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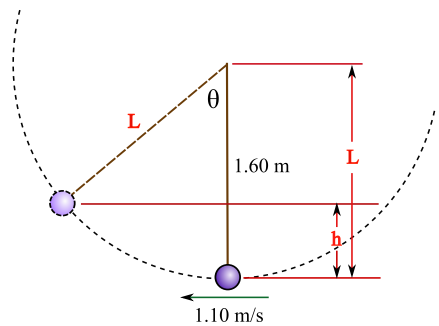
Oct. 26, 2012

Quiz #3 — Fall 2012

Phys 2110 – Sec 5

1. 2.00–kg mass swings on the end of a string of length 1.60 m. When it is at the lowest point it is suddenly given a speed of $1.10\frac{\text{m}}{\text{s}}$.

Find the maximum angle θ that the string will make with the vertical.



With h as given on the picture (height of the mass when it comes to a halt), conservation of energy gives

$$\tfrac{1}{2}mv^2 = mgh = mg(L - L\cos\theta) = mgL(1-\cos\theta)$$

where we've used a little geometry to incorporate θ. Then solve for θ:

$$(1-\cos\theta) = \frac{v^2}{2gL} 3.86\times10^{-2} \qquad \Longrightarrow \qquad \theta = \boxed{16.0^\circ}$$

2. A particle of mass 0.500 kg moves in a 1D region where the potential energy function is given by

$$U(x) = 2.00x^2 - 12.0x + 10.0$$

where when x is in meters, U is given in Joules.

a) Find the (one) equilibrium point. Is it a point of stable or unstable

This is where the force is zero and since $F_x = -\frac{dU}{dx}$, we find where:

$$\frac{dU}{dx} = 4.00x - 12.0 = 0 \qquad \Longrightarrow \qquad x = \frac{12.0}{4.00} = \boxed{3.00\ \text{m}}$$

This must be a point of $\boxed{\text{stable}}$ equilibrium since the function is a face-up parabola and it can only have a minimum. Or, as $\frac{d^2U}{dx^2} = 4.0$ is positive, it is a minimum.

b) If the (total) energy of the particle is 10.0 J, find the turning points of its motion.

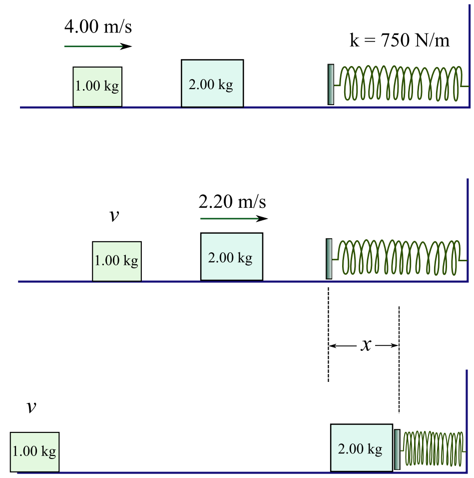
These are the points where $U = 10$ J, so

$$2.00x^2 - 12.0x + 10.0 = 10.0 \qquad \Longrightarrow \qquad x(2.0x - 12.0) = 0$$

whose solutions are

$$x = \boxed{0.0\ \text{m}} \qquad \text{and} \qquad x = \boxed{6.0\ \text{m}}$$

3. A 1.00–kg mass and a 2.00–kg mass move on a 1-D frictionless track on which there is also a horizontal spring with force constant $k = 750.0\,\frac{\text{N}}{\text{m}}$. The 1.00–kg mass moves toward the other mass (which is at rest) with a speed of $4.00\frac{\text{m}}{\text{s}}$. The masses collide and afterwards the 2.00–kg mass moves to the right at a speed of $2.20\frac{\text{m}}{\text{s}}$.



a) Find the *velocity* of the 1.00–kg mass after the collision.

Momentum is conserved in the collision. This gives

$$(1.00\text{ kg})(4.00\tfrac{\text{m}}{\text{s}}) = (1.00\text{ kg})v_x + (2.00\text{ kg})(2.20\tfrac{\text{m}}{\text{s}})$$

Solving for v_x gives

$$v_x = \boxed{-0.40\tfrac{\text{m}}{\text{s}}}$$

meaning that the mass is moving *to the left* with a speed of $0.40\frac{\text{m}}{\text{s}}$.

b) The 2.00–kg mass is then brought to a halt by the spring. By how much is the spring compressed?

After the collision, *mechanical energy is conserved*, so considering the 2.00 kg mass and the spring we get

$$\tfrac{1}{2}(2.00\text{ kg})(2.20\tfrac{\text{m}}{\text{s}})^2 = \tfrac{1}{2}(750\,\tfrac{\text{N}}{\text{m}})x^2$$

Solve for x:

$$x^2 = 1.29 \times 10^{-2}\text{ m}^2 \qquad \Longrightarrow \qquad x = 0.114\text{ m} = \boxed{11.4\text{ cm}}$$

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

$$W = fd\cos\theta \qquad W = \int_a^b F_x\,dx \qquad K = \tfrac{1}{2}mv^2 \qquad U_{\text{grav}} = mgy \qquad U_{\text{spr}} = \tfrac{1}{2}kx^2$$

$$E = K + U \qquad \Delta E = \Delta K + \Delta U = W_{\text{non-cons}} \qquad F_x = -\frac{dU}{dx}$$

$$\mathbf{p} = m\mathbf{v} \qquad \mathbf{F}_{\text{ext, net}} = M\mathbf{a}_{\text{CM}} = \frac{d\mathbf{P}}{dt} \qquad \mathbf{J} = \Delta\mathbf{p} \qquad \overline{\mathbf{F}} = \frac{\Delta\mathbf{p}}{\Delta t}$$