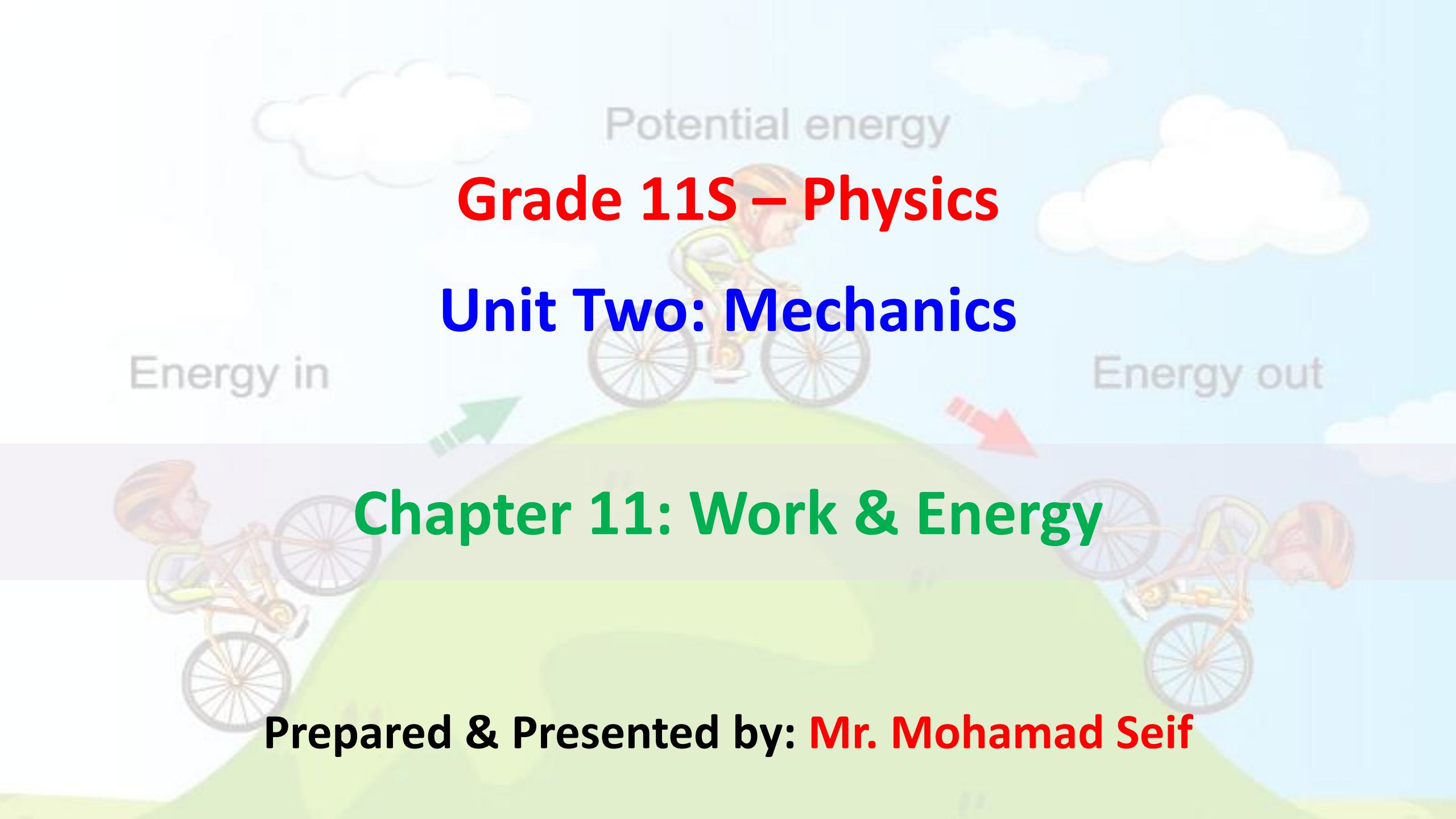


Grade 11S – Physics

Unit Two: Mechanics

Chapter 11: Work & Energy

Prepared & Presented by: Mr. Mohamad Seif

Think then solve

Exercise 1: Non – conservation of Mechanical Energy

A stone of mass $m = 1.5kg$, falls without initial velocity in air from a point A at a height $h = 3m$ from the ground.

A

During its downward motion, the stone reaches the ground at B with $V = 6m/s$

B $PE_g = 0$

The ground taken as a reference level; for gravitational potential energy. Given $g = 10m / s^2$.

1. Calculate mechanical energy of the system (stone-earth) at point A.

Exercise 1: Non – conservation of Mechanical Energy

2. Calculate the mechanical energy of the system(stone-earth) at point B at ground.
3. Is the mechanical energy of the system conserved or not?
4. Determine the variation in the mechanical energy of the system between A and B.
5. Deduce that a non-conservative force exist. Calculate its value.

Exercise 1: Non – conservation of Mechanical Energy

$m = 1.5kg; V_A = 0; h = 3m; V_B = 6m/s$

1.Calculate mechanical energy of the system (stone-earth) at point A.

$$\mathbf{ME_A = KE_A + PE_A}$$

$$ME_A = \frac{1}{2}mV_A^2 + mgh_A$$

$B \quad \mathbf{PE_g = 0}$

$$\mathbf{ME_A = 0.5 \times 1.5 \times (0)^2 + 1.5 \times 10 \times 3}$$

$$\mathbf{ME_A = 45J}$$

Exercise 1: Non – conservation of Mechanical Energy

$m = 1.5kg; V_A = 0; h = 3m; V_B = 6m/s$

2.Calculate the mechanical energy of the system(stone-earth) at point B at ground.

$$ME_B = KE_B + PE_B$$

$$ME_B = \frac{1}{2}mV_B^2 + mgh_B$$

$$ME_B = 0.5 \times 1.5 \times (6)^2 + 1.5 \times 10 \times (0)$$

$$ME_B = 27J$$

Exercise 1: Non – conservation of Mechanical Energy

3. Is the mechanical energy of the system conserved or not?

Since $ME_A > ME_B$; then the mechanical energy is not conserved

4. Determine the variation in the mechanical energy of the system between A and B.

$$\Delta ME = ME_B - ME_A \Rightarrow \Delta ME = 27J - 45J$$

$$\Delta ME = -18J$$

Exercise 1: Non – conservation of Mechanical Energy

5.Deduce that a non-conservative force exist. Calculate its value.

Since $\mathbf{ME}_B > ME_A$ **or** $\Delta ME \neq 0$;

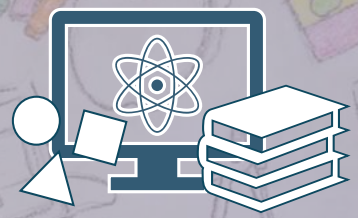
Therfore, the non-conservative force (friction) exist.

$$\Delta \mathbf{ME} = \sum W_{non-cons} \Rightarrow \Delta \mathbf{ME} = W_{fr}$$

$$\Delta \mathbf{ME} = -f_r \times d \Rightarrow -18\mathbf{J} = -f_r \times (3)$$

$$f_r = 6N$$

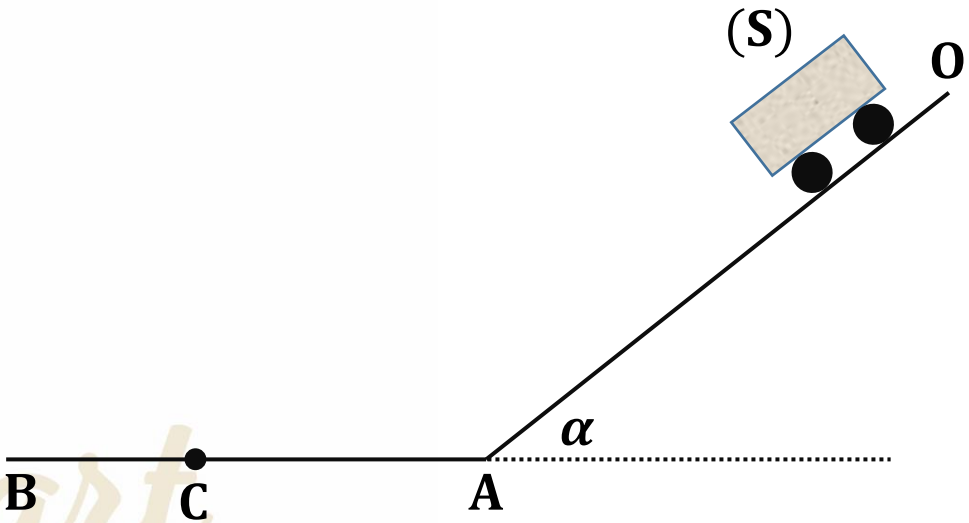
The End



Think then solve

Exercise 2: Mechanical Energy

A small particle (S) of mass $m = 300g$ is released without initial speed from the top O of an inclined plane making an angle $\alpha = 30^{\circ}$ with the horizontal.



Neglect the friction along the track OA, where $OA = 40cm$.

The particle (S) continues its motion along AB and stops at point C under the action of fictional force of magnitude $f_r = 3N$.

Take the horizontal line passing through A as a reference for the gravitational potential energy. $g = 10m/s^2$.

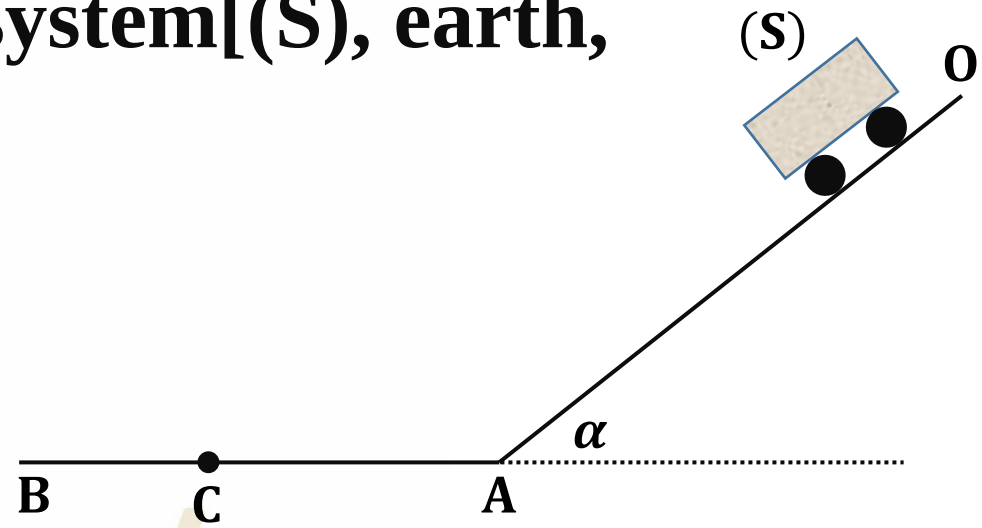
Exercise 2: Mechanical Energy

1. Calculate the mechanical energy of the system[(S), earth] at point O.
2. Deduce the speed at point A.
3. Calculate the mechanical energy of the system[(S), earth] at point C.
4. Find the variation of the mechanical energy of the system between A and C. Deduce the distance AC.

Exercise 2: Mechanical Energy

$m = 0.3\text{Kg}; V_O = 0; \alpha = 30^\circ; f_{OA} = 0; OA = 0.4m; f_{AB} = 3N\ g = 10m/s^2$

1.Calculate the mechanical energy of the system[(S), earth, support] at point O



$$ME_O = KE_O + PE_O$$

$$ME_O = 1/2mV_O^2 + mgh_O$$

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

$$h = OAsin\alpha$$

$$ME_O = 1/2mV_O^2 + mgOAsin\alpha$$

$$ME_O = 0 + 0.3 \times 10 \times 0.4 \times \sin 30$$

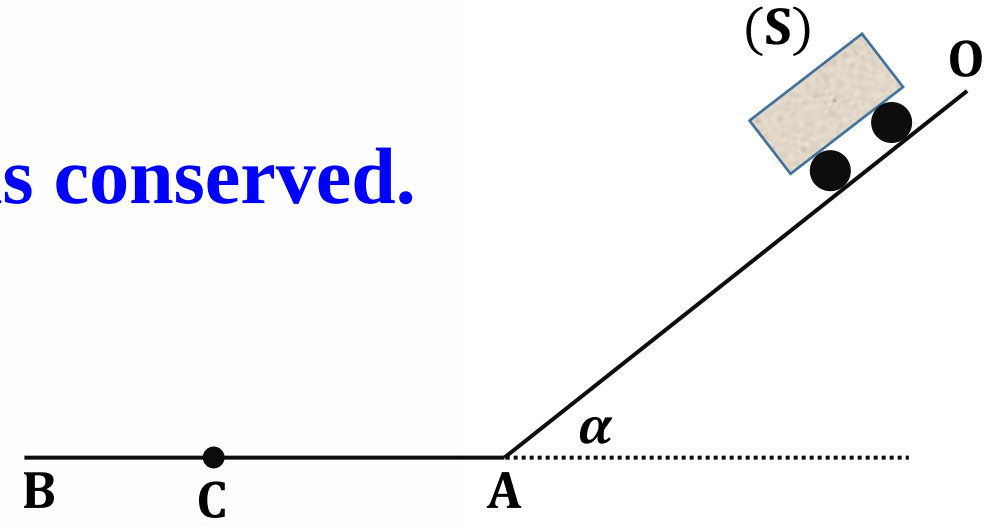
$$ME_O = 0.6\text{J}$$

Exercise 2: Mechanical Energy

$m = 0.3\text{Kg}; V_O = 0; \alpha = 30^\circ; f_{OA} = 0; OA = 0.4m; f_{AB} = 3N \; g = 10m/s^2$

2.Deduce the speed at point A

Since friction is neglected (f = 0); then ME is conserved.



$$ME_O = ME_A$$

$$0.6\text{J} = KE_A + PE_A$$

$$0.6\text{J} = 1/2mV_A^2 + \text{mg}h_A$$

$$0.6\text{J} = 0.5 \times 0.3 \times V_A^2 + 0$$

$$0.6\text{J} = 0.15 \times V_A^2$$

$$V_A^2 = \frac{0.6}{0.15} = 4$$

$$V_A = \sqrt{4} \Rightarrow V_A = 2m/s$$

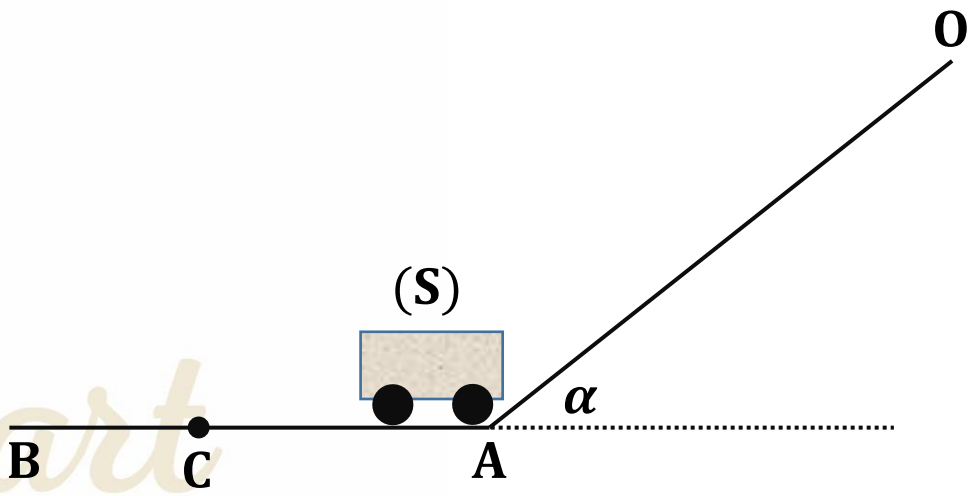
Exercise 2: Mechanical Energy

$m = 0.3\text{Kg}; V_O = 0; \alpha = 30^\circ; f_{OA} = 0; OA = 0.4m; f_{AB} = 3N \; g = 10m/s^2$

3. Calculate the mechanical energy of the system[(S), earth, support] at point C

$$\mathbf{ME_C = KE_C + PE_C}$$

$$ME_C = \frac{1}{2}mV_C^2 + \mathbf{mg}h_C$$



$$ME_C = 1/2 \times 0.3 \times (0)^2 + 0.3 \times 10 \times (0)$$

$$ME_C = 0J$$

Exercise 2: Mechanical Energy

4. Find the variation of the mechanical energy of the system between A and C. Deduce the distance AC.

$$\Delta \mathrm{ME} = \mathrm{ME}_C - \mathrm{ME}_A$$

$$\Delta \mathrm{ME} = 0\mathrm{J} - 0.6\mathrm{J}$$

$$\Delta ME = -0.6J$$

$$\Delta ME = \sum W_{non-cons}$$

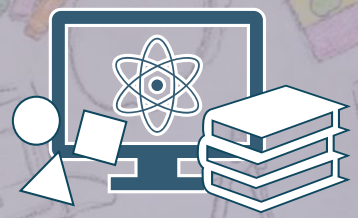
$$\Delta ME = W_{fr}$$

$$\Delta ME = -f_r \times d$$

$$-0.6J = -3 \times AC$$

$$\mathrm{AC} = 0.2\mathrm{m}$$

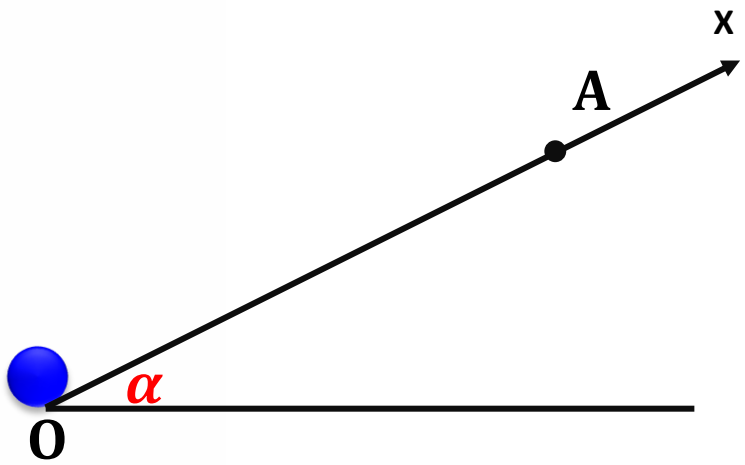
The End



Think then solve

Exercise 3: Mechanical Energy

A particle (S) of mass 200g, can slides without friction on an inclined plane making an angle $\alpha = 30^{\circ}$ with respect to the horizontal.

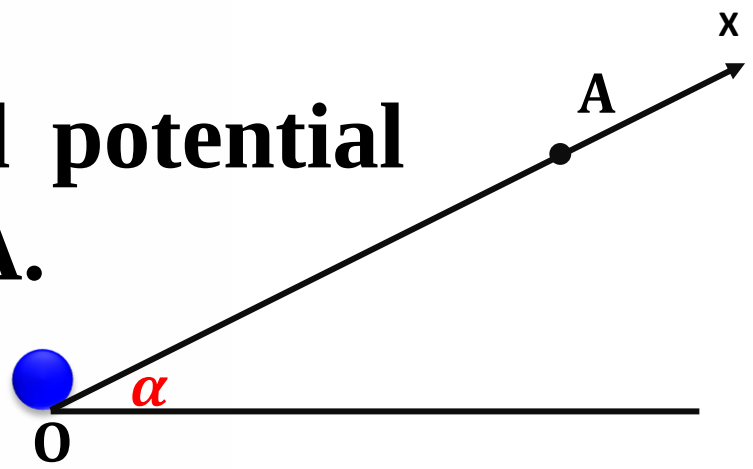


(S) is launched, at instant $t_0 = 0$, from O with a velocity of $V_0 = 5\text{m/s}$.
At any instant t, the position of (S) is given by its abscissa x = OA.

The horizontal plane passing through O is the reference level for the gravitational potential energy

Exercise 3: Mechanical Energy

1. Calculate the mechanical energy of the system [(S), earth] at point O.
2. Express, in terms of x, the gravitational potential energy of the system [(S), earth] at point A.



3. Sketch the graph of the mechanical energy and that of the gravitational potential energy. Use the following scales:

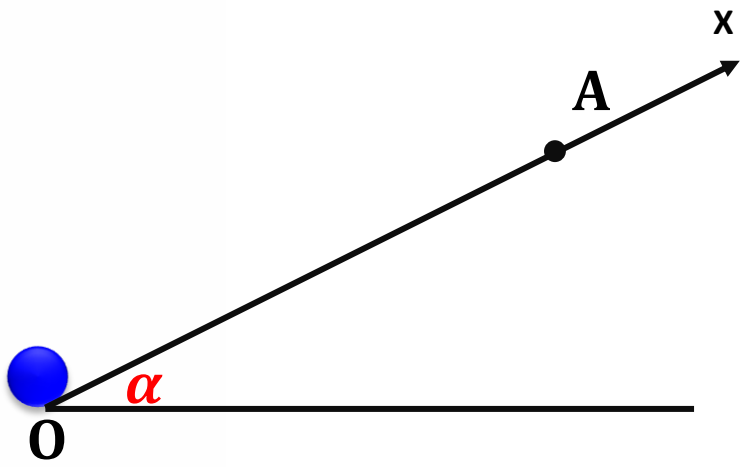
At x-axis: 1cm → 0.5m and at y-axis: 1cm → 0.5J

4. Determine, the expression of KE in terms of x then draw its curve on the same graph

Exercise 3: Mechanical Energy

$m = 0.2\text{kg};\ f_r = 0;\ \alpha = 30^\circ;\ V_0 = 5\text{m/s}$

1.Calculate the mechanical energy of the system [(S), earth] at point O.



$$ME_O = KE_O + PE_O$$

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

$$ME_O = \frac{1}{2} \times 0.2 \times (5)^2 + 0.2 \times 10(0)$$

$$ME_O = 2.5\text{J}$$

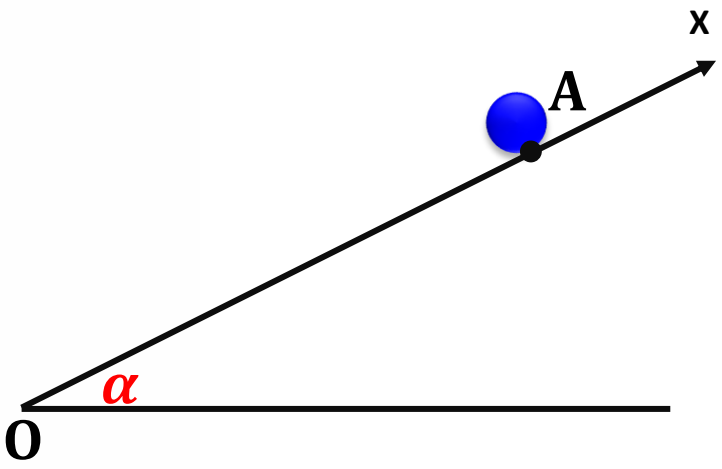
Exercise 3: Mechanical Energy

$m = 0.2\text{kg}; f_r = 0; \alpha = 30^\circ; V_0 = 5\text{m/s}$

2. Express, in terms of x, the gravitational potential energy of the system [(S), earth] at point A.

$$PE_A = mgh$$

$$sin\alpha = \frac{opp}{hyp} \Rightarrow sin\alpha = \frac{h}{x} \Rightarrow h = x.sin\alpha$$



$$PE_A = mgh = mgxsin\alpha$$

$$PE_A = 0.2 \times 10 \times x \times sin30 \Rightarrow PE_A = x$$

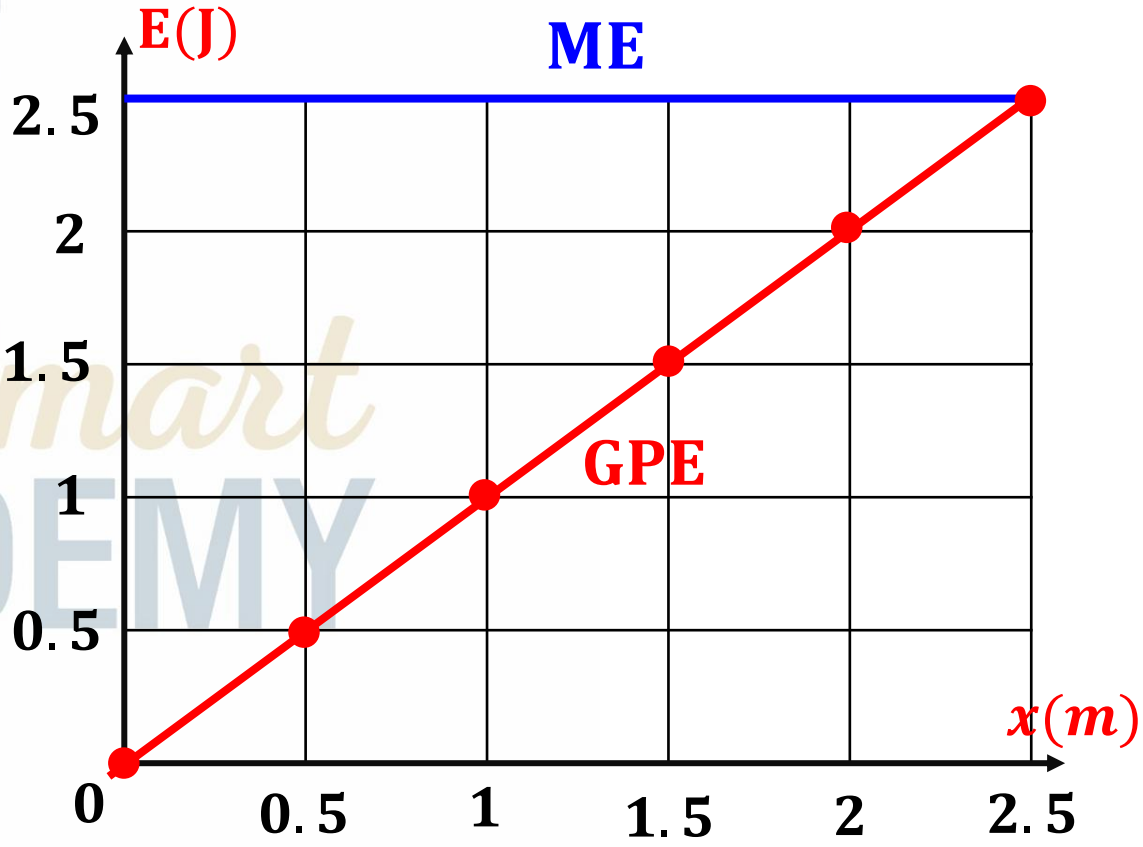
Exercise 3: Mechanical Energy

3.Sketch the graph of the mechanical energy and that of the gravitational potential energy. Use the following scales:
At x-axis: 1cm → 0.5m and at y-axis: 1cm → 0.5J

For $ME = 2.5J$: horizontal St. line

For $PE_g = x$: changes as x change

x(m)	0	0.5	1	1.5	2	2.5
PE_g(J)	0	0.5	1	1.5	2	2.5



Exercise 3: Mechanical Energy

4. Determine, the expression of KE in terms of x then draw its curve on the same graph.

Since $f = 0N$ then ME is conserved:

$$\mathbf{ME_O = ME_A}$$

$$\mathbf{2.5J = KE + GPE}$$

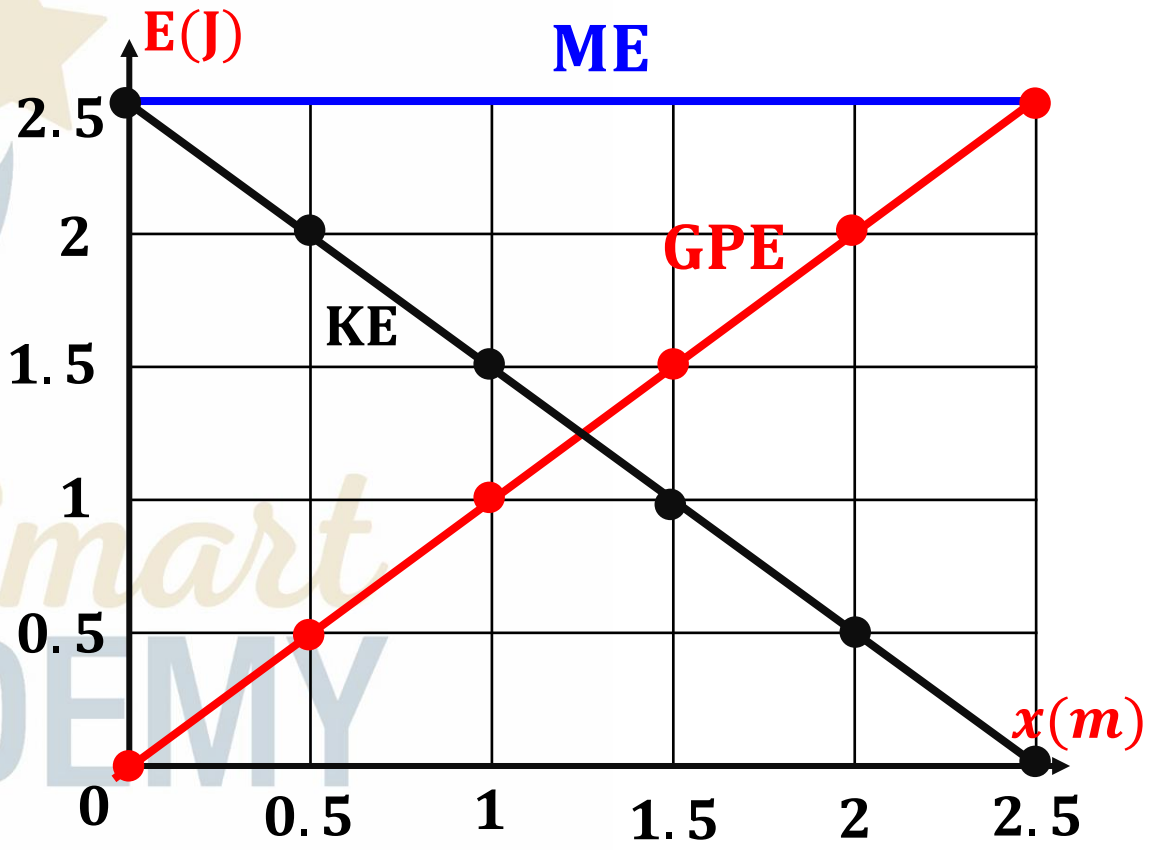
$$\mathbf{2.5J = KE + x}$$

$$\mathbf{KE = 2.5 - x}$$

x(m)	0	0.5	1	1.5	2	2.5
KE(J)	2.5	2	1.5	1	0.5	0

Exercise 3: Mechanical Energy

x(m)	0	0.5	1	1.5	2	2.5
KE(J)	2.5	2	1.5	1	0.5	0



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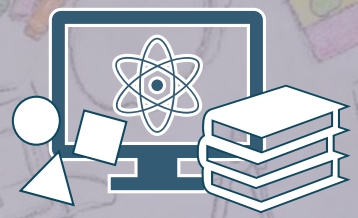
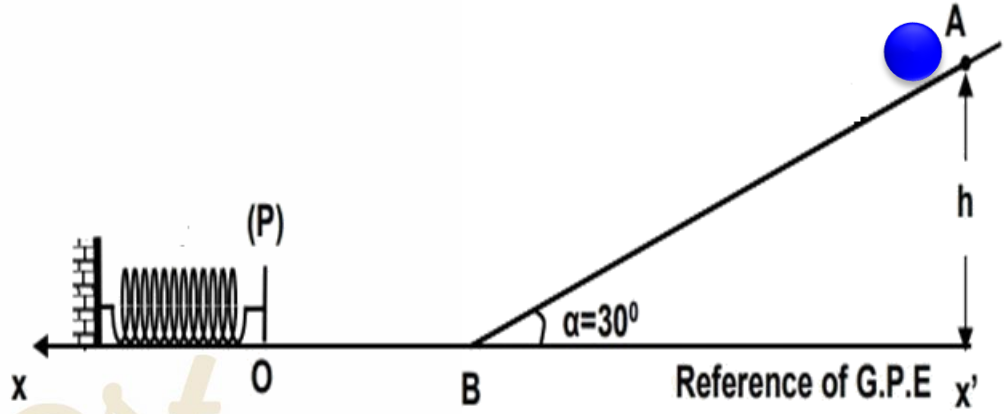


Think then solve

Exercise 4: Mechanical Energy

A particle (S), of mass $m = 2kg$ is released without initial velocity from the top A of an inclined plane making an angle of 30° with the horizontal and of length $AB = 2.5m$.



The force of friction along AB assumed constant of magnitude $f = 8.4N$.

(S) then moves on a horizontal frictionless plane where it compresses a massless spring of stiffness $k = 400N/m$.

Take the reference level of gravitational potential energy to be the horizontal plane passing through B. $g = 10N/Kg$

Exercise 4: Mechanical Energy

1. Calculate, the mechanical energy of the system at point A.
2. The mechanical energy on AB is not conserved. Why?
3. Deduce the using the velocity of (S) as it reaches point B.
4. On the horizontal plane, is the mechanical energy of (S) conserved? Justify your answer.
5. Determine the spring's maximum compression.

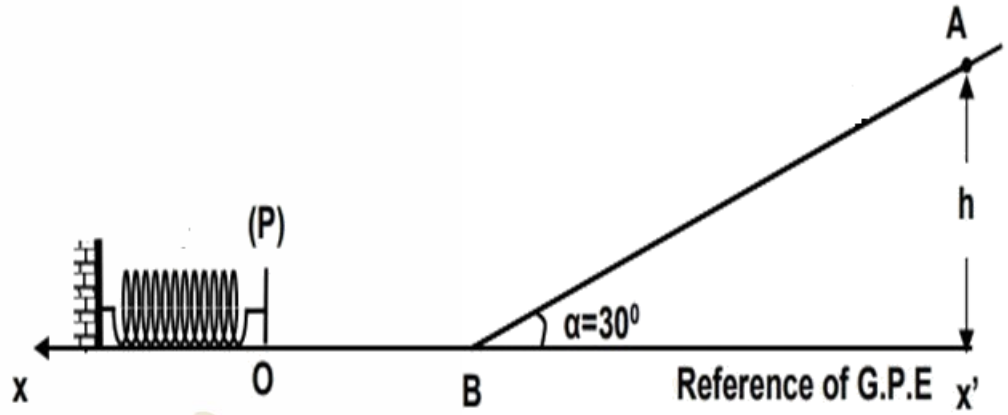
Exercise 4: Mechanical Energy

$m = 2kg; V_A = 0; \alpha = 30^\circ; AB = 2.5m; f_{AB} = 8.4N; k = 400N/m; f_{BO} = 0N$

1. Calculate, the mechanical energy of the system at point A.

$$ME_A = KE_A + PE_A$$

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



$$sin\alpha = \frac{opp}{hyp} \Rightarrow sin\alpha = \frac{h}{AB} \Rightarrow h = ABsin\alpha$$

$$ME_A = 1/2mV_A^2 + mgABsin\alpha$$

$$ME_A = 2 \times 10 \times 2.5 \times sin30 \Rightarrow ME_A = 25J$$

Exercise 4: Mechanical Energy

$m = 2kg; V_A = 0; \alpha = 30^\circ; AB = 2.5m; f_{AB} = 8.4N; k = 400N/m; f_{BO} = 0N$

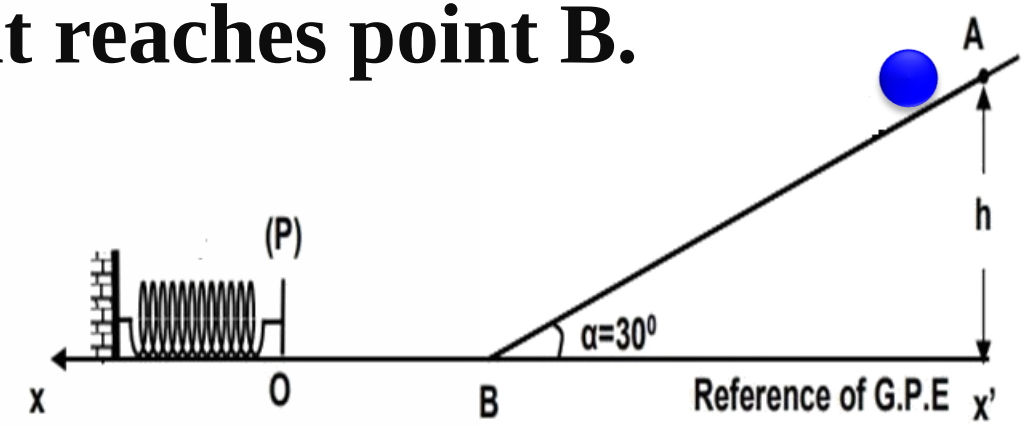
2. The mechanical energy between A and B is not conserved. Why?

Because the friction force along AB is not neglected ($f_r = 8.4N$); then ME is not conserved

Exercise 4: Mechanical Energy

$m = 2kg; V_A = 0; \alpha = 30^\circ; AB = 2.5m; f_{AB} = 8.4N; k = 400N/m; f_{BO} = 0N$

3. Deduce the using the velocity of (C) as it reaches point B.



$$\Delta ME_{A\to B} = W_f$$

$$ME_B - ME_A = f \times AB \times cos(180)$$

$$KE_B + PE_B - 25 = -8.4 \times 2.5$$

$$1/2mV_B^2 + 2 \times 10(0) - 25 = -21$$

$$0.5 \times 2 \times V_B^2 - 25 = -21$$

$$V_B^2 = -21 + 25$$

$$4 = V_B^2$$

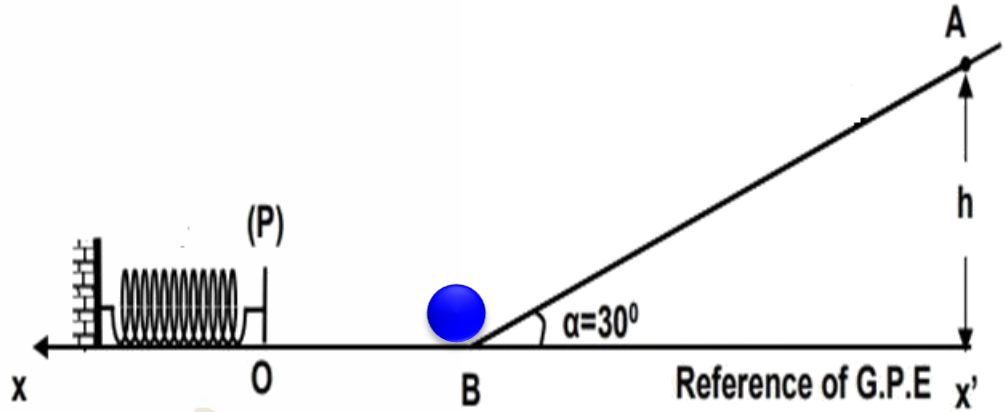
$$V_B = \sqrt{4}$$

$$V_B = 2m/s$$

Exercise 4: Mechanical Energy

$m = 2kg; V_A = 0; \alpha = 30^\circ; AB = 2.5m; f_{AB} = 8.4N; k = 400N/m; f_{BO} = 0N$

4. On the horizontal plane BO, is the mechanical energy of (S) conserved? Justify your answer.

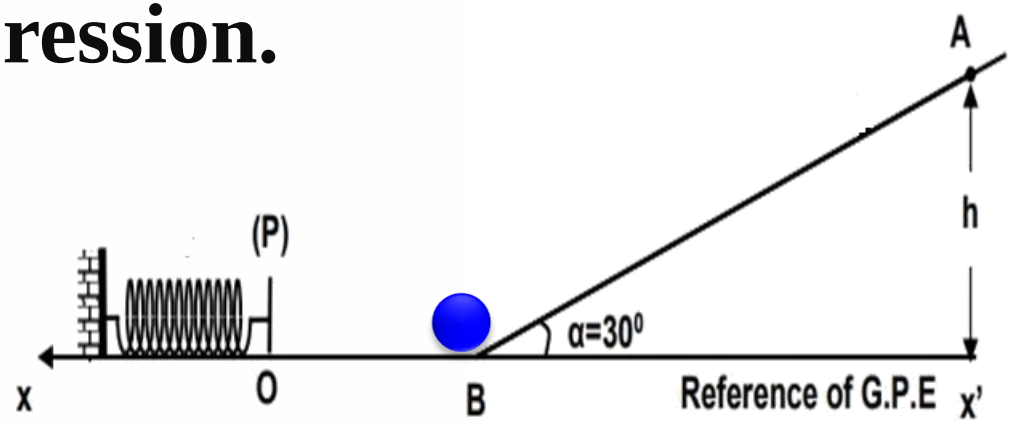


Because the horizontal plane containing B is frictionless ($f = 0N$) then ME is conserved.

Exercise 4: Mechanical Energy

$m = 2kg; V_A = 0; \alpha = 30^\circ; AB = 2.5m; f_{AB} = 8.4N; k = 400N/m; f_{BO} = 0N$

5. Determine the spring's maximum compression.



$$ME_B = ME_{max}$$

$$KE_B + PE_B = KE + PE_g + PE_e$$

$$1/2mV_B^2 + 0 = 0 + 0 + 1/2kX_m^2$$

$$0.5 \times 2 \times (2)^2 = 0.5 \times 400 \times X_m^2$$

$$X_m^2 = \frac{0.5 \times 2 \times 4}{0.5 \times 400} = 0.02$$

$$X_m = \sqrt{0.02}$$

$$X_m = 0.1414m$$

The End