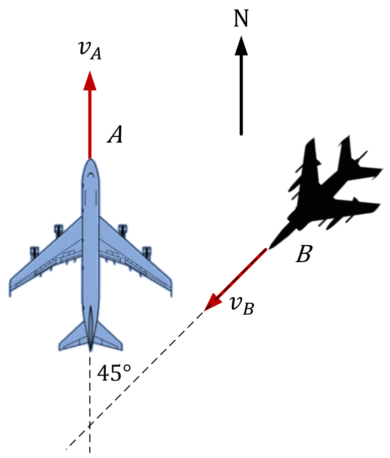
Question 8.15.

Airplane A is flying north with a constant horizontal velocity of 500 km/h. Airplane B is flying southwest at the same altitude with a velocity of 500 km/h. From the frame of reference of A, determine the magnitude v_r of the apparent or relative velocity of B. Also find the magnitude of the apparent velocity v_n with which B appears to be moving sideways or normal to its centerline.



Solution

$v_A = v_B + v_{A/B}$

where

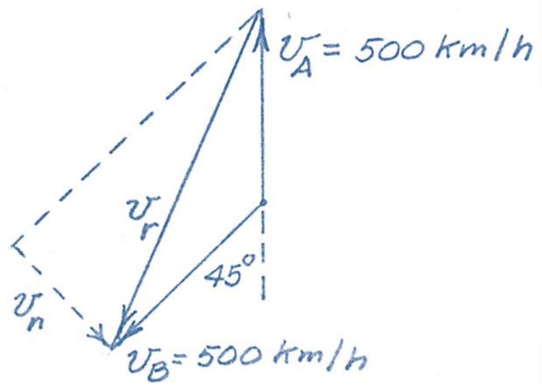
$v_{A/B} = v_r$

$v_r^2 = (500)^2 + (500)^2 + 2(500)(500)\cos 45°$

$v_r = 924\ \text{km/h}$ (Answer)

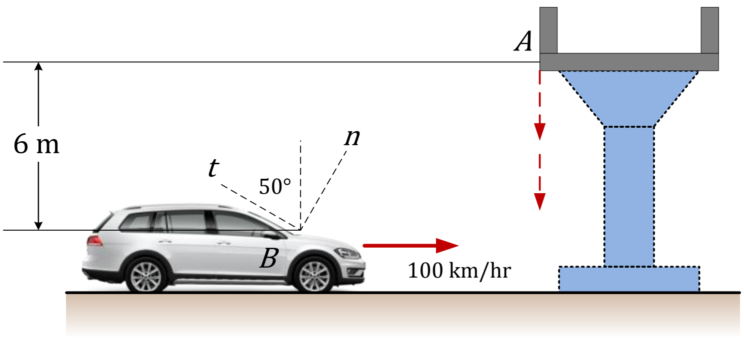
Also,

$v_n = 500 \cos 45° = 354\ \text{km/h}$ (Answer)

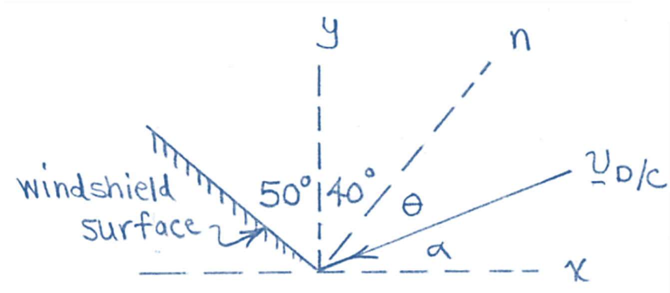


Question 8.16.

A drop of water falls with no initial speed from point A of a highway overpass. After dropping 6 m, it strikes the windshield at point B of a car which is traveling at a speed of 100 km/h on the horizontal road. If the windshield is inclined 50° from the vertical as shown, determine the angle relative to the normal n to the windshield at which the water drop strikes.



Solution



Drop:

$$v_D = \sqrt{2gh} = \sqrt{2(9.81)(6)} = 10.85 \text{ m/s}$$

Car:

$$v_C = \frac{100}{3.6} = 27.8 \text{ m/s}$$

$$\mathbf{v}_{D/C} = \mathbf{v}_D - \mathbf{v}_C$$

$$\mathbf{v}_{D/C} = -27.8\,\mathbf{i} - 10.85\,\mathbf{j}$$

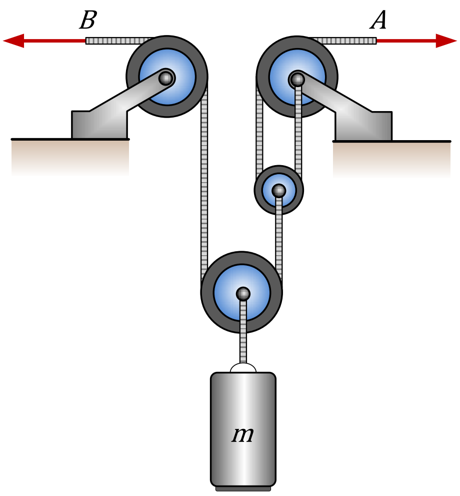
$$\alpha = \tan^{-1}\left(\frac{10.85}{27.8}\right)$$

$$\alpha = 21.3°$$

$$40° + \alpha + \theta = 90°$$

$\theta = 28.7°$ (below normal) (Answer)

Question 8.17.



For the pulley system shown, each of the cables at A and B is given a velocity of 2 m/s in the direction of the arrow. Determine the upward velocity v of the load m.

Solution

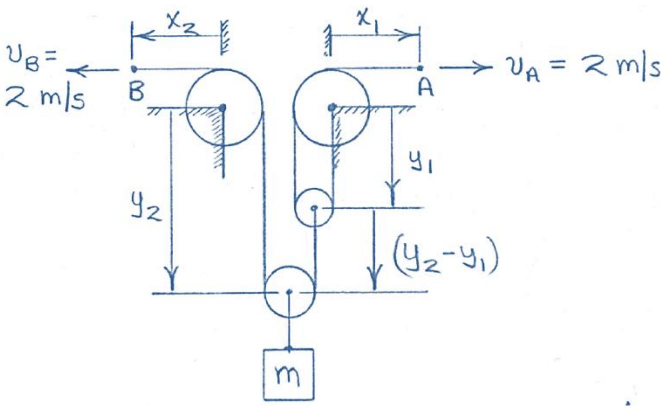
$x_1 + 2y_1 = constant$

Differentiate with respect to time:

$\dot{x}_1 + 2\dot{y}_1 = 0$

$\dot{y}_1 = -\frac{\dot{x}_1}{2}$ ----- (1)

also,



$x_2 + y_2 + (y_2 - y_1) = constant$

$x_2 + 2y_2 - y_1 = constant$

Differentiate with respect to time:

$\dot{x}_2 + 2\dot{y}_2 - \dot{y}_1 = 0$ ----- (2)

Substituting from (1) into (2)

$\dot{x}_2 + 2\dot{y}_2 + \left(\frac{\dot{x}_1}{2}\right) = 0$

Rearranging gives,

$\dot{y}_2 = -\frac{\dot{x}_2}{2} - \frac{\dot{x}_1}{4}$

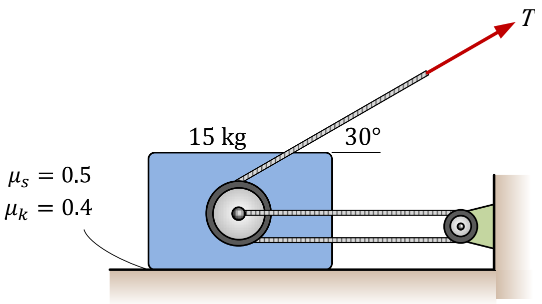
$\dot{y}_2 = -\frac{2}{2} - \frac{4}{4} = -1.5 \text{ m/s}$

Or

$\dot{y}_2 = v = 1.5 \text{ m/s (up)}$ (Answer)

Question 8.18.

Determine the initial acceleration of the 15 kg block if (a) $T = 23$ N and (b) $T = 26$ N. The system is initially at rest with no slack in the cable, and the mass and friction of the pulleys are negligible.



Solution

Assume static equilibrium

(a) For $T = 23$ N

$+\rightarrow \sum F_x = 0$:

$-F + T(2 + \cos 30°) = 0$

$F = (23)(2 + \cos 30°) = 65.9$ N

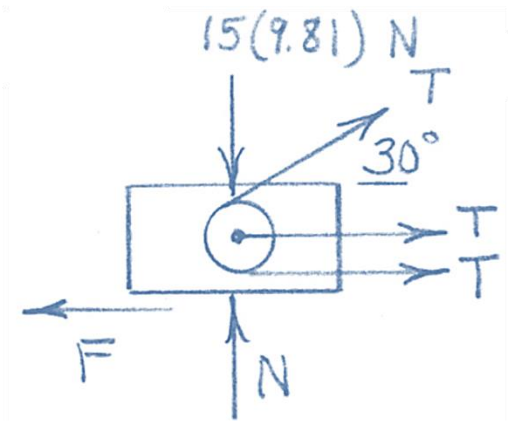
$+\uparrow \sum F_y = 0$:

$N + T \sin 30° - 15(9.81) = 0$

$N = 15(9.81) - (23) \sin 30° = 135.6$ N

$F_{max} = \mu_s N = (0.5)(135.6) = 67.8 \text{ N} > F$

So assumption is valid and $a = 0$ (Answer)



(b) For $T = 26$ N

$+\rightarrow \sum F_x = 0$:

$-F + T(2 + \cos 30°) = 0$

$F = (26)(2 + \cos 30°) = 74.5$ N

$+\uparrow \sum F_y = 0$:

$N + T \sin 30° - 15(9.81) = 0$

$N = 15(9.81) - (26) \sin 30° = 134.2$ N

$F_{max} = \mu_s N = (0.5)(134.2) = 67.1 \text{ N} < F$

So motion occurs and $F = F_k = \mu_k N = (0.4)(134.2) = 53.7$ N

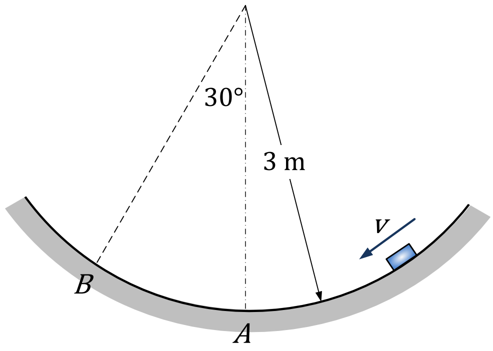
$+\rightarrow \sum F_x = ma_x$:

$-53.7 + 26(2 + \cos 30°) = 15a$

$a = 1.390 \text{ m/s}^2$ $(\rightarrow)$ (Answer)

Question 8.19.

The small 0.6 kg block slides with a small amount of friction on the circular path of radius 3 m in the vertical plane. If the speed of the block is 5 m/s as it passes point A and 4 m/s as it passes point B, determine the normal force exerted on the block by the surface at each of these two locations.



Solution

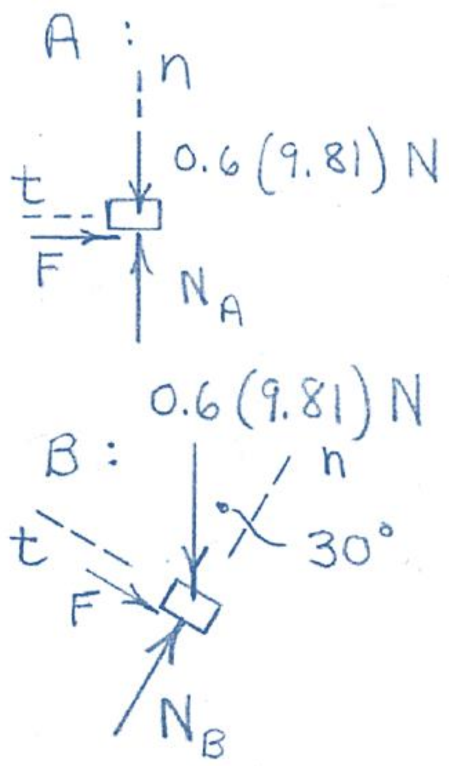
For position A

$$\sum F_n = ma_n$$

$$N_A - 0.6(9.81) = m\left(\frac{v_A^2}{\rho}\right)$$

$$N_A = 0.6(9.81) + 0.6\left(\frac{5^2}{3}\right)$$

$N_A = 10.89$ N (Answer)



For position B

$$\sum F_n = ma_n$$

$$N_B - 0.6(9.81)\cos 30° = m\left(\frac{v_B^2}{\rho}\right)$$

$$N_B = 0.6(9.81)\cos 30° + 0.6\left(\frac{4^2}{3}\right)$$

$N_B = 8.30$ N (Answer)

NOTE: Friction is along the t-axis and does not affect the above calculations