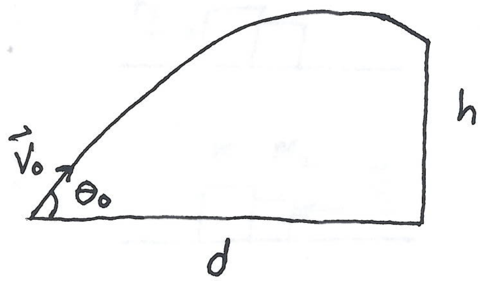
SMU Physics 1307 : Fall 2009

Exam 1

Problem 1 : The figure below shows a golfball that is struck at ground level at an initial angle $\theta_0 = 40°$ with magnitude of velocity $|\vec{v}_0| = 45\,\text{m/s}$. It travels a horizontal distance $d = 120\,\text{m}$ before striking the vertical face of an office building. Find the height h, the vertical component of the velocity v_y, and the time of flight of the ball t_f, all at the moment when the ball impacts the office building.



$V_{ox} = |\vec{V}_o| \cos\theta_o = \underline{34.47\,m/s}$

$V_{oy} = |\vec{V}_o| \sin\theta_o = \underline{28.93\,m/s}$

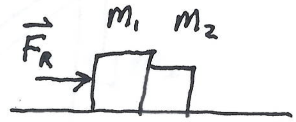
$d = V_{ox} t_f \qquad t_f = d/V_{ox} = \underline{3.48\,s}$

$y = V_{oy} t_f - \frac{1}{2} g t_f^2 = \underline{41.31\,m}$

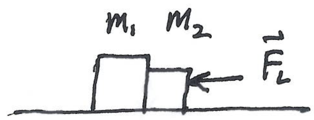
$V_y = V_{oy} - g t_f = \underline{-5.19\,m/s}$

Problem 2 : The figure below shows two blocks $m_1 = 6\,\text{kg}$ and $m_2 = 5\,\text{kg}$ which are directly in contact with each other on a frictionless surface. First consider a force of magnitude $|\vec{F}_R| = 15\,\text{N}$ applied to the left of m_1 and which acts to the right. Find the acceleration of the system a_R in this case and indicate its direction. Also find the magnitude $|\vec{N}_R|$ of the (equal and opposite) normal forces between the blocks. Secondly, consider a force of equal magnitude $|\vec{F}_L| = 15\,\text{N}$ applied to the right of m_2 and which acts to the left. Find the acceleration of the system a_L in this case and indicate its direction. Also find the magnitude $|\vec{N}_L|$ of the (equal and opposite) normal forces between the blocks.

situation 1 :



situation 2:



$F = |\vec{F}_L| = |\vec{F}_R|$

① (ignore $\hat{y}$)

$N_R = |\vec{N}_R|$

m_1: $-N_R$ F $\qquad$ m_2: N_R

$$F - N_R = m_1 a$$

$$N_R = m_2 a$$

$$a_1 = a_2 = a$$

$$F = (m_1 + m_2)\,a$$

$$a = \frac{F}{m_1 + m_2} = 1.36\ \text{m/s}^2$$

(to right)

$$N_R = m_2 a = 6.82\,\text{N}$$

② (ignore $\hat{y}$)

$N_L = |\vec{N}_L|$

m_1: $-N_L$ $\qquad$ m_2: $-F$ N_L

$$-N_L = m_1 a$$

$$-F + N_L = m_2 a$$

$$a_1 = a_2 = a$$

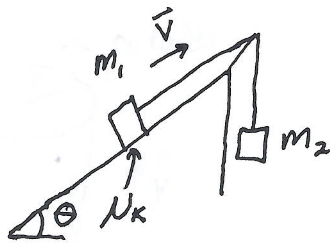
$$-F = (m_1 + m_2)\,a$$

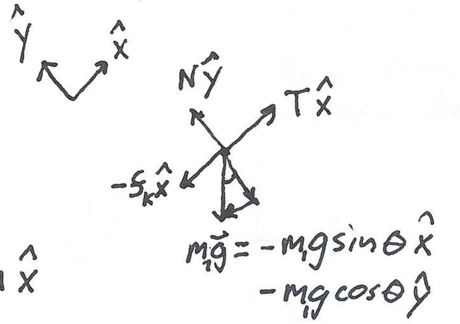
$$a = \frac{-F}{m_1 + m_2} = -1.36\ \text{m/s}^2$$

(to left)

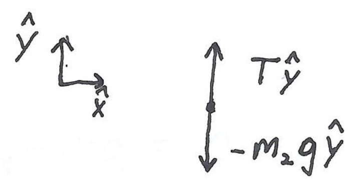
$$N_L = -m_1 a = 8.18\,\text{N}$$

Problem 3 : The figure below shows an inclined plane with angle $\theta = 30°$ and coefficient of kinetic friction $\mu_k = 0.6$. The block on the plane has mass $m_1 = 2\,\text{kg}$ and a velocity that is up the plane. The block hanging vertically has mass $m_2 = 6\,\text{kg}$ and is connected to the first mass with a string. Find the acceleration a of the system, with a taken to be positive if the vector $\vec{a}$ points up the plane. Also find the tension T in the string.





$\vec{a}_1 = a\hat{x}$



$\vec{a}_2 = -a\hat{y}$

$N - m_1 g\cos\theta = 0$

$T - f_K - m_1 g\sin\theta = m_1 a$

$f_K = \mu_K N$

$T - \mu_K m_1 g\cos\theta - m_1 g\sin\theta = m_1 a$

$T - m_2 g = -m_2 a$

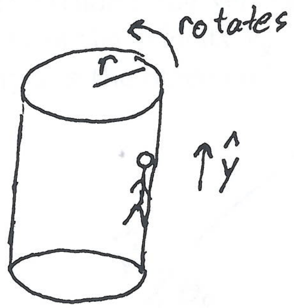
Thus,

$$m_2 g - \mu_K m_1 g\cos\theta - m_1 g\sin\theta = (m_1 + m_2)\,a$$

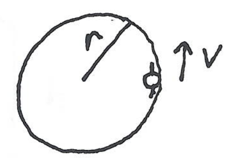
compute a : $\quad a = 4.85\ m/s^2$

compute T : $\quad T = m_2 g - m_2 a = 29.69\ N$

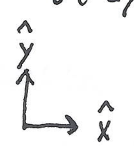
Problem 4 : The figure below shows a rotating vertical cylinder of radius $r = 6\,\mathrm{m}$ that is part of amusement park ride. The inside of the cylinder has a coefficient of static friction μ_s which holds the riders in place. Assume that the magnitude of the apparent acceleration that a rider feels is $|\vec{A}| = 2g$, where $\vec{A} = \vec{a} + g\hat{y}$ with $\hat{y}$ taken to be vertical. What is the magnitude of the velocity $|\vec{v}|$? What is the minimum value of μ_s which prevents the riders from slipping downward?



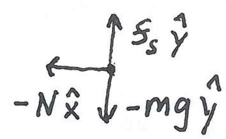
top view:



μ_s on sides of cylinder



$\vec{a} = -\frac{v^2}{r}\hat{x}$



$\vec{A} = \vec{a} + g\hat{y}$

$\vec{A} = -\frac{v^2}{r}\hat{x} + g\hat{y}$

$|\vec{A}|^2 = 4g^2 = \left(\frac{v^2}{r}\right)^2 + g^2$

$\underline{\frac{v^2}{r} = \sqrt{3}\,g}$

$f_s - mg = 0$

$-N = -\frac{mv^2}{r}$

$f_s \le \mu_s N$

$g \le \mu_s \frac{v^2}{r}$

slips when: $\underline{\mu_s = gr/v^2}$

$v^2 = \sqrt{3}\,g r$

$v = \underline{10.1\ \mathrm{m/s}}$

$\mu_s = 1/\sqrt{3} = \underline{0.578}$