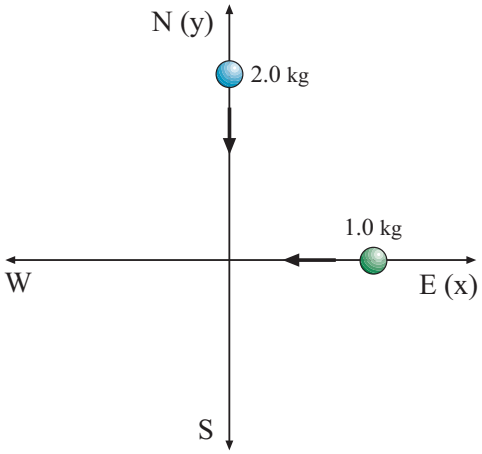
Name_____

Mar. 29, 2006

Quiz #4 — Spring 2006
Phys 2110

1. A 1.0 kg ball of clay traveling west at $8.30\frac{\text{m}}{\text{s}}$ collides with a 2.0 kg ball of clay traveling south at $2.70\frac{\text{m}}{\text{s}}$. They stick together; what are the speed and direction of the resulting 3.0 kg blob of clay?



We'll let the velocity components of the 3.0 kg blob be (v_x, v_y) and say that it moves off in a direction given by the angle θ, measured S of W (as shown here).

Conservation of momentum in the x direction gives

$$P_{ix} = P_{fx} \qquad \Longrightarrow \qquad (1.0\text{ kg})(-8.30\tfrac{\text{m}}{\text{s}}) = (3.0\text{ kg})v_x$$

which gives

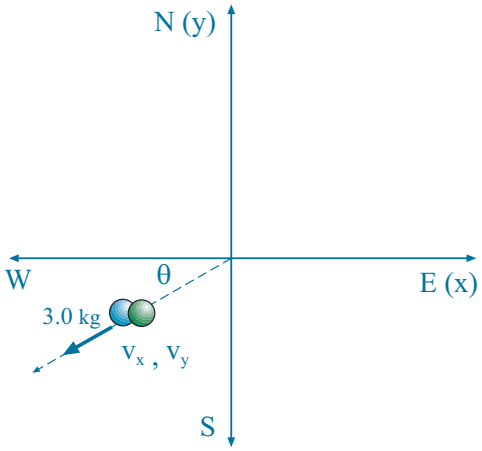
$$v_x = -2.77\tfrac{\text{m}}{\text{s}}$$

and conservation of momentum in the y direction gives

$$P_{iy} = P_{fy} \qquad \Longrightarrow \qquad (2.0\text{ kg})(-2.70\tfrac{\text{m}}{\text{s}}) = (3.0\text{ kg})v_y$$

which gives

$$v_y = -1.80\tfrac{\text{m}}{\text{s}}$$



So the (final) speed of the blob is

$$v = \sqrt{v_x^2 + v_y^2} = \sqrt{(-2.77\tfrac{\text{m}}{\text{s}})^2 + (-1.80\tfrac{\text{m}}{\text{s}})^2} = 3.30\tfrac{\text{m}}{\text{s}}$$

and to get the angle θ, calculate:

$$\tan\theta = \frac{(1.80\frac{\text{m}}{\text{s}})}{(2.77\frac{\text{m}}{\text{s}})} = 0.651 \qquad \Longrightarrow \qquad \theta = 33.0^\circ$$

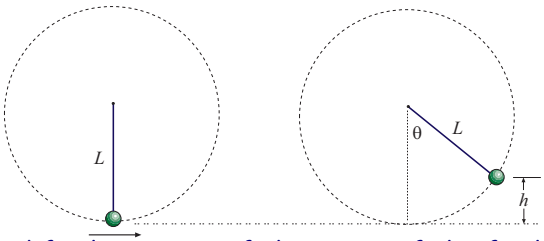
One can also express the direction as

$$\theta_0 = 180^\circ + 33.0^\circ = 213^\circ$$

as measured from the $+x$ axis.

2. A small 0.500 kg mass at the end of a string of length 0.800 m has a speed of $2.70\frac{\text{m}}{\text{s}}$ at the lowest point.

a) What is the height of the mass above its lowest point when it (momentarily) comes to rest?



Mechanical energy is conserved between the initial and final positions of the mass. If the final height above the lowest position is h, then

$$\tfrac{1}{2}mv^2 = mgh \qquad \Longrightarrow \qquad h = \frac{v^2}{2g}$$

Plug in the numbers:

$$h = \frac{(2.70\frac{\text{m}}{\text{s}})^2}{2(9.80\frac{\text{m}}{\text{s}^2})} = 0.372 \text{ m}$$

b) When the mass is at this point, what is the angle that the string makes with the vertical?

Using the answer from (a), the vertical distance of the mass below the center of the circle is

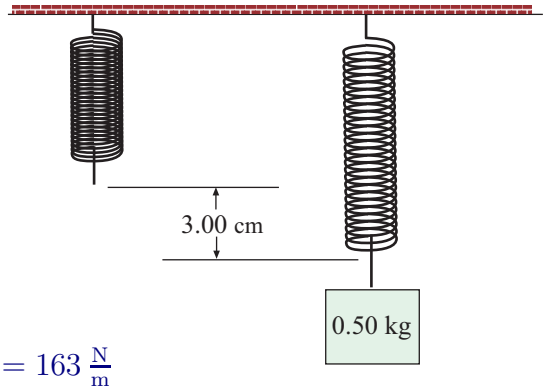
$$d = 0.800 \text{ m} - 0.372 \text{ m} = 0.428 \text{ m}$$

and then the angle θ is given by

$$\cos\theta = \frac{0.428 \text{ m}}{0.800 \text{ m}} = 0.535 \qquad \Longrightarrow \qquad \theta = 57.7^\circ$$

3. When a 0.500 kg mass is hung from an ideal spring, its length increases by 3.00 cm.

Find the force constant (spring constant) of this spring.



When the mass is hanging (i.e. at rest!) the net force on it is zero; using the force law for a spring, that gives

$$mg = kx \qquad \Longrightarrow \qquad k = \frac{mg}{x} = \frac{(0.500 \text{ kg})(9.80\frac{\text{m}}{\text{s}^2})}{(0.030 \text{ m})} = 163\,\frac{\text{N}}{\text{m}}$$

You must show all your work and include the right units with your answers!

$$\mathbf{p} = m\mathbf{v} \qquad \text{Isolated system, } \mathbf{P} = \sum_i \mathbf{p}_i \text{ conserved} \qquad F_x = -kx$$

$$K = \tfrac{1}{2}mv^2 \qquad U_g = mgy \qquad U_{spr} = \tfrac{1}{2}kx^2 \qquad F_x = -\frac{dU}{dx} \qquad \Delta K + \Delta U = W_{\text{nc}}$$

$$v_{1f} = \left(\frac{m_1 - m_2}{m_1 + m_2}\right) v_{1i} \qquad v_{2f} = \left(\frac{2m_1}{m_1 + m_2}\right) v_{1i} \qquad W = \int_{s_i}^{s_f} F_s ds \qquad W = \mathbf{F} \cdot \Delta\mathbf{s}$$