Grade 11S – Physics

Unit Two: Mechanics

Chapter 11: Work & Energy

Prepared & Presented by: Mr. Mohamad Seif

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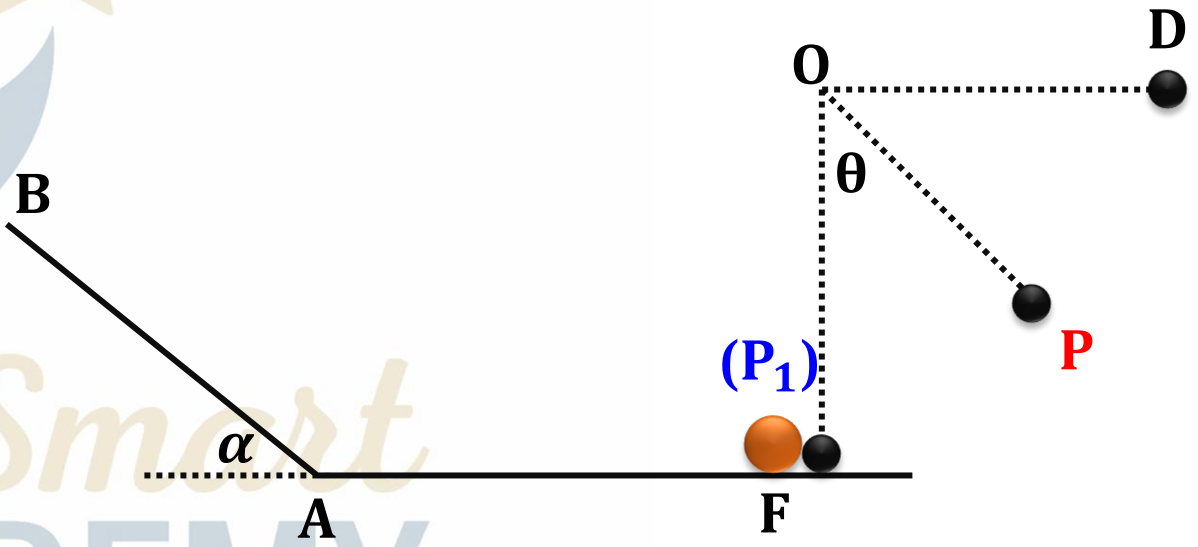
Quiz 1: Energy 20 min

Consider pendulum is formed of an inextensible and mass less string of length $l = 0.45m$ having one of its ends fixed while the other end carries a particle (P) of mass 100g. $g = 10m/s^2$.

The pendulum is shifted from its equilibrium position by $\theta_m = 90^\circ$, then released without initial velocity.



Take the horizontal plane containing FA as a gravitational potential energy reference for the system [(S), Earth].

We neglect friction on the axis through O and air resistance.

Quiz 1: Energy 20 min

1. Calculate the initial mechanical energy of the system [(S),Earth] when (P) was at D.

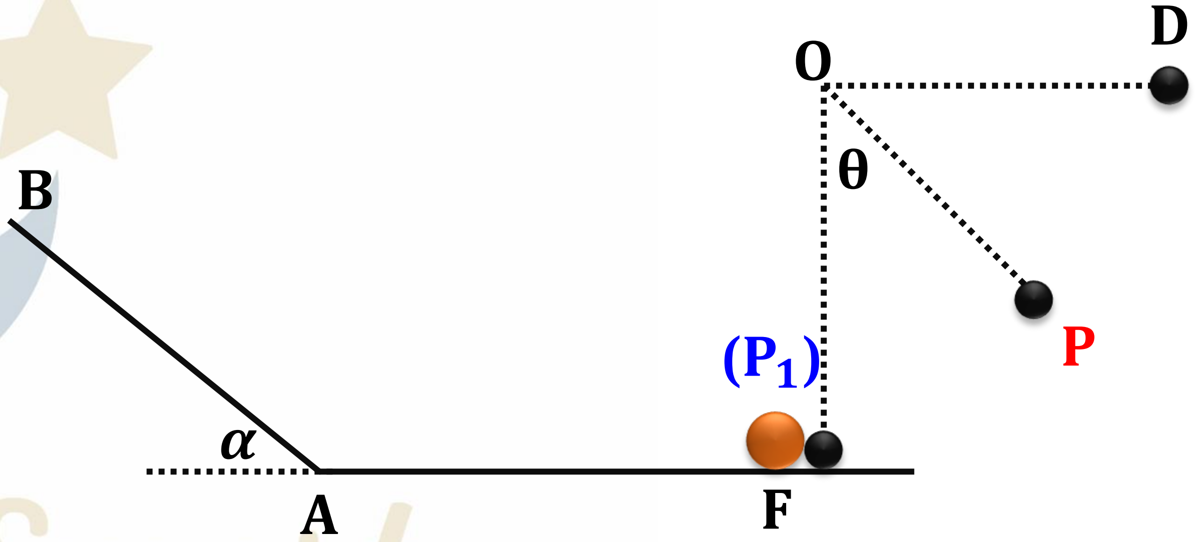
2. Determine the expression of the mechanical energy of the system [(S),Earth] in terms of l, m, g, V and θ, where v is the speed of (P) when the string passes through a position making an angle θ with the vertical.

3. Determine the value of θ, $(0 < \theta < 90^{\circ})$, for which the kinetic energy of (P) is equal to the gravitational potential energy of the system [(S),Earth].

4. Calculate the magnitude of the velocity V_0 of (P) as it passes through its equilibrium position.

$l = 0.45m$; $m = 0.1kg$; $g = 10m/s^2$; $\theta_m = 90^\circ, V_D = 0m/s$; $f = 0N$

1.Calculate the initial mechanical energy of the system [(S),Earth] when (P) was at D.



$$ME_D = KE_D + PE_D$$

$$ME_D = 1/2mV_D^2 + mgh_D$$

$$ME_D = 1/2\,(0.1)(0)^2 + 0.1 \times 10 \times l(1 - cos\theta)$$

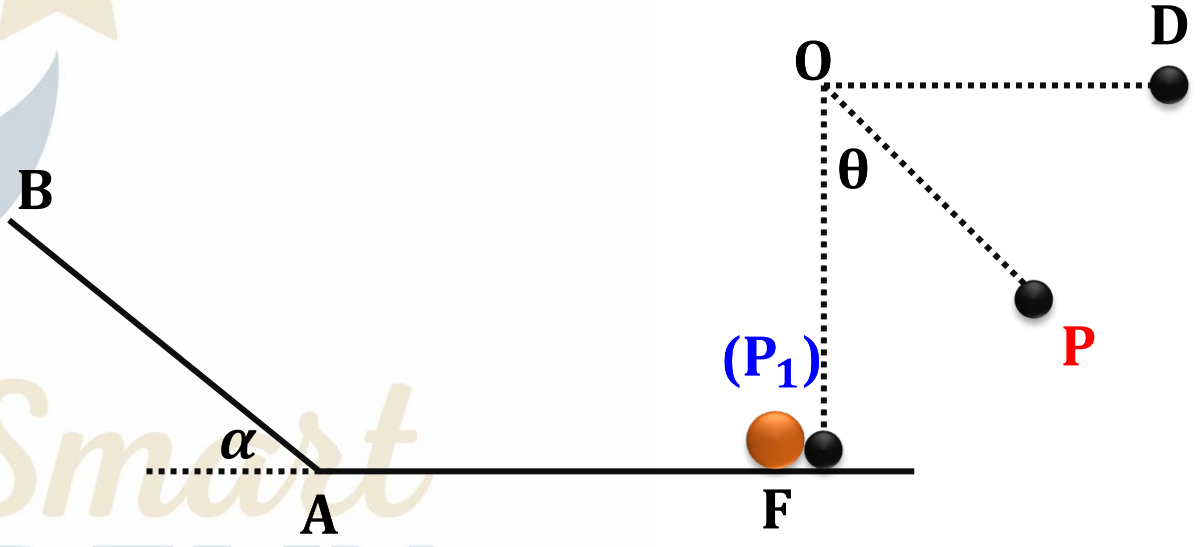
$$ME_D = 0 + 0.1 \times 10 \times 0.45(1 - cos90^\circ)$$

$$ME_D = 0.45J$$

$l = 0.45m$; $m = 0.1kg$; $g = 10m/s^2$; $\theta_m = 90^\circ$, $V_D = 0m/s$; $f = 0N$

2.Determine the expression of the ME of the system [(S),Earth] in terms of l, m, g, V and θ, where v is the speed of (P) when the string making an angle θ with the vertical.

$$ME = KE + PE$$



$$ME = \frac{1}{2}mV^2 + mgh$$

$$ME = \frac{1}{2}mV^2 + mgl(1 - cos\theta)$$

$l = 0.45m$; $m = 0.1kg$; $g = 10m/s^2$; $\theta_m = 90^\circ$, $V_D = 0m/s$; $f = 0N$

3.Determine the value of θ, $(0 < \theta < 90^\circ)$, for which the kinetic energy of (P) is equal to the gravitational potential energy of the system [(S),Earth].

The ME is conserved, because friction is neglected; then:

$$ME = ME_D \Rightarrow KE + PE = 0.45J$$

But given KE = PE then:

$$PE + PE = 0.45J$$

$$2PE = 0.45J$$

$$2mgl(1 - \cos\theta) = 0.45J$$

$$2 \times 0.1 \times 10 \times 0.45(1 - \cos\theta) = 0.45J$$

$$0.9(1 - \cos\theta) = 0.45J$$

$$1 - \cos\theta = \frac{0.45}{0.9}$$

$$1 - \cos\theta = 0.5$$

$$\cos\theta = 0.5 \Rightarrow \theta = 60^\circ$$

$l = 0.45m$; $m = 0.1\text{kg}$; $g = 10m/s^2$; $\theta_m = 90^\circ$, $V_D = 0m/s$; $f = 0N$

4.Calculate the magnitude of the velocity V_0 of (P) as it passes through its equilibrium position

$$ME_O = KE_O + GPE_O$$

$$0.45\text{J} = \frac{1}{2}mV_0^2 + mgh_0$$

$$0.45\text{J} = 0.5 \times 0.1V_0^2 + 0.1 \times 10(0)$$

$$0.45\text{J} = 0.05V_0^2$$

$$V_0^2 = \frac{0.45}{0.05}$$

$$V_0^2 = 9$$

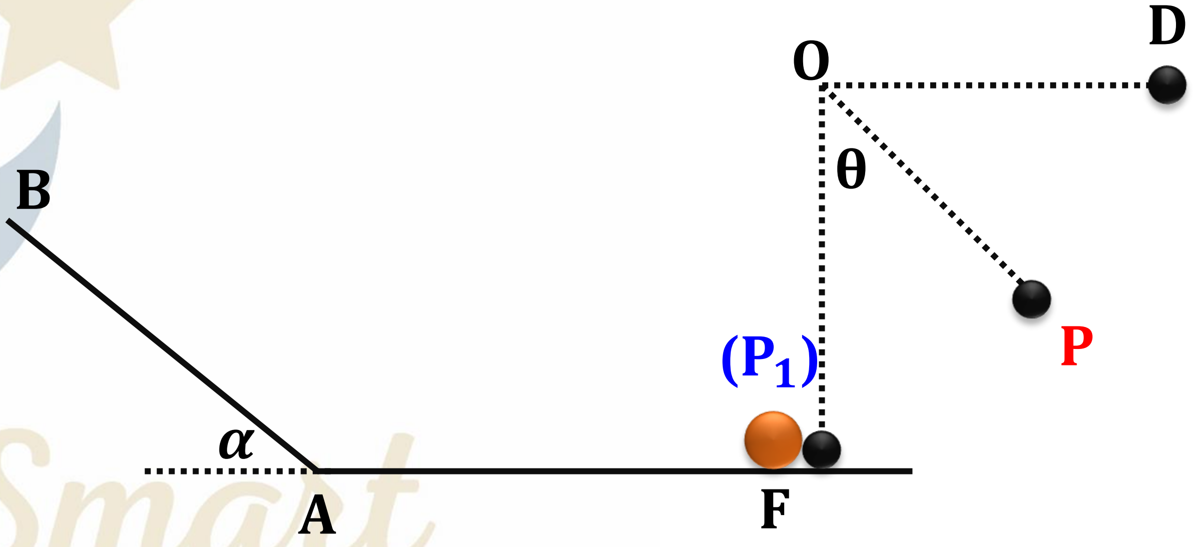
$$V_0 = \sqrt{9}$$

$$V_0 = 3m/s$$

Quiz **Energy** **20 min**

When (P) passes through the equilibrium position, the string is cut, and (P) enters in a collision with a stationary particle (P_1) of mass $m_1 = 200g$.

As a result of collision (P_1) moves along the frictionless horizontal track FA and reaches A with the speed $V_1 = 2m/s$.

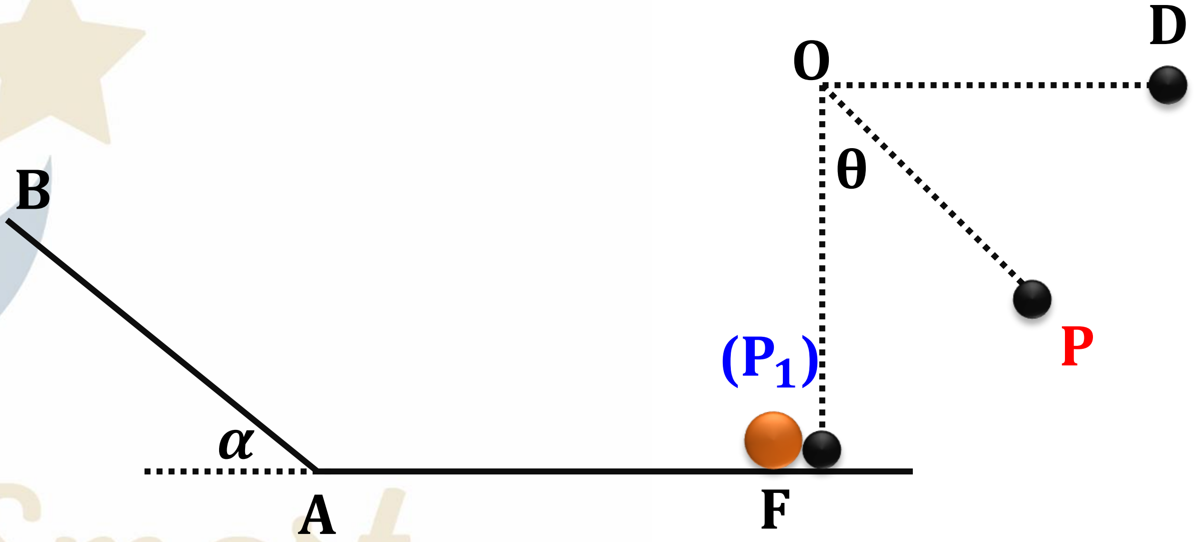


(P_1) continues along the line of greatest slope of the inclined plane AB that makes an angle $\alpha = 30^\circ$ with the horizontal.

Quiz **Energy** **20 min**

a. **Determine the altitude of the point M between A and B at which (P_1) turns back.**

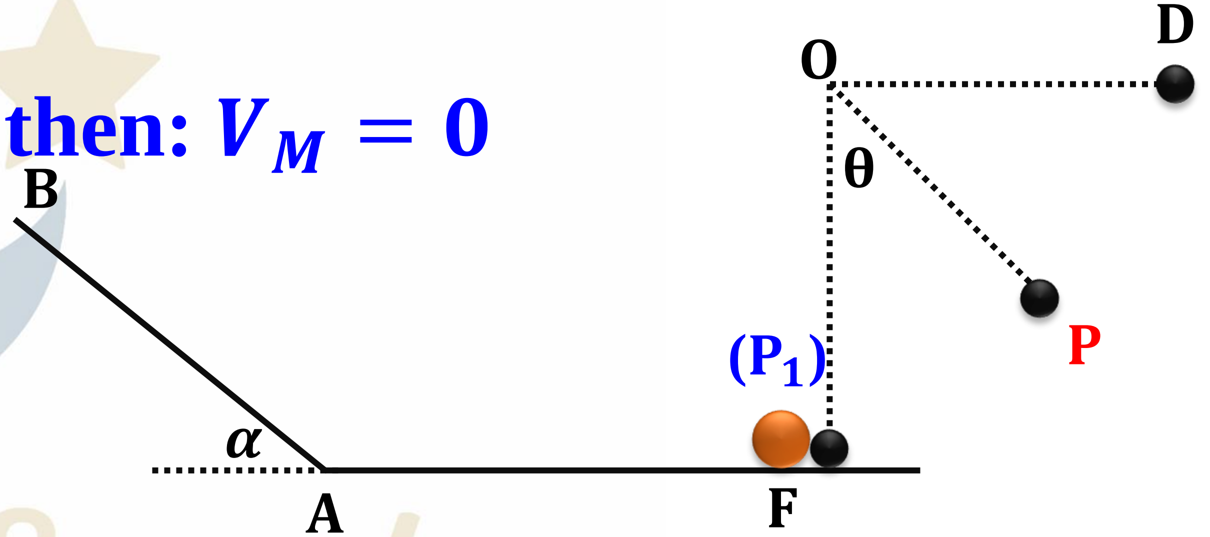
b. **In fact, AB is not frictionless, (P_1) reaches a point N and turns back, where AN = 20 cm.**



Calculate the magnitude of the force of friction (assumed constant) along AN.

$m_1 = 0.2\text{kg}; g = 10m/s^2; f = 0N; V_1 = 2m/s; \alpha = 30^\circ$

a)Determine the altitude of the point M between A and B at which (P_1) turns back.



At point M the particle (P_1) returns then: $V_M = 0$

$$ME_A = ME_M$$

$$KE_A + PE_A = KE_M + PE_M$$

$$1/2m_1V_A^2 + m_1gh_A = 1/2V_M^2 + m_1gh_M$$

$$0.5 \times 0.2 \times (2)^2 + 0 = 0 + 0.2 \times 10 \times h_M \Rightarrow 0.4 = 2 \times h_M$$

$$h_M = 0.2m$$

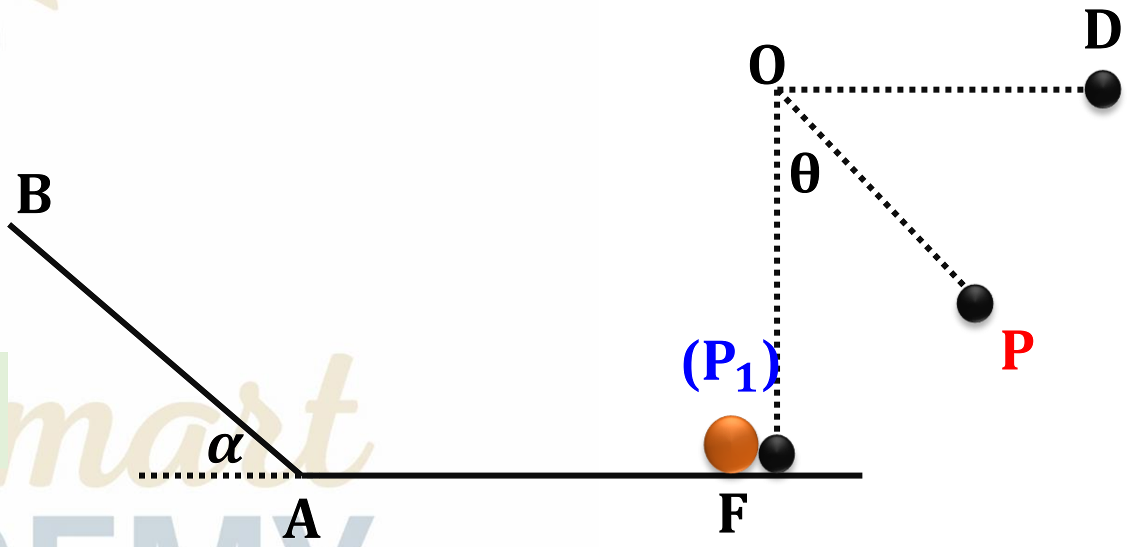
$m_1 = 0.2\text{kg}; g = 10m/s^2; f = 0N; V_1 = 2m/s; \alpha = 30^\circ$

b) In fact, AB is not frictionless, (P_1) reaches a point N and turns back, where $AN = 20cm$. Calculate the magnitude of the force of friction (assumed constant) along AN.

$$ME_N = KE_N + PE_N$$

$$ME_N = 1/2m_1V_N^2 + m_1gh_N$$

$$sin\alpha = \frac{opp}{hyp} = \frac{h_N}{AN} \Rightarrow h_N = ANsin\alpha$$



$$ME_N = 0 + mgANsin\alpha$$

$$ME_N = 0.2 \times 10 \times 0.2sin30 \Rightarrow ME_N = 0.2J$$

$$\Delta ME_{A\to N} = W_{\overrightarrow{fr}}$$

$$ME_N - ME_A = f \times d \times cos(\alpha)$$

$$ME_N - ME_A = f \times AN \times cos(180)$$

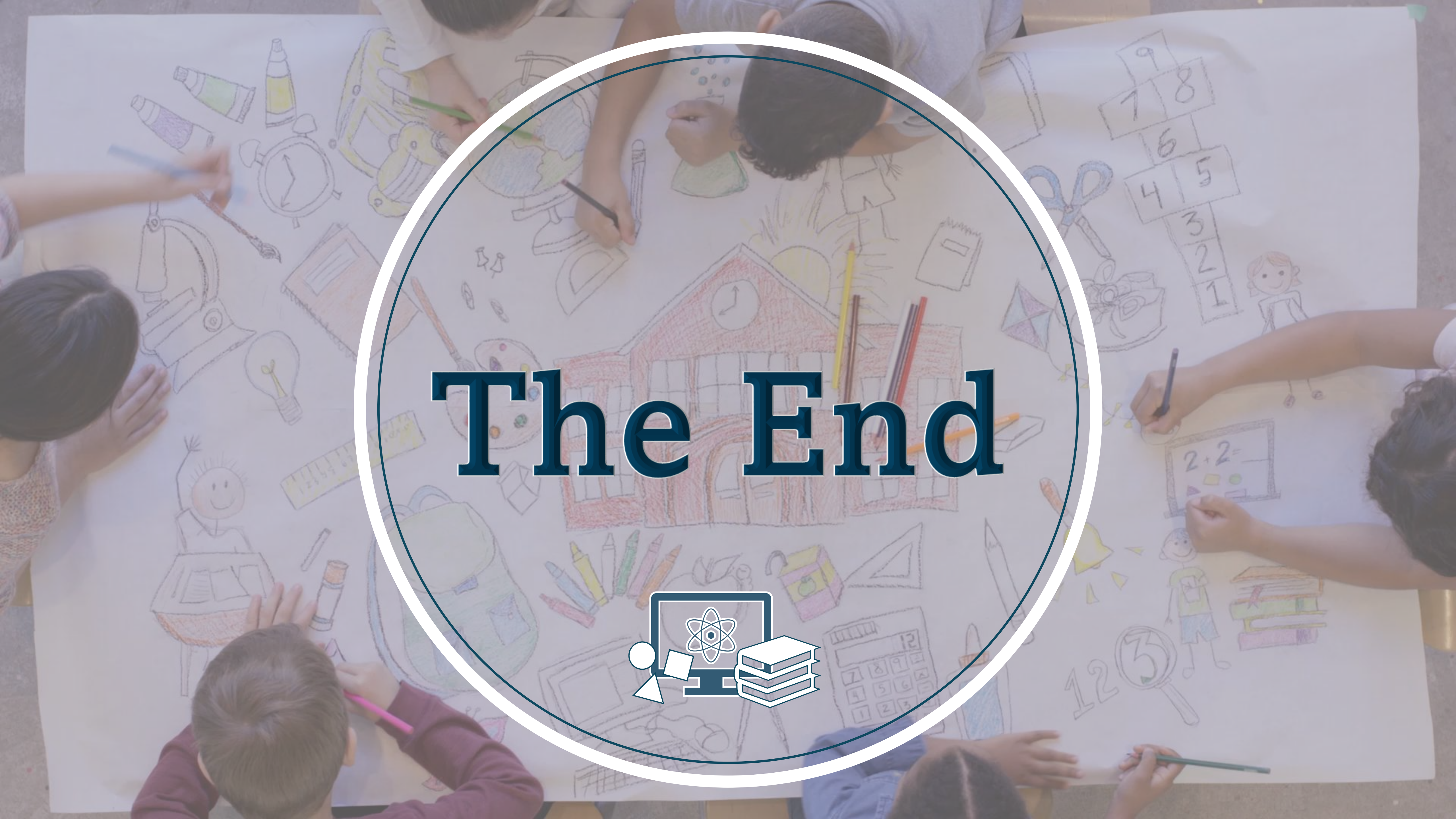
$$ME_N - ME_A = -f \times AN$$

$$0.2J - 0.4J = -f \times 0.2$$

$$-0.2J = -f_r \times 0.2$$

$$f_r = \frac{0.2}{0.2}$$

$$f_r = 1N$$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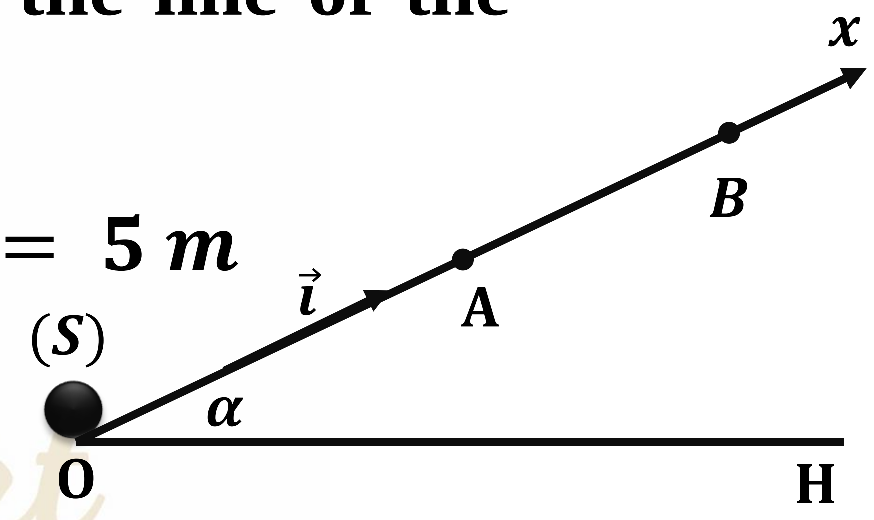
Quiz Time

Quiz 2 **Energy** **20 min**

A particle (S), of mass $m = 500g$ is launched from the bottom O of the inclined plane that makes an angle $\alpha = 30^{\circ}$, at the instant $t_0 = 0$, with a velocity $\vec{V}_0 = V_0\vec{i}$ along the line of the greatest slope (OB).

Let A be a point between O and B such that $OA = 5\,m$

The position of (S), at the instant t, is given by x.



The horizontal plane passing through OH is a gravitational potential energy reference. Take: $g = 10m / s^2$.

Quiz 2 **Energy** **20 min**

The variation of the mechanical energy of the system [(S), Earth], as a function of x, is represented by the graph of (fig.2).

1. **Determine using the graph the mechanical energy at point O then at point A.**
2. **Deduce the speed V_0 at O and the speed V at point A.**
3. **Show that (S) is subjected to a force of friction between the points O and A.**

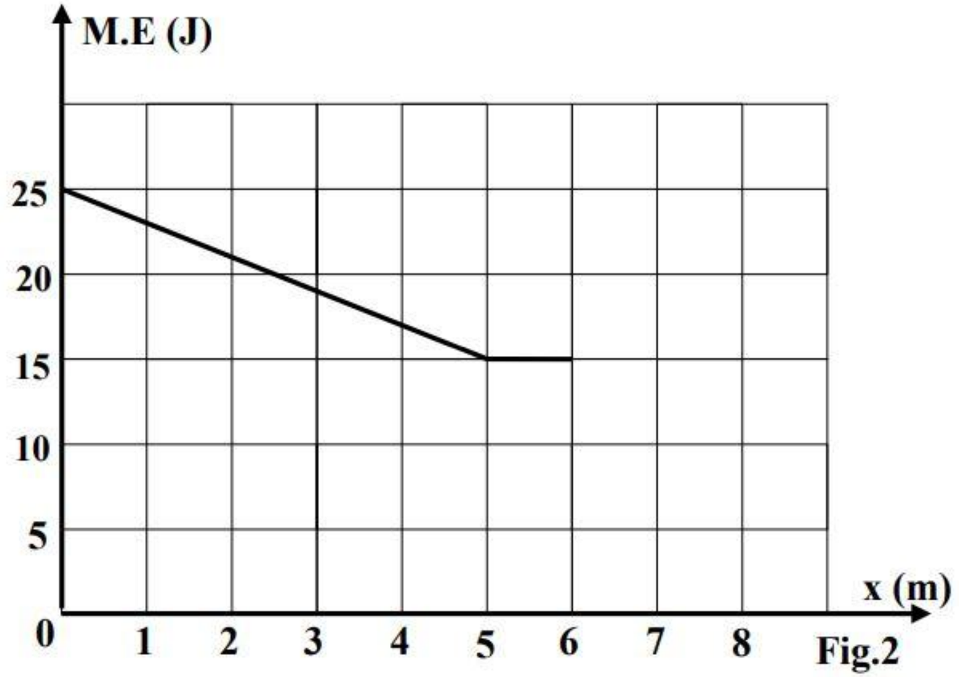


Fig.2

Quiz 2 Energy 20 min

4. Calculate the variation of the mechanical energy of the system [(S), Earth] between O and A.

5. Deduce the magnitude of the force of friction, supposed constant, between O and A.

6. Determine, for $0 \leq x \leq 5$, the expression of the mechanical energy of the system [(S),Earth] as a function of x.

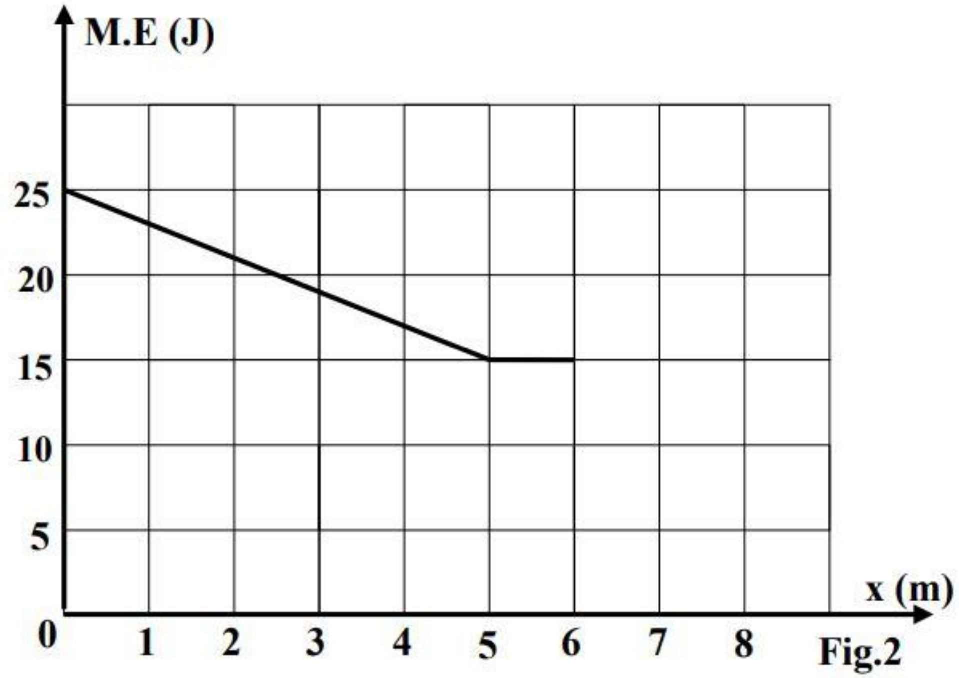


Fig.2

7. Determine the expression of mechanical energy between O and A using law of mechanical energy. Determine the speed of (S) at the point of abscissa $x = 6\,m$.

$m = 0.5kg; \alpha = 30^{\circ}; OA = 5\,m; g = 10N/Kg$

1. Determine using the graph the mechanical energy at point O and A.

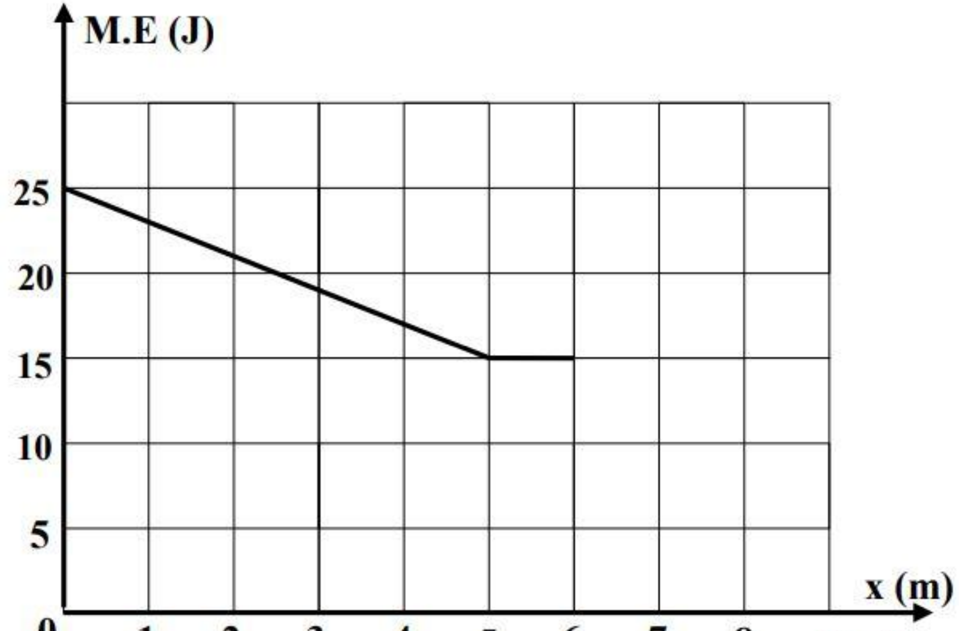


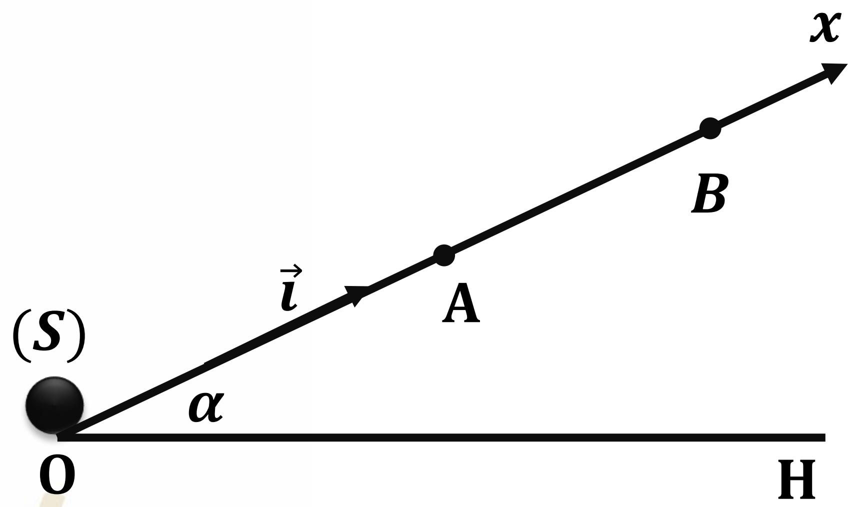
Fig.2

From the graph of figure 2:

- $ME_O = 25J$
- $ME_A = 15J$

$m = 0.5\text{kg};\ \alpha = 30^{\circ};\ \text{OA} = 5\ m;\ g = 10N/Kg$

2. Deduce the speed V_0 at O and the speed V at point A.



$$ME_O = KE_O + PE_O$$

$$ME_O = \frac{1}{2}mV_0^2 + mgh$$

$$25J = \frac{1}{2} \times 0.5 \times V_0^2 + 0.5 \times 10(0)$$

$$25J = 0.25 \times V_0^2 \Rightarrow V_0^2 = \frac{25}{0.25} \Rightarrow V_0^2 = 100$$

$$V_0 = \sqrt{100} \Rightarrow V_0 = 10m\ /\ s$$

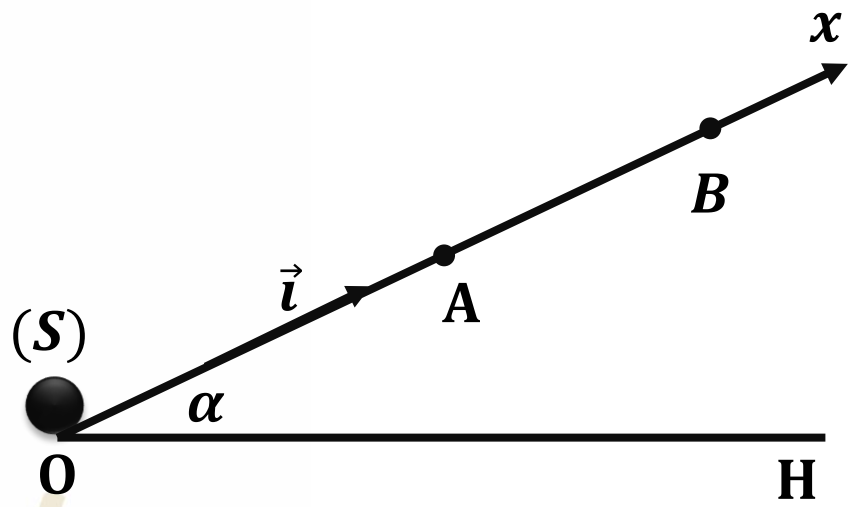
$m = 0.5kg; \alpha = 30^\circ; OA = 5\,m; g = 10N/Kg$

$$ME_A = KE_A + PE_A$$

$$ME_A = 1/2mV_A^2 + mgh_A$$

$$\sin\alpha = \frac{opp}{hyp} = \frac{h}{OA}$$

$$h = OA\sin\alpha$$



$$15J = 1/2mV_A^2 + mgOA\sin\alpha$$

$$15J = 1/2 \times 0.5 \times V^2 + 0.5 \times 10 \times 5 \times \sin30$$

$$25J = 0.25V_A^2 + 12.5$$

$$12.5 = 0.25V_A^2$$

$$V_A^2 = 50$$

$$V_A = V = 7.1m/s$$

$m = 0.5\text{kg}; \alpha = 30^\circ; \text{OA} = 5\,m; g = 10N/Kg$

3. Show that (S) is subjected to a force of friction between the points $x_0 = 0$ and $x_A = 5m$.

$$ME_O = 25J > ME_A = 15J$$

Then the solid (S) is subjected to a force of frictional.

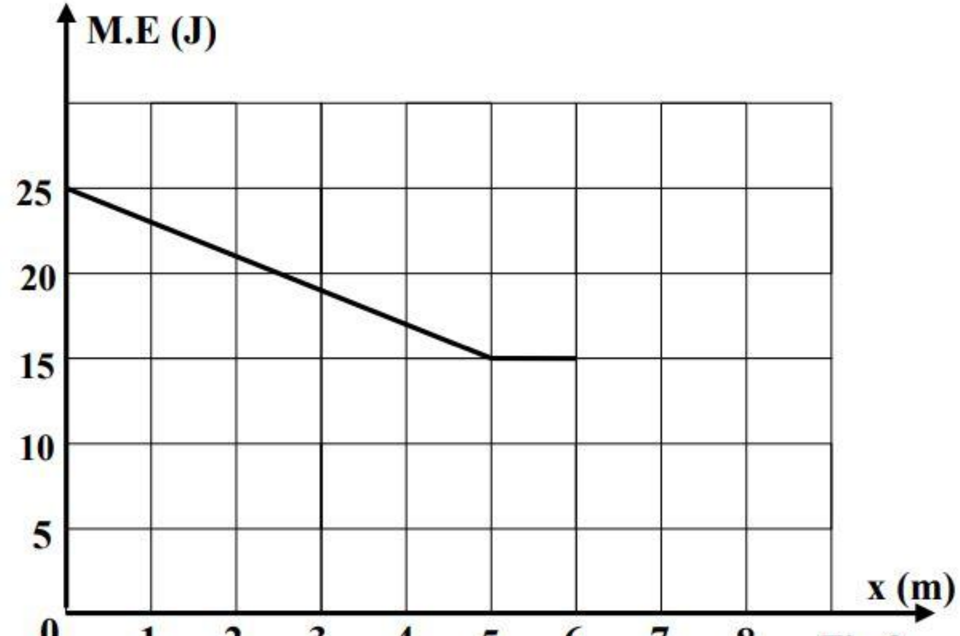


Fig.2

4. Calculate the variation of the mechanical energy of the system [(S), Earth] between O and A.

$$\Delta ME_{O\rightarrow A} = ME_A - ME_O \Rightarrow \Delta ME_{O\rightarrow A} = 15J - 25J$$

$$\Delta ME_{O\rightarrow A} = -10J$$

$m = 0.5\text{kg};\ \alpha = 30^{\circ};\ \text{OA} = 5\ m;\ g = 10N/Kg$

5.Deduce the magnitude of the force of friction, supposed constant, between O and A.

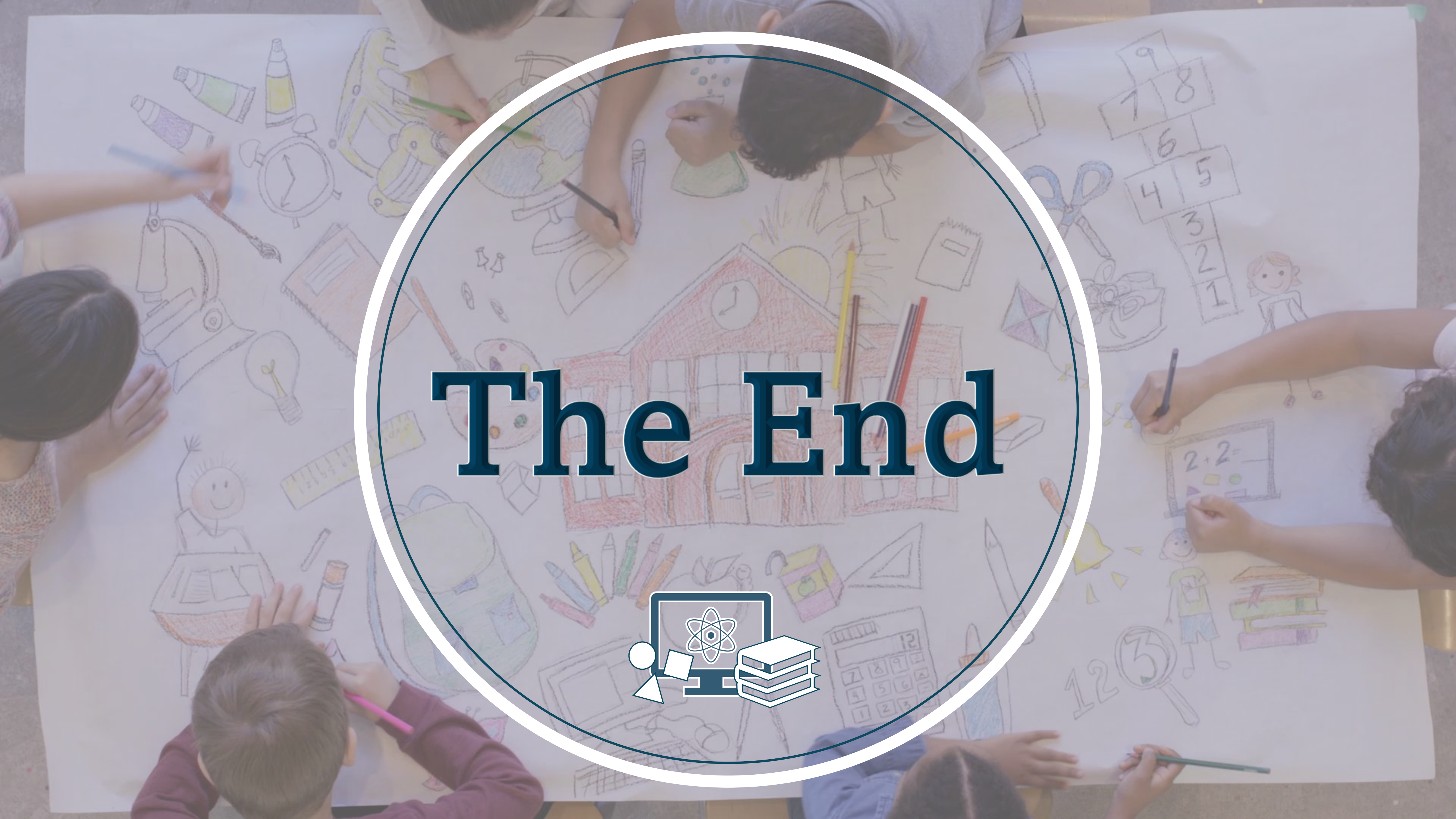
$$\Delta ME_{O\rightarrow A} = W_{\vec{f}}$$

$$\Delta ME_{O\rightarrow A} = f \times d \times cos(\alpha)$$

$$\Delta ME_{O\rightarrow A} = f \times OA \times cos(180)$$

$$-10 = -f \times 5$$

$$f = \frac{10}{5} \quad \Rightarrow \quad f_r = 2N$$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