بسم الله الرحمن الرحيم

King Saud University
College of Science
Physics & Astronomy Dept.

Phys 145 (General Physics)

Chapter 1: Motion in a straight Line

Week n° 01

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بسم الله الرحمن الرحيم
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المملكة العربية السعودية
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King Saud University
College of Science
Department of Physics and Astronomy

جامعة الملك سعود
كلية العلوم
قسم الفيزياء والفلك

General Physics For Health Colleges

Phys-145

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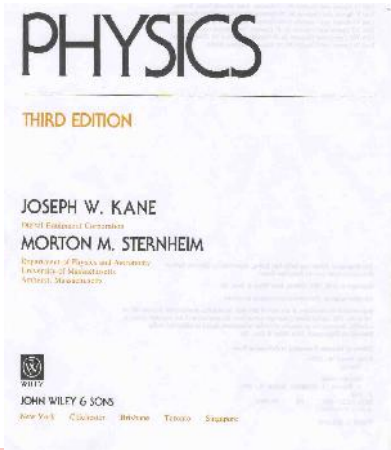
Textbook



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Chapter	Hours	Section	Title	Exercises and problems (*)
1	3	2,3,4,5	Motion in a Straight Line	16,17,26,28,33,38,43,71,72,77,80
2	1	1	Vectors (Components)	1,2,4,5,7,9,13
3	4	3,4,5,6,8,12	Newton's Laws of Motion	47,50,51,55,87,90,91,100,102,103
6	4	1,2,3,4,6,9	Work, Energy and Power	1,2,8,10.19,63,70,72,74
13	3	2,3,4,7	The Mechanics of Nonviscous Fluids	7,9,10,11,32
17	2	1,2,5,12	Direct Currents	1,10,11,13,18,24,25,45,46,71
24	4	1,2,3,4	Mirrors, Lenses and Imaging Systems	2,5,7,11,13,19
26	2	1,3	Particle Propertis of Light (The Photon)	1,3,4,6,16,17,19
30	3	1,2,9	Nuclear Physics	1,2,4,8,11,36,43
31	2	1,2	Ionizing Radiation	14,16,17,23,29,47

(*: Underlined exercises will be done in the classroom)

PHYSICS AND MATHEMATICS

Example showing the importance of mathematics in physics:

The gravitational force between two masses is proportional to the product of the masses and inversely proportional to the square of the distance apart.

$$F \propto \frac{m_1 m_2}{r^2}$$

Thus, Mathematics is the language of Physics

Some Greek letters	
	alpha
	beta
	gamma
	delta
	epsilon
	lambda
	mu
	nu
	pi
	rho
	sigma
	tau
	zeta

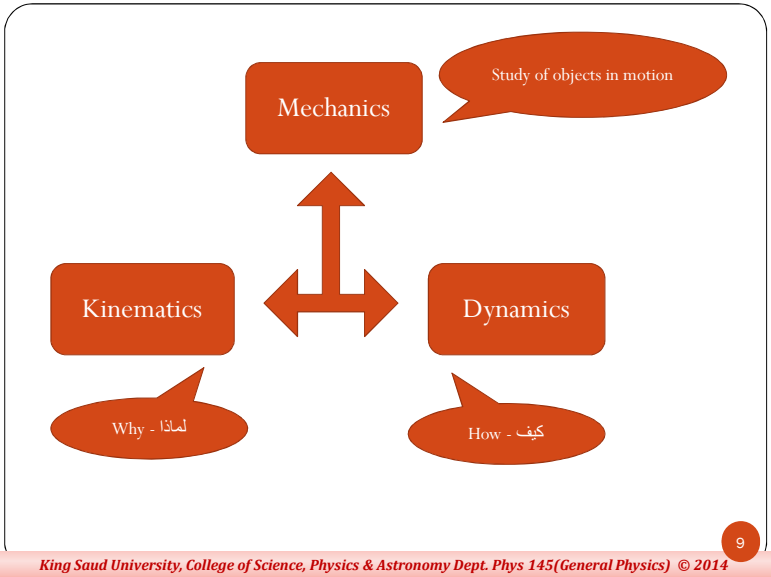
Prefixes for Powers of Ten

Power	Prefix	Abbreviation
10^{-15}	femto	f
10^{-12}	pico	p
10^{-9}	nano	n
10^{-6}	micro	μ
10^{-3}	milli	m
10^{-2}	centi	c
10^{-1}	deci	d
10^{3}	kilo	k
10^{6}	mega	M
10^{9}	giga	G
10^{12}	tera	T

Chapter 1: Motion in a straight Line

- **We will learn in this chapter:**

- Distance, average speed
- Displacement, average velocity
- Instantaneous velocity
- Average and instantaneous acceleration
- Finding the motion of an object



How to define a motion

To define a motion we have to know or calculate the following:

- Positions.
- Velocities.
- Accelerations.

In classical mechanics, positions and velocities of a mechanical system can be measured simultaneously and there is no limit in principle to the accuracy with which they can be measured.

Distance; Average speed

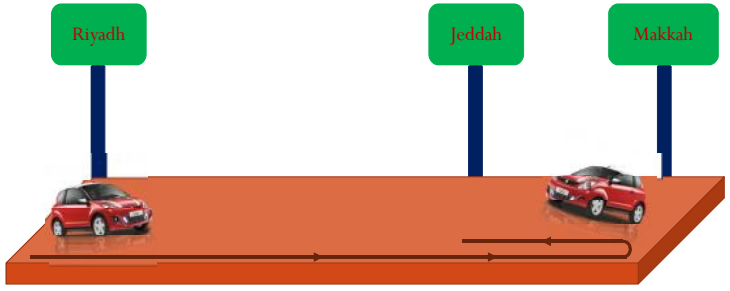
- The average speed is the distance traveled divided by the elapsed time.

$$\text{average speed} = \frac{\text{Distance}}{\text{elapsed time}} = \frac{\Delta x}{\Delta t}$$

- In the S.I., the distance is in meter (m), the time in second (s) and the average speed in m/s or $m.s^{-1}$.

Distance; Average speed

Example 1.1



Distance= مسافة = 930 km + 86 km = 1016 km

$$\text{Average speed} = \frac{\text{distance}}{\text{elapsed time}} = \frac{d}{\Delta t} = \frac{1016\ \text{km}}{11\ \text{h}} = 92\ \text{km/h}$$

Displacement; Average velocity

The displacement (change in position) of an object that occurs in a specified interval of time is describing how the object's final position has changed from its original position.

THE DISPLACEMENT IS NOT THE SAME AS THE DISTANCE IT HAS TRAVELED!!

The average velocity is the displacement divided by the elapsed time:

$$\text{average velocity} = \frac{\text{displacement}}{\text{elapsed time}} = \frac{\Delta x}{\Delta t}$$

The unit of the velocity is: **m/s** or **m.s^{-1}**

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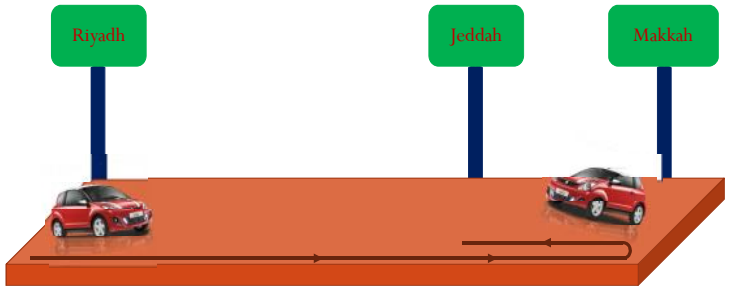
Displacement; Average Velocity

Example 1.2



Displacement= إزاحة = 930 km - 86 km = 844 km

$$\text{average velocity} = \frac{\text{displacement}}{\text{elapsed time}} = \frac{\Delta x}{\Delta t} = \frac{844\ \text{km}}{11\ \text{h}} = 77\ \text{km/h}$$

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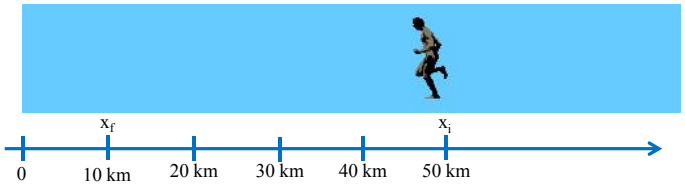
Example 1.3

A men is running in one hour from x_i to x_f. Calculate the average velocity and the average speed of the runner.



Displacement = $\Delta x = x_f - x_i$ = (10 km) - (50 km) = - 40 km, average velocity = - 40 km/h

Distance = $d = |x_f - x_i|$ = 40 km, average speed = 40 km/h

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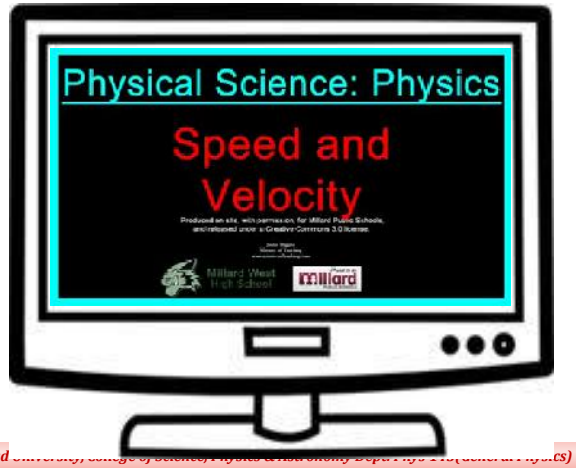
Video 01 of Chapter 01: Speed and velocity



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Instantaneous Velocity

Instantaneous velocity is defined as the velocity of an object at a given instant . It is the velocity at a particular instant in time (extremely small time interval).

It can be calculated in two ways:

a) Mathematical (differentiation)

It is the derivative (الاشتقاق) of the position:

$$v = \lim_{\Delta t \to 0}\left(\frac{\Delta x}{\Delta t}\right) = \frac{dx}{dt}$$

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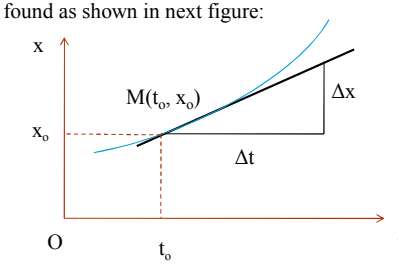
Instantaneous Velocity

b) Graphical (tangent)

The instantaneous velocity can be found graphically by drawing a tangent (straight line) to the curve at the instant of time when the velocity is to be found as shown in next figure:



The x-t graph for an object undergoing uniform Motion. The slope of the line is defined to be Δx / Δ t, which is the velocity.

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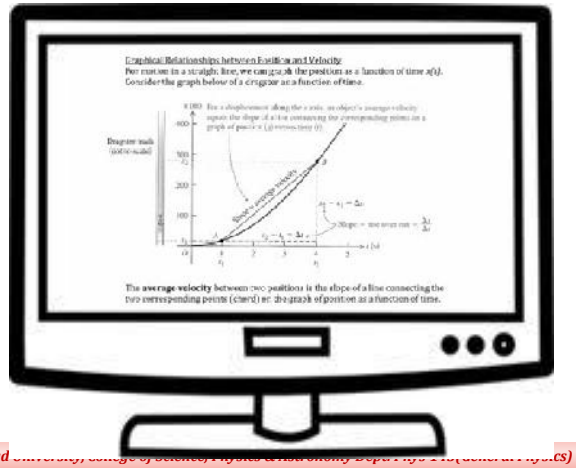
Video 02 of Chapter 01: average and instantanious velocity



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Average acceleration

- When the velocity changes with time that called acceleration (التسارع).
- It is the rate at which the velocity changes.
- The average acceleration $\bar{a}$ from t_1 to t_2, if the velocity changes from v_1 to v_2 is defined by:

$$\bar{a} = \frac{\textit{change in velocity}}{\textit{time elapsed}} = \frac{\Delta v}{\Delta t} = \frac{v_2 - v_1}{t_2 - t_1}$$

- The unit of the acceleration is: **m/s^2** or **m.s^{-2}**

An average acceleration 1**ms^{-2}** corresponds to an average increase in velocity of 1**ms^{-1}**

The signs or direction of the *velocity* and the *acceleration* need NOT be the same.

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Average and instantaneous acceleration

❖ Average acceleration

Average acceleration is defined as the change of velocity ($\Delta v = v_f - v_i$) divided by the elapsed time (Δt):

$$\bar{a} = \frac{\Delta v}{\Delta t}$$

❖ Instantaneous acceleration

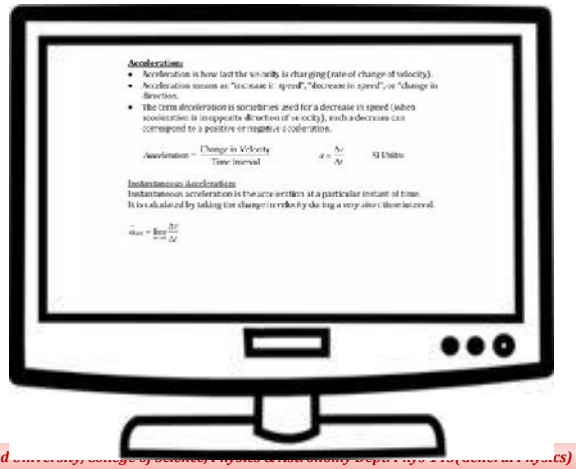
Instantaneous acceleration is defined as the acceleration of an object at a given instant:

$$a = \lim_{\Delta t \to 0}\left(\frac{\Delta v}{\Delta t}\right) = \frac{dv}{dt}$$

Acceleration can be either Constant or Variable.

In this course acceleration is constant

Video 03 of Chapter 01: average and instantanious acceleration



Finding the Motion of an Object

- The motion of an object can be described by a number of equations called the Equations of motion (Kinematics).
- Considering an object moving with initial velocity v_0 and constant acceleration a, for a time interval Δt.

  The final velocity v, can be found using the definition of the acceleration: $a = \frac{\Delta v}{\Delta t}$ where $\Delta v = a\Delta t$ is the change in the velocity can be expressed as:

  $$\Delta v = v - v_0$$
- Hence the first equation of motion can be written as:

  $$v = v_0 + a\Delta t \quad (1)$$

Finding the Motion of an Object

- The average velocity for a moving object between two points can be written as:

  $$\bar{v} = \frac{1}{2}(v_0 + v)$$
- The average velocity for a moving object can be written as defined before:

  $$\bar{v} = \frac{\Delta x}{\Delta t}$$
- This leads to the second equation of motion:

  $$\Delta x = \frac{1}{2}(v + v_0)\Delta t \quad (2)$$

Finding the Motion of an Object

- Δx can also be obtained by substituting the first equation into the second (eliminating v). The third equation of motion is obtained as follow:

$$\Delta x = \frac{1}{2}((v_0 + a\Delta t) + v_0)\Delta t$$

- This leads to the third equation which is:

$$\Delta x = v_0\Delta t + \frac{1}{2}a(\Delta t)^2 \quad (3)$$

- Using Δt in equation (1) and substituting it in equation (2) we obtain:

$$\Delta x = \frac{1}{2}(v + v_0)(\frac{v - v_0}{a})$$

- The fourth equation of motion is found to be:

$$v^2 = +v_0^2 + 2a\Delta x \quad (4)$$

Finding the Motion of an Object

$$v = v_0 + a\Delta t \quad (1)$$

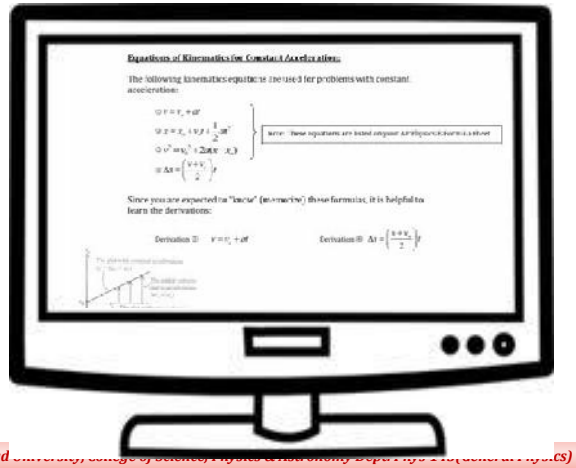
$$\Delta x = \frac{1}{2}(v + v_0)\Delta t \quad (2)$$

$$\Delta x = v_0\Delta t + \frac{1}{2}a(\Delta t)^2 \quad (3)$$

$$v^2 = +v_0^2 + 2a\Delta x \quad (4)$$

$$\bar{v} = \frac{1}{2}(v_0 + v)$$

Video 04 of Chapter 01: Motion with constant acceleration



Summary of week 01

- **Distance (d) and displacement (Δx) are defined.**
- **Distance is always positive but displacement can be positive, negative or zero.**

  Average speed $= \bar{s} = \frac{d}{\Delta t}$ average velocity $= \bar{v} = \frac{\Delta x}{\Delta t}$
- **Average speed is always positive but average velocity can be positive, negative or zero.**
- **Instantaneous velocity is obtained:**
  - **a) mathematically (differentiation)** $v = \frac{dx}{dt}$
  - **b) graphically (tangent)**
- **Average acceleration:** $\bar{a} = \frac{\Delta v}{\Delta t}$ **instantaneous acceleration:** $a = \frac{dv}{dt}$
- **Motion of an object with constant acceleration:**

$v = v_0 + a\Delta t$ (1) $\Delta x = \frac{1}{2}(v + v_0)\Delta t$ (2) $\Delta x = v_0\Delta t + \frac{1}{2}a(\Delta t)^2$ (3) $v^2 = +v_0^2 + 2a\Delta x$ (4)

(In this course only motion with constant acceleration is considered)

Quiz for Week 01