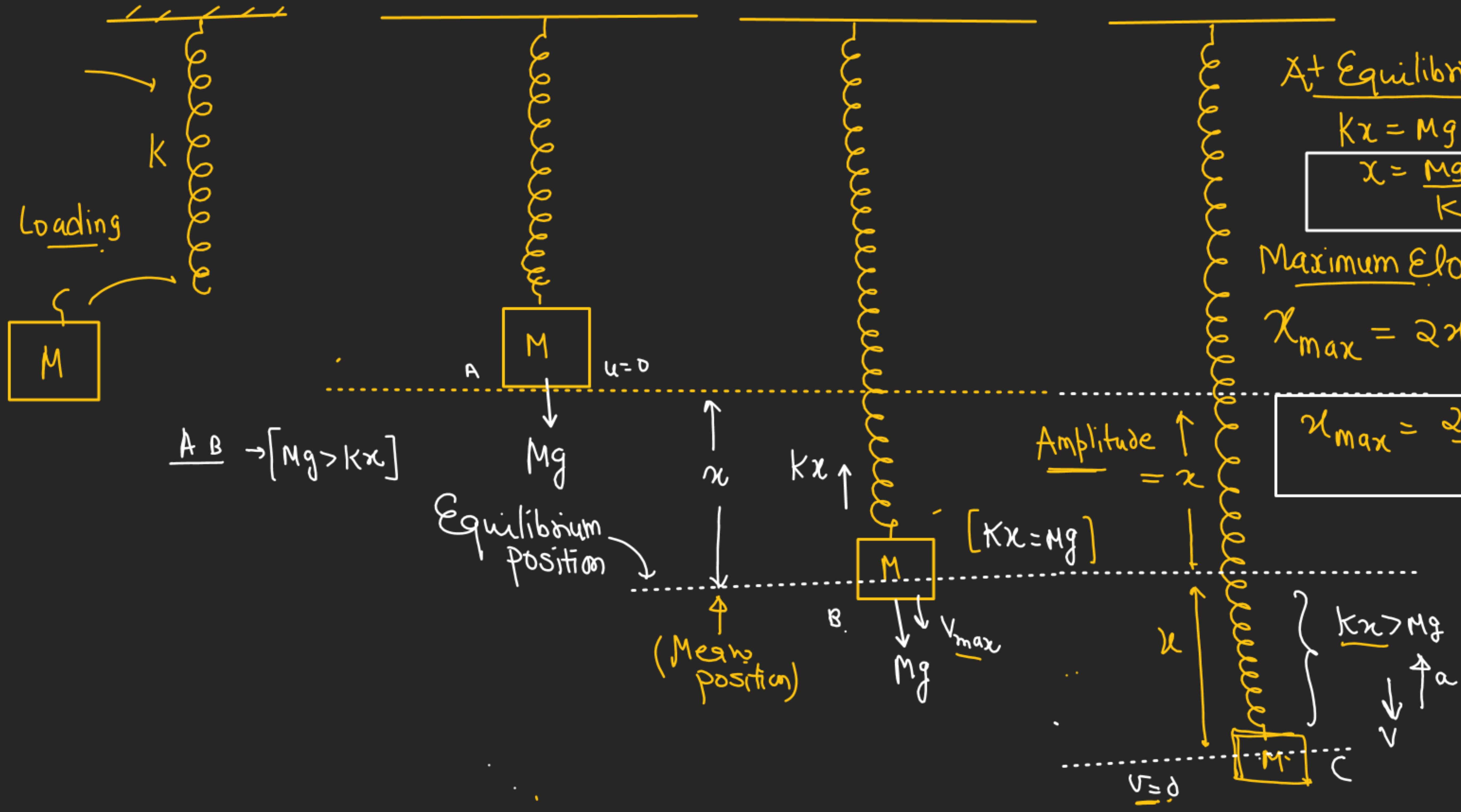
Nishant Jindal

Spring in NLM

Law of Motion



At Equilibrium

$Kx = Mg$

$$\boxed{x = \frac{Mg}{K}}$$

Maximum Elongation

$x_{max} = 2x$

$$\boxed{x_{max} = \frac{2Mg}{K}}$$

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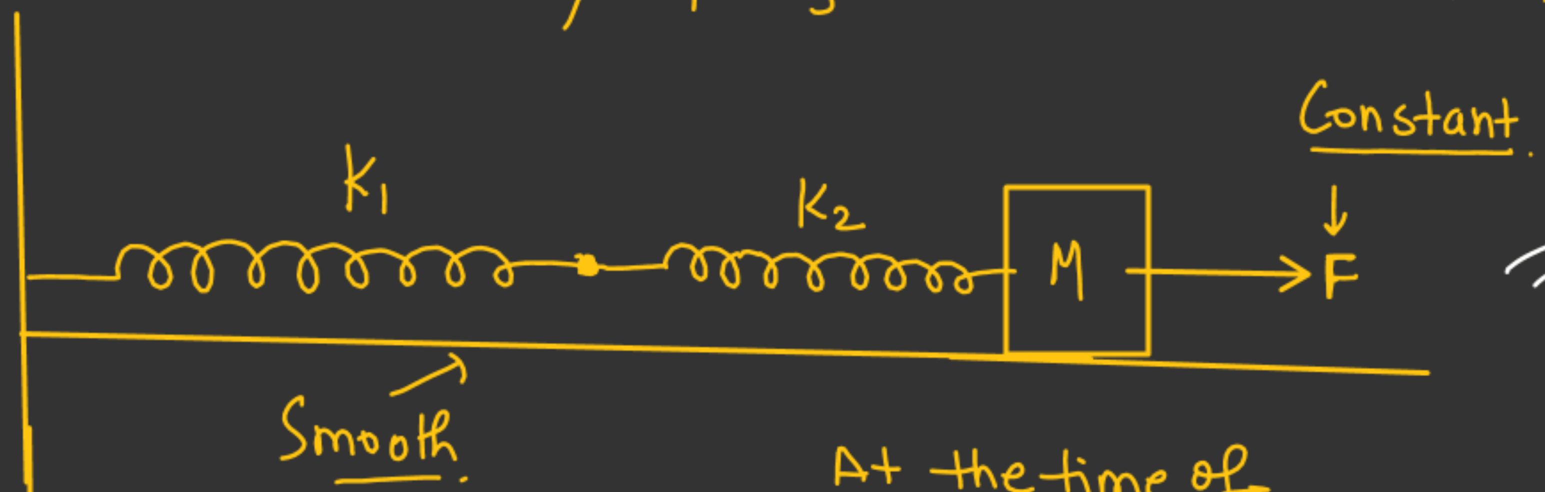
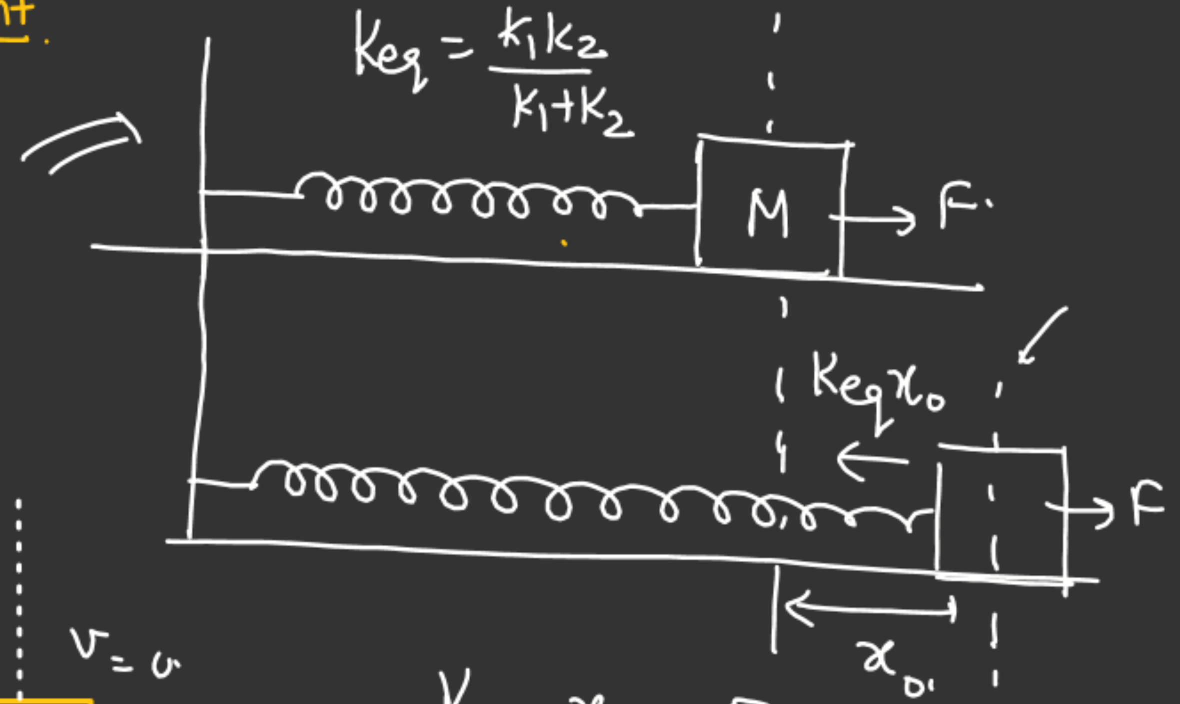
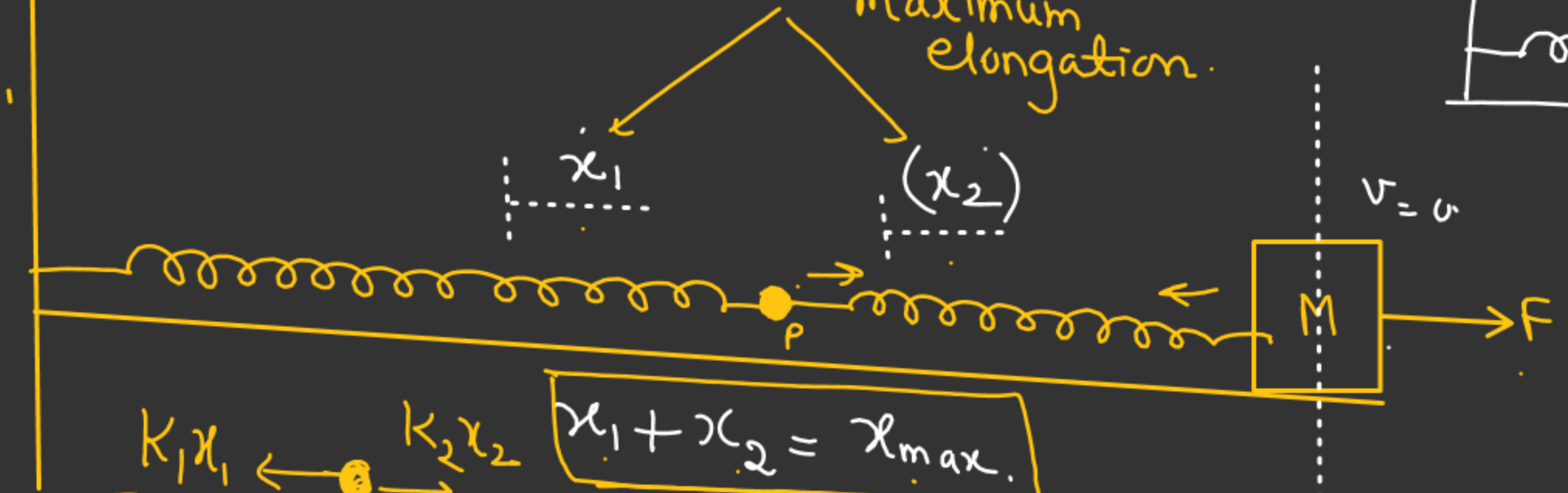
Maximum elongation in both the Spring.

Initially springs at its natural length befor F is applied.







$K_{eq} \cdot x_0 = F$

$x_0 = \frac{F}{K_{eq}} = \frac{F(K_1+K_2)}{(K_1K_2)}$

$x_{max} = 2x_0$

$= 2F\left(\frac{K_1+K_2}{K_1K_2}\right)$ ✓

$K_1x_1 \leftarrow \bullet \rightarrow K_2x_2$

$\boxed{x_1 + x_2 = x_{max}.}$

$K_1x_1 = K_2x_2$

$x_2 = \left(\frac{K_1}{K_2}x_1\right)$

$x_1\left(1+\frac{K_1}{K_2}\right) = x_{max}$

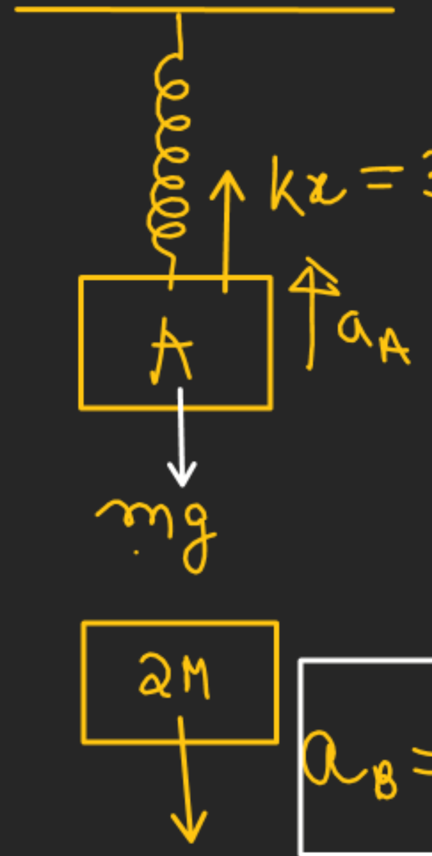
$x_1 = \left(\frac{K_2}{K_1+K_2}\right)x_{max}$, $x_2 = \left(\frac{K_1}{K_1+K_2}\right)x_{max}$

$(x_1) = \frac{2F}{K_1}$, $x_2 = \frac{2F}{K_2}$

Spring force

↳ Spring has Inertia.
So, Spring takes Some time to change its present state

Just After String is Cut



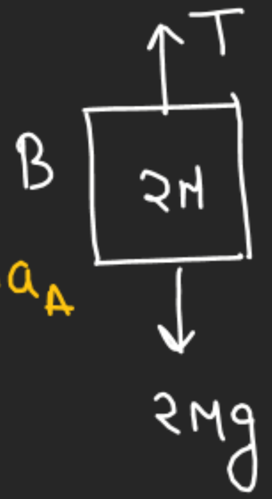
$kx = 3mg \Rightarrow 3mg - mg = ma_A$

$\boxed{a_A = 2g}$

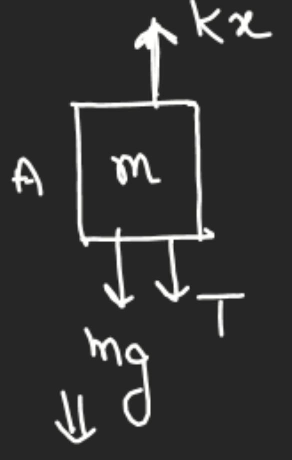
$a_B = \frac{2mg}{2m} = g$

$\boxed{a_B = g\ m s^{-2}}$

Before String is Cut

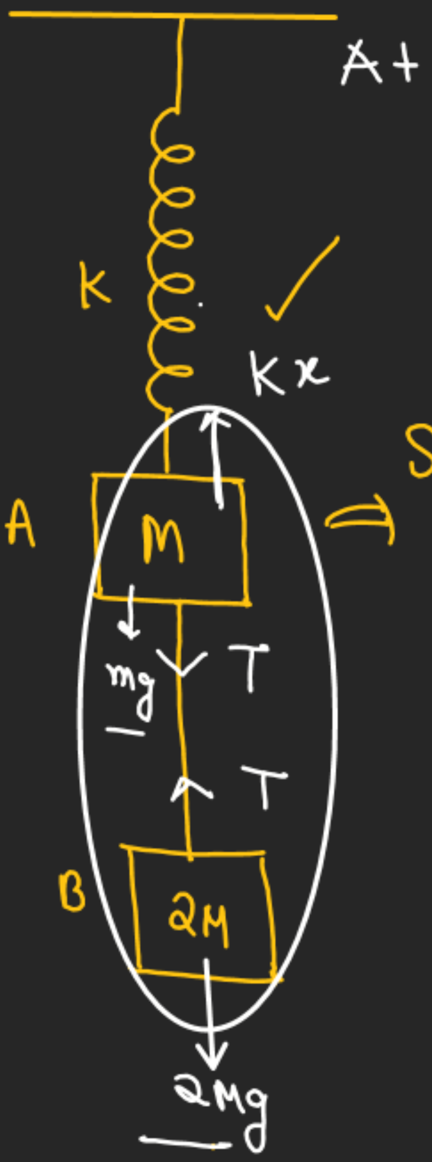


$T = 2Mg$



$Kx = T + Mg$

$Kx = 3Mg$



System boundary

$Kx = 3mg$

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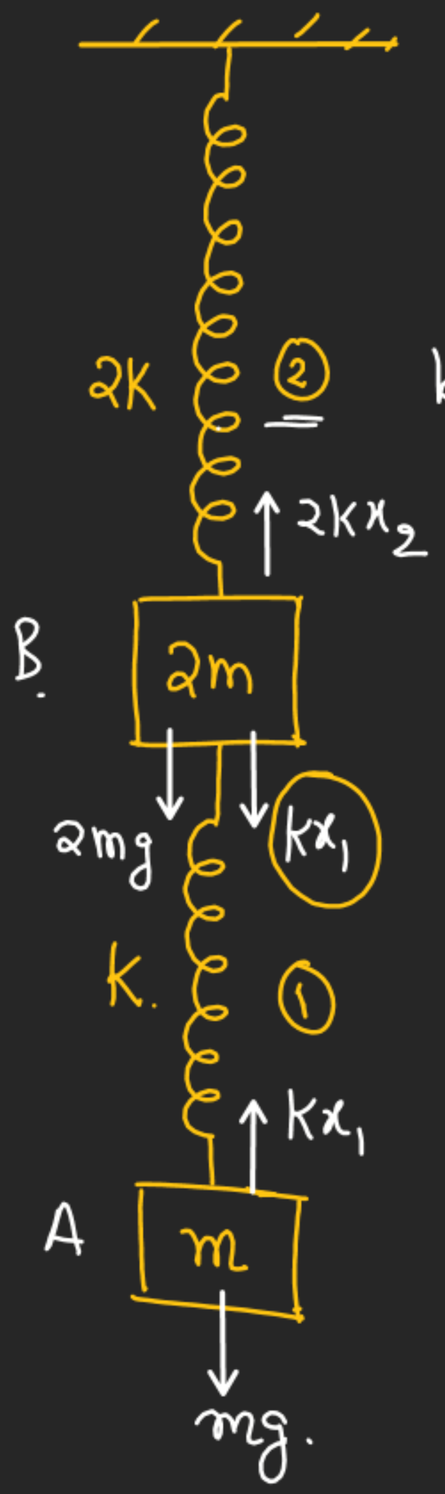
Law of Motion

Spring in NLM

AQ:



a) Spring ① is cut, find accleration of both the blocks just after cutting the spring.

H.W b) Spring ② is cut, find accleration of both the blocks.

Just before Cutting

For block A

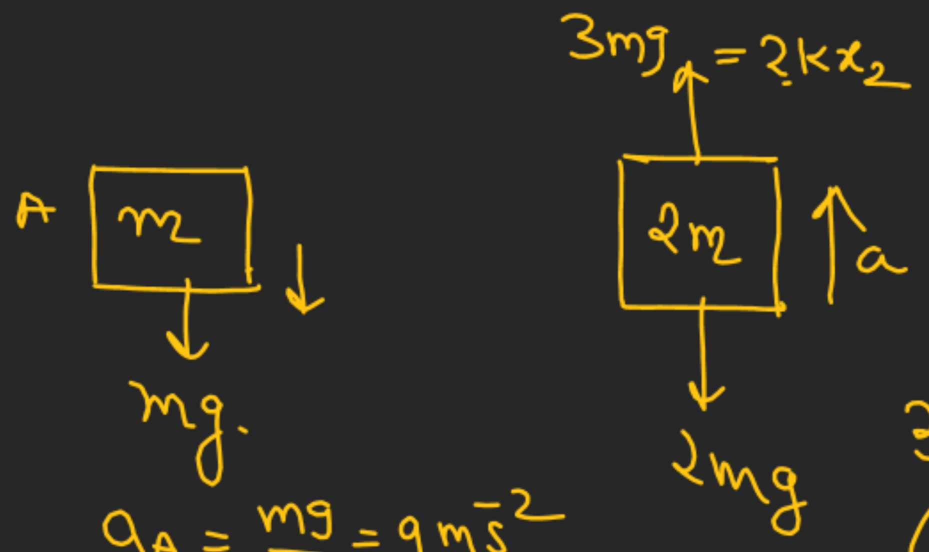
$$Kx_1 = mg \quad \text{—(1)}$$

For block B

$$2Kx_2 = 2mg + Kx_1$$

$$2Kx_2 = 3mg \quad \text{—(2)}$$

Just after Cutting the Spring ①



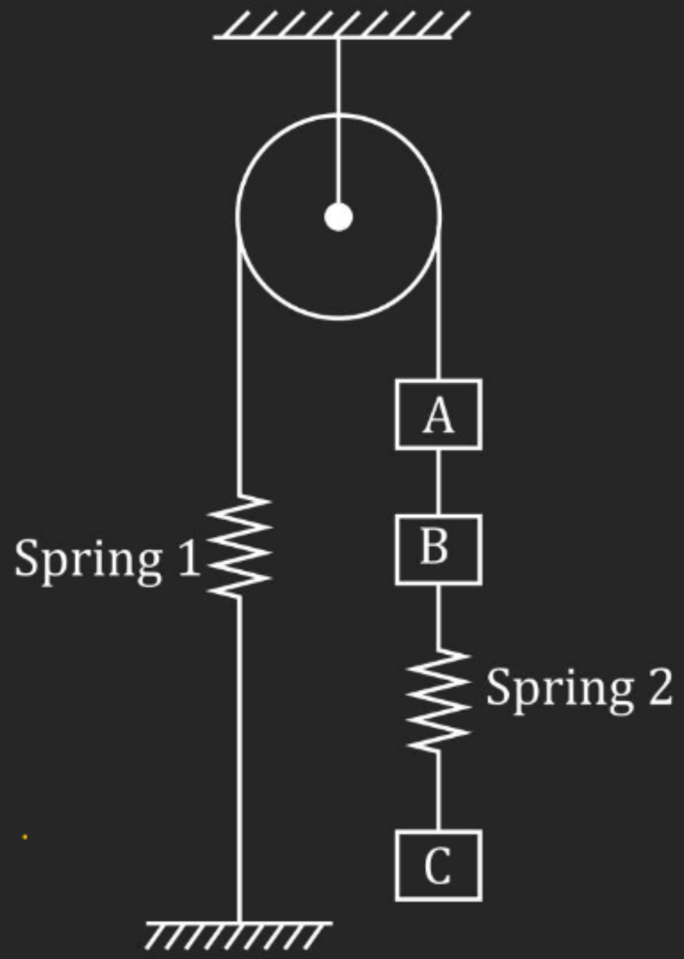
(State of Spring doesn't change just after cutting)

$$a_A = \frac{mg}{m} = g\ ms^{-2}$$

$$3mg - 2mg = 2ma$$

$$\left(a = g/2\right)$$

Q.2 The system shown in figure is in equilibrium. Pulley, springs and the strings are massless. The three blocks A, B and C have equal masses. x_1 and x_2 are extensions in the spring 1 and spring 2 respectively.



(a) Find the value of $\left|\frac{d^2x_2}{dt^2}\right|$ immediately after spring I is cut.

(b) Find the value of $\left|\frac{d^2x_1}{dt^2}\right|$ and $\left|\frac{d^2x_2}{dt^2}\right|$ immediately after string AB is cut.

(c) Find the value of $\left|\frac{d^2x_1}{dt^2}\right|$ and $\left|\frac{d^2x_2}{dt^2}\right|$ immediately after spring 2 is cut.

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Spring in NLM

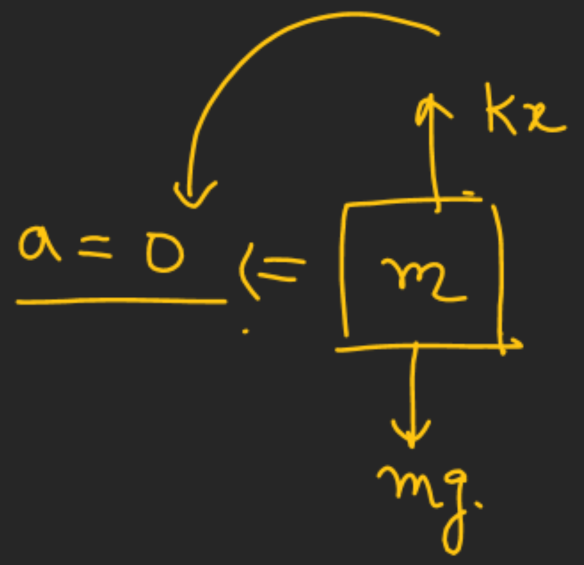
Law of Motion

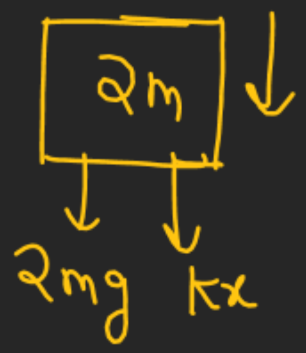
H-W ✓

Q.1 Two blocks are connected by a spring. The combination is suspended, at rest, from a string attached to the ceiling, as shown in Fig. The string breaks suddenly.

Immediately after the string breaks, what is the initial downward acceleration of the upper block of mass $2m$?

Just After breaking of string





$a = \frac{2mg + kx}{2m}$

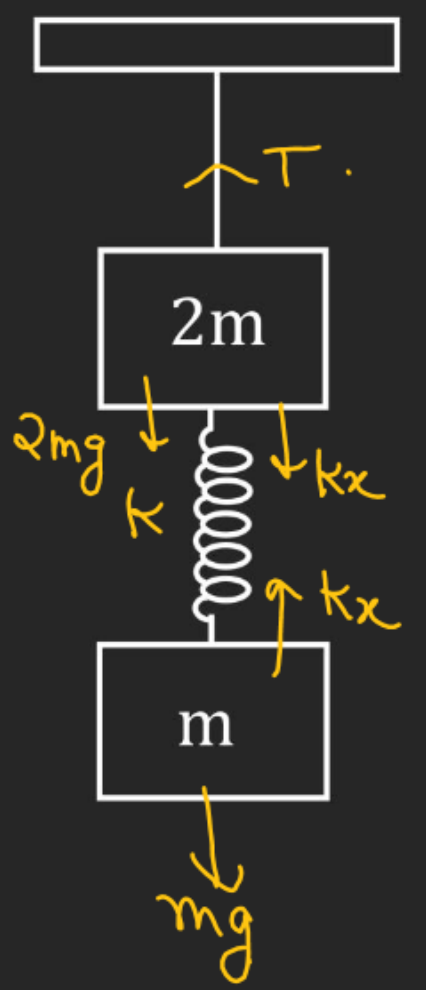
$a = \frac{3mg}{2m} = \frac{3g}{2}\ ms^{-2}$

Before string is break

$T = (2mg + kx)$

$kx = mg$

$T = 3mg$



H.W

Q.3 The fig. shows an infinite tower of identical springs each having force constant k. The connecting bars and all springs are massless. All springs are relaxed and the bottom row of springs is fixed to horizontal ground. The free end of the top spring is pulled up with a constant force F.

In equilibrium, find

(a) The displacement of free end A of the top spring from relaxed position.

(b) The displacement of the top bar $B1$ from the initial relaxed position.

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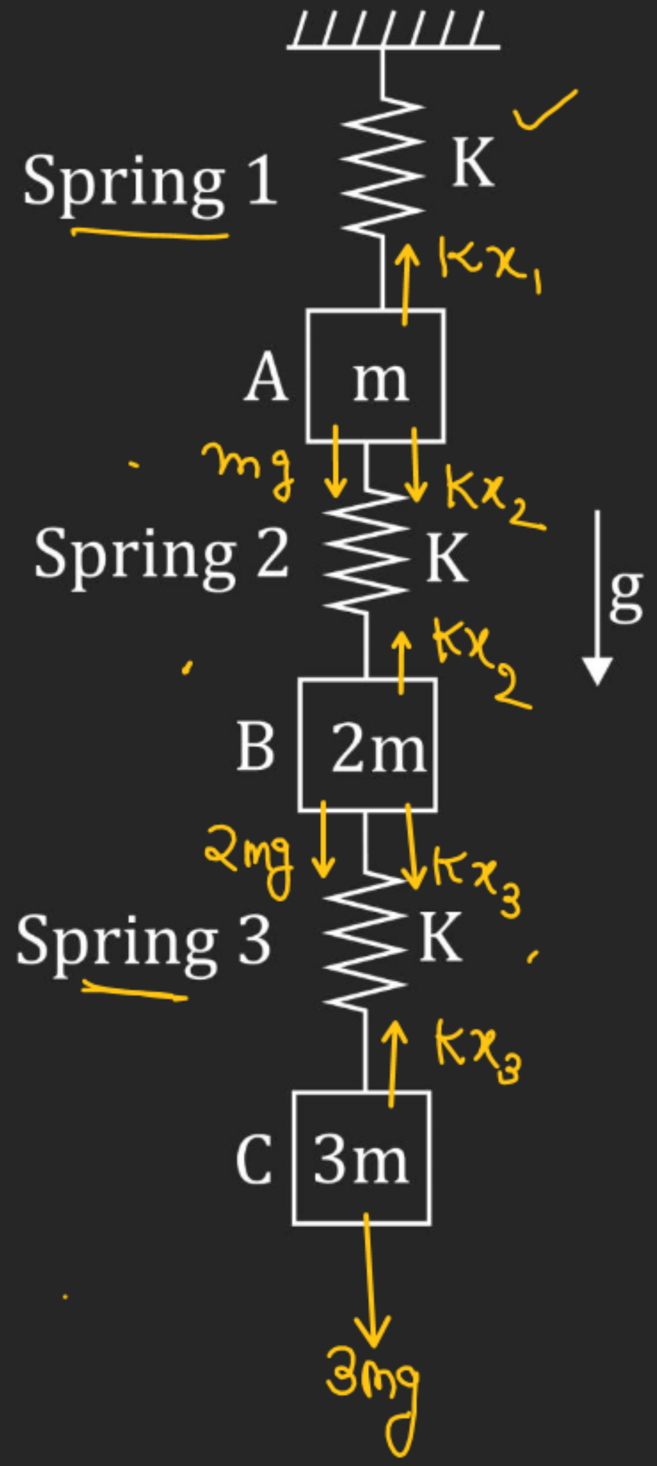
Law of Motion

Q.5 The system shown in the Fig (a) is in equilibrium. Find the initial acceleration of A, B and C just after the spring 2 is cut.



just after Spring → 2 is cut

$kx_3 = 3mg$

$kx_2 = 2mg + kx_3 = 5mg$

$kx_1 = mg + kx_2 = 6mg$

A: $kx_1 = 6mg$ (up), mg (down)

$a = \frac{6mg - mg}{m}$

$\boxed{a = (5g)\ ms^{-2}}$ ✓

B: kx_3, $2mg$ (down), $\downarrow a_B$

$a_B = \frac{kx_3 + 2mg}{2m} = \boxed{\frac{5g}{2}\ ms^{-2}}$ ✓

C: 3m, $kx_3 = 3mg$ (up), $3mg$ (down)

$\boxed{a_c = 0}$ ✓

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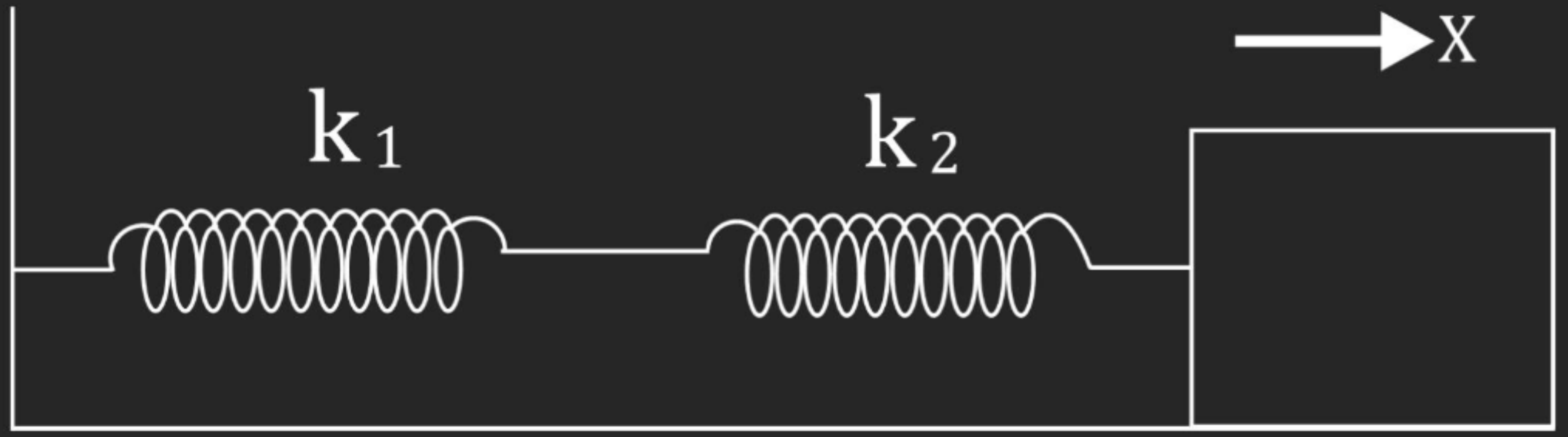
Spring in NLM

H-W

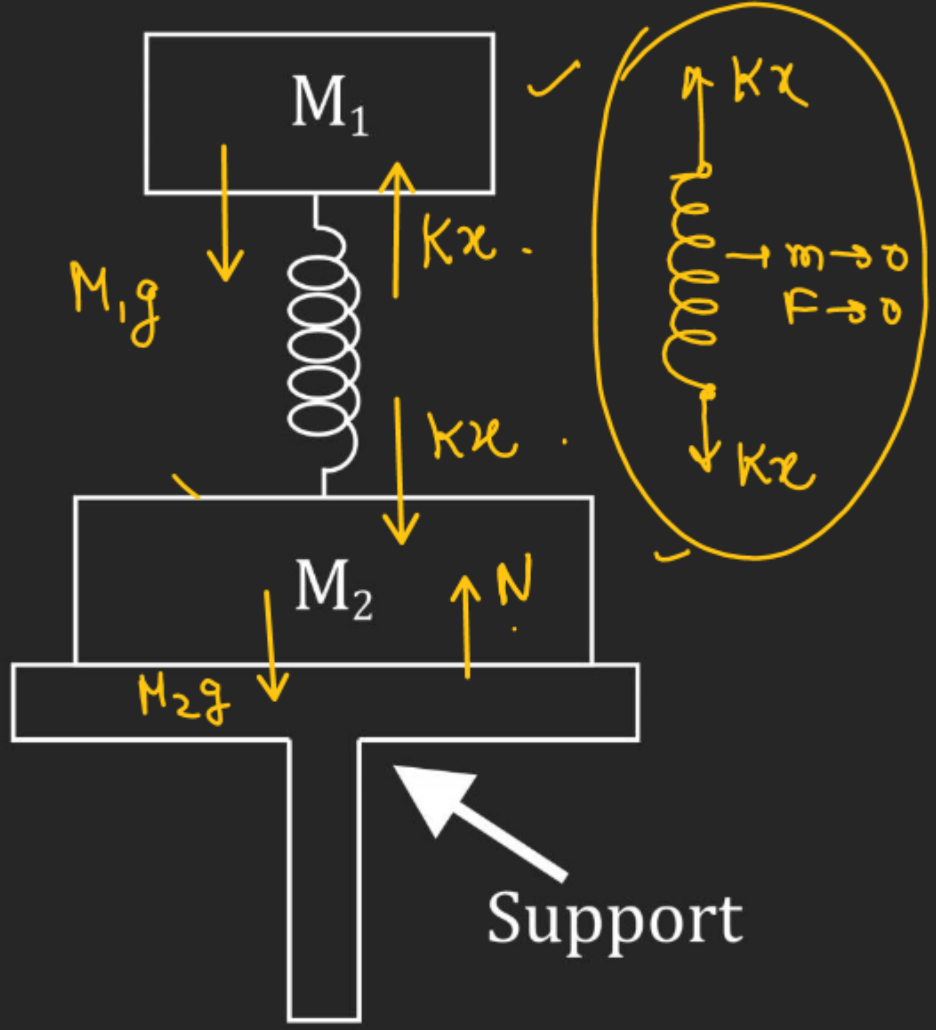
Law of Motion

Q.6 The mass in the Fig can slide on a frictionless surface. The mass is pulled out by a distance x. The spring constants are k_1 and k_2 respectively. Find the force pulling back on the mass and force on the wall.



Law of Motion

Q.7 The system of two weights with masses m_1 and m_2 are connected with weightless spring as shown. The system is resting on the support S. The support S is quickly removed. Find the accelerations of each of the weights right after the support S is removed.



Before Support is removed.

For M_1

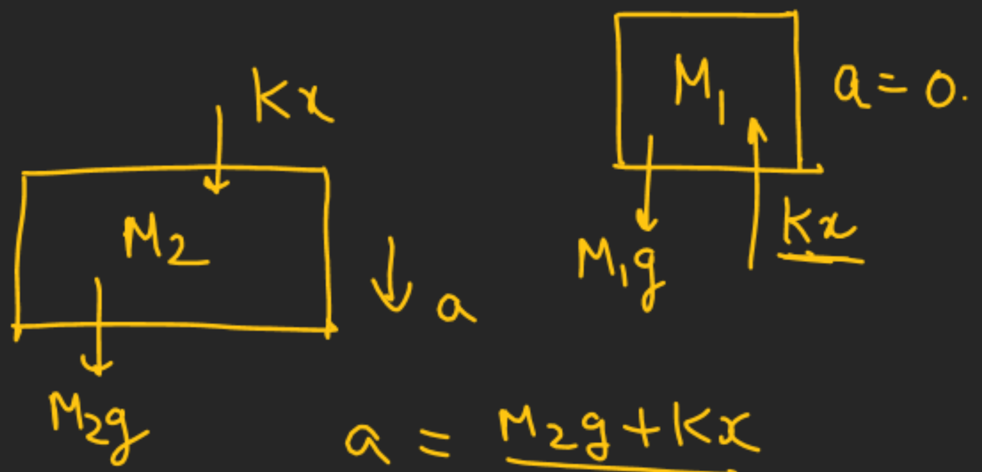
$$M_1 g = Kx \quad -(1)$$

For M_2

$$N = Kx + M_2 g$$

$$N = (M_1 + M_2) g.$$

Just after Support is removed.



$$a = \frac{M_2 g + Kx}{M_2}$$

$$a = \left(\frac{M_1 g + M_2 g}{M_2}\right) = \frac{(M_1 + M_2) g}{M_2}$$

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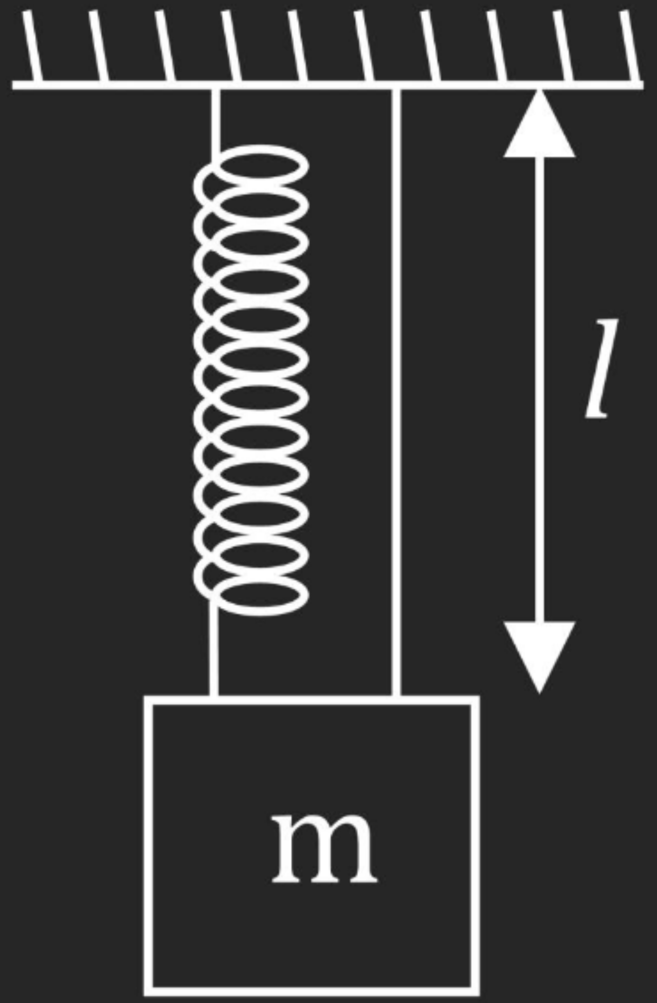
Spring in NLM P.W

Law of Motion

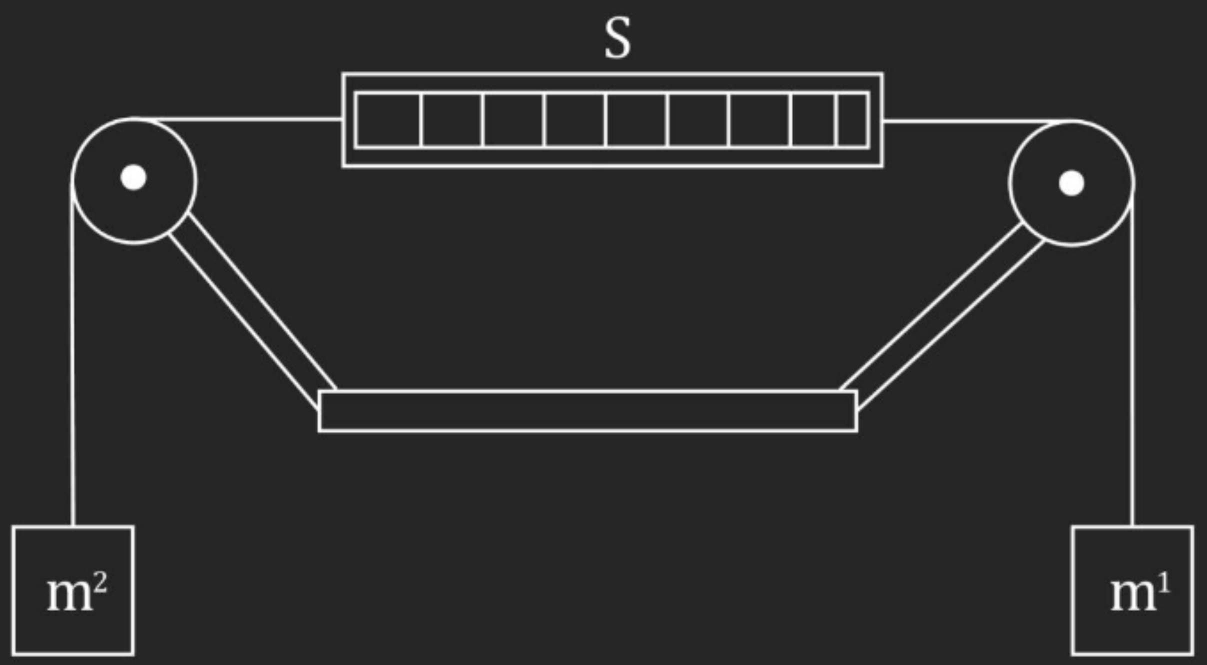
Q.8 An object of mass m is suspended in equilibrium using a string of length l and a spring of constant $K(< 2mg/l)$ and unstretched length y_2. Find the tension in the string. What happens if $K > 2mg/l$?



Law of Motion

H-W

Q.2 In the arrangement shown, the pulleys are fixed and ideal, the strings are light. $m_1 > m_2$ and S is a spring balance which is itself massless. The reading of S (in unit of mass) is :



(A) $(m_1 - m_2)g$

(B) $\frac{1}{2}(m_1 - m_2)g$

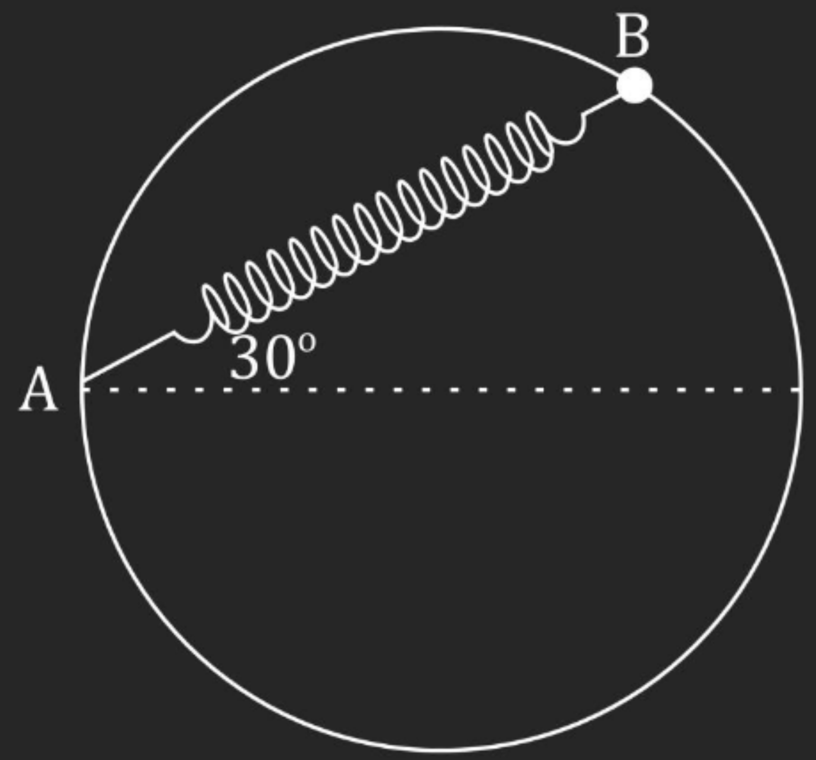
(C) $\frac{m_1 m_2}{m_1 + m_2} g$

(D) $\frac{2 m_1 m_2}{m_1 + m_2} g$

Law of Motion

H-W

Q.3 A bead of mass m is attached to one end of a spring of natural length R and spring constant $K = (\sqrt{3}+1)mg/R$. The other end of the spring is fixed at a point A on a smooth vertical ring of radius R as shown in the figure. The normal reaction at B just after it is released to move is:



(A) $mg/2$

(B) $\sqrt{3}mg$

(C) $3\sqrt{3}mg$

(D) $3\sqrt{3}mg/2$

Law of Motion

H-W

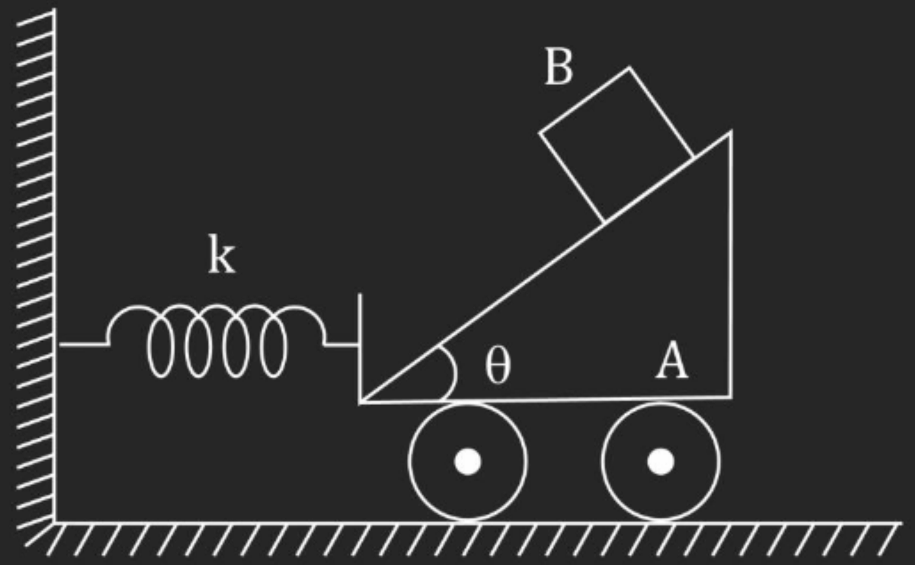
Q.4 Block B has a mass m and is released from rest when it is on top of wedge A, which has a mass 3 m. Determine the extension of the spring of force constant k while B is sliding down on A. Neglect friction :

(A) $2mg\cos\theta/k$

(B) $\frac{mg}{2k}\cos\theta$

(C) $\frac{mg}{2k}\sin 2\theta$

(D) $mg\sin 2\theta/k$



H-W

Law of Motion

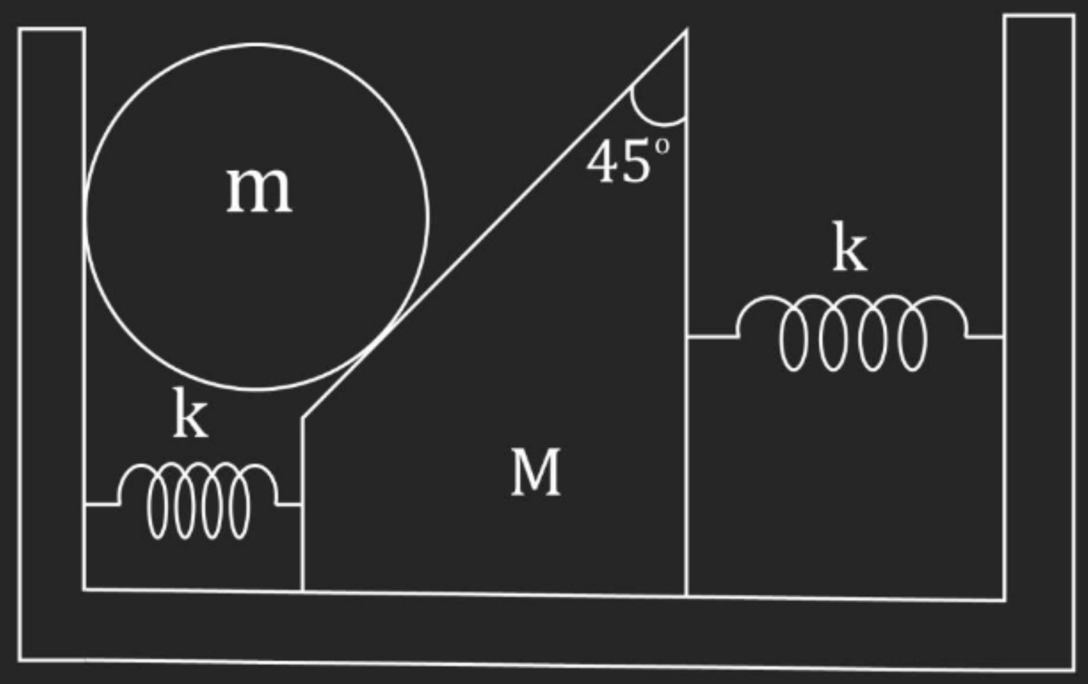
Q.5 All surfaces shown in figure are smooth. System is released with the spring unstretched. In equilibrium, compression in the spring will be :

(A) $\frac{2mg}{k}$

(B) $\frac{(M+m)g}{\sqrt{2}k}$

(C) $\frac{mg}{\sqrt{2}k}$

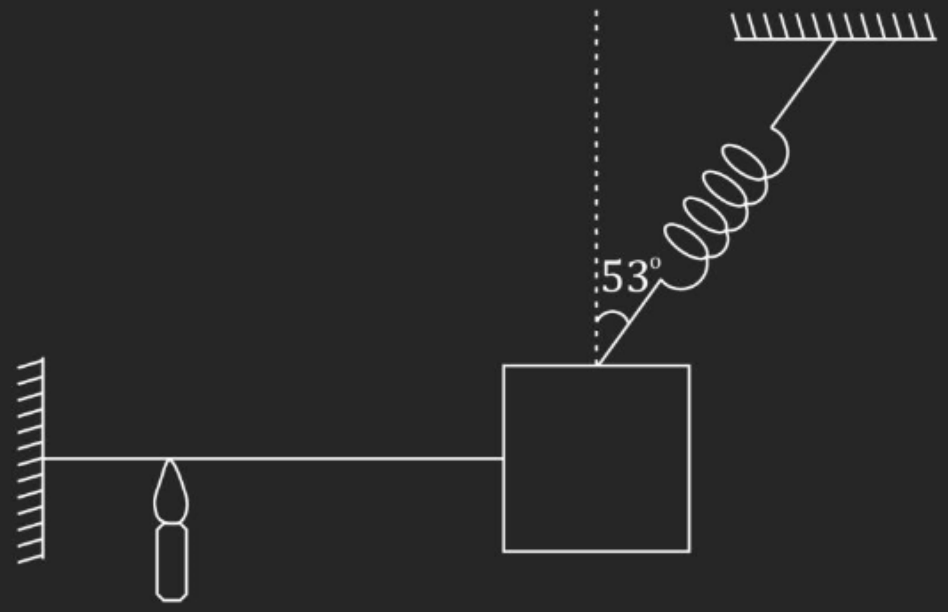
(D) $\frac{mg}{2k}$



H.W

Law of Motion

Q.6 The block shown in the figure is in equilibrium. Find the acceleration of the block just after the string burns :



(A) $\frac{3g}{5}$

(B) $\frac{4g}{5}$

(C) $\frac{4g}{3}$

(D) $\frac{3g}{4}$