Answer on Question #83379 - Physics - Mechanics – Relativity

For the period of oscillation, T depends on the mass M of the bob per unit of length of a rubber L, cross-sectional area, A of the bob and the young modulus, E. Use the method of dimension to derive the relationship of connecting them.

Solution

First, determine the units:

$$T = [\mathrm{s}],$$

$$M = [\mathrm{kg}],$$

$$L = [\mathrm{m}],$$

$$A = [\mathrm{m}^2],$$

$$E = \left[\frac{\mathrm{kg}}{\mathrm{m}\cdot\mathrm{s}^2}\right].$$

Maybe we will need the acceleration due to gravity $g = [\mathrm{m/s}^2]$ too. Let's combine! Our goal is to get seconds using all these units above. Let's suppose that

$$T = M^a \cdot L^b \cdot A^c \cdot E^d.$$

Write their

$$[\mathrm{s}]^1[\mathrm{kg}]^0[\mathrm{m}]^0 \leftrightarrow ([\mathrm{kg}])^a \cdot ([\mathrm{m}])^b \cdot ([\mathrm{m}]^2)^c \cdot ([\mathrm{kg}][\mathrm{m}]^{-1}[s]^{-2})^d,$$

$$[\mathrm{s}]^1[\mathrm{kg}]^0[\mathrm{m}]^0 \leftrightarrow [\mathrm{kg}]^{a+d} \cdot [\mathrm{m}]^{b+2c-d} \cdot [\mathrm{s}]^{-2\mathrm{d}}.$$

Now equal corresponding powers from the left part of the equation above and powers from the right:

$$[\mathrm{s}]: 1 = -2d \quad \Rightarrow \quad d = -\frac{1}{2},$$

$$[\mathrm{kg}]: 0 = a + d \quad \Rightarrow \quad a = -d = \frac{1}{2},$$

$$[\mathrm{m}]: 0 = b + 2c - d \quad \Rightarrow \quad b = \frac{1}{2}, c = -\frac{1}{2}.$$

Thus

$$T = M^a \cdot L^b \cdot A^c \cdot E^d = M^{1/2} \cdot L^{1/2} \cdot A^{-1/2} \cdot E^{-1/2}.$$

At this stage it's easy to see that

$$T = \sqrt{\frac{ML}{AE}}.$$

Answer $T = \sqrt{\frac{ML}{AE}}$

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