1. A marble rolls horizontally on a table top at a constant speed of 2.25 m/s. The marble rolls off the edge of the table and arcs towards the floor landing in a cup that is 1.50 m from the edge of the table. (No friction or air resistance). (a.) What is the height, h, of the table above the ground? (b.) What is the displacement $\vec{y}$ of the table top as measured from the top down to the ground?

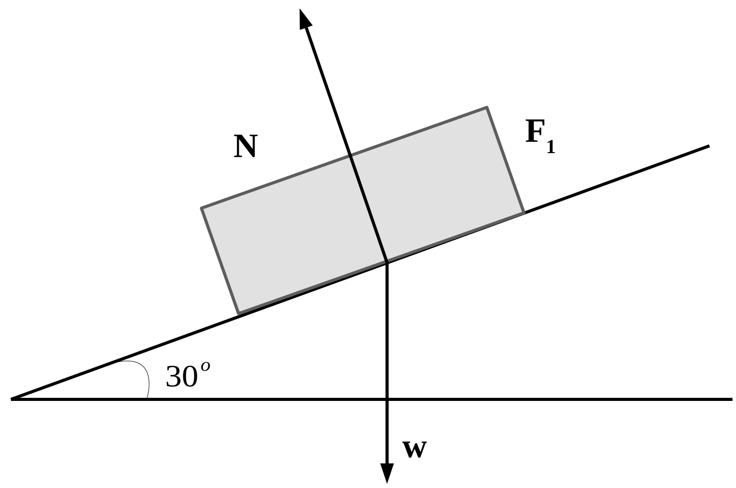
   Solution:
   (a.) Find time, t, from the x displacement equation without acceleration, $x = v_{0x}$ and solve for $t = x/v_{0x} = 1.5/2.25 = 0/67$ s. Now find the final velocity of the marble JUST before it lands in the cup using $v_{fy} = v_{f0} + gt = 0 + (-9.8)(0.67) = -6.53$ m/s. Finally, use v_f scalar equation to get height: $v_{yf}^2 = v_{f0}^2 + 2gy$ from which we get $y = (v_{yf}^2 - v_{f0}^2)/(2g) = (6.53)^2/19.6 = 2.18$ m. (b.) The displacement is the vector equivalent of the distance, $\vec{y} = -2.18$ m.

2. The acceleration due to gravity on the surface of the moon is $g = -1.67$ m/s° (as compared to $g = -9.80$ m/s° on the earths surface). How much higher will a ball thrown straight up at an initial velocity of $v = +10.0$ m/s rise on the moon as compared to it being thrown up at the same initial velocity on the earth?

   Solution:
   On earth: $t = \frac{-v_0}{g} = \frac{-10.0}{-9.80} = 1.02$ s,
   $y_e = y_0 + v_0 t + \frac{1}{2}gt^2 = 0 + (10.0)(1.02) + (\frac{1}{2})(-9.8)(1.02)^2 = 5.10$ m.
   On moon:
   $y_m = y_0 + v_0 t + \frac{1}{2}gt^2 = 0 + (10.0)(5.99) + (\frac{1}{2})(-1.67)(5.99)^2 = 29.94$ m.
   Thus, $\Delta y = y_m - y_e = 29.94 - 5.10 = 24.8$ m.

3. A block of mass m is pulled up at a 30° incline at constant velocity with a force $\vec{F}_1$ which is parallel to the incline. Ignore friction.

   What is the relation between the normal force $\vec{N}$ and the weight $\vec{w} = m\vec{g}$ of the block?



Solution:
$\vec{N} = m\vec{g}\cos(30)$

4. Calculate the weight of a 50.0 kg astronaut aboard the International Space Station (ISS), which orbits the earth at a distance of about 220 km above the earth's $surface$. The radius of the earth is 6.38×10^6 m and its mass is 5.97×10^{24} kg. (Recall that $\vec{w} = \vec{F_g}$)

Solution:
$w = F_g = \frac{GM_e m_a}{(R_e+d)^2} = (6.67 \times 10^{-11})(5.97 \times 10^{24})(50.0)/(6.38 \times 10^6 + 2.20 \times 10^5)^2$.
Notice the sum of the distances is used because gravity acts from the center of the earth and not the surface.

5. What is the ideal banking angle θ for a gentle turn of radius 1.20 km on an interstate highway with a speed limit of 105 km/h (about 65 mi/h)?

Solution:

Use the equation: $\tan(\theta) = \frac{v^2}{rg}$ but solve for θ. $\theta = \tan^{-1}(\frac{v^2}{rg})$. And we have $\theta = \tan^{-1}(29.2^2/(1200)(9.8)) = \tan^{-1}(0.073) = 4.14°$

6. A toy dart gun uses a compressed spring to fire a dart of mass 0.100 kg horizontally. The spring in the toy has a spring constant $k = 250$ N/m and it is pushed in a distance of 6.0 cm from the relaxed position of the spring.
(a) What *speed* does the dart leave the barrel of the toy gun? (Hint: use conservation of energy). // (b) If the toy is held horizontally above the ground at a height of 1.32 m when it is fired, how far did the dart travel?

Solution:
(a)

$$\begin{aligned} \Delta PE_s &= \Delta KE_{dart} \\ \frac{1}{2}kx^2 &= \frac{1}{2}mv^2 \\ v = \sqrt{\frac{k}{m}}x &= (\sqrt{\frac{250}{0.10}})(0.006) \\ &= 3.0m/s \end{aligned}$$

(b)

$$\begin{aligned} y &= (\frac{1}{2})gt^2 \\ t = \sqrt{\frac{2y}{g}} &= \sqrt{\frac{(2)(1.32)}{9.8}} = 0.52s \\ x = v_{0x}t &= (3.0m/s)(0.52) = 1.56m \end{aligned}$$