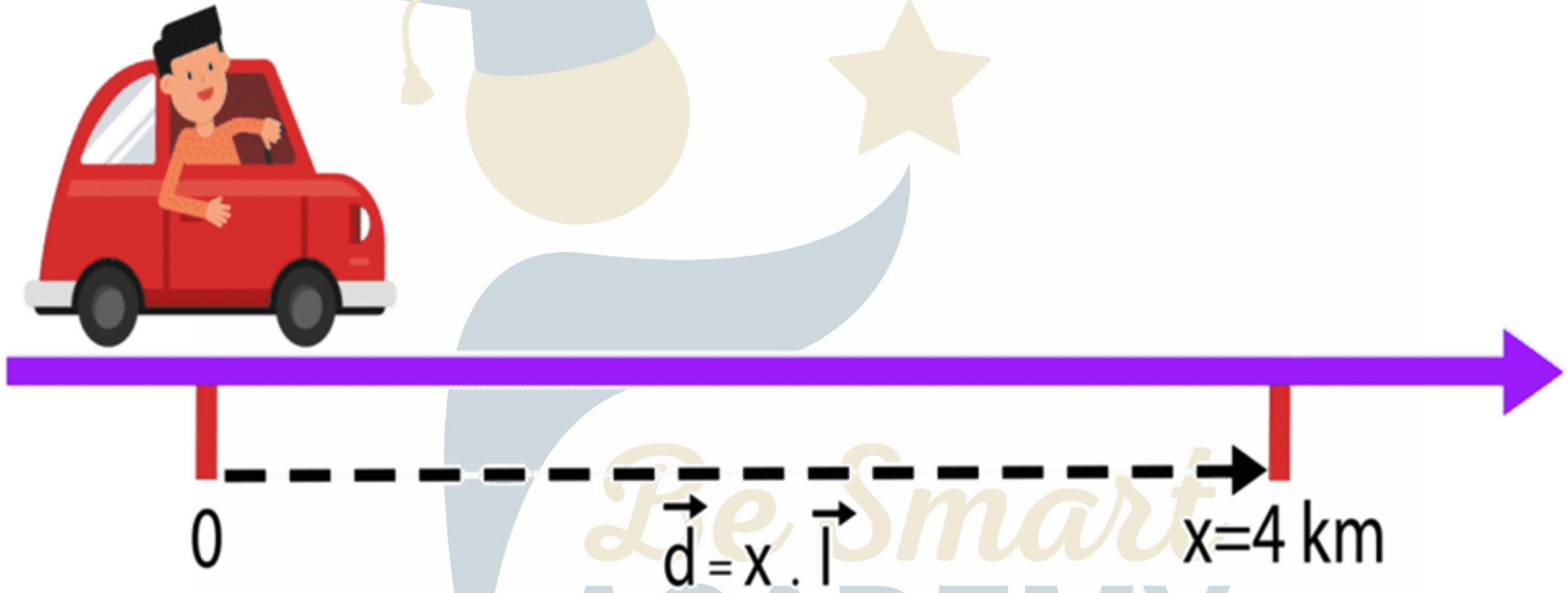
Physics – Grade 10

Unit Four – Mechanics



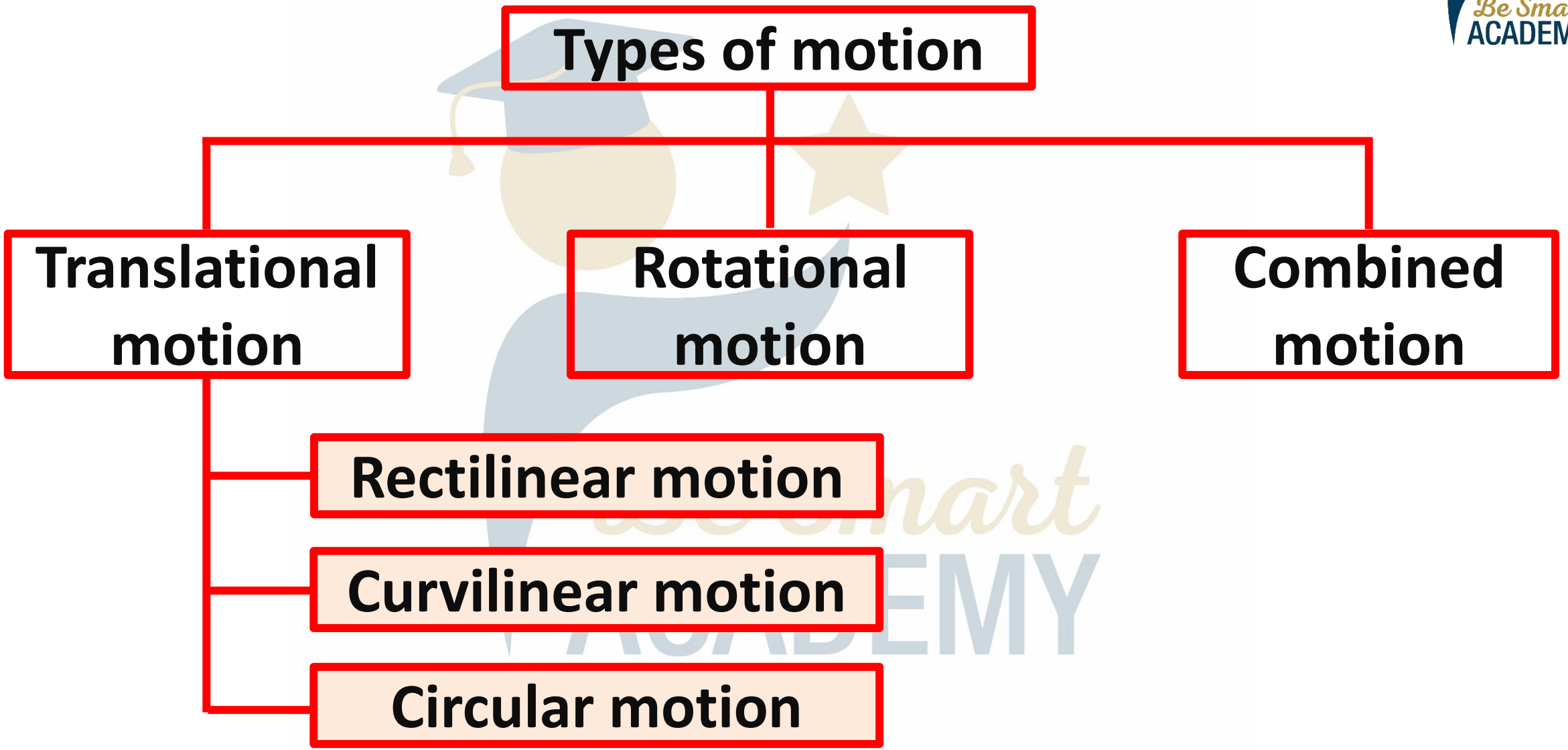
Chapter 15 – Rectilinear motion

Prepared & Presented by: Mr. Mohamad Seif

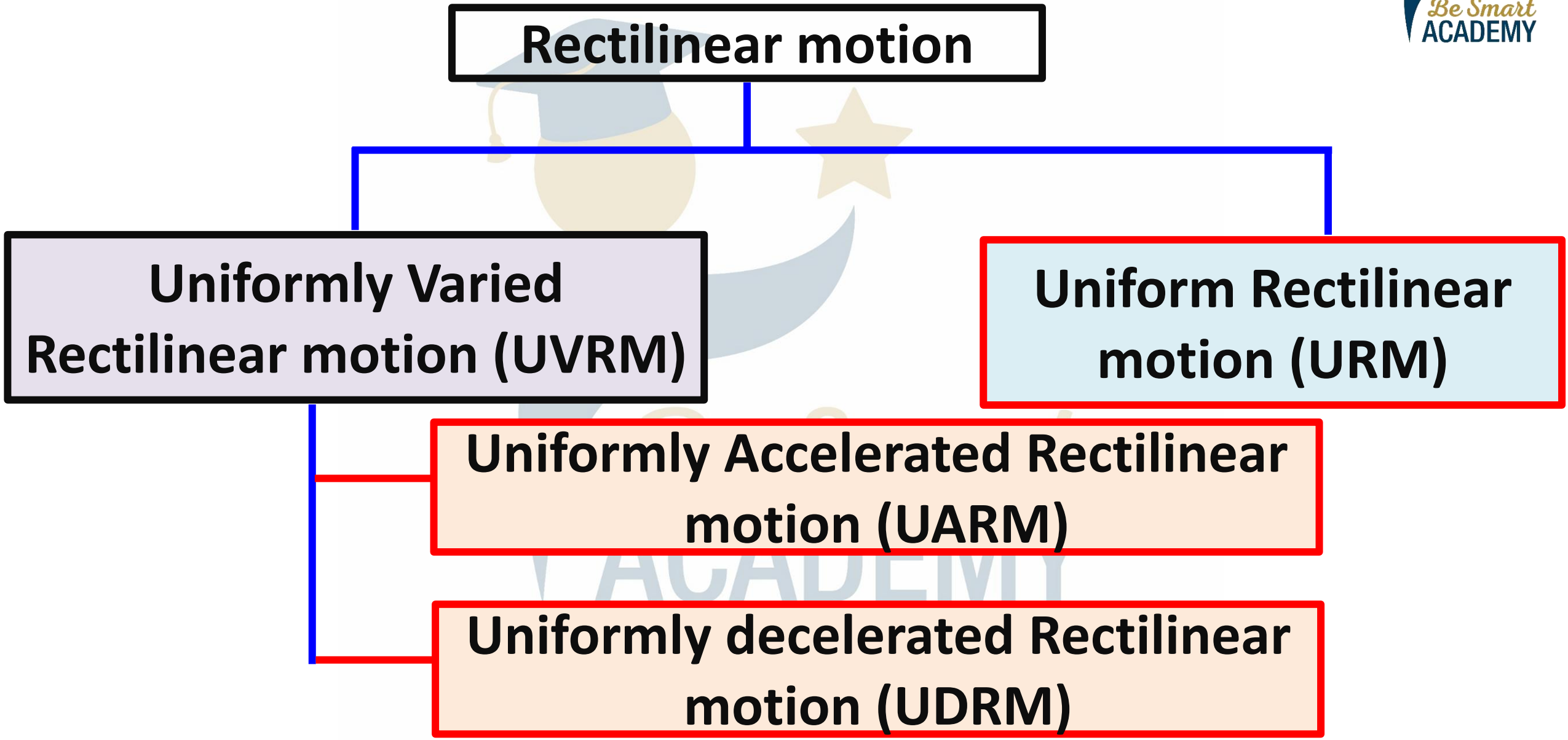
OBJECTIVES

1. Introduction about types of motion
2. Identify the types of rectilinear motion
3. Study the Uniform Rectilinear Motion (URM)

Types of rectilinear motion



Types of rectilinear motion



Uniform Rectilinear Motion (URM)

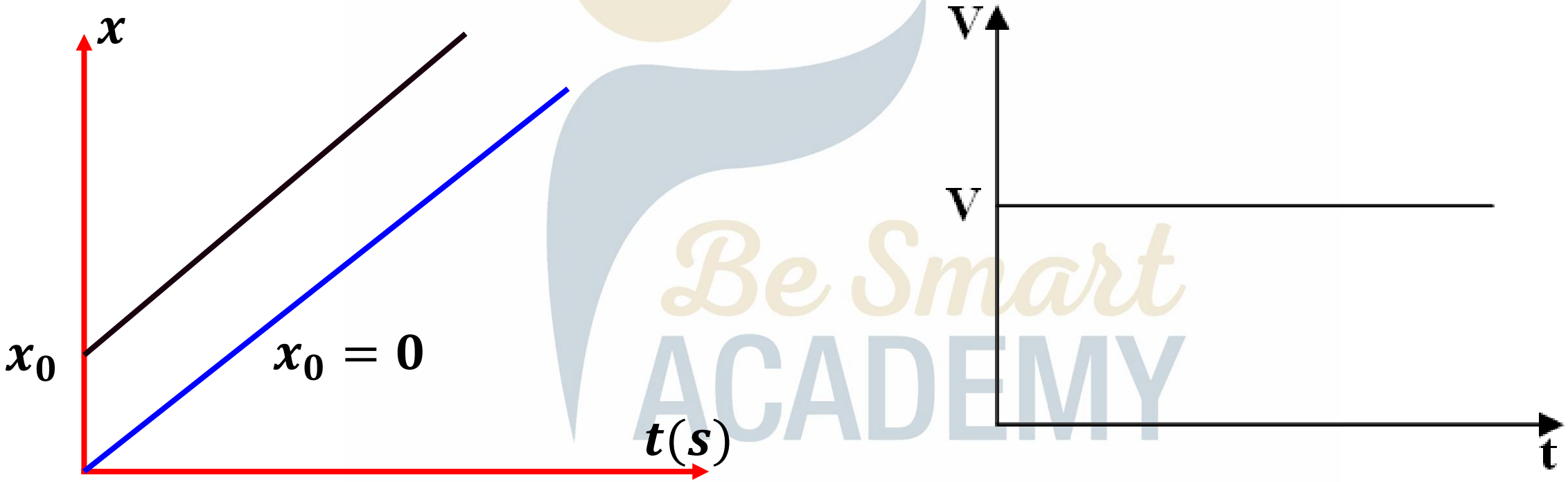
During the time interval τ, a motion is said to be U. R. M if:

- **The distance covered during equal interval of time are equal: $A_0A_1 = A_1A_2 = A_2A_3 = \cdots$**
- **The velocity is constant ($V_1 = V_2 = \cdots$),**
- **The acceleration is zero ($a_1 = a_2 = 0$),**

Uniform Rectilinear Motion (URM)

Time equation Motion of URM:

$$X = Vt + x_0$$



Where V is the slope of the obtained curve

Uniform Rectilinear Motion (URM)

Application 1:

Consider a moving particle with a time equation of motion given by: $x = 1.5t + 0.5$ where x in m & t in sec.

1. Specify the nature of motion of the particle.
2. Determine the initial position x_0 at $t_0 = 0$ and the speed V.
3. Calculate the positions: x_1, x_2, x_3 and x_4 at $t_1 = 1s, t_2 = 2s, t_3 = 3s$, and at $t_4 = 4s$, respectively.
4. Represent graphically x as a function of t.
5. Determine the acceleration of the particle.

Uniform Rectilinear Motion (URM)

$x = 1.5t + 0.5$

1.Specify the nature of motion of the particle.

The motion is URM, because the given time equation in the form of $x = Vt + x_0$

2.Determine the initial position x_0 at $t_0 = 0$ and the speed V

$$\begin{cases} x = Vt + x_0 \\ x = 1.5t + 0.5 \end{cases}$$

Compare the two equations:

$V = 1.5m/s$

$x_0 = 0.5m$

Uniform Rectilinear Motion (URM)

$x = 1.5t + 0.5$

3. Calculate the positions: x_1, x_2, x_3 and x_4 at $t_1 = 1s$, $t_2 = 2s$, $t_3 = 3s$, and at $t_4 = 4s$, respectively.

For $t_1 = 1s$:

$$x_1 = 1.5(1) + 0.5$$

$$x_1 = 1.5 + 0.5 = 2m$$

For $t_2 = 2s$:

$$x_2 = 1.5(2) + 0.5$$

$$x_2 = 3 + 0.5 = 3.5m$$

For $t_3 = 3s$:

$$x_3 = 1.5(3) + 0.5$$

$$x_3 = 4.5 + 0.5 = 5m$$

For $t_4 = 4s$:

$$x_4 = 1.5(4) + 0.5$$

$$x_4 = 6 + 0.5 = 6.5m$$

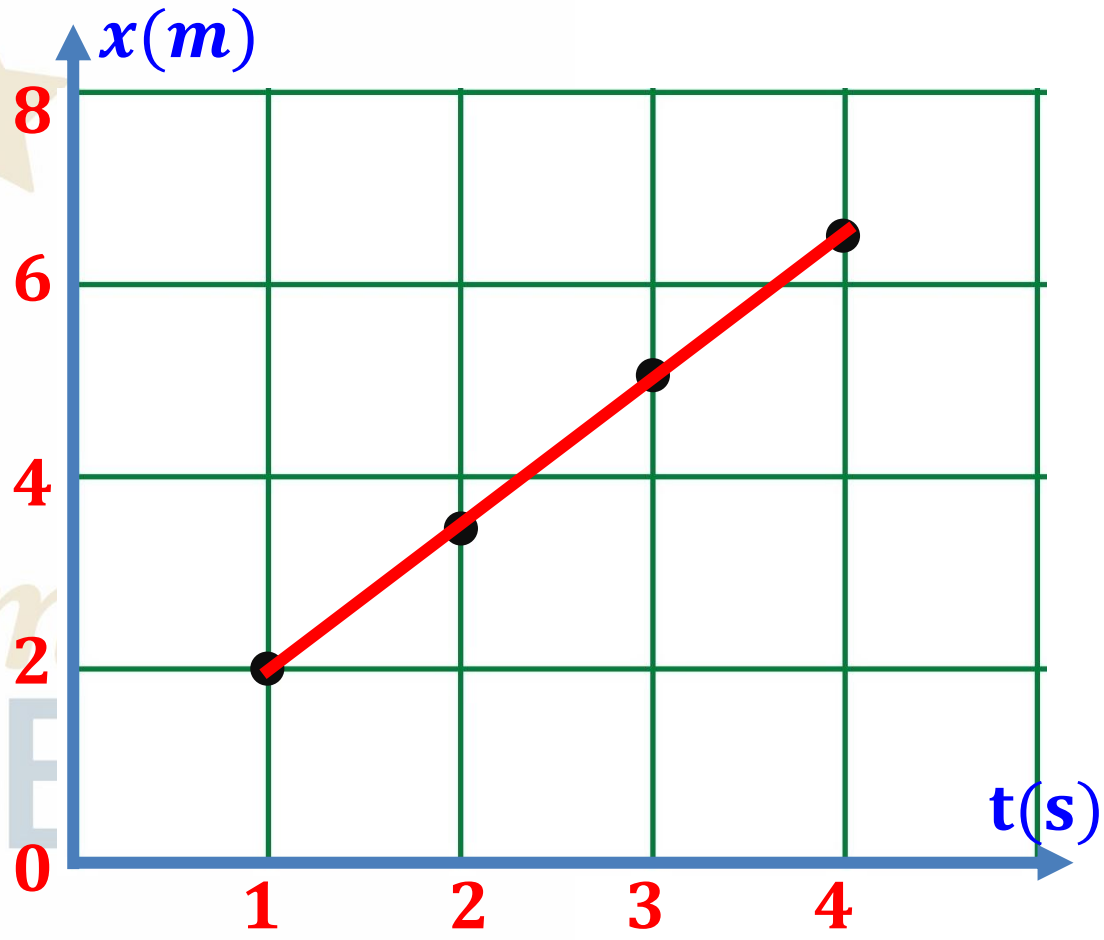
Uniform Rectilinear Motion (URM)

4. Represent graphically x as a function of t.

Scale:

- $x - axis: 1cm \rightarrow 1s$
- $y - axis: 1cm \rightarrow 2m$

t(s)	1	2	3	4
$x(m)$	2	3.5	5	6.5



Uniform Rectilinear Motion (URM)

5. Determine the acceleration of the particle.

The motion is URM then:

The speed is constant: $V_1 = V_2 = V_3 = \cdots$

$$a = \frac{V_3 - V_1}{t_3 - t_1} = \frac{1.5 - 1.5}{3\tau - \tau}$$

$$a_3 = 0 m / s^2$$

Uniform Rectilinear Motion (URM)

Application 2:

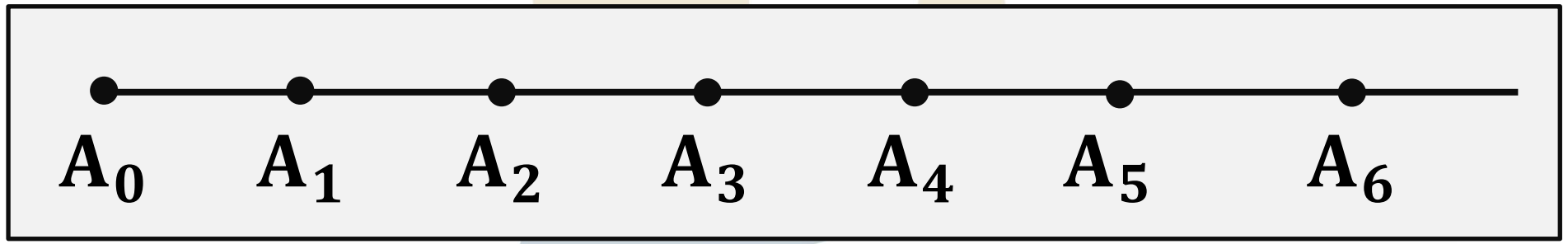
A puck moves on a horizontal air table with initial speed V_0. Given $A_0A_1 = A_1A_2 = \cdots = 4cm$.

The figure below shows the registrations of the puck during constant time interval $\tau = 50ms$.

1. Calculate the instantaneous speeds V_1, V_3 and V_5 at A_1, A_3 and A_5 respectively.
2. Calculate the instantaneous acceleration a_4.
3. Deduce is the nature of motion. Justify.
4. Write the time equation of motion.

Uniform Rectilinear Motion (URM)

1.Calculate the instantaneous speeds V_1, V_3 and V_5 at A_1, A_3 and A_5 respectively

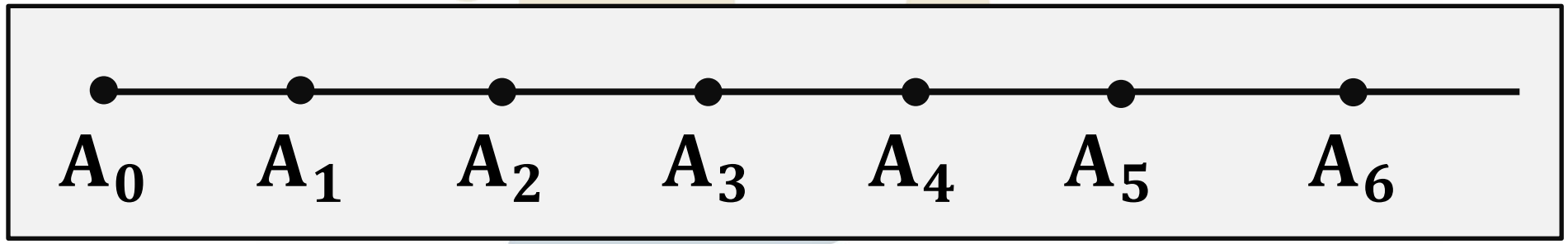


$$V_1 = \frac{A_0A_2}{t_2 - t_0} = \frac{A_0A_2}{2\tau - 0} \Rightarrow V_1 = \frac{(4+4) \div 100}{(2 \times 50) \div 1000}$$

$$V_1 = 0.8m/s$$

Uniform Rectilinear Motion (URM)

1.Calculate the instantaneous speeds V_1, V_3 and V_5 at A_1, A_3 and A_5 respectively

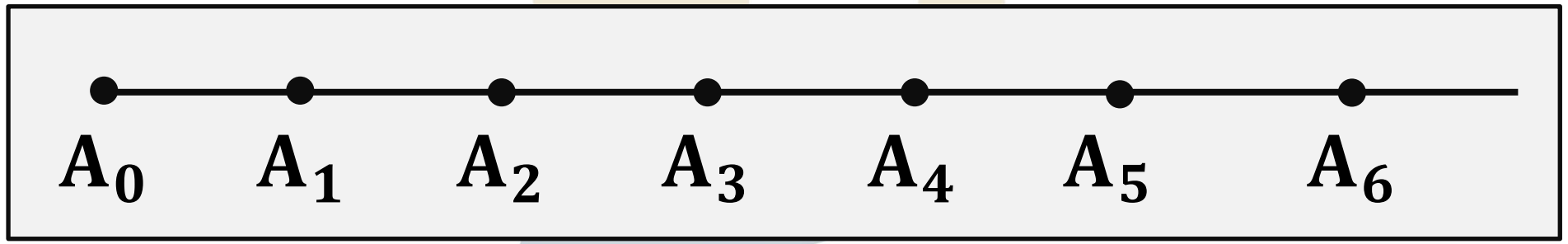


$$V_3 = \frac{A_2A_4}{t_4 - t_2} = \frac{A_2A_4}{4\tau - 2\tau} \Rightarrow V_3 = \frac{(4+4) \div 100}{(2 \times 50) \div 1000}$$

$$V_3 = 0.8m/s$$

Uniform Rectilinear Motion (URM)

1.Calculate the instantaneous speeds V_1, V_3 and V_5 at A_1, A_3 and A_5 respectively



$$V_5 = \frac{A_4A_6}{t_6 - t_4} = \frac{A_4A_6}{6\tau - 4\tau} \Rightarrow V_5 = \frac{(4+4) \div 100}{(2 \times 50) \div 1000}$$

$$V_5 = 0.8m/s$$

Uniform Rectilinear Motion (URM)

2. Calculate the instantaneous acceleration a_4.

$$a_4 = \frac{V_5 - V_3}{t_5 - t_3} \Rightarrow a_4 = \frac{0.8 - 0.8}{2\tau}$$

$$a_4 = 0\ m/s^2$$

3. What is the nature of motion. Justify.

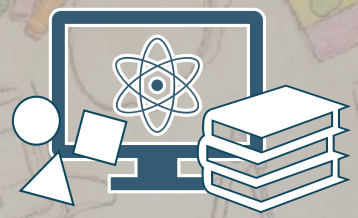
The velocity is constant at $V = 0.8 m/s$ and $a = 0 m/s^2$, then the motion is URM

4. Write the time equation of motion.

$$x = Vt + x_0$$

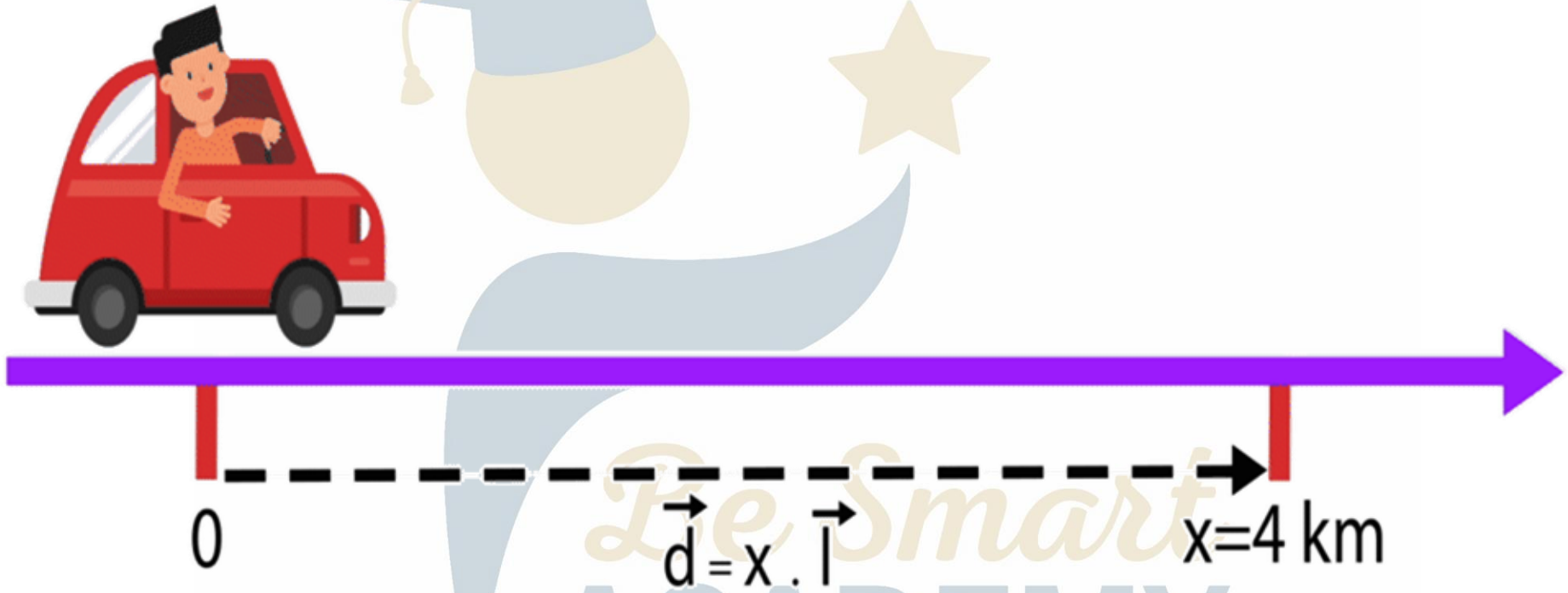
$$x = 0.8t$$

The End



Physics – Grade 10

Unit Four – Mechanics



Chapter 15 – Rectilinear motion

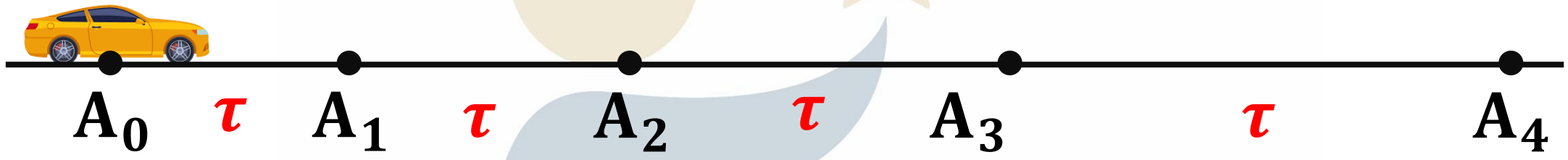
Prepared & Presented by: Mr. Mohamad Seif

OBJECTIVES

1. Study the **U**niformly **A**ccelerated **R**ectilinear **M**otion (UARM)

Uniformly Accelerated Rectilinear Motion (U.A.R.M):

A motion is said to be U.A.R.M if the <u>acceleration is positive & constant ($a > 0$)</u>.



- **The distance covered during equal interval of time increase:**

$$A_3A_4 > A_2A_3 > A_1A_2$$

- **The speed at different instants increases with time:**

$$V_3 > V_2 > V_1$$

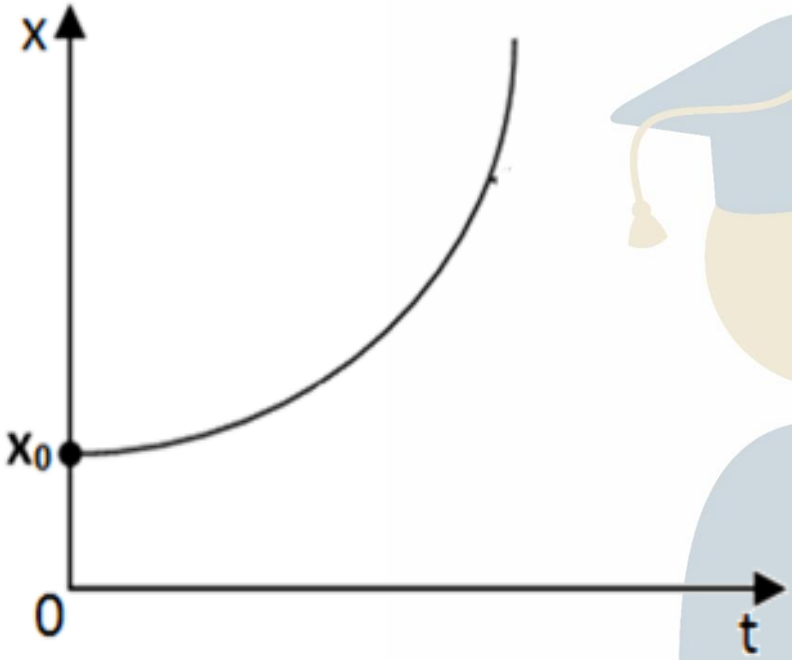
Uniformly Accelerated Rectilinear Motion (U.A.R.M):

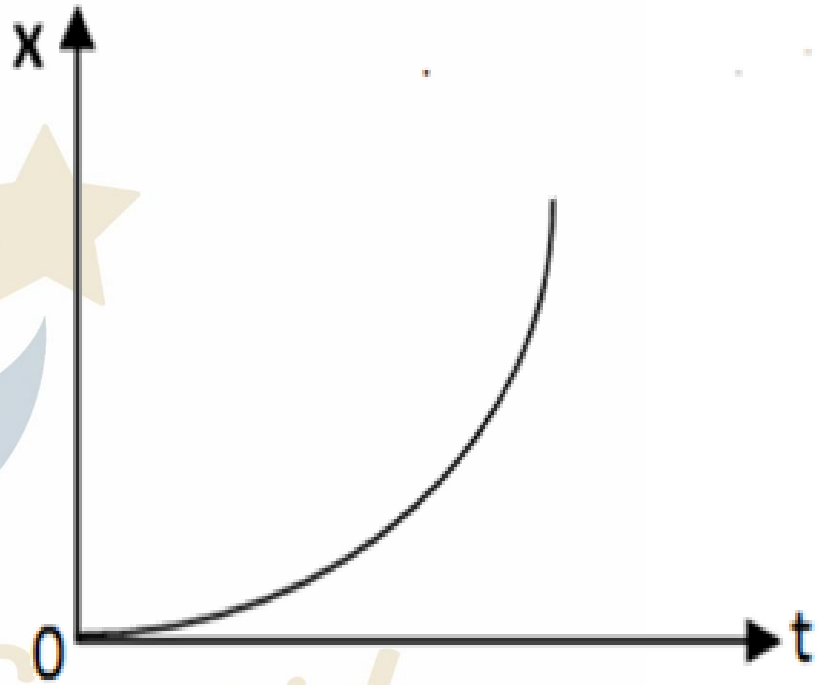
Time equation Motion in distance x:

$$x = \frac{1}{2}at^2 + V_0t + x_0$$

- a: acceleration of motion of the body in m / s^2.
- V_0: initial speed of the body at the starting point in m/s.
- x_0: The initial position of the body at the starting point in m.
- t: The time between initial point and reached point, in seconds

Uniformly Accelerated Rectilinear Motion (U.A.R.M):



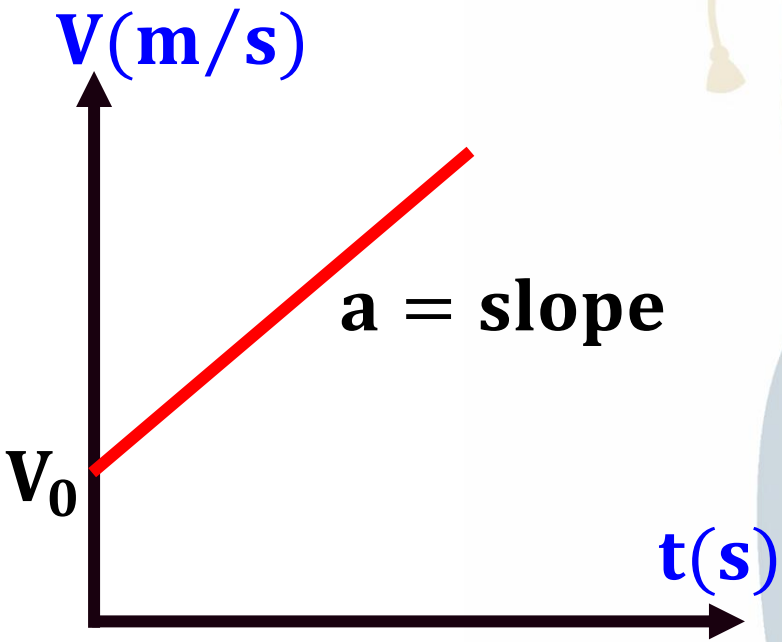


$$x = \frac{1}{2}at^2 + V_0t + x_0$$

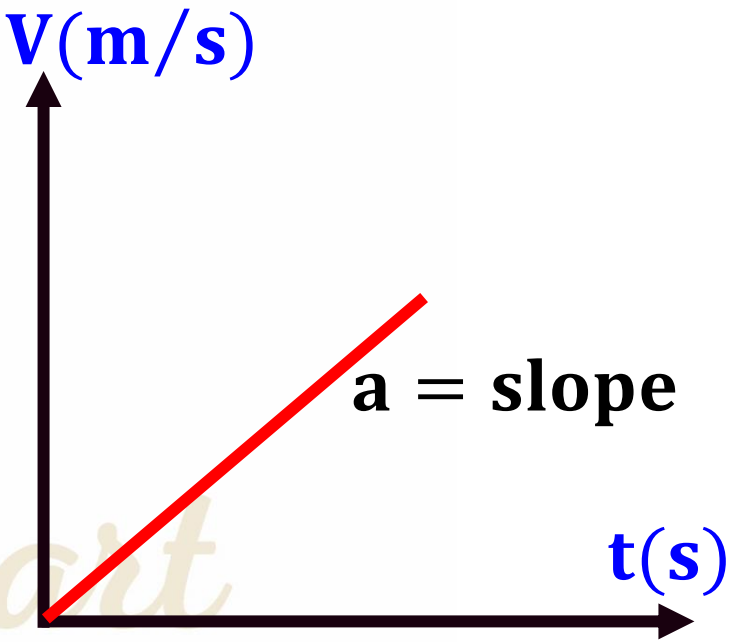
$$x = \frac{1}{2}at^2$$

Uniformly Accelerated Rectilinear Motion (U.A.R.M):

The speed time equation: $v = at + v_0$



$v = at + v_0$



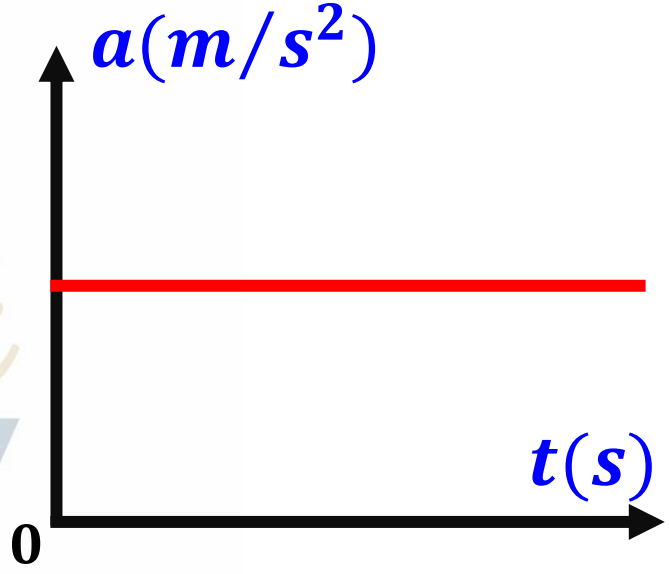
$v = at$

Uniformly Accelerated Rectilinear Motion (U.A.R.M):

The Relation of V and x is:

$$v^2 - v_0^2 = 2a(x - x_0)$$

Recall that the acceleration is constant and positive (a>0)



Uniformly Accelerated Rectilinear Motion (U.A.R.M):

Application 3:

Consider a moving body, moves according the time equation of motion: $x = 4\,t^2 + 10t + 2$

1.Specify the nature of motion? Justify.

2.Determine the value of V_0 and x_0.

3.Calculate the value of the acceleration.

4.Write the speed time equation

5.Determine the position of body at $t = 1s$.

6.Calculate the speed when the body covers a distance $x = 12m$.

Uniformly Accelerated Rectilinear Motion (U.A.R.M):

$x = 4\,t^2 + 10t + 2$

1.Specify the nature of motion? Justify.

The motion is U.A.R.M, because the given equation ($x = 4\,t^2 + 10t + 2$) in the form of $x = \frac{1}{2}at^2 + V_0t + x_0$, where $a > 0$.

Uniformly Accelerated Rectilinear Motion (U.A.R.M):

2.What is the value of $V_0, x_0, \& \ a$.

Compare the two equations:

$x = 4\,t^2 + 10t + 2$ **And** $x = \frac{1}{2}at^2 + V_0t + x_0$

$$V_0 = 10m/s$$

$$x_0 = 2m$$

Uniformly Accelerated Rectilinear Motion (U.A.R.M):

3.Calculate the value of the acceleration.

$$\begin{cases} x = 4t^2 + 10t + 2 \\ x = \frac{1}{2}at^2 + V_0t + x_0 \end{cases}$$

$$4 = \frac{1}{2}a \Rightarrow \frac{4}{1} = \frac{1 \times a}{2} \Rightarrow 4 \times 2 = 1 \times 1 \times a$$

$$a = 8m/s^2$$

Uniformly Accelerated Rectilinear Motion (U.A.R.M):

4. Write the speed time equation.

$$V = at + V_0$$

$V_0 = 10m/s$ and $a = 8m\ /\ s^2$

$$V = 8t + 10$$

5. Determine the position of body at $t = 1s$

$x = 4\ t^2 + 10t + 2$ ⇒ $x = 4\ (1)^2 + 10(1) + 2$

$$x = 16m$$

Uniformly Accelerated Rectilinear Motion (U.A.R.M):

6. Calculate the speed when the body covers a distance $x = 12m$.

$$V^2 - V_0^2 = 2ax \Rightarrow V^2 - (10)^2 = 2 \times 8 \times 12$$

$$V^2 - 100 = 192$$

$$V^2 = 192 + 100$$

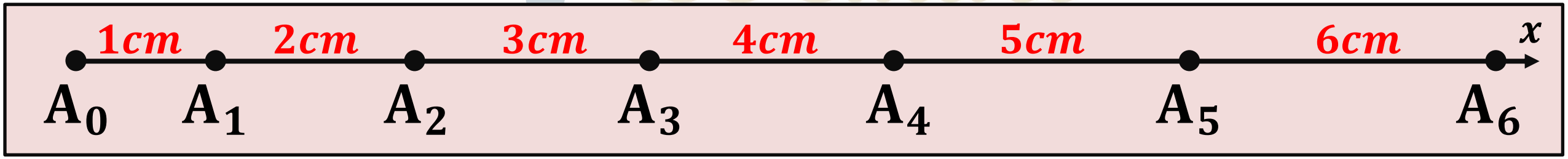
$$V^2 = 292 \Rightarrow V = \sqrt{292}$$

$$V \simeq 17m/s$$

Uniformly Accelerated Rectilinear Motion (U.A.R.M):

Application 4:

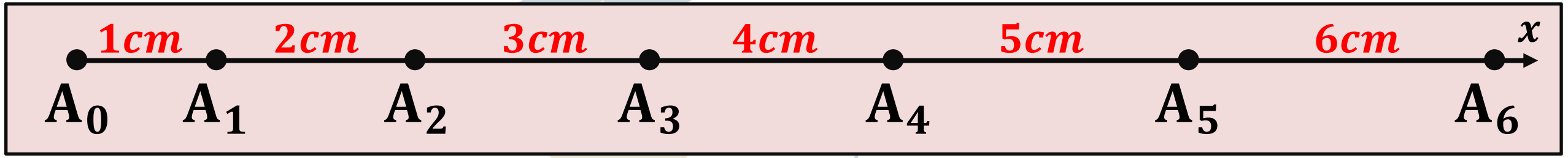
A puck moves along a on a horizontal line starting from A_0. The time intervals between successive points is $\tau = 100ms$ as shown in the figure below.



Uniformly Accelerated Rectilinear Motion (U.A.R.M):

1. Calculate the instantaneous speeds of the puck V_1, V_2 and V_4 at A_1, A_2 and A_4 respectively.
2. Calculate the instantaneous acceleration a_3 of the puck.
3. Deduce the nature of motion of the puck.
4. Calculate the value of the initial speed V_0.
5. Write the expressions of the time equations $x(t)$ and $V(t)$ of the motion of the puck.

Uniformly Accelerated Rectilinear Motion (U.A.R.M):



1.Calculate the instantaneous speeds of the puck V_1, V_2 and V_4 at A_1, A_2 and A_4 respectively.

$$V_1 = \frac{A_0A_2}{t_2 - t_0} = \frac{A_0A_2}{2\tau - 0} \Rightarrow V_1 = \frac{(1+2) \div 100}{(2 \times 100) \div 1000}$$

$$V_1 = \frac{0.03}{0.2} \Rightarrow V_1 = 0.15m/s$$

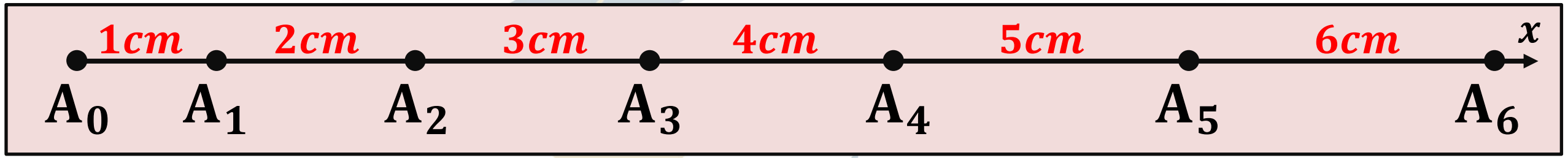
Uniformly Accelerated Rectilinear Motion (U.A.R.M):

1.Calculate the instantaneous speeds of the puck V_1, V_2 and V_4 at A_1, A_2 and A_4 respectively.

$$V_2 = \frac{A_1A_3}{t_3 - t_1} = \frac{A_1A_3}{3\tau - 1\tau} \Rightarrow V_2 = \frac{(2+3) \div 100}{(2 \times 100) \div 1000}$$

$$V_2 = \frac{0.05}{0.2} \Rightarrow V_2 = 0.25 m/s$$

Uniformly Accelerated Rectilinear Motion (U.A.R.M):

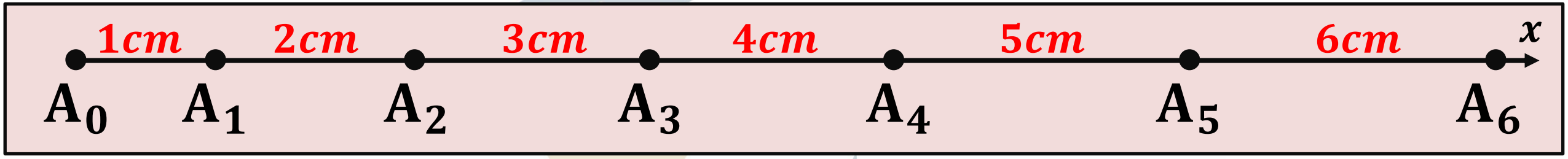


1.Calculate the instantaneous speeds of the puck V_1, V_2 and V_4 at A_1, A_2 and A_4 respectively.

$$V_4 = \frac{A_3A_5}{t_5 - t_3} = \frac{A_3A_5}{5\tau - 3\tau} \Rightarrow V_4 = \frac{(4+5) \div 100}{(2 \times 100) \div 1000}$$

$$V_4 = \frac{0.09}{0.2} \Rightarrow V_4 = 0.45m/s$$

Uniformly Accelerated Rectilinear Motion (U.A.R.M):



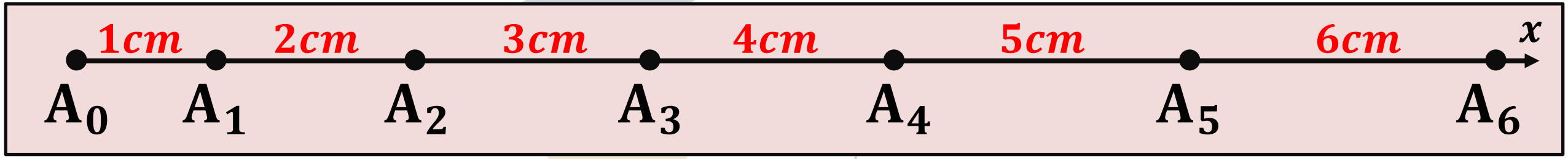
2. Calculate the acceleration $a_{1,2}$ and a_3 of the puck.

$$a_{1,2} = \frac{V_2 - V_1}{t_2 - t_1} \Rightarrow a_{1,2} = \frac{0.25 - 0.15}{2\tau - \tau}$$

$$a_{1,2} = \frac{0.2}{2\tau} = \frac{0.1}{100 \div 1000} \Rightarrow a_{1,2} = \frac{0.1}{0.1}$$

$$a_{1,2} = 1m / s^2$$

Uniformly Accelerated Rectilinear Motion (U.A.R.M):



2. Calculate the acceleration $a_{1,2}$ and a_3 of the puck.

$$a_3 = \frac{V_4 - V_2}{t_4 - t_2} \Rightarrow a_3 = \frac{0.45 - 0.25}{4\tau - 2\tau}$$

$$a_3 = \frac{0.2}{2\tau} = \frac{0.2}{(2 \times 100) \div 1000} \Rightarrow a_3 = \frac{0.2}{0.2}$$

$$a_3 = 1m / s^2$$

Uniformly Accelerated Rectilinear Motion (U.A.R.M):

3. Deduce the nature of motion of the puck.

Because the acceleration is constant and positive ($1m/s^2$), then the motion is U.A.R.M.

4. Calculate the value of the initial speed V_0.

$$V_2{}^2 - V_0^2 = 2ax \quad \Rightarrow \quad V_2{}^2 - V_0^2 = 2a(A_0A_2)$$

$$(0.25)^2 - V_0^2 = 2 \times 1 \times (3cm \div 100)$$

$$0.0625 - V_0^2 = 2 \times 0.03 \quad \Rightarrow \quad 0.0625 - V_0^2 = 0.06$$

$$0.0625 - 0.06 = V_0^2 \quad \Rightarrow \quad V_0^2 = 0.0025 \quad \Rightarrow \quad V_0 = 0.05m/s$$

Uniformly Accelerated Rectilinear Motion (U.A.R.M):

5. Write the expressions of the time equations $x(t)$ and $V(t)$ of the motion of the puck.

$$x = \frac{1}{2} a\, t^2 + V_0 t + x_0$$

$$x = \frac{1}{2}(1)\, t^2 + (0.05)t + 0$$

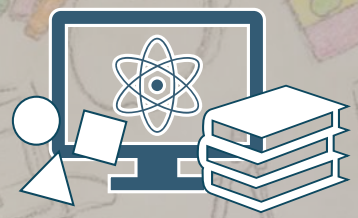
$$x = 0.5\, t^2 + 0.05t$$

$$V = at + V_0$$

$$V = (1)t + 0.05$$

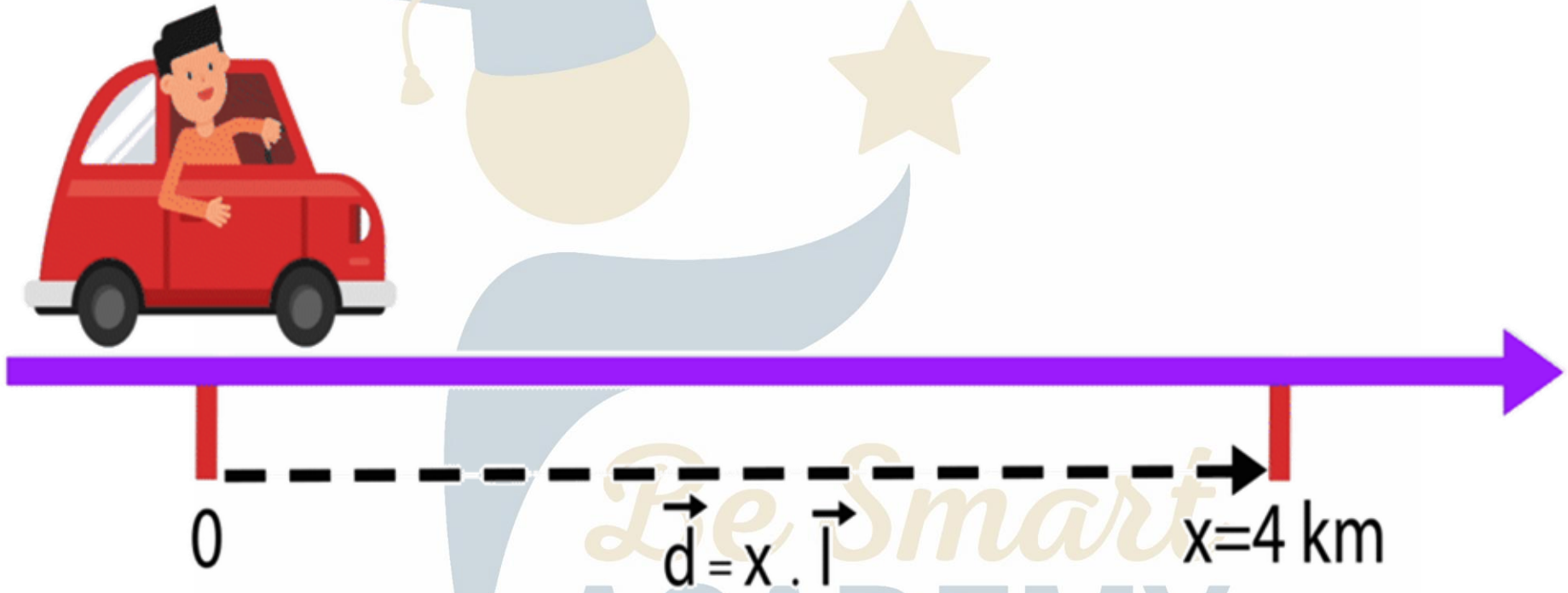
$$V = t + 0.05$$

The End



Physics – Grade 10

Unit Four – Mechanics



Chapter 15 – Rectilinear motion

Prepared & Presented by: Mr. Mohamad Seif

OBJECTIVES

1. Study the Uniformly Decelerated Rectilinear Motion (UDRM)

Uniformly Decelerated Rectilinear Motion (U.D.R.M):

A motion is said to be U.D.R.M if the <u>acceleration is negative & constant ($a < 0$)</u>.

- **The distance covered during equal interval of time decrease:**

$$A_0A_1 > A_1A_2 > A_2A_3$$

- **The speed at different instants decreases with time:**

$$V_3 < V_2 < V_1$$

Uniformly Decelerated Rectilinear Motion (U.D.R.M):

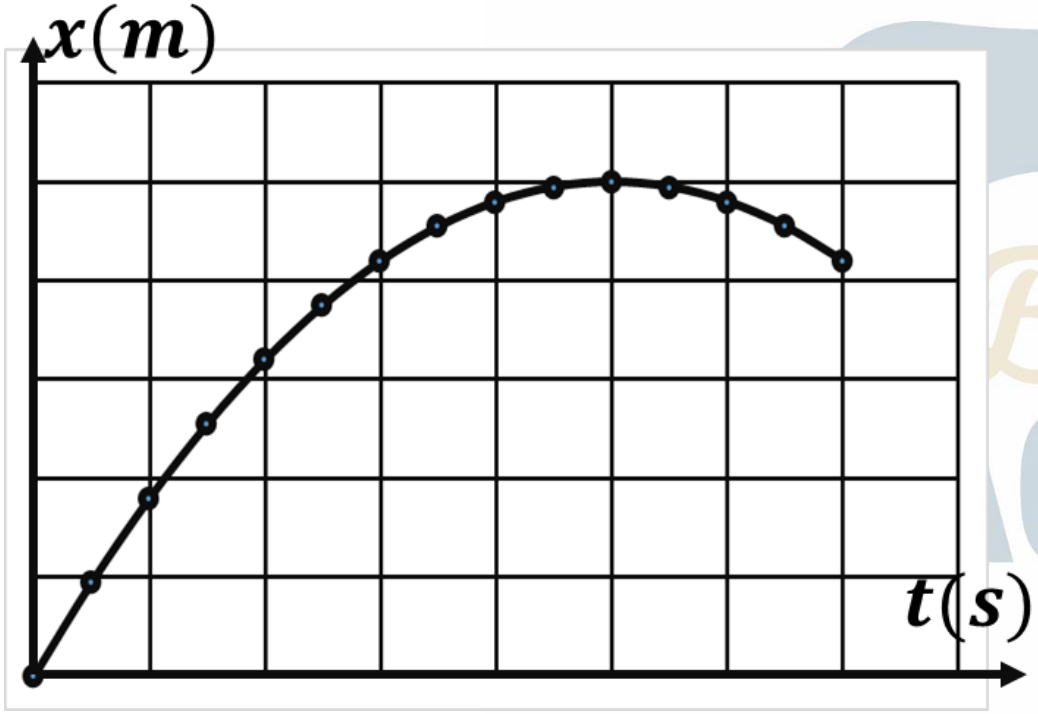
Time equation Motion in distance x:

$$x = \frac{1}{2}at^2 + V_0t + x_0$$

- $a < 0$: acceleration of motion of the body in m / s^2.
- V_0: initial speed of the body at the starting point in m/s.
- x_0: The initial position of the body at the starting point in m.
- t: The time between initial point and reached point, in seconds

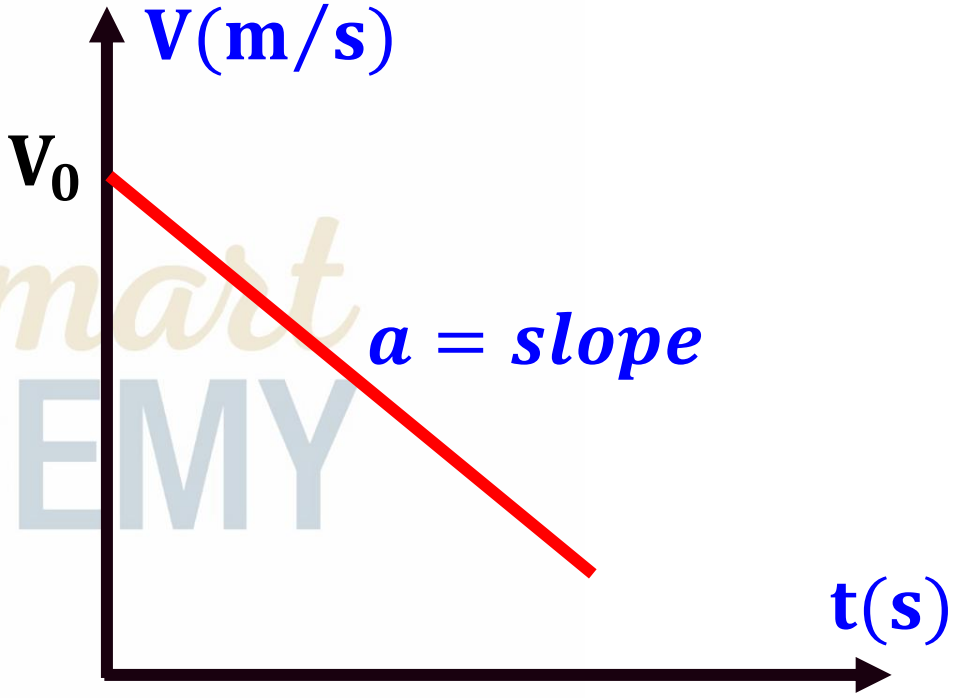
Uniformly Decelerated Rectilinear Motion (U.D.R.M):

$$x = \frac{1}{2}at^2 + V_0t + x_0$$



The speed time equation:

$$v = at + v_0$$

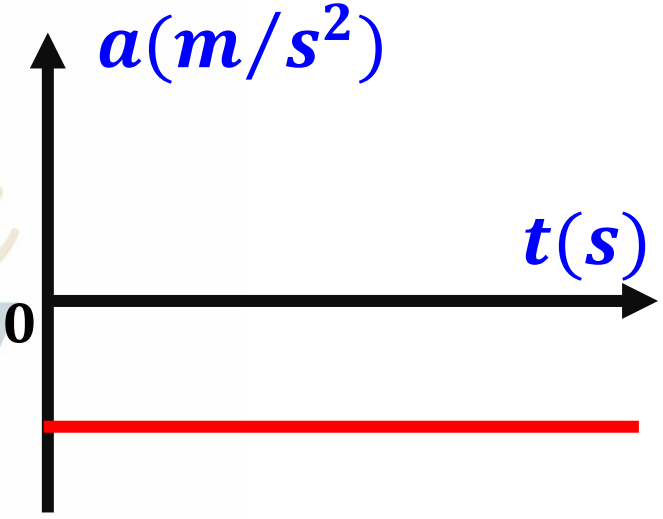


Uniformly Decelerated Rectilinear Motion (U.D.R.M):

The Relation of V and x is:

$$v^2 - v_0^2 = 2a(x - x_0)$$

Recall that the acceleration is constant and negative (a<0)



Uniformly Decelerated Rectilinear Motion (U.D.R.M):

Application 5:

A puck moves along a straight line having a time equation $x = -2t^2 + 20t$ in SI units.

1. Indicate the type of motion of the puck.

The motion of the puck is U.D.R.M, because the equation ($x = -2t^2 + 20t$) in the form of $x = \frac{1}{2}at^2 + V_0t + x_0$ with $a < 0$.

Uniformly Decelerated Rectilinear Motion (U.D.R.M):

2. Determine the value of V_0 and x_0.

$$x = \frac{1}{2}at^2 + V_0t + x_0$$

$$x = -2\,t^2 + 20t$$

Compare

$$V_0 = 20m/s$$

$$x_0 = 0m/s$$

Uniformly Decelerated Rectilinear Motion (U.D.R.M):

3. Calculate the acceleration of the puck.

$$x = \frac{1}{2}at^2 + V_0t + x_0$$

$$x = -2t^2 + 20t$$

Compare

$$\frac{1}{2}a = -2 \Rightarrow \frac{1 \times a}{2} = \frac{-2}{1} \Rightarrow (1 \times a) \times 1 = -2 \times 2$$

$$a = -4m/s^2$$

Uniformly Decelerated Rectilinear Motion (U.D.R.M):

4. Determine the position of body at $t = 1s$.

$$x = -2t^2 + 20t \Rightarrow x = -2(1)^2 + 20(1) \Rightarrow x = 18m$$

5. Write the speed time equation of particle (S).

$$V = at + V_0$$

$$V = -4t + 20$$

The End