Assumption :- [Spring is massless]

$$[m \to 0]$$

$\Rightarrow$ Always net force on the Spring is zero.

Spring force :-

$\qquad \hookrightarrow$ According to Hook's Law
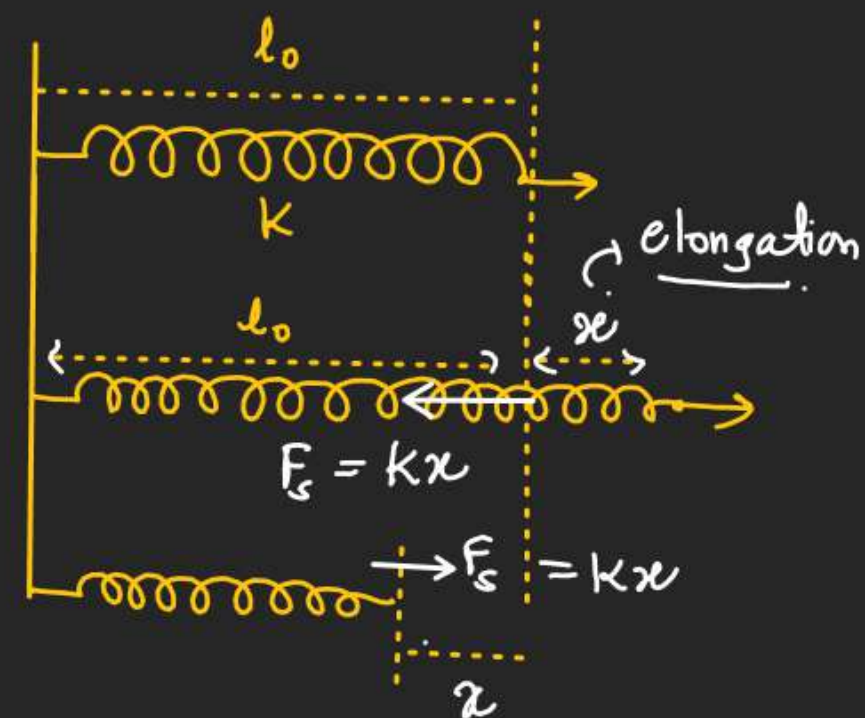
$(-) \to F_s$ is a restoring force

$$F_s \propto x$$

$$\boxed{F_s = -kx}$$

$$\overrightarrow{F_s} = -k\overrightarrow{x}$$

x = elongation or compression in Spring

k = Spring constant.

$(-) \Rightarrow F$ is always opposite to x.

l_0 = Natural length

l_0
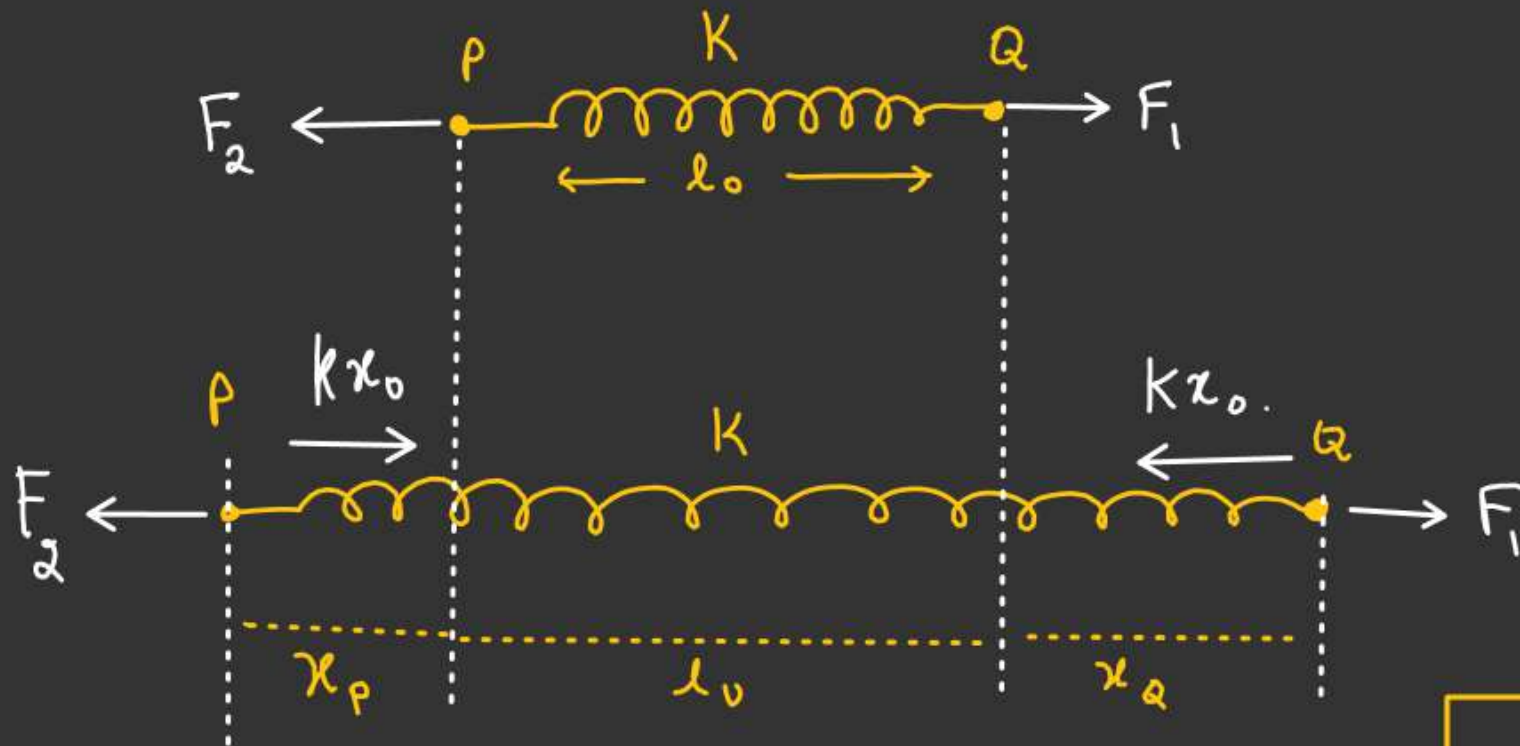
k

elongation

l_0

x

$F_s = kx$

$\to F_s = kx$

x

x_0 = Total Elongation in the Spring.

$x_0 = (l_f - l_i)$

$x_0 = (l_0 + x_P + x_Q) - l_0$

$$\boxed{x_0 = x_P + x_Q}$$

P K Q

$F_2 \leftarrow \quad \xrightarrow{} F_1$

$\longleftarrow l_0 \longrightarrow$

P kx_0

$F_2 \leftarrow$ K kx_0 ← Q $\rightarrow F_1$

x_P l_0 x_Q

$$\boxed{\begin{array}{c} F_{net} = ma \\ \text{if } m = 0 \\ F_{net} = 0 \end{array}}$$

$F_1 = F_2 = kx_0$

$m \rightarrow 0$

$F_2 \leftarrow \bullet \rightarrow kx_0$

Q

$F_2 = kx_0 - \text{①}$

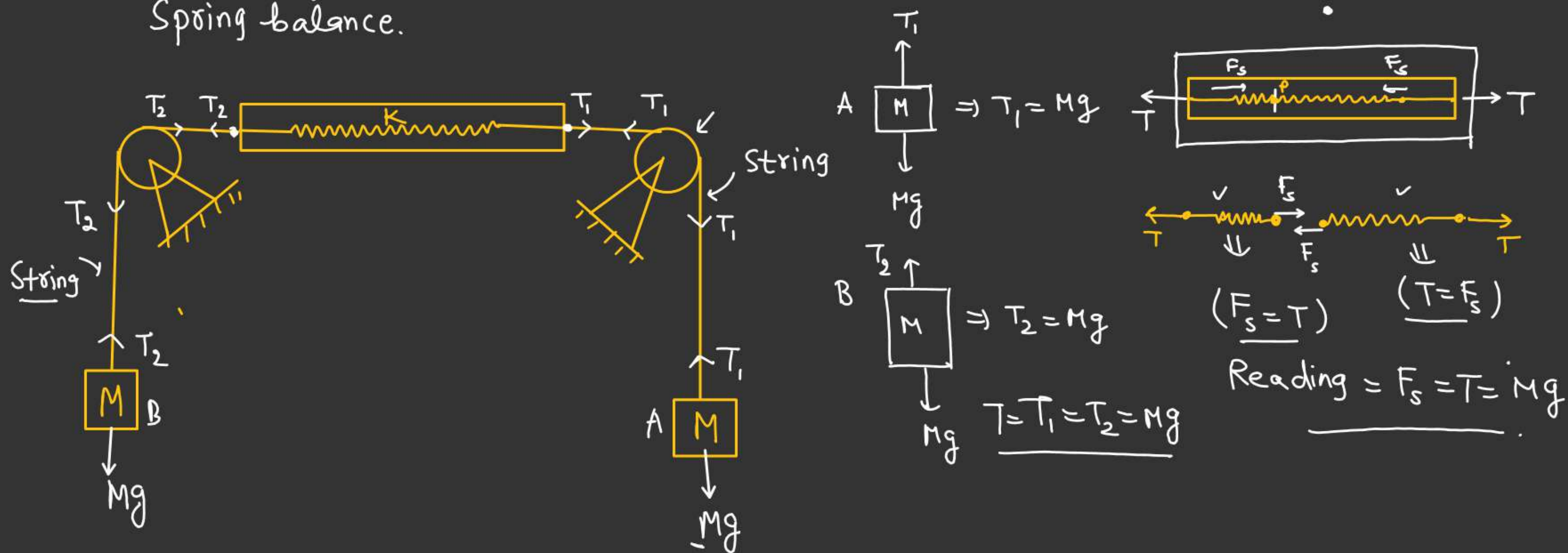$m \rightarrow 0$
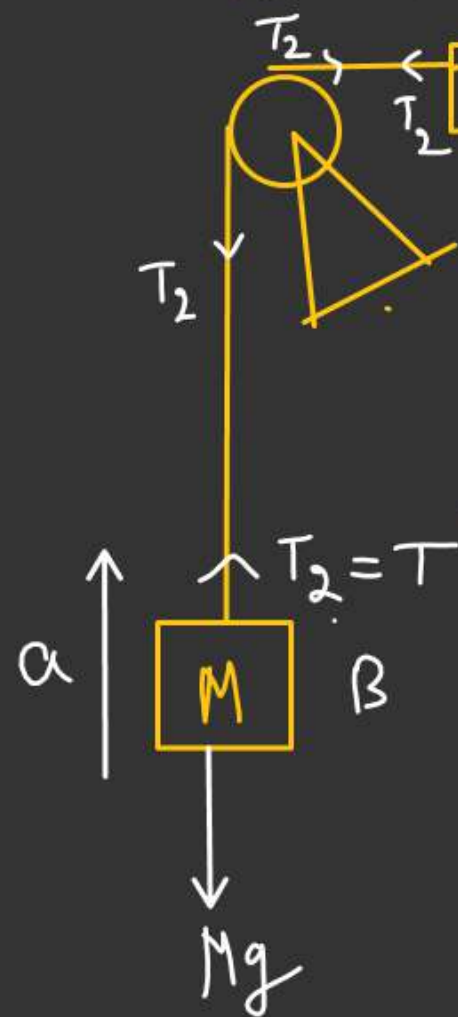
$kx_0 \leftarrow \bullet \rightarrow F_1$

Q

$F_1 = kx_0 - \text{②}$

Spring balance

↳ Reading of Spring balance always according to Spring force in the Spring balance

Reading of Spring balance.

T_2 T_2 ⟶ [K] ⟵ T_1 T_1

String

T_2

String

T_2

[M] B

Mg

T_1 T_1

String

T_1

T_1

A [M]

Mg

T_1

A [M] $\Rightarrow T_1 = Mg$

Mg

T_2

B [M] $\Rightarrow T_2 = Mg$

Mg $\quad T = T_1 = T_2 = Mg$

F_s $\qquad$ F_s

T ⟵ [wwwwww] ⟶ T

T ⟵ •wwww• ⟶ •wwww• ⟶ T

F_s

F_s

$(F_s = T)$ $\qquad (T = F_s)$

Reading $= F_s = T = Mg$

System is relased from rest. Find reading of Spring Balance.

Massless

$M \to 0$

$T_1 = T_2 = T$

$T = F_s$ ✓
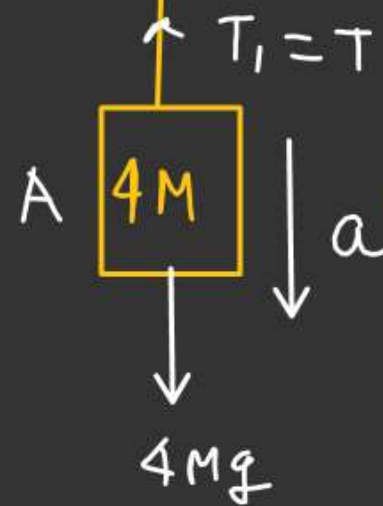
F.B.D of 4M
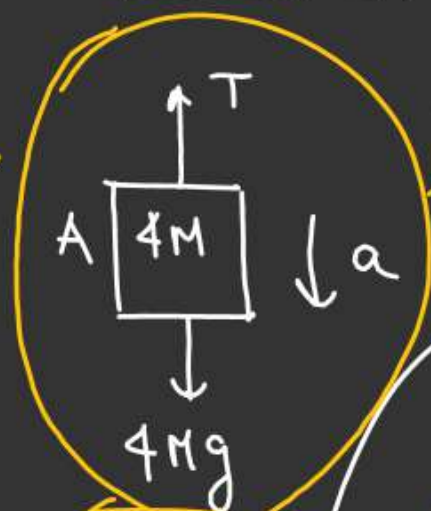
$4Mg - T = 4Ma$ — ①

$T - Mg = Ma$ — ②

① + ②

$3Mg = 5Ma$

$a = \dfrac{3Mg}{5M} = \left(\dfrac{3g}{5}\right) m\bar{s}^2$

From ②

$T = Mg + Ma = Mg + M\left(\dfrac{3g}{5}\right)$

$F_s \Rightarrow$ Reading $= \dfrac{8Mg}{5}$

Trick.

Mg

M

$Mg \leftarrow$ M $\rightarrow$

a

T T

Fs   Fs

$\leftarrow$ ⌇⌇⌇⌇⌇⌇⌇⌇⌇ $\leftarrow$

T T

a

4M

$4Mg$

a
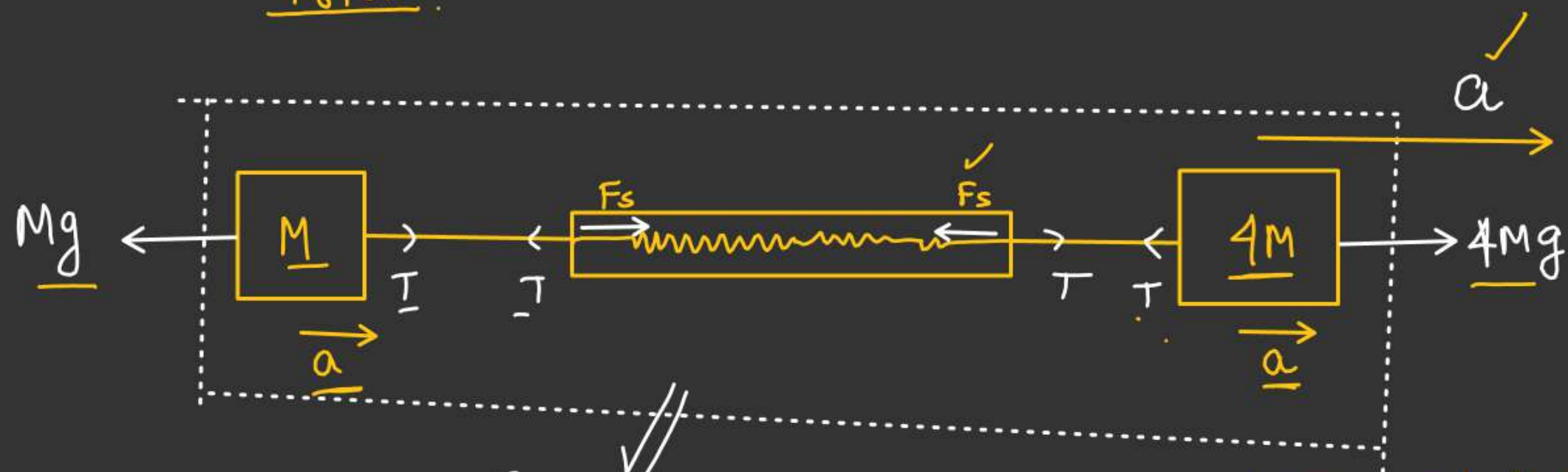
System boundary

For whole System

$$4mg - Mg = 5Ma$$

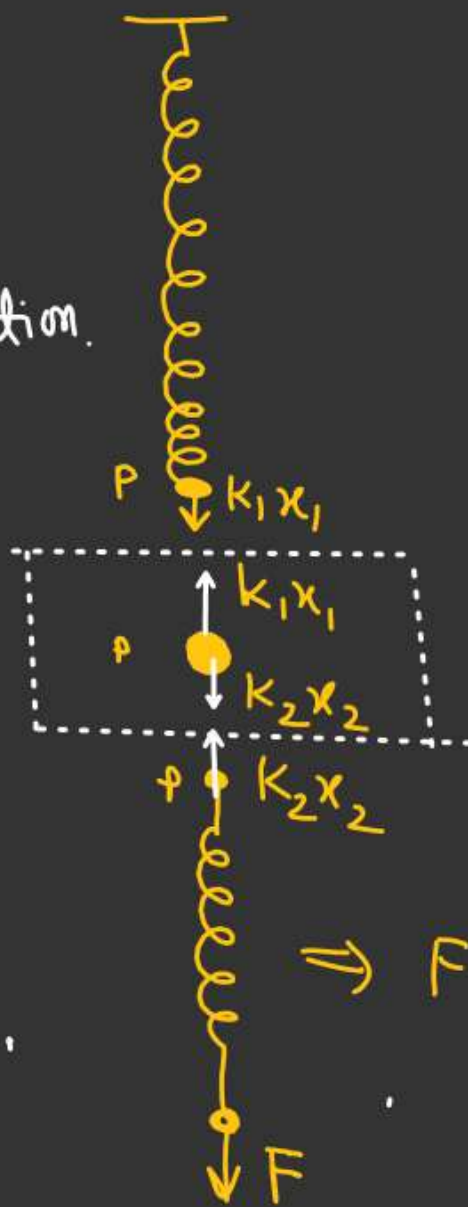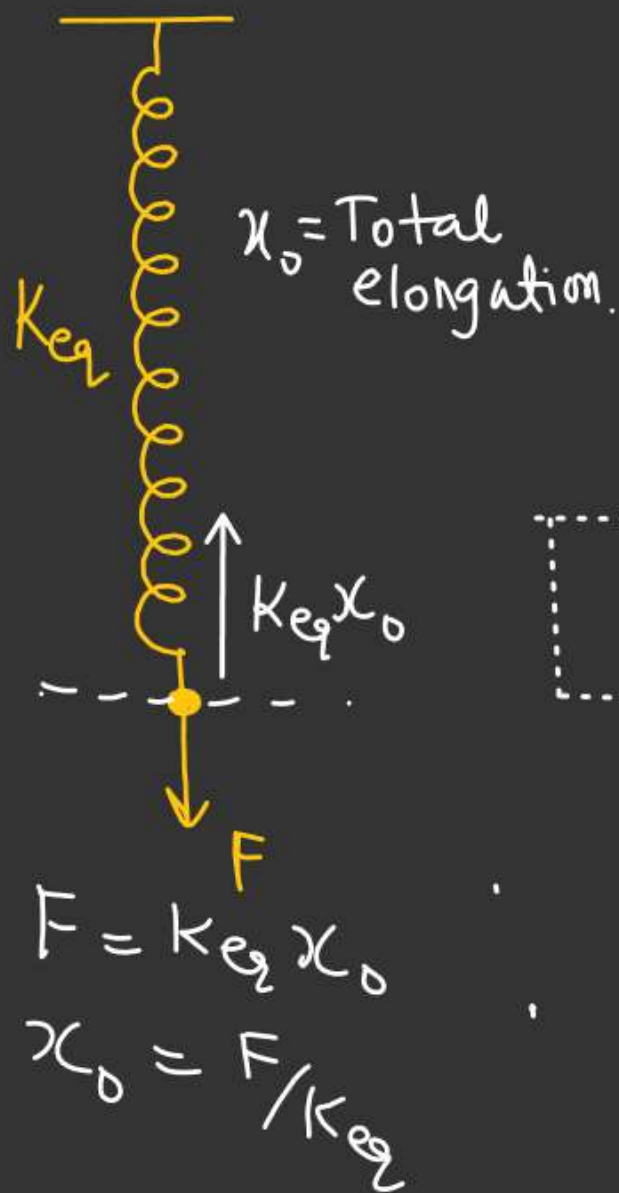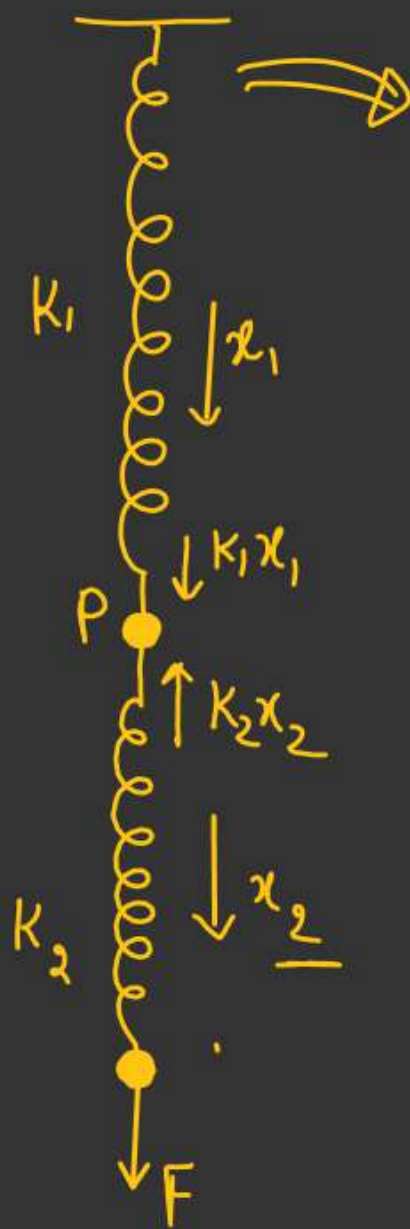$$3mg = 5Ma$$

$$\boxed{a = \frac{3g}{5}}$$

Combination of Spring $\rightarrow$.

Series Combination :- [In Series Combination Spring force in each Spring is same]

$$K_{eq} = ??$$

\#

K_1

$\downarrow x_1$

$\downarrow K_1 x_1$

P

$\uparrow K_2 x_2$

K_2

$\downarrow x_2$

$\downarrow F$

K_{eq}

$x_0 = $ Total elongation.

$\uparrow K_{eq} x_0$

$\downarrow F$

$F = K_{eq} x_0$

$x_0 = F/K_{eq}$

P $\downarrow K_1 x_1$

$\uparrow K_1 x_1$

P

$\downarrow K_2 x_2$

P $\uparrow K_2 x_2$

$\Rightarrow F = K_2 x_2$

$\downarrow F$

$K_1 x_1 = K_2 x_2 = F$

$x_1 = \dfrac{F}{K_1}$ ✓

$x_2 = \dfrac{F}{K_2}$ ✓

$$x_0 = x_1 + x_2$$

$=$

$$\dfrac{F}{K_{eq}} = \dfrac{F}{K_1} + \dfrac{F}{K_2} \; **$$

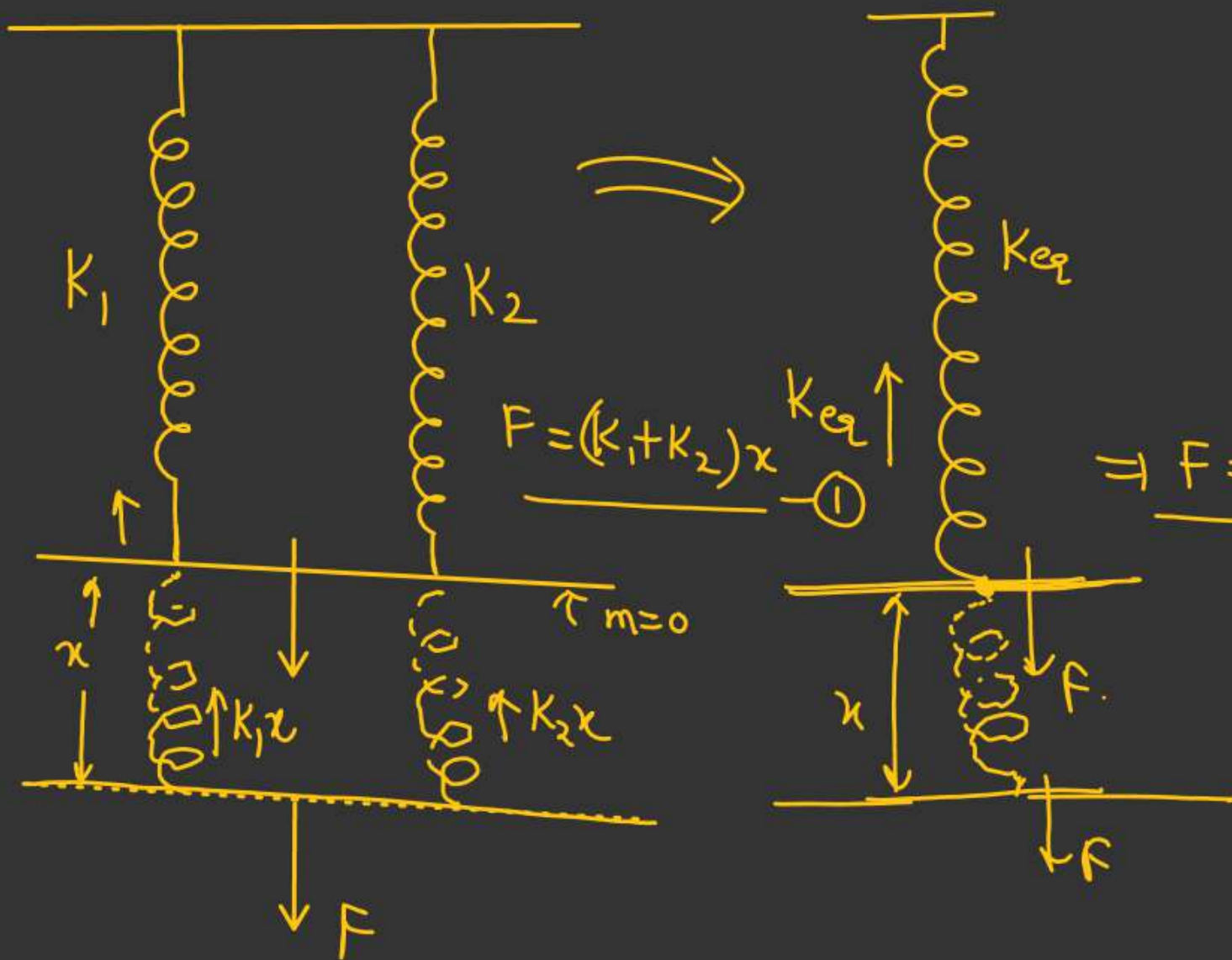$$\boxed{\dfrac{1}{K_{eq}} = \dfrac{1}{K_1} + \dfrac{1}{K_2}}$$

Note

$$\left[K \propto \dfrac{1}{x} \right]$$

$$\begin{cases} K_1 = \dfrac{F}{x_1} \\ K_2 = F/x_2 \end{cases}$$

Spring in parallel.

↳ Springs are said to be in parallel if elongation or Compression in each Spring is Same.

K_1 K_2 K_{eq}

$F = (K_1 + K_2)x$ — ①

K_{eq} ↑

$m = 0$

$\Rightarrow F = K_{eq}x$ — ②

x ↑   ↑ $K_1 x$ ↑ $K_2 x$

x

F

F

↓ F

From ① & ②

$$K_{eq}\,\cancel{x} = (K_1 + K_2)\,\cancel{x}$$

$$\boxed{K_{eq} = K_1 + K_2}$$