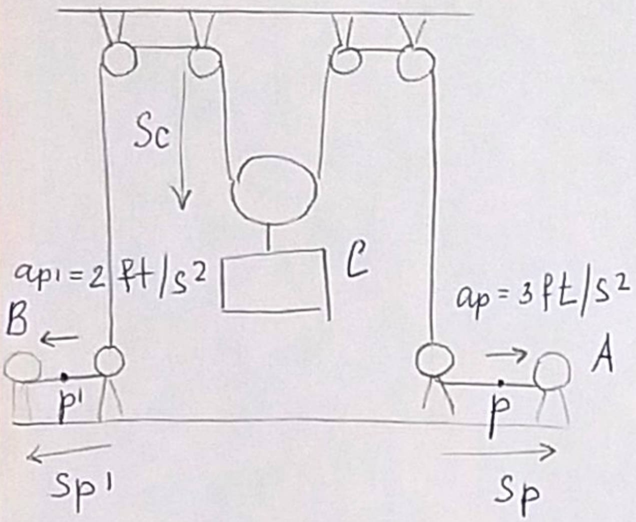
Zarema Balgabekova

13-6

Given

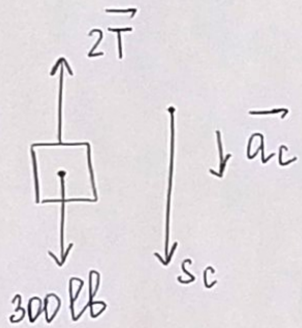


$W_c = 300\ lb$

a_c - ?

T - ?

Solution



$+\downarrow \Sigma F_y = ma_y$

$$300 - 2T = \left(\frac{300}{32.2}\right) a_c$$

$$T = \left[300 - \left(\frac{300}{32.2}\right) a_c\right] \cdot \frac{1}{2} \qquad [1]$$

$$2s_c + s_p + s_{p'} = l$$

$$\Rightarrow 2a_c + a_p + a_{p'} = 0$$

$$a_c = (-a_p - a_{p'}) \cdot \frac{1}{2} = \frac{1}{2}(-2-3) = -2.5\ ft/s^2 = 2.5\ ft/s^2 \uparrow$$

From [1], $T = \left[300 - \left(\frac{300}{32.2}\right)(-2.5)\right] \frac{1}{2} = 162\ lb$

Answer: $a_c = 2.5\ ft/s^2 \uparrow$

$T = 162\ lb$

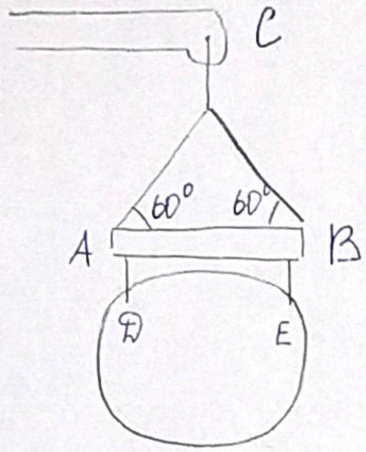
13-14

Given:

$m = 3.5$ Mg

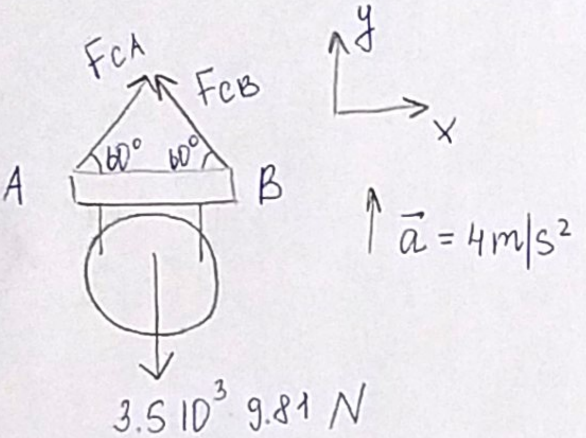
$a = 4\ m/s^2$

$v = 2\ m/s$



F_{CA}, F_{CB} - ?

Solution



$\xrightarrow{+} \Sigma F_x = ma_x$

$F_{CA} \cos 60° - F_{CB} \cos 60° = 0$

$\Rightarrow F_{CA} = F_{CB} = F$

$+\uparrow \Sigma F_y = ma_y$

$2F \sin 60° - 3.5\,10^3 \cdot 9.81 = 3.5\,10^3 \cdot 4$

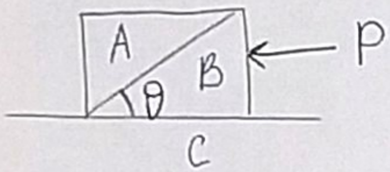
$$F = \frac{3.5\,10^3 (4 + 9.81)}{2 \sin 60°} = 27906\ N = 27.9\ kN$$

$F_{CA} = F_{CB} = F = 27.9\ kN$

Answer: $F_{CA} = F_{CB} = 27.9\ kN$

13-36

Given:

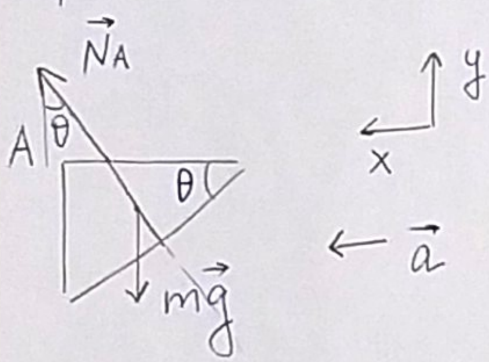


$m_A = m_B = m$

P_{max} - ? (so that A will not move relative to B)

Solution:

$\overset{+}{\leftarrow}$ $a_{A/B} = a_A - a_B = 0 \quad \Rightarrow \quad a_A = a_B = a$



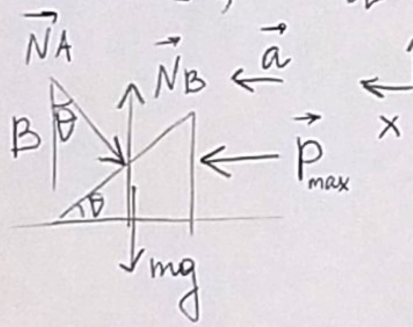
$\overset{+}{\leftarrow} \sum F_x = ma_x$

$N_A \sin\theta = ma \qquad [1]$

$+\uparrow \sum F_y = ma_y$

$N_A \cos\theta - mg = 0 \qquad N_A = \dfrac{mg}{\cos\theta}$

From [1], $a = \dfrac{N_A \sin\theta}{m} = \dfrac{\cancel{m}g \sin\theta}{\cos\theta \, \cancel{m}} = g\tan\theta$



$\overset{+}{\leftarrow} \sum F_x = ma_x$

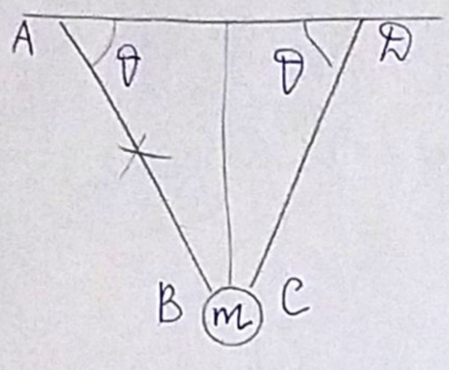
$P_{max} - N_A \sin\theta = ma$

$P_{max} = m(g\tan\theta) + \left(\dfrac{mg}{\cos\theta}\right)\sin\theta = 2mg\tan\theta$

<u>Answer</u> $P_{max} = 2mg\tan\theta$

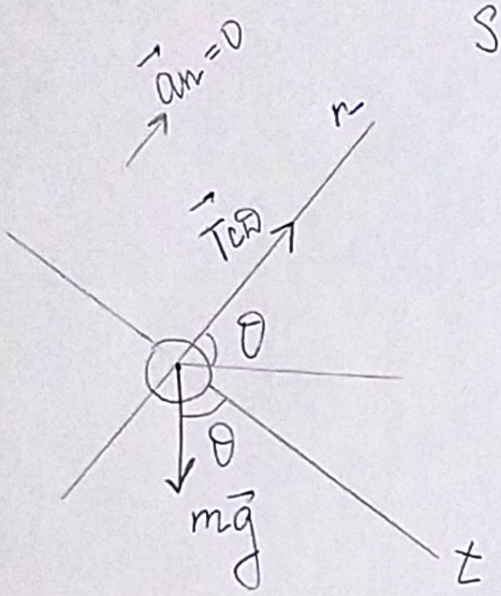
13-57

Given:



T_{CD} - ? (just after wire AB is cut)

Solution



$$+\nearrow \sum F_n = m a_n$$

$$T_{CD} - mg\sin\theta = m\left(\frac{v^2}{\rho}\right)$$

Just after the wire AB is cut,

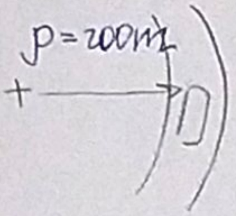
$v = 0 \quad \Rightarrow \quad T_{CD} - mg\sin\theta = 0$

$$T_{CD} = mg\sin\theta$$

Answer: $T_{CD} = mg\sin\theta$

13-67

Given:

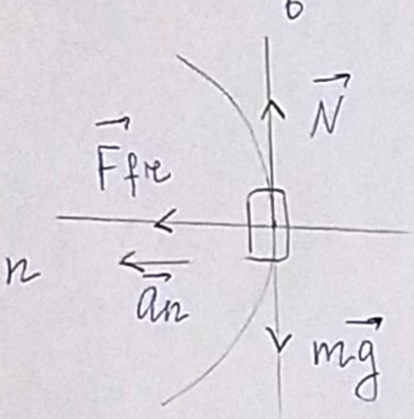


$\mu_s = 0.25$

$m = 1.5\ Mg$

v_{max} - ? (without causing the car to slide)

Solution.



$+\uparrow \sum F_b = 0 \qquad N - mg = 0$

$N = mg$

$\overset{+}{\leftarrow} \sum F_n = m a_n \qquad F_{fr} = m \dfrac{v_{max}^2}{\rho}$

$$\mu_s N = m \frac{v_{max}^2}{\rho}$$

$$\mu_s \cancel{m} g = \frac{\cancel{m} v_{max}^2}{\rho}$$

$$v_{max} = \sqrt{\mu_s g \rho} =$$

$$\sqrt{0.25 \cdot 9.81\ 200} = 22.1\ m/s$$

Answer: $v_{max} = 22.1\ m/s$

13-91

Given:

$m = 2\,kg$

$r = 0.1\,m$

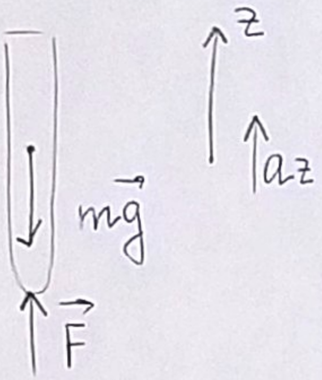
$z = 0.02 \sin\theta \; m$

$\dot{\theta} = 5\; rad/s$

F_{max} - ?

F_{min} - ?

Solution



$+\uparrow \sum F_z = m a_z$

$F - mg = m a_z$

$F = m a_z + mg = m(a_z + g) \quad [1]$

$a_z = \ddot{z}$

$\dot{\theta} = 5\; rad/s \Rightarrow \ddot{\theta} = 0$

$\dot{z} = 0.02 \cos\theta\, \dot{\theta}$

$\ddot{z} = -0.02 \sin\theta\, \dot{\theta}\dot{\theta} + 0.02 \cos\theta\, \ddot{\theta} = -0.02 \sin\theta\, (\dot{\theta})^2$

$\Rightarrow a_z = -0.02 \sin\theta\, (\dot{\theta})^2 \quad [2]$

From [1], F is maximum when a_z is maximum

From [2], a_z is maximum when $\sin\theta = -1$ $(\theta = -90^\circ)$

$(a_z)_{max} = -0.02(-1)\, 5^2 = 0.5\; m/s$

$F_{max} = 2(0.5 + 9.81) = 20.6\; N$

From [1], F is minimum when a_z is minimum

From [2], a_z is minimum when $\sin\theta = 1$ $(\theta = 90^\circ)$

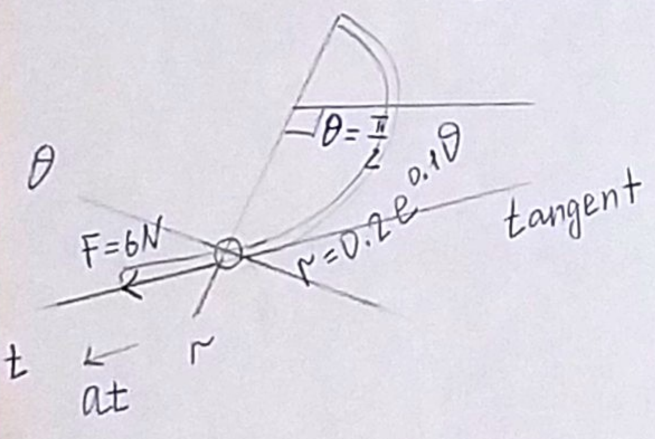
$$(a_z)_{min} = -0.02 \cdot 1 \cdot 5^2 = -0.5\ m/s$$

$$F_{min} = 2(-0.5 + 9.81) = 18.6\ N$$

Answer $F_{max} = 20.6\ N$ $F_{min} = 18.6\ N$

13-109	
Given:	a_t - ?
$m = 0.5\ kg$	ψ - ?
$F = 6\ N$	
$\theta = \frac{\pi}{2}$	

Solution.



$$\overset{+}{\swarrow} \Sigma F_t = m a_t$$

$$6 = 0.5 a_t$$

$$a_t = 12\ m/s^2$$

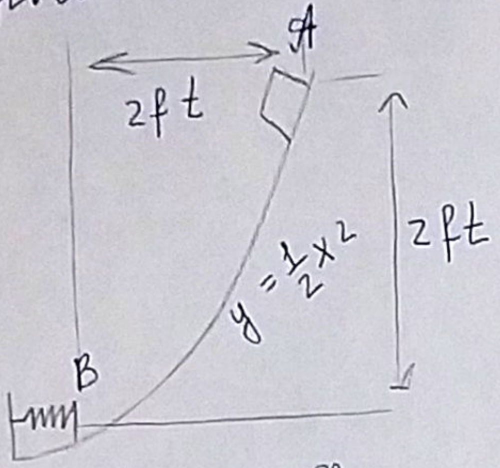
$$\tan\psi = \frac{r}{dr/d\theta} = \frac{\cancel{0.2}\cancel{e^{0.1\theta}}}{\cancel{0.2} \cdot 0.1 \cancel{e^{0.1\theta}}} = 10 \Rightarrow \psi = 84.3^\circ$$

Answer $a_t = 12\ m/s^2$

$\psi = 84.3^\circ$

14-7

Given



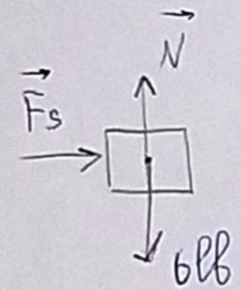
$k = 5\ lb/in = 60\ \frac{lb}{ft}$

$W = 6\ lb$

$V_A = 0$

$S_B - ?$

Solution:



$$T_A + \sum U_{A-B} = T_B$$

$$0 + \left(-\left(\frac{1}{2}kS_B^2 - \frac{1}{2}kS_A^2\right) + W \cdot 2\right) = 0$$

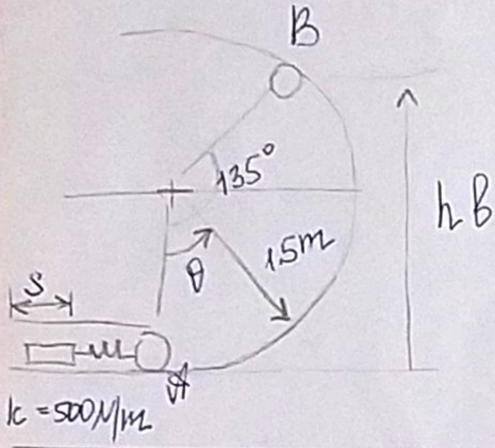
$$-\frac{1}{2}60S_B^2 + 0 + 6 \cdot 2 = 0$$

$$S_B = \sqrt{\frac{6 \cdot 2 \cdot 2}{60}} = 0.632\ ft$$

Answer: $S_B = 0.632\ ft$

14-21

Given:

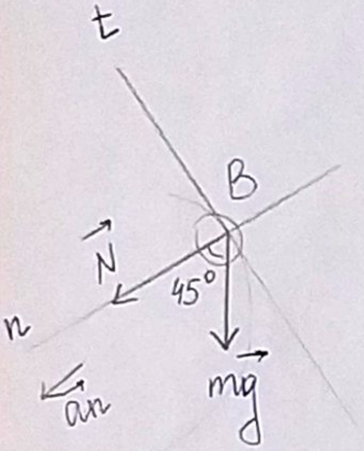


$m = 0.5$ kg

the spring compressed 0.08 m when $s = 0$

How far s the spring must be pulled back so that the ball will begin leave the track when $\theta = 135°$?

Solution:



$$+\swarrow \sum F_n = ma_n$$

$$N + mg\cos 45° = \frac{m v_B^2}{1.5}$$

When $\theta = 135°$, $N = 0$

$$\Rightarrow \quad v_B^2 = 1.5 g\cos 45° = 1.5 \cdot 9.81 \cos 45° = 10.405 (m/s)^2$$

$h_B = 1.5 + 1.5\sin 45° = 2.561$ m $\qquad v_A = 0$

$$T_A + \sum U_{A-B} = T_B$$

$$0 + \int_0^s 500(s + 0.08)\,ds - 0.5 \; 9.81 \; 2.561 = \frac{1}{2} 0.5 \cdot 10.405$$

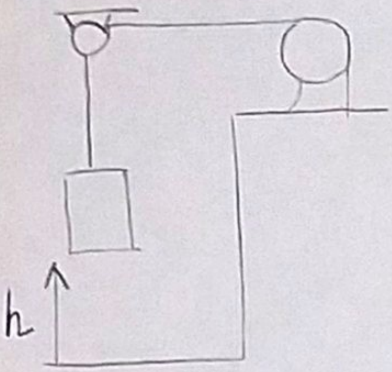
$$250 s^2 + 40 s - 15.16 = 0$$

$$s = 0.179 \text{ m}$$

Answer $s = 0.179$ m

14-62

Given:



$m = 60\,kg$

$h = 5\,m$

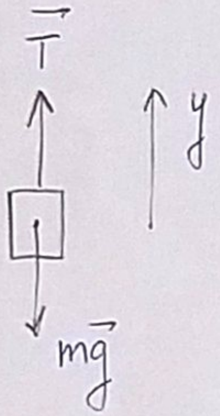
$t = 2\,s$ $\quad v$ - const

$P_{input} = 3.2\,kW$

ϵ - ?

Solution

$$v = \frac{h}{t} = \frac{5}{2} = 2.5\,m/s$$



$+\uparrow \Sigma F_y = 0$ $\quad T - mg = 0$

$T = mg = 60 \cdot 9.81 = 588.6\ N$

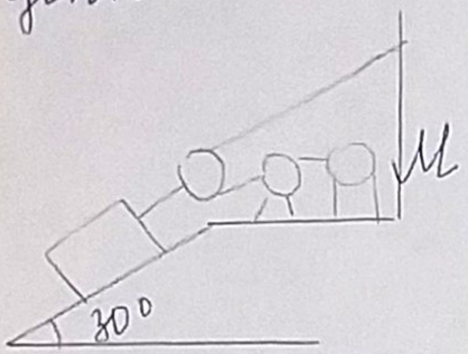
$$P_{output} = \vec{T} \cdot \vec{v} = Tv = 588.6 \cdot 2.5 = 1471.5\,W$$

$$\epsilon = \frac{P_{output}}{P_{input}} = \frac{1471.5}{3200} = 0.46$$

Answer $\epsilon = 0.46$

14.70

Given:



$m = 50\ kg$

$v_0 = 0$

$v = 4 m/s$ when $s = 8m$

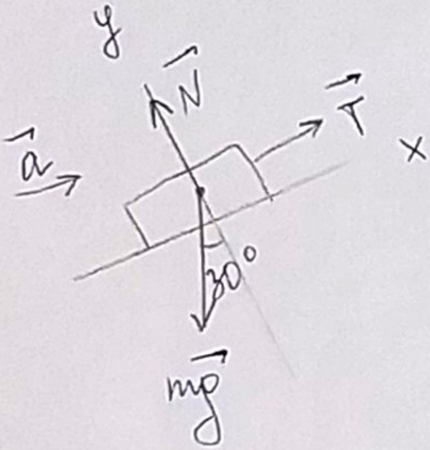
a - const

$\epsilon = 0.74$

P_{input} - ?

Solution

$$v^2 = v_0^2 + 2a(s - s_0) \qquad a = \frac{v^2 - v_0^2}{2(s - s_0)} = \frac{4^2 - 0}{2 \cdot 8} = 1 m/s^2$$



$$+\nearrow \sum F_x = ma_x$$

$$T - mg \sin 30° = ma$$

$$T = m(a + g \sin 30°) =$$

$$50(1 + 9.81 \sin 30°) = 295.25 N$$

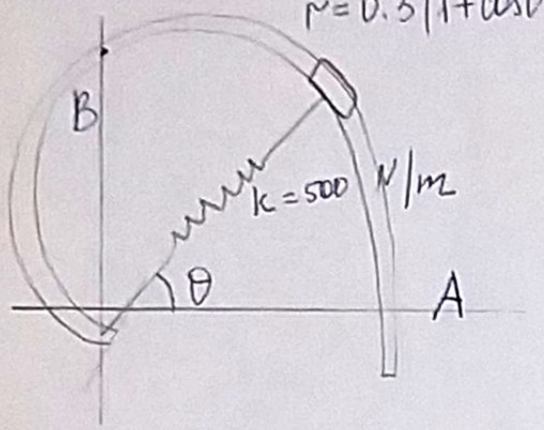
$$P_{output} = \vec{T} \cdot \vec{v} = Tv = 295.25 \cdot 4 = 1181\ W$$

$$\epsilon = \frac{P_{output}}{P_{input}} \qquad P_{input} = \frac{P_{output}}{\epsilon} = \frac{1181}{0.74} = 1596 W$$

Answer: $P_{input} = 1596 W$

14 - 84

Given:



$m = 5\ kg$

$v_A = 0$

$l_{unstretched} = 200\ mm$

$v_B - ?$

Solution.

When $\theta = 0$ $\quad h_A = 0$

$$s_A = 0.3(1+\cos 0) - 0.2 = 0.4\ m$$

When $\theta = 90°$ $\quad h_B = 0.3(1+\cos 90°) = 0.3m$

$$s_B = 0.3 - 0.2 = 0.1m$$

$$T_A + V_A = T_B + V_B$$

$$0 + \frac{1}{2} k s_A^2 = \frac{m v_B^2}{2} + \frac{1}{2} k s_B^2 + m g h_B$$

$$m v_B^2 = k s_A^2 - k s_B^2 - 2 m g h_B$$

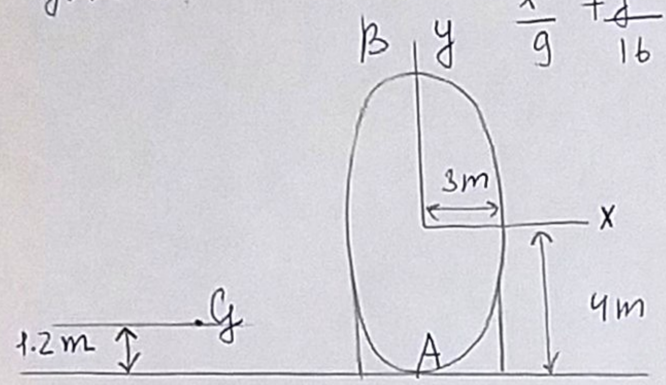
$$v_B = \sqrt{\frac{500(0.4^2 - 0.1^2) - 2 \cdot 5 \cdot 9.81 \cdot 0.3}{5}} = 3.02\ m/s$$

Answer: $v_B = 3.02\ m/s$

14-95

Given

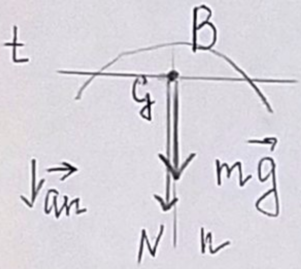
$$\frac{x^2}{9} + \frac{y^2}{16} = 1$$



$m = 85\,kg$

$v_A - ?$

Solution:



$+\downarrow \sum F_n = m a_n$

$$N + mg = \frac{m v_B^2}{\rho_G}$$

At B $N = 0 \Rightarrow v_B^2 = g\rho_G$ [1]

$$\rho = \frac{[1 + (dy/dx)^2]^{3/2}}{|d^2y/dx^2|}$$

$$\frac{x^2}{9} + \frac{y^2}{16} = 1$$

$$16x^2 + 9y^2 = 16 \cdot 9$$

$$9y^2 = 16(9 - x^2)$$

$$y = \frac{4}{3}\sqrt{9 - x^2}$$

$$\frac{dy}{dx} = -\frac{4x}{3\sqrt{9-x^2}}$$

$$\frac{d^2y}{dx^2} = -\frac{4}{3\sqrt{9-x^2}} - \frac{4x^2}{3\sqrt{(9-x^2)^3}}$$

$$\text{At B, } \rho = \left.\frac{\left[1 + \left(\frac{-4x}{3\sqrt{9-x^2}}\right)^2\right]^{3/2}}{\left|\frac{-4}{3\sqrt{9-x^2}} - \frac{4x^2}{3\sqrt{(9-x^2)^3}}\right|}\right|_{x=0} = \frac{1}{\left|-\frac{4}{9}\right|} = \frac{9}{4} = 2.25\,m$$

$\frac{P}{g} = 2.25 - 1.2 = 1.05\ m$

From [1], $v_B^{\,2} = 9.81 \cdot 1.05 = 10.3\ (m/s)^2$

$h_A = 1.2\ m$ $\qquad$ $h_B = 8 - 1.2 = 6.8\ m$

$$T_A + V_A = T_B + V_B$$

$$\frac{\cancel{m} v_A^2}{2} + \cancel{m} \cdot 1.2 \cdot 9.81 = \frac{\cancel{m} \cdot 10.3}{2} + \cancel{m} \cdot 6.8 \cdot 9.81$$

$$v_A = \sqrt{10.3 + 2 \cdot 6.8 \cdot 9.81 - 2 \cdot 1.2 \cdot 9.81} = 11\ m/s$$

<u>Answer</u>: $v_A = 11\ m/s$