Chapter 2

1

VECTORS

1

Lecture 01

2

Introduction

Properties Of Vectors

2

Vectors

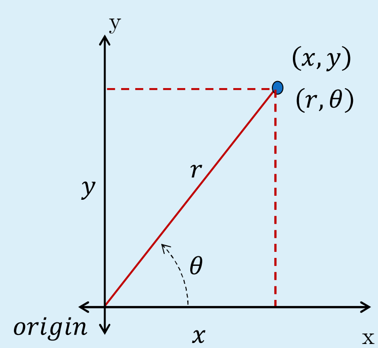
3

- Vector quantities
  - Physical quantities that have both numerical and directional properties.
- Mathematical operations of vectors in this chapter
  - Addition
  - Subtraction
  - Multiplication:
    - Multiplying with a scalar
    - Scalar product
    - Vector product

Coordinate Systems

4

- Used to describe the position of a point in space
- Common coordinate systems are:
  - Cartesian
  - Polar



Polar to Cartesian Coordinates

5

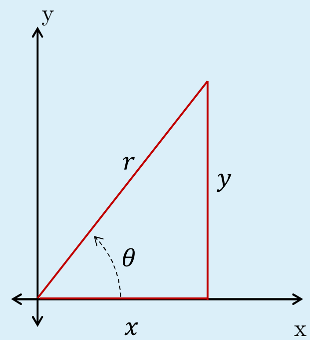
- Based on forming a right triangle from r and θ

$$cos\theta = \frac{x}{r} \Leftrightarrow x = rcos\theta$$

$$sin\theta = \frac{y}{r} \Leftrightarrow y = rsin\theta$$

- If the Cartesian coordinates are known:

$$r = \sqrt{x^2 + y^2}$$
$$tan\theta = \frac{y}{x} \Leftrightarrow \theta = tan^{-1}\frac{y}{x}$$



x: adjacent

y: opposite

r: hypotenuse

5

Vectors and Scalars

6

A scalar quantity is completely specified by a magnitude with an appropriate unit and has no direction.

- Many are always positive
- Some may be positive or negative
- Rules for ordinary arithmetic are used to manipulate scalar quantities.

A vector quantity is completely described by a magnitude, an appropriate units and a direction.

6

Vector and scalar Examples

7

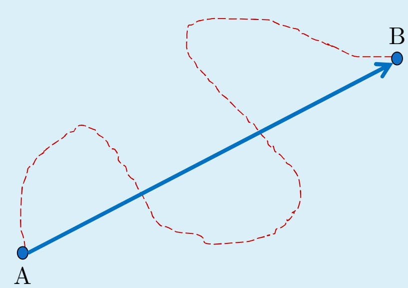
SCALARS	VECTORS
• Distance	• Displacement
• Speed	• Velocity
• Time intervals	• Acceleration
• Mass	• Force

7

Vector and scalar Example

8

- A particle travels from A to B along the path shown by the broken line.
  - This is the distance traveled and is a scalar.
- The displacement is the solid line from A to B
  - The displacement is independent of the path taken between the two points.
  - Displacement is a vector.



8

Vector Notation

9

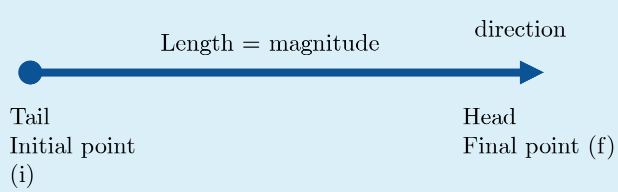
- Bold font is used for printing: **A**
- When dealing with just the magnitude of a vector in print, an italic letter will be used: A or $|\vec{A}|$
  - The magnitude of a vector is always a positive number.
- When handwritten, use an arrow: $\vec{A}$

Mustafa Al-Zyout - Philadelphia University 29-Sep-25

9

Vectors representation

10



Mustafa Al-Zyout - Philadelphia University 29-Sep-25

10

Vectors representation

11

$$\vec{A} = |\vec{A}|\,, \theta$$

Vector A

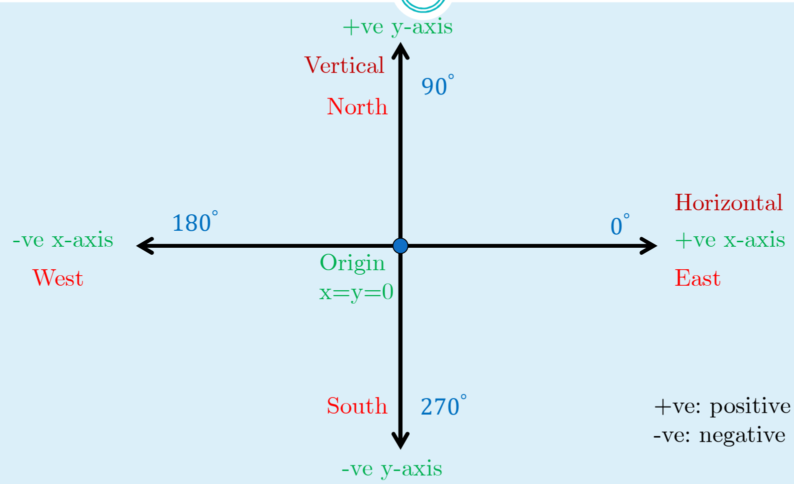
Its magnitude

Its direction

11

Directions

12

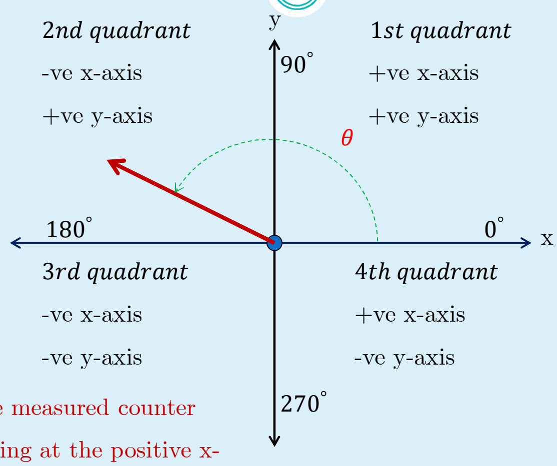


+ve: positive
-ve: negative

12

Directions ($\theta \equiv Theta$)

13



(θ) : should be measured counter clockwise starting at the positive x-axis

13

Properties of Vectors

14

Equality Of Two Vectors
Adding Vectors
Negative Of A Vector
Subtracting Vectors

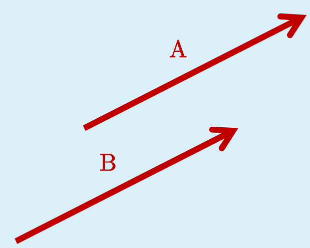
14

Equality of Two Vectors

15

- Two vectors are equal if:
  - they have the same magnitude and
  - points in the same direction.

- $\vec{A} = \vec{B}$ if:
- $|\vec{A}| = |\vec{B}|$ and
  - In the same direction, or
  - Parallel, or
  - $\theta_{A,B} = 0^{\circ}$



15

Adding Vectors

16

- Vector addition is very different from adding scalar quantities.
- When adding vectors, their directions must be taken into account.
- Units must be the same
- Graphical methods
  - Use scale drawings
- Algebraic methods
  - More convenient

16

Adding Vectors Graphically

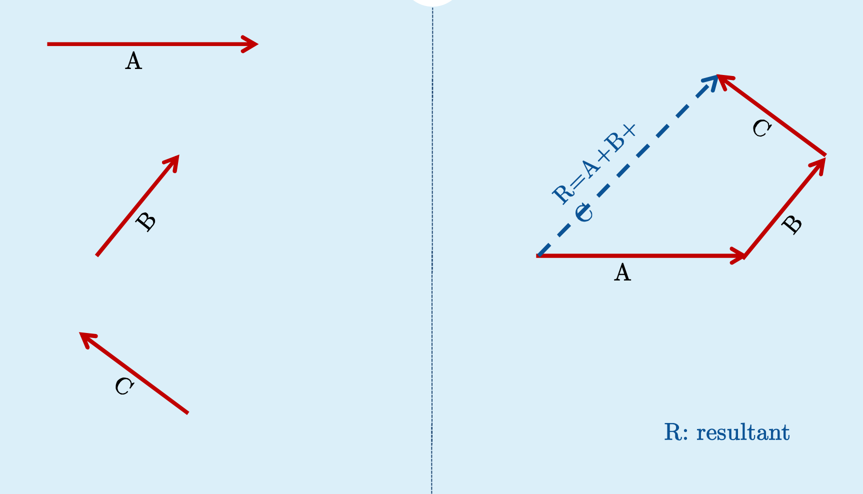
17

- Choose a scale.
- Draw the first vector, $\vec{A}$, with the appropriate length and in the direction specified, with respect to a coordinate system.
- Draw the next vector with the appropriate length and in the direction specified, with respect to a coordinate system whose origin is the end of vector $\vec{A}$ and parallel to the coordinate system used for $\vec{A}$.
- Continue drawing the vectors "tip-to-tail" or "head-to-tail".
- The resultant is drawn from the origin of the first vector to the end of the last vector.

17

Adding Vectors Graphically, cont.

18



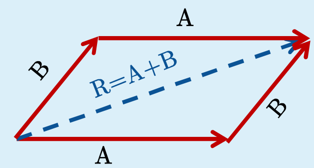
18

Adding Vectors, Rules

19

- The Commutative Law of Addition: when two vectors are added, the sum is independent of the order of the addition.
  - This is

$$\vec{R} = \vec{A} + \vec{B} = \vec{B} + \vec{A}$$



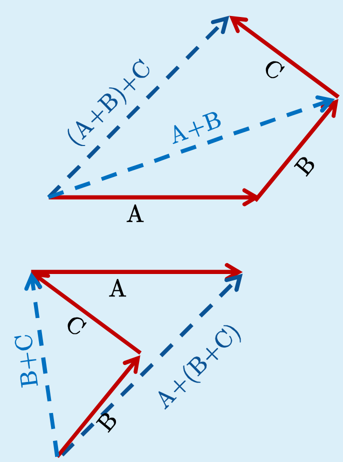
19

Adding Vectors, Rules cont.

20

- The Associative Property of Addition: when adding three or more vectors, their sum is independent of the way in which the individual vectors are grouped.

$$(\vec{A} + \vec{B}) + \vec{C} = \vec{A} + (\vec{B} + \vec{C})$$



20

Adding Vectors, Rules final

21

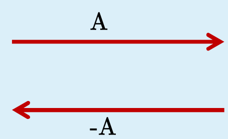
- When adding vectors, all of the vectors must have the same units.
- All of the vectors must be of the same type of quantity.
  - For example, you cannot add a displacement to a velocity.

21

Negative of a Vector

22

- The negative of a vector is defined as the vector that, when added to the original vector, gives a resultant of zero.
  - Represented as $-\vec{A}$
  - $\vec{A} + (-\vec{A}) = 0$
- The negative of the vector will have the same magnitude, but points in the opposite direction.

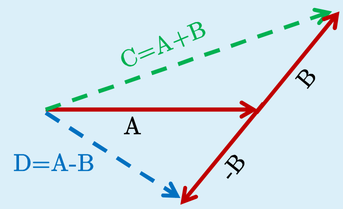


22

Subtracting Vectors

23

- Special case of vector addition.
- If $\vec{A} - \vec{B}$, then use $\vec{A} + (-\vec{B})$
- Continue with standard vector addition procedure.



23

Subtracting Vectors, Method 2

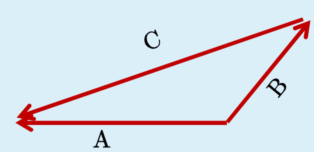
24

In the figure shown:

$$\vec{B} + \vec{C} = \vec{A}$$

$$\vec{C} = \vec{A} - \vec{B}$$

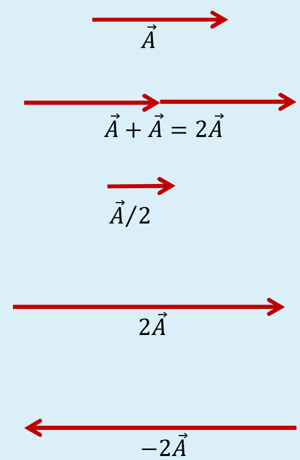
- The resultant vector $\vec{C}$ of subtracting $\vec{B}$ from $\vec{A}$ points from the tip of the second to the tip of the first.



24

Multiplying or Dividing a Vector by a Scalar

- The result of the multiplication or division of a vector by a scalar is a vector.
- The magnitude of the vector is multiplied or divided by the scalar.
- If the scalar is positive, the direction of the result is the same as of the original vector.
- If the scalar is negative, the direction of the result is opposite that of the original vector.



Finding components - 1

Friday, 29 January, 2021 21:11

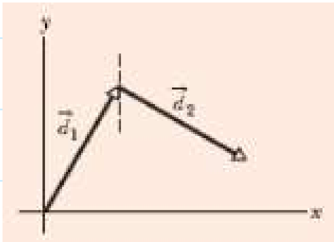
Lecturer: Mustafa Al-Zyout, Philadelphia University, Jordan.

- [ ] R. A. Serway and J. W. Jewett, Jr., *Physics for Scientists and Engineers*, 9th Ed., CENGAGE Learning, 2014.
- [x] J. Walker, D. Halliday and R. Resnick, *Fundamentals of Physics*, 10th ed., WILEY,2014.
- [ ] H. D. Young and R. A. Freedman, *University Physics with Modern Physics*, 14th ed., PEARSON, 2016.
- [ ] H. A. Radi and J. O. Rasmussen, *Principles of Physics For Scientists and Engineers*, 1st ed., SPRINGER, 2013.

(a) In the figure here, what are the signs of the x components of $\overrightarrow{d_1}$ and $\overrightarrow{d_2}$?

(b) What are the signs of the y components of $\overrightarrow{d_1}$and $\overrightarrow{d_2}$?

(c) What are the signs of the x and y components of $\overrightarrow{d_1}+\overrightarrow{d_2}$?



Answers:

(a) + , +

(b) + , −

(c) + , +

Finding components - 2

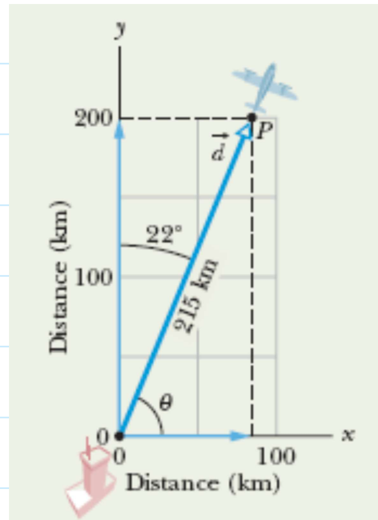
Friday, 29 January, 2021 21:11

Lecturer: Mustafa Al-Zyout, Philadelphia University, Jordan.

- [ ] R. A. Serway and J. W. Jewett, Jr., *Physics for Scientists and Engineers*, 9th Ed., CENGAGE Learning, 2014.
- [x] J. Walker, D. Halliday and R. Resnick, *Fundamentals of Physics*, 10th ed., WILEY,2014.
- [ ] H. D. Young and R. A. Freedman, *University Physics with Modern Physics*, 14th ed., PEARSON, 2016.
- [ ] H. A. Radi and J. O. Rasmussen, *Principles of Physics For Scientists and Engineers*, 1st ed., SPRINGER, 2013.

A small airplane leaves an airport on an overcast day and is later sighted $215\ km$ away, in a direction making an angle of 22° east of due north.

- How far east and north is the airplane from the airport when sighted?
- Write $\vec{d}$ in unit vector notation.



Solution

- With $\theta = 90° - 22° = 68°$, the east and north components, respectively, are:

$$d_x = d\cos\theta = (215)(\cos 68°) = 81 \text{ km}$$

$$d_y = d\sin\theta = (215)(\sin 68°) = 199 \text{ km}$$

- $$\vec{d} = 81\,\hat{\imath} + 199\,\hat{\jmath}$$