Mechanics Problem Set 1

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Problem 1. I drop a brick from the top of a building. Jim and Bob observe that the brick takes time T to pass by their classroom window. The height difference between the bottom and the top of the window is h. How high above the top of this window is the top of the building?

Problem 2. When a cannon is adjusted for a launch so that it shoots as far as possible, the horizontal range is $R_x = 160\text{m}$. How high does the cannonball reach?

Problem 3. A toy car is attached to a pole in the center of a circular track with radius $r = 2\text{m}$ with a string that we know breaks when the car reaches $v = 3m/s$. This happens $t = 10s$ after the car starts moving from rest. Determine the *total* acceleration of the toy car when that happens

Problem 4. A box with mass m is given initial velocity v up the ramp that makes angle θ with the horizon. The coefficient of kinetic friction between the box and the ramp is μ. Determine the time at which the speed of the body with again be v.

Problem 5. A spring with spring constant k hangs vertically from a ceiling, initially at its relaxed length. You attach a mass m to the end and bring it down to a position that is $\frac{3mg}{k}$ below the initial position. You then let go. What is the upward acceleration of the mass right after you let go?

Problem 6. Riders in a carnival ride stand with their backs against the wall of a circular room of diameter $8.0m$. The room is spinning horizontally about an axis through its center at a rate of 45 rev/min when the floor drops so that it no longer provides any support for the riders. What is the minimum coefficient of static friction between the wall and the rider required so that the rider does not slide down the wall?

Problem 7. A block with mass m is attached to a ceiling by a spring with spring constant k and relaxed length l. Initially, the spring is compressed to a length of $\frac{l}{2}$. If the block is released, at what distance below the ceiling will the block be brought to rest?

Problem 8. An introductory student celebrates by dropping a textbook from a balcony into a deep layer of soft snow which is 3.00 m below. Upon hitting the snow, the book sinks a further 1.00 m into it before coming to a stop. The mass of the book is 5.0 kg. Assuming a constant retarding force, what is the force from the snow on the book?

Problem 9. The force of friction on an airplane in level flight is given by $F_f = kv^2$, where k is some constant, and v is the speed of the airplane. When the power output from the engines is P_0, the plane is able to fly at a speed v_0. If the power output of the engines is doubled to $2P_0$, the airplane will be able to fly at a new speed given by

Problem 10. A toboggan sled is traveling at 2.0 m/s across the snow. The sled and its riders have a combined mass of 120 kg. Another child ($m_{\text{child}=40}$ kg) headed in the opposite direction jumps on the sled from the front. She has a speed of 5.0 m/s immediately before she lands on the sled. What is the new speed of the sled? Neglect any effects of friction.