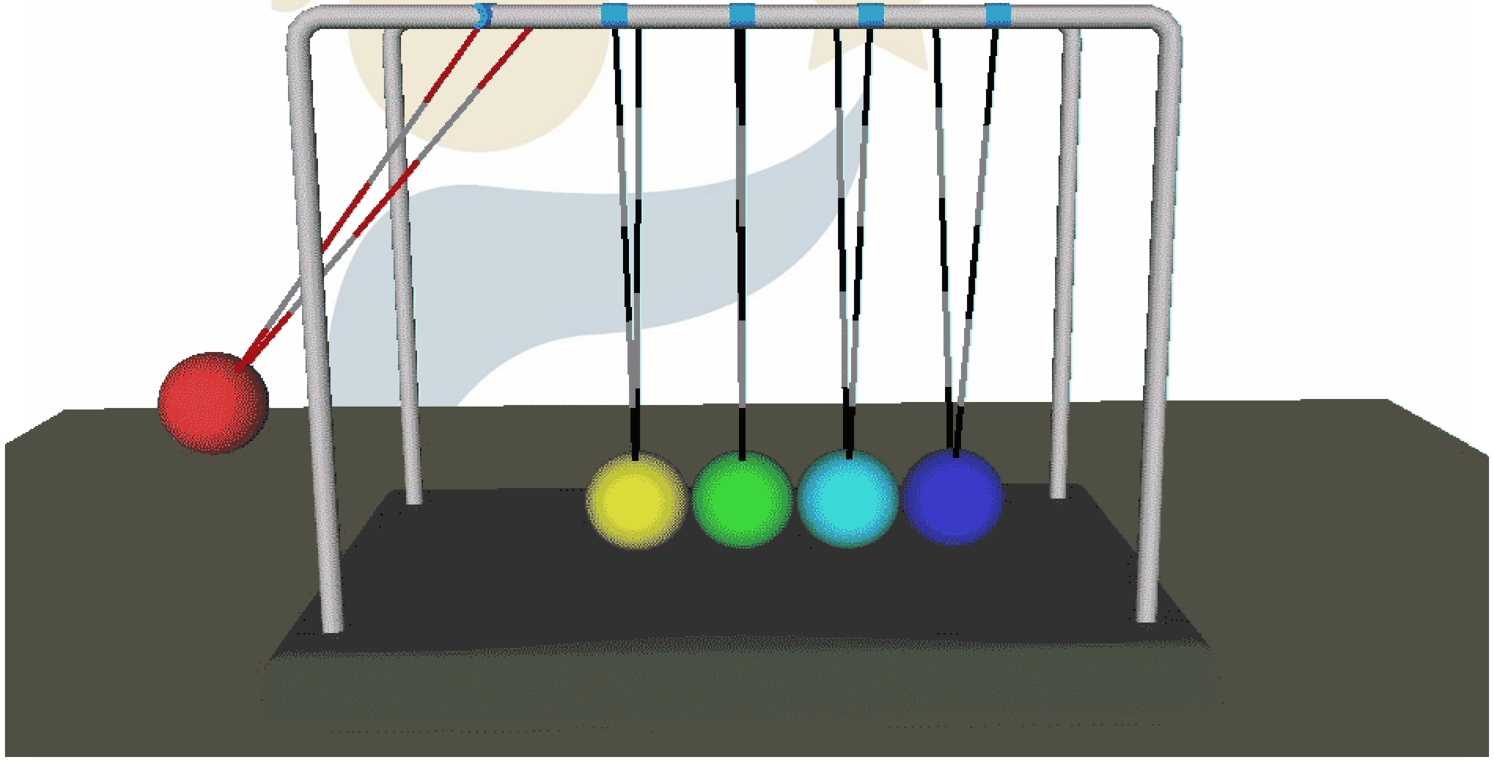
Grade 12 LS – Physics

Chapter 2: Linear Momentum



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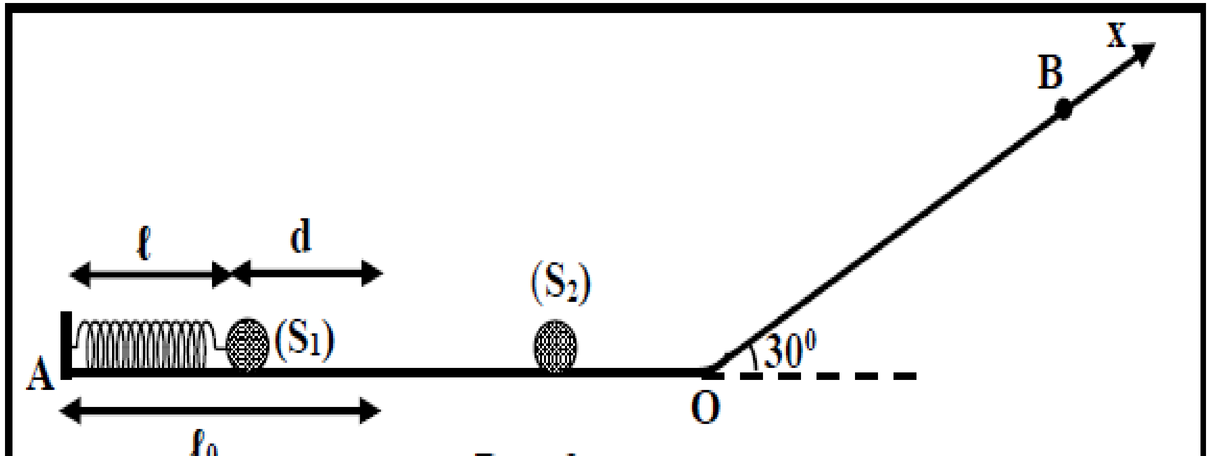
Official exam 2021_2 (LS)

Exercise 1 quiz 15 min

Consider a rail AOB located in a vertical plane composed of two straight parts: a horizontal part AO and an inclined part OB making an angle $\alpha = 30^{\circ}$ with the horizontal.



Doc. 3

Two objects (S_1) and (S_2) taken as particles of same mass m = 80 g;

- a massless spring (R), of force constant k = 200 N/m and natural length l_0, fixed from one of its ends to a support at A with the other end free.

Take the horizontal plane containing O as the reference level for gravitational potential energy and $g = 10m / s^2$.

Exercise 1 **quiz** **15 min**

1) Launching particle (S_1):

In order to launch (S_1), it is placed against the free end of the spring, the spring is compressed by a distance d, and then the system [Spring - (S_1)] is released from rest (Doc.3).

When the spring returns to its natural length l_0, (S_1) leaves the spring with a velocity V_1 parallel to AO .

After launching, (S_1) moving with the velocity V_1 , collides head-on with (S_2) which is placed initially at rest on the rail AO.

Just after the collision, (S_1) stops and (S_2) moves with a velocity V_2 parallel to AO and of magnitude $V_2 = 5m/s$.

(S_1) and (S_2) move without friction on the rail AO.

Exercise 1 **quiz** **15 min**

1.1) Apply the law of conservation of linear momentum to show that the magnitude of V_1 is $V_1 = 5m/s$.

1.2) Deduce that the collision between (S_1) and (S_2) is elastic.

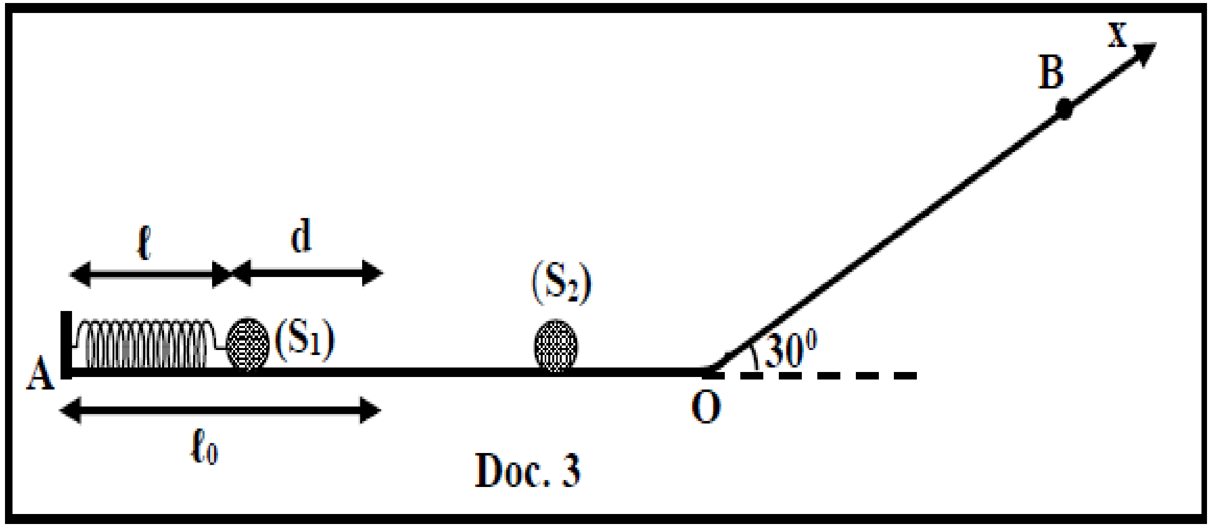
1.3) Determine the value of d.

Exercise 1 quiz 15 min

$\alpha = 30^\circ$; m=80g; k = 200 N/m; $g = 10m/s^2$; along AO, f=0N;

(S_1); V_1; (S_2); V=0. After collision: (S_1); $V'_1 = 0$ and (S_2); $V_2 = 5$m/s

1.1) Apply the law of conservation of linear momentum to show that the magnitude of V_1 is $V_1 = 5m/s$.



$$m\vec{V}_1 + m\vec{V} = m\vec{V}'_1 + m\vec{V}_2$$

$$m\vec{V}_1 + 0 = 0 + m\vec{V}_2$$

$$\vec{V}_1 = \vec{V}_2$$

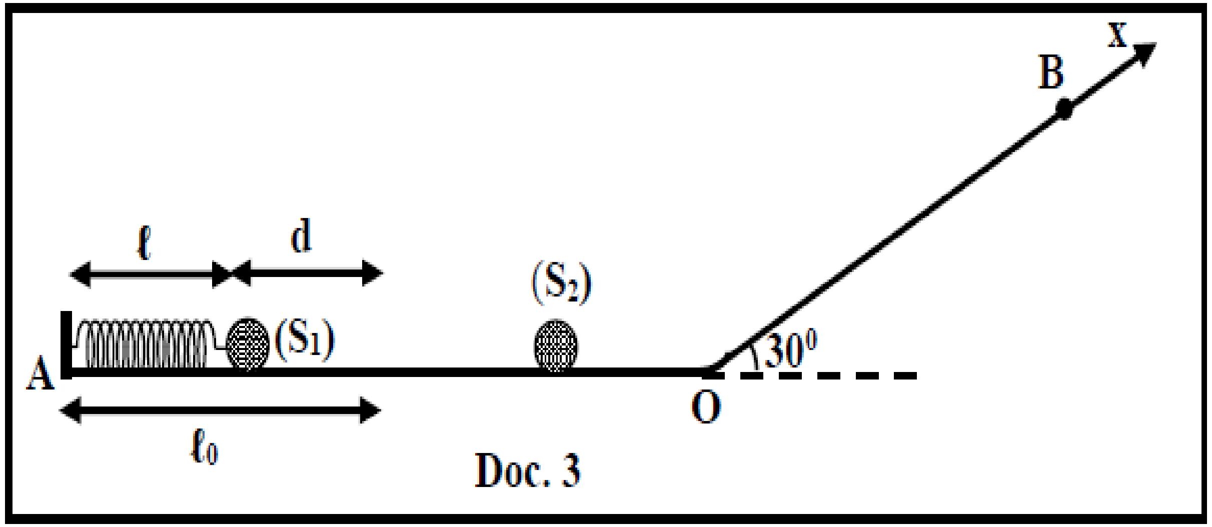
$$V_1 = V_2 = 5\text{m/s}$$

Exercise 1 **quiz** **15 min**

$\alpha = 30^{\circ}$; m=80g; k = 200 N/m; $g = 10 m / s^2$; along AO, f=0N;

(S_1); V_1; (S_2); V=0. After collision: (S_1); $V'_1 = 0$ and (S_2); $V_2 = 5$m/s

1.2) Deduce that the collision between (S_1) and (S_2) is elastic.



$$KE_{(bef)} = KE_{(S1)} + KE_{(S2)}$$

$$KE_{(bef)} = \frac{1}{2} mV_1^2 + \frac{1}{2} mV^2$$

$$KE_{(bef)} = \frac{1}{2} \times 0.08(5)^2 + 0.$$

$$KE_{(bef)} = 1J$$

Exercise 1 quiz 15 min

$\alpha = 30^\circ$; m=80g; k = 200 N/m; $g = 10m/s^2$; along AO, f=0N;

(S_1); V_1; (S_2); V=0. After collision: (S_1); $V'_1 = 0$ and (S_2); $V_2 = 5$m/s

$$KE_{(aft)} = KE_{(S1)} + KE_{(S2)}$$

$$KE_{(bef)} = \frac{1}{2}mV'^2_1 + \frac{1}{2}mV_2^2$$

$$KE_{(aft)} = 0 + \frac{1}{2} \times 0.08(5)^2$$

$$KE_{(bef)} = 1J$$

Since $KE_{(bef)} = KE_{aft} = 1J$

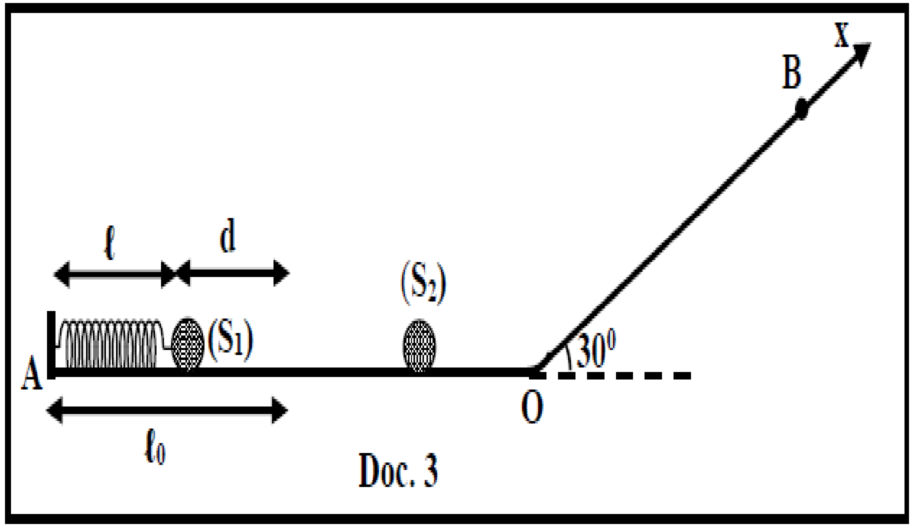
Then the collision is elastic

Exercise 1 quiz 15 min

$\alpha = 30^\circ$; m=80g; k = 200 N/m; $g = 10m/s^2$; along AO, f=0N;

(S_1); V_1; (S_2); V=0. After collision: (S_1); $V_1' = 0$ and (S_2); $V_2 = 5$m/s

1.3) Determine the value of d.



Apply the law of conservation of mechanical energy of the system [Oscillator- Earth].

$$ME_{compressed\ by\ d} = ME_{at\ initial\ length}$$

$$(KE + GPE + EPE)_{compressed} = (KE + GPE + EPE)_{initial}$$

Exercise 1	quiz	15 min

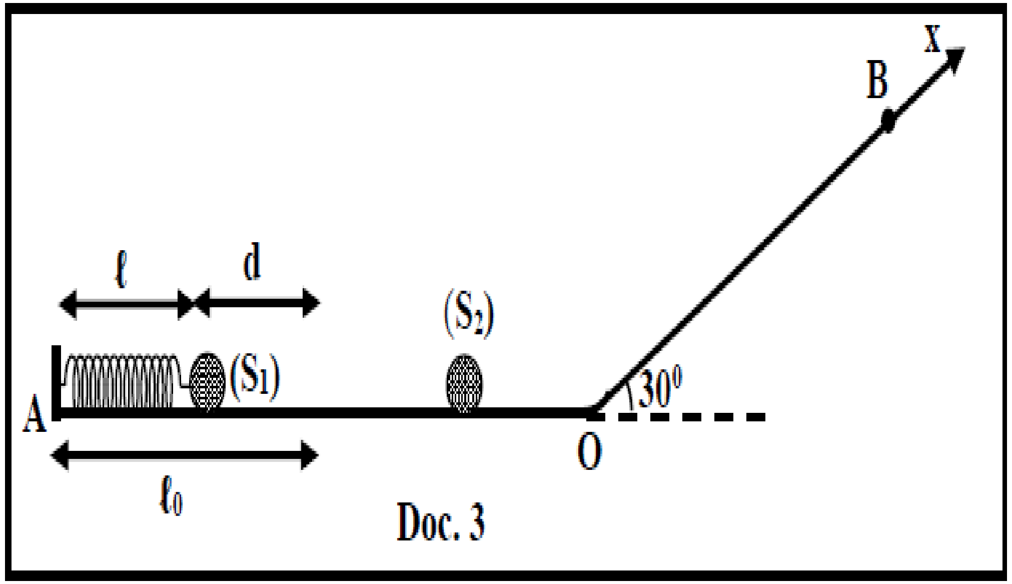
$$(KE + GPE + EPE)_{compressed} = (\mathbf{KE + GPE + EPE})_{initial}$$

$$0 + \frac{1}{2}kx^2 + 0 = \frac{1}{2}mV_1^2 + 0 + 0$$

$$0.5 \times 200 \times d^2 = 0.5 \times 0.08 \times 5^2$$

$$d = 0.1m$$

Exercise2 quiz 15 min



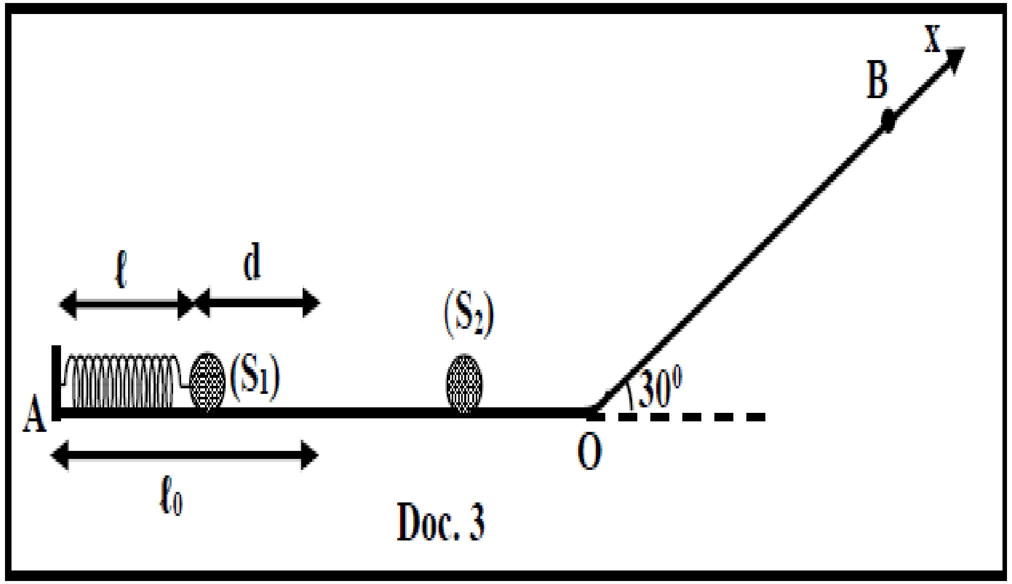
2) Motion of (S_2) on the inclined part OB:

At the instant $t_0 = 0$, (S_2) starts from O on the inclined part OB with a velocity $\vec{V}_0 = 5\vec{i}$ (m/s), where $\vec{i}$ is the unit vector along the x-axis parallel to OB.

On this part, (S_2) is submitted to a friction force f of constant magnitude f and of direction opposite to its motion.

2.1) Name the external forces acting on (S_2) during its motion along the track OB.

Exercise 2 quiz 15 min



2.2) Show that the sum of the external forces acting on (S_2) during its upward motion along OB is: $\sum\vec{F} = -(f + mgsin\alpha)\vec{i}$ (SI).

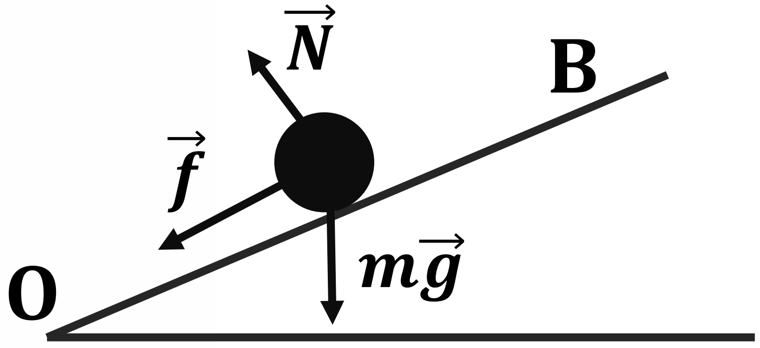
2.3) The expression of the linear momentum of (S_2) during its upward motion along OB is: $\vec{P} = (-0.9t + 0.4)\vec{i}$ (SI)

Knowing that $\frac{d\vec{P}}{dt} = \sum\vec{F}$, determine f.

Exercise 2 quiz 15 min

$\alpha = 30^\circ$; m=80g; $g = 10m / s^2$; $V_0 = 5$m/s

2.1) Name the external forces acting on (S_2) during its motion along the track OB.



The forces acting on (S_2) along OB are:

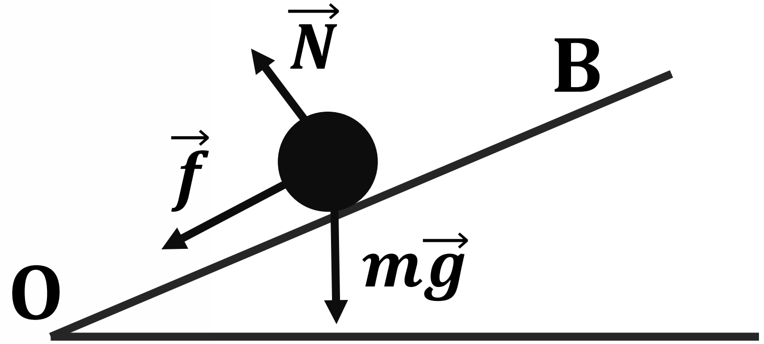
- Weight $(\vec{W} = m\vec{g})$.
- Normal $(\vec{N})$.
- Friction $(\vec{f})$

Exercise 2 quiz 15 min

$\alpha = 30^\circ$; m=80g; $g = 10m/s^2$; $V_0 = 5$m/s

2.2) Show that the sum of the external forces acting on (S_2) during its upward motion along OB is: $\sum \vec{F} = -(f + mgsin\alpha)\vec{i}$ (SI).

$$\sum \vec{F} = m\vec{g} + \vec{N} + \vec{f}$$



Project along x-axis:

$$\sum \vec{F} = -m\vec{g}sin\alpha - \vec{f} \Rightarrow \sum \vec{F} = -(m\vec{g}sin\alpha + \vec{f})\vec{i}$$

Exercise 2 quiz 15 min

$\alpha = 30^{\circ}$; m=80g; $g = 10m/s^2$; $V_0 = 5$m/s

2.3) The expression of the linear momentum of (S_2) during its upward motion along OB is: $\vec{P} = (-0.9t + 0.4)\vec{i}$ (SI)

Knowing that $\frac{d\vec{P}}{dt} = \sum \vec{F}$, determine f.

$\vec{P} = (-0.9t + 0.4)\vec{i}$ ➡ $\frac{d\vec{P}}{dt} = -0.9\vec{i}$ ➡ $0.9\vec{i} = (0.04 + \vec{f})\vec{i}$

Using newton's second law: $\frac{d\vec{P}}{dt} = \sum \vec{F}$

$$-0.9\vec{i} = -(m\vec{g}sin\alpha + \vec{f})\vec{i}$$

Exercise 2 **quiz** **15 min**

$\alpha = 30^{\circ}$; m=80g; $g = 10m/s^2$; $V_0 = 5$m/s

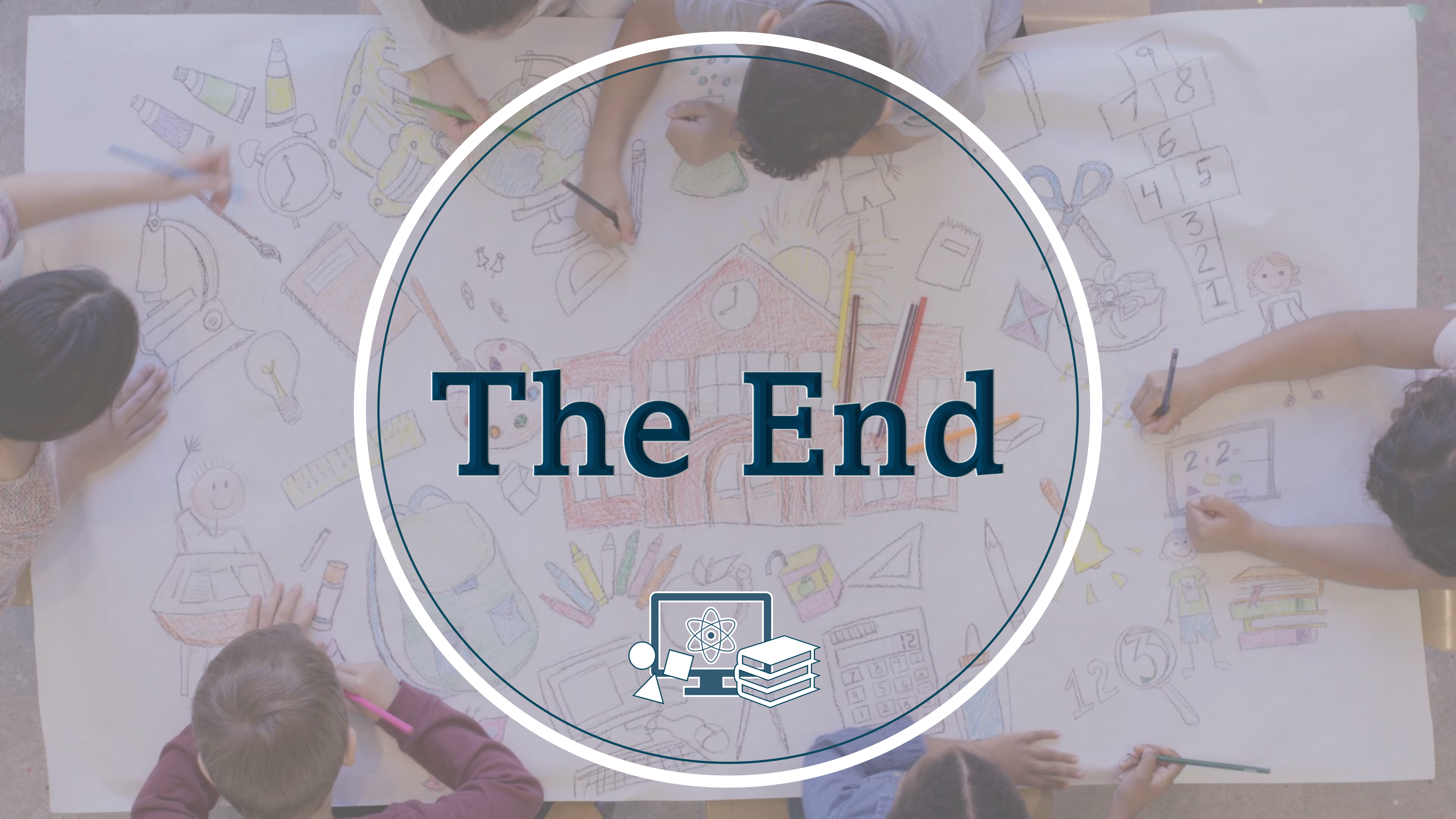
$$-0.9\vec{i} = -(m\vec{g}sin\alpha + \vec{f})\vec{i}$$

$$-0.9\vec{i} = -(0.08 \times 10 \times sin30 + \vec{f})\vec{i}$$

$$0.9\vec{i} = (0.04 + \vec{f})\vec{i}$$

$\vec{f} = 0.5\vec{i}$ (N).

$f = 0.5$ (N).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