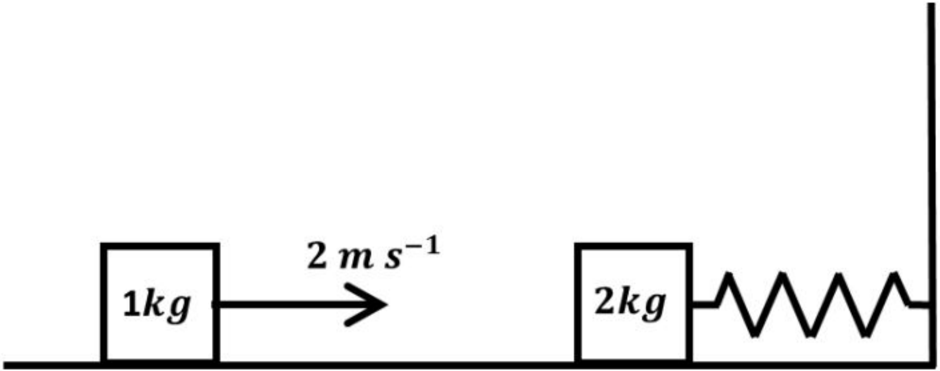
Q.10 A spring-block system is resting on a frictionless floor as shown in the figure. The spring constant is $2.0\ N\ m^{-1}$ and the mass of the block is $2.0\ kg$. Ignore the mass of the spring. Initially the spring is in an unstretched condition. Another block of mass $1.0\ kg$ moving with a speed of $2.0\ m\ s^{-1}$ collides elastically with the first block. The collision is such that the $2.0\ kg$ block does not hit the wall. The distance, in $metres$, between the two blocks when the spring returns to its unstretched position for the first time after the collision is ________.

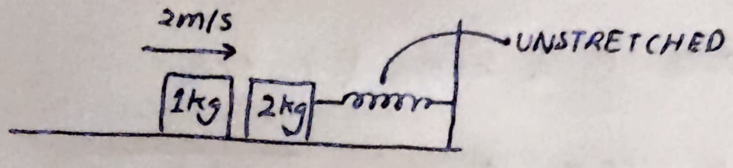


JEE ADVANCE 2018

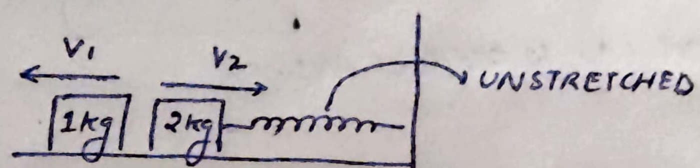
This question uses some concept of elastic collision.

firstly the two blocks will collide elastically

JUST BEFORE COLLISION



JUST AFTER COLLISION



Momentum conservation.

+ve →

$$1\times2 = V_2\times2 + (-V_1)\times1$$

$$2 = 2V_2 - V_1 \quad \text{—}(1)$$

Energy conservation.

$$KE_{initially} = KE_{final}$$

$$\frac{1}{2}\times1\times(2)^2 + 0 = \frac{1}{2}\times1\times V_1^2 + \frac{1}{2}\times2\times V_2^2$$

$$2 = \frac{V_1^2}{2} + V_2^2 \Rightarrow V_1^2 + 2V_2^2 = 4 \quad \text{—}(ii)$$

from (1) $V_1 = 2(V_2 - 1)$ Put in (ii)

$$4V_2^2 - 8V_2 + \cancel{4} + 2V_2^2 = \cancel{4} \Rightarrow 6V_2^2 = 8V_2 \Rightarrow V_2 = 0 \times$$

$$V_2 = \frac{4}{3}\ m/s$$

$$\text{So, } V_1 = 2\left(\frac{4}{3} - 1\right) = \frac{2}{3}\ m/s.$$

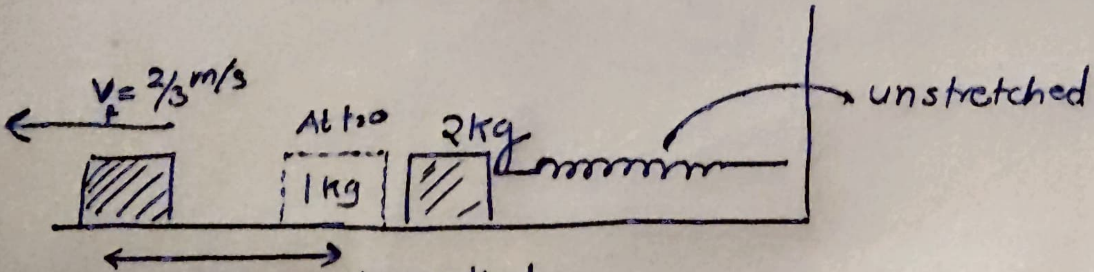
NOW, THE 2kg BLOCK WILL PERFORM SHM, and it will return to its original position after $\frac{T}{2}$, where T is time period of SHM.

Since in each 1 Time Period, the block comes to its original position 2 times!

Time Period of SHM of spring-block system $\Rightarrow T = 2\pi\sqrt{\frac{m}{k}} \Rightarrow 2\pi\sqrt{\frac{2}{2}} = 2\pi$

So, $\frac{T}{2} = \pi$

At $t = \pi$ sec



Distance travelled by 1 kg in π sec!

So, distance b/w 2 blocks after π sec $\equiv$ (Distance travelled by 1 kg)

$D = V_1 \times \text{time}$

$= \frac{2}{3} \times \pi = \frac{44}{21} \text{ m} = \boxed{2.09 \text{ m}}$