النادي الطبي

MEDICAL PHYSICS

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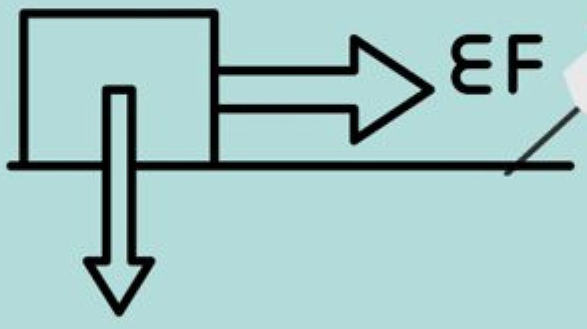
$\Sigma F = ma$



Chapter 1
Motion in a straight line

الحركة في بعد واحد

Dr. Ghassan Alna’washi

COURSE TOPICS:

- 1.1 Measurements, Standards and Units
- 1.2 Displacements; Average Velocity
- 1.3 Instantaneous Velocity
- 1.4 Acceleration
- 1.5 Finding the Motion of an Object
- 1.6 The Acceleration of Gravity and Falling Objects

Examples to be explained and solved:
1.2; 1.4; 1.14; 1.16 and 1.20

القياسات المعايير الوحدات الأخطاء

1.1 Measurements, standards, units and errors

الكميات الفيزيائية تصنيف كميات أساسية

Physical quantities are classified into **fundamental quantities** such as **mass**, **length**, **time** and

كتلة طول الوقت

كميات مشتقة

derived quantities such as **velocity**, **acceleration**, **force**, **energy**....

سرعة تسارع قوة طاقة

المعيار الأساسي

Primary standard: [ ]

- **Length** has a dimension **L** (m)
- **Time** has a dimension **T** (s)
- **Mass** has a dimension **M** (Kg)

كميات ميكانيكية التعبير مزيج

All mechanical quantities can be expressed in terms of some combination of these three fundamental dimensions.

الأبعاد الأساسية الثلاثة

Example:

سرعة مسافة زمن

$$velocity = v = \frac{distance}{time}$$

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

$$[a] = \frac{[\Delta v]}{[\Delta t]} = \frac{L}{T^2}$$

$$[v] = \frac{[distance]}{[time]} = \frac{L}{T}$$

1.1 Measurements, standards, units and errors

أنظمة الوحدات

Systems of units

	International system (S.I) =mks		British system		C.G.S System	
Physical quantity	unit	symbol	unit	symbol	unit	symbol
Length	Meter	m = 100 cm = 3048 ft	Foot	ft	centimeter	cm
			$1ft = 0.3048\,m$		$1cm = 10^{-2}m$	
Mass	kilogram	1 kg = 1000 g = 4536 lb	Pound	lb	gram	g
			$1lb = 0.4536\,kg$		$1g = 0.001\,kg$	
Time	second	s	Second	s	second	s

- The international system is also known as the *metric system* or the *m.k.s system.*
- In the medical area some units are more used than those of the S.I units, such as the use of calorie as unit for energy than the Joule ($1\ cal = 4.2\ J$) , the millimeter of mercury for the pressure than the Pascal ($1mmHg = 133.32\ Pa$) or the liter for the volume than the meter cube.

نظام الدولي — نظام المتري — سعرات حرارية — مجال الطب — ضغط — باسكال — اللتر — حجم — متر مكعب

1.1 Measurements, standards, units and errors

التدوين العلمي

The scientific notation

- A number is said to be in scientific notation when it is written as a number between 1 and 10,
- محصورة بالفترة
  times a power of 10.
- For example, 521 can be written as 5.21×10^{2}, or a small number like 0.000000521 can be written as 5.21×10^{-7}.
- إيجابيته ترميز صغر حجم عمليات حسابية رقمية
  The advantage of this notation is its compactness, it also facilitates numerical calculations.
- When a number is written with the powers of 10, we can use the following **prefixes** البدايات

Multiples		Prefix	symbol	Sub-multiples		Prefix	symbol
10		deca	da	0.1	10^{-1}	deci	d
100	10^{2}	hecto	h	0.01	10^{-2}	centi	c
1000	10^{3}	kilo	k	0.001	10^{-3}	milli	m
1000 000	10^{6}	Mega	M	0.000001	10^{-6}	micro	μ
1000 000 000	10^{9}	Giga	G	0.000 000 001	10^{-9}	nano	n
1000 000 000 000	10^{12}	Tera	T	0.000 000 000 001	10^{-12}	pico	p

1.1 Measurements, standards, units and errors

Conversion of units

طريقة نظامية

To convert quantities from a unit system to another, we can use the following **systematic method:**

Suppose we want to convert a length $L = 1.75\ m$ into foot . The conversion factor between the two units is given by: $1ft = 0.3048\ m$

To convert from meter to foot we have to follow these steps:

1. Multiply the quantity to convert by one:

$$L = 1.75\ m \times 1$$

2. Rearrange the conversion factor in quotient equal to 1 that allows the elimination of the unit from which we want to convert :

طريقة ثانية :-

$1\ ft = 0.3048\ m$

$? = 1.75\ m$

$1\ ft \times \frac{1.75\ m}{0.3048\ m} = \frac{0.304\ m}{0.3048\ m}$

$= 5.84\ ft$

$$1\ ft = 0.3048\ m \Rightarrow \frac{1\ ft}{0.3048\ m} = 1$$

3- Replace this form in the first step:

$$L = 1.75\ m \times (1) = 1.75\ m \times \frac{1\ ft}{0.3048\ m} = \cancel{30.48\ m}\ 5.84\ ft$$

1.1 Measurements, standards, units and errors

Conversion of units

Example 1.1: Convert $100\ ft$ into meters.

$$100\ ft = 100\ ft \times (1) = 100\ ft \times \left(\frac{0.3048m}{1f}\right) = 30.48\ m$$

طريقة الحل :-

$1m = 3048\ ft$

$? \ X = 100\ ft$

$1m \ast 100\ \cancel{ft} / 3048\ \cancel{ft} = \frac{3048\ \cancel{ft}}{3\cancel{0}48\ ft}$

$= 30.48m$

Example 1.2:

Convert the velocity of $24\ m/s$ into km/h.

We have $1\ km = 10^3\ m$ and $1\ h = 3600\ s$

Then $24\ m/s = 24\ \frac{m}{s} \times (1) \times (1)$ { (1) *is written twice because we have two units to convert*}

$$24\ mTs = 24\ \frac{\cancel{m}}{\cancel{s}} \times \left(\frac{1km}{10^3 \cancel{m}}\right) \times \left(\frac{3600 \cancel{s}}{1h}\right) = \frac{24 \times 3600}{10^3} \frac{km}{h} = 86.4\ km/h$$

طريقة الحل :

$\frac{1\ Km}{1\ h} = \frac{1000m}{3600\ S}$

$? \ X = 24 \frac{m}{s}$

$\frac{3600\ \cancel{s}}{1000\ \cancel{m}} \ast \frac{Km}{h} \ast 24 \frac{\cancel{m}}{\cancel{s}} = \frac{1000\ m}{3600\ s} \ast \frac{3600\ s}{1000\ m}$

$= 86.4\ Km/h$

1.1. Measurements, standards, units and errors

Conversion of units

حل آخر:

Example 1.3: The skin is the largest organ in the human body; for a human adult the average area of the skin surface is about $1.8\ m^2$, how much squared foot is this area?

$$(1\,ft)^2 = (0.3048\,m)^2$$
$$? = 1.8\,m^2$$

Solution: $Given\ that\ 1ft = 0.3048\ m\ ,then\ 1ft^2 = (0.3048)^2 m^2$

$$\frac{ft^2 * 1.8\,\cancel{m^2}}{(0.3048)^2\cancel{m^2}} = \frac{(0.3048m)^2}{(0.3048m)^2}$$
$$= 19\ ft^2$$

$$A = 1.8\ m^2 = 1.8\ \cancel{m^2} \times \left(\frac{1ft^2}{(0.3048)^2\cancel{m^2}}\right) = 19ft^2$$

Example 1.4*:* an ampoule contains a solution of drug of $300\mu g/5ml$, convert this dose into g/l.

Solution: $$\frac{300\ \mu g}{5ml} = \frac{300\times10^{-6}\ g}{5\times10^{-3}l} = 0.06g/l$$

1.1 Measurements, standards, units and errors

$\boxed{1\,mi = 1609m}$

Conversion of units

Example 1.4: Convert a velocity of 60 mi h^{-1} (mile per hour) to m s^{-1} (meter per second)

Multiplying 60 mi h^{-1} by 1 twice gives

$$(60 \text{ mi h}^{-1})(1)(1) = (60 \text{ mi h}^{-1})\left(\frac{1 \text{ h}}{3600 \text{ s}}\right)(1609 \text{ m mi}^{-1})$$

$$= 60\left(\frac{1609}{3600}\right) \text{ m s}^{-1} = 26.8 \text{ m s}^{-1}$$

$$\frac{1\,mi}{1\,h} = \frac{1609\,m}{3600\,S}$$

$$\frac{60\,mi}{h} = ?$$

$$\cancel{\frac{mi}{h}} = \frac{1609\,m}{3600\,s}\left(60\,\cancel{\frac{mi}{h}}\right)$$

$$= 26.8\,\frac{m}{s}$$

1.1 Measurements, standards, units and errors

Types of Errors

انواع الأخطاء

قياسات تنبؤات معرضة

Measurements and predictions are both subject to errors.

أخطاء القياس

Measurement errors are of two types:

تؤثر على الدقة مدى تكرار نفس القياس تحت ظروف مماثلة

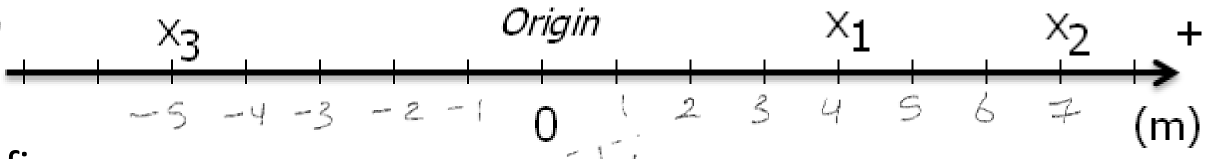
- 1 الأخطاء العشوائية **Random errors:** affects precision (how reproducible the same measurement is under equivalent circumstances.

تؤثر على دقة القياس مدى القرب قيمة موجودة

- 2 الأخطاء منهجية **Systematic errors:** affects the accuracy of a measurement (how close the observed value is to be true)

1.2 Displacement; Average velocity

- To describe the motion of an object we should first set up a **coordinate system** to locate the position.
- A **coordinate system** is made up of an origin, a positive direction and a unit of length.
- **Position (x):** is the location of an object with respect to a chosen reference point in the position
  - It could be positive or negative
  - S.I unit is meter



Example: In the above figure:

$x_1 = 4\ m, x_2 = 7\ m, x_3 = -5\ m$

- **Displacement:** is the change in the position:

$$\boxed{\Delta x = x_{final} - x_{initial} = x_f - x_i}$$

  - The displacement can be positive or negative; it is negative if the motion is in the negative direction
  - It is not the same as the distance travelled

Example: In the figure above, if the object moves from $x_1 to\ x_2$: $\Delta x = x_2 - x_1 = 7\ m - 4m = 3\ m.$

The displacement from $x_2\ to\ x_3$ is: $\Delta x = x_3 - x_2 = -5m - 7\ m = -12\ m.$

1.2 Displacement; Average velocity

الإزاحة خلال مدة زمنية

- **Average velocity:** the average velocity is the displacement over an elapsed time Δt:

سرعة متوسطة

الإزاحة

$$average\ velocity = \frac{displacemnet}{time\ eleapsed} \Rightarrow \bar{v} = \frac{\Delta x}{\Delta t} = \frac{x_f - x_i}{t_f - t_i}$$

الوقت المنقضي

(+) (-)

- It could be positive or negative
- S.I unit is m/s
- Direction of the average velocity is the same as that of the displacement

* أي أن سرعة نفس اتجاه الإزاحة

Example: A car is at $x_1 = 600\ m$ when $t_1 = 5\ s$ and at $x_2 = 500\ m$ when $t_2 = 15\ s$.
What is the average velocity?

Solution:

$$\bar{v} = \frac{\Delta x}{\Delta t} = \frac{x_f - x_i}{t_f - t_i} = \frac{(500-600)\ m}{(15-5)\ s} = -10\ m/s$$

1.2 Displacement; Average velocity

Example: The position of a car in successive time intervals is represented in the following figure.

a. Find the average velocity in the time interval 0 to 10 s

$$\bar{v} = \frac{\Delta x}{\Delta t} = \frac{x_f - x_i}{t_f - t_i} = \frac{(200-0)\ m}{(10-0)\ s} = 20\ m/s$$

b. Find the average velocity in the time interval 5 s to 20 s

$$\bar{v} = \frac{\Delta x}{\Delta t} = \frac{x_f - x_i}{t_f - t_i} = \frac{(400-100)\ m}{(20-5)\ s} = 20\ m/s$$

سرعة ثابتة (منتظمة)

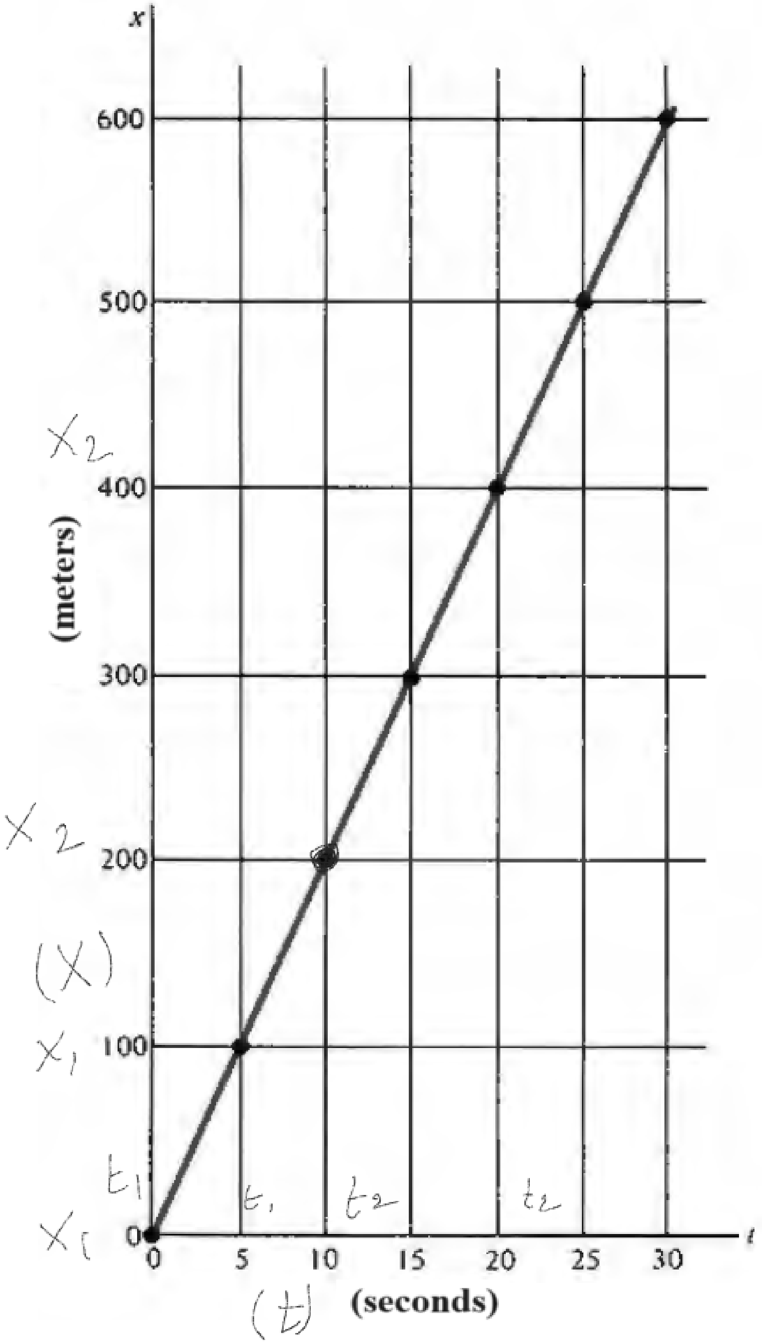
مسافات متساوية وقت متساوي

- Because the car in this example moves equal distances in equal times, the average velocity will be the same no matter what time interval is chosen. In this situation the motion is said to be **uniform.**

منتظمة

- Motion that is not uniform is said to be **accelerated**.

حركة غير منتظمة تسارع



1.2 Displacement; Average velocity

Example: A car moves as shown in figure. Find its average velocity from $t = 0$ to $t = 1$ s and from $t = 1$ s to $t = 2$ s .

Solution:

from $t = 0$ to $t = 1$ s, the average velocity is

$$\bar{v} = \frac{\Delta x}{\Delta t} = \frac{x_f - x_i}{t_f - t_i} = \frac{(1-0)\ m}{(1-0)\ s} = 1\ m/s$$

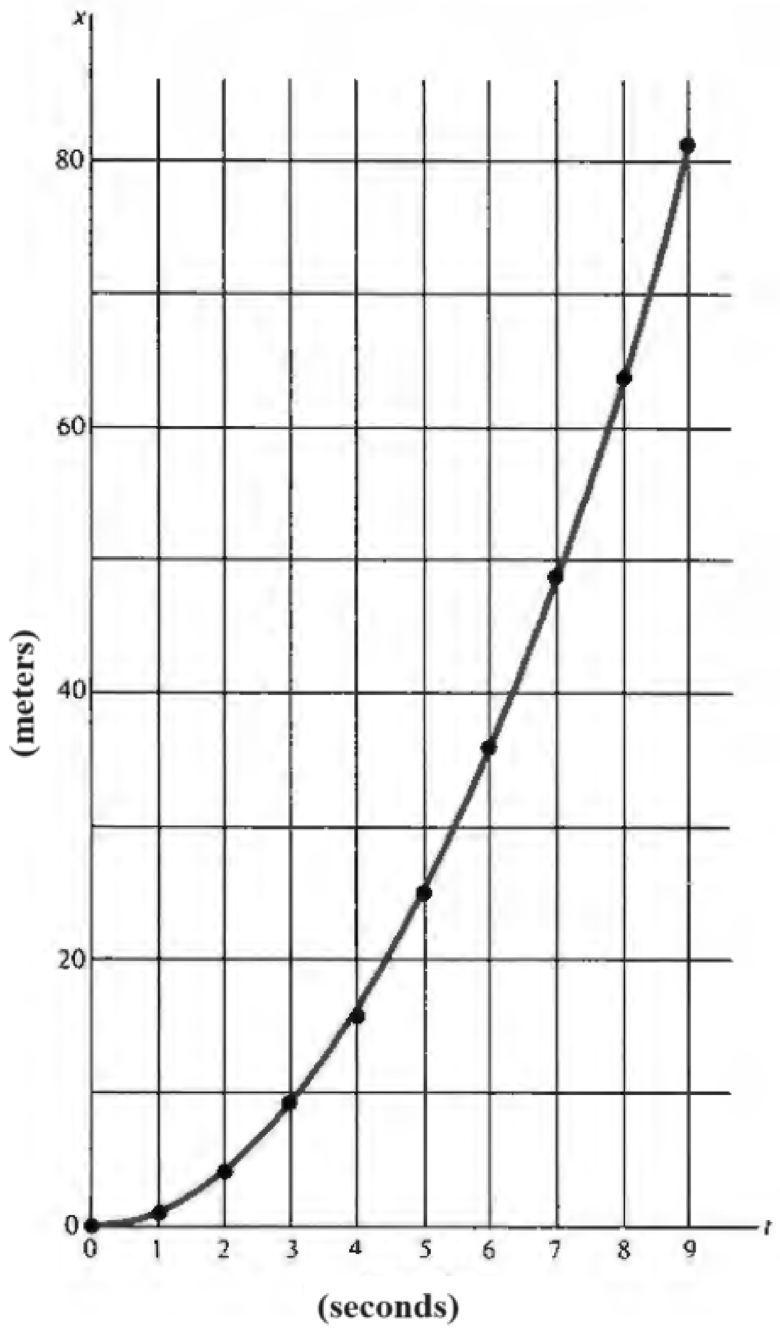
from $t = 1$ s to $t = 2$ s, the average velocity is

$$\bar{v} = \frac{\Delta x}{\Delta t} = \frac{x_f - x_i}{t_f - t_i} = \frac{(4-1)\ m}{(2-1)\ s} = 3\ m/s$$

Note that the average velocity is not constant because the car is accelerated.

سرعة ليست ثابتة

تسارع



1.2 Displacement; Average velocity

Example: A particle moved from $x_1 = 2\ m$ to $x_2 = -5\ m$ in time of 2 seconds and then back to $x_3 = x_1 = 2\ m$ in time of 2 seconds. Find

إزاحة

a. The displacement from x_1 to x_2.

سرعة متوسطة

b. The average velocity between x_1 and x_2.

c. The displacement when the particle returns to its initial position x_1. إزاحة عندما يعود لنقطة البداية

d. The average velocity in the whole trip

الرحلة كاملة

Solution

a. $\Delta x = x_2 - x_1 = -7\ m$

b. $\bar{v} = \dfrac{\Delta x}{\Delta t} = \dfrac{-7\ m}{2\ s} = -3.5\ m/s$

c. $\Delta x = x_3 - x_1 = 0\ m$

d. $\bar{v} = \dfrac{\Delta x}{\Delta t} = \dfrac{0\ m}{4\ s} = 0$

إزاحة $\Delta X = X_3 - X_1 = 2 - 2 = 0$

Note that the displacement in the example is zero but the distance travelled is

مسافة مقطوعة

$d = 7\ m + 7\ m = 14\ m$

1.2 Displacement; Average velocity

Example: A car moves along a straight highway at an average velocity of 100 km/h.
(a) How far will it go in 2 h?
(b) How long will it take to travel 350 km?

Solution

$$a. \quad \bar{v} = \frac{\Delta x}{\Delta t} \Rightarrow \Delta x = \bar{v}\Delta t = \left(100\,\frac{km}{h}\right)(2\ h) = 200\ km = 2 \times 10^5\ m$$

$$b. \quad \Delta t = \frac{\Delta x}{\bar{v}} = \frac{350\ km}{100\ km/h} = 3.5\ h = 3.5\ h \times \frac{3600\ s}{h} = 12600\ s$$

1 h → 100 km
? → 350 km

$\cancel{350}$ km . 1h = $\cancel{100}$ km (? h)

= 3.5 h

سرعة اللحظية

1.3 Instantaneous velocity

سرعة متوسطة لا تعطي وصف معدل التغير موقع في كل لحظة

- The average velocity doesn’t give a description about the rate of change of the position at each instant. We

معرفة سرعة في كل ثانية يشار إليها سرعة اللحظية

need often to know the velocity of an object at each second, referred to as **instantaneous velocity:**

تحديد حساب سرعة متوسطة

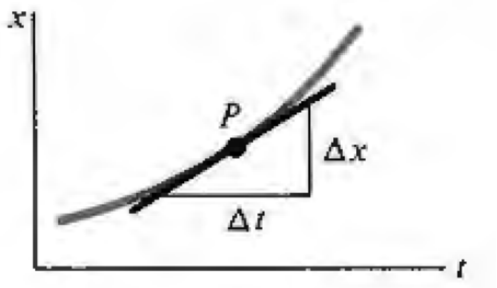
- **Instantaneous velocity:** The instantaneous velocity is determined by computing the average velocity for an

فترة قصيرة للغاية

extremely short time interval:

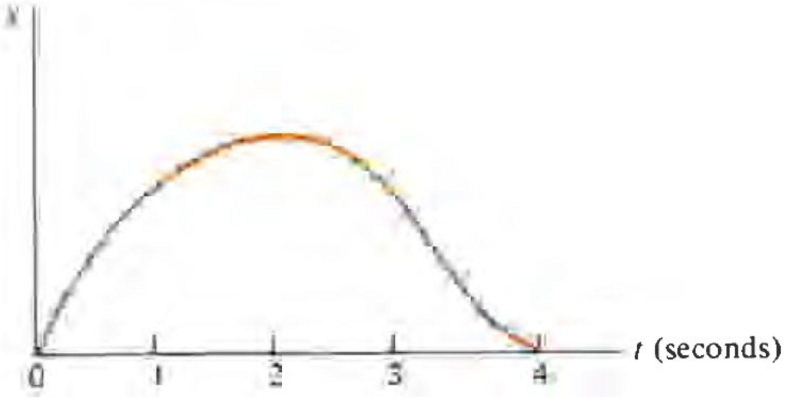
ميل مماس الرسم البياني وقت محدد

$$v = \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t} = \frac{dx}{dt} \equiv \text{slope of the tangent of } x - t \text{ graph at a definite time } t$$



The position versus time of an object is represented in the lowest graph:

- Between $t = 0$ and $t = 2$ s, the x-t curve is rising. The slope and v are positive
- At $t = 2$ s, x has its greatest value. The curve is flat there; Hence the slope and v are zero.
- After $t = 2$ s, the x is decreasing, so v is negative.



1.3 Instantaneous velocity

Example: حركة الجسم

الإزاحة

the motion of an object is given by the equation : $x(\,t) = 2 + 3t - 2t^2$, where

x *is the position in meter* and t *is the instant in second.*

* السرعة اللحظية

عبارة عن ميل الإزاحة (مشتقة الأولى) $V(t) = 3 - 4t$

(a) Find the velocity of the object at $t = 5\ s$.

(b) What is its average velocity between the two instants $t_1 = 3s$ and $t_2 = 5s$?

Answer:

(a) $v = \dfrac{dx}{dt} = 3 - 4t$;   then at the instant $\mathrm{t} = 5\ \mathrm{s}$, $v = 3 - 4 \times 5 = -17\ m/s$ → $t = 5$ نعوض في المشتقة

(b) At $t_1 = 3s$: $x_1 = 2 + 3 \times 3 - 2 \times 3^2 = -7\ m$

At $t_2 = 5s$: $x_2 = 2 + 3 \times 5 - 2 \times 5^2 = -33m$ →

* لما أطلب السرعة متوسطة (ما الك دخل بالمشتقة)
نجيب الإزاحة عند كل زمن
ونطرحهم عادي

Then the average velocity is:

$$\bar{v} = \frac{x_2 - x_1}{t_2 - t_1} = \frac{\{-33 - (-7)\}}{5 - 3} = -13\ m/s$$

1.4 Acceleration

تسارع

معدل تغير السرعة تسارع

سرعة معدل مسافة تتغير مع الوقت

- Like position, velocity can change with time. The rate at which velocity changes is the *acceleration*
- Again, we can discuss the average and the instantaneous acceleration.

متوسط التسارع معدل سرعة

- **The Average acceleration** is the change of velocity over an interval of time Δt:

تغير في السرعة خلال فترة زمنية

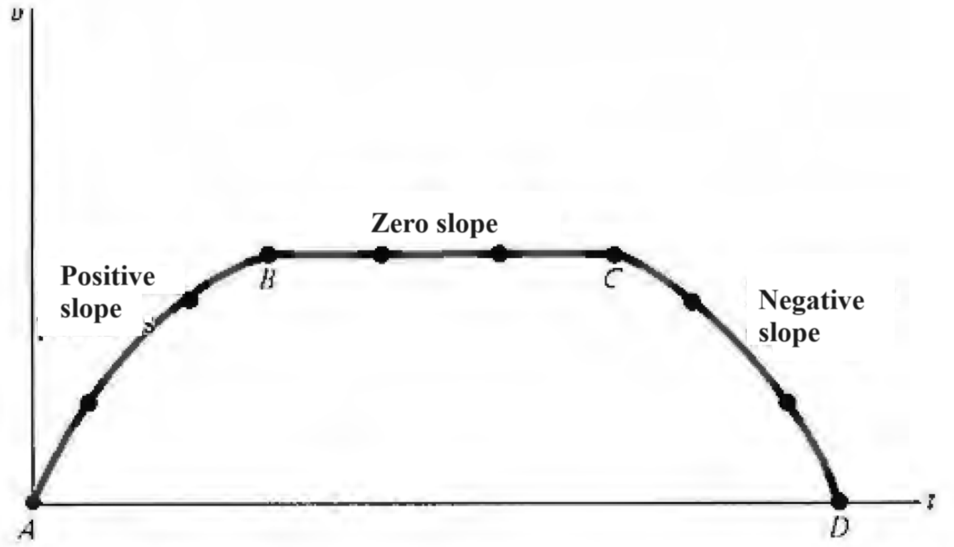
$$\bar{a} = \frac{change\ in\ velocity}{change\ in\ time} = \frac{\Delta v}{\Delta t} = \frac{v_f - v_i}{t_f - t_i}$$

  - S.I unit is $\boxed{m/s^2}$ وحدة قياس
  - The acceleration could be positive or negative حسب الاتجاه

التسارع اللحظي

- **The Instantaneous acceleration** is the rate change of velocity over an extremely short time interval

$$a = \lim_{\Delta t \to 0} \frac{\Delta v}{\Delta t} = \frac{dv}{dt} \equiv \frac{dx^2}{d^2t}$$ slope of the tangent of v-t graph at a definite time t



The graph represent velocity-versus-time for a car.
The slope and acceleration are positive from A to B, zero from B to C, and negative from C to D.

(مشتقة الثانية لـ (X(t)) أو مشتقة V(t))

1.4 Acceleration

Example: the motion of an object is given by the equation : $x(t) = 27t - 4t^2$. x is $in\ meter$ and

سرعة تسارع

$t\ in\ second$. Find the velocity and acceleration of the object at $t = 5\ s$.

مشتقة مرتين

Answer:

$$v(t) = \frac{dx}{dt} = 27 - 8t \Rightarrow \quad v(t = 5\ s) = 27 - 8 \times 5 = -13\ m/s$$

$$a = \frac{dv}{dt} = -8\ m/s^2$$

$x'(t) = v(t) = 27 - 8t$

$x''(t) = v'(t) = a(t) = -8$

the motion is with constant acceleration

الحركة بتسارع ثابت

1.4 Acceleration

Example: the motion of an object is given by the equation : $x(t) = 5t^2 - 2t + 4$. x is *in meter* and t *in second*. Find

$v(t) = 10t - 2$

$a(t) = 10$

$x(0) = 4m$ $x(2) = 20m$

مسافة

a. the position of the object at $t = 0$ s and at $t = 2$ s.

سرعة متوسطة

b. The average velocity in the time interval [0, 2] s. $\bar{v} = \frac{\Delta x}{\Delta t} = \frac{20-4}{2-0} = \frac{16}{2} = 8 m/s$

سرعة لحظية

c. The instantaneous velocity at at $t = 0$ s and at $t = 2$. $v(0) = -2 m/s$ $v(2) = 18 m/s$

تسارع متوسط

d. The average acceleration in the time interval from $t = 0$ to $t = 2$ s. $\bar{a} = \frac{\Delta v}{\Delta t} = \frac{18+2}{2-0} = \frac{20}{2} = 10 m/s^2$

تسارع لحظي

e. The instantaneous acceleration $a(t) = 10 m/s^2$

Answer:

a. $x(0) = 5 \times 0^2 - 2 \times 0 + 4 = 4\,m,$ $\qquad x(2) = 5 \times 2^2 - 2 \times 2 + 4 = 20\,m$

b. $\bar{v} = \frac{\Delta x}{\Delta t} = \frac{x(2) - x(0)}{(2-0)} = \frac{(20-4)m}{2\,s} = 8\,m/s$

c. $v(t) = \frac{dx}{dt} = 10t - 2 \Rightarrow$

$v(t = 0) = 10 \times 0 - 2 = -2\,m/s$ and $v(t = 2\,s) = 10 \times 2 - 2 = 18\,m/s$

d. $\bar{a} = \frac{\Delta v}{\Delta t} = \frac{v(t=2\,s) - v(t=0)}{2-0} = \frac{\{18-(-2)\}\,m/s}{2\,s} = 10\,m/s\text{^}2$

ثابت

e. $a = \frac{dv}{dt} = \frac{d^2x}{dt^2} = \frac{d}{dt}\left(\frac{dx}{dt}\right) = \frac{d}{dt}(10t - 2) = 10\,m/s^2 \Rightarrow$ the motion is with constant acceleration

1.4 Acceleration

Example: the velocity of a car is given by the equation : $v = 20 - 3t$. v is in m/s and t $in\ second$. Find

تسارع متوسط

a. The average acceleration from $t = 1\ \ s$ and at $t = 3$ s. $\bar{a} = \frac{\Delta v}{\Delta t} = \frac{v(3) - v(1)}{3 - 1} = \frac{11 - 17}{2} = \frac{-6}{2} = -3\ m/s^2$

تسارع لحظي

c. The instantaneous acceleration. $a = -3\ m/s^2$

d. The position at $t = 1$ s if the car starts motion at $t = 0\ s$. $x = \int_0^1 20 - 3t$

$x = 20t - \frac{3t^2}{2}\Big]_0^1$

Answer:

$$a.\ \ \bar{a} = \frac{\Delta v}{\Delta t} = \frac{v(t{=}3\ s) - v(t{=}1\ s)}{(3-1)s} = \frac{\{(20-3\times3)-(20-3\times1)\}\ m/s}{2\ s} = -3\ m/s^2$$

$x = (20 - 0) - (\frac{3}{2} - 0)$

$$b.\ \ a = \frac{dv}{dt} = \frac{d}{dt}(20 - 3t) = -3\ m/s^2$$

$= \frac{40 - 3}{2} = \frac{37}{2} = 18.5\ m$

$$\text{c.}\quad v = \frac{dx}{dt} \implies dx = v\,dt$$

$$\int_{x_i}^{x_f} dx = \int_{t_i}^{t_f} v\,dt \quad \implies \quad x(t_f) - x(t_i) = \int_{t_i}^{t_f} v\,dt$$

$$x(t = 1\ s) - x(t = 0) = \int_0^1 (20 - 3t)dt = (20t - \frac{3}{2}t^2)|_0^1 = 18.5\ m$$

$$x(t = 1\ s) - 0 = 18.5\ m$$

$$x(t = 1\ s) = 18.5\ m$$

اتجاه حركة الجسم

1.5 Finding the motion of an object

- If the initial position (x_i) and velocity (v_i) are known, then, at later time t, the final position (x_f) and velocity (v_f) can then be found if the acceleration is given.

تسارع ثابت

- When the acceleration is constant, we can find the equations of motion. In this case the average and the instantaneous accelerations are equal. and the following equations of motion with constant acceleration are obtained: * معادلات الحركة *

Average velocity	$\bar{v} = \frac{1}{2}(v_f + v_i)$ …… (1)	Relating the final velocity to the initial velocity
Velocity equation	$v_f = v_i + a\Delta t$ ………(2)	Relating the final velocity to the initial velocity and the acceleration
Equation of motion	$\Delta x = x_f - x_i = v_i\,\Delta t + \frac{1}{2}a(\Delta t)^2$ ……. (3)	Relating the final position to the initial position, the initial velocity and the acceleration
	$v_f^2 = v_i^2 + 2\,a\,\Delta x$ $= v_i^2 + 2a(x_f - x_i)$ ……. (4) $\Delta x = \frac{1}{2}(v_f + v_i)\Delta t$ ~ (5)	Relating the final velocity to the initial velocity, the acceleration and the position change

1.5 Finding the motion of an object

Example 1.16 P 14: $v_i = 0$ $\quad a \quad t$

A car, initially at rest at a traffic light, accelerates at $2\ m/s^2$ when the light turns green. After 4 seconds what are its velocity and position?

$v_f = v_i + a\Delta t$
$v_f = 0 + 2(4-0)$
$\boxed{v_f = 8\ m/s}$

Solution:

Since we know the acceleration a, the elapsed time Δt, and the initial velocity $v_i = 0$, we can use Equations (2) and (3) to find the velocity and the displacement. Thus

$$v_f = v_i + a\Delta t = 0 + (2\ m/s^2)(4\ s) = 8\ m/s$$

$$\Delta x = x_f - x_i = v_i t + \frac{1}{2}a(\Delta t)^2$$

$$x_f - 0 = 0 + \frac{1}{2}(2\ m/s^2)(4\ s)^2 = 16\ m$$

$$x_f = 16\ m$$

$v_f^2 = v_i^2 + 2a\Delta x$
$(8)^2 = \cancel{(0)^2} + 2(2)\Delta x$
$\boxed{\Delta x = 16\ m}$

After 4s the car has reached a velocity of 8m.s^{-1} *and is 16m far from the light. Note that we could also find* Δx *from Eq. (4) using our result for* v

Exercise: Resolve example 1.16 with an initial velocity $v_0 = 3\ m/s$.

$v_f = v_i + a\Delta t$
$= 3 + 2(4-0) = 11\ m/s$

$(v_f)^2 = (v_i)^2 + 2a\Delta x$
$(11)^2 = (3)^2 + 2(2)\Delta x$

$\Delta x = \frac{121-9}{4}$
$= 28\ m$

1.5 Finding the motion of an object

Example

$v_i = 0$ تسارع ثابت a

A car accelerates from rest with constant acceleration of 2 m/s^2 onto a highway where cars are moving steady at 24 m/s

Δt - الوقت v_f

$v_f = v_i + a\Delta t$

$24 = 0 + 2\Delta t$

$\boxed{\Delta t = 12\,s}$

(a) How long does it take for the car to reach the highway speed.

(b) How far will it travel in that time.

Answer: مسافة Δx

(a) We have $v_i = 0, v_f = 24\, m/s,\ a = 2\, m/s^2$

$$v_f = v_i + a\Delta t \;\Rightarrow \Delta t = \frac{v_f - v_i}{a} = \frac{(24-0)m/s}{2\, m/s^2} = 12\ s$$

$(v_f)^2 = (v_i)^2 + 2a\Delta x$

$(24)^2 = (0)^2 + 2(2)\Delta x$

$\Delta x = 144\,m$

(b) $\Delta x = x_f - x_i = v_i\Delta t + \frac{1}{2}a(\Delta t)^2 = 0 + \frac{1}{2}(\,2\, m/s^2)(12\ s)^2 = 144\ m$

تسارع الجاذبية سقوط الاجسام

1.6 The acceleration of gravity and Falling objects

تحصل على تسارع جاذبية جاذبية الارض

Falling objects undergo an acceleration, which we attribute to **gravity**, the gravitational attraction of the earth.

If gravity is the only factor affecting the motion of an object falling near the earth's surface, and air resistance is either absent or negligibly small. So long as the object's distance from the surface of the earth is small compared to the earth's radius, it is found that:

1. *The gravitational acceleration is the same for all falling objects, no matter what their size or composition or mass.*

   تسارع الجاذبية هو نفسه بالنسبة لجميع الاجسام الساقطة مهما كان حجمها او تكوينها او كتلتها

2. *The gravitational acceleration is constant. It does not change as the object falls.*

   تسارع الجاذبية ثابت ولا يتغير مع سقوط الجسم

قذف إلى الاعلى

- An object initially thrown upward has also the gravity acceleration . Its speed steadily decreases in magnitude until it becomes zero at the highest point reached.

  يصبح سرعته صفر حتى تتناقص

- Free falling problems can be solved using the equations of motion in a straight line (which is on the vertical direction) with a constant acceleration equal to $9.80\ m/s^2$.

  معادلات الحركة

- In the equations of motion, we will use

  لكن

$$a_y = -g = 9.80\ m/s^2$$

1.6 The acceleration of gravity and Falling objects

In the absence of any other forces, the equation of motion for a freely falling object near the surface of the earth are

$$g = 9.8\ m/s^2$$

$$a = -g\ = -\ 9.80\ m/s^2$$

$$v_f = v_i - g\ \Delta t$$

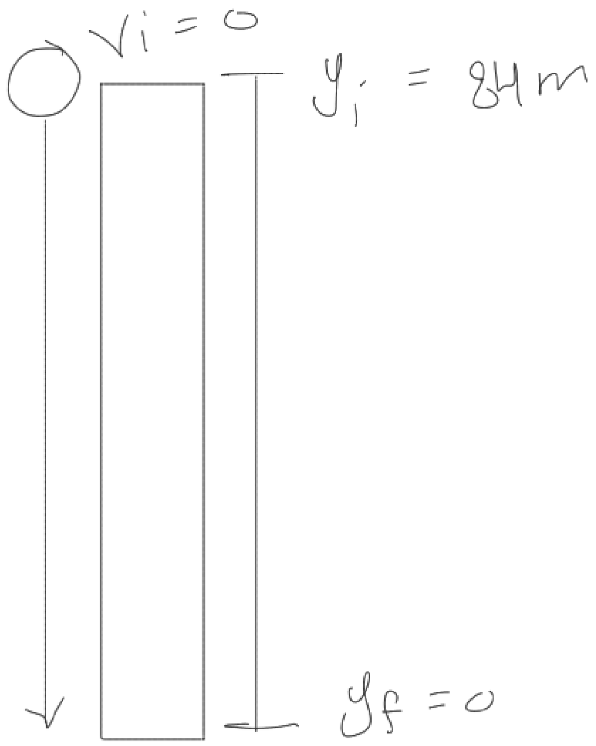
$$y_f - y_i = v_{y_i} t - \frac{1}{2} g(\Delta t)^2$$

$$v_f^2 = v_i^2 - 2g(y_f - y_i)$$

* يعني عادي نفس إلي فوق
بس عوض تسارع العادي
تسارع الجاذبية

$$\boxed{a = -g}$$

1.6 The acceleration of gravity and Falling objects



Example 1.20 P 17: A ball is dropped from a window 84 m above the ground.

تسقط

(a) when does the ball strike the ground?

(b) what is its velocity and its speed when it strikes the ground?

Answer:

(a) It is given that $v_i = 0$

$$y_f - y_i = v_{y_i} t - \frac{1}{2} g (\Delta t)^2$$

$$0 - 84\,m = 0 - \frac{1}{2}(9.8\,m/s^2)\,(\Delta t)^2$$

$$\Delta t = \sqrt{\frac{84}{4.9}}\ \mathrm{s} = 4.14\ \mathrm{s}$$

$$y_f - y_i = v_{y_i} t - \frac{1}{2} g (\Delta t)^2$$

$$0 - 84 = 0 - \frac{1}{2}(9.8)\,(\Delta t)^2$$

$$\Delta t = \sqrt{\frac{168}{9.8}}$$

$$\boxed{\Delta t = 4.14\ s}$$

(b) $v_f = v_i - g\Delta t = 0 - (9.8\,m/s^2)(4.14\,s) = -40.6\,m/s$

then the ball hits the ground with a speed of $40.6\,m/s$ downward

$$v_f = v_i - g\Delta t$$

$$v_f = 0 - (9.8)(4.14)$$

$$\boxed{v_f = -40.6\ m/s}$$

1.6 The acceleration of gravity and Falling objects

Example: A ball is thrown upward at 19.6 m/s from a window 58.8 m above the ground.

(a) How high does it go?

(b) When does it reach its highest point?

(c) When does it strike the ground?

Answer

قذف V_i

$V_f^2 = V_i^2 - 2g\,\Delta X$

$0 = (19.6)^2 - 2(9.8)\,\Delta X$

$\boxed{\Delta X = 19.6\ m}$

(a) It is given that $v_i = 19.6\ m/s$, $a = -9.8\ m/s^2$. At the highest point, $v_f = 0$

$$v_f^2 = v_i^2 - 2\,g\,\Delta x \quad \Longrightarrow \quad 0 = (19.6\ m/s)^2 - 2(9.8\ m/s^2)\Delta x$$

$$\Delta x = \frac{(19.6\ m/s)^2}{2(9.8\ m/s^2)} = 19.6\ m$$

$V_f = V_i - g\,\Delta t$

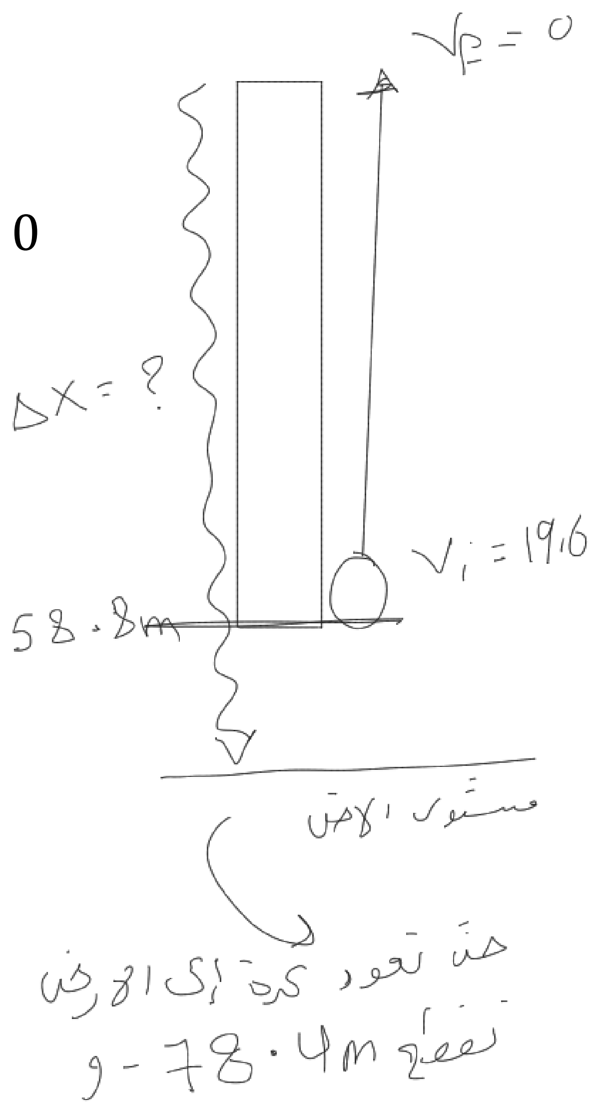
$0 = 19.6 - (9.8)\,\Delta t$

$\boxed{\Delta t = 2\ s}$

(b) $v_f = v_i - g\Delta t$

$$0 = (19.6\ m/s) - (9.8\ m/s^2)\ \Delta t$$

$$\Delta t = \frac{19.6\ m/s}{9.8\ m/s^2} = 2\ s$$



Problems:

1-13 A car travels 30 km in $\boxed{45\ \text{min}}$ on a straight highway. What is its average velocity in kilometres per hour (km h^{-1})? سرعة متوسطة

Answer:

$$\bar{v} = \frac{\Delta x}{\Delta t} = \frac{30\ km}{45\ min \times \frac{1h}{60\ min}} = 40\ km/h$$

* اول شيء نحول الوحدة

1 hour → 60 min
x → 45 min
45 = 60x
x = 0.75 hour

$\bar{V} = \frac{\Delta x}{\Delta t} = \frac{30\ Km}{0.75\ h} = 40\ Km h^{-1}$

1-45 A train traveling with a velocity of 30 m s^{-1} stops with a uniform acceleration in 50 s. (a) What is the acceleration of the train? (b) What is the distance traveled before coming to rest?

$V_i = 30$ $V_f = 0$ ثابت Δx

Answer:

(a) We are given: $v_i = 30$ m/s, $v_f = 0, \Delta t = 50\ s$

$v_f = v_i + a\Delta t$

$$a = \frac{(v_f - v_i)}{\Delta t} = \frac{(0-30)m/s}{50\ s} = -0.6\ m/s^2$$

(b) $\Delta x = v_i\ \Delta t + \frac{1}{2}a(\Delta t)^2$

$= (30\ m/s)(50\ s) + \frac{1}{2}(-0.6\ m/s^2)(50\ s)^2$

$= 750\ m$

a) $a = \frac{\Delta V}{\Delta t} = \frac{V_f - V_i}{\Delta t} = \frac{0 - 30}{50} = -0.6\ m/s^2$

b) $V_f^2 = V_i^2 + 2a\,\Delta X$

$0 = (30)^2 + 2(0.6)\Delta X$

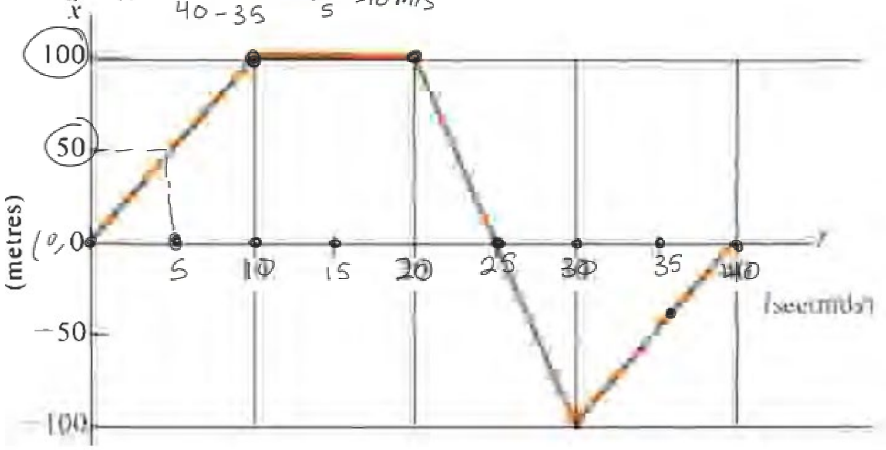
$\Delta X = 750\ m$

Problems:

سرعة لحظية (يعني الميل)

1-28 In Fig. 1.13, what is the instantaneous velocity at (a) $t = 5$ s; (b) $t = 15$ s; (c) $t = 25$ s; (d) $t = 35$ s?

(a) $v = \frac{50-0}{5-0} = 10\ m/s$ (b) $v = \frac{100-100}{15-10} = 0$ (c) $v = \frac{0-100}{25-20} = \frac{-100}{5} = -20\ m/s$ (d) $v = \frac{0+50}{40-35} = \frac{50}{5} = 10\ m/s$



Answer:

$$v = \frac{dx}{dt} = slope\ of\ x - t\ graph$$

(a) At t=5 s: $v = slope = \frac{(100-0)m}{(10-0)s} = 10\ m/s$

(b) At $t = 15\ s$: $v = slope = 0$

(c) At $t = 25\ s$: $v = slope = \frac{(-100-100)m}{(30-20)s} = -20\ m/s$

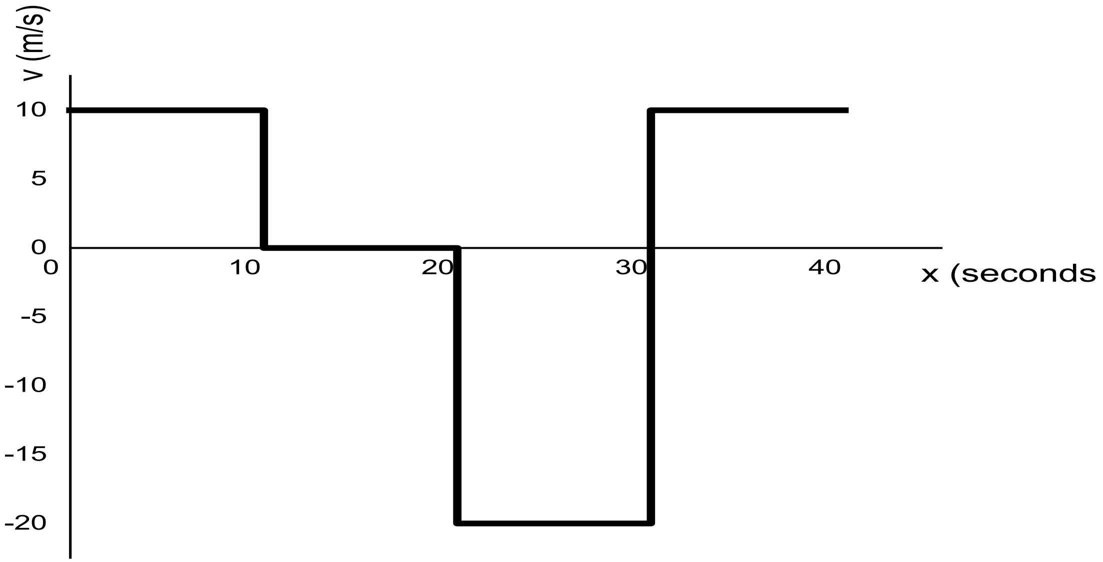
(d) At $t = 35\ s$: $v =$ slope $= \frac{(0-(-100))m}{(40-30)s} = 10\ m/s$

ارسم

سرعة اللحظية

1-29 Draw the instantaneous velocity-versus-time graph corresponding to Fig. 1.13.

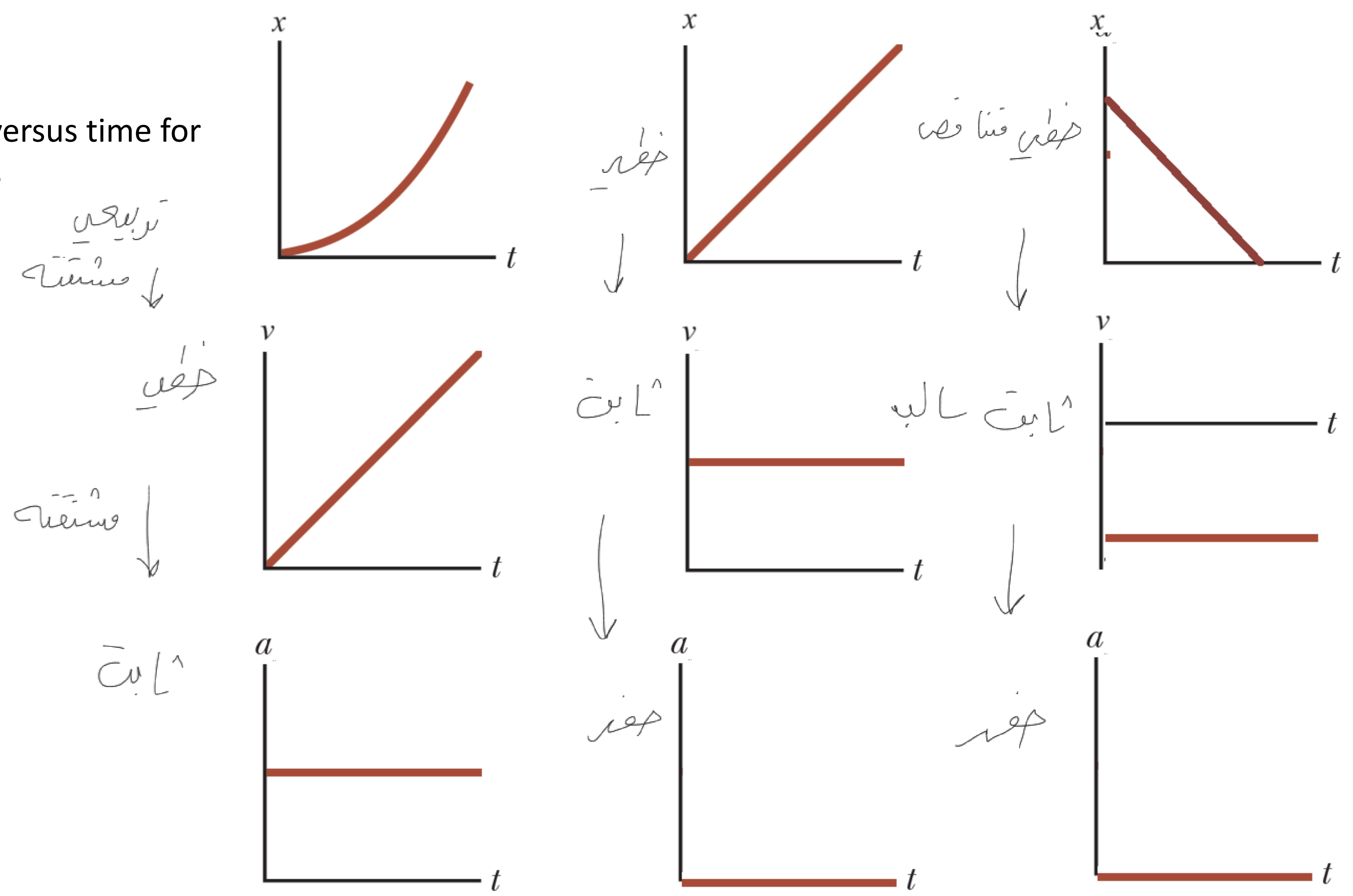
Using the answer of problem 1-28, the v-t graph becomes



Problems:

Problem:

Draw the acceleration versus time for the following x-t graphs



Problems:

Problems: (Chapter One): Motion in straight line.

① An object moves along the x-axis according to the equation:

$x(t) = 3t^2 - 2t + 3$ find:

$v(t) = 6t - 2$

$a(t) = 6$

متوسط سرعة

- the average speed between $t = 2s$ to $t = 3s$

$$\bar{v} = \frac{x(3) - x(2)}{3 - 2} = 13\ m/s$$

سرعة لحظية

- the instantaneous velocity at $t = 2s$ and at $t = 3s$

$v(2) = 12 - 2 = 10\ m/s$

$v(3) = 18 - 2 = 16\ m/s$

تسارع لحظي

- the instantaneous acceleration at $t = 2s$ and at $t = 3s$

$a(2) = 6\ m/s^2$

$a(3) = 6\ m/s^2$

② a truck moved $\underbrace{40m}_{}$ (Δx) in 8.5s (Δt) by smoothly slowing down to final speed of 2.8m/s (v_f); find the initial speed (v_i) and the acceleration (a)

$$\Delta x = \frac{1}{2}(v_f + v_i)\Delta t$$

$$40 = \frac{1}{2}(2.8 + v_i)(8.5)$$

$$\boxed{v_i = 6.6\ m/s}$$

$$v_f = v_i + a\Delta t$$

$$2.8 = 6.6 + a(8.5)$$

$$\boxed{a = -0.45\ m/s^2}$$

تسارع منتظم

③ a body moving with uniform acceleration has a velocity of 12 m/s (v_i) in the positive x-direction when its coordinate is $x = 3\ m$ (x_i); if the coordinate 2 seconds (Δt) later is $-5m$ (x_f) find the body's acceleration.

$$\Delta x = v_i\Delta t + \frac{1}{2}a\Delta t^2$$

$$-5 - 3 = 12(2) + \frac{1}{2}a(4)$$

$$\boxed{a = -16\ m/s^2}$$

Problems:

(4) a ball is thrown $\boxed{\text{upward}}$ from the ground with initial velocity of 15 m/s

فوق

$y_i = 0$; v_i

a) how long does it take to reach the maximum height

b) what is the maximum height y_f

c) determine the velocity and the acceleration of the ball at $t = 2$ s

a) $v_f = v_i - g\Delta t$

$0 = 15 - (9.8)\Delta t$

$\boxed{\Delta t = 1.53 \text{ s}}$

b) $y_f - y_i = v_i t - \frac{1}{2} g (\Delta t)^2$

$y_f - 0 = 15(1.53) - \frac{1}{2}(9.8)(1.53)^2$

$\boxed{y_f = 11.48 \text{ m}}$

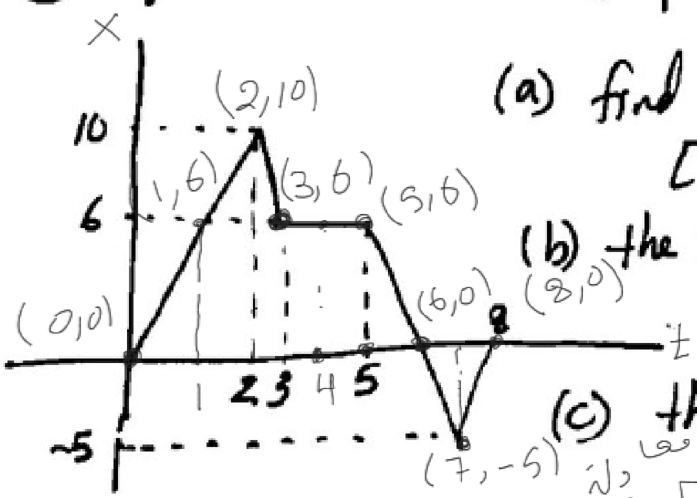
c) $\boxed{a = 9.8 \text{ m/s}^2}$

$v_f = v_i + at$

$v = 0 + 9.8(2 - 1.53)$

$\boxed{v = 4.606 \text{ m/s}}$

(5) given the x-t graph



(a) find the average velocity in the intervals [0,3]s ; [5,8 s]

سرعة نقطة

$\bar{v}_{[0,3]} = \frac{6-0}{3-0} = 2 \text{ m/s}$

$\bar{v}_{[5,8]} = \frac{0-6}{8-5} = \frac{-6}{3} = -2 \text{ m/s}$

(b) the instantaneous velocity at $t = 1$ sec. → $v = \frac{6-0}{1-0} = 6 \text{ m/s}$

at $t = 4$ sec. → $v = 0$

at $t = 6$ sec → $v = \frac{-5-0}{7-6} = -5 \text{ m/s}$

سرعة لحظية (ميل اكا)

(c) the acceleration in the intervals [0,2]s, [3,5]s

دالة خطية

$\boxed{y = 5x}$

$m = \frac{10-0}{2-0} = 5$

مشتقة خط → ثابت = 5 m/s^2

ثابت → صفر = 0