Al-Mustaqbal University / College of Engineering & Technology
Building and Construction Techniques Engineering Department
First Class
Subject: -ENGINEERING PHYSICS / Code: - UOMU023014
Lecturer Fatima Muslim
1st term – Lecture No.3 & Lecture Name Linear Motion

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Linear motion: refers to the movement of an object along a straight line, without any rotation or change in its direction. It is one of the simplest forms of motion, and the principles governing it are fundamental in physics and engineering.

الحركة الخطية تشير إلى حركة جسم على طول خط مستقيم، دون أي دوران أو تغيير في اتجاهه. وهي واحدة من أبسط أشكال الحركة، والمبادئ التي تحكمها أساسية في الفيزياء والهندسة.

The key characteristics of linear motion are:

الخصائص الرئيسية للحركة الخطية هي:

- **Position:** The specific location of an object at a given time.

  الموضع: الموقع المحدد للجسم في وقت معين.

- **Displacement:** The straight-line distance between the initial and final position of an object, with a direction.

  الإزاحة: المسافة في خط مستقيم بين الموضع الأولي والنهائي للجسم، مع وجود اتجاه.

- **Velocity:** The rate of change of displacement with respect to time.

  السرعة: معدل تغير الإزاحة بالنسبة للزمن.

- **Acceleration:** The rate of change of velocity with respect to time.

  التسارع: معدل تغير السرعة بالنسبة للزمن.

- **Time:** A key variable in determining how motion progresses.

  الزمن: متغير رئيسي في تحديد كيفية تقدم الحركة.

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To calculate **displacement**, we use the following equation,

<div dir="rtl">لحساب الإزاحة، نستخدم المعادلة التالية،</div>

$$\Delta x = \Delta x_f - \Delta x_i$$

Where

$\Delta x \ = \ is \ the \ displacement$

$\Delta x_f \ = \ is \ the \ final \ position$

$\Delta x_i \ = \ is \ the \ initial \ position$

Average velocity is the total displacement divided by the total time.

<div dir="rtl">السرعة المتوسطة هي الإزاحة الكلية مقسومة على الزمن الكلي.</div>

To calculate **average velocity**, we use the following equation,

<div dir="rtl">لحساب السرعة المتوسطة، نستخدم المعادلة التالية،</div>

$$v_{avg} = \frac{v_f + v_i}{2}$$

$$v_{avg} = \frac{\Delta x}{\Delta t} = \frac{x_2 - x_1}{t_2 - t_1}$$

Where:

$v_{avg} = average \ velocity$

$\Delta x \ = \ is \ the \ change \ in \ position$

$\Delta t \ = \ is \ the \ change \ in \ time$

$t_1 \ is \ the \ time \ at \ which \ the \ object \ was \ at \ position \ x_1$

$t_2 \ is \ the \ time \ at \ which \ the \ object \ was \ at \ position \ x_2$

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t_1هو الوقت الذي كان فيه الجسم في الموضعx_1

t_2 هو الوقت الذي كان فيه الجسم في الموضع x_2

Instantaneous velocity

السرعة اللحظية

Instantaneous velocity is the velocity at a specific point in time.

السرعة اللحظية هي السرعة عند نقطة زمنية محددة.

$$v = \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t} = \frac{x_2 - x_1}{t_2 - t_1}$$

$$v = \frac{dx}{dt}$$

To calculate **acceleration**, we use the following equation,

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

To calculate **average acceleration**, we use the following equation,

$$a_{avg} = \frac{v_2 - v_1}{t_2 - t_1}$$

Instantaneous acceleration

A change in velocity at any point in time is instantaneous acceleration. The calculation for instantaneous acceleration is similar to instantaneous velocity.

$$a = \lim_{\Delta t \to 0} \frac{\Delta v}{\Delta t} = \frac{v_2 - v_1}{t_2 - t_1}$$

$$a = \frac{dv}{dt} = \frac{d^2x}{dt^2}$$

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Example1: The velocity of a moving particle is given by $v(t) = 20t - 5t^2 m/s$
Calculate the instantaneous acceleration at t = 1, 2, 3, and 5s.

يتم إعطاء سرعة الجسيم المتحرك بواسطة v (t) = 20t − 5t²m / s احسب التسارع اللحظي عند 1 = t
و2 و3 و5.s

Solution:

$$v(t) = 20t - 5t^2$$

$$\frac{dv(t)}{dt} = a = 20 - 10t$$

$$a = 20 - 10(1) = 10ms^{-2}$$

$$a = 20 - 10(2) = 0ms^{-2}$$

$$a = 20 - 10(3) = -10ms^{-2}$$

$$a = 20 - 10(5) = -30ms^{-2}$$

Key Equations of Linear Motion

المعادلات الأساسية للحركة الخطية

The fundamental equations governing linear motion are derived from the basic definitions of velocity and acceleration. These equations are often referred to as the **"equations of motion**," and they apply when an object moves under constant acceleration (e.g., due to gravity or uniform acceleration).

تستمد المعادلات الأساسية التي تحكم الحركة الخطية من التعريفات الأساسية للسرعة والتسارع. وغالبًا ما يشار إلى هذه المعادلات باسم "معادلات الحركة"، وهي تنطبق عندما يتحرك جسم تحت تسارع ثابت (على سبيل المثال، بسبب الجاذبية أو التسارع المنتظم).

1. Displacement with Constant Acceleration:

الازاحة مع تسارع ثابت

$$s = ut + \frac{1}{2}at^2$$

Where:

- $s = displacement(m)$
- $u = initial\ velocity(m/s)$
- $a = acceleration(m/s^2)$
- $t = time(s)$

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2. Final Velocity after Time t:

السرعة النهائية بعد الزمن

$$v = u + at$$

Where:

- $v = final\ velocity(m/s)$
- $u = initial\ velocity(m/s)$
- $a = acceleration(m/s^2)$
- $t = time(s)$

3. Displacement with Final Velocity:

الازاحة مع السرعة النهائية

$$s = \frac{(u + v)}{2} \times t$$

Where:

- $s = displacement(m)$
- $u = initial\ velocity(m/s)$
- $v = final\ velocity(m/s)$
- $t = time(s)$

4. Velocity and Displacement without Time:

السرعة والازاحة بدون زمن

$$v^2 = u^2 + 2as$$

Where:

- $v = final\ velocity(m/s)$
- $u = initial\ velocity\ (m/s)$
- $a = acceleration(m/s^2)$
- $s = displacement(m)$

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Examples of Linear Motion

أمثلة على الحركة الخطية

1. **Free Fall (Gravity-Driven Motion):** A common example of linear motion is the fall of an object due to gravity. When an object is dropped from a height, it accelerates towards the Earth with an acceleration ($a = g = 9.8\ (m/s^2)$) (on Earth).

السقوط الحر (الحركة المدفوعة بالجاذبية): من الأمثلة الشائعة للحركة الخطية سقوط جسم بسبب الجاذبية. فعندما يسقط جسم من ارتفاع، فإنه يتسارع نحو الأرض بتسارع ((a= g= 9.8 (m/s²))(على الأرض).

Example2: A ball is dropped from a height of 20 meters. How long does it take to hit the ground?

مثال1: تسقط كرة من ارتفاع 20 مترًا. ما المدة التي تستغرقها الكرة حتى تصطدم بالأرض؟

Solution:

$$s = ut + \frac{1}{2}at^2$$

Given: $s = 20\ m, u = 0\ m/s, a = 9.8\ m/s^2$

$$20 = 0 \times t + \frac{1}{2} \times 9.8 \times t^2$$

$$20 = 4.9t^2$$

$$t^2 = \frac{20}{4.9} \approx 4.08$$

$$t = \sqrt{4.08} \approx 2.02\ sec$$

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2. **Uniform Motion:** If an object is moving at a constant velocity, there is no acceleration. For example, a car moving at a constant speed of 60 km/h for 2 hours.

الحركة المنتظمة: إذا تحرك جسم بسرعة ثابتة، فلا يوجد تسارع. على سبيل المثال، سيارة تتحرك بسرعة ثابتة 60 كم/س لمدة ساعتين.

Example3: A car travels at a speed of 60 km/h for 2 hours. How far does the car travel?

تتحرك سيارة بسرعة 60 كم/س لمدة ساعتين. ما المسافة التي تقطعها السيارة؟

Solution:

Since the car is moving at a constant velocity, we use:

نظرًا لأن السيارة تتحرك بسرعة ثابتة، فإننا نستخدم:

$$displacement = velocity \times time$$

$$displacement = 60 \ km/h \times 2 \ h = 120 \ km/h$$