Kinematics Station Review

Station 1: Uniform versus Non-Uniform Motion

Uniform motion is motion at a constant velocity. This means both the Speed and direction of the motion is constant.

Non-uniform motion means the object is undergoing acceleration.

Either the Speed and/or direction of motion is Changing.

Classify each of the following as uniform or non-uniform motion:

1. A ball thrown up in the air: Non-uniform
   Reason: ball slows down due to gravity
2. A shopper riding up an escalator at constant speed: uniform
   Reason: Speed of motion + direction are constant
3. A car slowing down as it approaches a stoplight: non-uniform
   Reason: speed of motion is changing
4. A rider goes round a Ferris wheel at a constant speed: non-uniform
   Reason: direction of motion changing
5. A batter drives a homerun into the bleachers: non-uniform
   Reason: direction + speed is changing

Station 2: Vector versus Scalar

Measured quantities with units and direction are referred to as Vector quantities.

Measured quantities which do not consider direction are referred to as Scalar quantities.

Identify each of the following as vector or scalar and use the correct symbol to represent the quantity described.

Symbols: Δt, $\vec{a}$, Δd, $\vec{v}$, v, $\vec{d}$, $\overrightarrow{\Delta d}$

Quantities: distance, velocity, speed, displacement, position, time

Description	Vector/ Scalar?	Symbol ?	Quantity Shown?
The puck was 20 m North of the blue line when the play ended.	V	$\vec{d}$	position
The power play lasted 2.00 minutes.	S	Δt	time
The player skated at 15 km/h.	S	v	speed
The car braked at 3.0 km/h/s backwards.	V	$\vec{a}$	acceleration
The train travelled 150 km.	S	Δd	distance
The plane travelled 500 km [NW].	V	$\Delta\vec{d}$	displacement
The truck travelled at 50 km/h [East] on the 401 Highway.	V	$\vec{v}$	Velocity

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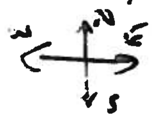
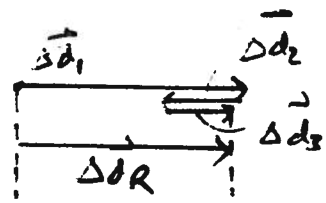
Station 3: Distance versus Displacement

Starting from school, you walk **1.5 km East** to Tim Horton's for an IceCap. You then walk **0.5 km West** to pick up your little brother at SunnyView Public School. You and your brother then walk **0.4 km East** to your house.

Find your distance travelled. Find your resultant displacement.





$\Delta\vec{d}_1 = 1.5$ Km [E]

$\Delta\vec{d}_2 = 0.5$ Km [W]

$\Delta\vec{d}_3 = 0.4$ Km [E]

$\Delta\vec{d}_R = ?$

$\Delta d = ?$

Let [E] = +

$\Delta\vec{d}_R = \Delta\vec{d}_1 + \Delta\vec{d}_2 + \Delta\vec{d}_3$

$= 1.5\text{ Km} - 0.5\text{ Km} + 0.4\text{ Km}$

$= 1.4\text{ Km}$

$= 1.4$ Km [E]

∴ Your displacement was 1.4 Km [E] and your distance travelled was 2.4 Km.

$\Delta d = \Delta d_1 + \Delta d_2 + \Delta d_3$

$= 1.5\text{ Km} + 0.5\text{ Km} + 0.4\text{ Km}$

$= 2.4\text{ Km}$

Station 4: Acceleration

The kinematics of a jumping flea can be analyzed using high resolution video. In the first part of the motion, the flea uses its legs to "push off" the ground. This motion lasts

1.0 x 10 $^{-3}$ seconds. What is its acceleration if it reaches a velocity of 1.0 m/s [up] at the end of the push off?

$\Delta t = 1.0 \times 10^{-3}$ s

$\vec{v}_1 = 0.0$ m/s

$\vec{v}_2 = 1.0$ m/s [up]

$\vec{a} = ?$

Let up = +

$$\vec{a} = \frac{\vec{v}_2 - \vec{v}_1}{\Delta t}$$

$$= \frac{1.0\text{ m/s} - 0.0\text{ m/s}}{1.0 \times 10^{-3}\text{ s}}$$

$$= 1.0 \times 10^{3}\text{ m/s}^2\text{ [up]}$$

$\therefore$ the flea accelerated at 1.0×10^{3} m/s^2 [up].

Station 5: Displacement

During a 30.0 second booster phase, the velocity of a rocket changes from 200.0 m/s [Up] to 500.0 m/s [Up]. Assuming constant acceleration, determine the displacement of the rocket during this time interval.

$\Delta t = 30.0 s$

$\vec{v}_1 = 200.0 m/s [up]$

$\vec{v}_2 = 500.0 m/s [up]$

$\Delta \vec{d} = ?$

let up = +

$\Delta \vec{d} = \frac{1}{2}(\vec{v}_1 + \vec{v}_2)\Delta t$

$= \frac{1}{2}(200.0 m/s + 500.0 m/s) \times 30.0 s$

$= \frac{1}{2}(700.0 m/s)(30.0 s)$

$= 10,500 m [up]$

$= 1.05 \times 10^4 m [up]$

$\therefore$ the displacement was $1.05 \times 10^4 m$ [up].

Station 6: Final Velocity

As it approaches a construction zone, a car travelling at 17.0 m/s [East] slows down at a rate of 1.5 m/s² [West] for 9.0 seconds. What is its final velocity at the end of the acceleration phase?

$\vec{a} = \frac{\vec{v}_2 - \vec{v}_1}{\Delta t}$

$\vec{V}_1 = 17.0 m/s$ [E]

$\vec{a} = 1.5 m/s^2$ [W]

$\Delta t = 9.0 s$

$\vec{V}_2 = ?$

Let E = +

$\vec{V}_2 = \vec{V}_1 + \vec{a}\Delta t$

$= 17.0 m/s + (-1.5 m/s^2)(9.0 s)$

$= 17.0 m/s - 13.5 m/s$

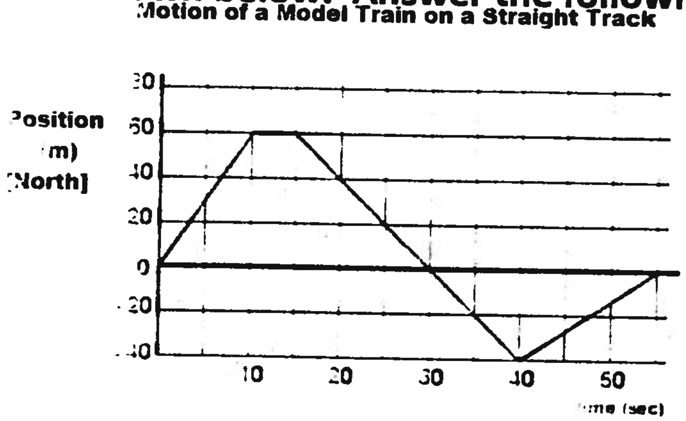
$= 3.5 m/s$

$= 3.5 m/s$ [E]

∴ the car's final velocity is 3.5 m/s [E].

Station 7: Position- Time Graph Analysis

The position time graph for a model train moving back and forth on a straight track is shown below. Answer the following questions:



a) What analysis technique do you use to find velocity? Slope of $\vec{d}$-t graph

b) What is the instantaneous velocity at:

5.0 seconds? $\vec{v}_{avg} = \frac{60-0}{10-0} = 6.0\,m/s$ [N]

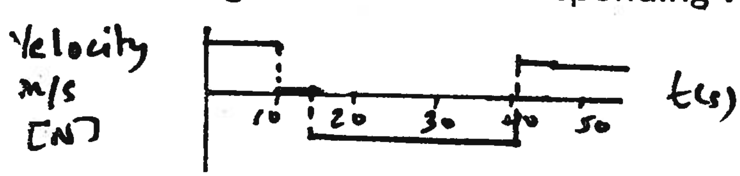
12 seconds? $\vec{v} = 0.0\,m/s$

25 seconds? $\vec{v}_{avg} = -\frac{40-60}{40-15} = \frac{-100}{25} = -4.0\,m/s$ [N] or $4.0\,m/s$ [S]

c) How would the average velocity over the interval from 15 to 40 seconds compare with the instantaneous velocity at 25 seconds? The velocity is uniform over the interval so the instantaneous velocity is the same as the average velocity.

d) Write a brief description of the train's motion.
The train moves forward at a constant velocity, then stops briefly. It then begins moving backwards at a constant velocity passing the origin at 30s. Finally, it moves forward at a constant velocity and returns to the starting point.

e) Make a rough sketch the corresponding velocity time graph.

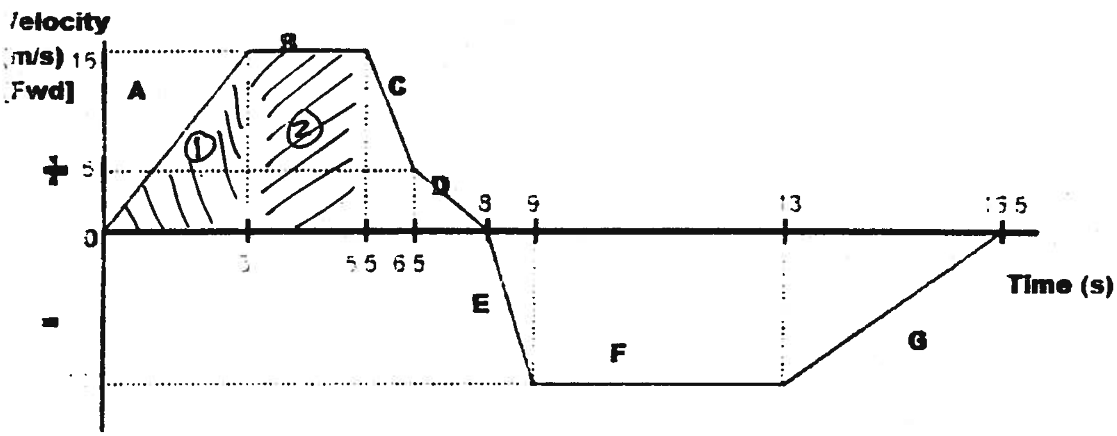


Station 8: Velocity- Time Graph Analysis

The motion of shuttle train moving in 1-D on a straight track is shown below. Note that this graph represents velocity!

Hint: Forward motion is above the x-axis (the + side)!

Velocity of a Airport Shuttle Train on a Straight Rail



a) In what interval(s) is the train going forward and speeding up? A

b) In what interval(s) is the train moving at constant velocity? B, F

c) In what interval(s) is the train going forward and slowing down? C, D

d) In what interval (s) in the train going backward? E, F, G

e) In what interval(s) is the train going backward & speeding up? E

f) Where is the train at rest? Time 0s, 8s, 16.5s

g) What analysis technique gives you acceleration? Slope of v-t graph

What is acceleration of the train over the first 3.0 seconds?

$\vec{a} = \frac{\Delta v}{\Delta t} = \frac{15-0}{3} = 5.0\ m/s^2\ [F]$

h) What analysis technique gives you displacement? Area under v-t graph

What is the displacement after 5.5 seconds?

$\Delta d = area_{1} + area_{2} = \frac{1}{2}(15\frac{m}{s})(3s) + (15 m/s)(2.5s)$

$= 22.5m\ [F] + 37.5m\ [F] = 60.0m\ [F]$