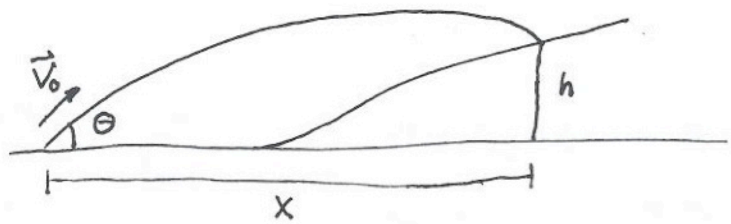
SMU Physics 1307 : Spring 2009

Exam 1

Problem 1 : As shown in the figure below, a golf ball is hit from ground level with a velocity of magnitude $|\vec{v}_0| = 40\,\mathrm{m/s}$ at an angle of $\theta = 50°$ from the horizontal. After a time of flight t, the ball strikes a hillside at a horizontal distance $x = 100\,\mathrm{m}$ and height h. Find the time t, the height h, and the vertical component of the velocity v_y when it strikes the ground. Use $g = 9.8\,\mathrm{m/s^2}$.



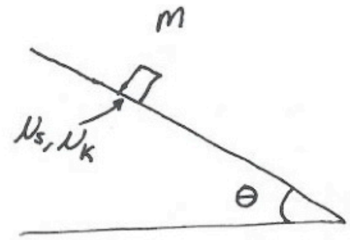
$V_{ox} = |\vec{V}_o| \cos\theta = \underline{25.7\,m/s}$ $\quad X = V_{ox} t$

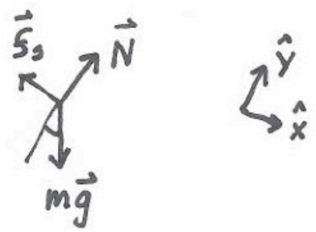
$V_{oy} = |\vec{V}_o| \sin\theta = \underline{30.6\,m/s}$ $\quad t = \frac{X}{V_{ox}} = \frac{100\,m}{25.7\,m/s} = \underline{3.89\,s}$

$h = V_{oy}t - \frac{1}{2}gt^2 = \underline{45.05\,m}$

$V_y = V_{oy} - gt = \underline{-7.47\,m/s}$

Problem 2 : As shown in the figure below, a box of mass m rests on an adjustable inclined plane. If the coefficient of static friction is $\mu_s = 0.7$, find the angle θ_s of the plane above which the box will slide. Assuming the box begins to slide at θ_s, and the coefficient of kinetic friction is $\mu_k = 0.6$, find the acceleration a of the box.



① 

$$N - mg\cos\theta = 0$$

$$mg\sin\theta - f_s = 0$$

at θ_s: $f_s = \mu_s N$ $\qquad$ $mg\sin\theta_s = \mu_s mg\cos\theta_s$

$\tan\theta_s = \mu_s$ $\qquad$ $\underline{\theta_s = 35^\circ}$

②

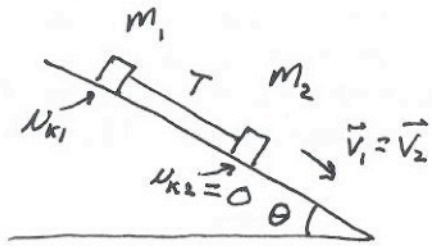
$N - mg\cos\theta_s = 0$ $\qquad$ $f_K = \mu_K N$

$$mg\sin\theta_s - f_K = ma$$

$$mg\sin\theta_s - \mu_K mg\cos\theta_s = ma$$

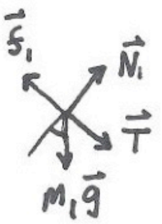
$$a = g(\sin\theta_s - \mu_K\cos\theta_s) = \underline{0.80\ m/s^2}$$

Problem 3 : The figure below shows two blocks connected by a massless string moving down an inclined plane of angle $\theta = 30°$. The upper block of mass $m_1 = 3\,\mathrm{kg}$ has coefficient of kinetic friction $\mu_{k1} = 0.6$, and the lower block of mass $m_2 = 5\,\mathrm{kg}$ has coefficient of kinetic friction $\mu_{k2} = 0$; that is, m_2 experiences no friction with the surface. Find the tension T in the string, and the acceleration a of the combined system.

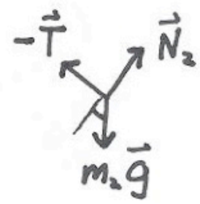


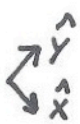
$a_1 = a_2 = a$

m_1:



m_2:





$\vec{f}_1 = -f_1\hat{x}$

$f_1 = \mu_K N_1$

$$N_1 - m_1 g\cos\theta = 0$$
$$T + m_1 g\sin\theta - f_1 = m_1 a$$

$$N_2 - m_2 g\cos\theta = 0$$
$$m_2 g\sin\theta - T = m_2 a$$

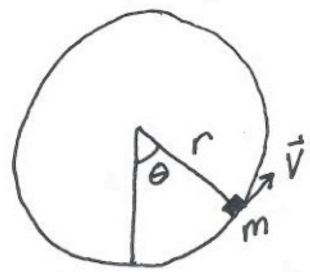
$$T + m_1 g(\sin\theta - \mu_K\cos\theta) = m_1 a$$
$$m_2 g\sin\theta - T = m_2 a$$

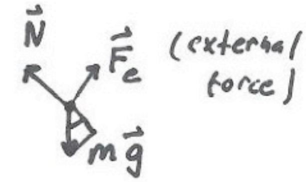
$$(m_1 + m_2) g\sin\theta - m_1 g\mu_K\cos\theta = (m_1 + m_2) a$$

$$a = \underline{3.0\ \mathrm{m/s^2}}$$

$$T = m_2 g\sin\theta - m_2 a = \underline{9.55\ \mathrm{N}}$$

Problem 4 : An automobile of mass $m = 1000\,\text{kg}$ attempts to go around a circular loop of radius $r = 10\,\text{m}$ at a velocity of constant magnitude $|\vec{v}|$. It feels a normal force $N(\theta)$ which depends on where it is on the circular loop. If the normal force is equal to $N(90°) = 0.5mg$ when it is at $\theta = 90°$, find the magnitude $|\vec{v}|$ of the velocity of the vehicle. Will the vehicle make it around the loop; that is, does the normal force vanish for any θ? If the car will make it around the loop, find the normal force $N(180°)$ at the top of the loop. If the car will fall off the loop, find the angle θ_c such that $N(\theta_c) = 0$. Note that there will have to be a tangential force applied by the car in order to maintain constant $|\vec{v}|$; this can be solved for in terms of m and θ, but is not relevant for the solution to the problem. Only the radial component of Newton's second law will be required to solve the problem.





$$N - mg\cos\theta = m\frac{v^2}{r}$$

$\theta = 90°$:

$$N = 0.5\,mg = m\frac{v^2}{r}$$

$$v^2 = 0.5\,gr$$

$$v = 7\,\text{m/s}$$

$N = 0$:

$$\cos\theta_c = \frac{-v^2}{gr} = -0.5$$

so falls off at:

$$\theta_c = 120°$$