RECTILINEAR MOVEMENT

This teaching unit continues the study of movement which we began in these two previous units:

Moving bodies and Trajectory and Displacement

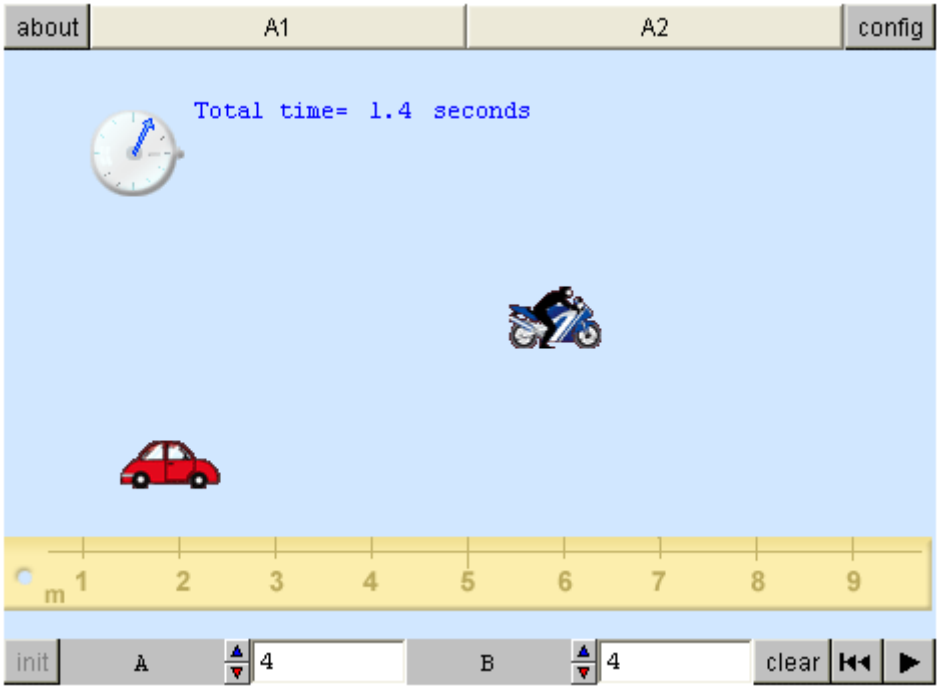
In this one we look separately at Uniform movement and Uniformly accelerating movement, although we constantly compare them.

OBJECTIVES

- To recognize the characteristics of uniform rectilinear movements and uniformly accelerating movements.
- To relate data tables with graphs.
- To use the concept of the slope of a straight line to calculate velocities and acceleration.
- To calculate the space covered by a moving body from its v/t .
- To know and apply the equations of the movements studied.

1.2 What is a uniform movement?

A body describes a uniform rectilinear movement when its trajectory is a straight line and also its velocity remains invariable.

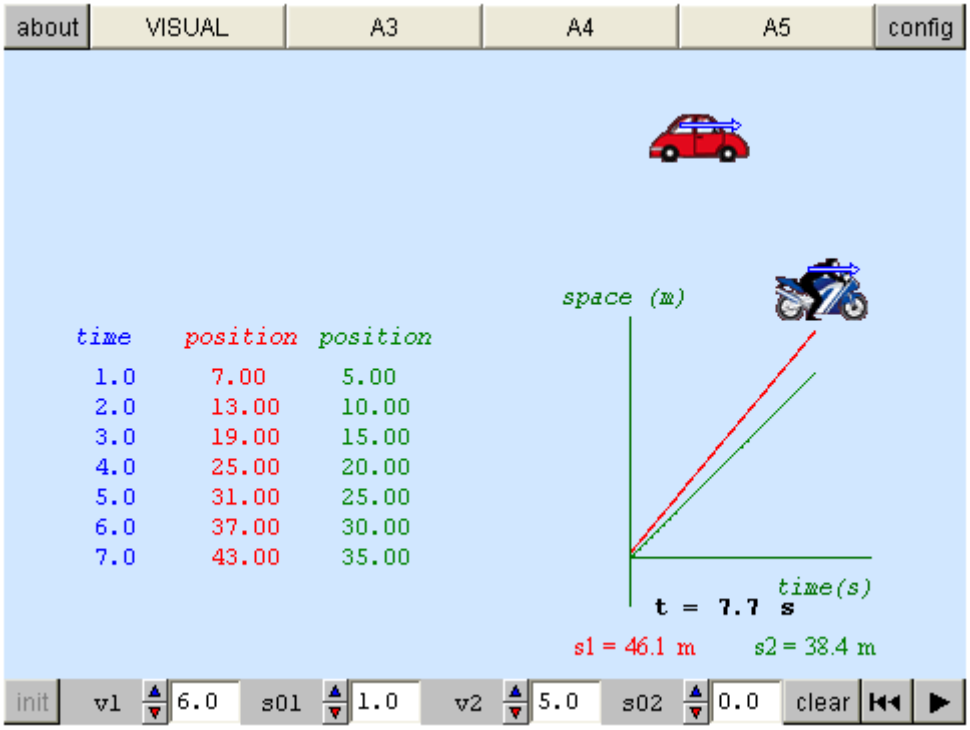


A1: Here are two bodies in uniform rectilinear movement. Find out which letter (A or B) is responsible for each movement.

A2: Modify the values of the letters so that: a) both objects reach the end at the same time. b) the winner of the first race arrives last in your race.

1.2 Uniform movement: data table and s/t graph

The space covered in a Uniform Movement can be represented as a function of time. As in this movement the space covered and the time taken are proportional: the graph is always a straight line whose slope represents the speed of the movement. Regardless of the direction of the movement the space covered by the moving body is always positive.



VISUAL: This visual represents a body in a uniform movement. The velocity is represented by a vector. A data table is represented simultaneously with the movement: It shows the displacement (s-s0) every second, and the space (s-s0) vs. time graph. Remember that when the body does not change the orientation of its movement, the displacement (s-s0) is equal to the space covered.

A3: Modify the starting point of the movement (s01 and s02) and observe how the values of the data table and graph change.

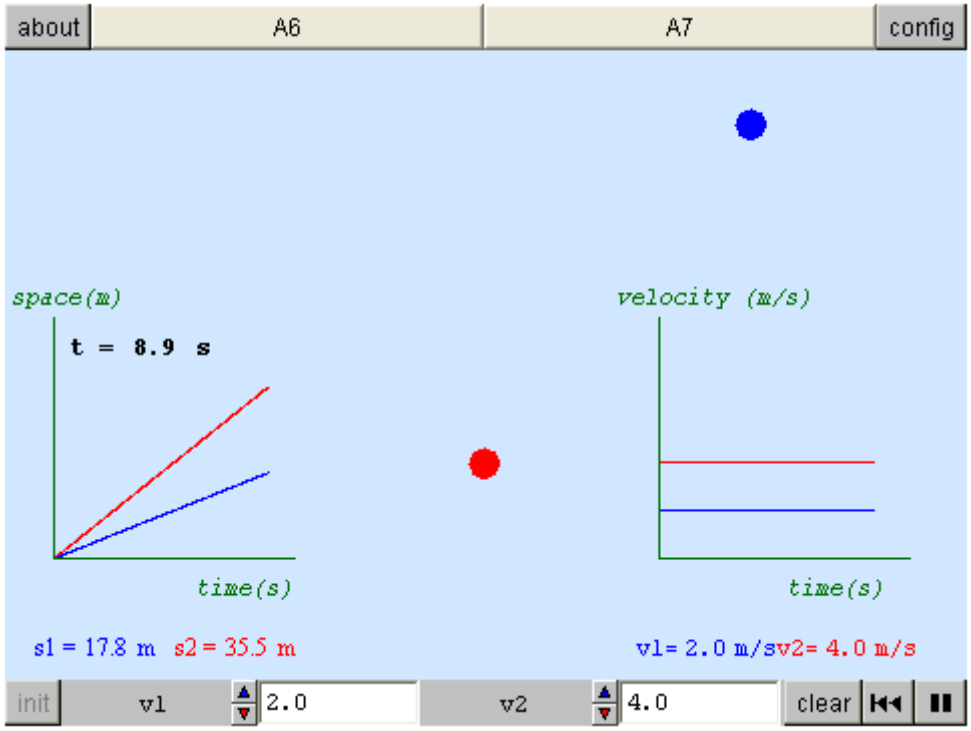
A4: Change the speed and observe the change in the values on the data table and in the slope of the graph.

A5: Modify the values of the velocity in order to change the orientation of the movement. Try to make the two s/t graphs intersect. What does the intersection point mean, from a physical point of view?

2.1 Uniform movement: s/t and v/t graphs

The space covered in a movement can be represented as a function of time. As in this (UNIFORM) movement the space covered and the time taken are proportional: the graph is **always a straight line whose slope is velocity**. Regardless of the orientation and direction of the movement, the space covered by the moving body is always positive.

The velocity of a uniform movement can be represented as a function of time. As the velocity does not vary in this type of movement, the graph is **always a straight line parallel to the time axis**.

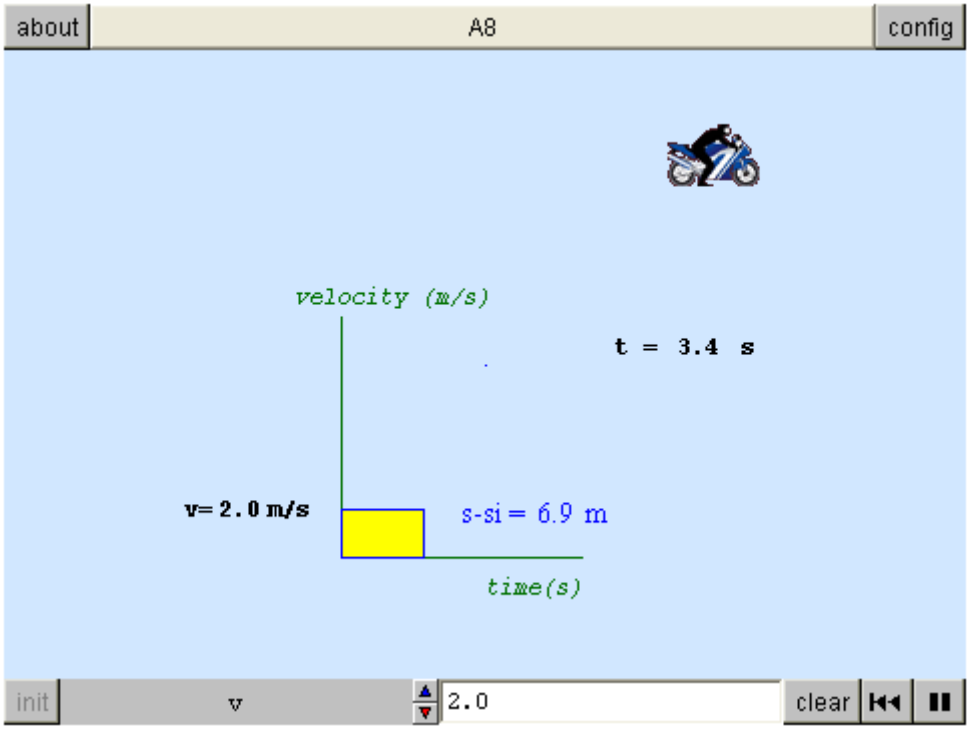


A6: Modify the values of the controls and you will see how the two graphs change.

A7: Choose the maximum and minimum values of the velocity and you will observe great changes.

2.2 Uniform movement: area under the v/t curve

The area under the v/t curve coincides with the displacement of the moving body.



A8: Change the values of v and observe the value of the area of the rectangle that is formed as time goes by. Verify that, whatever value you choose, this is always true.

The area under the v/t curve coincides with the displacement of the moving body.

More than a coincidence this is a law:

"The area under the v/t graph always coincides with the space covered by the moving body".

The figure formed between the v/t graph and the time axis is a rectangle. As the area of a rectangle is base x height, we can say that in any uniform rectilinear movement:

$s-s_0=v.t$	Equation you can apply to any **Uniform Movement.**

3.1 What is acceleration?

The area under the v/t curve coincides with the displacement of the moving body.

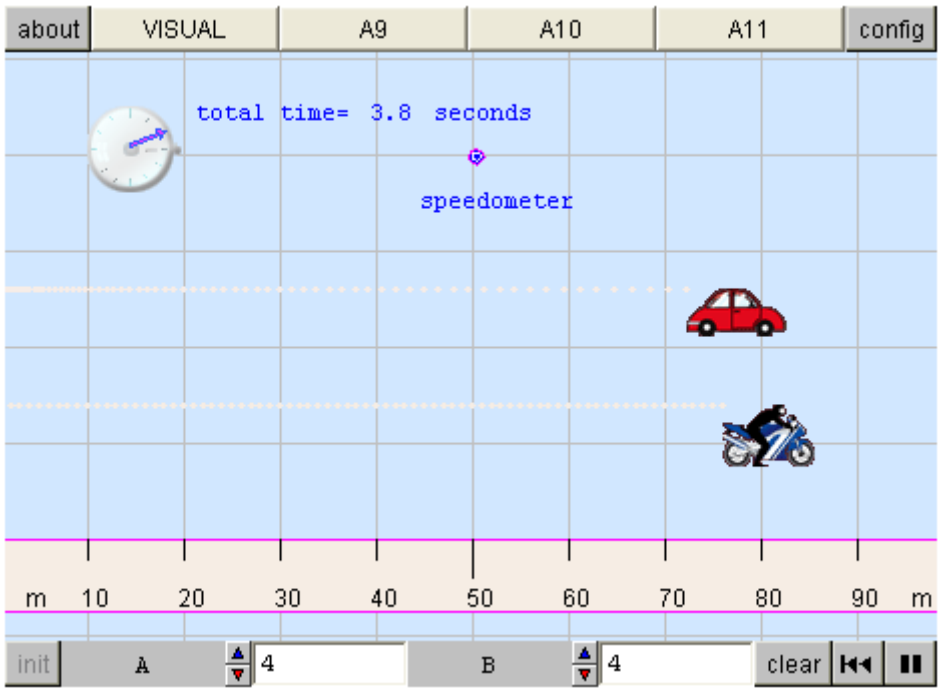
A body **accelerates** when its velocity varies. If the velocity decreases, we say that it is a decelerating movement, or that it has negative acceleration. The body in the visual is accelerating.

To calculate the acceleration of a body over an interval of time, $(t-t_0)$ you divide the variation in velocity by that time.

$$a = \frac{(v-v_0)}{(t-t_0)}$$

Given that acceleration is a quotient relating velocity and time, its SI units are m/s^2.

A body **accelerates** when its velocity varies. If the velocity decreases, it is also said to be a **decelerated** movement or that it has negative acceleration.



VISUAL: In this visual there are two objects: one changes it´s velocity, the other does not; which is which? With the help of the speedometer (blue dot) you can see the speed at which it was moving at any moment. To see the time, click on pause at the right moment and look at the chronometer.

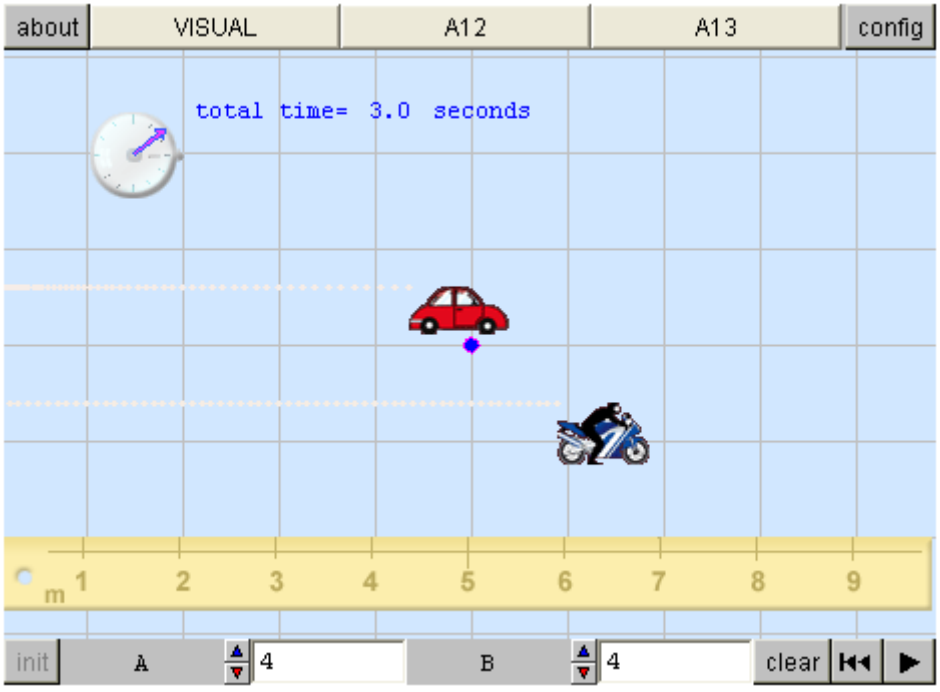
A9: Which of the objects is accelerating? Drag the speedometer to different points of the trajectory to see the velocity of the body when it went through that point.

A10: Calculate the acceleration. As the accelerated body starts its movement still, you only have to measure the speed at any point and divide it by the time it took the body to get there. Pause the visual frequently. Is the acceleration constant?

A11: Use the controls to make both objects arrive simultaneously at the end of the visual

3.2 Uniformly accelerated movement

A body is said to have a Uniformly Accelerated Movement (U.A.M.) when its acceleration is constant.



VISUAL: In this visual two accelerated movements are represented, one of them is uniformly accelerated and the other is not. You have a control that allows you to see the values of the velocity and the time (speedometer/chronometer). Drag it to the point where you want to know the velocity and time.

A12: Which of the two movements is uniformly accelerated? Drag the speedometer to points separated by a fixed time. Observe, for example, how much the velocity increases per second for each object.

A13: What is the speed of each object when it leaves the visual? Drag the speedometer/chronometer along each trajectory and measure the speed at the edge of the visual.

3.3 Uniformly accelerated movements: data table and s/t graph

The following visual represents two bodies: one with a **uniform movement** and the other with a **uniformly accelerated movement**. Velocity is represented by a vector.

Simultaneously with the movements we see:

- a data table:indicating the position of the body ($s-s_0$) for each second that passes,
- the graph ($s-s_0$) versus time.

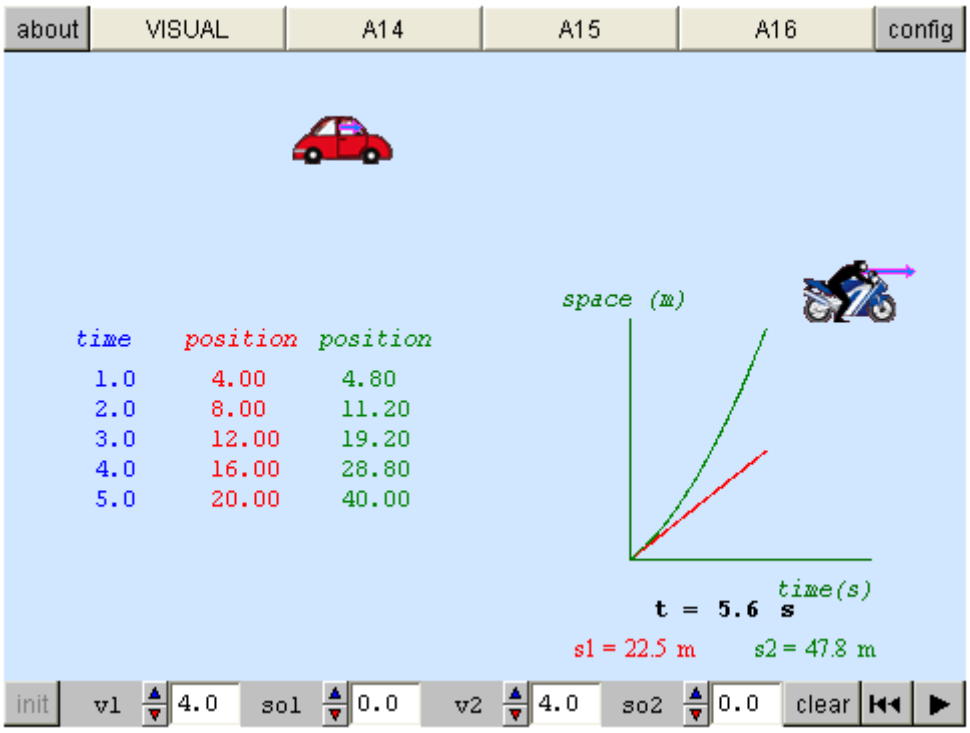
Remember that when the moving body does not change its direction, displacement ($s-s_0$) coincides with the space covered.

In ***uniform movements*** bodies cover equal space in equal time.	The graph of ($s-s_0$) as a function of t is a ***straight line***. The gradient of the straight line (slope) is the velocity. The point of intersection with the vertical axis is the initial position.
In uniformly accelerated movements bodies cover more space as time passes.	The graph of (s-s0) as a function of t is a parabola. Velocity varies at each point; it is the slope of the straight line tangential to the curve at that point. The point of intersection with the vertical axis is the initial position.

Simultaneously with the movements we see:

- a data table indicating the position of the body ($s-s_0$) for each second that passes
- the ($s-s_0$) curve as a function of time.

Remember that when the moving body does not change the direction of movement, displacement ($s-s_0$) coincides with the space covered.



VISUAL: This visual represents two objects: one is moving uniformly and the other is uniformly accelerated. Speed is represented by a vector.

A14: Observe the movement of the objects. A data table and the (s-s0)/t graph are created simultaneously. Modify the starting point of the movement (s0) and observe the variation in the data table and the graph. Use the clear button every time you change the values of the controls. Then click init to erase the table and graph.

A15: Calculate how much the space covered increases for each movement by using the values in the data table.

A16: Change the velocities and observe the variation of the values in the data table and the slope of the graph of the Uniform Movement. Note the stretching and squashing of the parabola for the Uniformly Accelerated Movement.

4.1 Uniformly accelerated movements: s/t, v/t and a/t graphs

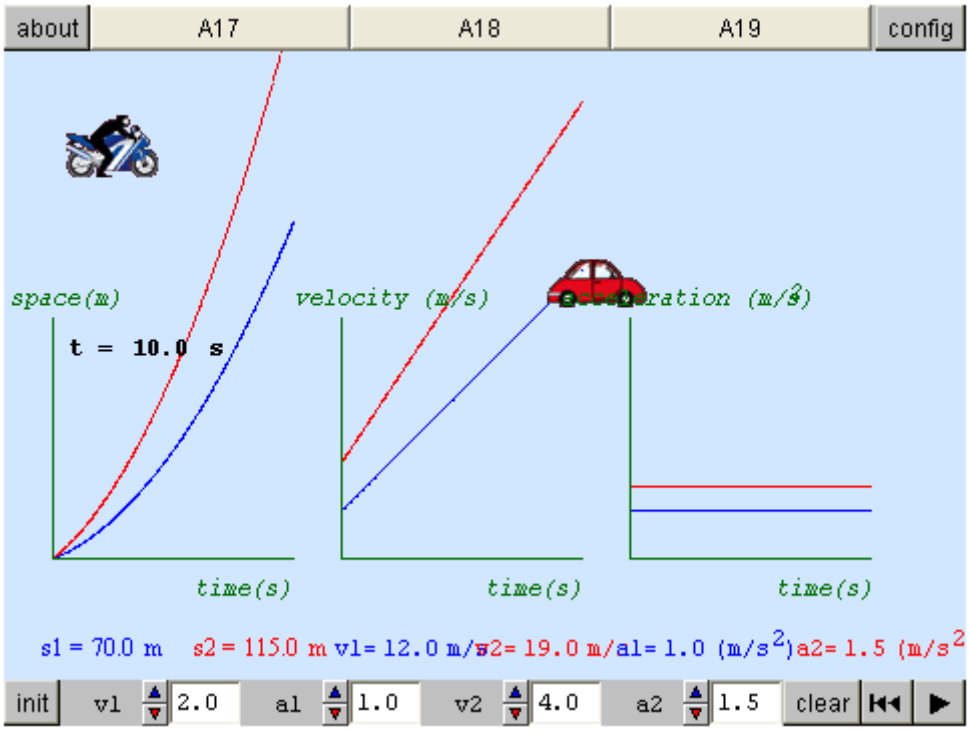
The v/t and a/t graphs as well as the s/t graph we have already seen give us a lot of information about the movement of bodies. In a Uniformly Accelerated Movement velocity varies proportionally to time, so that the v/t curve is a

straight line. In this type of movement acceleration is constant, so that the a/t graph is a straight line parallel to the time axis.

To summarise, and comparing the graphs of Uniform Movement and Uniformly Accelerated Movement:

Graph	s/t	v/t	a/t
Uniform Movement	straight line	straight line with 0 slope	straight line coinciding with t
Uniformly Accelerated Movement	parabola	straight line with # 0 slope	straight line with 0 slope

Can you tell what type of movement it represents by looking at a graph?...



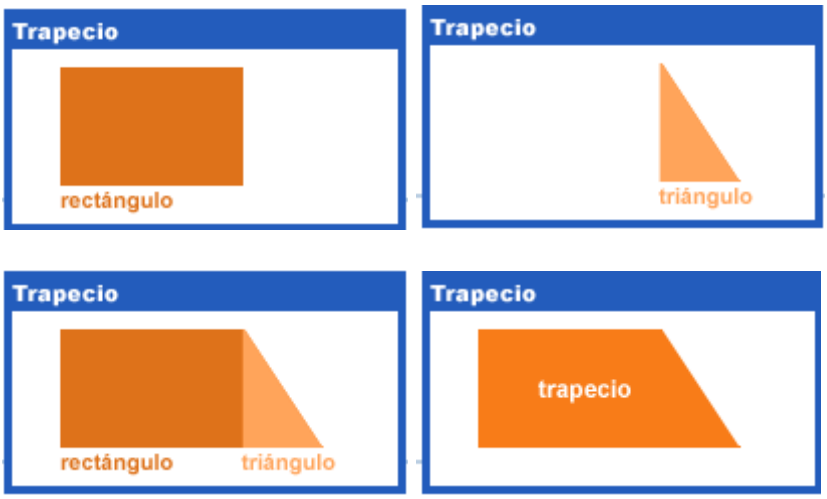
A17: See if the graphs correspond to a Uniform Movement

A18: Change the value of the acceleration of one of the objects and observe the variation in the s/t and v/t graphs.

A19: Modify the values with the controls, select the greatest and smallest values of velocity and acceleration. You will see great differences.

4.1 Uniformly accelerated movement: area under the v/t curve

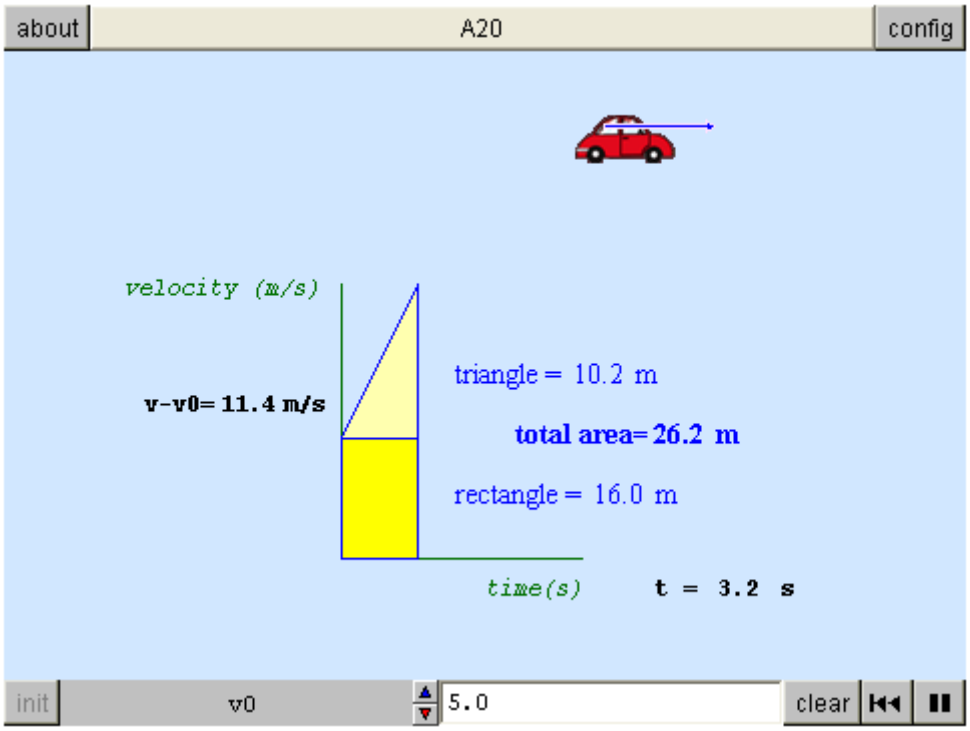
In a Uniformly Accelerated Movement, as in Uniform Movement, the area under the v/t curve always coincides with the space covered by the moving body.
In a Uniformly Accelerated Movement, the figure formed by the v/t graph and the time axis is a trapezium. The trapezium is formed by a rectangle and a triangle.



The area of the trapezium is equal to the area of the triangle plus the area of the rectangle

Area of the rectangle:
base x height
Area of the triangle:
(base x height)/2

However much you vary the speed, the shape of the v/t graph does not vary, it is a trapezium, that is, a rectangle and a triangle.



A20: Change the values of v and observe the change in the value of the area of the trapezium (triangle plus rectangle) that is formed as time goes by. Remember that the area of the triangle is (base x height)/2. Here, the base is t and the height is v-v0.

EVALUATION

Have you learned a lot, a little, anything?

Can you

- Recognize the characteristics of uniform and uniformly accelerated rectilinear movements?
- Relate data tables with graphs?
- Use the concept of the slope of a straight line to calculate velocities and acceleration?

Calculate the space covered by a moving body from its v/t graph?

EVALUATION

Have you learned a lot, a little, anything?

Can you

- Recognize the characteristics of uniform and uniformly accelerated rectilinear movements?
- Relate data tables with graphs?
- Use the concept of the slope of a straight line to calculate velocities and acceleration?
- Calculate the space covered by a moving body from its v/t graph?
- Recognize and apply the equations of the movements studied?

To find out, do the following exercise in Evaluation

1	A moving body with an acceleration of 2 m/s2
☐	increases its velocity by 2 metres every second squared.
☐	increases its velocity by 2 m/s per second.
☐	decreases its speed by 2m/s per second
☐	increases its velocity by 2 m/s.
2	The area under the v/t curve
☐	remains constant as time goes by.
☐	is equal to the time at which the movement started.
☐	is equal to the distance covered by the moving body.
☐	is equal to the speed of the moving body.
3	In this visual, what values must the controls be set to so that the objects reach the end of the visual at the same time?
☐	A=8 and B=8
☐	A=8 and B=6
☐	A=6 and B=8
☐	A=6 and B=6
4	In this visual

☐	the speed of the car is 4*B
☐	the speed of the car is 5*B
☐	the speed of the motorbike is 4*B
☐	the speed of the motorbike is 5*B

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5 In a Uniformly Accelerated Movement, the v/t graph

☐	is a curve like this: 
☐	is a straight line like this: 
☐	is a curve like this: 
☐	is a straight line like this: 

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6 The area under the v/t graph of a Uniformly Accelerated Movement

☐	is equal to the area of a triangle
☐	is equal to the area of a trapezium
☐	is equal to the average velocity.
☐	is equal to the distance covered

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7 When an object moving uniformly along a straight line starts to move in the opposite direction:

☐	the slope of the s/t graph might change
☐	the slope of the s/t graph changes.
☐	the slope of the s/t graph does not change

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8 In this visual

☐	The acceleration of the car is constant.
☐	the speed of the car is constant.
☐	The acceleration of the car increases.
☐	The acceleration of the car decreases.

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9 Every Uniform Rectilinear Movement

- [ ] has an s/t graph that may or may not be a line that goes through the origin of coordinates
- [ ] has an s/t graph that is a straight line that may, or may not go through the origin
- [ ] has an s/t graph that is a curve that does not go through the origin
- [ ] has a straight s/t graph that goes through the origin of coordinates

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10 If the v/t graph of the movement of two objects is like this  , then

- [ ] the blue object moves faster than the red one
- [ ] the blue object leaves before the red object
- [ ] the red object moves faster than the blue one
- [ ] the red object leaves before the blue object

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11 In a Uniform Rectilinear Movement

- [ ] the v/t graph looks like this: 
- [ ] the v/t graph looks like this: 
- [ ] the v/t graph looks like this: 
- [ ] the v/t graph looks like this: 

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12 In a Uniformly accelerated Movement, the s/t graph

- [ ] is a straight line like this: 
- [ ] is a curve that looks like this: 
- [ ] is a curve that looks like this: 
- [ ] is a straight line like this: 

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13 An accelerating body

- [ ] is changing its speed
- [ ] may be moving at a constant speed

- [ ] is moving at a great speed

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14 A movement is rectilinear and uniform when

- [ ] its trajectory is a straight line and it is uniformly accelerated
- [ ] its velocity is constant and its trajectory is a straight line
- [ ] its speed is constant
- [ ] its trajectory is a straight line

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15 The s/t graphs of Uniform Rectilinear Movements

- [ ] have no slope.
- [ ] have a slope that is independent of their speed.
- [ ] have a smaller slope the greater the velocity is.
- [ ] have a greater slope the greater the velocity is.

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16 In a Uniform Rectilinear Movement

- [ ] the s/t graph looks like this: 
- [ ] the s/t graph looks like this: 
- [ ] the s/t graph looks like this: 
- [ ] the s/t graph looks like this: 

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17 In a Uniformly Accelerated Movement, the a/t graph

- [ ] is a curve like this: 
- [ ] is a curve like this: 
- [ ] is a straight line like this: 
- [ ] is a straight line like this: