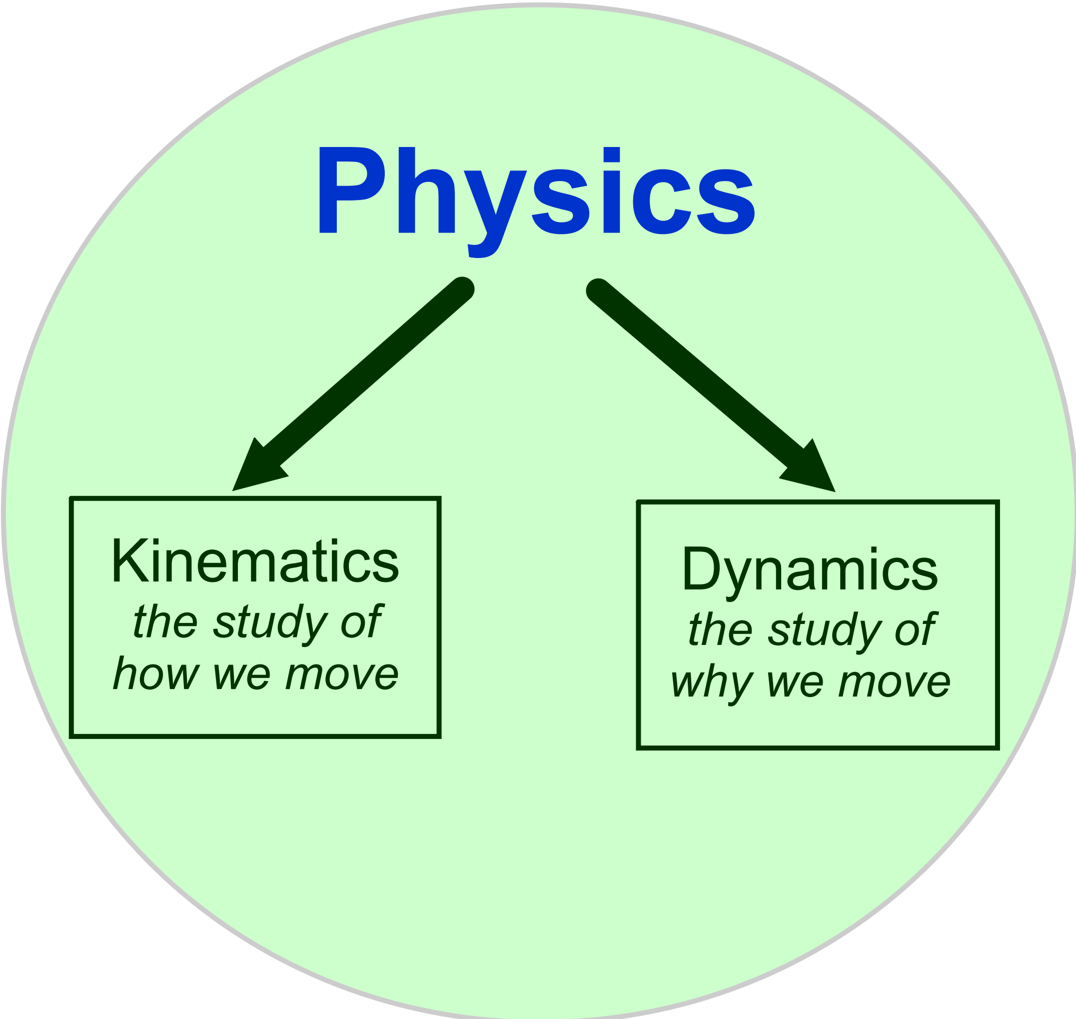
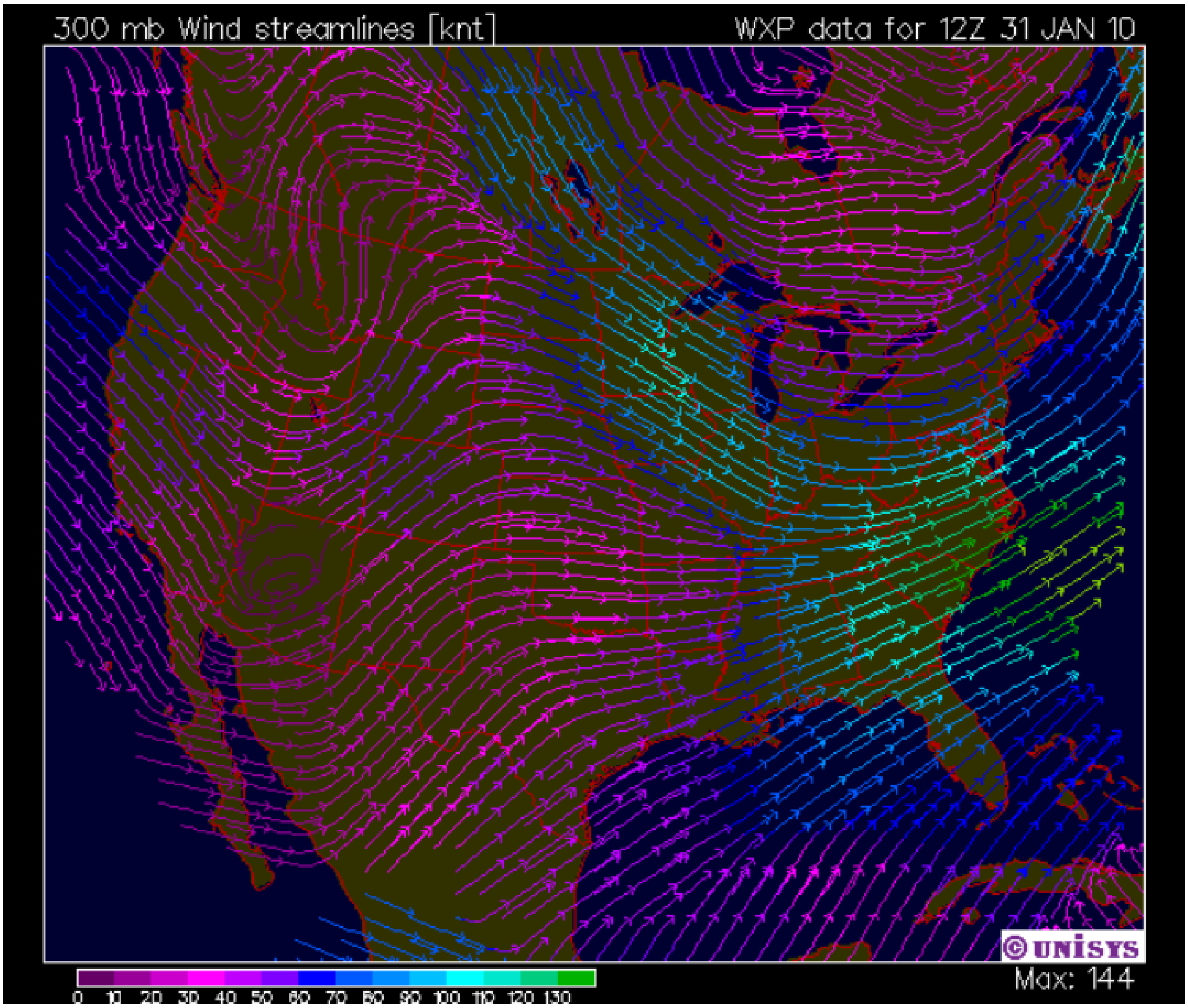
Physics 112
Mr. P. MacDonald
Room 522

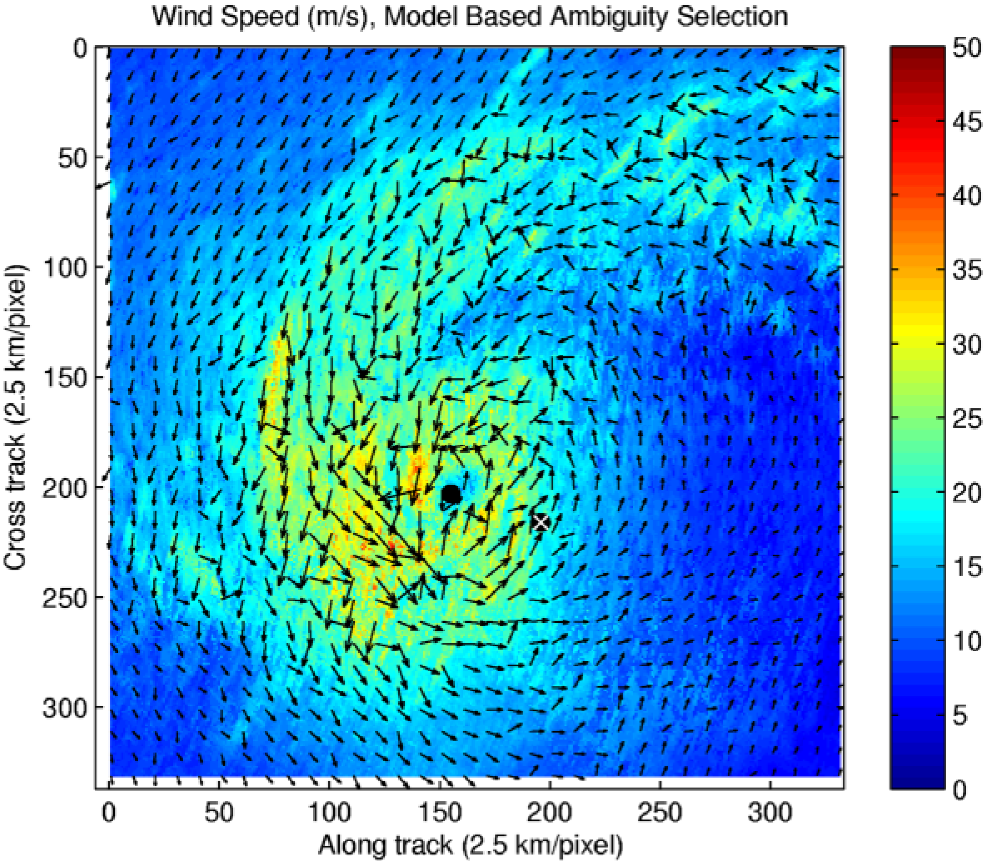

Physics
Kinematics
the study of
how we move
Dynamics
the study of
why we move

Vectors

Scalars: these quantities have only magnitude.
Ex. 2.0kg, 5.0m/s
Ex. mass, speed, distance

Vectors: these quantities have magnitude and direction.
Ex. position, displacement, velocity, acceleration.
Ex. 15km[E], 30m/s[E30^{0}N]


300 mb Wind streamlines [knt]
WXP data for 12Z 31 JAN 10
©UNISYS
Max: 144
0 10 20 30 40 50 60 70 80 90 100 110 120 130



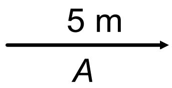
Wind Speed (m/s), Model Based Ambiguity Selection
Cross track (2.5 km/pixel)
Along track (2.5 km/pixel)
0
50
100
150
200
250
300
0
5
10
15
20
25
30
35
40
45
50

Graphical Representation of Vectors

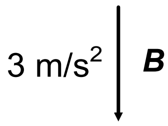
Vectors are represented by ***arrows***.

- The ***length*** of the arrow corresponds to the magnitude of the vector.
- The ***direction in which the arrow points*** represents the direction of the vector.

Vector ***A*** or $\vec{A}$ has a magnitude of 5 m and is directed to the right:



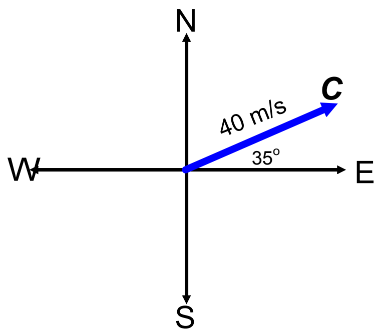
Vector ***B*** or $\vec{B}$ has a magnitude of 3 m/s^2 and is directed downward:



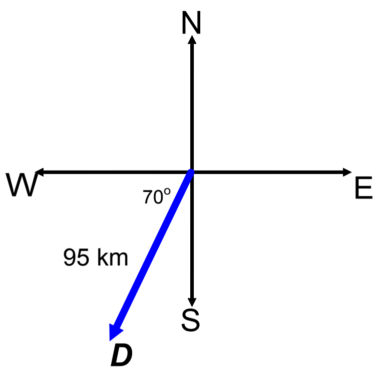
Vector ***C*** or $\vec{C}$ represents a vector of 40 m/s E35°N or 35° NofE

reference

reference

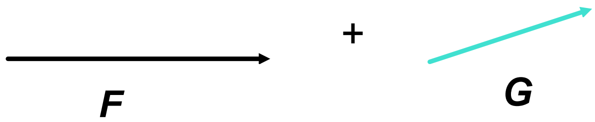


Vector ***D***, or $\vec{D}$ represents a vector of 95 km, W70°S:

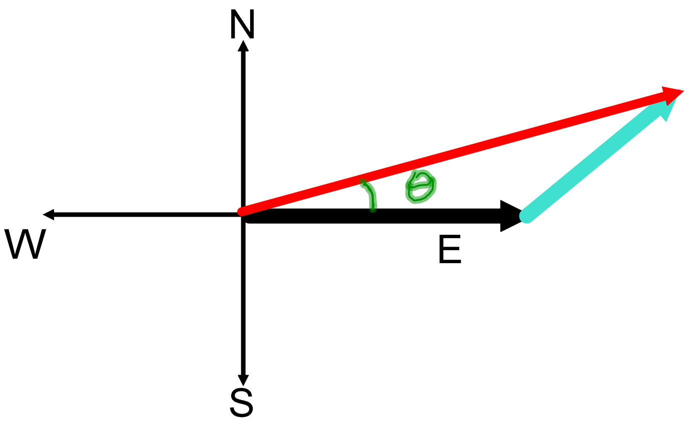


Adding Vectors Graphically

Method #1: Tip-To-Tail Method



*To add vectors graphically, they must first be **lined up tip-to-tail.***



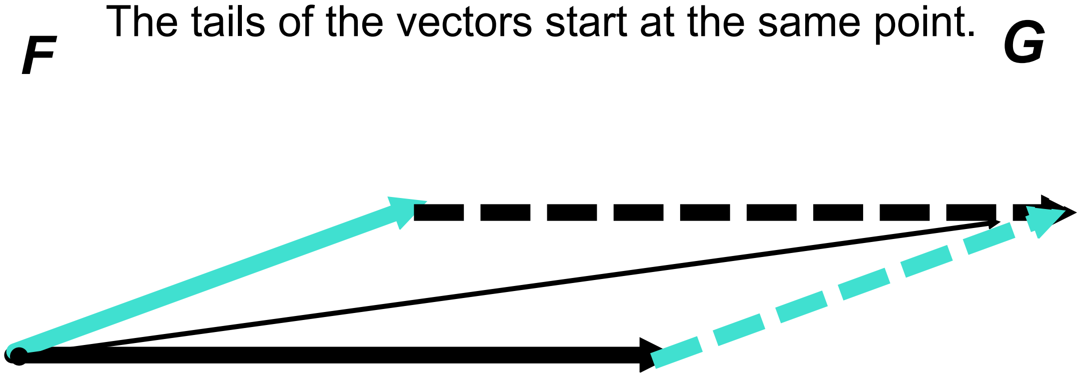
The vector sum of ***F*** and ***G*** is the vector, ***R***. It connects the tail of the first arrow to the tip of the last arrow.

Why is the letter ***R*** used for the vector sum?
*Physicists call the vector sum the **resultant vector** or the **resultant**.*

Why is the graphical method not considered the best method to use when adding vectors?
If the vectors are not drawn precisely, your final answer will not be accurate.

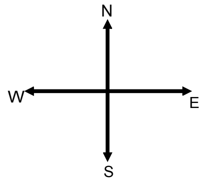
Method #2 - Parallelogram Method (2 vectors only)

The tails of the vectors start at the same point.



<u>**Examples - Graphing Analysis of Vectors**</u>

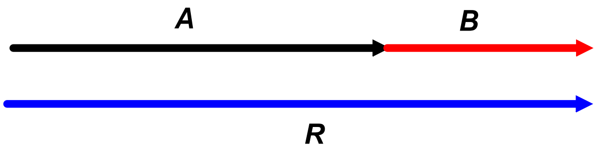
*Let the magnitudes of vector **A** and vector **B** be 8.0 m and 6.0 m, respectively.*



☆ Choose a scale.

Let 1.0 cm = 1.0 m

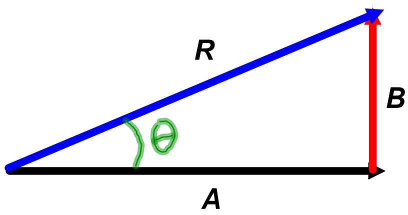
a) If vector ***A*** and vector ***B*** are both directed East, what is the angle between the vectors? What is the magnitude and direction of their resultant?

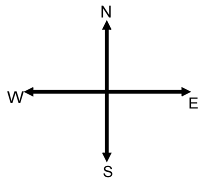


Angle between vectors: 0^o

R = 14 m, East
= 14 m, right
= + 14 m

b) If vector ***A*** is directed East and vector ***B*** is directed North, what is the angle between the vectors? What is the magnitude and direction of their resultant?

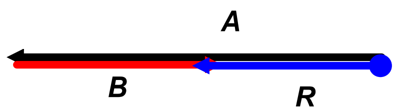




Angle between the vectors: 90^o

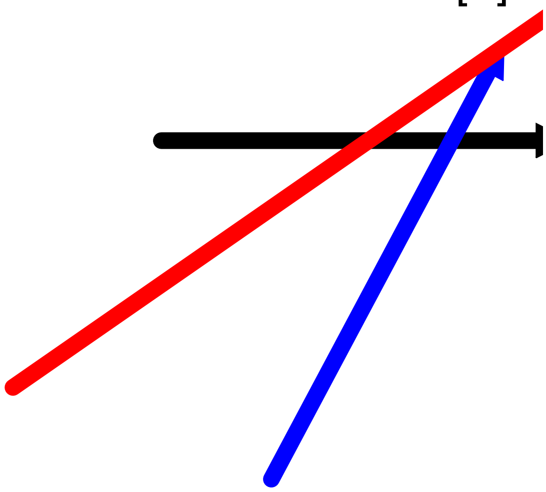
R = 10. m, [E29^oN]
= 10. m, 29^oN of E
= 10. m, 29^o above the +x axis

c) If Vector ***A*** is directed West and vector ***B*** is directed East, what is the magnitude and direction of their resultant?

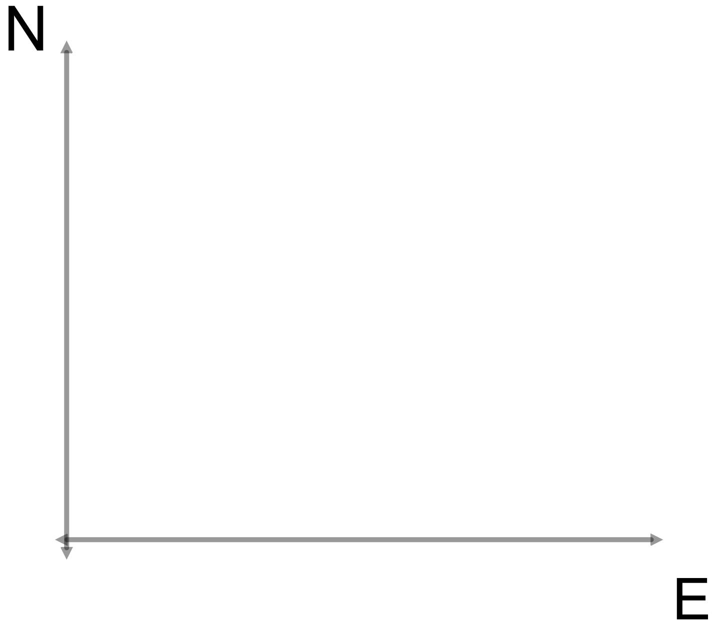


R = 2.0 m, West
= -2.0 m, East

Example 1: Find the resultant displacement if vector ***A*** = 24 km [E] and vector ***B*** = 32 km [E60^{o}N].



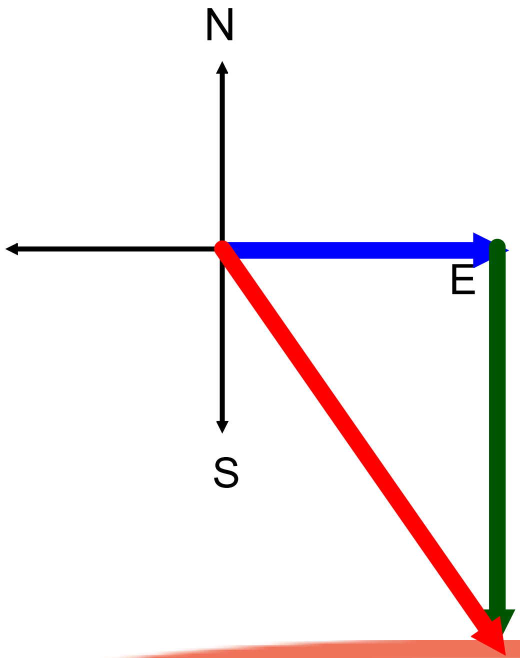
Scale: Let 1.0 cm = 4.0 km



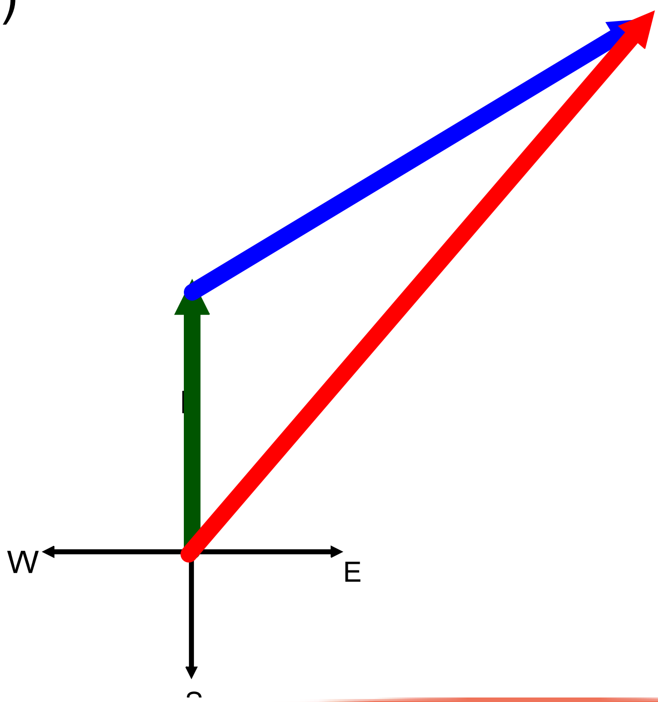
Class Work: Resultant Vectors Worksheet - Part 1

Resultant Vectors Worksheet

#1)



#2)



Resultant Vectors Worksheet - Solutions

#1) 1:4, 29 km [E58S]

#2) 1:1, 5.4 m/s [E50N]

#3) 1:5, 42.5 m [W30N]

#4) 1:2, 20.4 m [W70N]

#5) 1:10, 145 km [E42N]

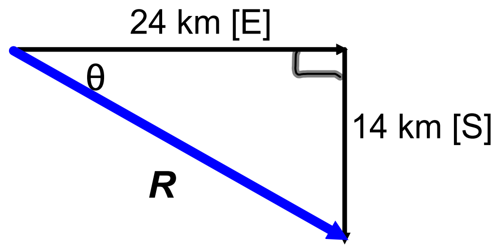
#6) 1:300, 2800 km [W45S]

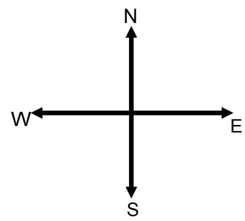
Examples - Finding a Resultant Analytically

(no scale needed)

Solution must include:
Labelled sketch (all vectors, ***R***, θ, and arrows)
magnitude of ***R*** and direction of ***R***.

1. Find the resultant of the following displacements: 24 km [E] and 14 km [S].





Try

2. Find the resultant of the following accelerations: 12 m/s^2 [N] and 5.5 m/s^2 [W]

13 m/s^2 [W65^{o}N]

3. Find the resultant of the following displacements: 34 m [W] and 42 m [S].

54 m [W51^{o}S]

Class Work: Resultant Vectors Worksheet - Part 2

Resultant Vector Worksheet - Solutions

Part II

1. 59.3 Km [E 55.6° N]
2. 130 m/s [E 54° S]
3. 1700 m [W 30.° S]
4. 120 Km [E 65° N]
5. 13 m/s [W 77° S]
6. 84 Km [E 75° N]

Unit I Kinematics

How fast am I moving?...relative to what?

- How can you tell if a car is moving fast towards you or slow?
- What about from a distance?
- At night?

Objectives:

- Plot and interpret Position-Time graphs, find the average and instantaneous velocities using the slope.
- Plot and interpret a Velocity-Time graph, find the average and instantaneous acceleration using the slope.
- Use area on a V-T graph to find displacement.
- Use formulas to solve multistep problems
- Convert between position-time, velocity-time, and acceleration time graphs.
- Determine relative velocities of two objects.
- Calculate acceleration due to gravity at JMH.

Assigned Reading: Pg 30 - 33

FRAME OF REFERENCE (Ch. 2.1 - pg 30):

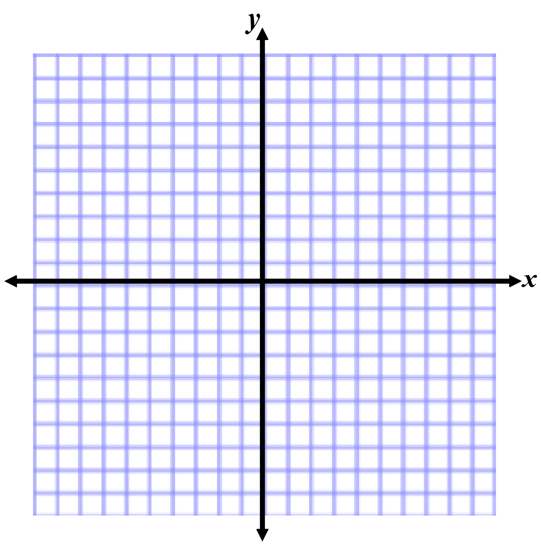
a subset of the physical world defined by an observer in which positions or motions can be discussed or compared. This can be stationary or moving.

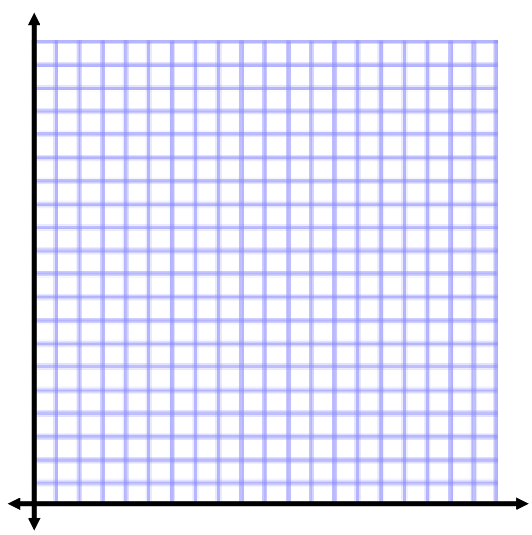
Ex. If you are in a stopped school bus and you walk towards the front of the bus you are moving with respect to others sitting in the bus, the floor of the bus and the ground.

If you are sitting in a moving school bus, you are NOT moving with respect to the floor of the bus, or others around you sitting down. You ARE moving with respect to the ground and landscape outside the bus.

Coordinate System

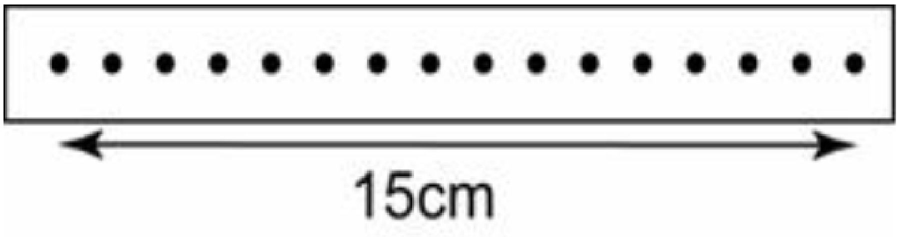
Used to describe an object's position and motion mathematically.

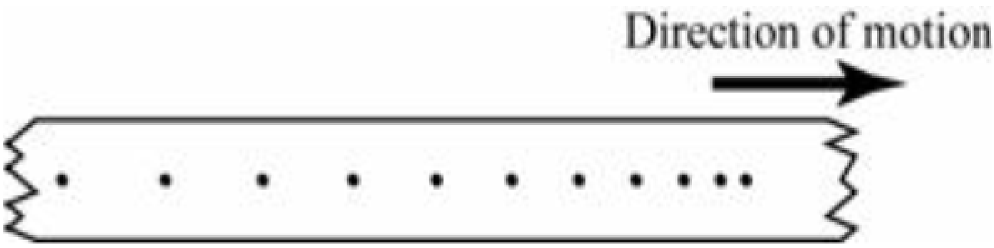


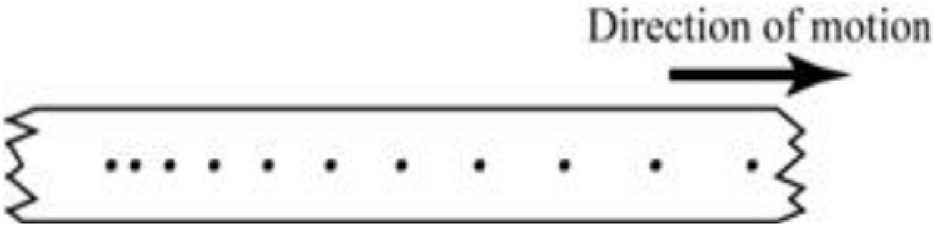


Visualizing Motion

The time interval is the same between each dot.







Examples - Dot diagram sketches

A person walking by at a constant speed:

A person is biking by at a constant speed:

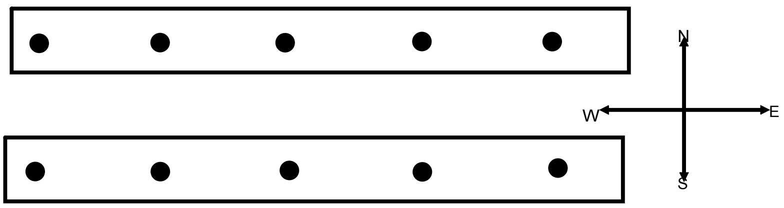
First couple of seconds when a soccer ball is kicked:

A car accelerates, drives at a constant speed, then brakes:

Incorporating different frames of reference

John's speed:

Kim's speed:



Kim is walking far behind John on a straight sidewalk. They are traveling due East. Sketch:

a) John's velocity relative to Kim.

b) John turns around and walks due west toward Kim. Sketch John's velocity relative to Kim:

Pg 34 # 1 & 2

Kinematics - Describing Motion

Distance

- the separation between two points (how far an object has traveled)
- scalar quantity
- symbol: d
- units: nm, μm, cm, m, km, Mm, etc.

Position

- separation between an object and a reference point
- vector quantity
- symbol: $\vec{x}$
- units: cm, m, km, etc.

Note: Instantaneous position is the location of an object at an instant (at a single time, t)

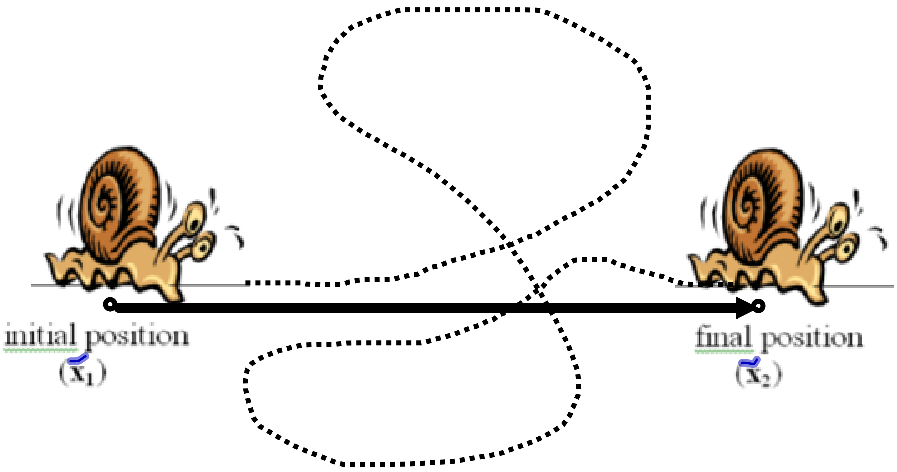
Displacement

- change in position (the difference between two positions)
- vector quantity
- symbol: $\Delta\vec{x}$

$$\Delta\vec{x} = \vec{x}_2 - \vec{x}_1$$

- units: cm, m, km, etc.

Snail - on his morning walk…



$$\Delta \vec{x} = \vec{x}_2 - \vec{x}_1$$

Time Interval

- the amount of time that passes between two instants of time
- symbol: Δt
- units: s, h
- scalar quantity

Speed

- the distance an object travels divided by the time interval during which the object was traveling (how fast an object is traveling)

$$\text{speed} = \frac{\text{distance}}{\Delta t}$$

- scalar quantity
- symbol: v
- units: cm/s, m/h, km/h , m/s

Note: ***Instantaneous speed*** is the speed at which an object is traveling at time, t.

(Average) Velocity

- describes how fast an object moves from one position to another ***and*** indicates the direction in which the object is travelling
- the rate of change of position or the displacement of an object over a time interval
- vector quantity
- symbol: $\vec{v}$
- units: cm/s, m/s, km/h, etc.

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

(Average) Acceleration

- the rate of change of velocity of an object over a time interval
- vector quantity
- symbol: $\vec{a}$
- units: m/s^2

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

Example Questions

1. 32 s after the start of a race a runner is at the first marker 55 m [E] from the start. 105 s after the start that runner is at the second marker 125 m [E] from the start line.

a) What is the runner's average velocity for the first 55 m?

b) What is the runner's average velocity between the first and second marker?

c) What is the runner's average velocity for the entire 125 m [E]?

d) What velocity must a runner average to run to the second marker in 65 s?

e) A second runner averages a velocity of 2.8 m/s [E]. How long does it take her to reach the second marker?

Homework:

1. Conceptual Problems bottom of pg 41.
2. Practice problem 2 pg 45.
3. Section Review 2.2 pg 46 #'s 1, 2, 3.
4. Speed worksheet # 1 - 8.
5. Read Section 2.3 pg 47 - 60.

Types of Motion

Uniform Motion
(velocity is constant in magnitude and direction)

Uniformly Accelerated Motion
(velocity is changing in magnitude/or direction)

Constant, Average and Instantaneous Velocity

Uniform Motion (Constant Velocity): the velocity of an object remains constant. Constant Velocity means magnitude and direction remain constant.

Non-Uniform Motion: means that the velocity is changing, either in magnitude or in direction.

Question: A physics book is moving across a table. Can the book have a

a) constant speed and a changing velocity?
b) constant velocity and a changing speed?

Question 2: A race car is travelling at a constant speed around a race track. Is this considered uniform motion?

1. Constant velocity: object travels the same distance for each unit of time.

When graphed on a displacement-time graph,it produces a straight diagonal up or down OR a straight horizontal line.

The slope of the graph equals the velocity.

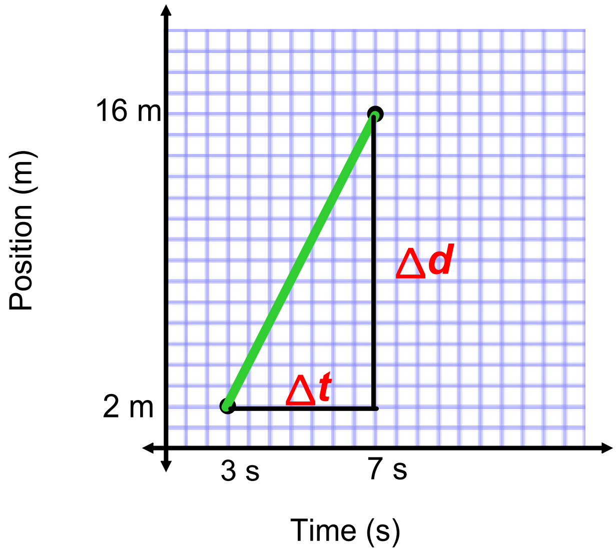
2. Average velocity: is the ratio of the total displacement to the total time. If in the case of constant velocity it is also the average.

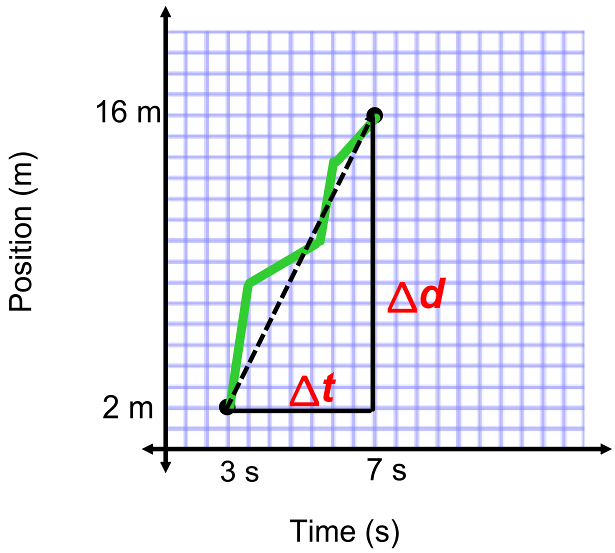
When graphed on a displacement-time graph,

the slope of the line of best fit is equal to the average velocity.

3. Instantaneous velocity: the velocity of an object at one instant of time.

To find its value from a displacement-time graph, the slope of the tangent at that instant of time must be found


16 m
2 m
Position (m)
Δd
Δt
3 s
7 s
Time (s)


16 m
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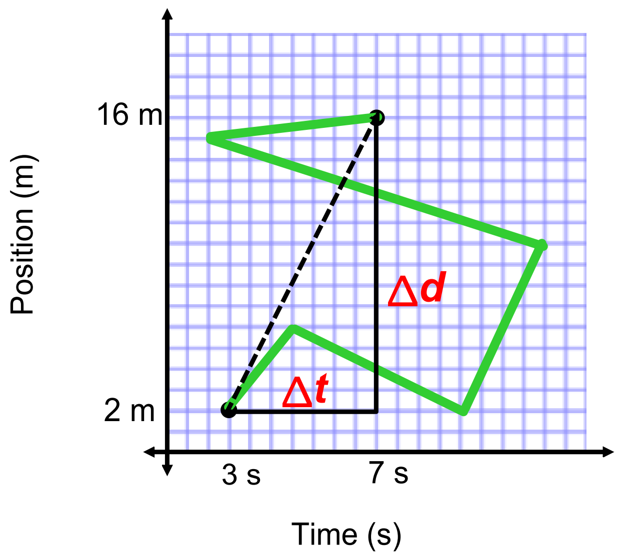
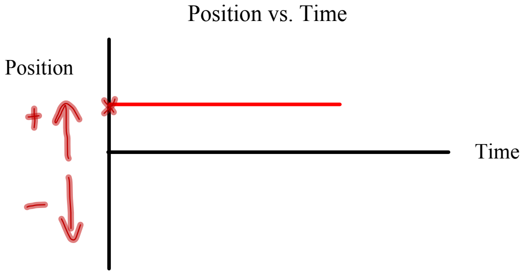
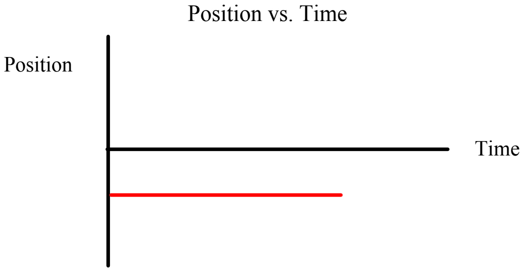
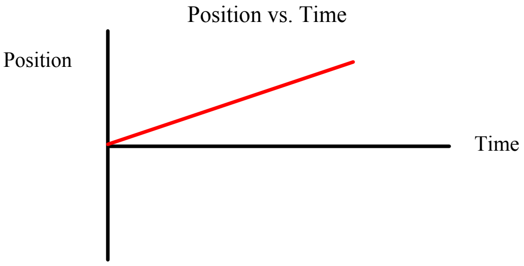
Time (s)

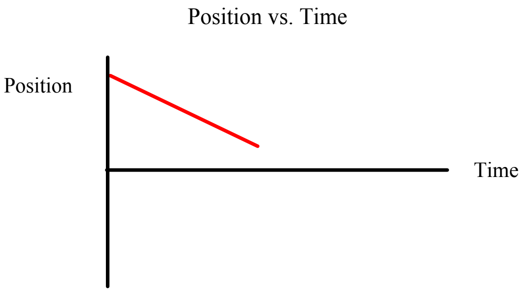

16 m
2 m
Position (m)
Δd
Δt
3 s
7 s
Time (s)

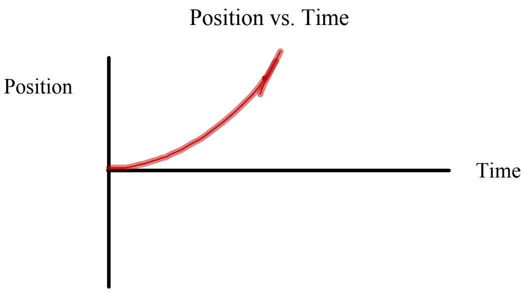
Position-Time Graphs

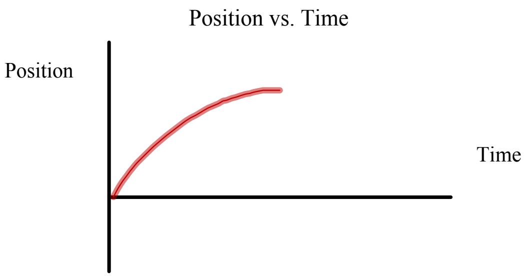








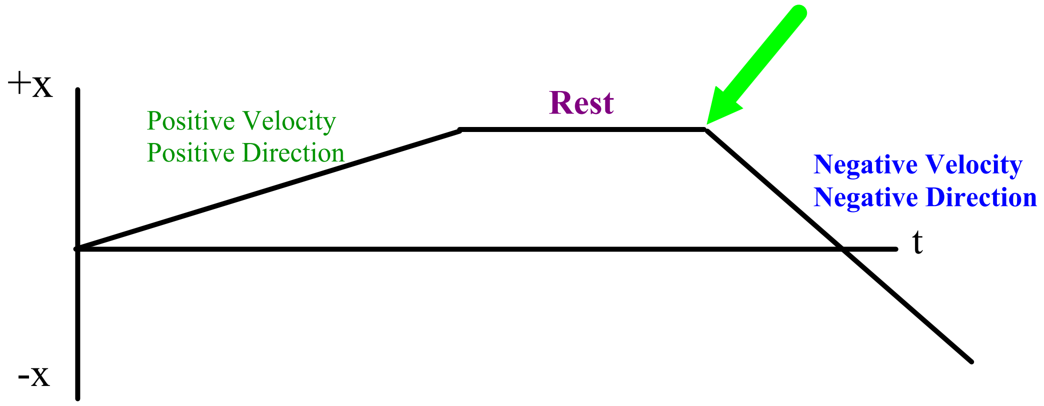




Position-Time Graphs

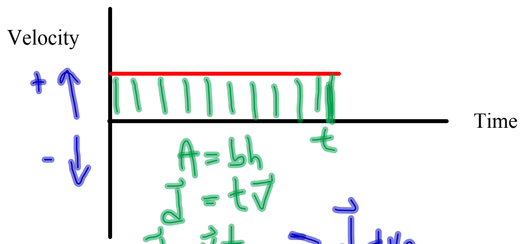
Direction of Motion

If the velocity of an object changes from positive to negative (or vice versa) it simply means that it has changed direction. On a position-time graph this occurs when the velocity changes signs.



Velocity-Time Graphs

Velocity vs. Time



$A = bh$

$\vec{d} = t\vec{v}$

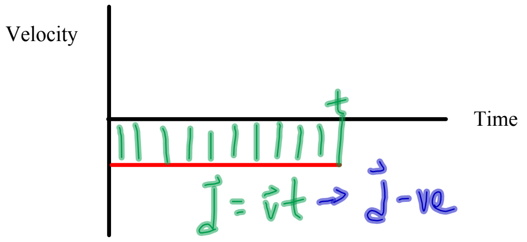
$\vec{d} = \vec{v}t \Rightarrow \vec{d}$ +ve

$m = \frac{\Delta \vec{v}}{\Delta t} \Rightarrow$ acceleration ⇓ $0\,m/s^2$

→ velocity is constant ⇓ +ve

→ uniform motion

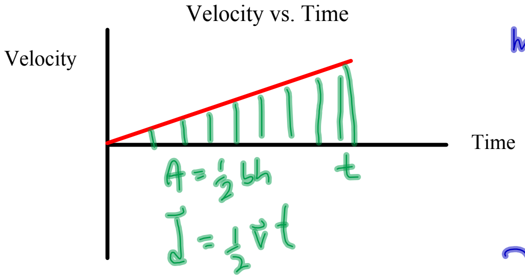
Velocity vs. Time



$\vec{d} = \vec{v}t \rightarrow \vec{d}$ -ve

Same as above except $\vec{v}$ is -ve (negative)

Velocity vs. Time



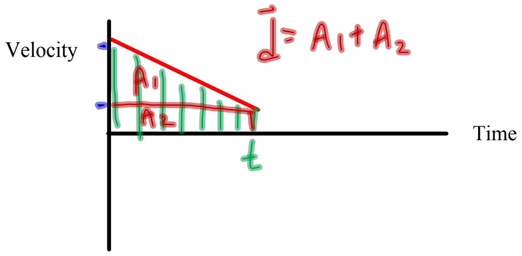
$A = \frac{1}{2}bh$

$\vec{d} = \frac{1}{2}\vec{v}t$

$m = \frac{\Delta \vec{v}}{\Delta t} \Rightarrow$ acc. +ve

uniformly acc'd motion

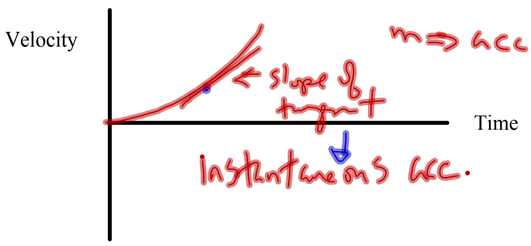
Velocity vs. Time



$\vec{d} = A_1 + A_2$

Same as above except acc. -ve

Velocity vs. Time

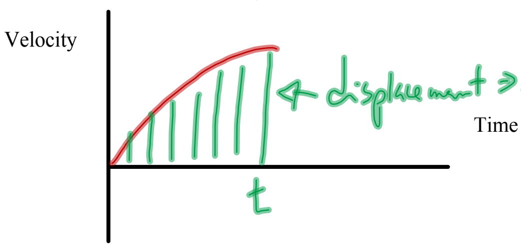


↓ instantaneous acc.

m ⇒ acc. → not constant

non-uniform

Velocity vs. Time



m ⇒ acc ⇒ not constant

non-uniform

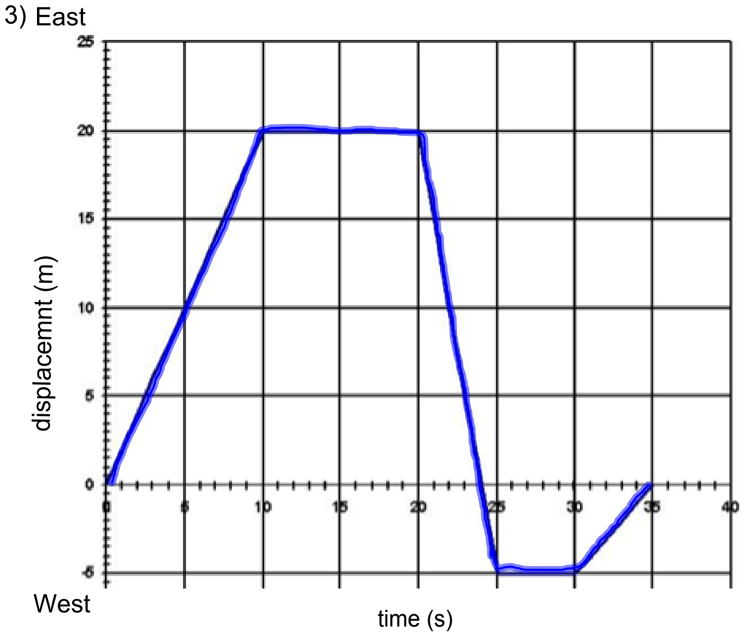
← displacement ⇒ calculus required

More Practice & Review

1) Use a scale diagram to find the resultant of 90 km [W35°S], 60 km [E], and 70km [W75°N]

2) Calculate the resultant of 58 m [N], 12 m [S], 45 m [E], and 112 m [W].

3)



(a) What was the instantaneous velocity at $t = 7.25$ s?

(b) What was the displacement at t = 35 s?

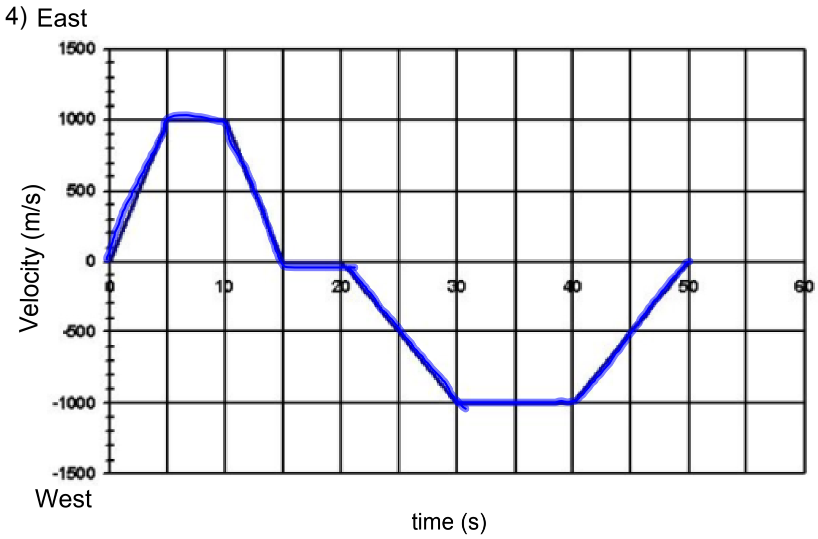
(c) What was the distance travelled during the 35 s trip?

(d) What was the average speed for the entire trip? Average velocity?

(e) What was the instantaneous velocity at $t = 21.83$ s?

(f) What was the average velocity for the first 25 s?

4)



(a) Determine the displacement and distance traveled.

(b) Determine the average speed and velocity.

(c) What was the instantaneous acceleration at $t = 42.3$ s? at $t = 24.8$ s?

5) A car accelerates from rest to 32 m/s [E] in 12.5 s. (a) Find the average acceleration. (b) What distance is does this car cover in that time?

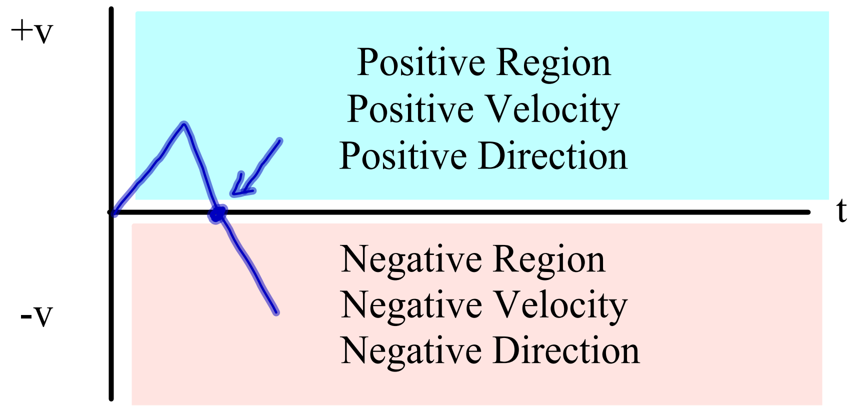
6) A plane lands with a velocity of 47 m/s [E]. It takes 17 s to stop. (a) What was the average acceleration of the plane? (b) What distance was required to stop?

7) A police car initially at 100 km/h [E] accelerates at 5 km/h/s [E] (your speed increases by 5 km/h each second) for 8.9 s. (a) What is the final velocity of the car? (b) What distance was covered during the acceleration?

8) A car traveling at 25 m/s [E] accelerates to 10 m/s in 5.0 s. (a) What is the acceleration of the car? (b) What distance was covered in that time? (c) What distance is need to come to a stop? (hint: find the time needed to come to a stop first)

Velocity-Time Graphs

Direction of Motion



If the graph line crosses over the time axis from the positive region to the negative region (or vice versa), then the object has changed directions.

Direction of Acceleration and Velocity

Rule of Thumb

When an object is slowing down, the direction of the acceleration is in the opposite direction of the object's motion.

Page 63 - Conceptual Problems
- Use Figures 2.19 and 2.20

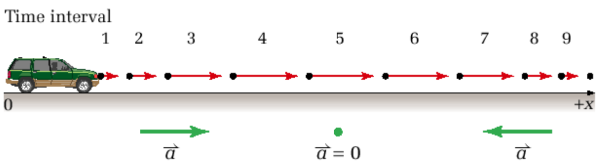
- 

Figure 2.19 When the van is moving in a positive direction but slowing

Images in figure	Direction of velocity vector	Direction of acceleration vector	Description of motion
Figure 2.19 Van is moving in the positive direction.			
1-2-3	positive	positive	speeding up in positive direction
4-5-6			
7-8-9			
Figure 2.20 Van is moving in the negative direction			
1-2-3			
4-5-6			
7-8-9	negative	positive	slowing down in negative direction

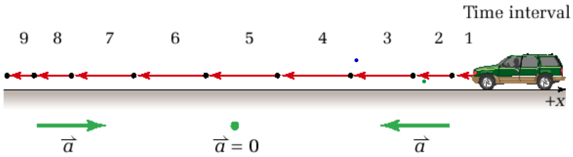


Figure 2.20 When the van is moving in a negative direction and slowing down, the direction of acceleration is positive.

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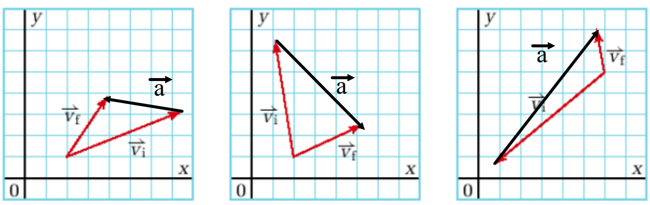
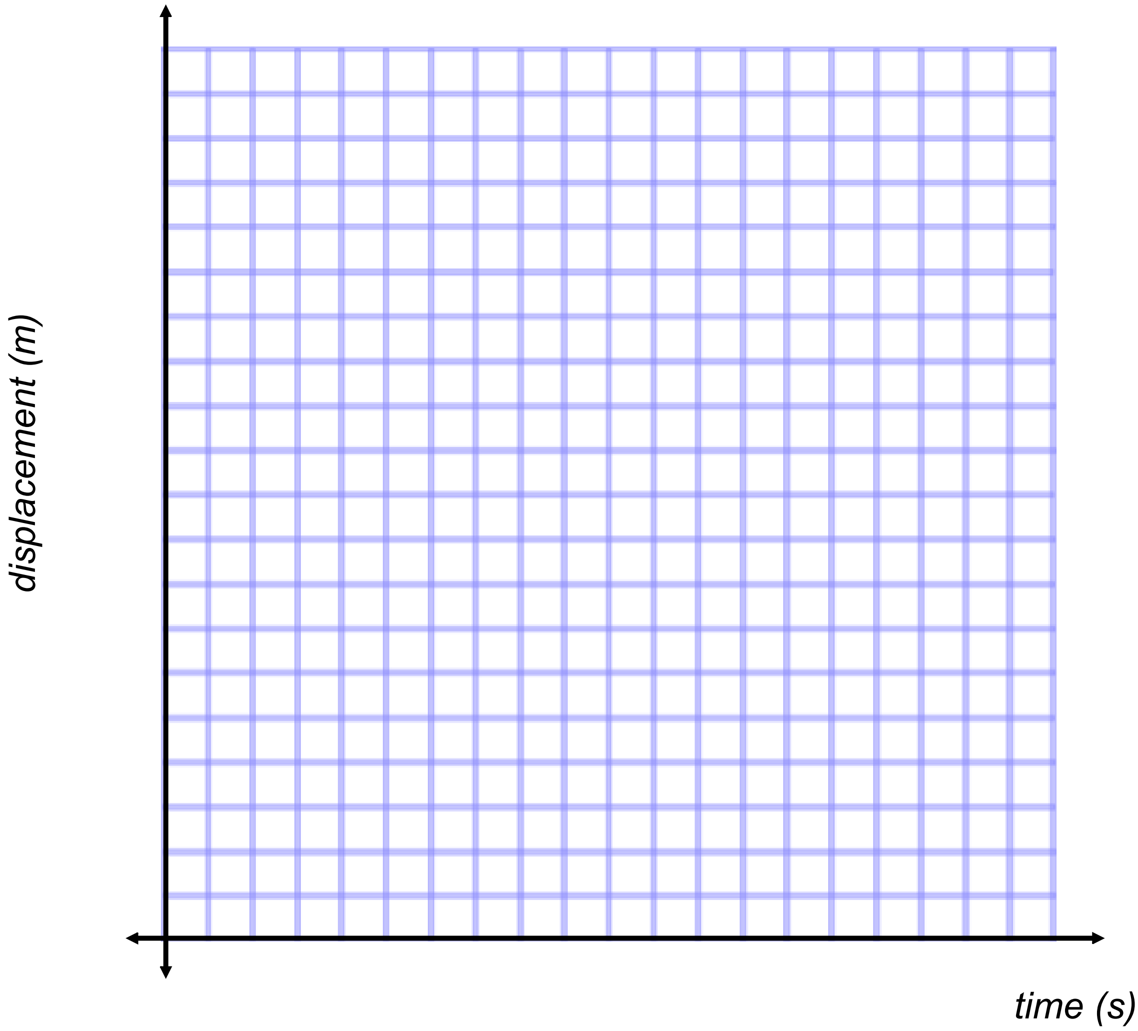
- 

Chapter 2 Describing Motion • MHR **63**

Page 62 - MISCONCEPTION
Deceleration and Negative Acceleration
They Don't Mean the Same Thing

Tangent: is a line drawn to a curve that touches the curve at only one point.

We use this to determine the instantaneous velocity (or speed) of an object from analyzing the graph of the system.



Sketching a V-T Graph

- Identify *key points* on the d-t graph and determine the instantaneous velocity.
- Key points are minimum and maximum areas, a point between a min and max, and the beginning and end of straight sections.

Example: A car's d-t graph is shown below.

a) Find the instantaneous velocity at

2.0, 4.0, 6.0, 10.0, 12.0, 15.0, 16.5, and 18.0 s.

b) Sketch the V-T graph.