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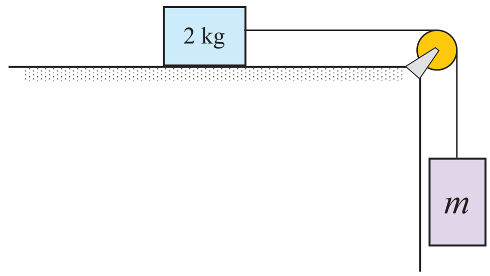
Oct. 19, 2005

Phys 2010, NSCC
Quiz #2 — Fall 2005

1. A 2.0-kg mass slides on a horizontal rough table (the coefficient of kinetic friction between block and table is 0.22). It is attached by a string to a hanging mass m; the string runs over an ideal pulley.

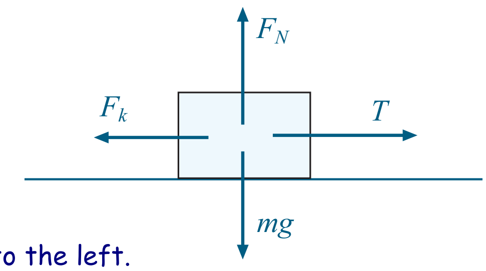
When the masses are released, their common acceleration is $2.5\frac{\mathrm{m}}{\mathrm{s}^2}$.



a) What is the friction force which acts on the 2.0-kg mass?

The forces which act on the 2.0-kg mass are shown here. The vertical forces must cancel out which gives us $F_N = mg = (2.0\ \mathrm{kg})g$. The magnitude of the kinetic friction force is $F_\mathrm{k} = \mu_\mathrm{k} F_N$, so we get

$$F_\mathrm{k} = \mu mg = (0.22)(2.0\ \mathrm{kg})(9.8\tfrac{\mathrm{m}}{\mathrm{s}^2}) = 4.31\ \mathrm{N}$$



and the direction of the friction is opposite the motion, i.e. to the left.

b) What is the tension in the string?

The 2.0-kg mass is accelerating (to the right) so applying Newton's 2nd law for the horizontal forces gives

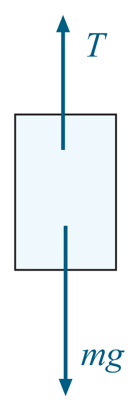
$$F_\mathrm{net} = T - F_\mathrm{k} = ma$$

Solve for T:

$$T = ma + F_\mathrm{k} = (2.0\ \mathrm{kg})(2.50\tfrac{\mathrm{m}}{\mathrm{s}^2}) + 4.31\ \mathrm{N} = 9.31\ \mathrm{N}$$

c) What is the value m of the hanging mass?

The hanging mass is accelerating at $2.50\frac{\mathrm{m}}{\mathrm{s}^2}$ *downward*, so applying Newton's 2nd law to that mass (for *downward* forces),



$$F_\mathrm{net} = mg - T = ma$$

Only m is unknown and we can solve for it with a little algebra:

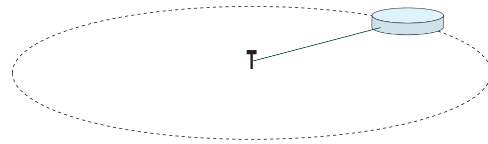
$$mg - ma = T \quad \Longrightarrow \quad m(g-a) = T \quad \Longrightarrow \quad m = \frac{T}{(g-a)}$$

Plug in the the numbers:

$$m = \frac{(9.31\ \mathrm{N})}{(9.8\frac{\mathrm{m}}{\mathrm{s}^2} - 2.5\frac{\mathrm{m}}{\mathrm{s}^2})} = 1.28\ \mathrm{kg}$$

The value of the hanging mass is $\boxed{1.28\ \mathrm{kg}}$.

2. A 1.6-kg mass is attached to a string of length 0.60 m, with the other end of the string attached to a fixed point on a smooth, flat table. The mass moves in a circle, under the influence of the (taut) string. The speed of the mass is $3.4\frac{\mathrm{m}}{\mathrm{s}}$.



a) Find the time it takes for the mass to make one trip around the circle.

The speed is related to the radius and period by $v = \frac{2\pi R}{T}$ so a little algebra gives:

$$T = \frac{2\pi R}{v} = \frac{2\pi(0.60\ \mathrm{m})}{(3.4\frac{\mathrm{m}}{\mathrm{s}})} = 1.11\ \mathrm{s}$$

The time to make one revolution is $\boxed{1.11\ \mathrm{s}}$.

b) Find the tension in the string.

The tension is the only (inward) force on the mass and it is equal to the centripetal force which acts on the mass (since it moves in a circle at uniform speed). Thus

$$T = F_{\mathrm{cent}} = \frac{mv^2}{R} = \frac{(1.6\ \mathrm{kg})(3.4\frac{\mathrm{m}}{\mathrm{s}})^2}{(0.60\ \mathrm{m})} = 30.8\ \mathrm{N}$$

The tension in the string is $\boxed{30.8\ \mathrm{N}}$.

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

$$v = v_0 + at \qquad x = v_0 t + \tfrac{1}{2}at^2 \qquad v^2 = v_0^2 + 2ax \qquad x = \tfrac{1}{2}(v_0 + v)t \qquad g = 9.80\tfrac{\mathrm{m}}{\mathrm{s}^2}$$

$$\mathbf{F}_{\mathrm{net}} = m\mathbf{a} \qquad F_{\mathrm{s}}^{\mathrm{MAX}} = \mu_{\mathrm{s}} F_{\mathrm{N}} \qquad F_{\mathrm{k}} = \mu_{\mathrm{k}} F_{\mathrm{N}}$$

$$v = \frac{2\pi R}{T} \qquad a_{\mathrm{cent}} = \frac{v^2}{r} \qquad F_{\mathrm{cent}} = \frac{mv^2}{r}$$