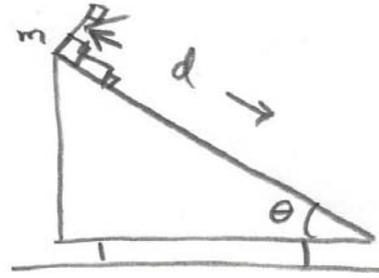


Problem 4: (Energy, Force, and Kinematics)

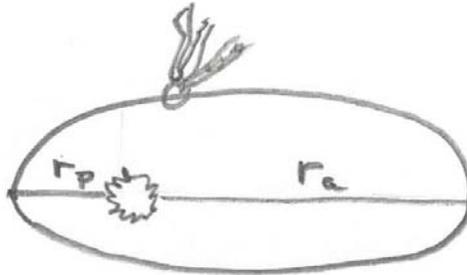
A child's playground slide is $d = 5.0m$ in length and is at an angle of $\theta = 2.0 \times 10^1 \text{ deg}$ with respect to the ground. A child of mass $m_b = 2.0 \times 10^1 \text{ kg}$ starts from rest at the top of the slide. The coefficient of sliding friction for the slide is $\mu_k = 0.2$.



- What is the total work done by the friction force on the child?
- What is the speed of the child at the bottom of the slide?
- How long does the child take to slide down the ramp?

~~**Problem 5: (Planetary Orbits)**~~

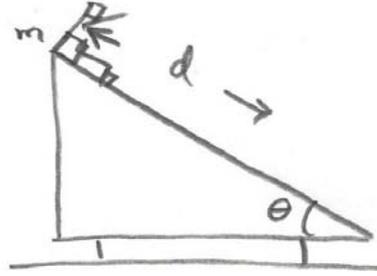
~~Comet Eneke was discovered in 1786 by Pierre Mechain and in 1822 Johann Eneke determined that its period was 3.3 years. It was photographed in 1913 at the aphelion distance, $r_a = 6.1 \times 10^{11} m$, (furthest distance from the sun) by the telescope at Mt. Wilson. The distance of closest approach to the sun, perihelion, is $r_p = 5.1 \times 10^{10} m$. The universal gravitation constant $G = 6.7 \times 10^{-11} N \cdot m^2 \cdot kg^{-2}$. The mass of the sun is $m_s = 2.0 \times 10^{30} kg$.~~



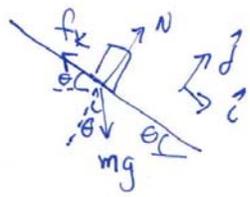
- ~~Explain why angular momentum is conserved about the focal point and then write down an equation for the conservation of angular momentum between aphelion and perihelion.~~
- ~~Explain why mechanical energy is conserved and then write down an equation for conservation of energy between aphelion and perihelion.~~
- ~~Find the velocities at perihelion and aphelion.~~

Problem 4: (Energy, Force, and Kinematics)

A child's playground slide is $d = 5.0m$ in length and is at an angle of $\theta = 2.0 \times 10^1 \text{ deg}$ with respect to the ground. A child of mass $m_b = 2.0 \times 10^1 \text{ kg}$ starts from rest at the top of the slide. The coefficient of sliding friction for the slide is $\mu_k = 0.2$.



- a) What is the total work done by the friction force on the child?
- b) What is the speed of the child at the bottom of the slide?
- c) How long does the child take to slide down the ramp?



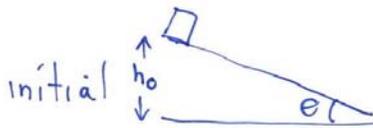
$$\hat{i}: mg \sin \theta - f_k = m a_x$$

$$\hat{j}: N - mg \cos \theta = 0$$

$$f_k = \mu_k N = \mu_k mg \cos \theta$$

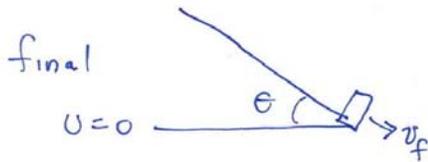
$$W_{nc} = -f_k d = -\mu_k mg \cos \theta d$$

$$W_{nc} = -(0.2)(2.0 \times 10^1 \text{ kg})(9.8 \text{ m/s}^2)(\cos 20^\circ)(5.0 \text{ m}) = 1.8 \times 10^2 \text{ J}$$



$$U_0 = mgh_0 = mgd \sin \theta$$

$$K_0 = 0, E_0 = mgd \sin \theta$$



$$U_f = 0, E_f = \frac{1}{2} m v_f^2$$

$$K_f = \frac{1}{2} m v_f^2$$

$$U = 0$$

$$W_{nc} = \Delta E = \frac{1}{2} m v_f^2 - mgd \sin \theta$$

$$-f_k d = \frac{1}{2} m v_f^2 - mgd \sin \theta$$

$$v_f = (2dg(\sin \theta - \mu_k \cos \theta))^{1/2}$$

$$v_f = ((2)(5.0 \text{ m})(9.8 \text{ m/s}^2)(\sin 20^\circ - (0.2)(\cos 20^\circ)))^{1/2} = 3.9 \text{ m} \cdot \text{s}^{-1}$$

$$a_x = \frac{1}{m}(mg \sin \theta - f_k) = g(\sin \theta - \mu_k \cos \theta)$$

$$v_f = a_x t \Rightarrow t = \frac{v_f}{a_x} = \frac{(2dg(\sin \theta - \mu_k \cos \theta))^{1/2}}{g(\sin \theta - \mu_k \cos \theta)}$$

$$t = \left(\frac{2d}{g(\sin \theta - \mu_k \cos \theta)} \right)^{1/2} = \left(\frac{(2)(5.0 \text{ m})}{(9.8 \text{ m/s}^2)(\sin 20^\circ - (0.2)(\cos 20^\circ))} \right)^{1/2} = 2.7 \text{ s}$$