s}}$$

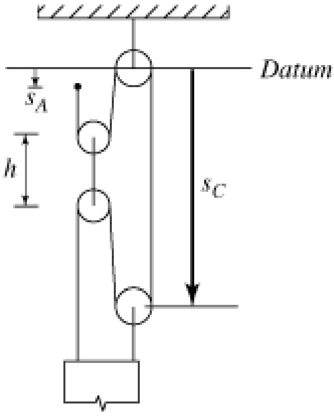
$$v_B = v_C \qquad v_B = -2\ \frac{\text{m}}{\text{s}}$$

Positive means down,
Negative means up

Problem 12-186

The cylinder *C* is being lifted using the cable and pulley system shown. If point *A* on the cable is being drawn toward the drum with speed of v_A, determine the speed of the cylinder.





Given:

$$v_A = -2 \frac{\text{m}}{\text{s}}$$

Solution:

$$L = 2s_C + (s_C - s_A)$$

$$0 = 3v_C - v_A$$

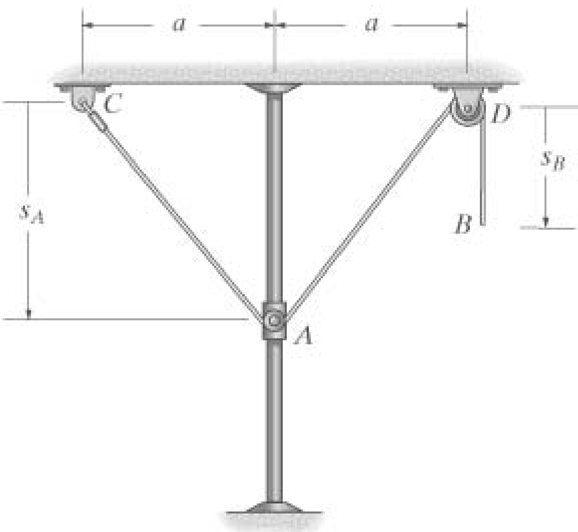
$$v_C = \frac{v_A}{3}$$

$$v_C = -0.667 \frac{\text{m}}{\text{s}}$$

Positive means down, negative means up.

Problem 12–187

The cord is attached to the pin at *C* and passes over the two pulleys at *A* and *D*. The pulley at *A* is attached to the smooth collar that travels along the vertical rod. Determine the velocity and acceleration of the end of the cord at *B* if at the instant $s_A = b$ the collar is moving upwards at speed *v*, which is decreasing at rate *a*.



Given:

$$a = 3 \text{ ft} \qquad v_A = -5 \frac{\text{ft}}{\text{s}}$$

$$b = 4 \text{ ft} \qquad a_A = 2 \frac{\text{ft}}{\text{s}^2}$$

Solution:

$$L = 2\sqrt{a^2 + s_A^2} + s_B \qquad s_A = b$$

Guesses $\quad v_B = 1 \frac{\text{ft}}{\text{s}} \qquad a_B = 1 \frac{\text{ft}}{\text{s}^2}$

Given

$$0 = \frac{2s_A v_A}{\sqrt{a^2 + s_A^2}} + v_B$$