Physics 201

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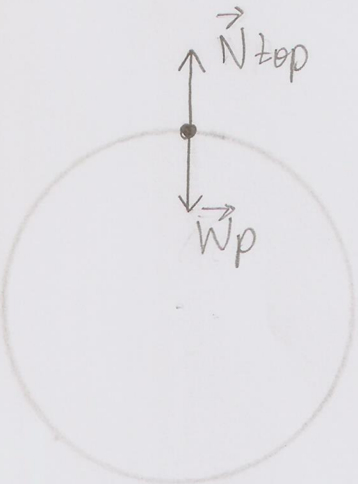
① The Free Body Diagrams (top and bottom)

(a) $\vec{W}_p \rightarrow$ weight of the



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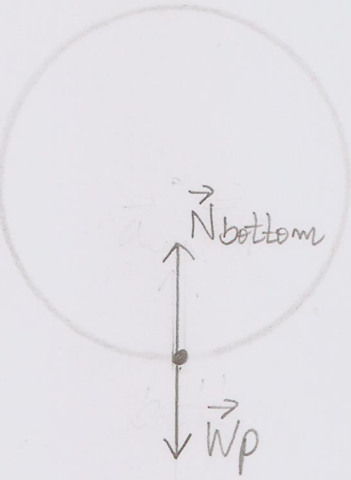


(b) The velocity in this case is:

$$V_\theta = \frac{2\pi r}{T} = \frac{2\pi(50m)}{60s} = \boxed{5.24 m/s}$$

(c) The mass of the passenger is:

$$m = \frac{682N}{9.80 m/s^2} = 69.6 Kg$$

the apparent weight (highest point) is the difference of his weight and the centripetal force:

$$W_a = W - \frac{mv^2}{r} = 682N - \frac{(69.6Kg).(5.24m/s)^2}{50m} = \boxed{644N}$$

and the apparent weight (lowest point) is the sum of his weight and the centripetal force:

$$W_a = W + \frac{mv^2}{r} = 682N + \frac{(69.6Kg).(5.24m/s)^2}{50m} = \boxed{720N}$$

(2) (a) We can use a kinematic equation that relates the initial and final positions with the velocity and cleaning the time, we have:

$$y - y_0 = V_{0y} t - \frac{1}{2} g t^2$$

$$(15.7 - 1.50)m = (46.6 m/s) \sin(50.7°) t - \frac{1}{2} (9.80 m/s^2) t^2$$

$$14.2m = (36.1 m/s) t - (4.9 m/s^2) t^2$$

$$(4.9 m/s^2) t^2 - (36.1 m/s) t + 14.2m = 0$$

The quadratic equation obtained is:

$$t = \frac{-(-36.1 m/s) \pm \sqrt{(-36.1 m/s)^2 - (4)(4.9 m/s^2)(14.2m)}}{(2)(4.9 m/s^2)}$$

$$t_1 = 6.95s$$
$$t_2 = 0.42s$$

the time that has physical meaning is $t_1 = 6.95s$.

(b) We start the analysis from the equation of the trajectory, but once again we take into account the initial and final positions:

$$y - y_0 = x \left[\tan(\theta) - \frac{g}{2(V_0 \cos(\theta))^2} x \right]$$

$$14.2m = (1.222) x + (5.62 \cdot 10^{-3} 1/m) x^2$$

$$-(5.62 \cdot 10^{-3} 1/m) x^2 - (1.222) x + 14.2m = 0$$

The quadratic equation obtained is:

$$x = \frac{-(-1.222) \pm \sqrt{(1.222 - (4)(-5.62 \cdot 10^{-3} 1/m)(14.2m)}}{(2)(5.62 \cdot 10^{-3} 1/m)}$$

$$x_1 = -1.95 m$$
$$x_2 = 219.4 m$$

the distance that has physical meaning is $x_2 = 219 m$.

(c) The kinematic equation useful for this situation is:

$V_{fy}^2 = V_{oy}^2 - 2g(y-y_0)$

$V_{fy} = \sqrt{V_{oy}^2 - 2g(y-y_0)}$

$V_{fy} = \sqrt{1300.39 m^2/s^2 - 278.32 m^2/s^2}$

$V_{fy} = 31.9 m/s$

As the horizontal speed is constant, the same value of the initial speed will be the value of the final speed but with negative sign:

$V_{fx} = V_{ox} = -29.5 m/s$

the magnitude of the final velocity is:

$V_f = \sqrt{(-29.5 m/s)^2 + (31.9 m/s)^2} = \boxed{43.4 m/s}$

The direction of the final velocity is as follows:

$\theta = \tan^{-1}\left(\frac{V_{fy}}{V_{fx}}\right) = \tan^{-1}\left(\frac{31.9 m/s}{-29.5 m/s}\right) = \boxed{-47.2°}$

(d) The time of flight is:

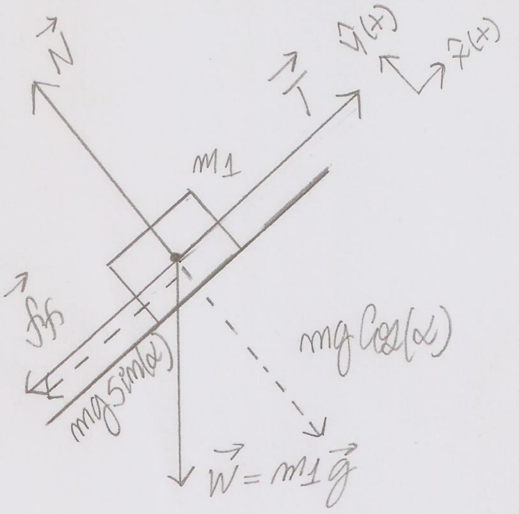
$t = \frac{V_{oy}}{g} = \frac{36.06 m/s}{9.80 m/s^2} = 3.68 s$

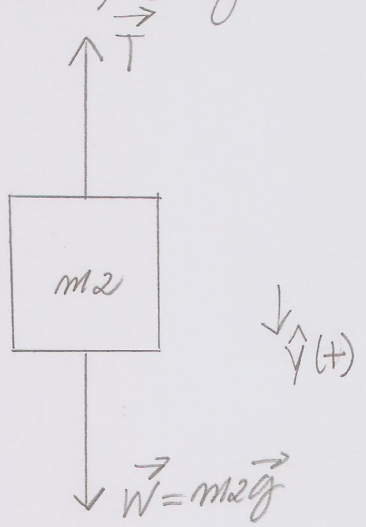
the maximum height reached is:

$h = V_{oy}t - \frac{1}{2}gt^2 = (36.06 m/s)(3.68 s)\sin(50.7°) - \frac{1}{2}(9.80 m/s^2)(3.68 s)^2$

$\boxed{h = 36.3 m}$

③ This situation have the following Free Body Diagrams:





If we use a kinematic equation to calculate the acceleration, we have:

$$y = y_0 + \cancel{v_0 t}^{\,0} + \frac{1}{2} a_y t^2$$

$$a_y = \frac{2(y - y_0)}{t^2} = \frac{2(1.00\,m)}{(3s)^2} = 0.22\,m/s^2$$

The normal force for m_1 is:

$$N = m_1 g\,Cos(\alpha) = (23\,Kg)(9.80\,m/s^2)\,Cos(50.2^\circ) = 144.3\,N$$

The force of friction on m_1 is:

$$f_k = \mu_k m_1 g\,Cos(\alpha) = (0.42)(23\,Kg)(9.80\,m/s^2)\,Cos(50.2^\circ) = 60.6\,N$$

Applying Newton's second law to m_1:

$$T - f_k - m_1 g\,Sin(\alpha) = m_1 a$$

solving for T:

$$T = f_k + m_1 g\,Sin(\alpha) + m_1 a = 60.6\,N + 173.2\,N + 5.06\,N = 239\,N$$

Newton's second law for m_2 gives:

$$m_2 g - T = m_2 a \rightarrow m_2 = \frac{T}{g - a} = \frac{239\,N}{9.8\,m/s^2 - 0.22\,m/s^2} = \boxed{24.9\,Kg}$$

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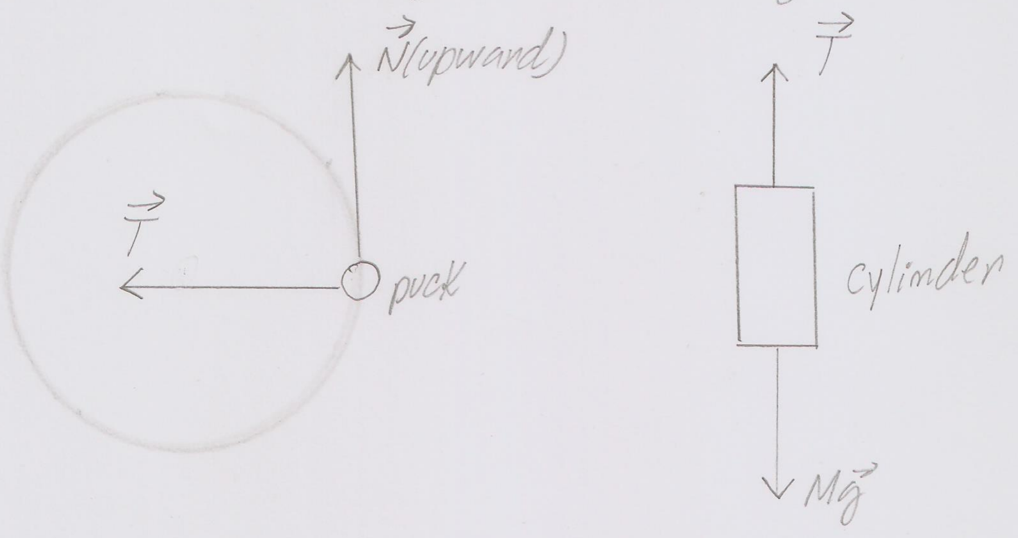


For the puck to remain in equilibrium (at rest), the magnitude of the tension force T of the cord must be equal to the gravitational force on the cylinder. The tension force giver the centripetal force that keeps the puck in its circular orbit:

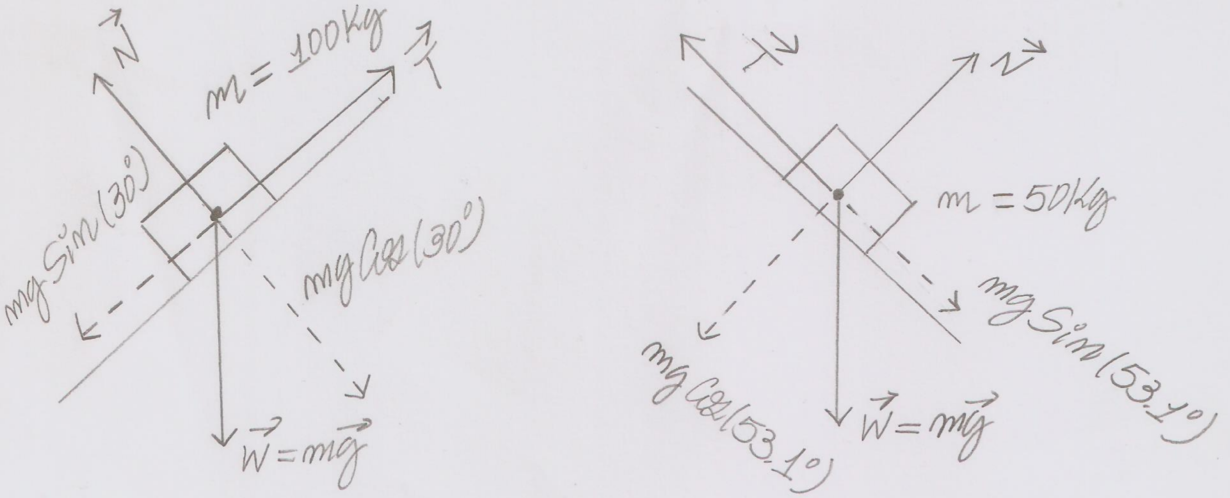
$$T = \frac{mv^2}{r} \rightarrow Mg = \frac{mv^2}{r}$$

thus, we solve for the speep: $V = \sqrt{\frac{Mgr}{m}} = \sqrt{\frac{(1.30\,Kg)(9.81\,m/s^2)(0.37\,m)}{0.55\,Kg}}$

$$\boxed{V = 2.93\,m/s}$$

Extra Credit

(a) The free body diagrams are as follow:



The forces according to the Newton's Second Law along the incline and the accelerations are related by:

$$T - (100Kg) g Sin(30°) = (100Kg)a$$
$$(50Kg) g Sin(53.1°) - T = (50Kg)a$$

where a represents the mutual magnitude of acceleration. If we add these two relations:

$$(50Kg) g Sin(53.1°) - (100Kg) g Sin(30°) = (50Kg + 100Kg)a$$
$$\boxed{a = -0.067g}$$

Since a is negative, the blocks will slide to the left and the 100Kg will slide down (taking the positive direction to the right).

(b) The value of the magnitude of acceleration of the blocks is:

$$a = 0.067g = +(0.067)(9.80 m/s^2) = \boxed{0.657 m/s^2}$$

(c) Inserting the value of the acceleration found (with the negative sign) into either of the equations of part (a), we have tension of the cord:

$$T = (100Kg)(9.80 m/s^2)(Sin(30°)) + (100Kg)(-0.657 m/s^2) = \boxed{424N}$$