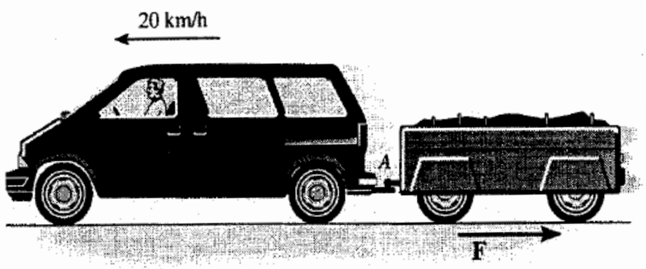
DİNAMİK SINAVLARA HAZIRLIK, ÇALIŞMA SORULARI

DOĞRUSAL HAREKETTE KUVVET VE İVME

Örnek

The van is traveling at 20 km/h when the coupling of the trailer at A fails. If the trailer has a mass of 250 kg and coasts 45 m before coming to rest, determine the constant horizontal force F created by rolling friction which causes the trailer to stop.



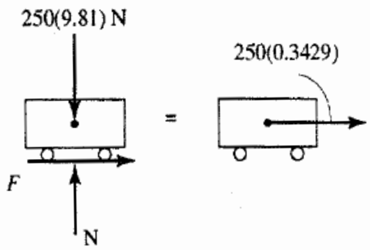
$$20 \text{ km/h} = \frac{20(10^3)}{3600} = 5.556 \text{ m/s}$$

$$(\overset{+}{\leftarrow}) \quad v^2 = v_0^2 + 2a_c(s - s_0)$$

$$0 = 5.556^2 + 2(a)(45 - 0)$$

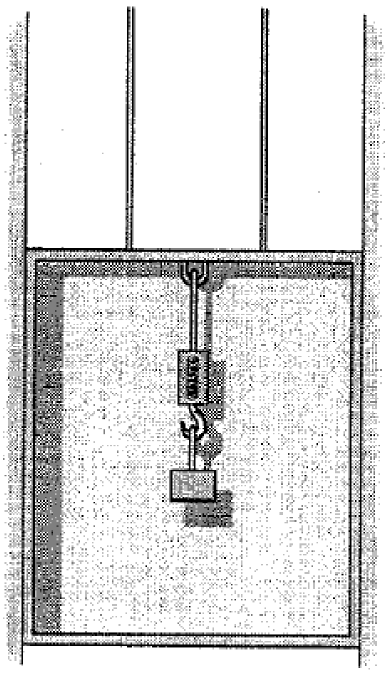
$$a = -0.3429 \text{ m/s}^2 = 0.3429 \text{ m/s}^2 \rightarrow$$

$$\overset{+}{\rightarrow} \sum F_x = ma_x; \quad F = 250(0.3429) = 85.7 \text{ N} \quad \textbf{Ans}$$



Örnek

A block having a mass of 2 kg is placed on a spring scale located in an elevator that is moving downward. If the scale reading, which measures the force in the spring, is 20 N, determine the acceleration of the elevator. Neglect the mass of the scale.



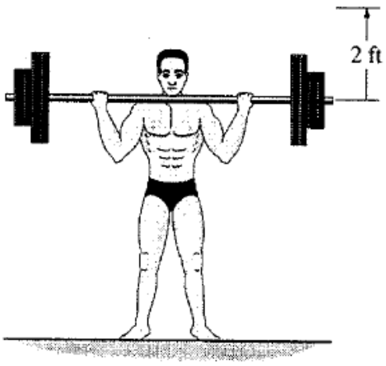
$$+\uparrow \sum F_y = ma_y; \quad 20 - 2(9.81) = 2a$$

$$a = 0.19 \text{ m/s}^2 \uparrow \qquad \textbf{Ans}$$

The elevator is slowing down.

Örnek

The man weighs 180 lb and supports the barbells which have a weight of 100 lb. If he lifts them 2 ft in the air in 1.5 s starting from rest, determine the reaction of *both* of his feet on the ground during the lift. Assume the motion is with uniform acceleration.



$+\uparrow \sum F_y = ma_y; \qquad F - 100 - 180 = \frac{100}{32.2}a$

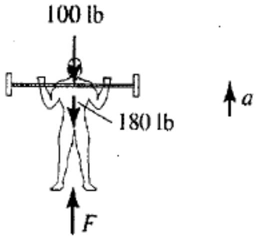
$(+\uparrow)\ s = s_0 + v_0 t + \frac{1}{2}a_c t^2$

$2 = 0 + 0 + \frac{1}{2}a(1.5)^2$

$a = 1.778\ \text{ft/s}^2$

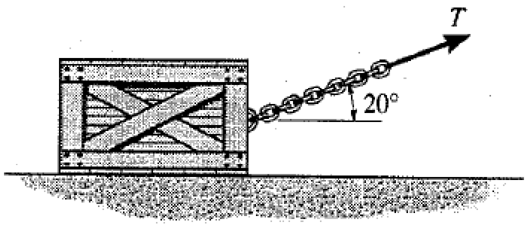
Thus,

$F = 285.52 = 286\ \text{lb}$ **Ans**



Örnek

The crate has a mass of 80 kg and is being towed by a chain which is always directed at 20° from the horizontal as shown. If the magnitude of **T** is increased until the crate begins to slide, determine the crate's initial acceleration if the coefficient of static friction is $\mu_s = 0.5$ and the coefficient of kinetic friction is $\mu_k = 0.3$.



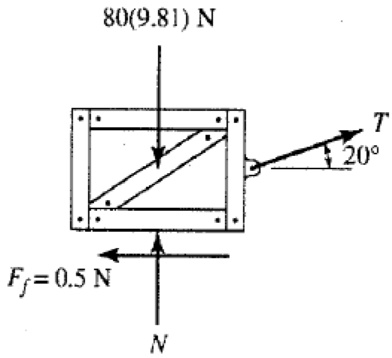
Equations of Equilibrium: If the crate is on the verge of slipping, $F_f = \mu_s N = 0.5N$. From FBD(a)

$+\uparrow \sum F_y = 0; \quad N + P\sin 20° - 80(9.81) = 0 \quad [1]$

$\xrightarrow{+} \sum F_x = 0; \quad T\cos 20° - 0.5N = 0 \quad [2]$

Solving Eqs. [1] and [2] yields

$T = 353.29\ \text{N} \qquad N = 663.97\ \text{N}$



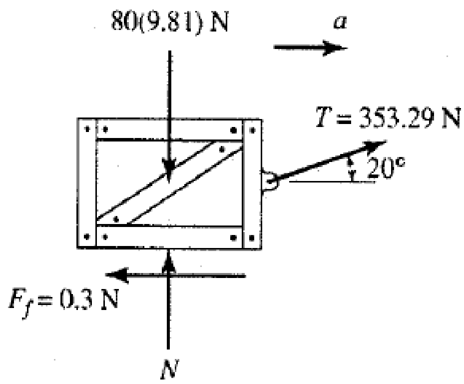
Equation of Motion: The friction force developed between the crate and its contacting surface is $F_f = \mu_k N = 0.3N$ since the crate is moving. From FBD(b),

$+\uparrow \sum F_y = ma_y; \quad N - 80(9.81) + 353.29\sin 20° = 80(0)$

$N = 663.97\ \text{N}$

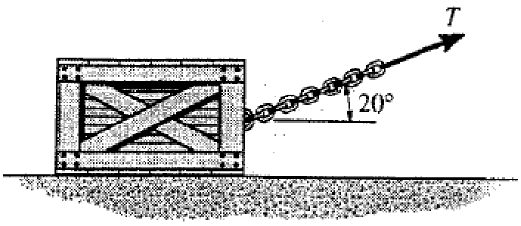
$\xrightarrow{+} \sum F_x = ma_x; \quad 353.29\cos 20° - 0.3(663.97) = 80a$

$a = 1.66\ \text{m/s}^2$ **Ans**



Örnek

The crate has a mass of 80 kg and is being towed by a chain which is always directed at 20° from the horizontal as shown. Determine the crate's acceleration in $t = 2$ s if the coefficient of static friction is $\mu_s = 0.4$ and the coefficient of kinetic friction is $\mu_k = 0.3$ and the towing force is $T = (90t^2)$ N, where t is in seconds.



Equations of Equilibrium: At $t = 2$ s, $T = 90(2^2) = 360$ N. From FBD(a)

$$+\uparrow \sum F_y = 0; \qquad N + 360\sin 20° - 80(9.81) = 0 \qquad N = 661.67\text{ N}$$

$$\overset{+}{\rightarrow} \sum F_x = 0; \qquad 360\cos 20° - F_f = 0 \qquad F_f = 338.29\text{ N}$$

Since $F_f > (F_f)_{max} = \mu_s N = 0.4(661.67) = 264.67$ N, the crate accelerates.

Equation of Motion: The friction force developed between the crate and its contacting surface is $F_f = \mu_k N = 0.3N$ since the crate is moving. From FBD(b),

$$+\uparrow \sum F_y = ma_y; \quad N - 80(9.81) + 360\sin 20° = 80(0)$$

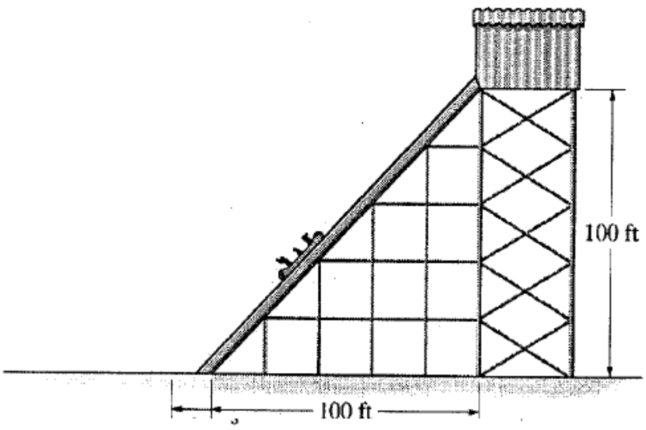
$$N = 661.67\text{ N}$$

$$\overset{+}{\rightarrow} \sum F_x = ma_x; \quad 360\cos 20° - 0.3(661.67) = 80a$$

$$a = 1.75\text{ m/s}^2$$ **Ans**

Örnek

The water-park ride consists of an 800-lb sled which slides from rest down the incline and then into the pool. If the frictional resistance on the incline is $F_r = 30$ lb, and in the pool for a short distance $F_r = 80$ lb, determine how fast the sled is traveling when $s = 5$ ft.



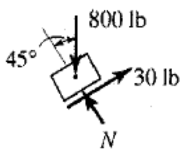
$$+\swarrow \sum F_x = ma_x; \qquad 800\sin 45° - 30 = \frac{800}{32.2}a$$

$$a = 21.561\text{ ft/s}^2$$

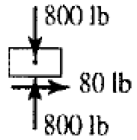
$$v_1^2 = v_0^2 + 2a_c(s - s_0)$$

$$v_1^2 = 0 + 2(21.561)(100\sqrt{(2-0)})$$

$$v_1 = 78.093\text{ ft/s}$$



$$\overset{+}{\leftarrow} \sum F_x = ma_x: \qquad -80 = \frac{800}{32.2} a$$



$$a = -3.22 \text{ ft/s}^2$$

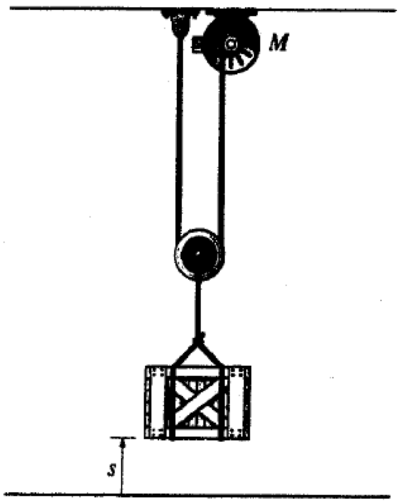
$$v_2^2 = v_1^2 + 2a_c(s_2 - s_1)$$

$$v_2^2 = (78.093)^2 + 2(-3.22)(5 - 0)$$

$$v_2 = 77.9 \text{ ft/s} \qquad \textbf{Ans}$$

Örnek

The crate, having a weight of 50 lb, is hoisted by the pulley system and motor M. If the crate starts from rest and, by constant acceleration, attains a speed of 12 ft/s after rising 10 ft, determine the power that must be supplied to the motor at the instant $s = 10$ ft. The motor has an efficiency $\epsilon = 0.74$.

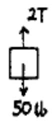


$$(+\uparrow) \qquad v^2 = v_0^2 + 2a_c(s - s_0)$$

$$(12)^2 = 0 + 2a_c(10 - 0)$$

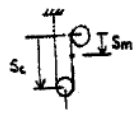
$$a_c = 7.20 \text{ ft/s}^2$$

$$+\uparrow \Sigma F_y = ma_y; \qquad 2T - 50 = \frac{50}{32.2}(7.20)$$



$$T = 30.6 \text{ lb}$$

$$s_C + (s_C - s_M) = l$$



$$v_M = 2v_C$$

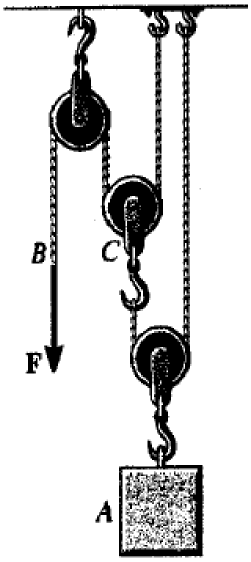
$$v_M = 2(12) = 24 \text{ ft/s}$$

$$P_0 = \mathbf{T} \cdot \mathbf{v} = 30.6(24) = 734.2 \text{ lb·ft/s}$$

$$P_i = \frac{734.2}{0.74} = 992.1 \text{ lb·ft/s} = 1.80 \text{ hp} \qquad \textbf{Ans}$$

Örnek

A force $F = 15$ lb is applied to the cord. Determine how high the 30-lb block A rises in 2 s starting from rest. Neglect the weight of the pulleys and cord.



$+\uparrow \Sigma F_y = ma_y; \qquad -30 + 4F = \frac{30}{32.2} a_A$

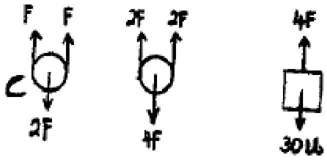
$F = 15$ lb

$a_A = 32.2$ ft/s^2

$(+\uparrow)\ s = s_0 + v_0 t + \frac{1}{2} a_c t^2$

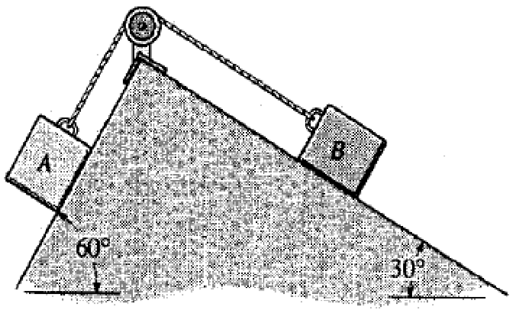
$s = 0 + 0 + \frac{1}{2}(32.2)(2)^2$

$s = 64.4$ ft **Ans**



Örnek

The double inclined plane supports two blocks A and B, each having a weight of 10 lb. If the coefficient of kinetic friction between the blocks and the plane is $\mu_k = 0.1$, determine the acceleration of each block.



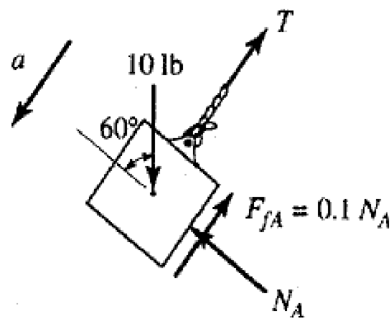
Equation of Motion: Since blocks A and B are sliding along the plane, the friction forces developed between the blocks and the plane are $(F_f)_A = \mu_k N_A = 0.1N_A$ and $(F_f)_B = \mu_k N_B = 0.1N_B$. Here, $a_A = a_B = a$. Applying Eq. 13-7 to FBD(a), we have

$$\nwarrow + \sum F_{y'} = ma_{y'}; \quad N_A - 10\cos 60° = \left(\frac{10}{32.2}\right)(0) \quad N_A = 5.00 \text{ lb}$$

$$\nearrow + \sum F_{x'} = ma_{x'}; \quad T + 0.1(5.00) - 10\sin 60° = -\left(\frac{10}{32.2}\right)a \quad [1]$$

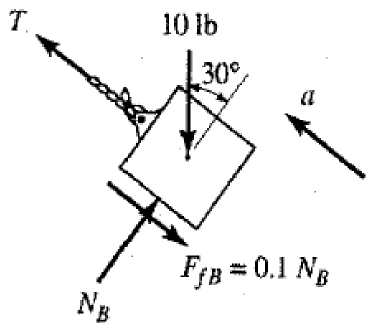
From FBD(b),

$$\nearrow + \sum F_{y'} = ma_{y'}; \quad N_B - 10\cos 30° = \left(\frac{10}{32.2}\right)(0) \quad N_B = 8.660 \text{ lb}$$



(a)

$$\nwarrow + \sum F_{x'} = ma_{x'}; \quad T - 0.1(8.660) - 10\sin 30^\circ = \left(\frac{10}{32.2}\right)a \qquad [2]$$



(b)

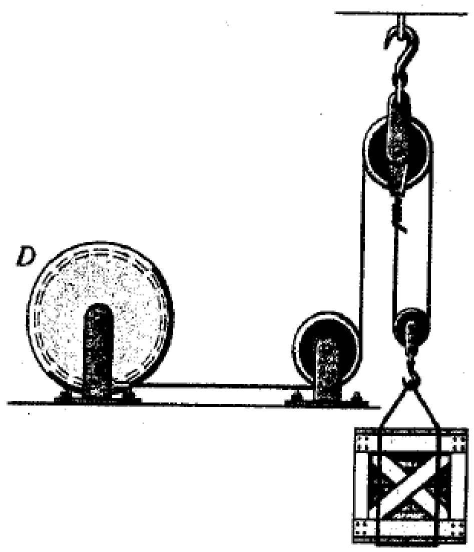
Solving Eqs. [1] and [2] yields

$a = 3.69$ ft/s^2 **Ans**

$T = 7.013$ lb

Örnek

The winding drum D is drawing in the cable at an accelerated rate of 5 m/s^2. Determine the cable tension if the suspended crate has a mass of 800 kg.



$s_A + 2s_B = l$

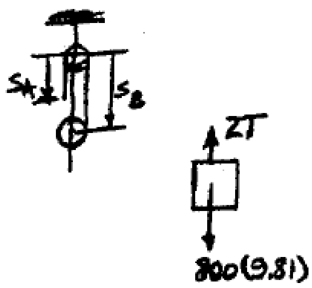
$a_A = -2a_B$

$5 = -2a_B$

$a_B = -2.5$ m/s^2 $= 2.5$ m/s^2 ↑

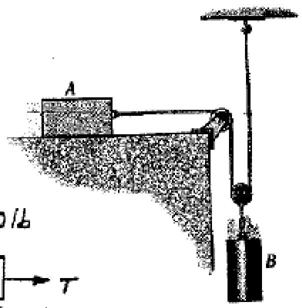
$+\uparrow \Sigma F_y = ma_y; \quad 2T - 800(9.81) = 800(2.5)$

$T = 4924$ N $= 4.92$ kN **Ans**



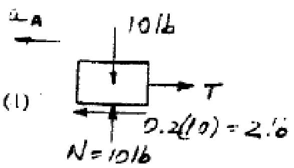
Örnek

The 10-lb block A is traveling to the right at $v_A = 2$ ft/s at the instant shown. If the coefficient of kinetic friction is $\mu_k = 0.2$ between the surface and A, determine the velocity of A when it has moved 4 ft. Block B has a weight of 20 lb.



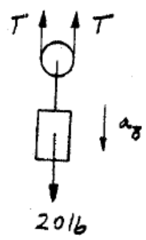
Block A :

$\overset{+}{\leftarrow} \Sigma F_x = ma_x; \quad -T + 2 = \left(\frac{10}{32.2}\right)a_A \qquad (1)$



Weight B :

$+\downarrow \Sigma F_y = ma_y; \quad 20 - 2T = \left(\frac{20}{32.2}\right)a_B \qquad (2)$



Kinematics :

$s_A + 2s_B = l$

$a_A = -2a_B \qquad (3)$

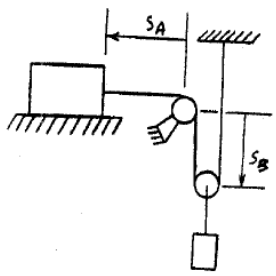
Solving Eq.s (1) – (3) :

$a_A = -17.173$ ft/s^2 $\quad a_B = 8.587$ ft/s^2 $\quad T = 7.33$ lb

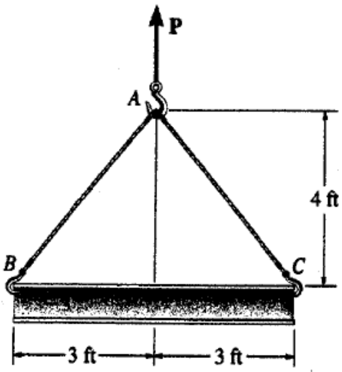
$v^2 = v_0^2 + 2a_c(s - s_0)$

$v^2 = (2)^2 + 2(17.173)(4 - 0)$

$v = 11.9$ ft/s **Ans**



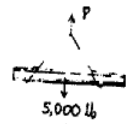
15-18. The uniform beam has a weight of 5000 lb. Determine the average tension in each of the two cables AB and AC if the beam is given an upward speed of 8 ft/s in 1.5 s starting from rest. Neglect the mass of the cables.



$(+\uparrow)\quad mv_1 + \Sigma\int F\,dt = mv_2$

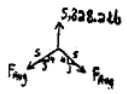
$0 + P_{avg}(1.5) - 5000(1.5) = \frac{5000}{32.2}(8)$

$P_{avg} = 5828.157 = 5828.2$ lb

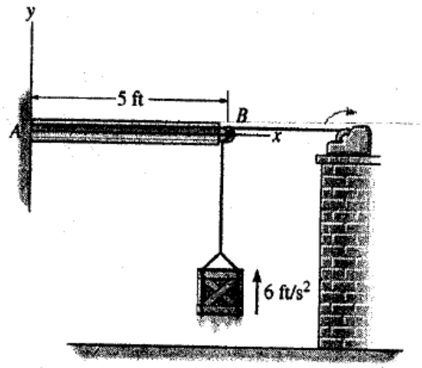


$+\uparrow\Sigma F_y = 0;\quad 5828.157 - 2(\frac{4}{5})F_{avg} = 0$

$F_{avg} = 3642.598$ lb $= 3.64$ kip **Ans**

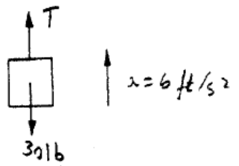


13-35. The 30-lb crate is being hoisted upward with a constant acceleration of 6 ft/s^2. If the uniform beam AB has a weight of 200 lb, determine the components of reaction at A. Neglect the size and mass of the pulley at B. *Hint:* First find the tension in the cable, then analyze the forces in the beam using statics.



Crate:

$+\uparrow\Sigma F_y = ma_y;\quad T - 30 = \left(\frac{30}{32.2}\right)(6)\quad T = 35.59$ lb

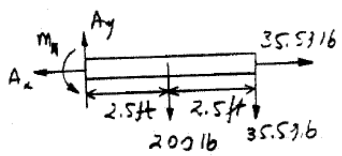


Beam:

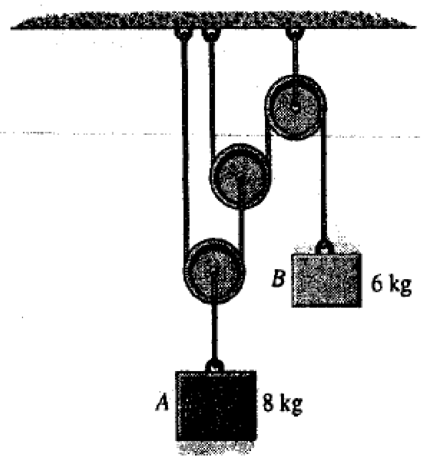
$\xrightarrow{+}\Sigma F_x = 0;\quad -A_x + 35.59 = 0\quad A_x = 35.6$ lb **Ans**

$+\uparrow\Sigma F_y = 0;\quad A_y - 200 - 35.59 = 0\quad A_y = 236$ lb **Ans**

$\circlearrowleft +\Sigma M_A = 0;\quad M_A - 200(2.5) - (35.59)(5) = 0\quad M_A = 678$ lb·ft **Ans**



13-30. Determine the tension developed in the cords attached to each block and the accelerations of the blocks. Neglect the mass of the pulleys and cords.



Equation of Motion : From FBD(a),

$+\uparrow \Sigma F_y = ma_y;\qquad T_A - 8(9.81) = -8a_A \qquad [1]$

From FBD(b),

$+\uparrow \Sigma F_y = ma_y;\qquad T_B - 6(9.81) = -6a_B \qquad [2]$

From FBD(c),

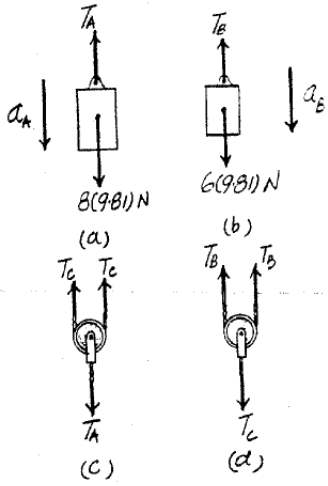
$+\uparrow \Sigma F_y = 0;\qquad 2T_C - T_A = 0 \qquad [3]$

From FBD(d),

$+\uparrow \Sigma F_y = 0;\qquad 2T_B - T_C = 0 \qquad [4]$

Eliminate T_C from Eqs. [3] and [4] yields

$$T_A = 4T_B \qquad [5]$$

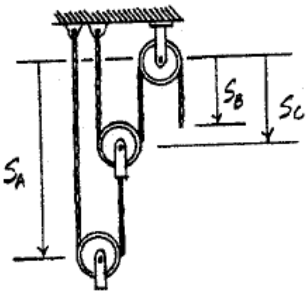


Kinematic : Establish the position - coordinate equation, we have

$$s_A + (s_A - s_C) = l_1 \qquad [6]$$
$$2s_C + s_B = l_2 \qquad [7]$$

Eliminate s_C from Eqs. [6] and [7] yields

$$4s_A + s_B = 2l_1 + l_2 \qquad [8]$$



Taking time derivative twice for Eq. [8] yields

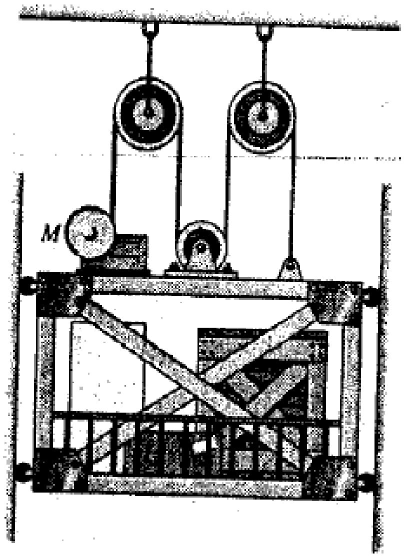
$$(+\downarrow)\qquad 4a_A + a_B = 0 \qquad [9]$$

Solving Eqs. [1], [2], [5] and [9] yields

$a_A = -1.51\ \text{m/s}^2 = 1.51\ \text{m/s}^2 \uparrow \qquad a_B = 6.04\ \text{m/s}^2 \downarrow \qquad$ **Ans**

$T_A = 90.6\ \text{N} \qquad T_B = 22.6\ \text{N} \qquad$ **Ans**

13-26. A freight elevator, including its load, has a mass of 500 kg. It is prevented from rotating by using the track and wheels mounted along its sides. Starting from rest, in $t = 2$ s, the motor M draws in the cable with a speed of 6 m/s, *measured relative to the elevator.* Determine the constant acceleration of the elevator and the tension in the cable. Neglect the mass of the pulleys and cables.



$3s_E + s_P = l$

$3v_E = -v_P$

$(+\downarrow)\quad v_P = v_E + v_{P/E}$

$-3v_E = v_E + 6$

$v_E = -\frac{6}{4} = -1.5\ \text{m/s} = 1.5\ \text{m/s}\uparrow$

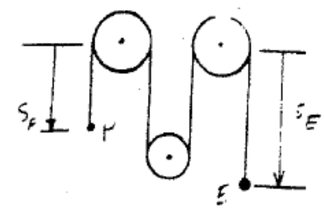
$(+\uparrow)\quad v = v_0 + a_c t$

$1.5 = 0 + a_E(2)$

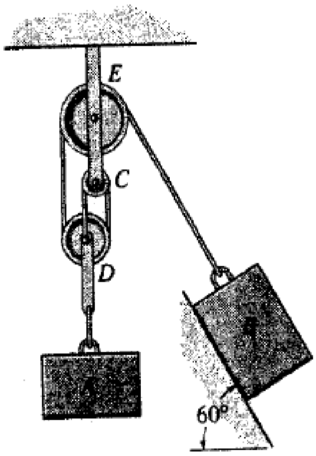
$a_E = 0.75\ \text{m/s}^2\uparrow$ **Ans**

$+\uparrow\Sigma F_y = ma_y;\quad 4T - 500(9.81) = 500(0.75)$

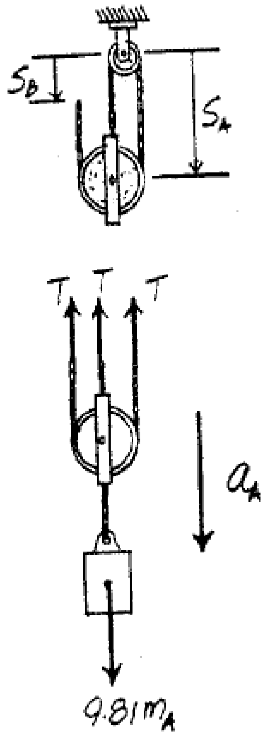
$T = 1320\ \text{N} = 1.32\ \text{kN}$ **Ans**



13-25. Determine the required mass of block A so that when it is released from rest it moves the 5-kg block B 0.75 m up along the smooth inclined plane in $t = 2$ s. Neglect the mass of the pulleys and cords.



Kinematic : Applying equation $s = s_0 + v_0 t + \frac{1}{2} a_c t^2$, we have



(a)

$$(\;+) \qquad 0.75 = 0 + 0 + \frac{1}{2} a_B \left(2^2\right) \qquad a_B = 0.375 \text{ m/s}^2$$

Establish the position - coordinate equation, we have

$$2s_A + (s_A - s_B) = l \qquad 3s_A - s_B = l$$

Taking time derivative twice yields

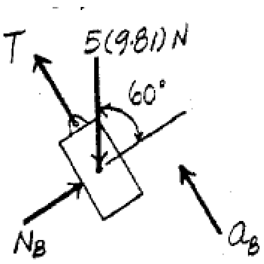
$$3a_A - a_B = 0 \qquad [1]$$

From Eq.[1],

$$3a_A - 0.375 = 0 \qquad a_A = 0.125 \text{ m/s}^2$$

Equation of Motion : The tension T developed in the cord is the same throughout the entire cord since the cord passes over the smooth pulleys. From FBD(b),

$$+\Sigma F_{y'} = ma_{y'}; \qquad T - 5(9.81)\sin 60° = 5(0.375)$$
$$T = 44.35 \text{ N}$$

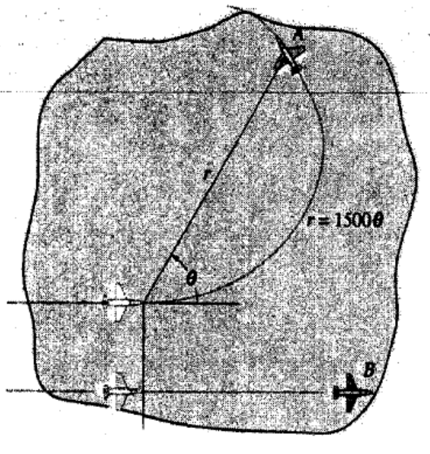


(b)

From FBD(a),

$$+\uparrow \Sigma F_y = ma_y; \qquad 3(44.35) - 9.81 m_A = m_A(-0.125)$$
$$m_A = 13.7 \text{ kg} \qquad \textbf{Ans}$$

***12-200.** Two planes A and B are flying side by side at a constant speed of 900 km/h. Maintaining this speed, plane A begins to travel along the spiral path $r = (1500\theta)$ km, where θ is in radians, whereas plane B continues to fly in a straight line. Determine the speed of plane A with respect to plane B when $r = 750$ km.



Relative Velocity : At $r = 750$ km, $750 = 1500\theta$, $\theta = 0.5$ rad $= 28.64°$. Here,

$\tan\psi = \dfrac{r}{dr/d\theta} = \dfrac{1500\theta}{1500} = \theta = 0.5$, $\psi = 26.57°$ and $\theta + \psi = 55.21°$. Applying Eq. 12 – 34 gives

$$\mathbf{v}_A = \mathbf{v}_B + \mathbf{v}_{A/B}$$

$$900\cos 55.21°\mathbf{i} + 900\sin 55.21°\mathbf{j} = 900\mathbf{i} + \mathbf{v}_{A/B}$$

$$\mathbf{v}_{A/B} = \{-386.52\mathbf{i} + 739.15\mathbf{j}\}\ \text{km/h}$$

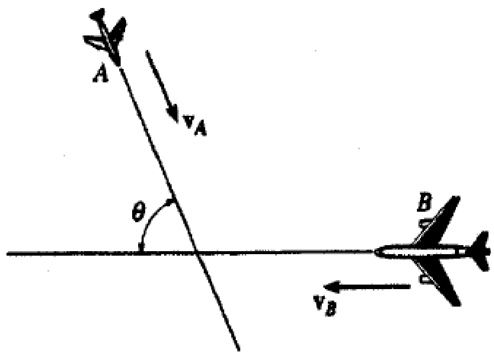
Thus, the magnitude of the relative velocity $\mathbf{v}_{A/B}$ is

$$v_{A/B} = \sqrt{(-386.52)^2 + 739.15^2} = 834\ \text{km/h} \qquad \textbf{Ans}$$

The direction of the relative velocity is the same as the drection of that for relative acceleration. Thus

$$\theta = \tan^{-1}\frac{739.15}{386.52} = 62.4° \qquad \textbf{Ans}$$

***12-196.** Two planes, A and B, are flying at the same altitude. If their velocities are $v_A = 600$ km/h and $v_B = 500$ km/h such that the angle between their straight-line courses is $\theta = 75°$, determine the velocity of plane B with respect to plane A.



$$\mathbf{v}_B = \mathbf{v}_A + \mathbf{v}_{B/A}$$

$$[500 \leftarrow] = [600 \overset{75°}{\swarrow}] + \mathbf{v}_{B/A}$$

$(\overset{+}{\leftarrow})\quad 500 = -600\cos 75° + (v_{B/A})_x$

$$(v_{B/A})_x = 655.29 \leftarrow$$

$(+\uparrow)\quad 0 = -600\sin 75° + (v_{B/A})_y$

$$(v_{B/A})_y = 579.56 \uparrow$$

$$(v_{B/A}) = \sqrt{(655.29)^2 + (579.56)^2}$$

$$v_{A/B} = 875\ \text{km/h} \qquad \textbf{Ans}$$

$$\theta = \tan^{-1}\left(\frac{579.56}{655.29}\right) = 41.5° \qquad \textbf{Ans}$$

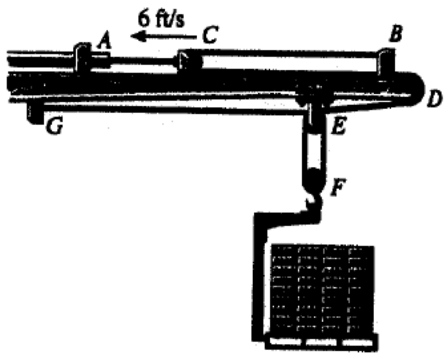
12-194. Vertical motion of the load is produced by movement of the piston at A on the boom. Determine the distance the piston or pulley at C must move to the left in order to lift the load 2 ft. The cable is attached at B, passes over the pulley at C, then D, E, F, and again around E, and is attached at G.

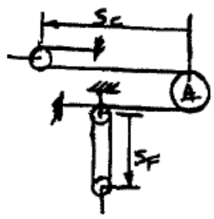
$$2s_C + 2s_F = l$$

$$2\Delta s_C = -2\Delta s_F$$

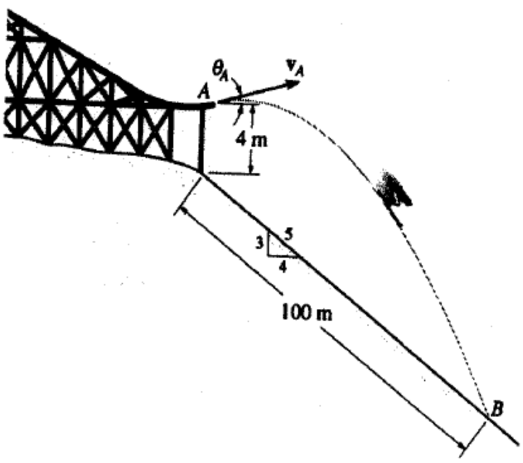
$$\Delta s_C = -\Delta s_F$$

$$\Delta s_C = -(-2 \text{ ft}) = 2 \text{ ft} \qquad \textbf{Ans}$$





12-91. It is observed that the skier leaves the ramp A at an angle $\theta_A = 25°$ with the horizontal. If he strikes the ground at B, determine his initial speed v_A and the time of flight t_{AB}.

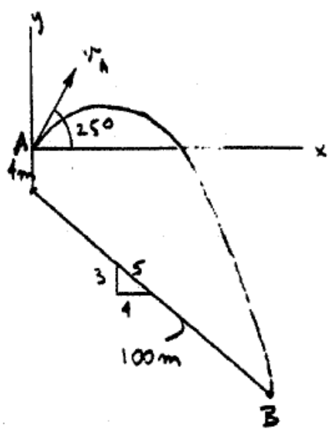


$(\overset{+}{\rightarrow})$ $\quad s = v_0 t$

$$100\left(\frac{4}{5}\right) = v_A \cos 25° t_{AB}$$

$(+\uparrow)$ $\quad s = s_0 + v_0 t + \frac{1}{2}a_c t^2$

$$-4 - 100\left(\frac{3}{5}\right) = 0 + v_A \sin 25° t_{AB} + \frac{1}{2}(-9.81)t_{AB}^2$$



Solving,

$v_A = 19.4$ m/s $\quad$ **Ans**

$t_{AB} = 4.54$ s $\quad$ **Ans**