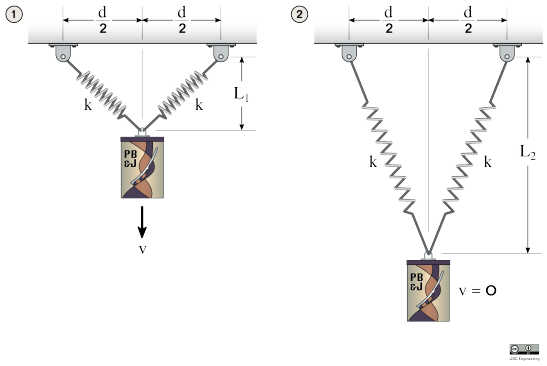
22-P-WE-JL-22



You have recently decided that you love peanut butter so much that you have prepared some experiments to perform on your favourite jar of peanut butter. Using two equal springs you suspend your 18 kg jar and push it down so that initially it is a distance $L_1 = 3$ m from the attachments and falls at $v = 2.75$ m/s. The attachments are a distance $d = 2.5$ m away from each other with the jar of peanut butter at the horizontal midpoint. If the springs have an unstretched length of 2.7 m, for what spring constant k would the jar reach its lowest point at a distance $L_2 = 10$ m from the top?

Solution

The first thing to notice is that the only forces in the system are a spring force and a gravitational force. Both are conservative forces, so we will approach this problem using conservation of energy. The starting spring length will be called L_{s1} and final spring length L_{s2}. Lastly we will consider the top where the attachments are located to be the datum (horizontal).

Looking at the initial position:

$T_1 = \frac{1}{2} m\, v^2 = 68.06$ [J]

$V_{g1} = -m\, g\, L_1 = -18\,(9.81)\,(3) = -529.7$ [J]

$L_{s1} = \sqrt{L_1^2 + (d/2)^2} = 3.25$ [m]

$V_{e1} = \frac{1}{2}\, k\, (L_{s1} - 2.7)^2 = 0.15125\, k$ [J]

Then looking at the final position (where $T_2 = 0$ since it is at rest):

$V_{g2} = -m\, g\, L_2 = -18\,(9.81)\,(10) = -1766$ [J]

$L_{s2} = \sqrt{L_2^2 + (d/2)^2} = 10.08$ [m]

$V_{e2} = \frac{1}{2}\, k\, (L_{s2} - 2.7)^2 = 27.23\, k$ [J]

(continued on next page)

Then by conservation of energy:

$T_1 + V_1 = T_2 + V_2$

$68.06 + (-529.7 + 0.15125\,k) = 0 + (-1766 + 27.23\,k)$

$1304 = 27.08\,k \implies k = 48.15 \;\; [\text{N/m}]$