SMU Physics 1307 : Summer 2009

Exam 1

Problem 1 : Assume a baseball player can throw a ball with a velocity of magnitude $|\vec{v}_0| = 40\,\mathrm{m/s}$. How high y_1 can he throw the ball if he throws it straight up? How much time t_1 will it take to return to the ground? Now assume that he throws it at an angle of $\theta = 45°$ from the horizontal. How far x_2 does the ball travel horizontally? How high y_2 does the ball go vertically? How much time t_2 will it take to return to the ground? Use $g = 9.8\,\mathrm{m/s^2}$.

① $V_y = V_{oy} - gt$ $\quad V_{oy} = 40 = |\vec{V}_o|$

$y = V_{oy}t - \frac{1}{2}gt^2$ $\quad$ at peak (t_p): $V_y(t_p) = 0 = V_{oy} - gt_p$

$t_p = V_{oy}/g = \underline{\underline{4.08\,s}}$

$y_1 = V_{oy}t_p - \frac{1}{2}gt_p^2 = \underline{81.63\,m}$

at t_1: $y(t_1) = 0 = V_{oy}t_1 - \frac{1}{2}gt_1^2$

$t_1 = 2V_{oy}/g = 2t_p = \underline{\underline{8.16\,s}}$

② $V_y = V_{oy} - gt$ $\quad V_{ox} = |\vec{V}_o|\cos 45° = 40/\sqrt{2} = \underline{28.28\,m/s}$

$y = V_{oy}t - \frac{1}{2}gt^2$ $\quad V_{oy} = |\vec{V}_o|\sin 45° = 40/\sqrt{2} = \underline{28.28\,m/s}$

$x = V_{ox}t$

at peak (t_p): $V_y(t_p) = 0 = V_{oy} - gt_p$

$t_p = V_{oy}/g = \underline{\underline{2.89\,s}}$

$y_2 = y(t_p) = V_{oy}t_p - \frac{1}{2}gt_p^2$

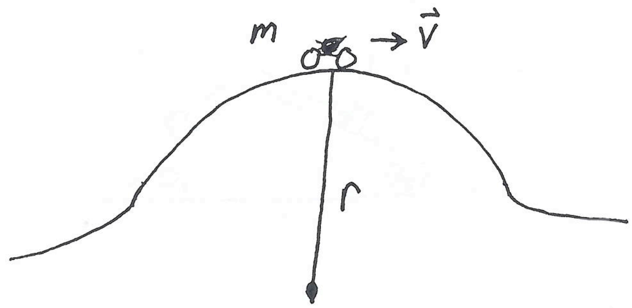
$y_2 = \underline{\underline{40.82\,m}}$

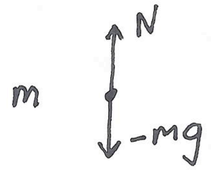
to ground (t_2): $y(t_2) = 0 = V_{oy}t_2 - \frac{1}{2}gt_2^2$

$t_2 = 2V_{oy}/g = 2t_p = \underline{\underline{5.77\,s}}$

$x_2 = V_{ox}t_2 = \underline{\underline{163.3\,m}}$

Problem 2 : As shown in the figure below, a motorcycle of mass $m = 350\,\mathrm{kg}$ is moving with a velocity of magnitude $|\vec{v}| = 10\,\mathrm{m/s}$ and has just reached the top of a hill which has a circular profile of radius $r = 30\,\mathrm{m}$. Find the normal force N that road exerts on the motorcycle. For what magnitude of velocity $|\vec{v}_c|$ will the motorcycle leave the road; that is, what is the magnitude of velocity at which the normal force vanishes?





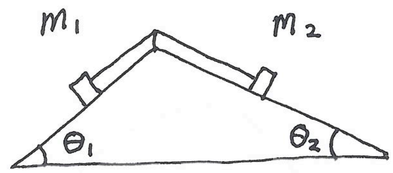
$$N - mg = -mv^2/r$$

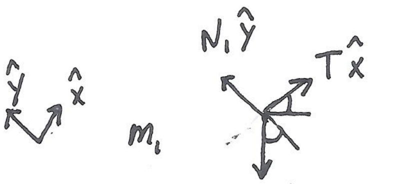
① $V = 10$ $$N = m(g - V^2/r) = \underline{\underline{2263\,N}}$$

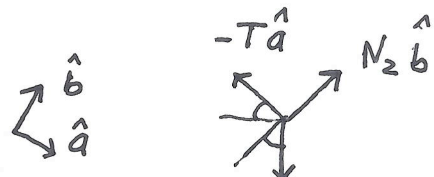
② $N = 0$ $$mg = mV^2/r$$

$$V = \sqrt{gr} = \underline{\underline{17.15\,m/s}}$$

Problem 3 : As shown in the figure below, two masses are connected by a massless string and slide without friction on opposite sides of a double inclined plane. The masses are $m_1 = 3\,\text{kg}$ and $m_2 = 5\,\text{kg}$, and the angles are $\theta_1 = 30°$ and $\theta_2 = 20°$. Find the acceleration a (indicate direction) of the masses, and the tension T in the string.







m_2

$m_2\vec{g} = m_2 g \sin\theta_2\,\hat{a} - m_2 g\cos\theta_2\,\hat{b}$

$\vec{a}_1 = a_1\hat{x}$

$m_1\vec{g} = -m_1 g\cos\theta_1\,\hat{y} - m_1 g\sin\theta_1\,\hat{x}$

$\vec{a}_2 = a_2\hat{a}$

$T - m_1 g\sin\theta_1 = m_1 a_1$

$N_1 - m_1 g\cos\theta_1 = 0$

$m_2 g\sin\theta_2 - T = m_2 a_2$

$N - m_2 g\cos\theta_2 = 0$

$a_1 = a_2 = a$ (y equations not relevant)

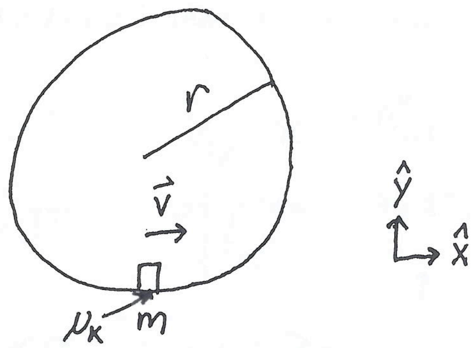
$T - m_1 g\sin\theta_1 = m_1 a$

$m_2 g\sin\theta_2 - T = m_2 a$

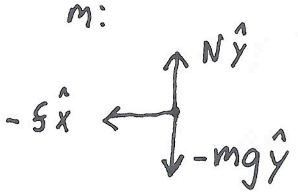
$a = g\,(m_2\sin\theta_2 - m_1\sin\theta_1)/(m_1 + m_2) = \underline{0.257\,\text{m/s}^2}$

$T = m_1 g\sin\theta_1 + m_1 a = \underline{15.47\,\text{N}}$

Problem 4 : As shown in the figure below, an object of mass $m = 70\,\mathrm{kg}$ is moving with velocity of magnitude $|\vec{v}| = 15\,\mathrm{m/s}$ (with direction as indicated) around a circular loop of radius $r = 12\,\mathrm{m}$. Assume that the object is at the very bottom of the loop, and that the coefficient of kinetic friction of the surface is $\mu_k = 0.8$. Find the normal force N on the object. Also, choosing the x axis to point to the right and the y axis to point upward, find both the vertical a_y and horizontal a_x components of the acceleration.



m:



$$N - mg = mv^2/r$$

$$-f = m a_x$$

$$\vec{a} = a_x \hat{x} + a_y \hat{y}$$

$$a_y = v^2/r = \underline{\underline{18.75\,\mathrm{m/s^2}}}$$

$$N = m(g + v^2/r) = \underline{\underline{1998.5\,\mathrm{N}}}$$

$$f = \mu_K N \qquad a_x = -\mu_K N/m = \underline{\underline{-22.84\,\mathrm{m/s^2}}}$$