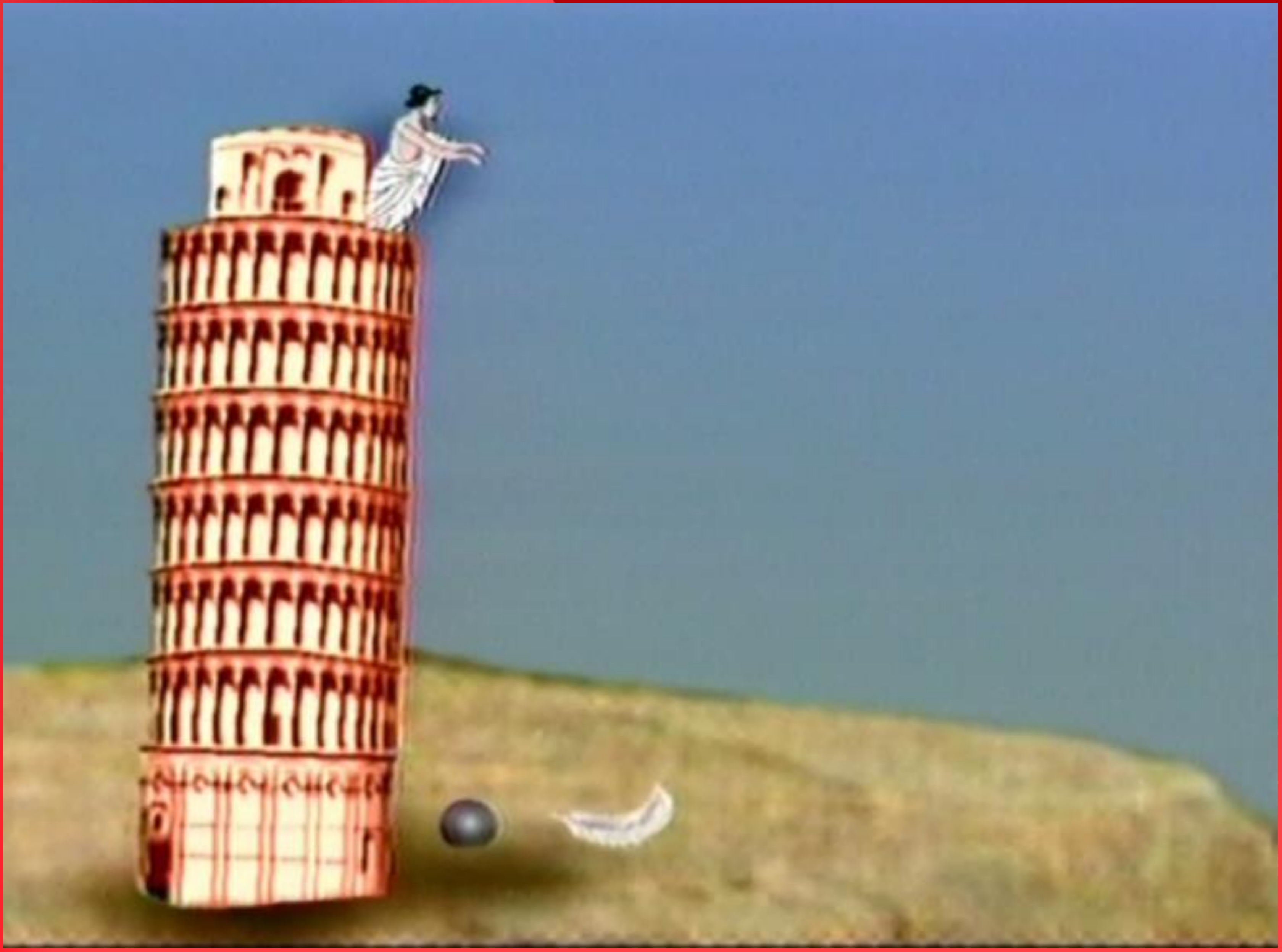
Welcome to Physics

Fluid friction

The direction of the fluid resistance force on a body is always opposite to the direction of the body’s velocity relative to the fluid.

The magnitude of the fluid resistance force usually increases with the speed of the body through the fluid.

Example of equilibrium under two forces:



Example: the magnitude f of the resisting force of fluid is approximately proportional to the body's speed v:

$$f = kv$$

$$mg + (-kv) = ma$$

$$v_T = \frac{mg}{k}$$

Solving Problems

1- Draw free body diagram; define x,y coordinate system

2- Identify all forces: tension, normal, friction, weight — Find x and y components

3- Apply Newton's 2nd Law on each axis:

$$\begin{cases} \Sigma F_x = ma_x \\ \Sigma F_y = ma_y \end{cases}$$

4- Determine known quantities:

- **acceleration:** $x = x_o + v_{ox}t + \frac{1}{2}a_x t^2$

  $v_x = v_{ox} + a_x t$

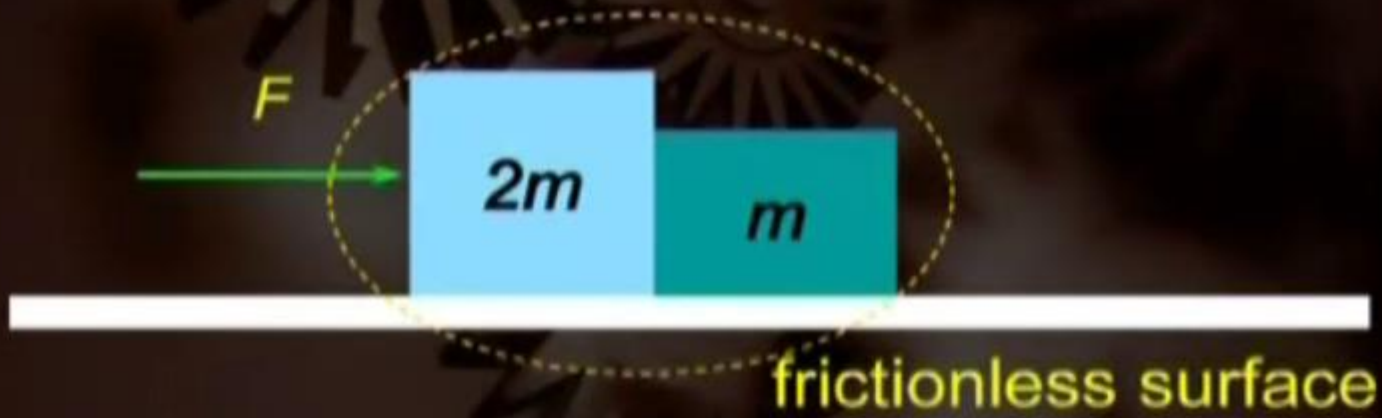
- **forces** **gravity:** $W = mg$

  friction: $f = \mu N$

5- Algebra: Solve for unknowns

Applications to solve frictional problems:

Consider two blocks together:



Realize that:

$$F = (2m + m)\,a = 3m\,a$$

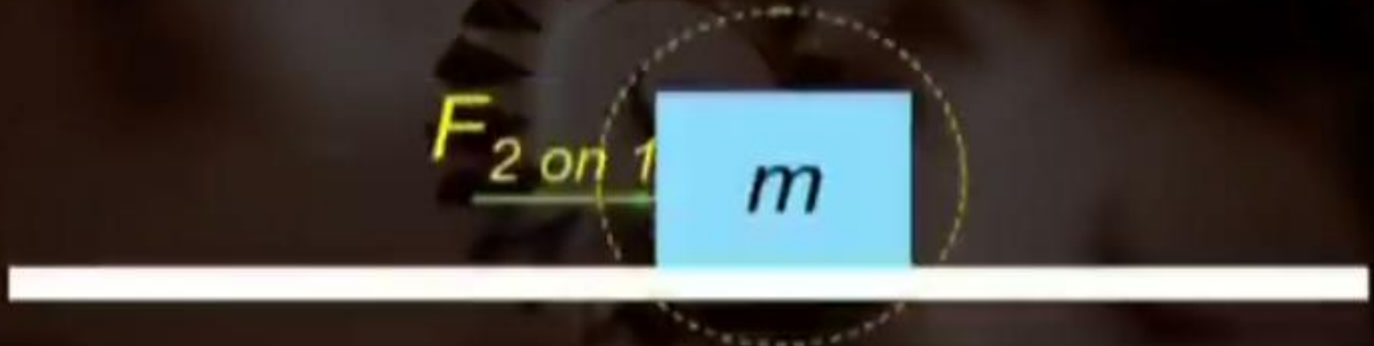
Hence the acceleration of the whole system is:

$$a = F / 3m$$

Now isolate block m and then apply $\Sigma F = ma$:

Substitute for a: ($a = F/3m$)

$$F_{2\ on\ 1} = m\,(F/3m) = F/3$$




Your weight
in a lift

The lift is either at rest or moving with a constant velocity. In this case a=0:

$$N - Mg = 0 \Rightarrow N = Mg$$

Thus apparent weight **equals** the true weight.

The lift is accelerating upwards.
We have

$$N - Mg = Ma$$

or

$$N = M(g + a)$$

Thus apparent weight is more than the true weight.

The lift is accelerating downwards.
We have

$$Mg - N = Ma$$

or

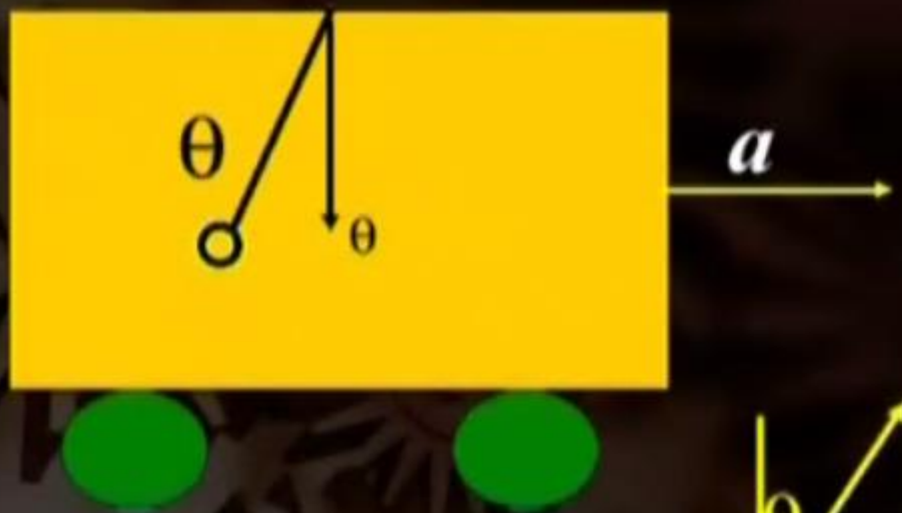
$$N = M(g - a)$$

Thus apparent weight is less than the true weight.

If the cable supporting the lift breaks, the lift falls downwards with **a=g**. Then:

$$N = M(g - g) = 0$$

Hence the apparent weight under the free fall is **zero**.

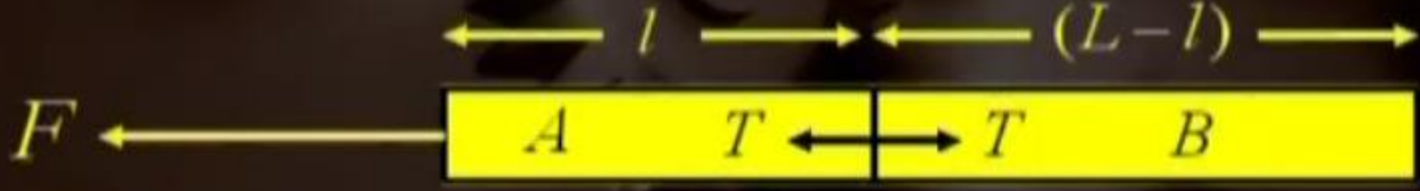


$$T\cos\theta - mg = 0$$

$$T\sin\theta = ma$$

$$\therefore \tan\theta = \frac{a}{g}$$

A uniform rope of length L, lying on a horizontal smooth floor, is pulled by a horizontal force F. What is the tension in the rope at a distance l from the end where the force is applied?

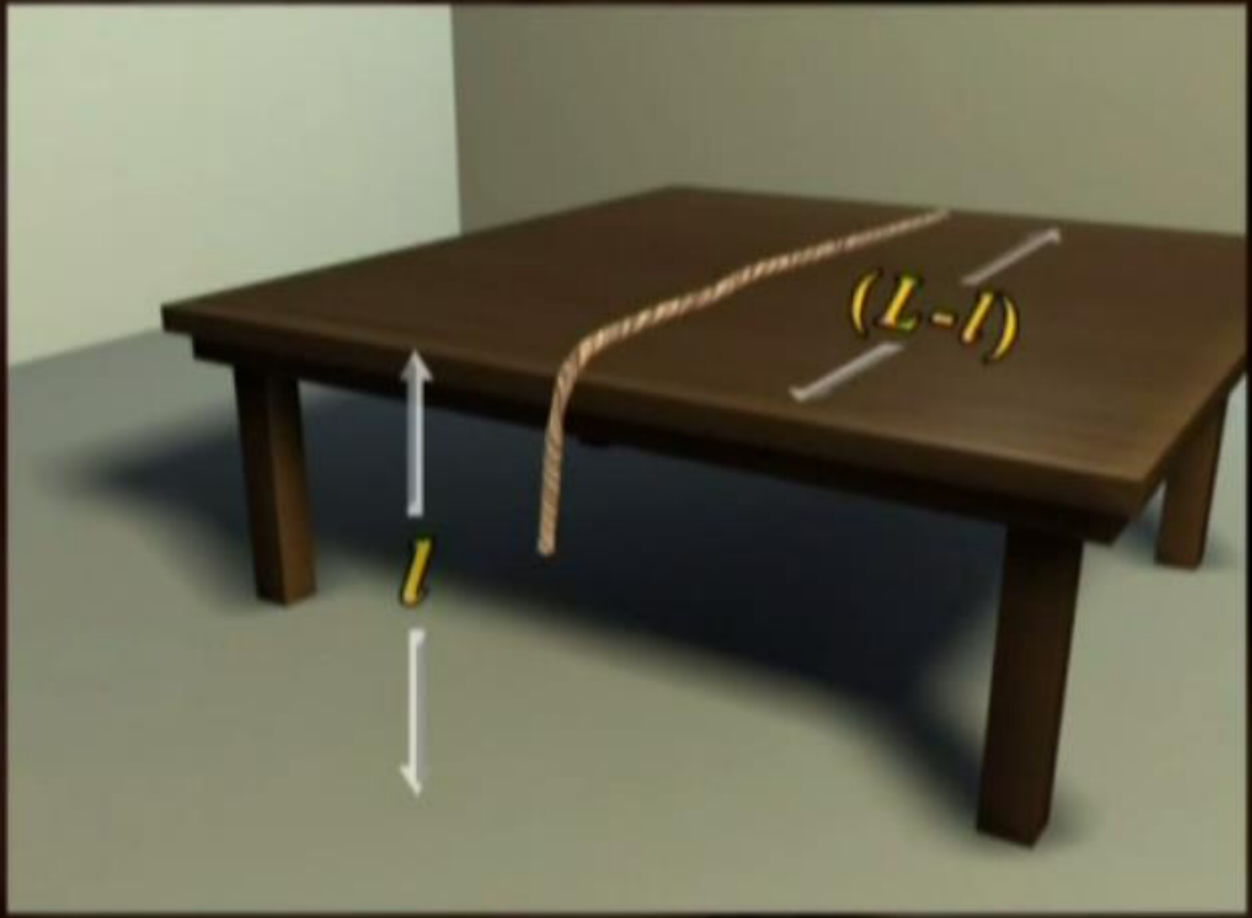


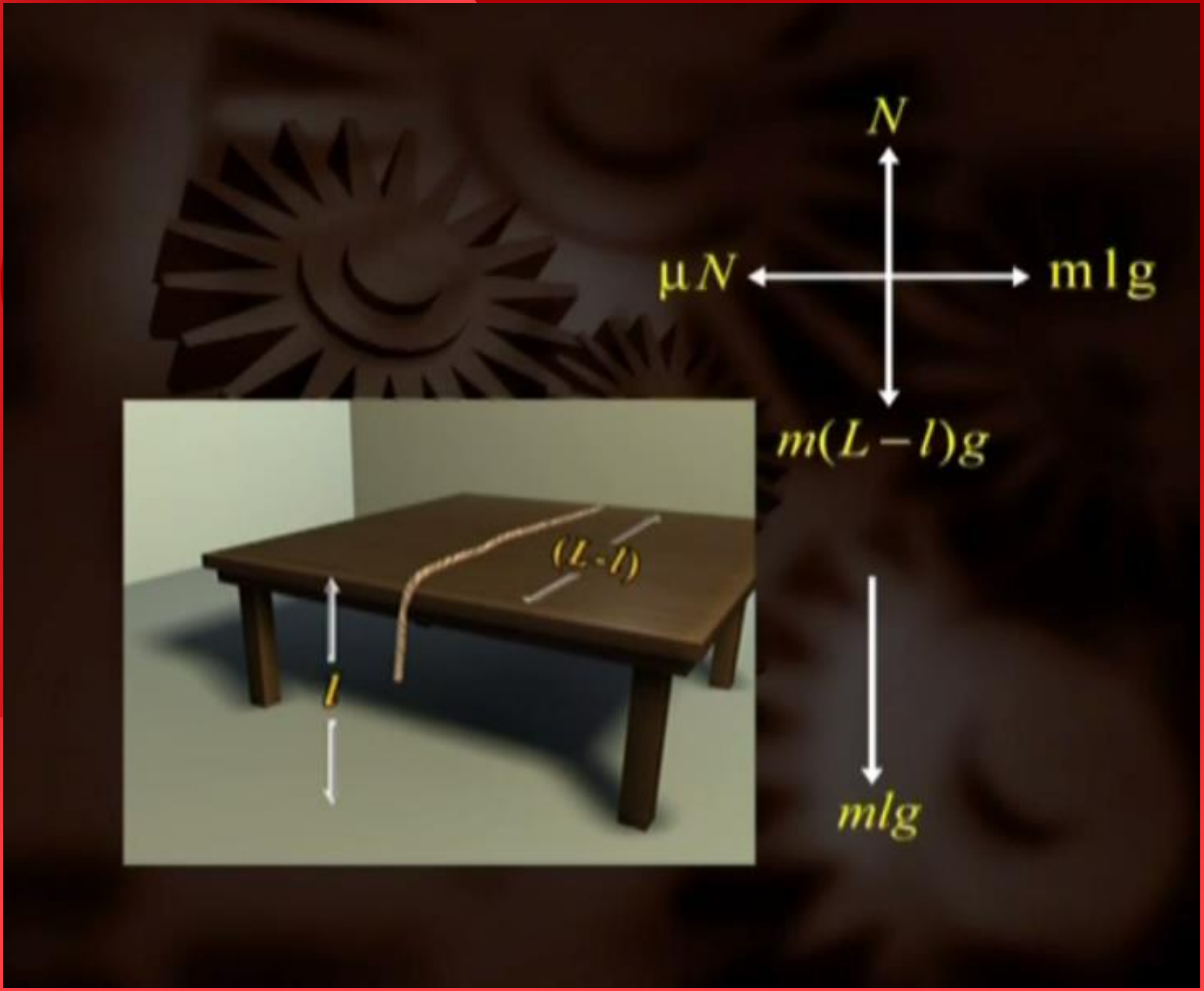
(let m=M/L)

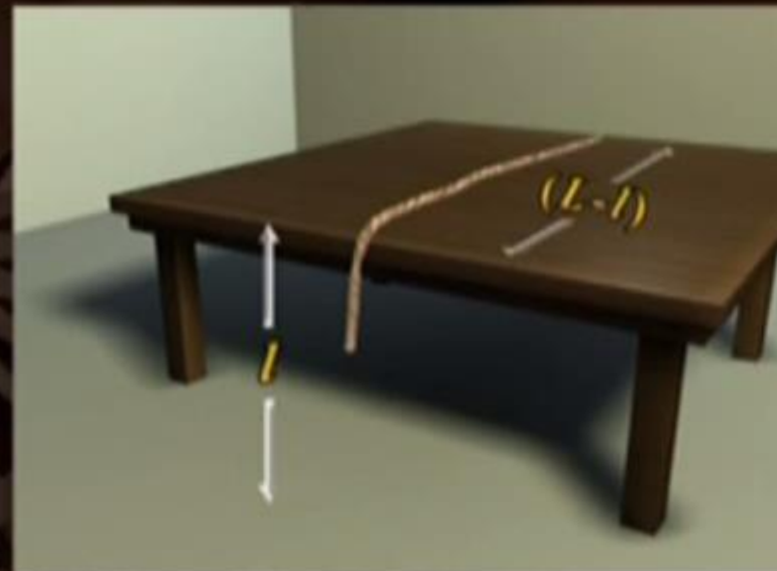
$$F - T = m\,l\,a$$

$$T = m(L - l)a$$

$$\therefore T = F\left(1 - \frac{l}{L}\right)$$


(L-l)
l


N
μN
m l g
m(L – l)g
(L - l)
l
mlg



$$\mu N = mlg$$

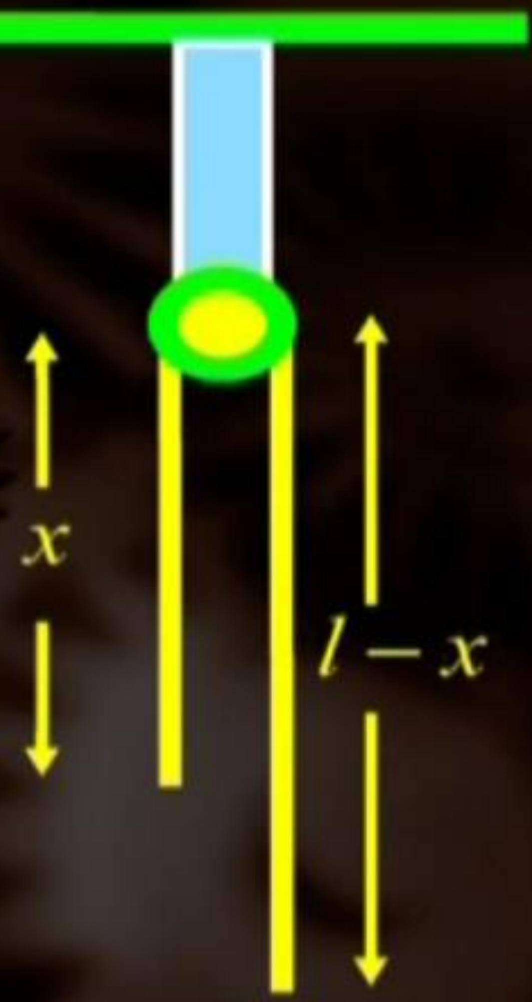
$$N = m(L-l)g$$

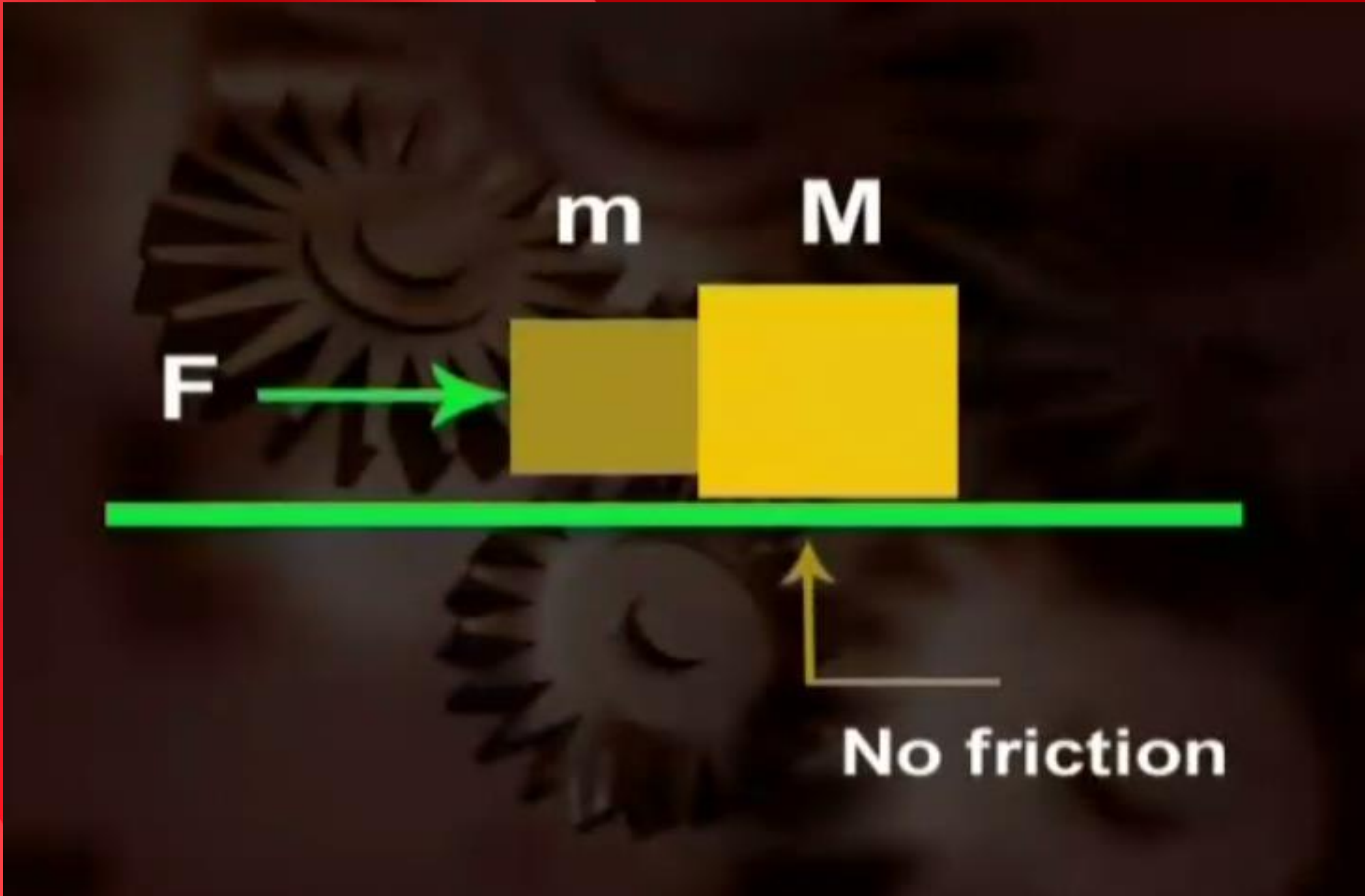
$$l = \frac{\mu L}{\mu + 1}$$

$$(l - x - x)mg = lma$$

$$(l - 2x)mg = mla$$

$$a = \left(1 - \frac{2x}{l}\right)g$$



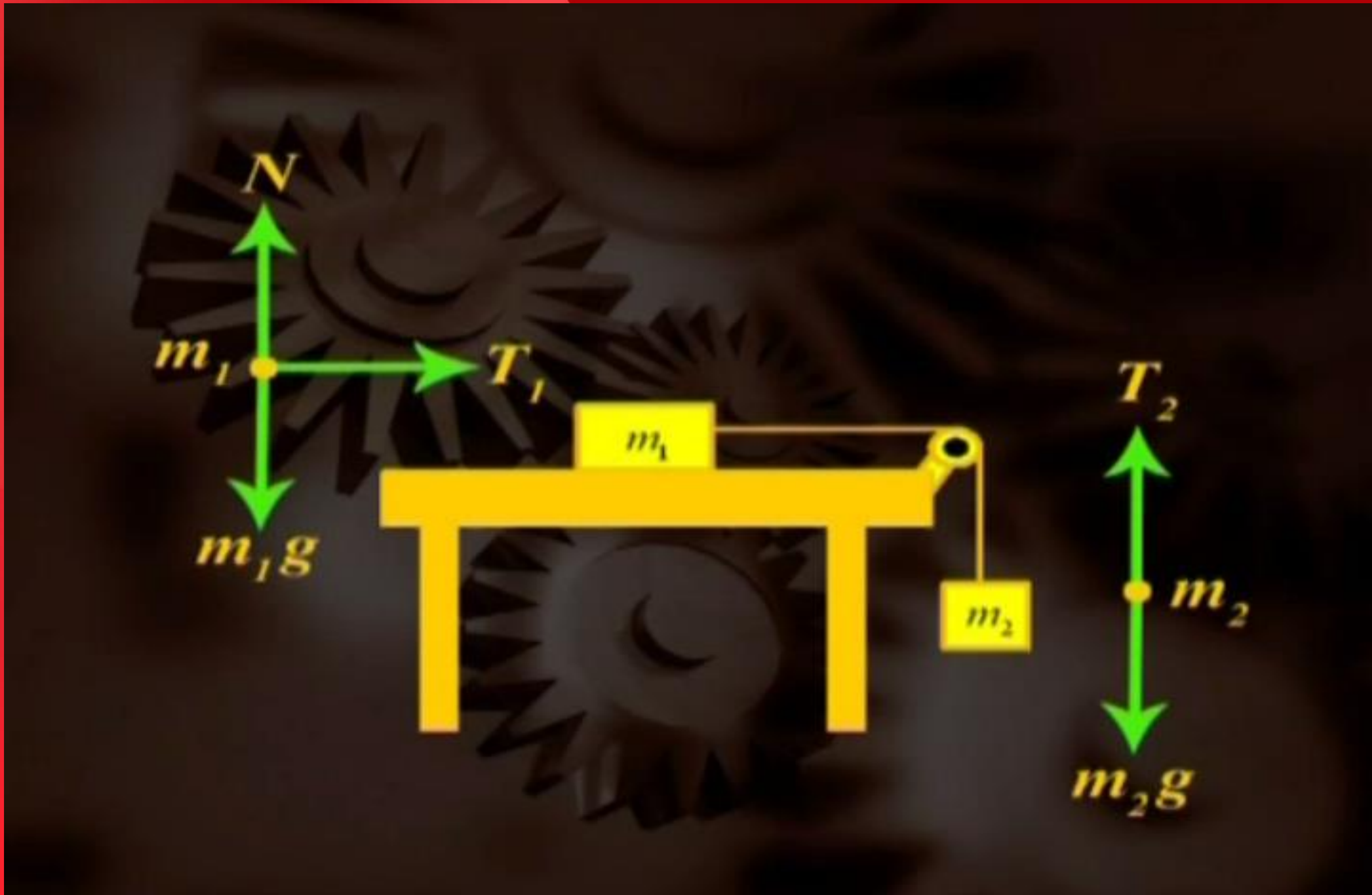

m
M
F
No friction

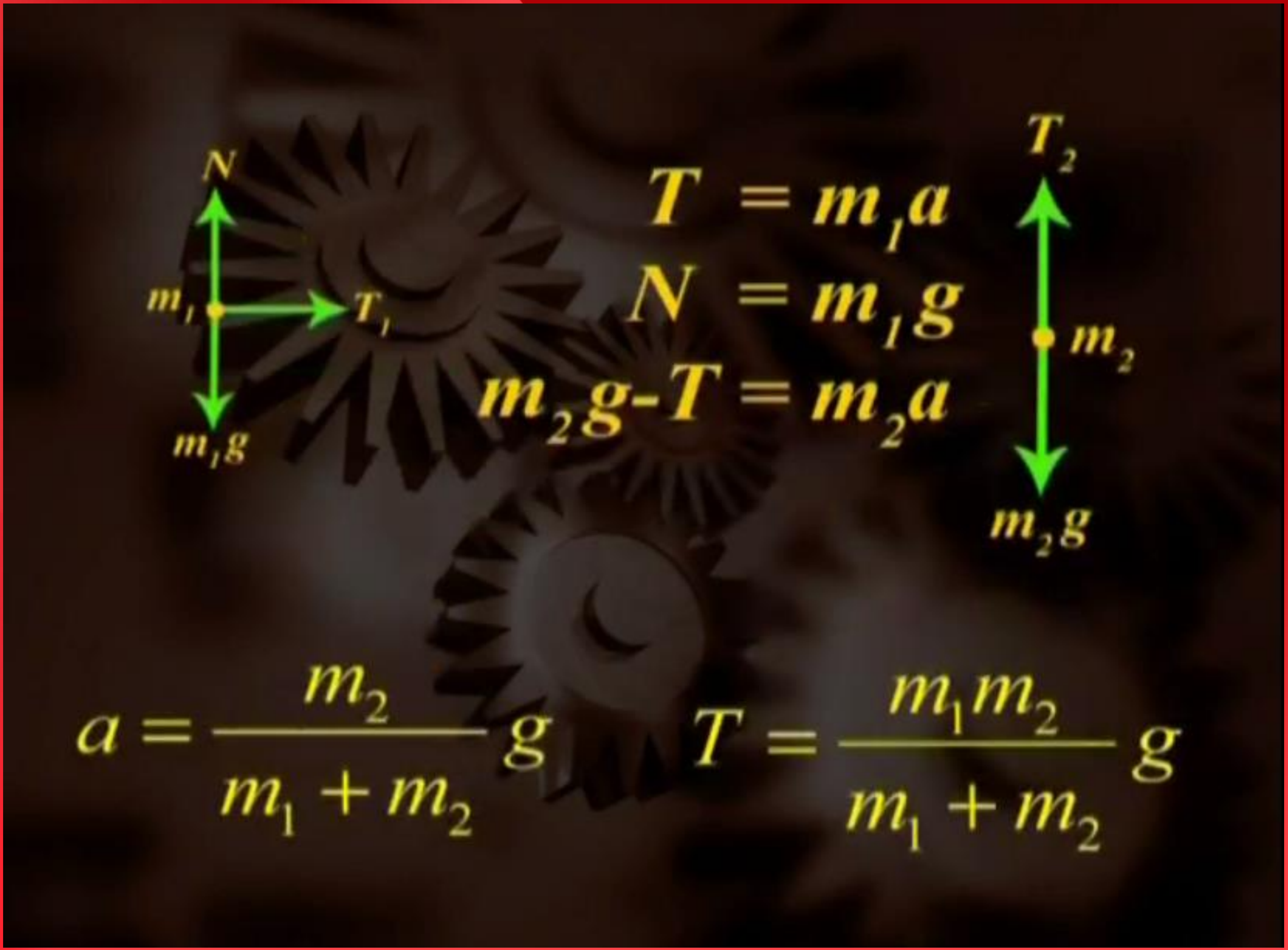
$$F = (m+M)a \Rightarrow a = \frac{F}{(m+M)}$$

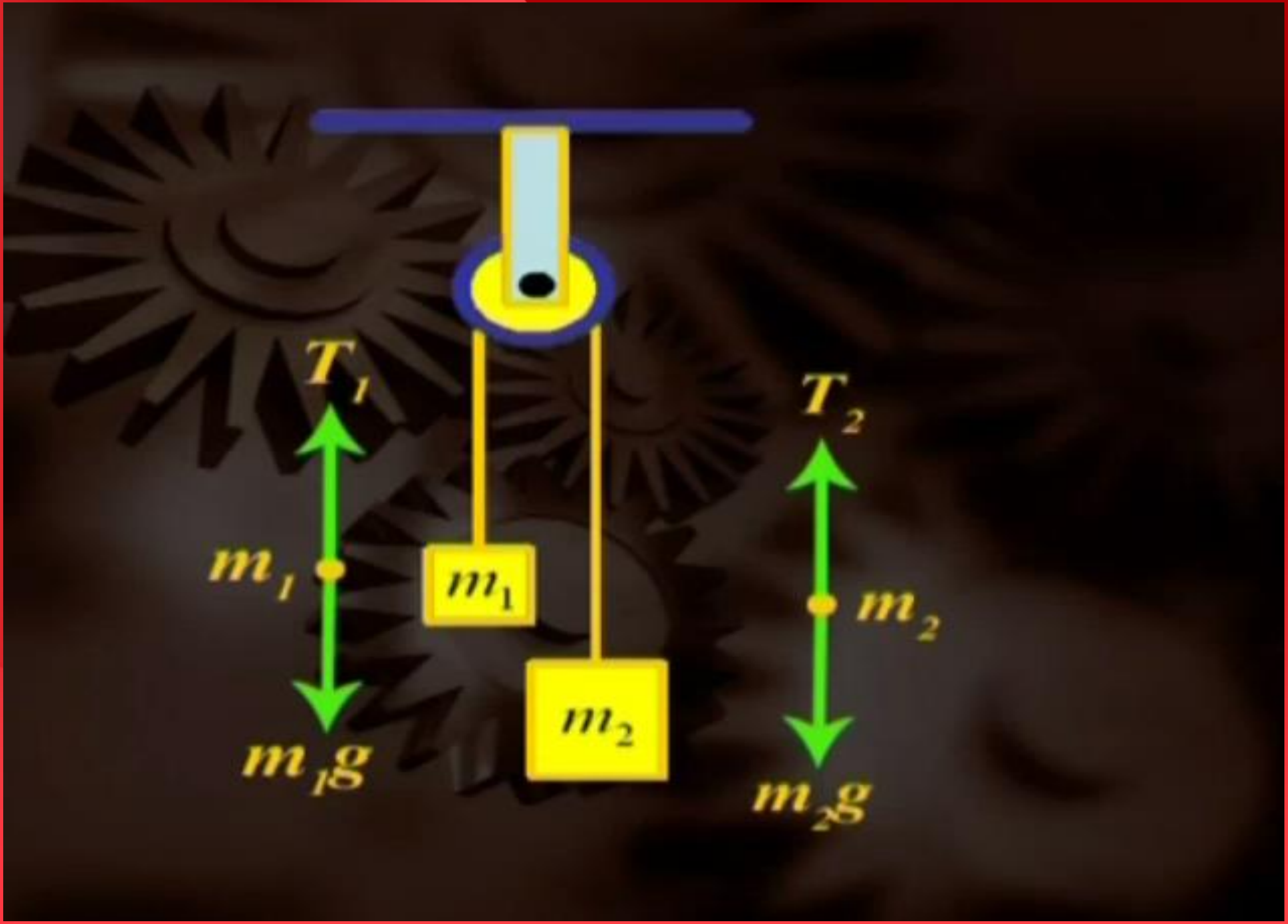
$$f_s = mg \text{ but } f_s \le \mu N$$

$$\mu N \ge mg \quad \text{but } N = ma = m\left(\frac{F}{(m+M)}\right)$$

$$\therefore F \ge \frac{(m+M)g}{\mu}$$


N
m1
T1
m1g
m1
m2
T2
m2
m2g


N
m_1
T_1
$m_1 g$
$T = m_1 a$
$N = m_1 g$
$m_2 g - T = m_2 a$
T_2
m_2
$m_2 g$
$a = \frac{m_2}{m_1 + m_2} g$
$T = \frac{m_1 m_2}{m_1 + m_2} g$



T1
T2
m1
m1
m2
m2
m1g
m2g

Forces on m_1;

$$\sum F_y = T - m_1 g$$

$$m_1 a = T - m_1 g \rightarrow 1$$

Forces on m_2;

$$\sum F_y = m_2 g - T$$

$$m_2 a = m_2 g - T \rightarrow 2$$

On subtracting, eq.1 & eq.2, we will get acceleration as,

$$m_1 a = T - m_1 g$$

$$\underline{m_2 a = m_2 g - T}$$

$$(m_1 + m_2)a = (m_2 - m_1)g$$

$$a = \left(\frac{m_2 - m_1}{m_1 + m_2}\right)g \rightarrow 3$$

To calculate 'T', multiply eq.1 to m_2

and multiply eq.2 to m_1 and then on subtracting, we get

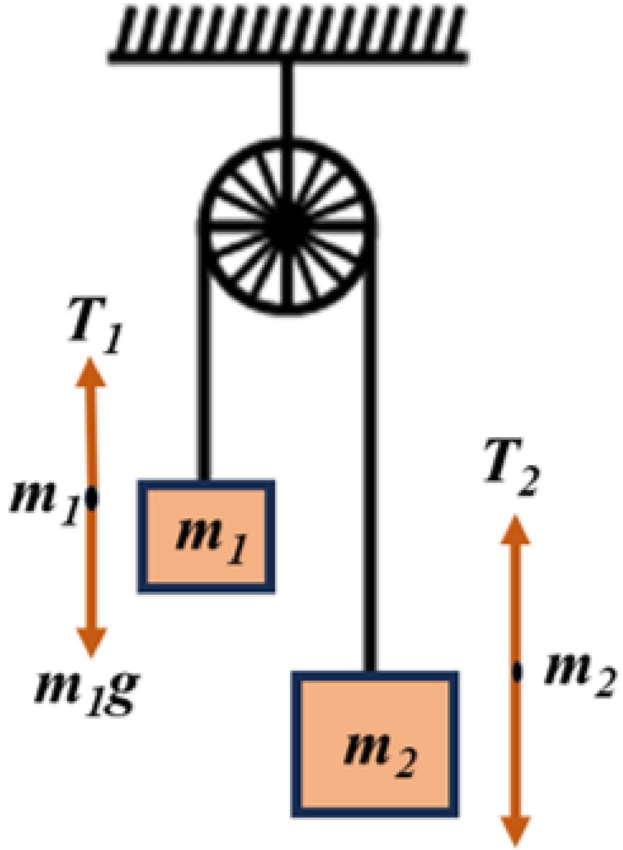
$$m_1 m_2 a = m_2 T - m_1 m_2 g$$

$$\underline{m_1 m_2 a = m_1 m_2 g - m_1 T}$$

$$0 = (m_1 + m_2)T - 2m_1 m_2 g$$

$$(m_1 + m_2)T = 2m_1 m_2 g$$

$$T = \left(\frac{2m_1 m_2}{m_1 + m_2}\right)g \rightarrow 4$$



$\therefore m_2 > m_1$