CHAPTER 1
Introduction

Content

اي شيء يمكن قياسه

Physical Quantity: Quantity that can be measured.

كميات الفيزيائيه

Physical quantities is divided into:

a- Basic quantities

b-Derived quantities

كميات اساسيه

a-Basic quantities: Cannot be defined in terms of other physical quantities .

Example: Length, Mass, and Time

الكمية الاساسية :- هي التي لا يمكن تعريفها من خلال كميات اخرى

الطول ، الزمن ، الكتلة

1-Length: Distance between two points in space.

2-Mass : Amount of matter in an object.

3-Time: Duration between two events.

الطول :- المسافه بين نقطتين في الفضاء

الكتله :- كميه المادة في الجسم

الزمن :- الفتره الزمنيه بين حدثين

كميات مشتقه

b- Derived quantities: derived by combining base quantities

Example: Velocity, Acceleration, Density

الكميات المشتقه :- تعرف من خلال دمج كميات اساسية

السرعة

1- Velocity: (Displacement / time).

التسارع

2- Acceleration: (Velocity / time).

الكثافه

3- Density: (mass/Volume)

السرعة = المسافه / الزمن

التسارع = السرعة / الزمن

الكثافه = كتله / حجم

SI UNIT SYSTEM

النظام العالمي للوحدات

SI (System International) units = metric system

النظام العالمي (الدولي) SI

Base units:

Table 1.1 Base unit in SI (see page 5)

Unit وحدات الاساسية	Symbol رمز	Quantity كميات اساسية
meter	m	length طول
kilogram	kg	mass كتلة
second ثانية	s	time زمن
ampere امبير	A	current تيار كهربائي
kelvin كلفن	K	temperature درجة حرارة
mole مول	mol	amount of a substance كمية المادة
candela شمعة	cd	luminous intensity شدة الاضاءة

SI UNIT SYSTEM

كميات المشتقة

Derived Quantities:

Units for all other physical quantities can be derived form the seven base units

كل الكميات عكن اشتقاقها من السبع كميات الاساسية

Examples:

Quantity	SI unit
Area = m x m	m^2
Volume = m x m x m	m^3
Density = Kg ÷ m3	kg/m^3
Velocity = m ÷ S	m/s
Acceleration = m/S ÷ S	m/s^2

مساحة = الطول x العرض

حجم = طول x عرض x ارتفاع

كثافه = الكتله ÷ الحجم

السرعه = المسافه ÷ الزمن

التارع = السرعه ÷ الزمن

$\frac{kg}{m^3} = kg/m^3 = kgm^{-3}$

$\frac{m}{s^2}$

*For more derived units see Table 1·2 page 6

Assessment

Exercise 1:

- What is the SI unit of temperature? K (Kelvin)

Exercise 2:

- Which of following is Base (fundamental) unit and which is derived in SI unit system: B D

القوه = الكتله x العجله N·m

candela	B	kelvin	B
joule N·m	D	hour	D
kilogram	B	kilometer	D
mole	B	gram	D
second	B	volt	D

Prefixes

Table 1-2

Prefixes for SI Units

Factor	Prefix[a]	Symbol	Factor	Prefix[a]	Symbol
10^{24}	yotta-	Y	10^{-1}	deci-	d
10^{21}	zetta-	Z	**10^{-2}**	**centi-**	**c**
10^{18}	exa-	E	**10^{-3}**	**milli-**	**m**
10^{15}	peta-	P	**10^{-6}**	**micro-**	**μ**
10^{12}	tera-	T	**10^{-9}**	**nano-**	**n**
10^{9}	**giga-**	**G**	**10^{-12}**	**pico-**	**p**
10^{6}	**mega-**	**M**	10^{-15}	femto-	f
10^{3}	**kilo-**	**k**	10^{-18}	atto-	a
10^{2}	hecto-	h	10^{-21}	zepto-	z
10^{1}	deka-	da	10^{-24}	yocto-	y

[a]The most frequently used prefixes are shown in bold type.

- Table (page 7)

Scientific Notation

الصيغة العلمية

كتابة الرقم كي تكون رقم بين ١ ــ ١٠ ضرب با ــ س

2531782.

2.5×10^{6}

Number = mantissa x10 exponent (power)

اس

0.0000254

2.5×10^{-5}

Example:

$460000 = 4.6 \times 10^{5}$

$0.0023 = 2.3 \times 10^{-3}$

Assessment

Exercise 3: Solve the following:

1. $5.0 \times 10^5 + 3.0 \times 10^6 =$ 3500000 = 3.5×10^6
2. $(5.0 \times 10^4) \times (3.0 \times 10^{-6}) =$ 0.15 = 1.5×10^{-1}
3. $(7.0 \times 10^6)/(2.0 \times 10^{-6}) =$ 3.5×10^{12}
4. *The number of significant figures in 0.00150 equals ....3.*
5. *The number of significant figures in 15.0 is 3*

الارقام المعنوية

قواعد الارقام المعنوية

① كل الاعداد غير المصفرية هي ارقام معنوية

23.6 ⇒ 3 SF

② كل الاصفار داخل العدد وعلى يمين الفاصلة تعتبر ارقام معنوية

1005 ⇒ 4 SF

1.00 ⇒ 3 SF

③ الاصفار على اليسار لا تعد ارقام معنوية

0.0008 ⇒ 1 SF

④ الاصفار على اليمين بدون لا تعد ارقام معنوية

1000 1 SF

1000.0 5 SF

⑤ الرقم المكتوب بالصيغة العلمية لا تعد الارقام في الاس

5.3×10^6 = 2 SF

Converting (Changing) Units

Time Units

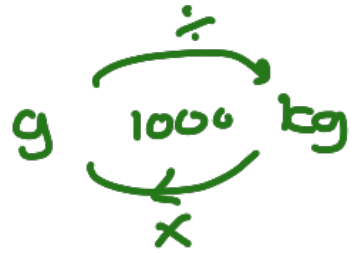
- 1 year = 365 days
- 1 day = 24 hours
- 1 hours = 60 min
- 1 hours = 3600 sec
- 1 min = 60 sec

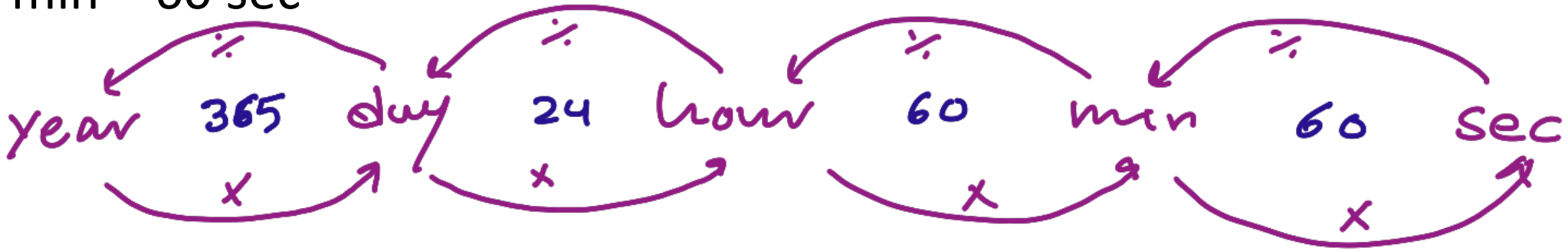
Other Units

1 m = 100 cm

1 m = 1000 mm

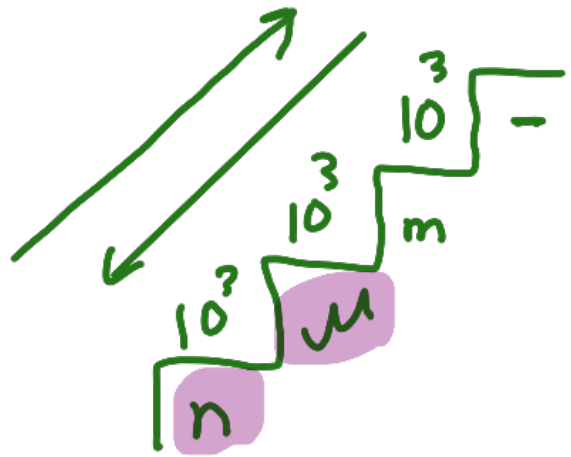
1 Kg = 1000 gm





3 days → $3 \times 24 \times 60 \times 60$ Se = 5.592×10^5 Se

Assessment



Exercise 4: Make the following transformations:

5 min = s $5 \times 60 = 300\,s$

2 hours = s $2 \times 60 \times 60 = 7200\,s$

6.2 km/h = m/s $1.72\ m/s$

5.2kg = g $5.2 \times 1000 = 5200\,g = 5.2 \times 10^3$

$3\mu m =$ nm $3 \times 10^3\ nm = 3000$

50 m/hr = cm/hr

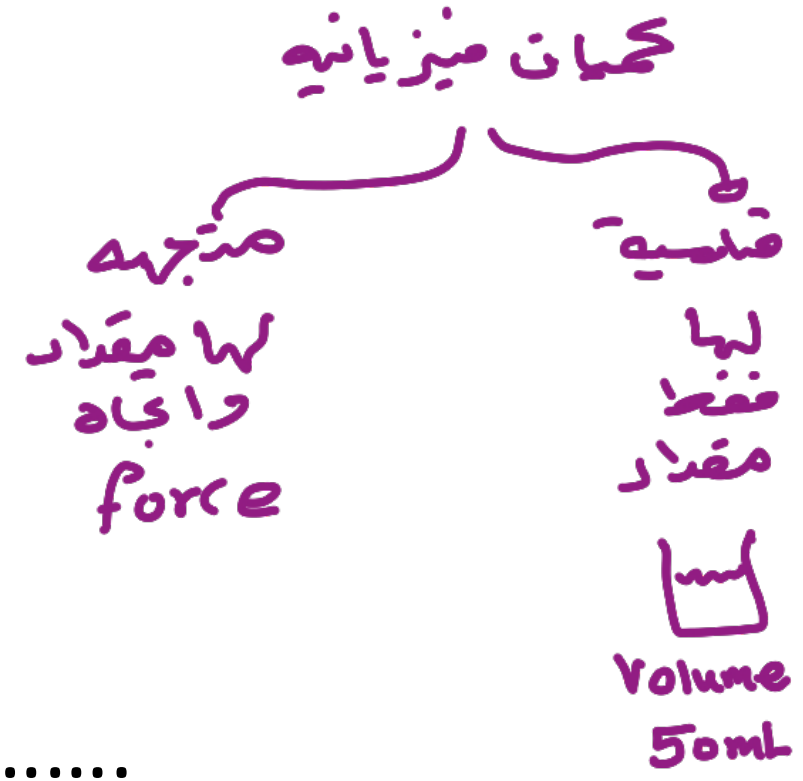
$\frac{50\ m}{hr} = \frac{50 \times 100\ cm}{hr}$

$= 5000\ cm/hr$

$5 \times 10^3\ cm/hr$

$\frac{6.2\ km}{1\ h} = \frac{6.2 \times 1000}{1 \times 60 \times 60}\ \frac{m}{s} = 1.72\ m/s$

Vectors



Types of Physical Quantities:

A- **Vectors** quantity متجهة

magnitude and direction

المقدار الزاوية

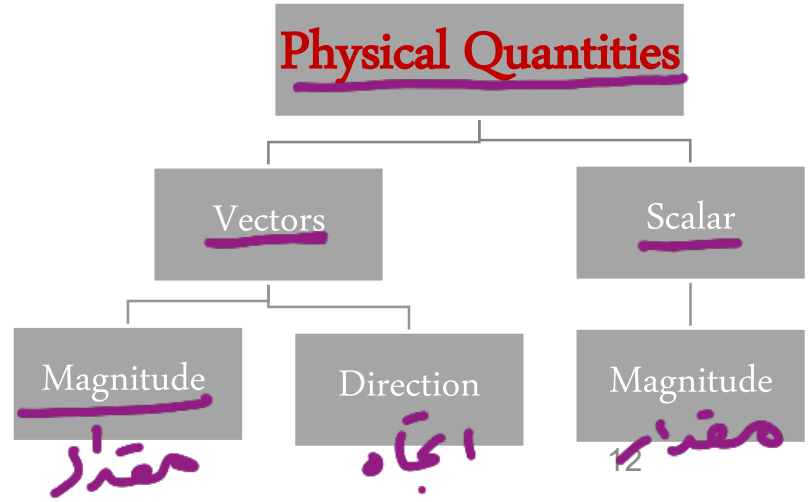
Ex: displacement, velocity ,etc.....

B- **Scalars** quantity قياسية

magnitude only

Ex: time, temperature, etc.....

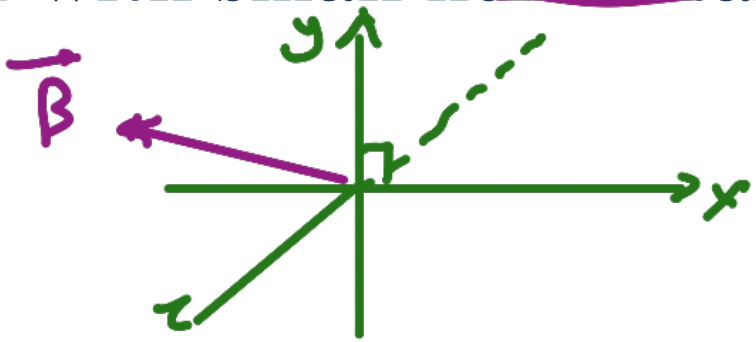
الزمن درجة الحرارة



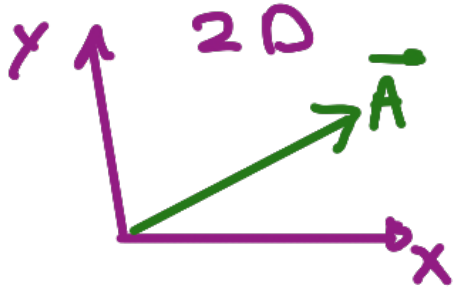
Vectors

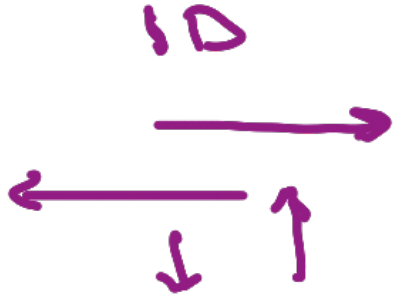
- Vector quantity symbol

A letter with small horizontal arrow pointing to the right above it



$\vec{A}$



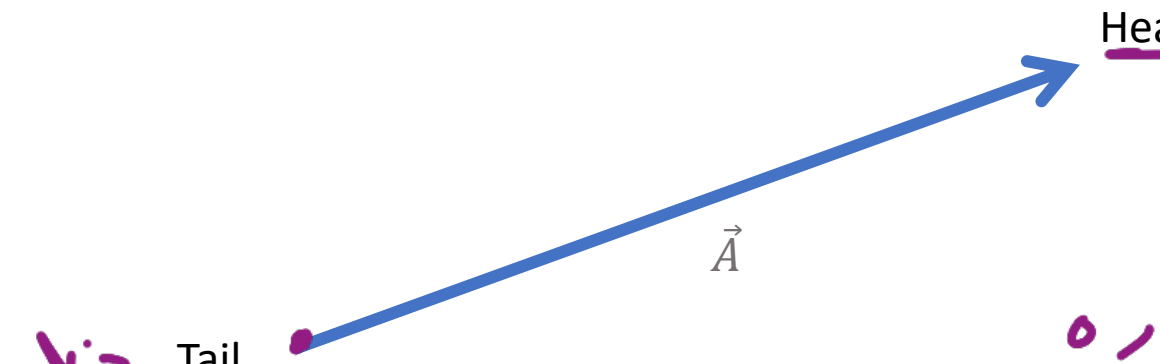


- Cartesian Coordinate System used to describe objects in 1D, 2D and 3D (see page 18)

Set of three axes with angle of **90°** between axis. (x, y and z)

كيف نعبر عن المتجه في الاحداثيات

How to represent a vector in Cartesian coordinate system?



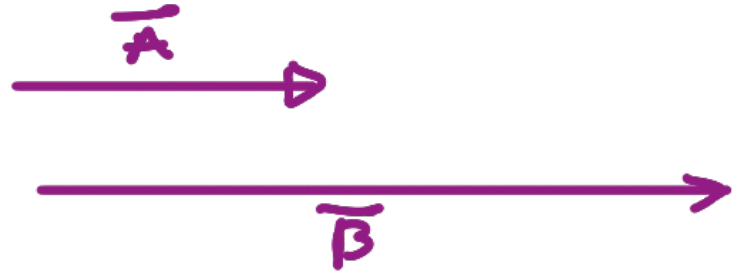
المقدار طول السهم

- Magnitude = arrow length
- Direction = arrow head

الاتجاه اتجاه الرأس

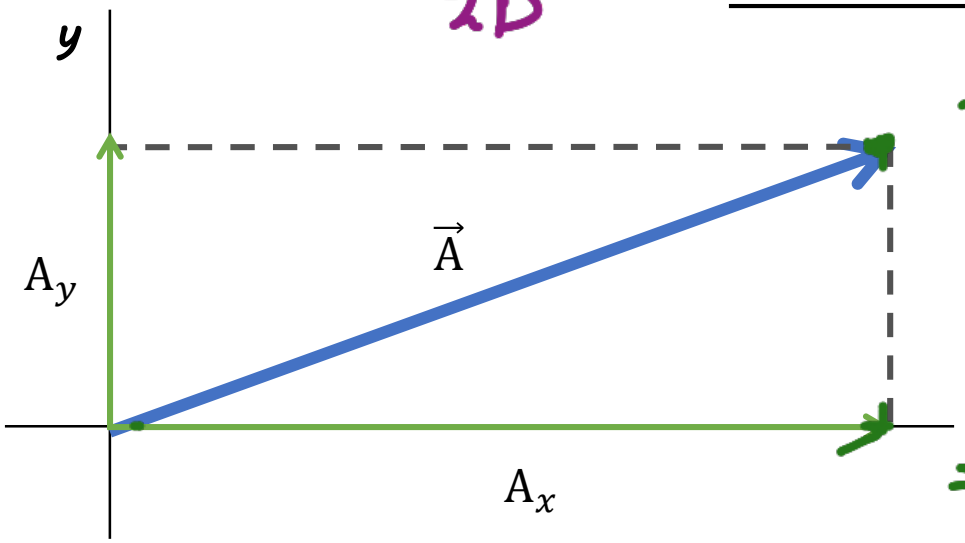
طول المتجه يعبر عن مقداره

$\vec{A} = 5$ $\vec{B} = 15$



Vector Components:

2D

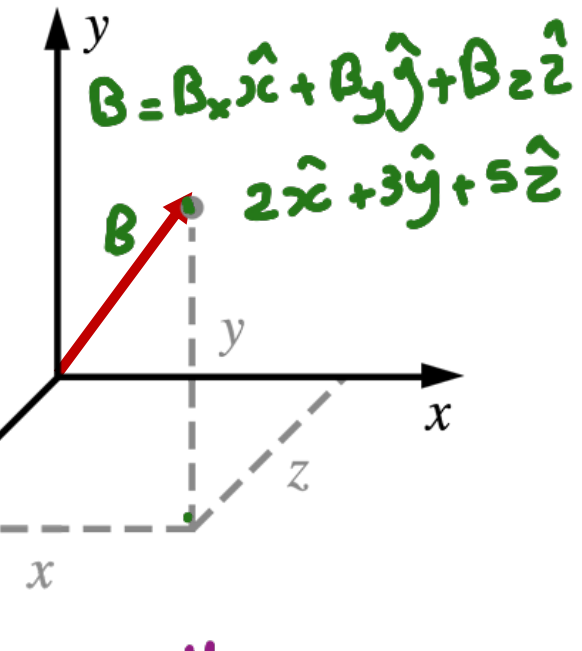


$\vec{A} = (A_x, A_y)$

$A_x\hat{x}$ $A_y\hat{y}$

$= 5\hat{x} + 4\hat{y}$

3D



- $\vec{A} = (A_x, A_y) = A_x\hat{x} + A_y\hat{y}$ 2D
- $\vec{A} = (A_x, A_y, A_z) = A_x\hat{x} + A_y\hat{y} + A_z\hat{z}$ 3D

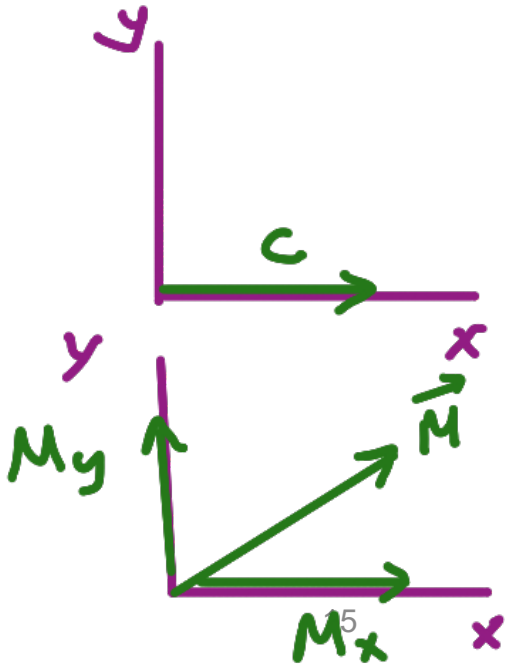
متجه الوحدة

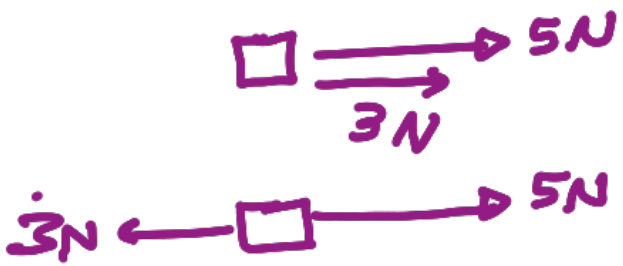
Unit Vectors $(\hat{x}, \hat{y}, \hat{z})$

Magnitude = 1

Direction → along the main coordinate axes.

متجه الوحدة بدون طوله = 1 ويتجه باتجاه المحور





$\vec{A}+\vec{B}=5+3=8N$

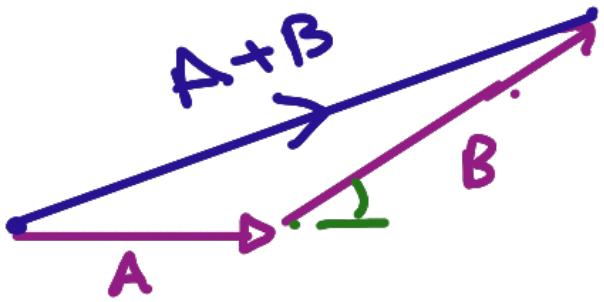
$\vec{A}+\vec{B}=5+-3=2N$

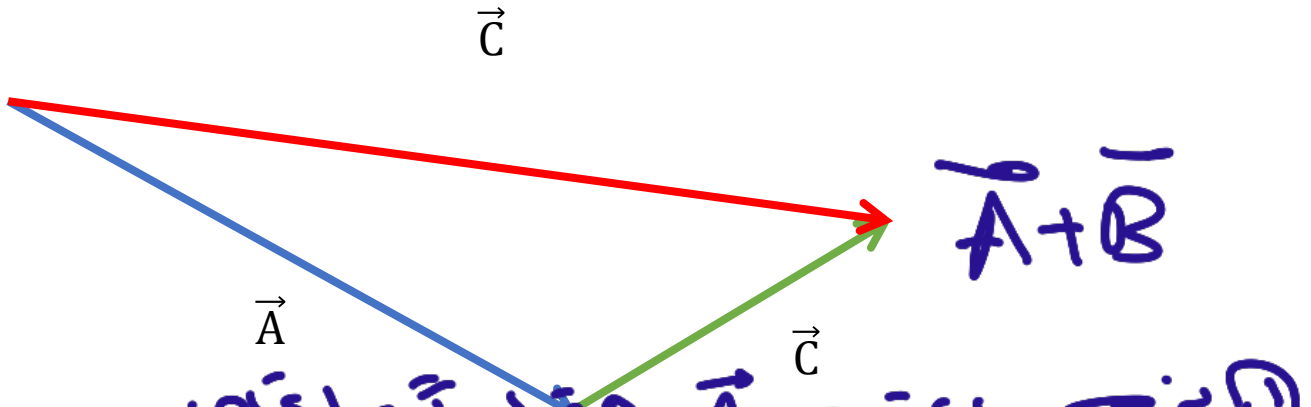
جمع المتجهات وطرحها

Graphical vector Addition and subtraction: العلاقة الهندسية (الرسم)

Addition: the beginning of vector $\vec{B}$ moves to the tip of vector $\vec{A}$

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

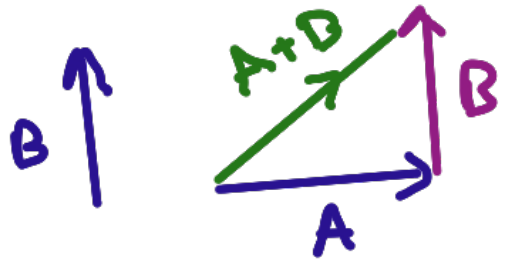




① نرسم المتجه $\vec{A}$ بمقدار آ واتجاه

② من راس المتجه A نرسم ذيل B

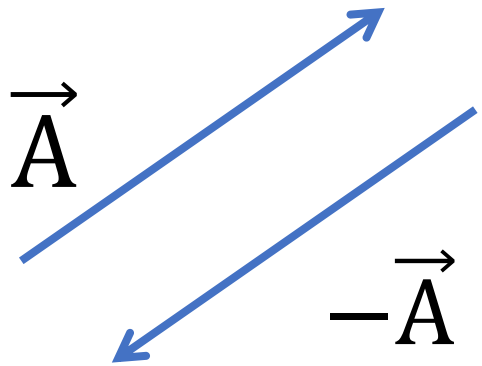
③ المحصلة هي المتجه المرسوم من ذيل الاول لراس الثاني



Graphical vector Addition and subtraction:

- **The inverse (reverse or negative):**

Vector with the same length , in the opposite direction



$\vec{A}$ = ⟶

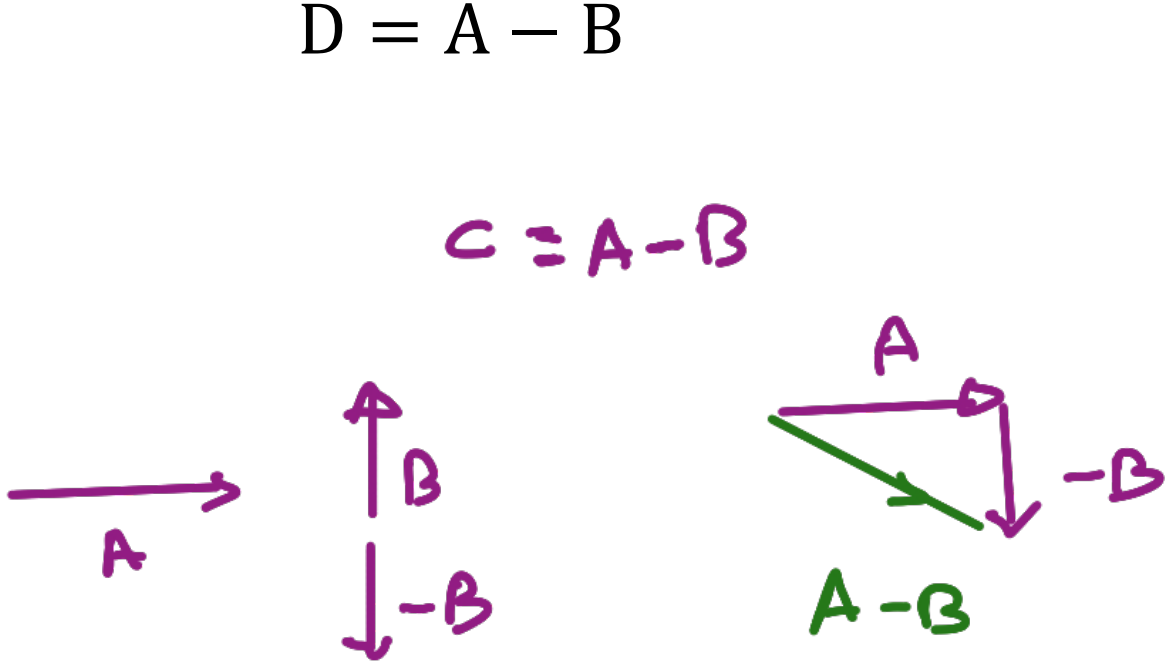
$-\vec{A}$ = ⟵

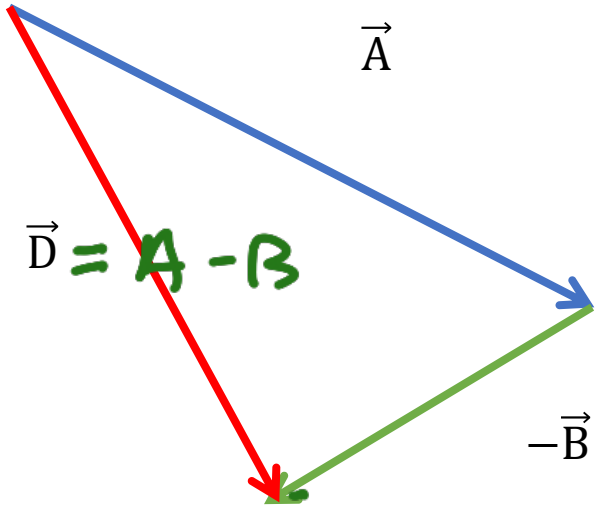
سالب المتجه هو نفس المقدار لكن معاكس في الاتجاه

Graphical vector Addition and subtraction:

Subtraction: adding the inverse of vector $\vec{B}$ to vector $\vec{A}$

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





في جمع المتجهات (أو طرحها) نجمع المركبات

Vector Addition using component

$$\vec{A} = (A_x, A_y, A_z) \qquad A = (2, 1, 5)$$
$$\vec{B} = (B_x, B_y, B_z) \qquad B = (3, -2, 4)$$

$$A + B = (5, -1, 9)$$

$$\vec{A} + \vec{B} = (A_x + B_x, A_y + B_y, A_z + B_z)$$

$$\vec{A} - \vec{B} = (A_x - B_x, A_y - B_y, A_z - B_z)$$

$$A + B = (8, 2, 11)$$

- Exercise 4:

Find $\vec{A} - \vec{B}$ where $\vec{A} = (5, 3, 9)$ and $\vec{B} = (3, -1, 2)$

$$A - B = (5-3, 3-(-1), 9-2) = (2, 4, 7)$$

عند ضرب المتجه بكمية ثابت موجب لا يتغير اتجاه يتضاعف طوله
عند ضرب المتجه بكمية ثابت سالب يتغير طوله وينعكس اتجاهه

ضرب المتجه في عدد ثابت

$A = (1, 2, 3)$

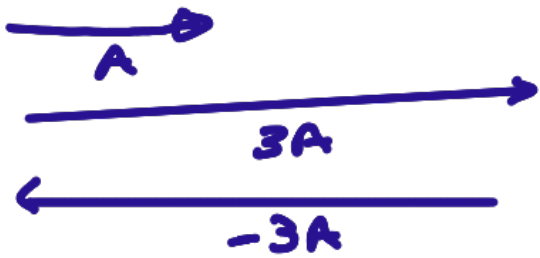
$3A = 3(1, 2, 3)$

$3A = (3, 6, 9)$

$-3A = (-3, -6, -9)$

Multiplication of a vector with scalar :

Scalar * vector = vector



$$\vec{E} = s\vec{A} = s(A_x, A_y, A_z) = (sA_x, sA_y, sA_z)$$

scalar * vector

عدد قياسي — المتجه

عدد موجب يؤشر بنفس الاتجاه
points in the same direction → positive scalar

عدد سالب يؤشر لعكس الاتجاه
points in the opposite direction → negative scalar

Exercise 5:

Given a vector $\vec{A} = (2, 3)$, find $3\vec{A}$

$3(2,3) = (6, 9)$

طوله يتضاعف وزاد وبنفس الاتجاه

متجهات الوحدة

• Unit Vectors

- $\hat{x} = \hat{\imath}$
- $\hat{y} = \hat{\jmath}$
- $\hat{z} = \hat{k}$

- $\vec{A} = A_x\hat{x} + A_y\hat{y} + A_z\hat{z}$

$$= A_x\,\hat{\imath} + A_y\hat{\jmath} + A_z\hat{k}$$

مقدار المتجه

• Vector Magnitude

$$A = |\vec{A}| = \sqrt{{A_x}^2 + {A_y}^2 + {A_z}^2}$$

Exercise 6:

Represent the following vectors in unit vector notation and find the magnitude:

$\vec{A} = (9,12,7) = 9i + 12j + 7k$

$\vec{B} = (45,-32) = 45i - 32j$

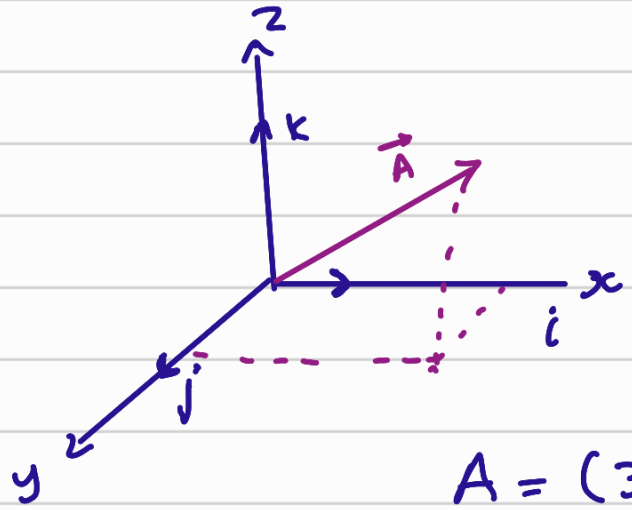
$\vec{C} = (3,0,8) = 3i + 8k$

$|A| = \sqrt{9^2 + 12^2 + 7^2} = 16.55$

$|B| = \sqrt{45^2 + (-32)^2} = 55.2$

$|C| = \sqrt{3^2 + 8^2} = 8.54$

التعبير عن المتجه باستخدام (متجهات الوحدة)



x ← i
y ← j
z ← k

$$A = (3,2,1)$$

$$\vec{A} = 3i + 2j + k$$
$$\vec{B} = 4i + j - 3k$$

$$\vec{A} + \vec{B} = (3+4)i + (2+1)j + (1-3)k$$

$$= 7i + 3j - 2k$$

Magnitude (مقدار المتجه) طول المتجه

$$|\vec{A}| = \sqrt{A_x^2 + A_y^2 + A_z^2}$$

$A = 3i + 2j + k$ calculate $|A|$

$$A = \sqrt{3^2 + 2^2 + 1^2} = \sqrt{14}$$

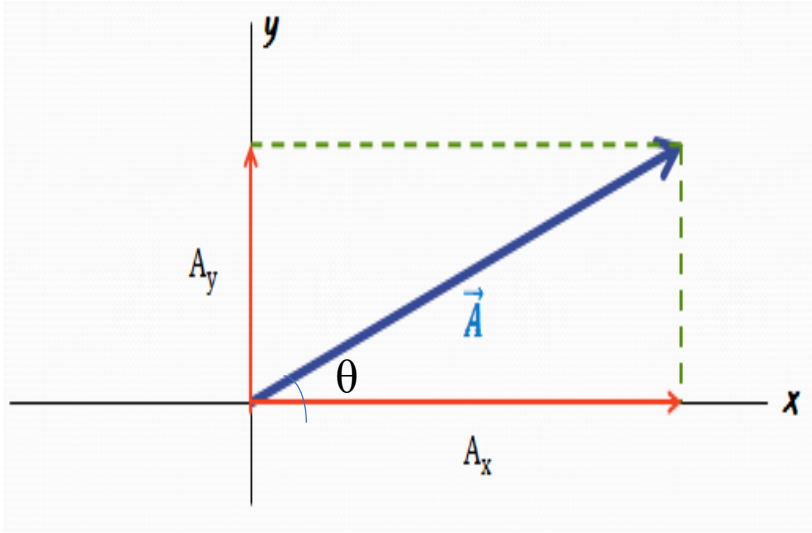
طول, كتجه

Vector Length and Direction in 2D

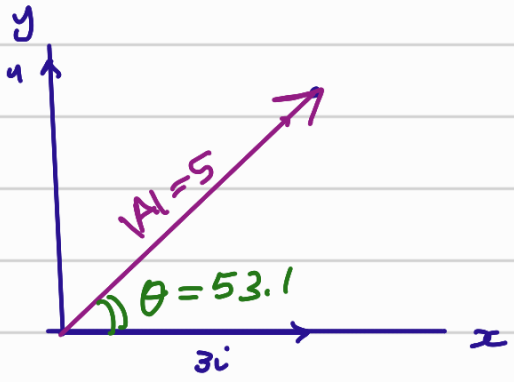
Length (magnitude)	$A = \sqrt{A_x^2 + A_y^2}$
Direction	$\theta = \tan^{-1}\frac{A_y}{A_x}$

$$A_x = A\cos\theta \qquad x - component$$

$$A_y = A\sin\theta \qquad y - component$$



2D Vectors

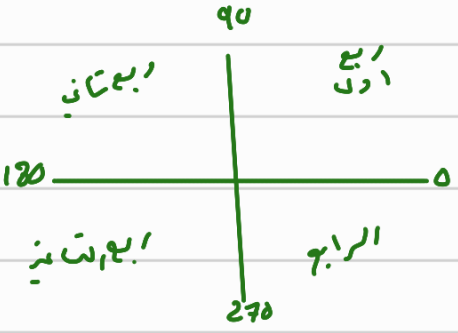


$$A = 3i + 4j$$

calculate the length (magnitude)

$$|A| = \sqrt{3^2+4^2} = 5$$

Direction (θ الزاوية)



$$\theta = \tan^{-1}\left(\frac{A_y}{A_x}\right) = \tan^{-1}\left(\frac{4}{3}\right) = 53.1$$

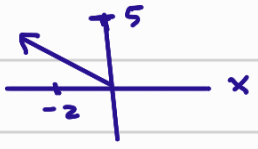
ملاحظات لحساب الزاوية

اذا كان	$x=+$	$y=+$	الزاوية في الربع الاول
اذا كانت	$x=-$	$y=+$	الزاوية في الربع الثاني
اذا كانت	$x=-$	$y=-$	الزاوية في الربع الثالث
اذا كانت	$x=+$	$y=-$	الزاوية في الربع الرابع

مباشرة على الحاسبة
نجمع 180 للاجابة
نجمع 180 للاجابة
ناخذ الزاوية المحاصرة
ونجمع 360

* Example : Find magintude and diretion

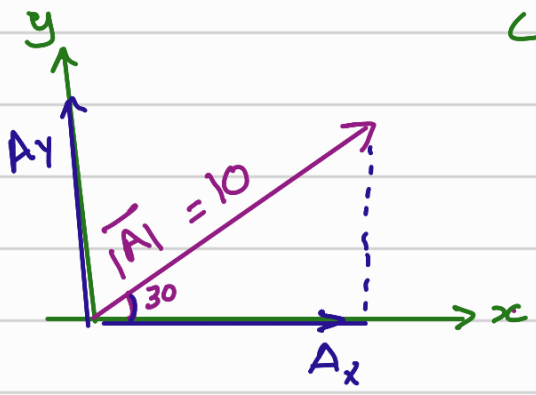
$$\vec{B} = -2i + 5j$$



$$|\vec{B}| = \sqrt{(-2)^2+5^2} = 5.38$$

$$\theta = \tan^{-1}\left(\frac{5}{-2}\right) = -68.2 + 180 = 111.8$$

حساب المركبات
component



find the component

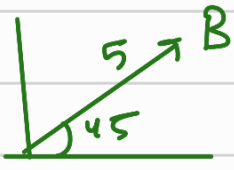
$$A_x = A\cos\theta$$
$$A_y = A\sin\theta$$

$A_x = 10\cos 30 = 8.66$

$A_y = 10\sin 30 = 5$

$$\vec{A} = 8.66\hat{i} + 5\hat{j}$$

Example Find the component of vector $|\vec{B}| = 5$ m with the direction 45° with x axis



$B_x = B\cos\theta = 5\cos 45 = 3.53$

$B_y = B\sin\theta = 5\sin 45 = 3.53$

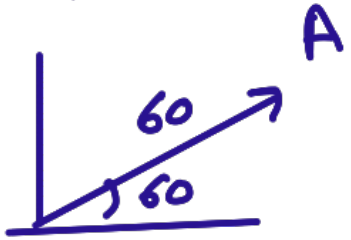
Assessment

مرکبہ x

طول

Q1. What is the x-component of a vector having length 60 m at an angle of 60° with x-axis?

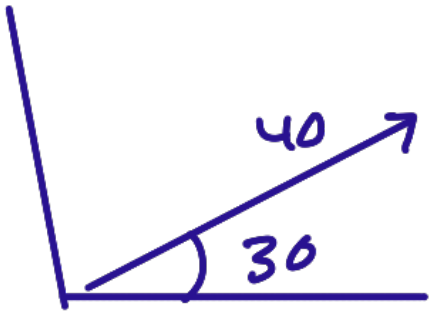
$$A_x = A\cos(\theta) = 60\cos(60) = 30\ m$$



Q2.Find the y-component of a vector having length 40 m at an angle of 30° with x-axis?

$$A_y = A\sin\theta$$

$$= 40\sin 30 = 20\ m$$



Q3. What is the magnitude (مقدار) of a vector $\vec{A} = 4\hat{x} - 3\hat{y}$?

$$|A| = \sqrt{4^2 + (-3)^2} = 5$$

Q4. What is the direction (الاتجاه) of a vector $\vec{A} = 2\hat{x} + 6\hat{y}$?

$$\theta = \tan^{-1}\left(\frac{6}{2}\right) = 71.56^{\circ}$$

$b - 2a$

Q5. Two vectors are given by

$$\vec{a} = 2\hat{x} + \hat{y} + 3\hat{z} \quad \text{and} \quad \vec{b} = 8\hat{x} + 5\hat{y} + 6\hat{z}$$

What is the magnitude of $\vec{b} - 2\vec{a}$?

$$2a = 2(2\hat{x} + \hat{y} + 3\hat{z}) = 4\hat{x} + 2\hat{y} + 6\hat{z}$$

$$b - 2a = (8\hat{x} + 5\hat{y} + 6\hat{z}) - (4\hat{x} + 2\hat{y} + 6\hat{z})$$

$$= 4\hat{x} + 3\hat{y}$$

$$|b-2a| = \sqrt{4^2+3^2} = 5$$

Useful software:

- http://phet.colorado.edu/sims/vector-addition/vector-addition_en.html.
- https://fnoschese.wordpress.com/physics-applets-animations/.

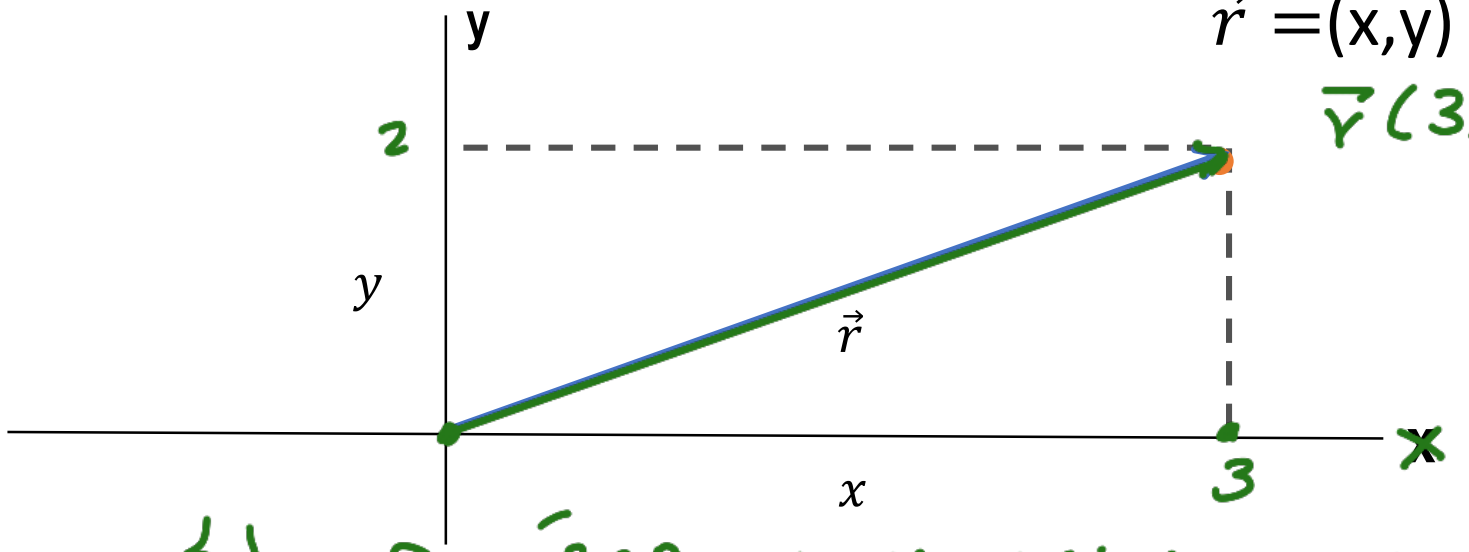
Chapter 2
Motion in a straight line

الحركه بخط مستقيم

POSITION VECTOR DISPLACEMENT VECTOR AND DISTANCE

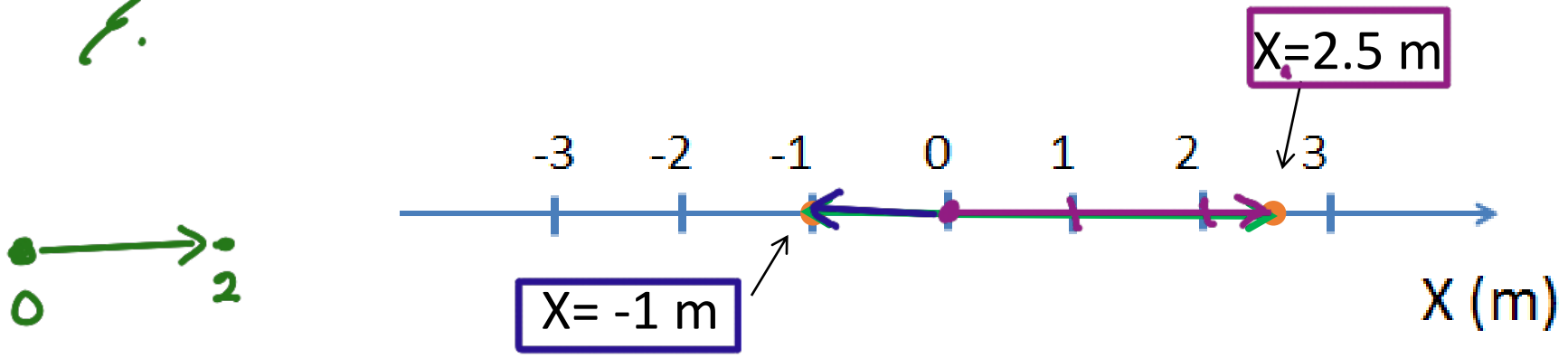
Position vector:

Describes an object's position in space



The vector that links the location of the body with the origin of the coordinate system

Position vector in one dimension



- **In one dimension, position vector has only one component , x-component**
- **It can be positive or negative to the origin point**

الازاحة المسافة

Displacement and Distance

الازاحة هي الفرق بين الموقع النهائي و الابتدائي الازاحة

- **Displacement** is the difference between the final position vector $\vec{r}_2$,at the end of a motion, and the initial position vector $\vec{r}_1$

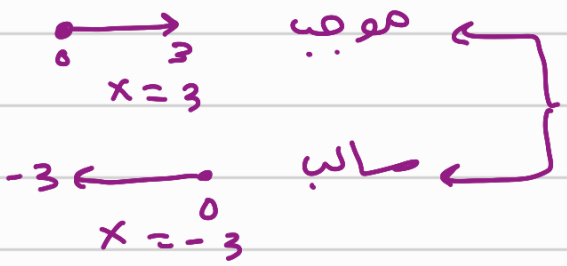
- Displacement in one dimension :

$$\Delta x = x_2 - x_1$$

- Displacement can be (+ ve) or (- ve)

موجبه ← سالبه →

Position : vector موقع الجسم X

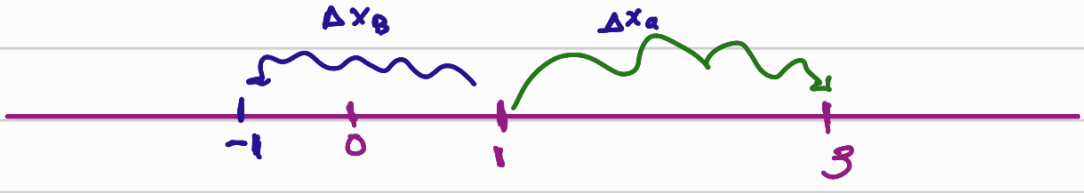


Displacment : vector الازاحة ΔX

تدل على التغير في موقع الجسم : الموقع النهائي - الموقع البدائي

$$\Delta X = X_2 - X_1$$

الاشاره الموجبه تدل على ازاحة الجسم نحو اليمين
الاشاره السالبه تدل على ازاحه نحو اليسار
* لا يهم المسار الذي ترك فيه الجسم

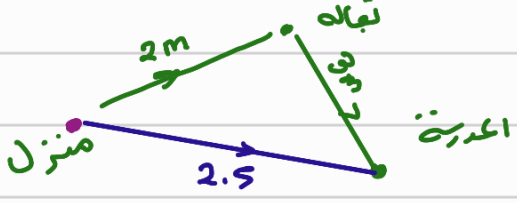


$X_1 = 1$ $X_2 = 3$ $\Delta x_a = 3-1 = 2m$

$X_1 = 1$ $X_2 = -1$ $\Delta x_B = -1-1 = -2m$

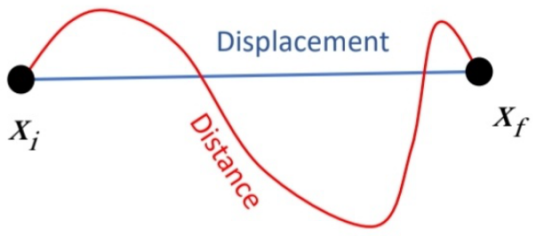
Distance : المسافة scalar

تمثل طول الرحلة الكامله دون الاعتماد على نقطه البدايه والنهايه



Distane: $2+3 = 5m$ بدون اتجاه

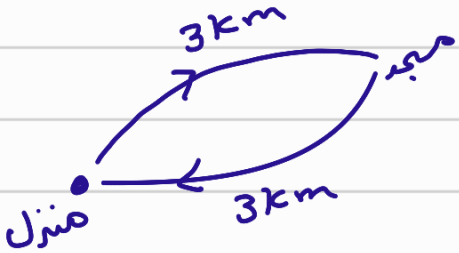
Displacment: ⟶ = 2.5 مع الاتجاه



Displacement	Distance
Net change between initial position x_i to a final position x_f	Total trip from initial position x_i to a final position x_f
Does not depend on the path of motion	Depends on the path of motion
Vector	Scalar
SI unit: m	SI unit: m

جدول مقارنه بين المسافه و الازاحة

Displacment	Distance
الفرق بين الموقع الابتدائي والنهائي $\Delta X = X_f - X_i$	هي طول الرحلة كاملة
لا تعتمد على مسار الرحلة	تتغير بتغير المسار
كمية متجهة (لها مقدار واتجاه) يتعين ان تكون + او −	كمية قياسية لها مقدار فقط (موجبة دائما)
m وحدة القياس	m وحدة القياس



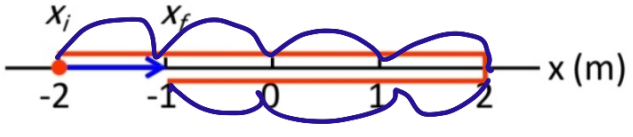
Distance = 6 km

Displacment = zero

اضافي

Position and Displacement

Here you can see the difference between displacement and distance on the *x*-axis:

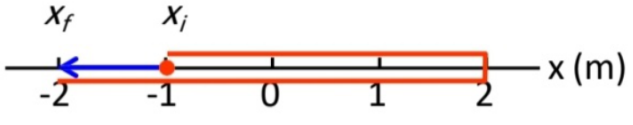


$\Delta x = x_f - x_i = -1 - -2$

$= -1 + 2 = 1$ m

$\Delta x = 1$ m.

Total distance = 7 m.

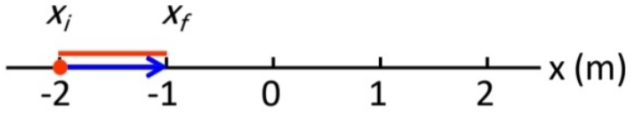


$\Delta x = -2 - -1 = -1$

$\Delta x = -1$ m.

Total distance = 7 m.

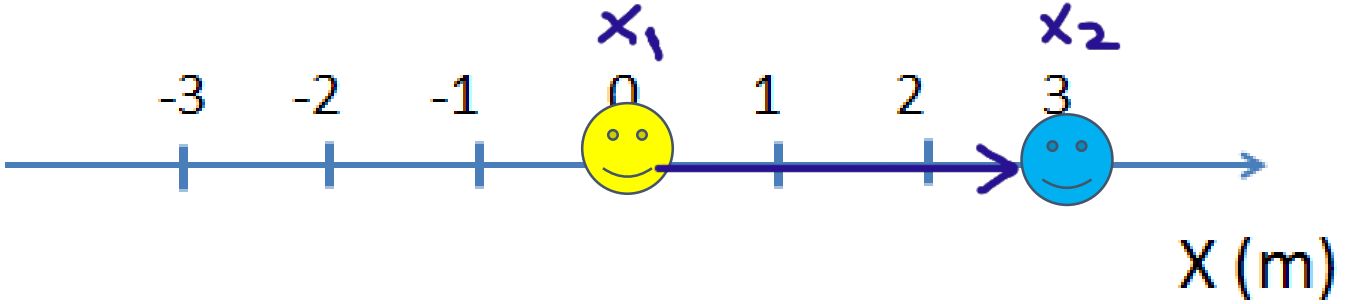
$\Delta x = -1 - -2 = 1$ m



$\Delta x = 1$ m.

Total distance = 1 m.

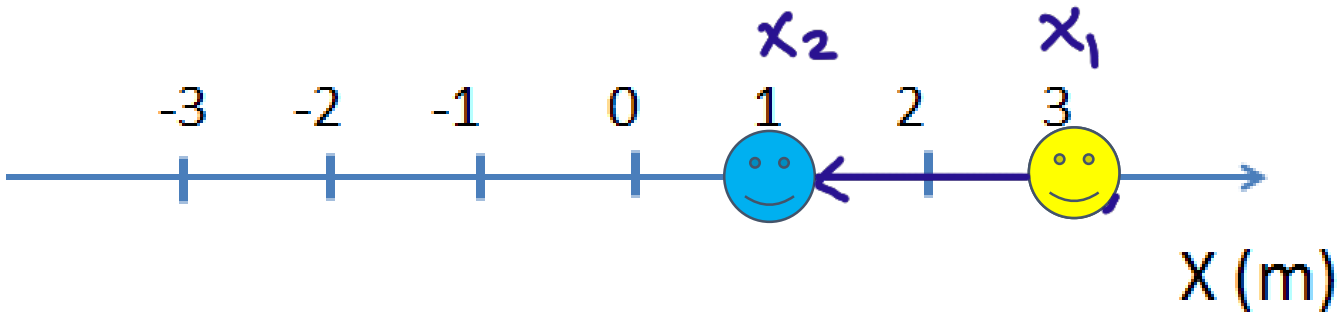
Displacement and Distance



ازاحه موجبه

$\Delta x = x_2 - x_1$= 3-0 = 3 m

positive displacement +



ازاحه سالبه

$\Delta x = x_2 - x_1$= 1-3 = -2 m

negative displacement

Displacement and Distance

مسافة

القيمة المطلقة لمتجه الإزاحة

Distance: the distance I that moving object travels is the absolute value (the magnitude) of the displacement vector.

In one dimension

Distance ≥ 0

$l = |\Delta x|$

(if the object does not reverse its direction)

SI unit of distance = m (meter)

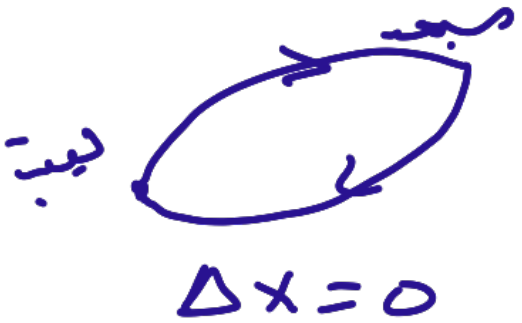
دائماً موجبة

الإزاحة تكون موجبة

أو سالبة

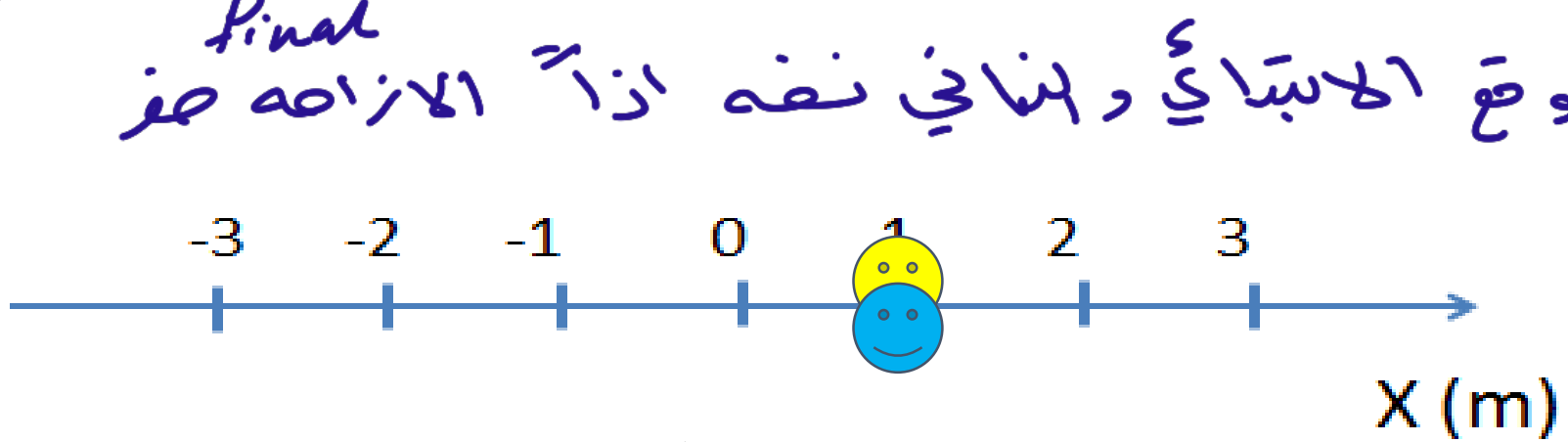
إذا كان الجسم يتحرك باتجاه واحد فإن بعد نقطة الإزاحة لكن بدون إشارة

Displacement and Distance



Remember

- Displacement is vector
- Distance is scalar
- If the initial and final positions are the same . the total displacement is 0



$\Delta x = 0$

Velocity Vector , Average Velocity and Speed

What is velocity?

Velocity: the change in position in a given time interval.

- Velocity is **vector**.
- Velocity can be +ve or –ve

✦**What is the velocity of stationary object?**

$v = 0$

① Average velocity السرعة المتوسطة

$$\bar{V} = V_{avg} = \frac{\Delta X}{\Delta t} = \frac{X_2 - X_1}{t_2 - t_1}$$ (m/s)

$\bar{V}$ = الازاحة / الزمن (كمية متجهة (موجبة او سالبة))

② Speed السرعة القياسية

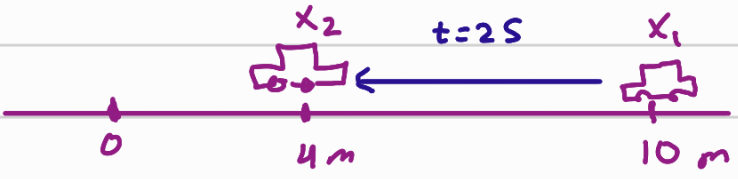
$$|V| = S = Speed = \frac{Distance}{\Delta t} =$$ المسافة / الزمن

(m/s) كمية قياسية دائماً موجبة

③ Instantanous velocity السرعة اللحظية

$$\vec{V} =$$ مشتقة معادلة الموقع $= \frac{dX}{dt}$

السرعة عند لحظة معينة (كمية متجهة (-ve , +ve))

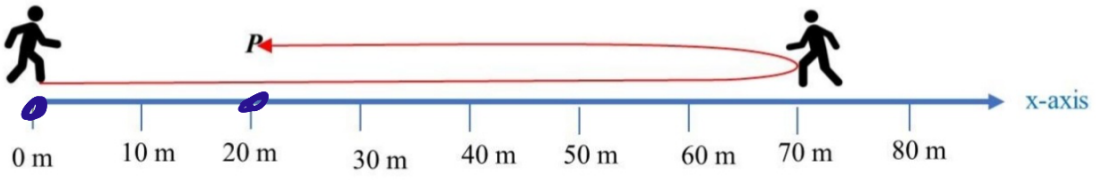


$$V_{avg} = \frac{\Delta X}{\Delta t} = \frac{4-10}{2} = \frac{-6}{2} = -3 m/s$$

$$V = Speed = \frac{6}{2} = 3 m/s$$

Velocity	Speed
$= \frac{\text{displacement}}{\text{time}}$ $\frac{\Delta x}{\Delta t}$	$= \frac{\text{distance}}{\text{time}}$
Does not depend on the path of motion	Depends on the path of motion
Vector	Scalar
SI unit: m/s	SI unit: m/s

Example: a man walked as shown in the figure, then stopped at the point *P*. The total time that he takes during his walk was 250 s. calculate the distance, displacement, average speed, and average velocity.



Solution:

Distance = 70 + 50 = 120 m

Displacement = +20 m

The + sign means that the displacement and the velocity are in the positive direction of x-axis

Average speed $= \frac{\text{distance}}{\text{time}} = \frac{120}{250} = 0.48$ m/s

Average velocity $= \frac{\text{displacement}}{\text{time}} = \frac{+20}{250} = +0.08$ m/s

Distance = 120m

Displacement $= x_2 - x_1 = 20 - 0 = +20$ m

Speed $= \frac{\text{Distance}}{\text{time}} = \frac{120}{250} = 0.48$ m/s

$\bar{V} = V_{avg} = \frac{\Delta x}{\Delta t} = \frac{20}{250} = +0.08$ m/s

Example 2.

The displacement x of an object is given as a function of time, $x = 2t + 3t^2$. The instantaneous velocity of the object at t = 2s is

$X = 2t + 3t^2$

نشتق المعادله ثم نعوض

$\vec{V} = \frac{dx}{dt} = 2 + 6t$

$\vec{V} = 2 + 6(2)$

$= 14$ m/s

Average and instantaneous velocity

- $\bar{v} = \frac{\Delta x}{\Delta t} = \frac{x_2 - x_1}{t_2 - t_1}$ السرعه المتوسطة average velocity = الازاحه / الزمن
- $v = \frac{dx}{dt}$ السرعه اللحظيه instantaneous velocity

مشتقه معادله x

السرعة القياسية

Speed

مقدار السرعة بدون اتجاه (بدون اشارة)

Speed: is the absolute value (magnitude) of velocity.

$$v = |\vec{v}|$$

قياسية

- Speed is scalar.
- Speed is always positive.

دائماً موجبة

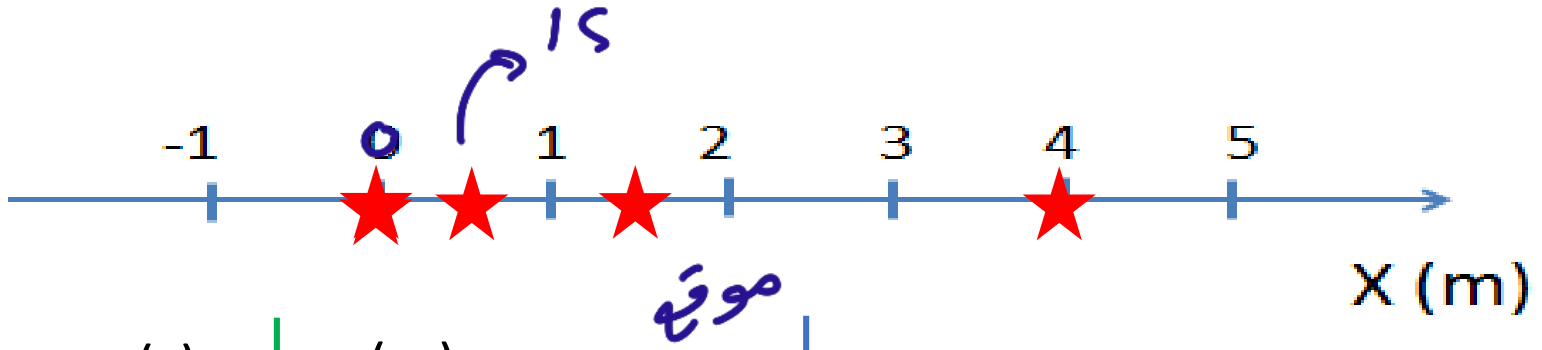
Speed can be found by dividing distance by time interval

قسمة المسافة على الزمن

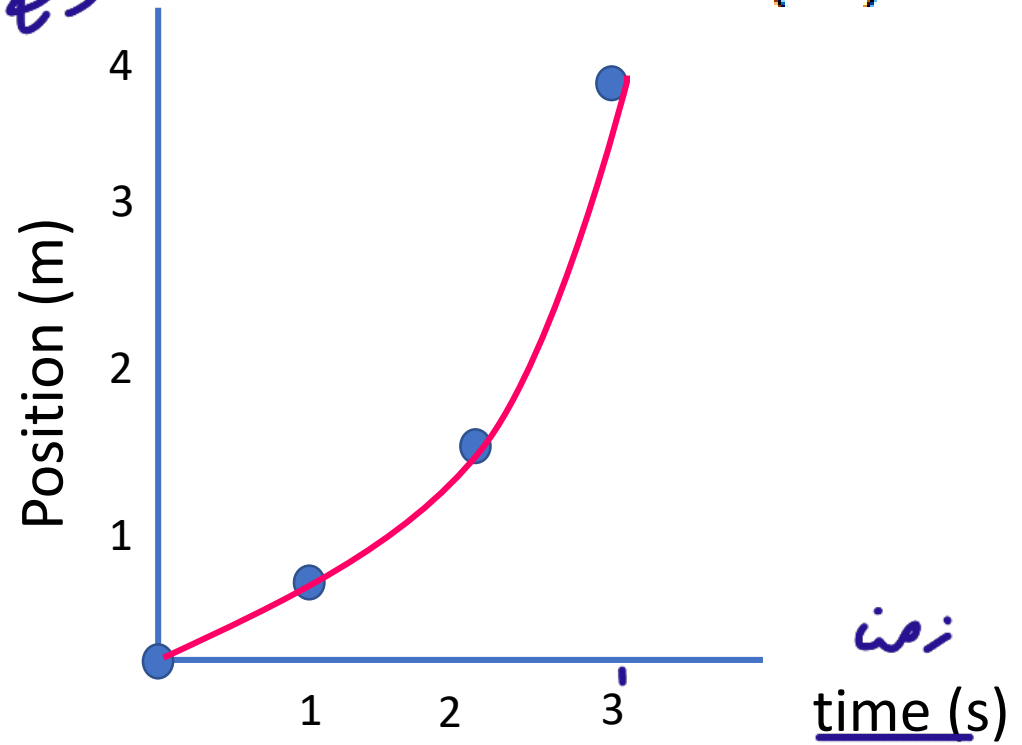
$$v = \frac{l}{\Delta t} \quad = \quad \frac{\text{المسافة}}{\text{الزمن}}$$

Position Graph

•Position graph or position-time graph is a graph between the position of an object on the y-axis, and time on the x-axis.



t (s)	x (m)
0	0
1	0.5
2	1.5
3	4

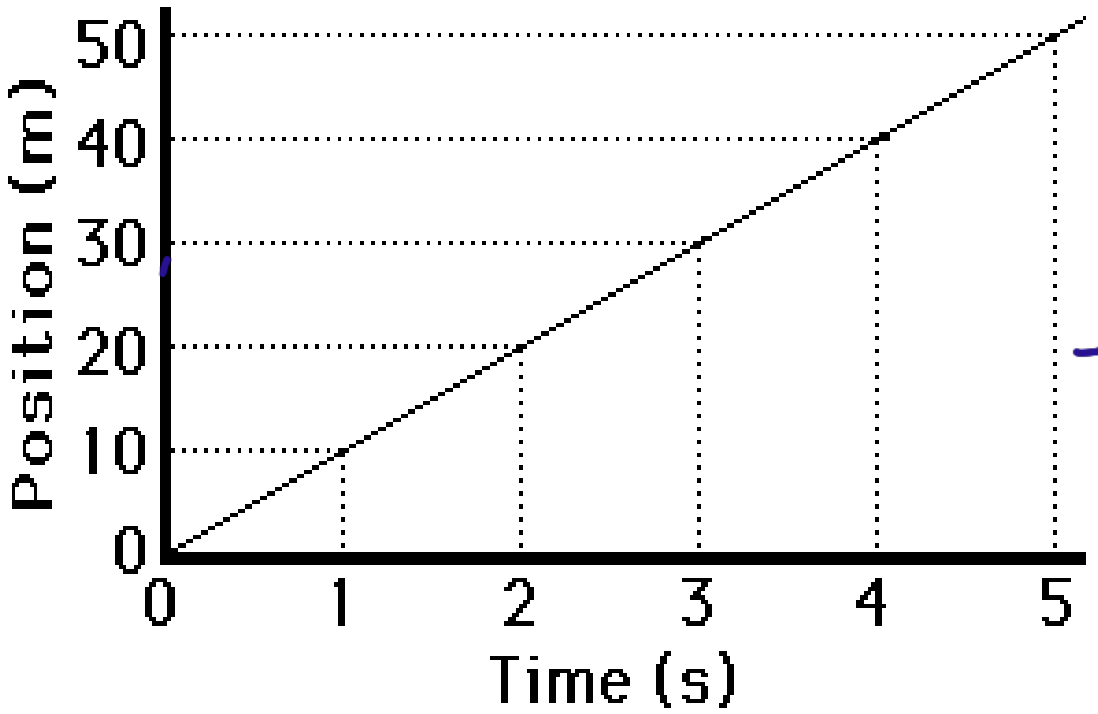


Position-time graph

السرعة تساوي ميل خط الموقع - الزمن

اعيد

- The slope of the position-time graph at any point gives the velocity of the object at the corresponding position

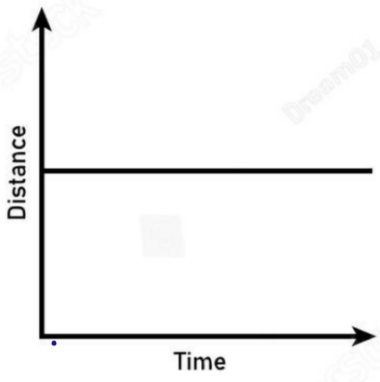


الجسم يتحرك بسرعة منتظمة

السرعة = ميل الخط

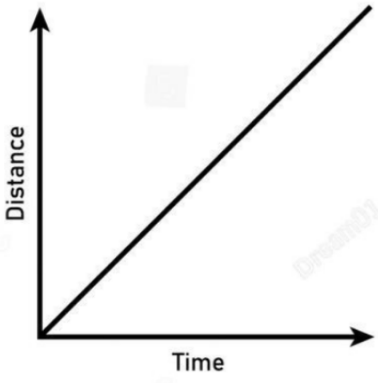
Position-Time Graph

جسم ساكن
Stationary Object



السرعة = صفر
Velocity=Zero

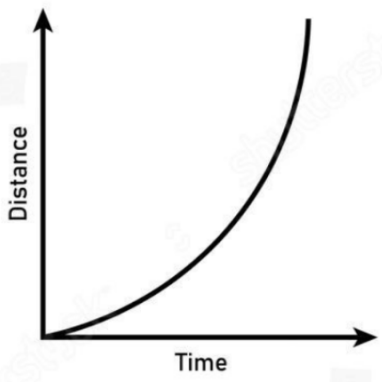
حركة منتظمة
Uniform Speed



يدل ان السرعة ثابتة
السرعة = ميل الخط

Velocity = slope
$= \frac{\Delta x}{\Delta t}$

حركة غير منتظمة
Non-Uniform speed



يتزايد لكن السرعة غير ثابتة

Acceleration : التسارع $\vec{a}$

تسارع لحظي
Instantaneous acceleration

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

اشتقاق معادلة السرعة

تسارع متوسط
Average acceleration

a_{avg} $\bar{a}$

$$a = \frac{\Delta V}{\Delta t} = \frac{V_2 - V_2}{t_2 - t_1}$$

التسارع

Acceleration Vector

$\vec{a}$ m/s^2

تغير السرعة لكل وحدة زمن

Average acceleration : the velocity change per time interval

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

تسارع متوسط

average acceleration

$$a = \frac{dv}{dt} \quad , \quad a = \frac{d^2x}{dt^2} = \frac{d}{dt}\left(\frac{dx}{dt}\right)$$

تسارع اللحظي

instantaneous acceleration

- Acceleration can be +ve or –ve

يمكن التسارع ان يكون موجب او سالب

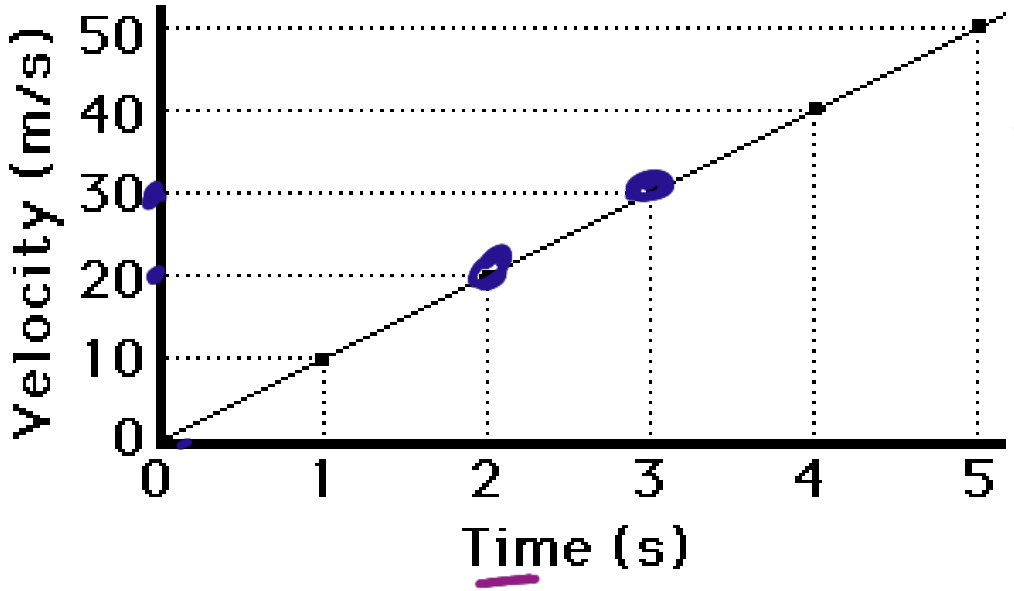
- Acceleration unit is $^{m}/_{s^2}$

m/s^2 الوحدة

✦**What is the acceleration of an objects that moves with constant velocity?**

$\vec{a} = 0$:- هاستاد ع جسم يتحرك سرعة ثابتة

Velocity-time graph



$$a = \text{slope} = \frac{\Delta v}{\Delta t} = \frac{v_2 - v_1}{t_2 - t_1} = \frac{30-20}{3-2} = 10\ m/s^2$$

The slope of velocity-time graph gives acceleration

Acceleration

سرعه الجسم تزداد

اذا كان اتجاه السرعه والتسارع بنفس الاتجاه اذاً السرعه تزداد

- **If the velocity and acceleration are in the same direction**

  ⇨ **the object moves faster**

- **If the velocity and acceleration are in opposite direction**

  ⇨ **the object slows down**

اذا كانت السرعة تعاكس الاتجاه اذاً الجسم حركته تقل

Remember

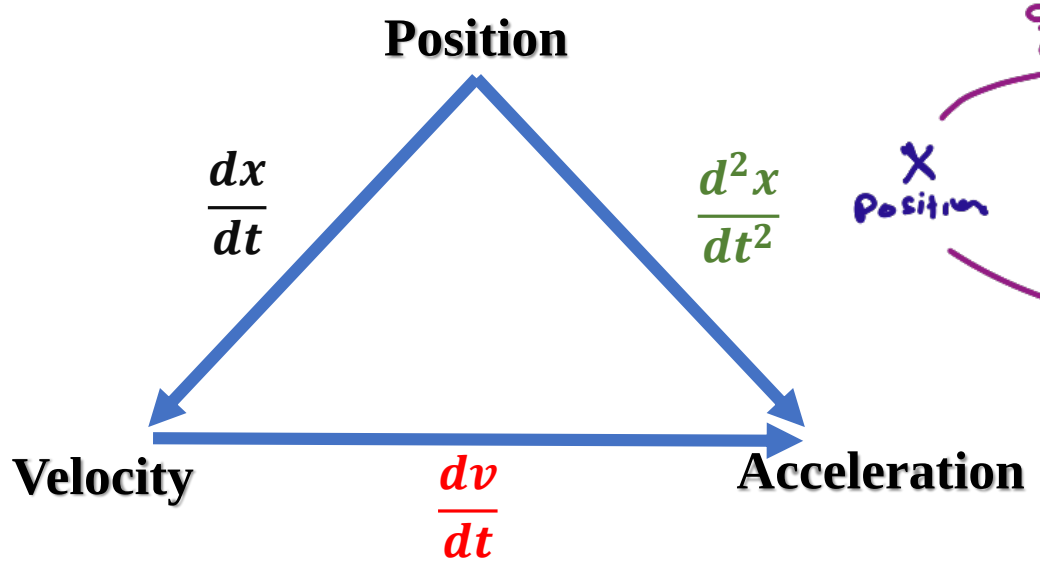
ساکن ساکن

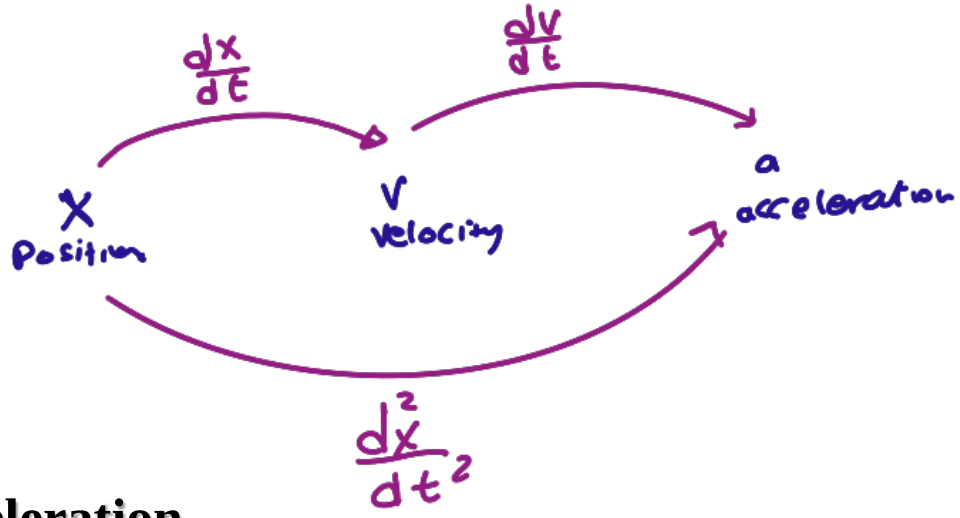
- The velocity of stationary object (object at rest) is zero

No Change in position

- The acceleration of an object that moves with constant velocity is zero

No Change in velocity





Assessment

Q1. The position vector of an object is given by: $x(t)=3t^2-t+2$ m find its position at t=2 s

$x(t) = 3t^2 - t + 2$ $\quad x(2) = 3(2)^2 - (2) + 2 = 12 - 2 + 2 = 12m$

Q2. The position vector of an object is given by: $x(t)=3t^2-t+2$ m find its displacement in time interval from t_1=2 s to t_2=3 s

$x_1 = 3(2)^2 - 2 + 2 = 12$ $\quad x_2 = 3(3)^2 - 3 + 2 = 26$ $\quad \Delta x = x_2 - x_1 = 26 - 12 = +14m$

Q3. A particle moves along the x-axis according to the equation $x(t)= t^2+5t+4$ m, find the velocity of the particle at t = 1 s

المطلوب حساب السرعة اللحظية عند = نفاضل بالنسبة للزمن

$\vec{V} = \frac{dx}{dt} = 2t + 5$ $\quad \vec{V} = 2(1) + 5 = 7 m/s$

Q4. The position of a particle is given by

$x(t)= t^2+4t-2$ m, what is the average velocity during time interval from t_1= 1 s to t_1= 2 s

$t_1 = 1s$ $\quad x_1 = (1)^2 + 4(1) - 2 = 1 + 4 - 2 = 3m$

$t_2 = 2s$ $\quad x_2 = (2)^2 + 4(2) - 2 = 4 + 8 - 2 = 10m$

$\bar{V} = \frac{x_2 - x_1}{t_2 - t_1} = \frac{10 - 3}{2 - 1} = 7 m/s$

Assessment

$V = 2t^3 + 4t^2 - 2$

Q5. The velocity of a particle is given by v=2t3+4t2-2 m/s find its acceleration at t=3 s

$\vec{a} = \frac{dV}{dt} = 6t^2 + 8t$ ⟹ نعوض $t=3$ $\quad \vec{a} = 6(3)^2 + 8(3) = 78\ m/s^2$

Q6. The position of a particle is given by x=t2+2t-2 m find its acceleration at t=1s

$X = t^2 + 2t - 2$

$$V = \frac{dx}{dt} = 2t + 2$$

$$a = \frac{dV}{dt} = \frac{d^2x}{dt^2} = 2\ m/s^2$$

Motion with Constant Acceleration

Start to move form rest $x_0=0$ $v_0=0$

Stationary $v_0=0$

Change rate of acceleration with time is zero

x :final position
x_o :initial position
v : final velocity
v_o : initial velocity
a : acceleration
t : time

$v = v_o + at$

$x - x_o = v_o t + \frac{1}{2} a t^2$

$v^2 = v_o^2 + 2a(x - x_o)$

Equations of Motion are:

	Equation	x	v	a	t
1	$x = x_o + v_o t + \frac{1}{2} a t^2$	✓	×	✓	✓
2	$x = x_o + \bar{v} t$	✓	✓	×	✓
3	$v = v_o + at$	×	✓	✓	✓
4	$v^2 = v_o^2 + 2a(x - x_o)$	✓	✓	✓	×

Remember:

- a = constant
- If the object is initially at rest
  $v_o = 0$

هي متزل بيتوقف

- When a moving object stops
  $v = 0$

$$\bar{v} = \frac{v + v_o}{2}$$

السرعة المتوسطة = مجموع السرعتين ÷ 2

Exercises

Q6. A particle starts from rest with constant acceleration of 9 m/s^2, what is its velocity after 4 sec

Q7. An object starts its motion from rest with constant acceleration of 10 m/s^2, find the displacement of the particle after 1 sec

Q8. A car starts from rest to 40 m/s in 8 s, What is the acceleration of that car?

Q9. A particle starts its motion with initial velocity 10 m/s and constant acceleration 6 m/s^2. How far does it move in 2 s?

Exercises

Q6. A particle starts from rest with constant acceleration of 9 m/s², what is its velocity after 4 sec

$V_0=0 \quad a=9 m/s^2 \quad V=?? \quad t=4 sec$

$V=V_0+at \qquad V=0+9(4)=36 m/s$

Q7. An object starts its motion from rest with constant acceleration of 10 m/s², find the displacement of the particle after 1 sec

$V_0=0 \quad a=10 m/s^2 \quad \Delta x = x-x_0 = ?? \quad t=1 s$

$x-x_0 = V_0t+\frac{1}{2}at^2$

$\Delta x = 0(1)+\frac{1}{2}(10)(1)^2 = 5 m$

Q8. A car starts from rest to 40 m/s in 8 s, What is the acceleration of that car?

$V_0=0 \quad V=40 m/s \quad t=8 \quad a=??$

$V=V_0+at \qquad \frac{V-V_0}{t}=\frac{at}{t} \qquad a=\frac{V-V_0}{t}$

$a=\frac{40-0}{8}=5 m/s^2$

Q9. A particle starts its motion with initial velocity 10 m/s and constant acceleration 6 m/s². How far does it move in 2 s?

مسافة

$V_0=10 m/s \quad a=6 m/s^2 \quad t=2s \quad x-x_0=??$

$x-x_0 = V_0t+\frac{1}{2}at^2$

$\Delta x = 10(2)+\frac{1}{2}(6)(2)^2 = 20+12 = 32 m$

Free Fall

السقوط الحر

التسارع الناتج عن قوة الجاذبية ثابت

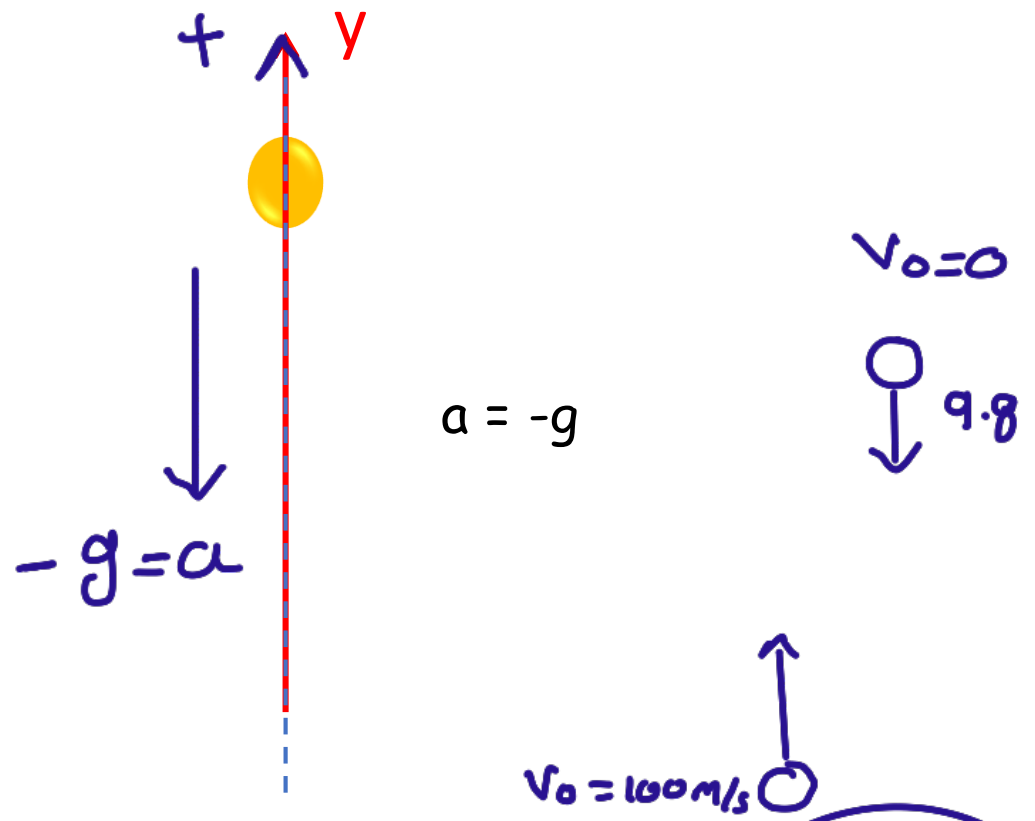
- The acceleration due to the gravitational force is constant

$g = 9.8\ m/s^2$ ↓

حركة الجسم تحت تأثير الجاذبية تسمى السقوط الحر

- Motion under the influence of a gravitational acceleration is called *Free Fall*

- Free fall is one dimension motion

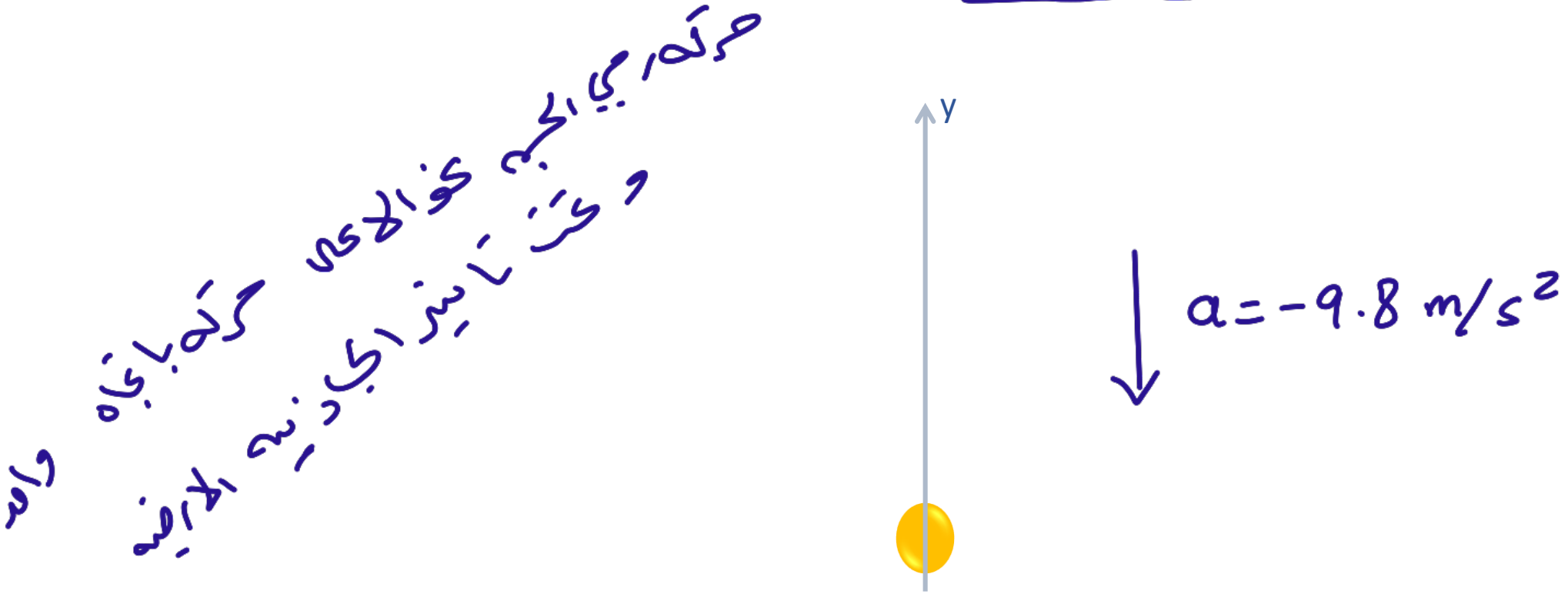


السقوط : كل ثانية تزداد السرعة بمقدار ثابت (9.8) ↓

رمي صعب للاعلى : كل ثانية تقل سرعة الجسم بمقدار (9.8) ↑↓

Free Fall

Motion of object thrown up in air



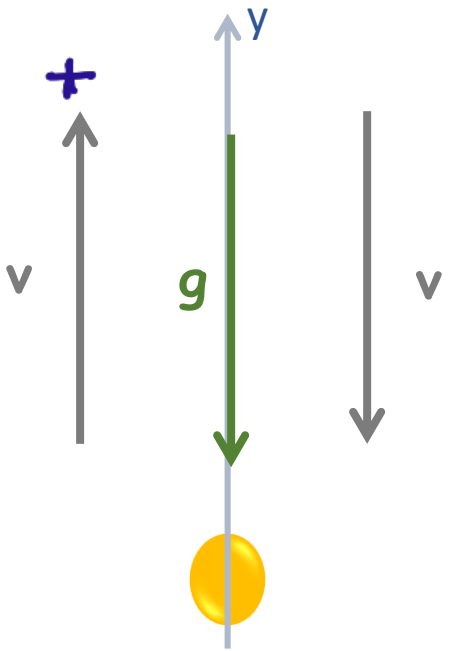
Free Fall

$V=0$ عند اقصى ارتفاع

At maximum height
Velocity = 0

Up
Velocity:
Upward
Decrease
⬇
Slows down

السرعه تكون لاعلى بتناقص



Down
Velocity:
Downward
Increases
⬇
Speeds up

السرعه تكون لاسفل تزداد

التسارع تكون لاسفل

The acceleration is downward all the time

Be careful slow down and speed up are tricky terms

Think About That

في القمة السرعة = صفر التسارع ثابت ↓ 9.8

- At the top, the velocity is zero although still there is acceleration

- A particle moves with a constant velocity
  ➔ the acceleration is zero
  ↳ عندما تكون السرعة ثابتة = التسارع = صفر

Free Fall

x → y vertical axis
a = -g positive direction is up

		y	v	t
1	$y = y_o + v_o t - \frac{1}{2} g t^2$	✓	×	✓
2	$y = y_o + \bar{v} t$	✓	✓	✓
3	$v = v_o - gt$	×	✓	✓
4	$v^2 = v_o^2 - 2g(y - y_o)$	✓	✓	×

في هذه حركة الجسم تحت
مجال الجاذبية الارضيه
سنستخدم نفس قوانين
الحركة بتسارع ثابت

$v = v_o - gt$

$y - y_o = v_o t - \frac{1}{2} g t^2$

$v^2 = v_o^2 - 2g(y - y_o)$

y_o : الارتفاع الابتدائي
y : الارتفاع النهائي

Assessment

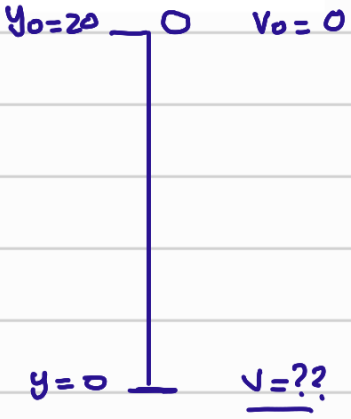
Q10. A ball falls freely from a top of a building 20 m high find its velocity when it reaches the ground.

Q11. stone thrown vertically down from a top of a building 20 m, find the time taken by the stone to reach the ground ?

Q12. A ball thrown straight upward from a top of a building with an initial velocity of 12 m/s. What is the time at which the ball reaches its maximum height?

Assessment

Q10. A ball falls freely from a top of a building 20 m high find its velocity when it reaches the ground.



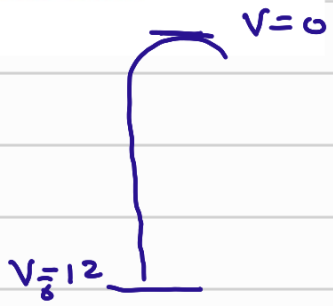
$$v^2 = v_o^2 - 2g(y-y_o)$$
$$v^2 = 0^2 - 2(9.8)(0-20)$$
$$v^2 = +2(9.8)(20) = 392$$
$$\sqrt{v^2} = \sqrt{392} \Rightarrow v = 19.8 \text{ m/s}$$

Q11. stone thrown vertically down from a top of a building 20 m, find the time taken by the stone to reach the ground ?

$y_o=20$ $y=0$ $v_o=0$ $v=19.8$

$$v = v_o - gt \qquad t = \frac{v-v_o}{-g} = \frac{-19.8-0}{-9.8} = 2\,s$$

Q12. A ball thrown straight upward from a top of a building with an initial velocity of 12 m/s. What is the time at which the ball reaches its maximum height?



$v_o = 12$ $v=0$ $t = ?$

$$v = v_o - gt \qquad t = \frac{v-v_o}{-g}$$
$$t = \frac{0-12}{-9.8} = 1.22\,s$$

Free Fall

في حال طلب السؤال :: الزمن اللازم لوصول الجسم الى اقصى ارتفاع

الزمن اللازم للوصول الى اقصى ارتفاع

Time to reach maximum height (top):

$$t = \frac{v_o}{g}$$

$$t = \frac{v_o}{g}$$

$$v = v_o - g t$$

$$t = \frac{v - v_o}{-g} = \frac{-v_o}{-g} = \frac{v_o}{g}$$

Prove!!

Assessment

Problem 1:

$t_0 = 2$ $x_0 = 4$ $\bar{V}$

The initial position of a particle at time t=2s is 4m. What is the average velocity if the particle at time t=12s is located at a final position 6m?

$t = 12$ $x = 6$

Problem 2:

The position of a particle at any time is described as the following $x(t) = 4t^2$m/s. What is the velocity of the particle at time t=1s?

1) $\bar{V} = \frac{x - x_0}{t - t_0}$

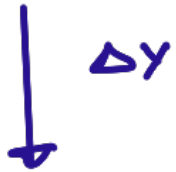
$= \frac{6 - 4}{12 - 2}$

$= 0.2$ m/s

$x(t) = 4t^2$

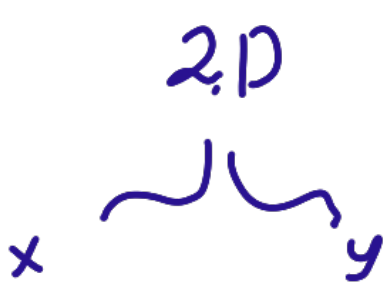
$V = \frac{dx}{dt} = 8t$

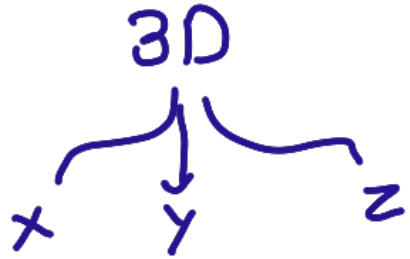
$V = 8(1) = 8$ m/s

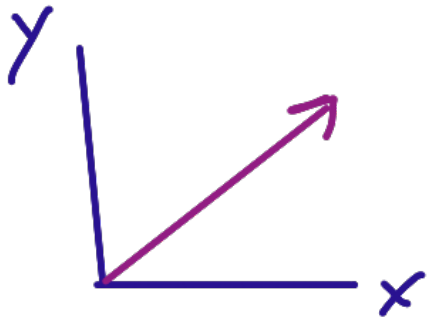


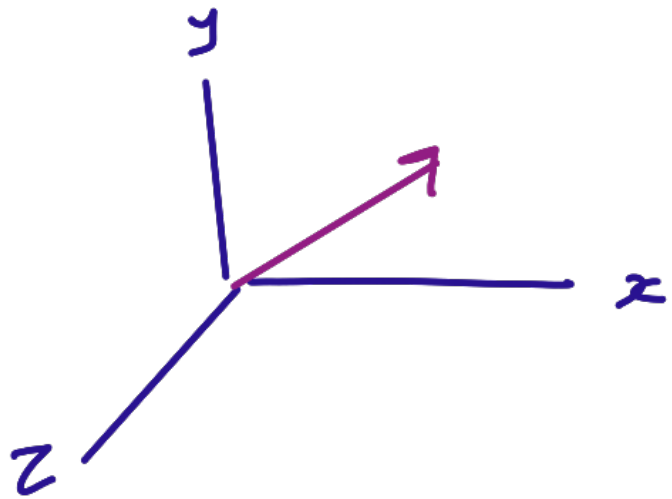
Chapter 3

Motion to two and three Dimensions





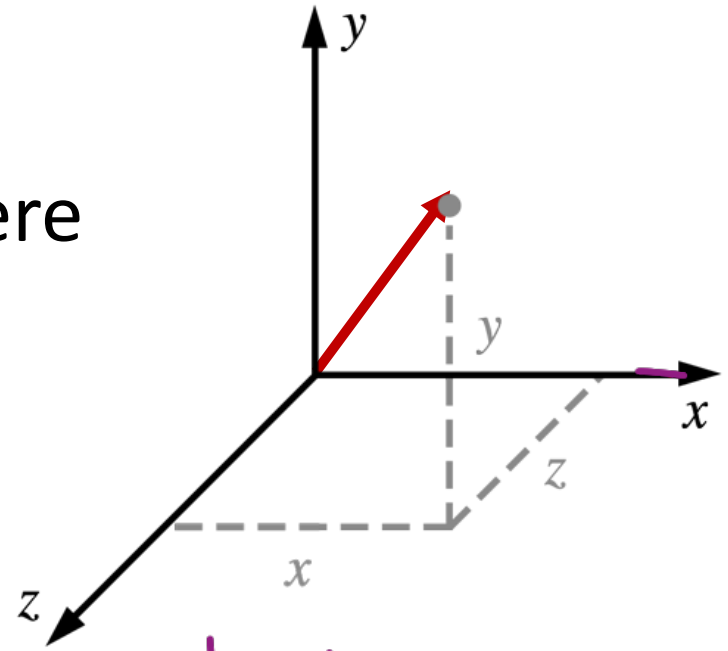




3D coordinate system

In three dimensional coordinate system there are three orthogonal axes: x, y and z that make 90° to each other.

متعامد



Position vector , velocity vector and acceleration vector each has three components

- $\vec{A} = (A_x, A_y, A_z) = A_x\hat{x} + A_y\hat{y} + A_z\hat{z}$

موقع	x	r
ازاحة	Δx	Δr
السرعة v	$\frac{dx}{dt}$	$\frac{dr}{dt}$
التسارع a	$\frac{dv}{dt}$	$\frac{dv}{dt}$

$\vec{A} = 3\hat{x}$ بعد واحد

$\vec{A} = 3\hat{x} + 4\hat{y}$ بعدين

$\vec{A} = 3\hat{x} + 4\hat{y} + 2\hat{z}$ 3 ابعاد

Velocity and acceleration in plane:

السرعة في بعدين او ٣ ابعاد تتغير مقدارا واتجاه

- In 2D & 3D: velocity can change magnitude and direction.

يمكن ان يبدأ الشارع محفظ عن تغير الاتجاه
دون تغير السرعة

الشارع له تغير السرعة + يتغير الاتجاه

- There can be acceleration even when the magnitudes of the velocity does not change.

- An object that travels along curved path must have acceleration .

اي جسم يتحرك في مسار منحني اذا هو يتسارع

الموقع **Position vector:**

$$\vec{r} = (r_x, r_y, r_z) = r_x\hat{x} + r_y\hat{y} + r_z\hat{z}$$

السرعة **Velocity vector:**

$$\vec{v} = (v_x, v_y, v_z) = v_x\hat{x} + v_y\hat{y} + v_z\hat{z}$$

$$v_x = \frac{dx}{dt} \quad , \qquad v_y = \frac{dy}{dt} \quad , \qquad v_z = \frac{dz}{dt}$$

التسارع **Acceleration vector:**

$$\vec{a} = (a_x, a_y, a_z) = a_x\hat{x} + a_y\hat{y} + a_z\hat{z}$$

$$a_x = \frac{dv_x}{dt} \quad , \qquad a_y = \frac{dv_y}{dt} \quad , \qquad a_z = \frac{dv_z}{dt}$$

$\vec{r} = t^3\hat{x} + 3t^2\hat{y} + 5t\hat{z}$

موقع الجسم عندما $t=1$

$\vec{r} = 1\hat{x} + 3\hat{y} + 5\hat{z}$ m

سرعة الجسم

$\vec{v} = 3t^2\hat{x} + 6t\hat{y} + 5\hat{z}$

v_x v_y v_z

السرعة عندما $t=1$

$\vec{v} = 3\hat{x} + 6\hat{y} + 5\hat{z}$ m/s

التسارع

$\vec{a} = 6t\hat{x} + 6\hat{y}$

التسارع عندما $t=1$

$\vec{a} = 6\hat{x} + 6\hat{y}$ m/s^2

Assessment

Q1.

Velocity of a particle moving in space is given by:

$$\vec{v} = 4t\hat{x} + t^3\hat{y} - 8\hat{z}$$

What is the magnitude of the acceleration of the particle at t=1s?

ماهو مقدار التسارع عندما يكون الزمن 1s

$$\vec{a} = \frac{d\vec{v}}{dt} = 4\hat{x} + 3t^2\hat{y}$$

نعوض t=1

$$\vec{a} = 4\hat{x} + 3\hat{y} \qquad |\vec{a}| = \sqrt{4^2 + 3^2} = 5\,m/s^2$$

Q2:

The position vector of a particle is given by

$$r(t) = [(2t-3)\hat{x} - 3t^2\hat{y} + 4t\hat{z}]m$$

Find the magnitude of acceleration at any time?

$$\vec{r}(t) = (2t-3)\hat{x} - (3t^2)\hat{y} + (4t)\hat{z}$$

$$\vec{v} = \frac{d\vec{r}}{dt} = 2\hat{x} - 6t\hat{y} + 4\hat{z}$$

$$\vec{a} = \frac{d\vec{v}}{dt} = 0\hat{x} - 6\hat{y} + 0\hat{z}$$

$$\vec{a} = -6\hat{y} \quad m/s^2$$

$$= -6\ m/s^2$$

حركة المقذوفات المثالية

Ideal projectile motion:

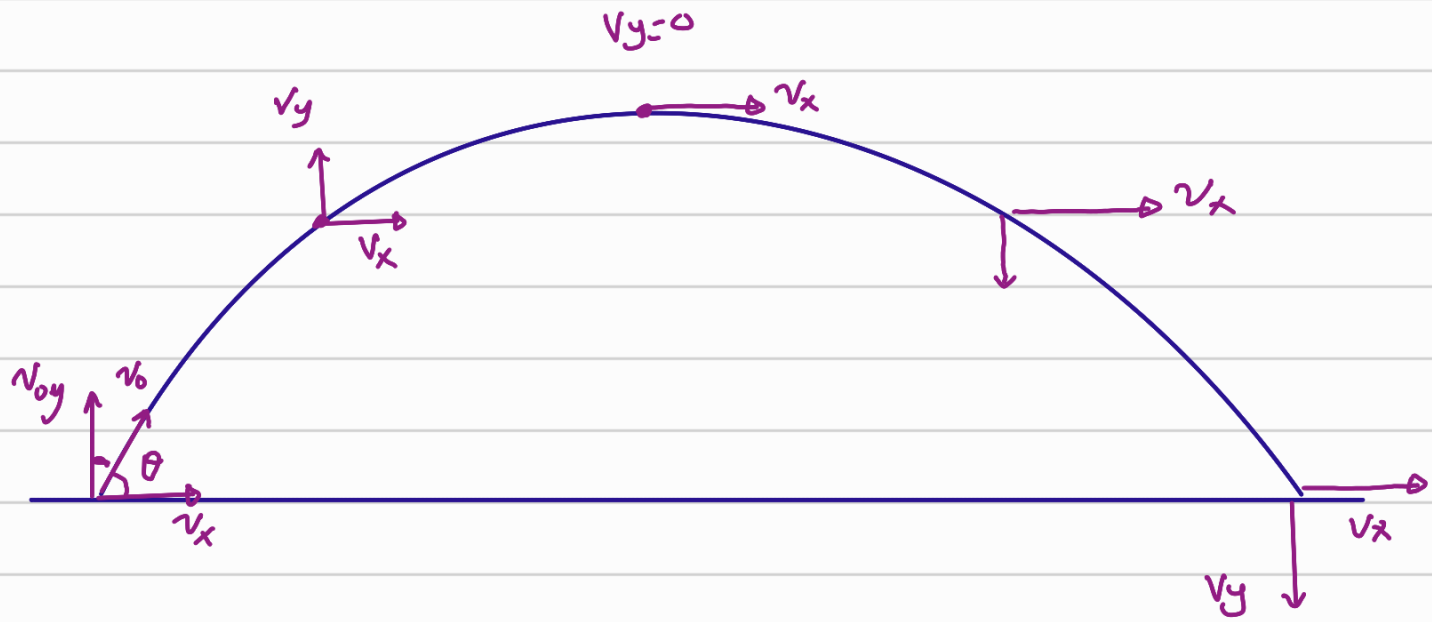
حركة الجسم المقذوف هي حركة في بعدين

- Projectile motion can be described as a motion in two dimensions.

مثالية

- **Ideal project motion** is any object that is released with some initial velocity and then moves only under the influence of gravitational acceleration. حركة المقذوف المثالية ينطلق فيها الجسم بسرعة ابتدائية ويتحرك فقط تأثير الجاذبية الأرضية

- Ideal projectile motion neglect air resistance and wind speed , spin of the projectile and other effects influencing the flight of real life projectiles تهمل مقاومة الهواء و سرعة الرياح و الحركة الدورانية للجسم



* القوه الوحيده المؤثره في الجسم هي قوه الجاذبيه $a=\bar{g}\downarrow$

* بالاتجاه بالافقي لايوجد قوه مؤثره $a_x=0$ التسارع
السرعه الافقيه ثابته V_x ثابته

$$a_x = 0 \qquad V_x = V_o \cos\theta$$

* السرعه العموديه تتغير باستمرار (حسب علاقات السقوط الحر)

السرعه العموديه عند لحظة الانطلاق $V_{oy} = V_o \sin\theta$

السرعه العموديه عند اي لحظة $V_y = V_o \sin\theta - gt$

السرعه العموديه عند اقصى ارتفاع $V_y = zero$

* الموقع عند اي لحظة

$$\bar{r} = x\,\hat{x} + y\,\hat{y} \qquad |r| = \sqrt{x^2+y^2}$$

* السرعه عند اي لحظة

$$\bar{v} = v_x\,\hat{x} + v_y\,\hat{y} \qquad |\bar{v}| = \sqrt{v_x^2+v_y^2}$$

* التسارع عند اي لحظة

$$\bar{a} = 0\,\hat{x} - g\,\hat{y}$$

Projectile motion has two components :

- x-component in the horizontal direction
- y-component in the vertical direction

- position vector:

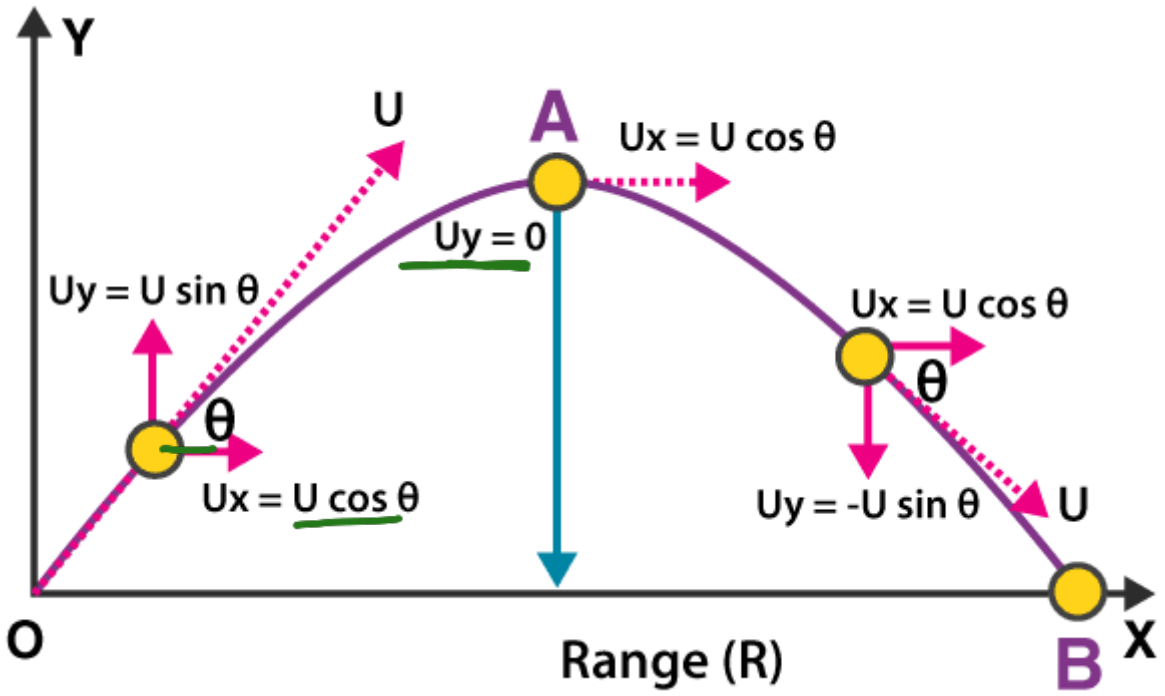
$$\vec{r} = (x, y) = x\,\hat{x} + y\hat{y}$$

- velocity vector:

$$\vec{v} = (v_x, v_y) = \frac{dx}{dt}\,\hat{x} + \frac{dy}{dt}\,\hat{y}$$

- acceleration vector:

$$\vec{a} = (0, -g) = -g\hat{y}$$

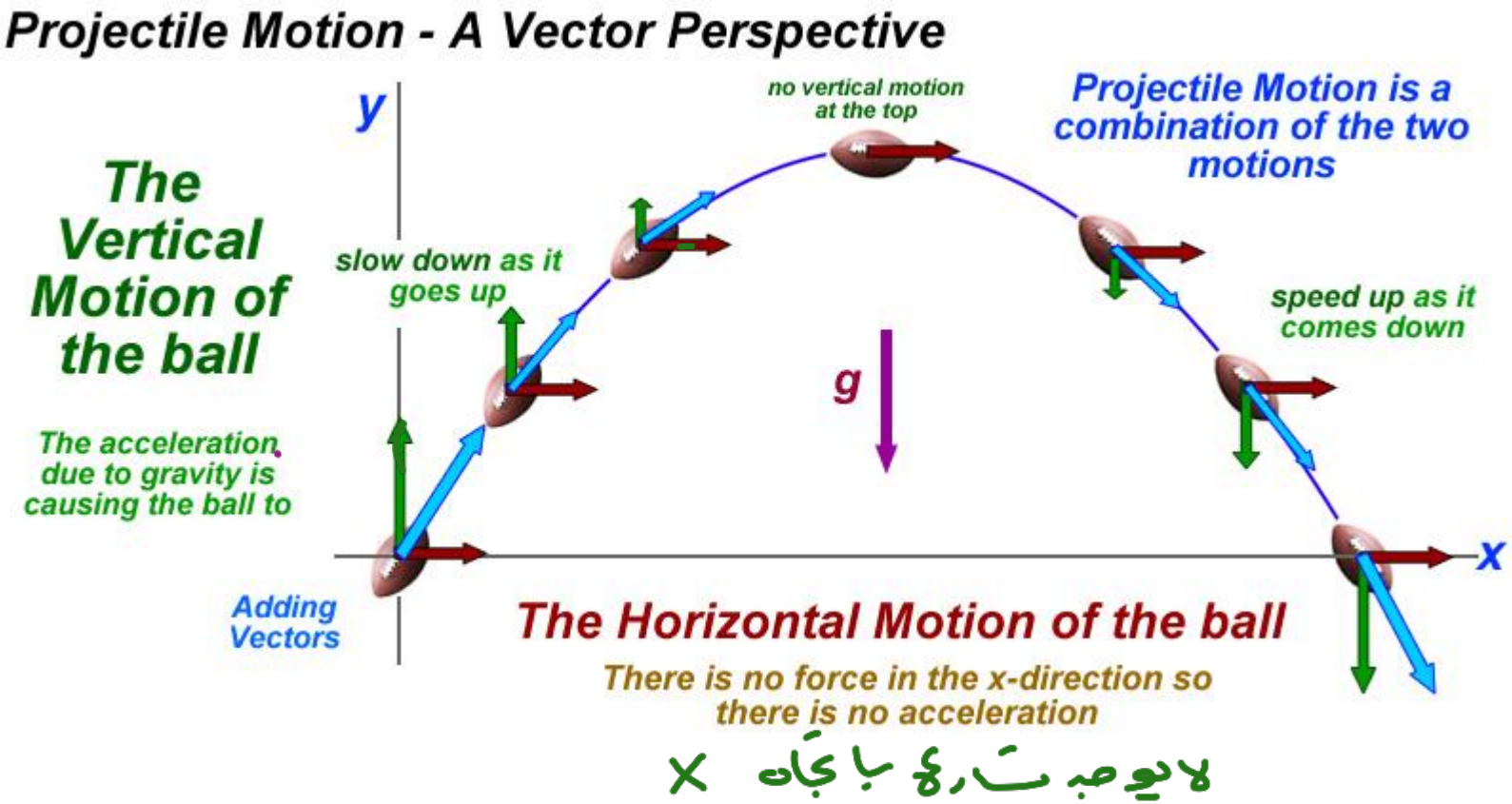


Projectile motion has two independent component :

Acceleration:

In ***x*- direction** → motion with constant velocity $a_x = 0\ m/s^2$

In ***y*- direction** → free fall $a_y = -\mathrm{g} = 9.8\ m/s^2$



Velocity:

Initial Velocity components:

$$v_{ox} = v_o \cos\theta_0$$

$$v_{oy} = v_o \sin\theta_0$$

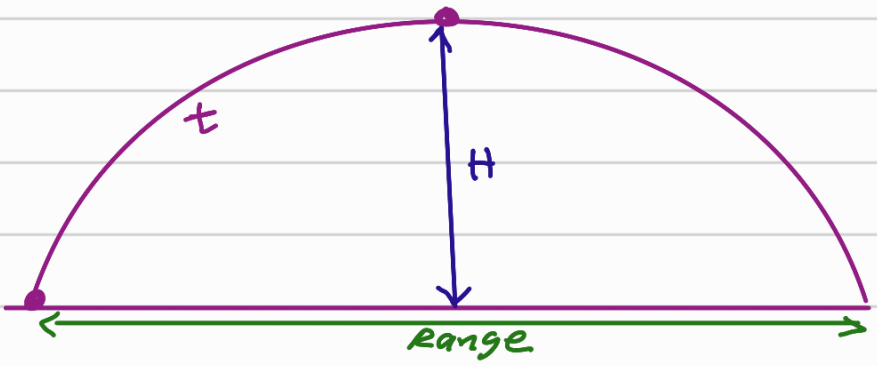
$$v_o = \sqrt{v_{0x}^2 + v_{0y}^2}$$

Final Velocity components:

Constant $v_x = v_o \cos\theta_0$

Changing $v_y = v_o \sin\theta_0 - gt$

$$v = \sqrt{v_x^2 + v_y^2}$$



Maximum Height

اقصى ارتفاع

$$H = \frac{(V_0 \sin\theta)^2}{2g}$$

Range

المدى الافقي

$$R = \frac{V_0^2 \sin 2\theta}{g}$$

$\theta = 45$

$$R_{MAX} = \frac{V_0^2}{g}$$

Flight time
Time to Max Height

زمن التحليق

$$t = \frac{V_0 \sin\theta}{g}$$

زمن الوصول الى اقصى ارتفاع

$$t = \frac{2 V_0 \sin\theta}{g}$$

زمن التحليق كامل

Assessment

Q2. An arrow is released with an initial velocity of 100 m/s with an angle 60° above the horizon, what is its horizontal velocity?

Q3. An object is thrown with initial velocity of 40 m/s at initial angle of 30°, what is the initial vertical velocity?

Q4. A ball shot has initial velocity 50 m/s and initial angle 60° find ball's position at t =2 s

Assessment

Q2. An arrow is released with an initial velocity of 100 m/s with an angle 60° above the horizon, what is its horizontal velocity?

ما مقدار السرعه الافقيه

$$V_x = V_o \cos\theta = 100 \cos 60 = 50 m/s$$

Q3. An object is thrown with initial velocity of 40 m/s at initial angle of 30°, what is the initial vertical velocity?

$$V_{oy} = V_o \sin\theta = 40 \sin 30 = 20 m/s$$

Q4. A ball shot has initial velocity 50 m/s and initial angle 60° find ball's position at t =2 s

رميت كره بزاويه 60° وسرعه 50m/s ما موقع الجسم بعد ثانيتين

(افقي (حركة ثابته

$V_x = V_o \cos\theta$

$V_x = \frac{x}{t}$

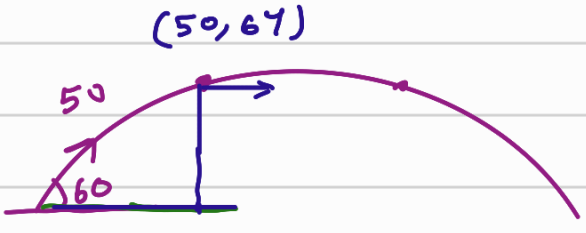
(عمودي (سرعة متغيرة

$V_{y_o} = V_o \sin\theta$

$V_y = V_o \sin\theta - gt$

$y - y_o = V_o \sin\theta\, t - \frac{1}{2}gt^2$

$V_y^2 = (V_o \sin\theta)^2 - 2g(y - y_o)$



$V_{oy} = V_o \sin\theta = 50 \sin 60 = 43.3$

$V_{ox} = V_o \cos\theta = 50 \cos 60 = 25$

$\vec{r} = 50\hat{x} + 67\hat{y}$ m

موقع x حيث مرور ثانيتين

$X = V_x t = 25 \times 2 = 50m$

موقع y

$y - y_o = V_o \sin\theta\, t - \frac{1}{2}gt^2$

$y - 0 = 43.3(2) - \frac{1}{2}(9.8)(2)^2$

$y = 67m$

Maximum Height, time and range of a projectile

- **Maximum Height :** اقصى ارتفاع

$$H = \frac{v_o^2 \sin^2\theta}{2g}$$

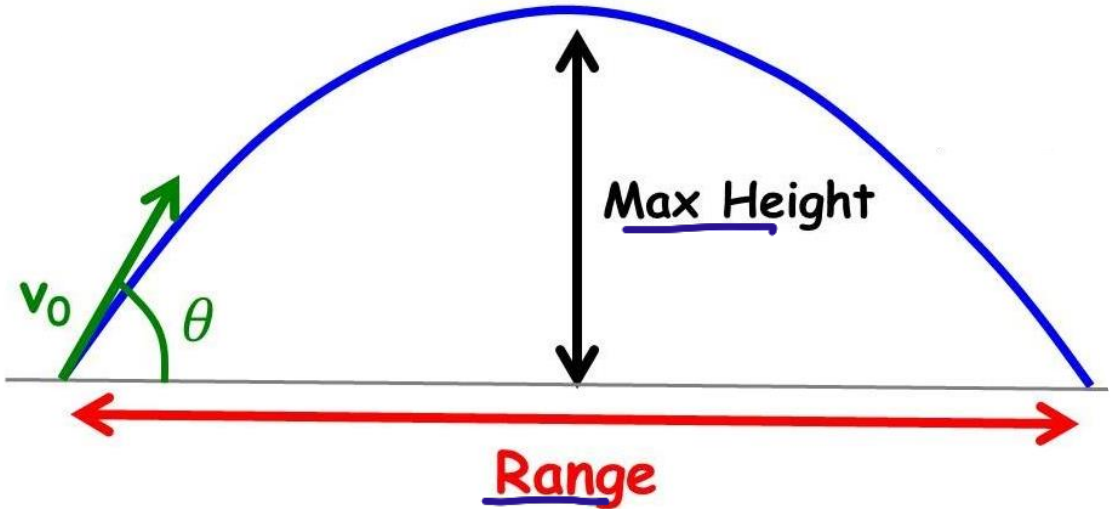
- **Range:** المدى

$$R = \frac{v_o^2 \sin 2\theta}{g}$$

- **Time to Maximum Height:** زمن الوصول الى اقصى ارتفاع

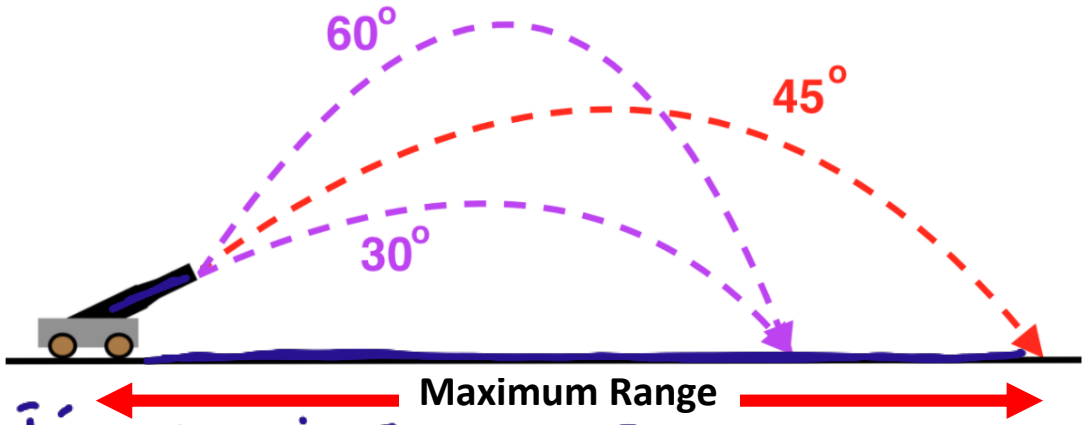
$$t = \frac{v_o \sin\theta}{g}$$

Projectiles trajectory take a parabola shape



- A projectile reaches its maximum height when the launch **angle is 45º**

$$R_{max} = \frac{v_o^2}{g} \qquad at \quad \theta = 45^o$$



المدى الاعظمي تصل له القذيفه عندما تكون الزاويه 45

Assessment

Q6. An object is thrown with initial velocity 20 m/s and an angel of 30° above the horizon, what is the maximum height for the object?

Q7. A ball is thrown with an initial velocity 30 m/s with an angel of 15° above the horizon what is it's horizontal range ?

Q8. A projectile is thrown with an initial speed $10m/s$ at an angle 30° above the x-axis.

1. **What is the magnitude of it's velocity at t=1s?**
2. **What is the *maximum height*, the *time* needed to reach max. height, and the *range* of motion?**

Assessment

Q6. An object is thrown with initial velocity 20 m/s and an angel of 30° above the horizon, what is the maximum height for the object?

المطلوب حساب اقصى ارتفاع

$$H = \frac{(V_0 \sin\theta)^2}{2g} = \frac{(20 \sin 30)^2}{2(9.8)} = 5.1\ m$$

Q7. A ball is thrown with an initial velocity 30 m/s with an angel of 15° above the horizon what is it's horizontal range ?

المطلوب حساب المدى الافقي

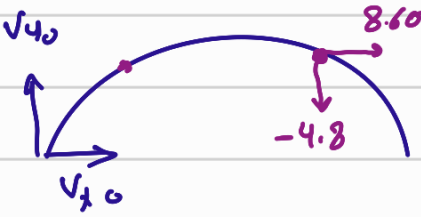
$$R = \frac{V_0^2 \sin 2\theta}{g} = \frac{30^2 \sin(2 \times 15)}{9.8} = 45.9m$$

Q8. A projectile is thrown with an initial speed $10m/s$ at an angle 30° above the x-axis.

1. **What is the magnitude of it's velocity at t=1s?**
2. **What is the *maximum height*, the *time* needed to reach max. height, and the *range* of motion?**

ما مقدار السرعه بعد مرور ثانيه واحدة

1)



$V_{0x} = V_0 \cos\theta = 10 \cos 30 = 8.66$

$V_{0y} = V_0 \sin\theta = 10 \sin 30 = 5$

السرعه بعد مرور 1s

$V_x \Rightarrow$ ثابته $\quad V_x = 8.66\ m/s$

$V_y \Rightarrow V_y = V_0 \sin\theta - gt = 5 - 9.8(1) = -4.8\ m/s$

$$\vec{V} = 8.66\hat{x} - 4.8\hat{y} \qquad |\vec{V}| = \sqrt{8.66^2 + (-4.8^2)} = 9.9\ m/s$$

2) Max height

$$H = \frac{(V_0 \sin\theta)^2}{2g} = \frac{(10 \sin 30)^2}{2(9.8)} = 1.27m$$

time to Max-height

$$t = \frac{V_0 \sin\theta}{g} \qquad t = \frac{10 \sin 30}{9.8} = 0.51\ s$$

Range

$$R = \frac{V_0^2 \sin(2\theta)}{g} \qquad R = \frac{10^2 \sin(60)}{9.8} = 8.8\ m$$

CHAPTER 4

Force

القوة

تأثير الاجسام ببعضها

مقياس لمقدار التفاعل بين الاجسام

Force:

- The mean for objects to influence each other.
- A measure of how an object interacts with other objects
- All force are vectors كمية

$$\vec{f} = f_x\hat{x} + f_y\hat{y} + f_z\hat{z}$$

$\vec{f} = 3\hat{x}$

$\vec{f} = 4\hat{y}$

$\vec{f} = 3\hat{x} + 4\hat{y}$

SI unit: Newton (N)

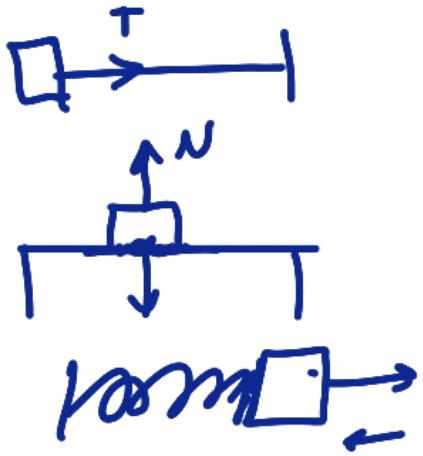
In SI base units: 1 N = 1kg.m/s²

$1N = 1\ \frac{kg\ m}{s^2}$ = نيوتن = وحدة القياس

Types of forces

- *Fundamental Forces:*
  A. Gravitational: Force where an object attracts another object toward itself.
  B. Electromagnetic: Attraction and repulsion forces associated with electric and magnetic fields
  C. Strong nuclear Force: which binds elementary particles to form larger particles.
  D. Weak nuclear Force: acts between elementary particles on the length scale of an atomic nuclei

- *Contact Forces:*
  A. Tension Force: transmitted force through rope, cable, or wire when its pulled.
  B. Normal Force (Surface reaction): exerted force upon an object in contact with another stable object.
  C. Spring Force: exerted by compressing or stretching a spring attached to an object.
  D. Friction Force (Static or Kinetic): exerted force by a surface on an object moves across it.



Weight versus Mass

الوزن الكتلة

- **Gravitational force ($\vec{F}_g$):**

قوة الجاذبية

$F_g = W$

Magnitude:

$$w = mg$$

N ← **w : object's weight**

kg ← **m : object's mass**

m/s² ← **g : gravitational acceleration**

حسب وزنك

$W = mg$

$= 70 \times 9.8$

$686\ N$

Direction:

$$\vec{F}_g = -w\hat{y} = -mg\,\hat{y}$$

points in the –ve y-direction (-y)

$F_g = -686\ \hat{y}$

- **Weight:**

مقدار قوة الجاذبية على الجسم

The magnitude of a force that acts on an object due to its gravitational interaction with the earth or another object

SI unit: Newton (N)

- **Mass:**

كتلة

The amount of matter in the object.

Mass is **scalar**.

The term "mass" refers to the same physical concept as inertia تعور

SI unit: kilogram (kg)

$W = mg$

$m = \frac{W}{g}$

Assessment

Q1. Find the mass of a body that has 294 N weight

$$m = \frac{W}{g} = \frac{294}{9.8} = 30\ kg$$

Q2. What is the gravitational force on a 20 kg body?

$$F_g = W = mg = 20 \times 9.8 = 196\ N \downarrow$$

$$= -196\,\hat{y}$$

Q3. if two forces act on a block, $\vec{F}_1 = 8\hat{x} - 3\hat{y}\ N$ and $\vec{F}_2 = -8\hat{x} + 3\hat{y} + 4\hat{z}\ N$ what is their net force?

محصلة القوى

$$F_{net} = F_1 + F_2 = (8\hat{x} - 3\hat{y}) + (-8\hat{x} + 3\hat{y} + 4\hat{z}) = 0\hat{x} + 0\hat{y} + 4\hat{z} = 4\hat{z}$$

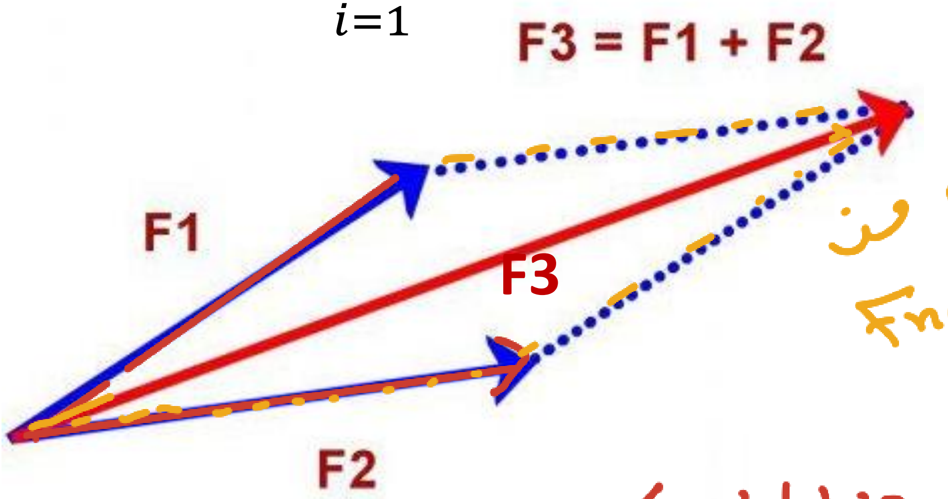
Net Force

القوة المحصلة

Net Force: the vector sum of all force vectors that acts on an object.

مجموع متجهات

$$\vec{F}_{net} = \sum_{i=1}^{n} \vec{F}_i = \vec{F}_1 + \vec{F}_2 + .. + \vec{F}_n$$



قطر متوازي الأضلاع مجموع متجهين

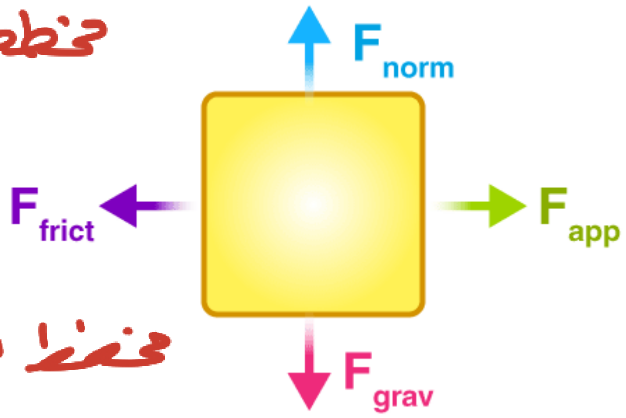
Fnet =

Free-Body Diagrams

مخطط الجسم الحر

diagrams used to show the relative magnitude and direction of all forces acting upon an object in a given situation.

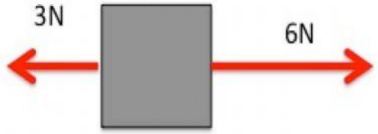
مخطط يوضح كل القوى في الجسم



Net of Forces

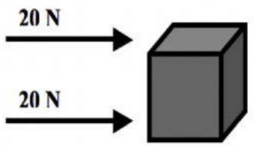
Instruction : Calculate the net of forces act to an object and the direction of net forces.

1. Look at the figure.



Fnet = 6-3 = 3N →
= 3x̂

2. Look at the figure.

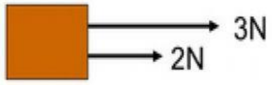


Fnet = 20+20 = 40N
40x̂

3. Look at the figure.

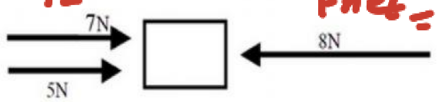
Fnet = 12-5
= 7
-7x̂

4. Look at the figure.



Fnet = 5N
= 5x̂

5. Look at the figure.



Fnet = 12-8 = 4
F = 4x̂

Newton's Laws I

Inertia: is an object resistance to change its motion

Newton's First Law: The law of inertia

If the net force on an object is equal to zero, the object will remain at rest if it was at rest. If it was moving, it will remain in motion in a straight line with the same constant velocity.

$\vec{F}_{net} = 0$

$\vec{a} = 0$

Rest

constant velocity

With no outside forces, this object will never move

With no outside forces, this object will never stop

- A particle is in EQUILIBRUM, the net forces acting on it are zero.

Newton's Laws II

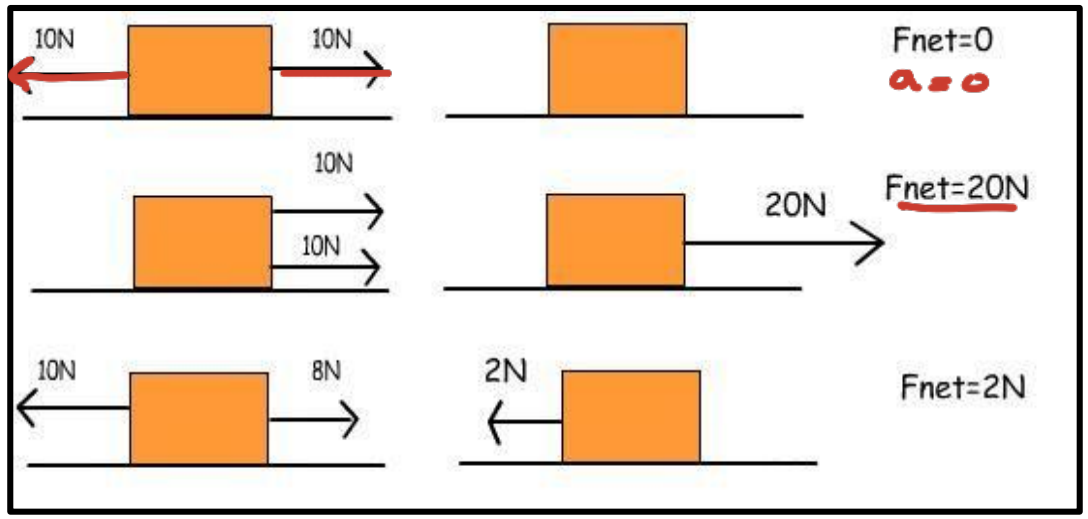
Newton's Second Law:

If an net external force, $\vec{F}_{net}$, acts on an object with mass m, the force will cause an acceleration, $\vec{a}$, in the same direction as the force:

$$\vec{F}_{net} = m\vec{a}$$

- Acceleration has the same direction of the net force that coursing it.

- No Force No acceleration.(constant velocity)



- In 3D:

$F_{net,x} = ma_x$, $F_{net,y} = ma_y$, $F_{net,z} = ma_z$

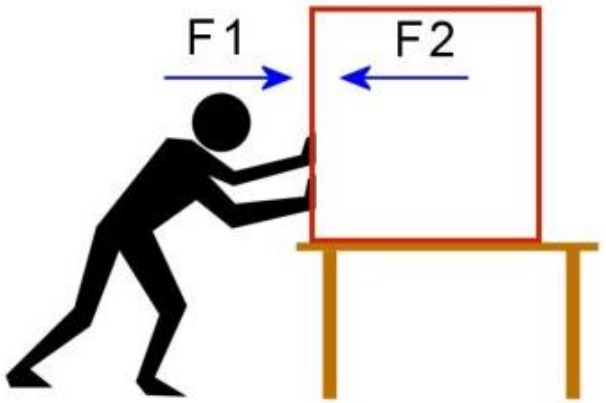
Newton's Laws III

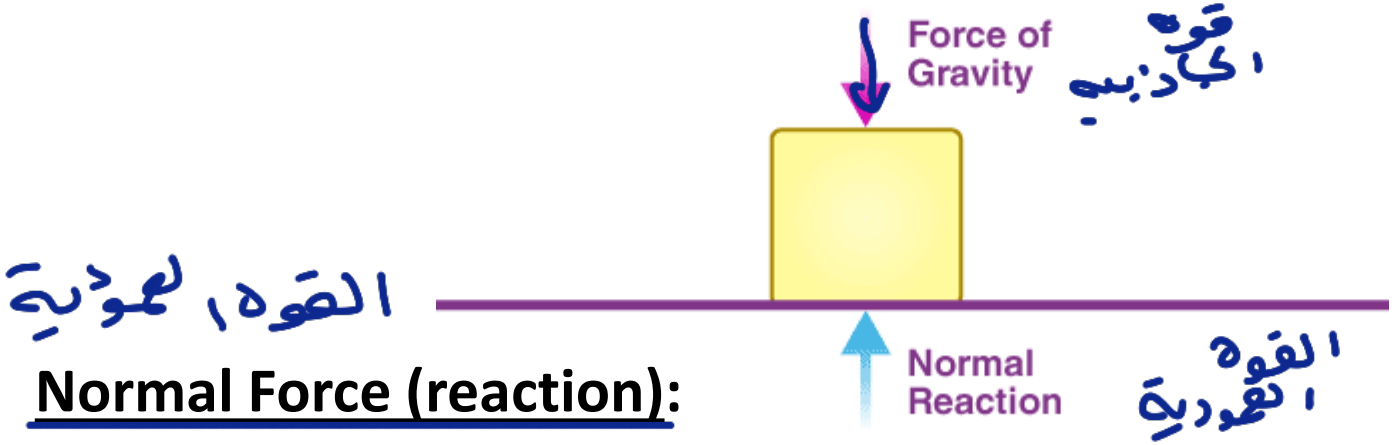
القوه المتبادله بين جسمين تكون
متساويه في المقدار ومتعاكسه في الاتجاه

Newton's Third Law:

the forces that two interacting objects exert on each other are always exactly equal in magnitude and opposite in direction:

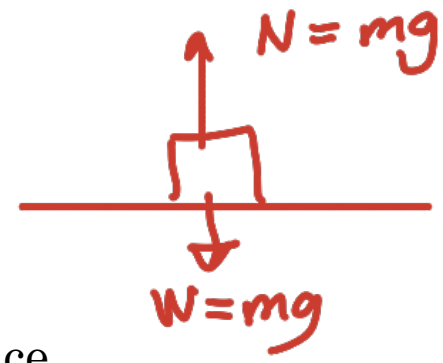
$$\vec{F}_{1\to 2} = -\vec{F}_{2\to 1}$$





Normal Force (reaction):

contact force that acts at the surface between two objects.



The Normal force direction is always perpendicular to the plane of the contact surface.

دائما عمودية

Assessment

Q1: When a force of 10 N Applied to a body and make it moves with acceleration of 2 m/s^2. What is the body's mass?

$m = \frac{F}{a} = \frac{10}{2} = 5\ kg$

Q2: two forces $\vec{F}_1 = -5\hat{x} - 3\hat{y}\ N$ and $\vec{F}_2 = 8\hat{x} + 3\hat{y} + 4\hat{z}\ N$ acts on a 20 kg block, what is the magnitude of the acceleration?

$F_{net} = 3\hat{x} + 4\hat{z}$ $\quad |F| = \sqrt{3^2+4^2} = 5N$ $\quad a = \frac{F}{m} = \frac{5}{20} = 0.25\ m/s^2$

Q3: A particle of mass 3kg moves with acceleration of 5m/s2. Find the magnitude of the force acting on the particle?

$F = ma = 3(5) = 15N$

Q4: The force acting on a body of mass 10kg is 300N, Calculate its acceleration?

$a = \frac{F}{m} = \frac{300}{10} = 30 m/s^2$

Q5: A 3kg object undergoes an acceleration given by a=(2$\hat{x}$+5$\hat{y}$)m/s2. Find the resultant acting force on it?

$F = m\bar{a}$ $\quad F = 3(2x+5y) = 6\hat{x} + 15\hat{y}$ $\quad F = \sqrt{6^2+15^2} = 16.2\ N$

Q6: Two Forces acting on an object are given by F1=(2$\hat{x}$+3$\hat{y}$)N, and F2=(3$\hat{x}$+4$\hat{y}$)N. The object experiences an acceleration of magnitude 2m/s2. What is the mass of the object?

Q7: Two forces, F1=($\hat{x}$+2$\hat{y}$)N, and F2=(3$\hat{x}$+2$\hat{y}$)N acting on an object of mass 10kg. Find the magnitude of the acceleration?

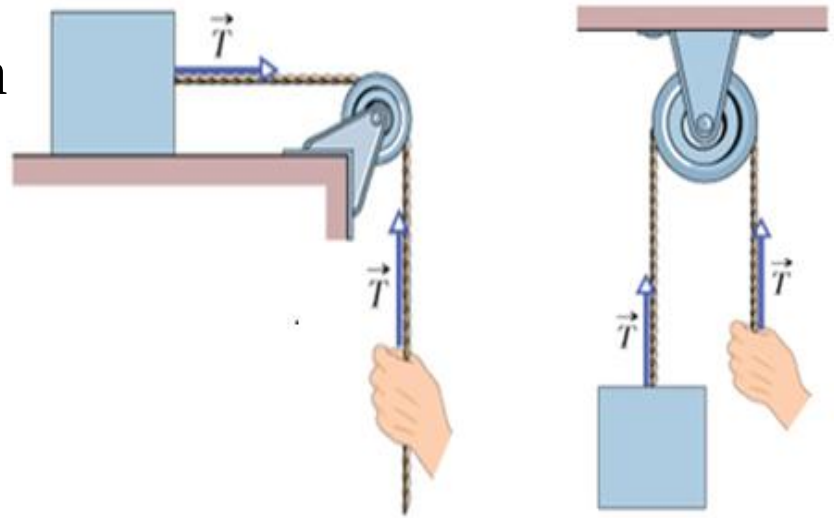
Q6) $F_{net} = 5\hat{x} + 7\hat{y}$ $\quad |F| = \sqrt{5^2+7^2} = 8.6N$ $\quad m = \frac{F}{a} = \frac{8.6}{2} = 4.3\ kg$

Q7) $\vec{F}_{net} = 4\hat{x} + 4\hat{y}$ $|F| = \sqrt{4^2+4^2} = 5.66N$ $a = \frac{F}{m} = \frac{5.66}{10} = 0.566\ m/s^2$

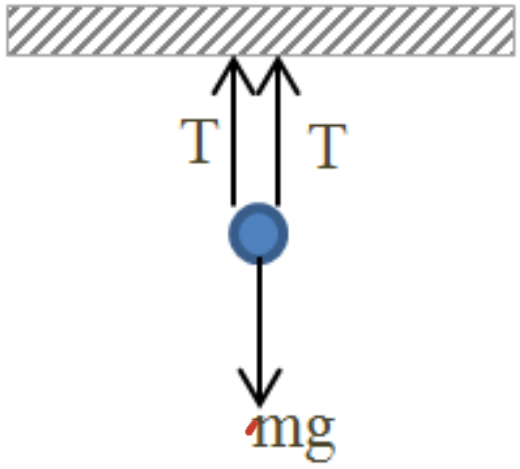
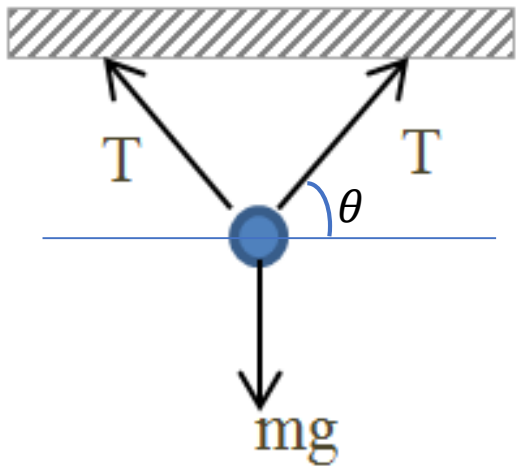
Ropes and Pulleys

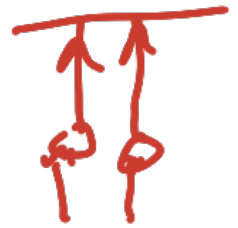
Tension in a rope has the following characteristics:

1. It is always directed along the rope
2. It is always pulling the object
3. It has the same value along the rope
4. When rope runs over a pulley, the force has:
   - Same magnitude
   - Different direction



Ropes and Pulleys

Forces for different cases	
	
$T = \frac{1}{2}mg$	$T = \frac{1}{2\sin\theta}mg$



$T = \frac{1}{2}(55)9.8$

$= 269.5\ N$

- A gymnast of mass 55 kg hangs vertically from a pair of parallel rings.
  1. What is the tension in each rope if the ropes are vertically attached to the ceiling?
  2. What is the tension in each rope if the ropes are attached so that they make an angle θ= 45?

$T = \frac{1}{2\sin\theta}mg = \frac{1}{2\sin 45}(55)9.8 = 381.1\ N$

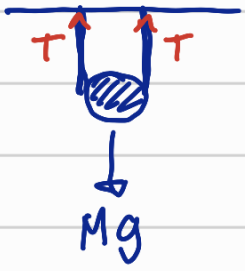
القوى في الحبال والبكرات

① Tension — الشد في الحبال

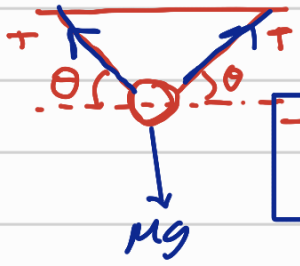
قوة الشد في جزء الحبل متساويتين ومتعاكستين

② Tension

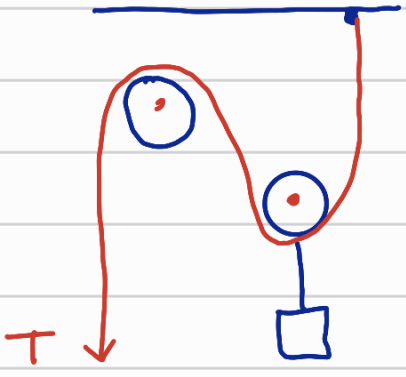
القوى متساوية في طول الحبل ومتعاكسة



$$T = \frac{1}{2} mg$$



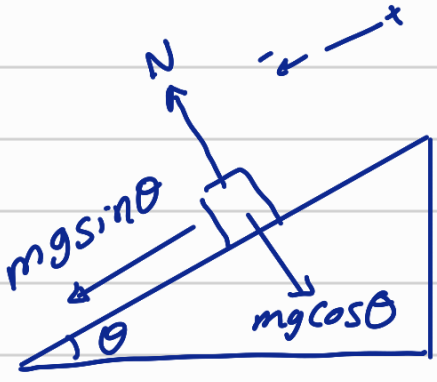
$$T = \frac{mg}{2\sin\theta}$$



$$T = \frac{mg}{2n}$$

n: عدد الأفرع التي يمر خلالها الحبل حول البكرة

القوى على السطح المائل

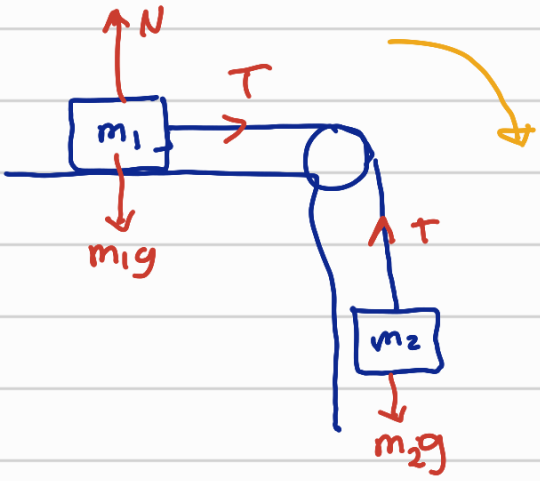


القوة العمودية = $mg\cos\theta$

التسارع $a = g\sin\theta$

القوة الأفقية = $-mg\sin\theta$

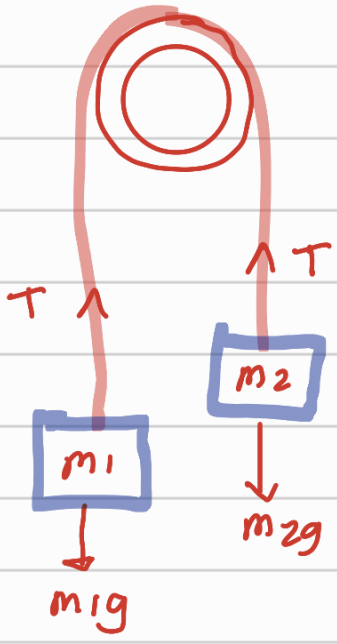
الأجسام المربوطة في بكرات



في حالة $m_2 > m_1$ سوف يتحرك الجسم

$$a = \frac{m_2}{m_1+m_2}\,g \qquad N = m_1 g \qquad T = \frac{m_1 m_2}{m+m_2}\,g$$

الشكل المربوط على بكرة



في حالة $m_2 < m_1$ سوف تتحرك البكرة باتجاه m_1 نحو الأسفل و m_2 نحو الأعلى

$$a = \frac{m_1 - m_2}{m_1+m_2}\,g$$

$$T = m_1(g \pm a)$$

4.5 Ropes and Pulleys

- Force multiplier

$$T = \frac{1}{2n} mg$$

m : mass

T : tension required to left the mass with constant

n : times the rope turns over the pulleys

g : gravitational acceleration

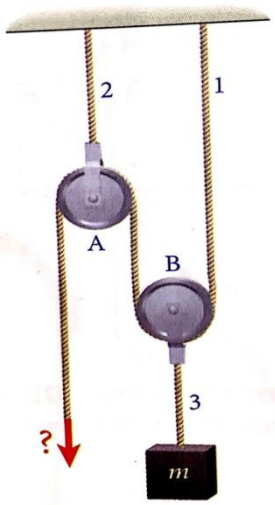


FIGURE 4.12 Rope guided over two pulleys.

FIGURE 4.14 Pulley with three loops.

4.6 Applying Newton's Laws

خطوات حل المسائل

أولًا: القوى

1. **ارسمي** المحاور بحيث تكون نقطة الأصل في مركز الجسم
2. **حددي** القوى التي تؤثر على كل جسم في المسألة
3. **حللي** جميع القوى التي لا تقع على المحاور الرئيسية إلى مركباتها

ثانيًا: التسارع

4. **حددي مركبات** التسارع لكل جسم على المحاور الرئيسية

(قد تحتاجين لتحليل متجه التسارع إذا لم يكن واقعًا على أحد المحاور)

أخيرًا:

5. **طبقي** قانون نيوتن الثاني.
6. **حلي** المعادلات الناتجة لإيجاد المطلوب

4.6 Applying Newton's Laws

ملاحظات مهمة لحل المسائل

- مركبات القوى أو التسارع التي تشير إلى الاتجاه الموجب (**اليمين أو الأعلى**) نعوض عنها بإشارة **موجبة** في قانون نيوتن الثاني.

- مركبات القوى أو التسارع التي تشير إلى الاتجاه السالب (**اليسار أو الأسفل**) نعوض عنها بإشارة **سالبة** في قانون نيوتن الثاني.

- إذا كان الجسم يتحرك **بسرعة ثابتة** أو لا يتحرك مطلقًا (**ساكنًا**) على أحد المحاور فإن التسارع على ذلك المحور يساوي **صفرًا**

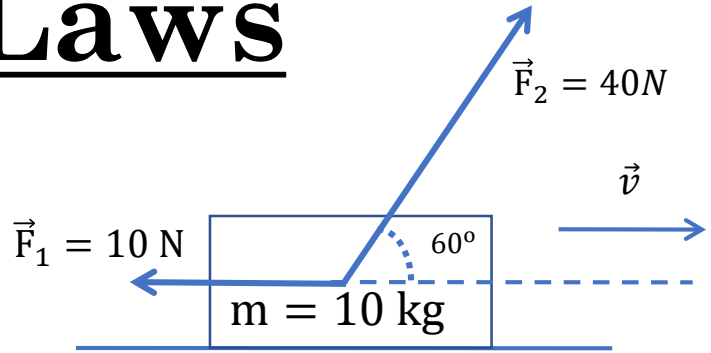
.

Applying Newton's Laws

Example1:

A box moves horizontally on a frictionless surface as shown:

1. What is the acceleration?
2. What is the normal force?



frictionless

x-axis: $a_x = +a$

$\mathbf{F_2 \cos(\theta) - F_1 = +ma}$

$\mathbf{40 \cos(60) - 10 = 10a}$

$\mathbf{20 - 10 = 10a}$

$\mathbf{10 = 10a}$

$\mathbf{a = 1\ m/s^2}$

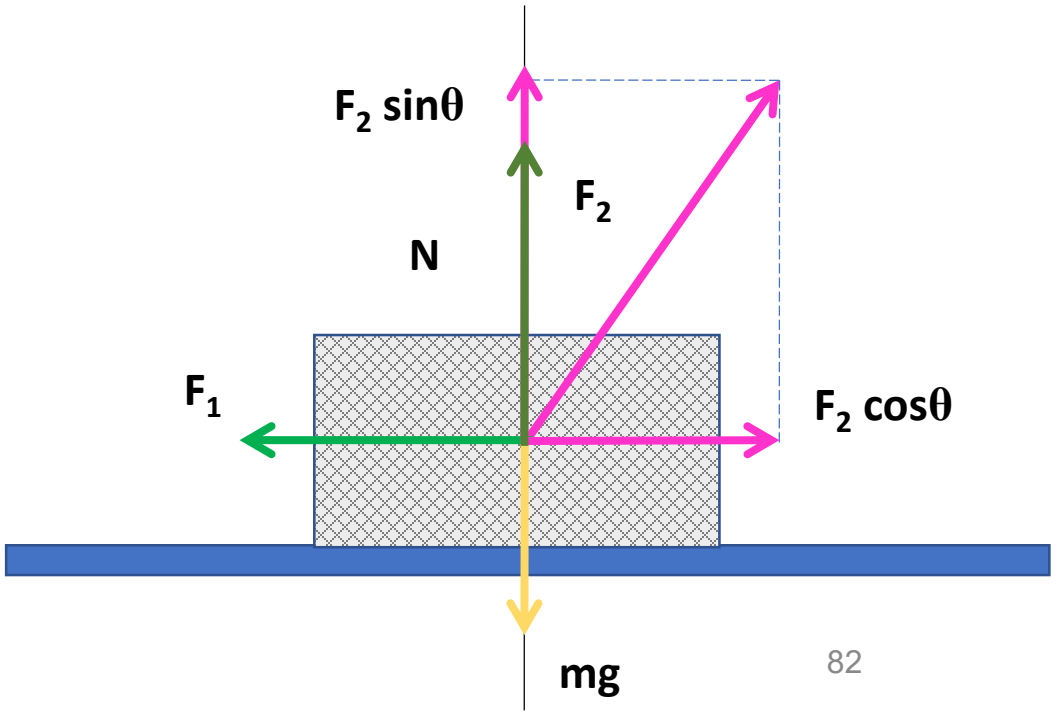
y-axis: $a_y = 0 m/s^2$

$\mathbf{F_2 \sin(\theta) + N - mg = 0}$

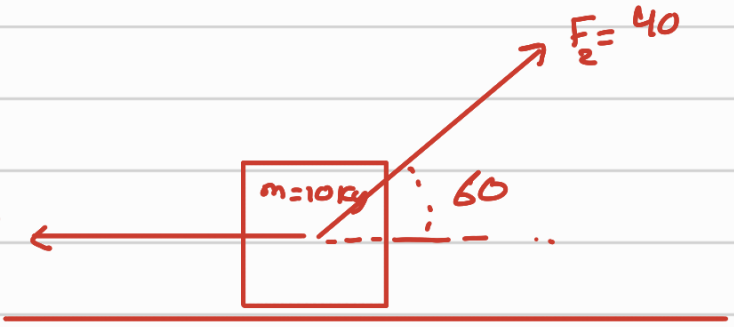
$\mathbf{40 \sin(60) + N - (10)(9.8) = 0}$

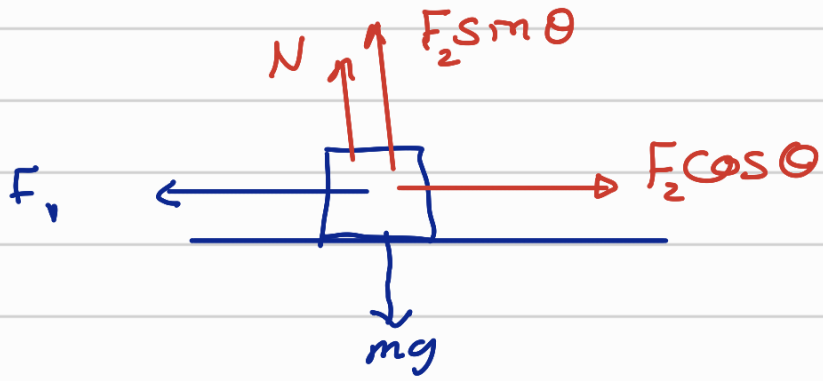
$\mathbf{N = 98 - 40 \sin(60)}$

$\mathbf{N = 63.36\ N}$



① ارسم مخطط الحر

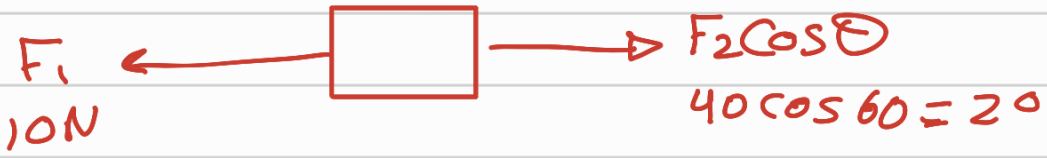




② حساب التسارع لايوجد تسارع باتجاه y

$$\boxed{a_y = 0}$$

لحساب التسارع باتجاه x يجب حساب F_x



$$F_x = 20 - 10 = 10\ N \rightarrow$$

$$a_x = \frac{F_x}{m} = \frac{10}{10} = 1\ m/s^2 \rightarrow$$

③ حساب القوى العمودية

$a_y = 0$

التسارع صفر معنى ان القوه

$0 = F_y$

$40 \sin 60 = 34.64\ N$

$mg = 10(9.8) = 98\ N$

$$F_y = N + F_2 \sin\theta - mg$$

$$0 = N + 34.64 - 98$$

$$N = 98 - 34.64 = 63.36\ N$$

Applying Newton's Laws

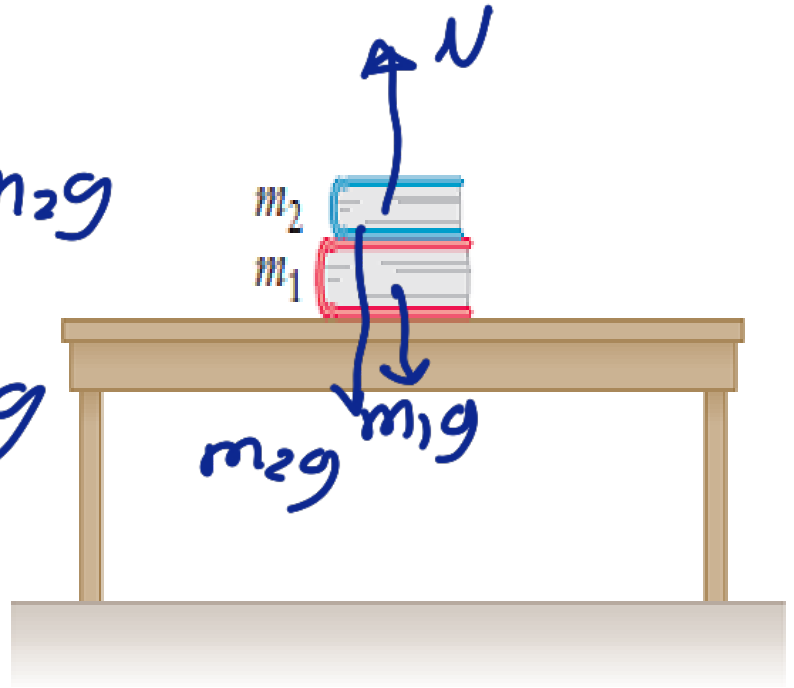
- Example2:

What is the normal force of the two books of an arbitrary masses on a table shown in figure?

$$\vec{F}_{net} = 0$$
$$\vec{N} + \vec{F}_{g1} + \vec{F}_{g2} = 0$$
$$\vec{N} = -(\vec{F}_{g1} + \vec{F}_{g2})$$
$$N = -(-m_1 g - m_2 g)$$
$$N = (m_1 + m_2)g$$

$N = m_1 g + m_2 g$

$N = (m_1 + m_2)g$



Note: Normal force points upward (+ve) and gravitational forces points downwards (-ve)

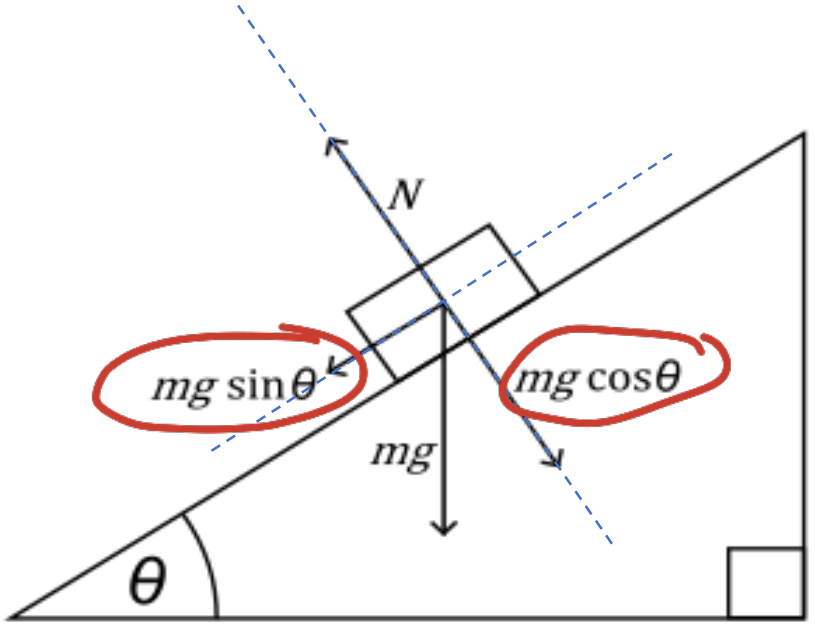
Applying Newton's Laws

Inclined Plane (Wedge):

What is the acceleration and the Normal force?

Forces:

1. Gravitational force(mg)
2. Normal force (N)



Horizontal axis:

$$-mg \sin\theta = -ma$$

$$\mathbf{a = g \sin\theta}$$

vertical axis:

$$N - mg \cos\theta = 0$$

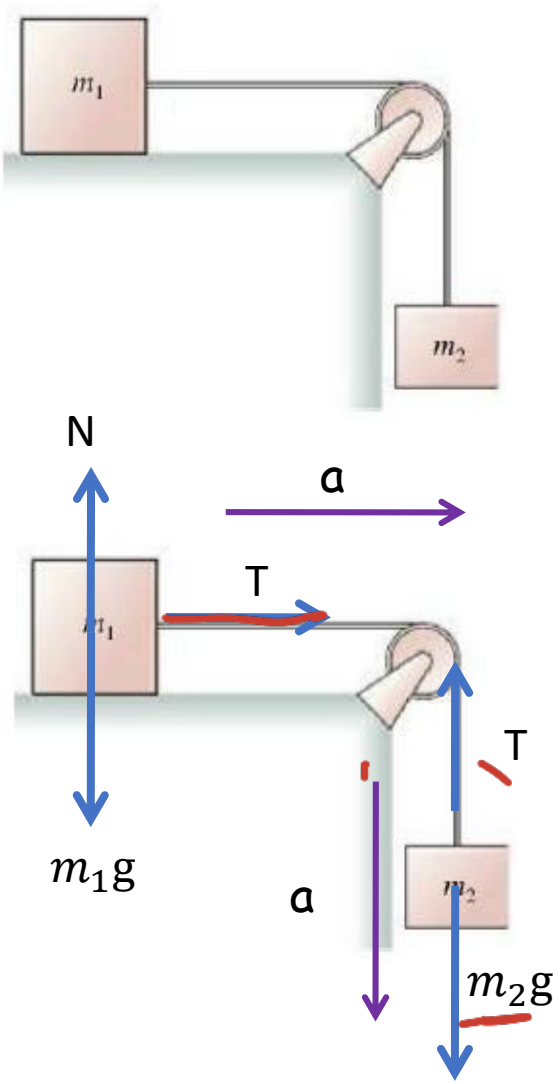
$$\mathbf{N = mg \cos\theta}$$

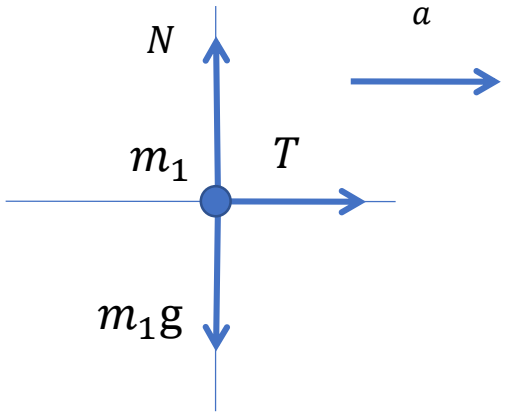
Applying Newton's Laws

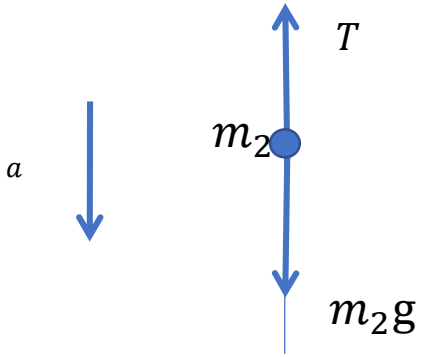
Two Blocks Connected by a Rope $m_1 < m_2$:

- Block m_1 placed on frictionless surface.
- Forces on block m_1 :
  1. Gravitational force $m_1 g$
  2. Normal force N
  3. Tension T
- Acceleration (a) : In the same direction of tension [right direction = positive value]

- Forces on block m_2:
  1. Gravitational force $m_2 g$
  2. Tension T
- Acceleration (a) : downward direction = negative value







Block m_1

x-axis:

$$T = m_1 a \quad (1)$$

y-axis:

$$N - m_1 \mathrm{g} = 0 \quad (2)$$

Block m_2

y-axis:

$$T - m_2 \mathrm{g} = -m_2 a \quad (3)$$

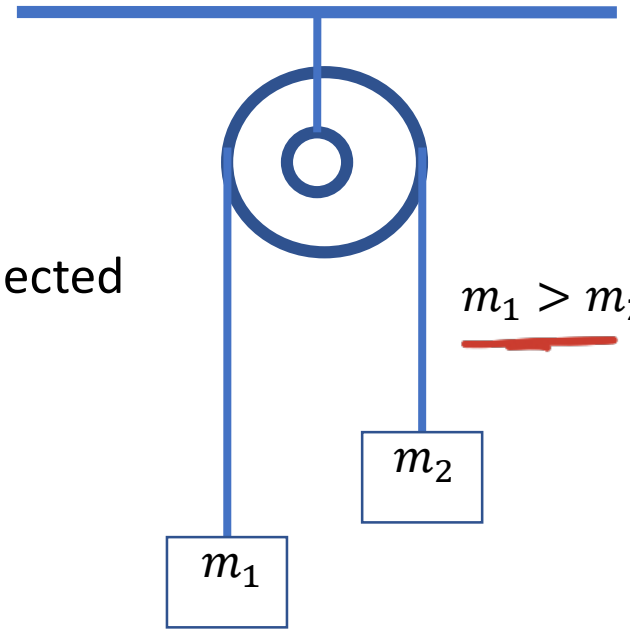
Solving equations (1), (2) and (3) together to find for a, N and T :

$$a = \frac{m_2}{m_1 + m_2} \mathrm{g}$$

$$N = m_1 \mathrm{g}$$

$$T = \frac{m_1 m_2}{m_1 + m_2} \mathrm{g}$$

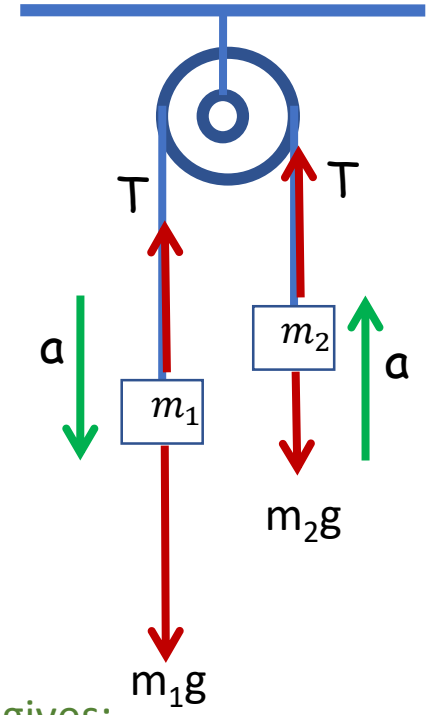
Applying Newton's Laws



Atwood Machine

The Atwood Machine consists of two hanging weight (with masses m_1 and m_2) connected by a rope running over a pulley.

Find the tension force and acceleration?



Block m_1

Forces:

1. Gravitational force m_1g
2. Tension T

Acceleration (a) :Downward

y-axis:

$$m_1 \mathrm{g} - T = m_1 a \quad (1)$$

Block m_2

Forces:

1. Gravitational force m_2g
2. Tension T

Acceleration (a) :Upward

y-axis:

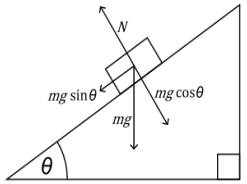
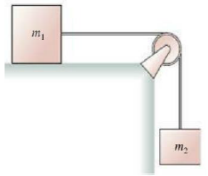
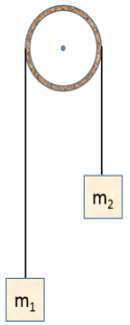
$$T - m_2 \mathrm{g} = -m_2 a \quad (2)$$

Solving equations (1) and (2) together gives:

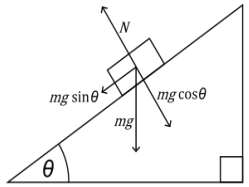
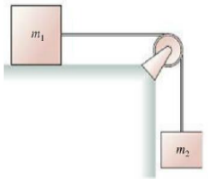
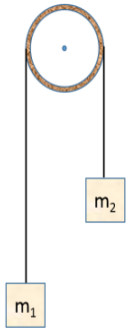
$$a = \frac{m_1 - m_2}{m_1 + m_2} \mathrm{g}$$

$$T = m_1(\mathrm{g} - a) \quad or \quad T = m_1(\mathrm{g} + a)$$

Summary I

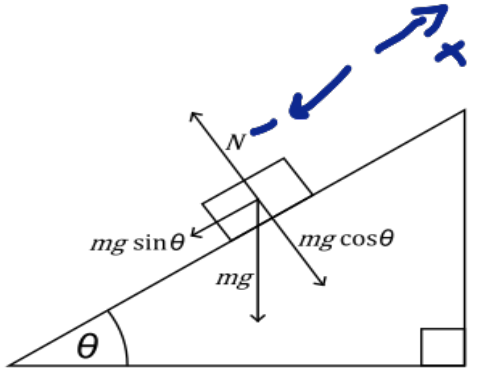
Acceleration for different cases				
				
frictionless	$a = g \sin\theta$	frictionless	$a = g\left(\frac{m_2}{m_1 + m_2}\right)$	
$m_1 > m_2$				
$a = g\left(\frac{m_1 - m_2}{m_1 + m_2}\right)$				

Summary II

<table>
<tr><th colspan="4">Forces for different cases</th></tr>
<tr><td colspan="2"> 
</td><td colspan="2">  </td></tr>
<tr><td>frictionless</td><td>$N = mg\cos\theta$</td><td>frictionless</td><td>$T = g\left(\frac{m_1 m_2}{m_1 + m_2}\right)$</td></tr>
<tr><td colspan="4"> 

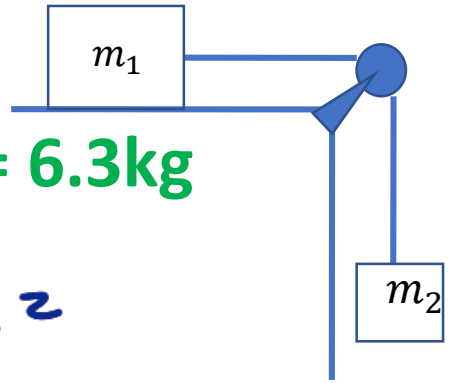
$m_1 > m_2$</td></tr>
<tr><td colspan="4">$T = m_1(g - a) = m_2(g + a)$</td></tr>
</table>

Assessment



Q6. A block (m = 2.7 kg) moves down a frictionless plane with an angle of 9°, what is its acceleration?

$$a = -g\sin\theta = -9.8\sin 9 = -1.533\ m/s^2$$

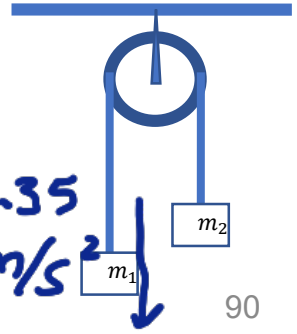


Q7. Two blocks connected by a rope as shown in figure (m_1 = 6.3kg and m_2 = 3.5kg) , what is the acceleration?

$$a = \frac{m_2}{m_1+m_2}\,g = \frac{3.5}{6.3+3.5}(9.8) = 3.5\ m/s^2$$

Q8. Two masses are suspended by a rope as shown in figure if m_1 = 6.5 kg and m_2 = 2.5kg , what is the system acceleration?

$$a = \frac{m_1 - m_2}{m_1+m_2}\,g = \frac{6.5-2.5}{6.5+2.5}(9.8) = 4.35\ m/s^2$$



Friction Force

Basic characteristic of friction:

1-If an object is at rest, it takes an external force with a certain threshold to overcome the friction force and make object move

2- The force needed to move an object at rest is greater than the force needed to keep it moving with constant velocity.

3- The magnitude of friction force is proportional to the normal force .

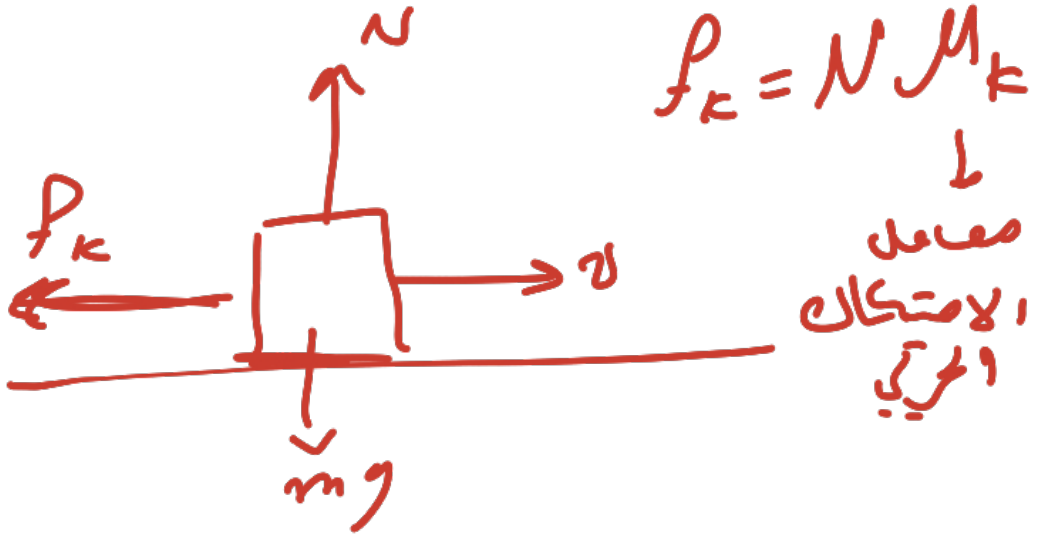
4- Friction force is independent on the area.

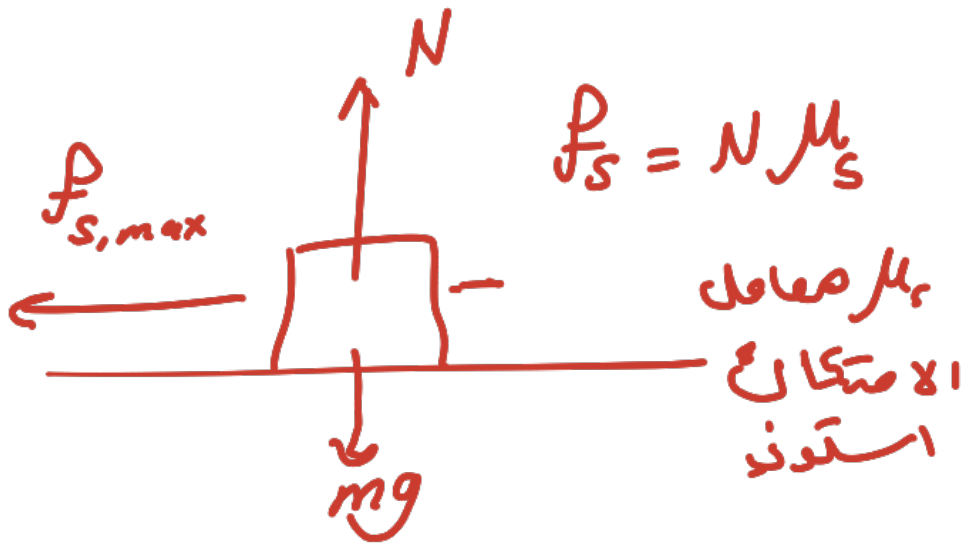
5- Friction force depends on the roughness of the surfaces.

6- Friction force is independent on velocity.

Friction Force types

1. **static friction:** the case where an object is at rest relative to its supporting surface
2. **kinetic friction** the case where the object moves across the surface





Static friction:

•For any external force acting on an object that remains at rest, the friction force f_s is exactly equal in magnitude and opposite in direction to the component of the external force that acts along the contact surface between the object and its supporting force.

•The magnitude of the static friction force has a maximum value

$\mu_s > \mu_k$

قانون قوة الاحتكاك السكونية

$$f_{s,\max} = \mu_s N$$

$f_{s,\max}$: maximum static friction force
μ_s : c oefficient of static friction
N : N ormal force mg

Kinetic friction:

دائما قوة الاحتكاك عكس اتجاه الحركة

Kinetic friction force is always opposite to the direction of motion of the object.

قانون قوة الاحتكاك الحركية

$$f_k = \mu_k N$$

f_k : kientic friction force
μ_k : c oefficient of kinetic friction
N : N ormal force mg

Friction Force Summary

Normal force

Kinetic friction force

Kinetic Friction	Static Friction
$f_k = \mu_k N$	$f_{s,max} = \mu_s N$

معامل الاحتكاك الحركي

μ_s معامل الاحتكاك الستاتيكي

static friction coefficient

Kinetic friction coefficient

Maximum static friction force

- Friction coefficient is always equal to or greater than zero

$\mu \geq 0$

معامل الاحتكاك دائما اكبر من صفر واقل من ١

- In almost all cases, is less than 1.

$1 > \mu \geq 0$

وليس له وحدة

- Friction coefficient has no unit

$$\mu_s > \mu_k \text{ or } \mu_k < \mu_s$$

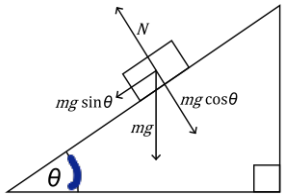
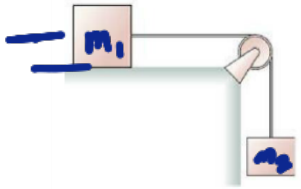
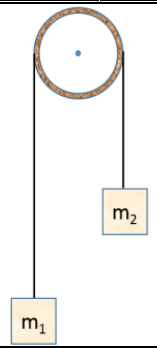
معامل الاحتكاك الستاتيكي اكبر من معامل الاحتكاك الحركي

قوانين نيوتن

Applying Newton's Laws with friction

بدون احتكاك

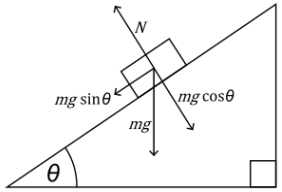
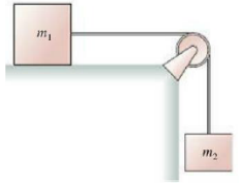
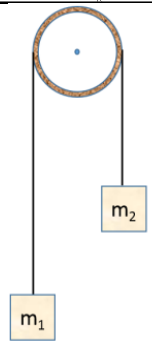
مع احتكاك

Acceleration for different cases			
			
frictionless	$a = g \sin\theta$	frictionless	$a = g\left(\frac{m_2}{m_1 + m_2}\right)$
with friction	$a = g\,(\sin\theta - \mu_k \cos\theta)$	with friction	$a = g\left(\frac{m_2 - \mu_k m_1}{m_1 + m_2}\right)$
بدون احتكاك 		$m_1 > m_2$	
$a = g\left(\frac{m_1 - m_2}{m_1 + m_2}\right)$			

Applying Newton's Laws with friction

القوة العمودية

قوة الشد

Forces for different cases			
			
frictionless	$N = mg\cos\theta$	frictionless	$T = g\left(\frac{m_1 m_2}{m_1 + m_2}\right)$
with friction	$N = mg\cos\theta$	with friction	$T = m_1 m_2 g\left(\frac{1+\mu_k}{m_1 + m_2}\right)$
 $m_1 > m_2$			
$T = m_1(g-a) = m_2(g+a)$			

Assessment

Q1:

A block (m = 2.7 kg) moves down a plane with an angle of 9^o . If the friction coefficient equals 0.3, what is its acceleration?

Q2:

A block of mass 5kg which slides down on a plane having an inclination of 15 degrees.

1. Calculate the normal force?
2. Calculate the acceleration, assuming the plane is frictionless?
3. Calculate the acceleration again assuming the plane has a friction coefficient equal to 0.25?

Q3:

A 5Kg object is placed on a table and is connected to a 9kg object using a cord that passes over a pulley:

1. Calculate the normal force, tension force, and acceleration assuming the table is frictionless?
2. If the table friction coefficient is 0.3, recalculate the tension force and the acceleration?

Q4:

A particle experiences multiple forces as follows:

$\overrightarrow{F_1} = [(-3)\hat{x} + 3\hat{y} + 4\hat{z}]N$, $\overrightarrow{F_2} = [\hat{x} - 5\hat{y} - 4\hat{z}]N$, $\overrightarrow{F_3} = [A\hat{x} + B\hat{y} + C\hat{z}]N$

If the particle at equilibrium (The net force is zero), what are the parameters A, B, and C that satisfy this state?

Q1:

A block (m = 2.7 kg) moves down a plane with an angle of 9° . If the friction coefficient equals 0.3, what is its acceleration?

$$a = g(\sin\theta - \mu_K \cos\theta)$$

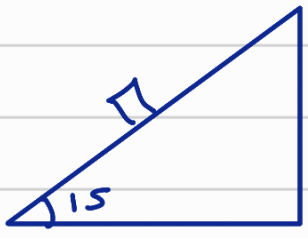
$$= 9.8(\sin 9 - 0.3\cos 9)$$

$$a = -1.37 \ m/s^2$$

Q2:

A block of mass 5kg which slides down on a plane having an inclination of 15 degrees.

1. Calculate the normal force?
2. Calculate the acceleration, assuming the plane is frictionless?
3. Calculate the acceleration again assuming the plane has a friction coefficient equal to 0.25?



1) $N = mg\cos\theta$

$$= 5(9.8)\cos 15 = 47.3 N$$

2) $a = g\sin 15 = 9.8\sin 15$

$$= 2.45 \ m/s^2$$

3) $a = g(\sin\theta - \mu\cos\theta)$

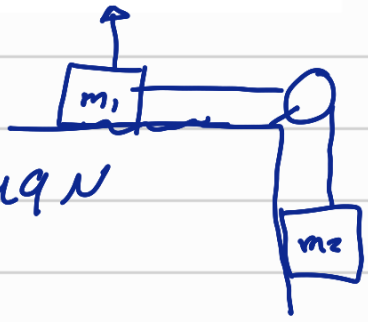
$$= 9.8(\sin 15 - 0.25\cos 15)$$

$$0.169 \ m/s^2$$

Q3:

A 5Kg object is placed on a table and is connected to a 9kg object using a cord that passes over a pulley:

1. Calculate the normal force, tension force, and acceleration assuming the table is frictionless?
2. If the table friction coefficient is 0.3, recalculate the tension force and the acceleration?



(1) بدون احتكاك

$$N = m_1 g = 5(9.8) = 49\,N$$

$$T = g\left(\frac{m_1 m_2}{m_1+m_2}\right)$$

$$= 9.8\left(\frac{5\times 9}{14}\right) = 31.5\,N$$

$$a = g\left(\frac{m_2}{m_1+m_2}\right)$$

$$= 9.8\left(\frac{9}{14}\right) = 6.3\ m/s^2$$

(2) مع احتكاك

$$a = g\left(\frac{m_2 - \mu_k m_1}{m_1+m_2}\right) = 9.8\left(\frac{9 - 0.3(5)}{14}\right)$$

$$= 5.25\ m/s^2$$

$$T = m_1 m_2 g\left(\frac{1+\mu_k}{m_1+m_2}\right)$$

$$= 9\times 5\times 9.8\left(\frac{1+0.3}{14}\right) = 40.95\,N$$

$\Sigma F = 0$

Q4:

A particle experiences multiple forces as follows:

$\overrightarrow{F_1} = [(-3)\hat{x} + 3\hat{y} + 4\hat{z}]N$, $\overrightarrow{F_2} = [\hat{x} - 5\hat{y} - 4\hat{z}]N$, $\overrightarrow{F_3} = [A\hat{x} + B\hat{y} + C\hat{z}]N$

If the particle at equilibrium (The net force is zero), what are the parameters A, B, and C that satisfy this state?

$F_1 + F_2 + F_3 = 0$

$(-3+1+A)\hat{x} + (3-5+B)\hat{y} + (4-4+C)\hat{z} = 0$

$-2+A=0$ $\quad A = 2$

$-2+B=0$ $\quad B = 2$

$0+C=0$ $\quad C = 0$

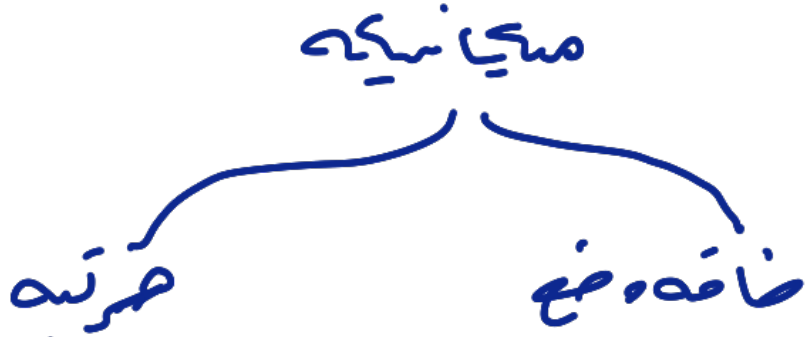
CHAPTER 5

Kinetic Energy, Work, and Power

الطاقة الحركية الشغل القدرة

Energy in our daily lives

1. Mechanical energy: Kinetic energy & Potential energy
2. Thermal Energy
3. Chemical Energy
4. Electromagnetic energy
5. Solar energy
6. Electrical energy
7. Nuclear energy



Energy: The ability to do work

Kinetic Energy

الطاقة الحركية

الطاقة المرتبطة بالحركة

اي جسم له كتلة يتحرك اذا له طاقة

- Energy associated with motion
- Kinetic Energy :

$$K = \frac{1}{2} mv^2$$

K: kinetic energy

m: mass

v: velocity

- Kinetic energy is scalar .
- Unit : Joule (J)

الطاقة الحركية = $\frac{1}{2}$ × الكتلة × مربع السرعة

كل انواع الطاقة تقاس بوحدة الجول

- $1J = 1\ Nm = 1kg.m^2.s^{-2}$
- Kinetic energy is always positive or zero (K=0 for an object at rest)

طاقة الحركة دائما موجبة او صفر

$1J = 1kg.m^2.s^{-2}$

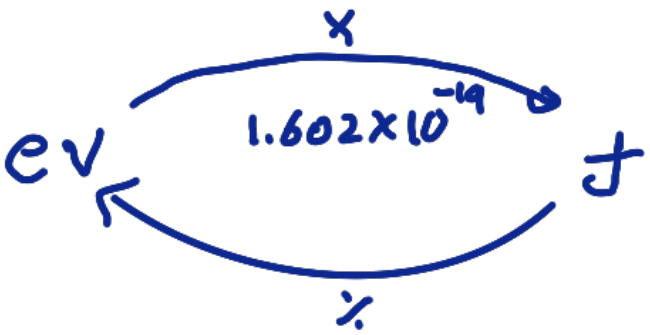
Other units for energy:

وحدات اخرى لقياس

الكترون فولت
• electron-volt 1ev = 1.602× 10^{-19} J

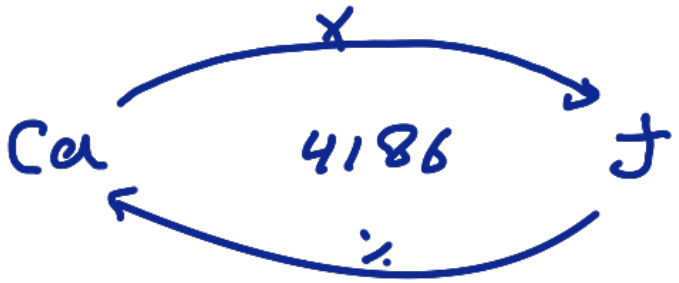
سعراتوري
• calorie 1 cal = 4186 J

• mega-ton 1 Mt = 4.18×10^{15} J



Kinetic energy in 3D:

• $v^2 = v_x^2 + v_y^2 + v_z^2$

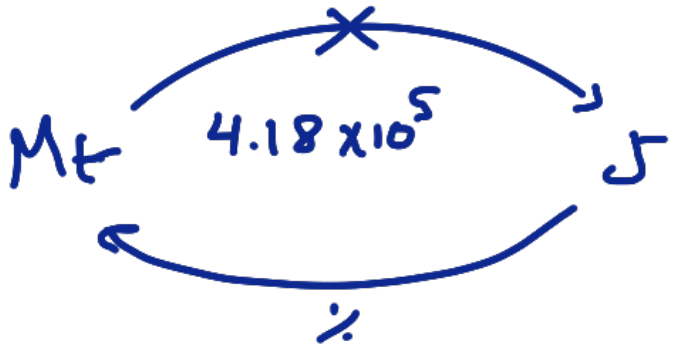


$K = \frac{1}{2}mv_x^2$

• $K = \frac{1}{2}mv^2$

• $K = \frac{1}{2}mv_x^2 + \frac{1}{2}mv_y^2 + \frac{1}{2}mv_z^2$

K_x K_y K_z



$v = \sqrt{\frac{2K}{m}}$

Assessment

Q1. What is the Kinetic energy of 30 kg object moves in 4 m/s?

$$K = \frac{1}{2} m v^2 = \frac{1}{2} 30 \cdot 4^2 = 240 J$$

Q2. The kinetic energy of a 2 kg (m) object is 100 J (K). Find its velocity (v).

$K = \frac{1}{2} m v^2$

$2K = mv^2$

$\sqrt{v^2} = \sqrt{\frac{2K}{m}}$

$m = 2\ kg \quad KE = 100 \quad V = ?$

$$V = \sqrt{\frac{2K}{m}} = \sqrt{\frac{2(100)}{2}} = 10 m/s^2$$

Work

- **Work**:

  The energy transferred to or from an object due to the action of a force.

- Work is **scalar**
- SI unit : **Joule (J)**
- **Positive work** : Transfer of energy **to** the object.
- **Negative work** : Transfer of energy **from** the object.

تنتقل الطاقة من او الى الجسم بسبب عمل تقوم به قوه

الشغل هو الطريقة التي تنتقل بها الطاقة من شكل الى شكل آخر

الشغل
① كمية قياسية
② الوحدة - جول
③ شغل موجب يعني الطاقة انتقلت الى الجسم (طاقة الجسم زادت)
④ شغل سالب يعني الطاقة انتقلت من الجسم

Contents:

- Work Done by a constant Force
- Work Done by the Gravitational force
- Work Done by a varying Force

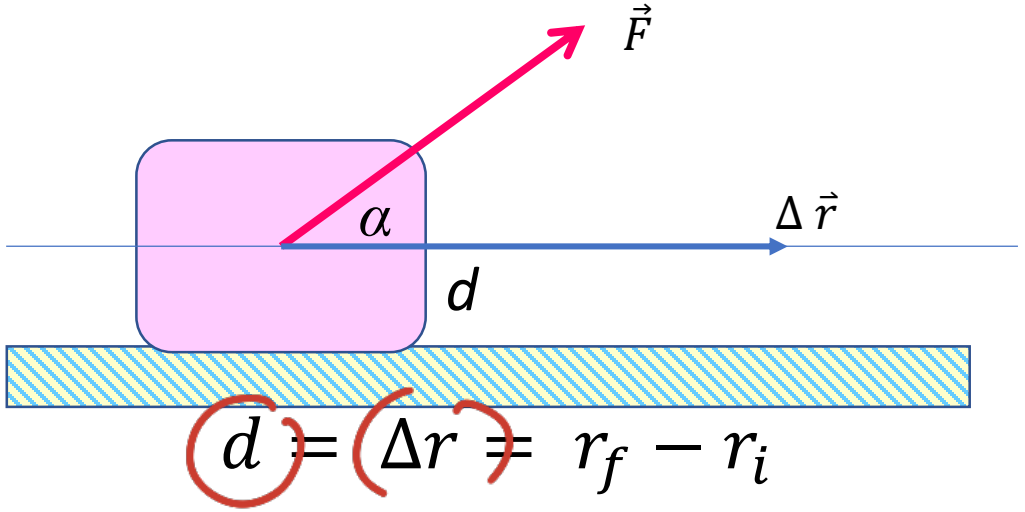
- شغل قوة ثابتة
- شغل قوة الجاذبية
- شغل قوة متغيرة

Work Done by a Constant Force

Work is given by

$$W = \vec{F} \cdot \Delta \vec{r}$$

Using scalar product



force displacement

work

$$W = Fd\cos\alpha$$

angle between *F* and *d*

- For more than one force acting on the object

$$W_{net} = \overrightarrow{F}_{net} \cdot \Delta \vec{r}$$

or:

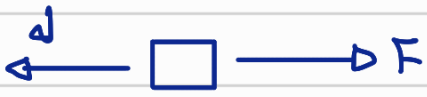
$$W_{net} = W_1 + W_2 + \cdots + W_n$$

The net work done by the net force is equal to the sum of the work done by the individual forces .

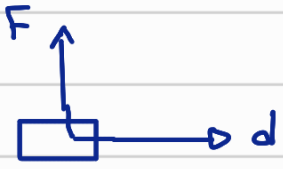
Maximum work	No work
$\overrightarrow{F}$ and $\Delta\vec{r}$ in the same direction	$\overrightarrow{F}$ and $\Delta\vec{r}$ perpendicular (normal)
$\alpha = 0$	$\alpha = 90^o$
$W = Fd$	$W = 0$

الشغل المبذول من قوة ثابتة

$W = Fd$ $\quad \alpha = 0$

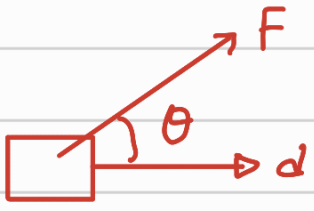


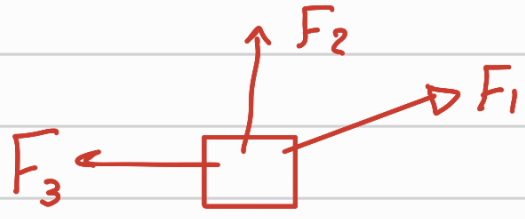
$W = -Fd$ $\quad \alpha = 180$



$W = 0$

$$W = Fd\cos\theta = F \cdot d$$





$W = W_1 + W_2 + W_3$

$W = F_{net} \cdot d$

$d = \Delta r = r_2 - r_1$

$\bar{A} = 3\hat{x} + 2\hat{y} + \hat{z}$

$\bar{B} = 4\hat{x} + 3\hat{y} + 2\hat{z}$

$A \cdot B = 12 + 6 + 2 = 20$

كما نوجد حساب الزاوية بين متجهين

$$\cos^{-1}\alpha = \frac{A \cdot B}{|A||B|}$$

احسب الزاوية المحصورة بين المتجهين A و B

$$\cos^{-1}\alpha = \frac{\bar{A} \cdot \bar{B}}{|A|\,|B|} = \frac{20}{\sqrt{9+4+1}\sqrt{16+9+4}} = \frac{20}{\sqrt{14}\sqrt{29}} \approx 6.9$$

Mathematical Insert : Scalar Product of Vectors

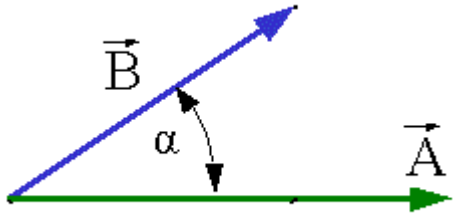
- $\overrightarrow{A} = (A_x , A_y , A_z)$ $\overrightarrow{B} = (B_x , B_y , B_z)$

حقائق رياضية للضرب القياسي

- Scalar product

1. $\overrightarrow{A} . \overrightarrow{B} = AB \cos \propto$
2. $\overrightarrow{A} . \overrightarrow{B} = A_x B_x + A_y B_y + A_z B_z$
3. $\overrightarrow{A} . \overrightarrow{B} = \overrightarrow{B} . \overrightarrow{A}$ تبديلية (commutative)
4. $\overrightarrow{A} . \overrightarrow{A} = |\vec{A}|^2$
5. $\propto = \cos^{-1}(\frac{\overrightarrow{A} . \overrightarrow{B}}{AB})$
6. $\overrightarrow{A} . (\overrightarrow{B} + \overrightarrow{C}) = \overrightarrow{A} . \overrightarrow{B} + \overrightarrow{A} . \overrightarrow{C}$ توزيعية (Distributive)
7. $\hat{x} . \hat{x} = \hat{y} . \hat{y} = \hat{z} . \hat{z} = 1$
8. $\hat{x} . \hat{y} = \hat{x} . \hat{z} = \hat{y} . \hat{z} = 0$

متعامدين



$\overrightarrow{A} \cdot \overrightarrow{B} = A B \cos \alpha$

$A = A_x \hat{x} + A_y \hat{y} + A_z \hat{z}$

$B = B_x \hat{x} + B_y \hat{y} + B_z \hat{z}$

$\overrightarrow{A} \cdot \overrightarrow{B} = A_x B_x + A_y B_y + A_z B_z$

Assessment

Q1: What is the angle α between the two positive vectors $\overrightarrow{A} = (4,2.5)cm$ and $\overrightarrow{B} = (4.5,4,3)cm$?

Q2. A constant force $\vec{F} = 2\hat{x} + 2\hat{y}$ N acts on a particle causing a displacement $\vec{r} = 3\hat{x} + \hat{y}$ m, what is the work done by the force on the particle?

Q3. A 50N force pulled a box on the ground from x1=0m to x2=6m, Find the work done by this force on the particle.

Assessment

(4, 2.5, 0)

Q1: What is the angle α between the two positive vectors $\vec{A} = (4,2.5)cm$ and $\vec{B} = (4.5,4,3)cm$?

(4.5, 4, 3)

$\vec{A}.\vec{B} = 4(4.5) + 2.5(4) + 0(3) = 28$

$|A| = \sqrt{4^2+2.5^2} = 4.716$ $\quad$ $|B| = \sqrt{4.5^2+4^2+3^2} = 6.727$

$$\cos^{-1}\alpha = \frac{A \cdot B}{|A||B|} = \frac{28}{(4.716)(6.727)} = 28.06^{\circ}$$

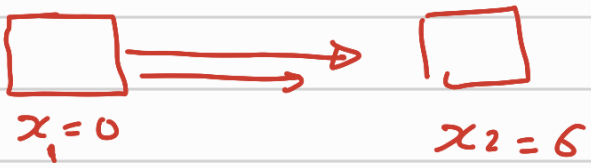
Q2. A constant force $\vec{F} = 2\hat{x} + 2\hat{y}$ N acts on a particle causing a displacement $\vec{r} = 3\hat{x} + \hat{y}$ m, what is the work done by the force on the particle?

$W = \cancel{Fd\cos\theta} = F.d =$

$(2\hat{x}+2\hat{y}) \cdot (3\hat{x}+\hat{y}) = 2(3)+2(1)$

$= 8J$

Q3. A 50N force pulled a box on the ground from x1=0m to x2=6m, Find the work done by this force on the particle.



$W = Fd = 50(6) = 300J$

Work Done by a Constant Force in 1D

- For one dimension case:

$$F \rightarrow F_x$$

$$\Delta r \rightarrow \Delta x$$

- Then the work

$$W = F_x \, \Delta x = F_x \, (x - x_0)$$

- If the force and displacement points in the same direction

$$(\alpha = 0 \, , \cos\alpha = +1) \Rightarrow W = Fd \quad \text{(positive work)}$$

- If the force and displacement points in the opposite direction

$$(\alpha = 180^o \, , \cos\alpha = -1) \Rightarrow W = -Fd \quad \text{(negative work)}$$

Work – kinetic energy theorem:

نظريه الشغل و الطاقه الحركيه

The relationship between kinetic energy of an object and the work done by the forces acting on it .

$$\Delta K = K - K_0 = W$$

Where K and K_o are the final and initial kinetic energy and W is the work.

Assessment:

The driver of 1000 kg car traveling at speed of 16.7 m/s applies the car brakes when he sees a red light, what is the work needed to stop the car?

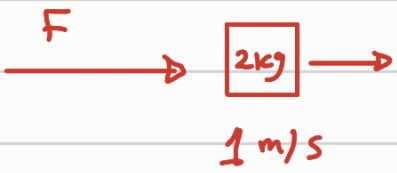
نظرية الشغل و الطاقة

$K_0 = \frac{1}{2}(2)(1)$

$K_0 = 1\,J$

$K = \frac{1}{2}(2)5^2$

$K = 25\,J$



عندما تزداد القوة على الجسم وتزداد السرعة فان الطاقة تزداد

الشغل = التغير في الطاقة

$W = 25 - 1 = 24\,J$

$$W = K - K_0$$

Assessment:

The driver of 1000 kg car traveling at speed of 16.7 m/s applies the car brakes when he sees a red light, what is the work needed to stop the car?

$m = 1000\,kg$

$K = \frac{1}{2}mv^2$

$v = 16.7\,m/s$

$K = 0$

$V = 0\,m/s$

$$W = \Delta K = K - K_0$$

$$W = 0 - \frac{1}{2}mv^2$$

$$W = -\frac{1}{2}(1000)(16.7)^2 = -139445\,J$$

$$= -139.445\,KK$$

Work Done by the Gravitational force

The work done by the gravitational force on an object falling down is

$$W_g = mgh \qquad \text{(down)}$$

Where h is height that an object falls.

Since the displacement and the force point in the same direction ⇒ the work is positive ($W > 0$) ⇒ it increases the kinetic energy of the object

Work Done by the Gravitational force

في حاله رمي الجسم للاعلى ($W = -$) الطاقه الحركيه تقل

The work done by the gravitational force on an object tossed vertically upward is

$$W_g = -mgh \qquad \text{(up)}$$

Where *h* is height that an object moves upward.

لان القوه و الازاحه عكس بعض اذا الشغل صالب و تقل الطاقه الحركيه

Since the displacement and the force point in the opposite directions ⇒ the work is negative ($W < 0$) ⇒ it reduces the kinetic energy of the object during its upward motion.

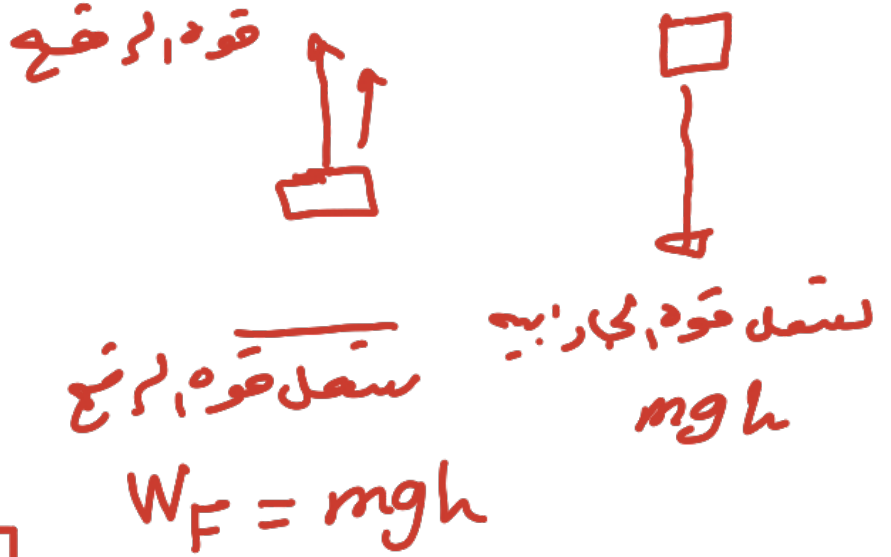
شغل القوه في مجال الجاذبيه الارضيه لرفع او خفض جسم

Work Done in Lifting and Lowering an Object

- For lifting:

$$W_F = mgh$$

رفع



شغل قوه الخفض

- For lowering:

$$W_F = -mgh$$

Assessment

Example 5.3 (weightlifting) pa.144

Problem1 :

A lifter lifted 257.5 kg to a height of 1.83 m and held it there, what was the work he did in this process?

$W = mgh = 257.5(9.8)(1.83) = 4618\,J$

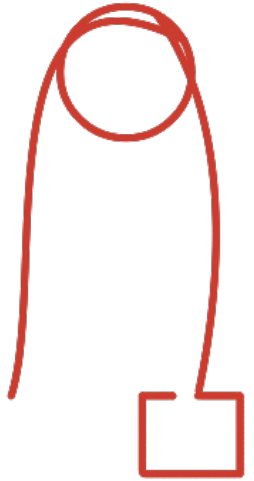
Problem2 :

What was the work done by him in lowering the weight slowly back down to the ground?

$W = -mgh = -4618\,J$

الرفع بالبكرات

Lifting with Pulleys



لغرض مقدار الشغل المبذول في استخدام او عدم استخدام البكره لكن باستخدام البكره ستكون المسافه اكبر وبالتالي قوه رفع اقل

The same amount of work is done because it is necessary to compensate (تعويض) for reduced force by pulling the rope through a longer distance.

الشغل المبذول من القوة المتغيرة

Work Done by a Variable Force

$$W = \int_{x_o}^{x} F_x(x')dx'$$

$W = F \cdot \Delta x$

$$W = \int_{x_o}^{x} F(x)\,dx$$

Example:

Spring Force: قوة النابض

Hooke's Law

$$F_s = -kx$$

ثابت النابض — الإزاحة

k : spring constant.

Spring constant unit : N/m

$$W = \int_{0}^{x} -kx\,dx$$

Work Done by the spring force

$$W_s = -\frac{1}{2}kx^2$$

$$W = -k\int_{0}^{x} x\,dx = \frac{-kx^2}{2}$$

Power

القدرة

المعدل الزمني لانجاز الشغل

Power: the rate at which work is done

في حاله كانت الشغل متغير

$$P = \frac{dW}{dt}$$

القدره (P) = الشغل المبذول / الزمن

Average power

$$P = \frac{W}{\Delta t}$$

شغل / زمنه

SI unit: Watt (W)

$$1W = \frac{1J}{s} = 1Kg.m^2/s^3$$

Watt = J/s = P

وحده قياس القدره = Watt

1W = 1J/s = 1 Kg m²/s³

Power for Constant Force:

قدره القوه الثابته

$$P = \vec{F}.\vec{v}$$

$$P = Fv\cos\alpha$$

القدرة = القوه (المقدار) cosα

Where P is the power , F is the constant force , v is the velocity of the object and α is the angle between the force vector and the velocity vector.

power

P = 10(20)cos60 = 100 wat

Assessment

Q6. What is the power needed to lift a 49 kg person a vertical distance of 5 m in 20 s?

$$P = \frac{W}{\Delta t} = \frac{mgh}{\Delta t} = \frac{49(9.8)(5)}{20} = 120.05 \text{ watt}$$

Q7. If a force of 14 N acts on a body and makes it moves with velocity of 3 m/s. what is the power?

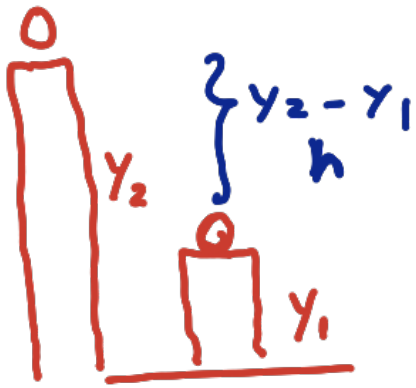
$$P = Fv = 14(3) = 42 \text{ watt}$$

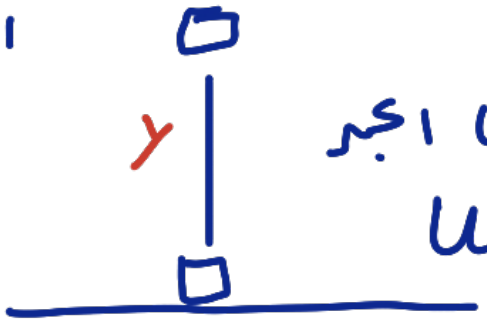
CHAPTER 6

potential energy and energy Conservation

طاقة الوضع حفظ الطاقة

$U = mgy$





طاقة الوضع الجاذبية لها
كلما ارتفع الجسم كانت U اكبر
كلما نزلت, بكتلة زادت U

طاقة الوضع

Potential Energy

الطاقة المختزنة في نظام تؤثر فيه الاجسام مع بعض لقوى

the energy stored in the configuration of a system of objects that exert forces on each other.

طاقة الوضع الجاذبية

- **Gravitational Potential Energy (U)**

$$U = mgy$$

$g = 9.8 m/s^2$
m is the mass — كتلة
y is the height — الارتفاع

متباعد

- potential energy is scalar .
- Unit : Joule (J) : 1J = 1 Nm = $1 kg.m^2.s^{-2}$ = جول
- The change of the potential energy is given by

$$\Delta U = U - U_o = mg(y - y_o)$$

$$\Delta U = mgh$$

التغير في الطاقة ΔU

$\Delta U = U - U_o = mg(y-y_o)$
$= mgh$

شغل قوة الرفع

- The work for lifting an object is given by

$$W = -mgh$$

h is the height of the object.

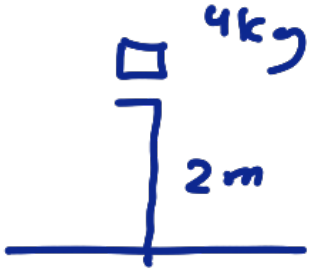
ارتفاع الجسم

- Thus,

الشغل = التغير في الطاقة

$$\Delta U = -W$$

Assessment



U

Q1. What is the gravitational potential energy of 4Kg body placed at 2m above the floor?

$$U = mgy = 4(9.8)(2) = 78.4\ J$$

الارتفاع

Q2. What is the height of 10 kg body that has potential energy of 981 J?

$$U = mgy \qquad y = \frac{U}{mg} = \frac{981}{9.8 \times 10} \approx 1\ m$$

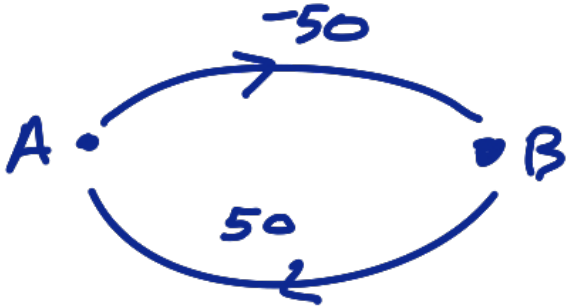
محافظه غير محافظة

Conservative and nonconservative Forces

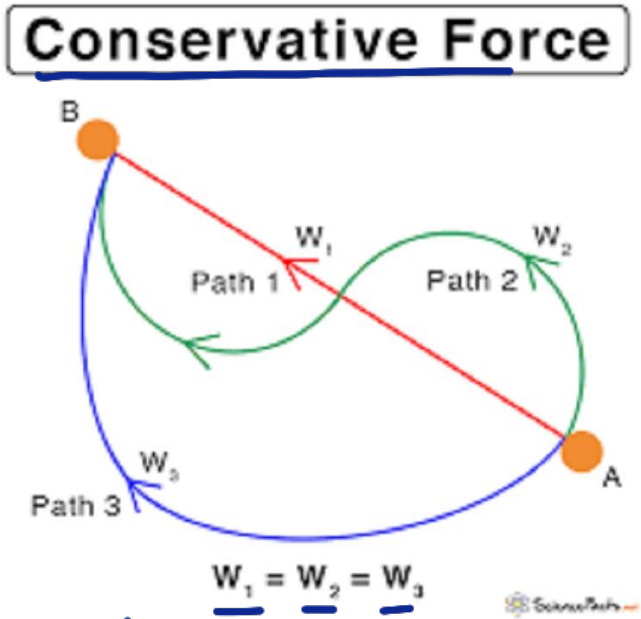
- A Conservative force: any force for which the work done over any closed path is zero.
  - $W_{B\to A} = -W_{A\to B}$ or $W_{B\to A} + W_{A\to B} = 0$
  - Independent of path, i.e.
    - $W_{A\to B,\text{path 2}} = W_{A\to B,\text{path 1}}$

50 + -50 = 0

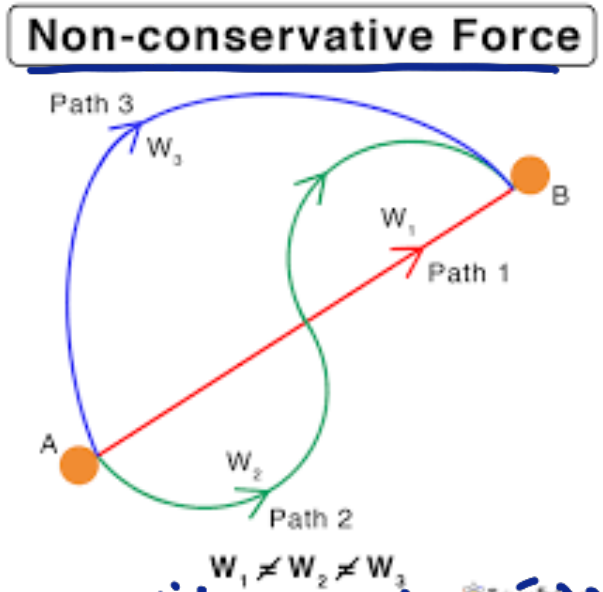
W = 0



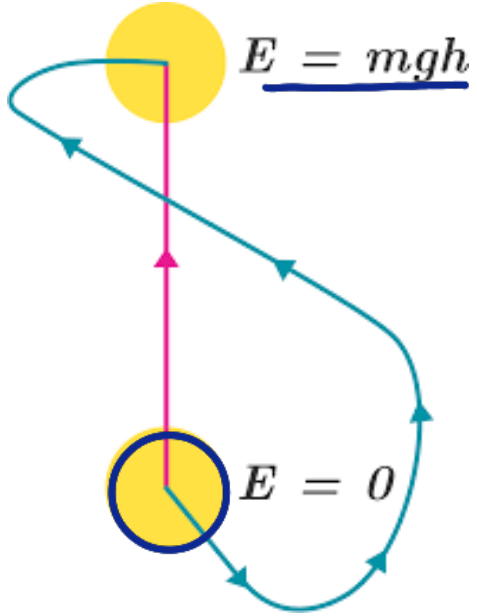
- Nonconservative force : any other force



كل المسارات متساوية بالشغل



اذا كانت القوة غير محافظة يختلف الشغل حسب المسار



Examples Conservative and nonconservative Forces

Force	Type	Equation	Potential Energy
Weight	Conservative	mg	mgh
Spring	Conservative	kx	$\frac{1}{2}kx^2$
Coulomb	Conservative	$\frac{kq_1q_2}{r^2}$	$\frac{kq_1q_2}{r}$
Friction	Non-conservative	μN	–
Air Drag	Non-conservative	$Cd\ \frac{\rho v^2}{2}\ A$	–

Table 4.3 Comparison of conservative and non-conservative forces

S.No	Conservative forces	Non-conservative forces
1.	Work done is independent of the path	Work done depends upon the path
2.	Work done in a round trip is zero	Work done in a round trip is not zero
3.	Total energy remains constant	Energy is dissipated as heat energy
4.	Work done is completely recoverable	Work done is not completely recoverable
5.	Force is the negative gradient of potential energy	No such relation exists.

قوى الاحتكاك غير محافظة

Friction Forces are nonconservative

- The work done by a constant force to slid a box across a horizontal surface from point A to point B is given and then back from B to A is

$$W = -2\mu_k mg(x_B - x_A)$$

الشغل الكلي على مسار مغلق ≠ صفر

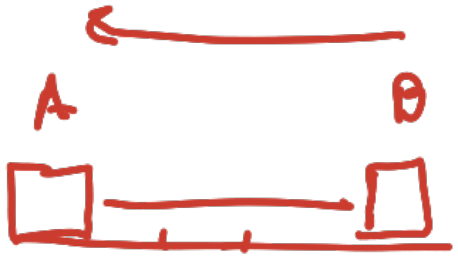
- The total work done friction force on the closed path is not zero.

متجه قوة الاحتكاك دائما تكون موازية ومعاكسة لمتجه السرعة

- The friction force vector is always antiparallel to the velocity vector

(i.e. they are in opposite directions)

- Any force with this property cannot be conserved



$F_f = \mu_k mg$

$W = -2\mu_k mg(x_B - x_A)$

يستغل قوة الاحتكاك في مسار مغلق

Work and Potential Energy

For any conservative force, the change in potential energy is equal to the negative of the work done by the conservative force

$$\Delta U = -W$$

السؤال = مقدار التغير في الطاقة

Potential Energy and Force

The force can be derived from the potential energy:

القوه المحافظه = سالب تدرج طاقة الوضع

- 1D:

$$F(x) = -\frac{dU}{dx}$$

- 3D:

$$\vec{F}(\vec{r}) = -[\frac{\partial U}{\partial x}\hat{x} + \frac{\partial U}{\partial y}\hat{y} + \frac{\partial U}{\partial z}\hat{z}]$$

Assessment

Q3. A particle is moving along the x-axis subject to the potential energy $U(X)= x^2+x+4$ J, what is the net force on the particle at x=5m?

القوة = السالب المشتقة الطاقة

$$F = \frac{dU}{dx} = 2x + 1$$

عندما $x=5$

$$F = 2x + 1$$
$$= 2(5) + 1 = 11\ N$$

حفظ الطاقة الحيكانيكيه $E = U + k$

6.5 Conservation of Mechanical Energy:

النظام المعزول :- تؤثر فيه الاجسام بقوه بدون قوى خارجيه تؤدي الى تغير الطاقه

نظام معزول

Isolated system: a system of objects that exert force on one another but for which no force external to the system causes energy changes within the system.

النظام المعزول :- لايوجد طاقه تخرج او تدخل الى النظام

(no energy is transferred into or out of the isolated system)

Mechanical energy E

الطاقه الميكانيكيه = طاقه الوضع + طاقه الحركه

$$E = K + U$$

For isolated system with only conservative forces, the total energy is conserved

$$\Delta E = \Delta K + \Delta U = 0$$

$$K + U = K_0 + U_0$$

For conservative force isolated system.

في حالة النظام المعزول والقوه المحافظه تكون الطاقه الميكانيكيه محفوظة

التغير في الطاقه الحيكانيكيه = صفر

Work and Energy for the Spring Force:

- For block-spring system, the total energy E is given by:

$$E = K + U = \frac{1}{2}mv^2 + \frac{1}{2}kx^2$$

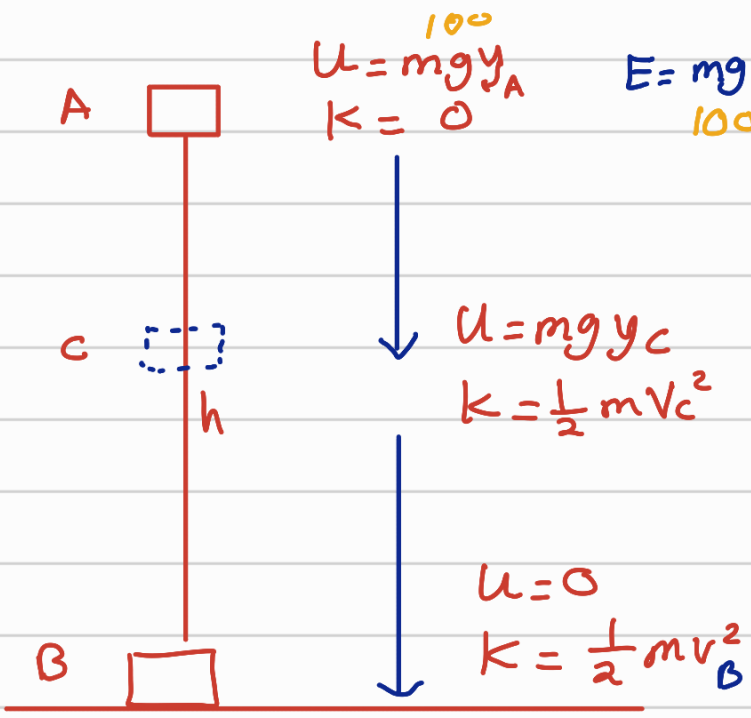
- At the maximum point x=A

$$E = \frac{1}{2}kA^2$$

Where A is the amplitude (maximum elongation of spring from equilibrium position)

- Thus, the speed of the block at any point x is given by

$$v = \sqrt{(A^2 - x^2)\frac{k}{m}}$$



حفظ الطاقة الميكانيكية

عند سقوط الجسم تتحول طاقة الوضع الى طاقة حركة وتزداد السرعة

الطاقة الميكانيكية عند اي نقطة دائما ثابتة

$$E = K + U = \text{constant}$$

$$\Delta E = \Delta K + \Delta U = 0$$

طاقة الوضع عند اعلى نقطة = طاقة الحركة عند اسفل نقطة

$$\boxed{mgy_A = \frac{1}{2}mV_B^2}$$

CHAPTER 7

Momentum and Collision

الزخم الخطي

التصادم

Linear Momentum: P

الزخم = حاصل ضرب الكتلة x السرعة

$\vec{P} = m\vec{v}$

Momentum : the product of an object's mass and its velocity

$$\vec{P} = m\vec{v}$$

متجه

- Momentum is vector.
- It points in the same direction as velocity.

اتجاه الزخم نفس اتجاه السرعة

- SI Unit : 1kg m/s = 1kg.m.s^{-1}

= kg m/s

- **Momentum and Force**

العلاقة بين الزخم و القوة

القوة = مشتقة الزخم

$$\vec{F} = \frac{d\vec{p}}{dt}$$

$F = \frac{dP}{dt}$

- **Momentum and Kinetic Energy**

العلاقة بين الزخم و الطاقة

$$K = \frac{p^2}{2m}$$

$k = \frac{p^2}{2m}$

Assessment

$\vec{p}$

$P = mv = 10\,(120) = 1200$ Kg m/s

Q1. Find the momentum of 10 kg cannonball moving with speed of 120 m/s?

القوه = مشتقه الزخم

Q2. If $p = 3t^2 + 2t$ kg.m/s, find the force F at t=1s.

$\vec{F} = \frac{d\vec{P}}{dt} = 6t^2 + 2$

$= 6(1) + 2 = 8\ N$

Q3. Find the kinetic energy for a 2kg particle with linear momentum of 10 kg m/s

$$K = \frac{P^2}{2m} = \frac{10^2}{2(2)} = \frac{100}{4} = 25\ J$$

(الدفع) J

Impulse: the time integral of force or the change in momentum.

التغير في زخم الجسم و التكامل للقوه خلال فتره

- Impulse is vector.
- SI unit: kg.m/s or N.s

$$\vec{J} = \Delta\vec{p} = \vec{p}_f - \vec{p}_i$$

$J = \Delta P = P_f - P_i$

$= mv_f - mv_i$

- For constant force

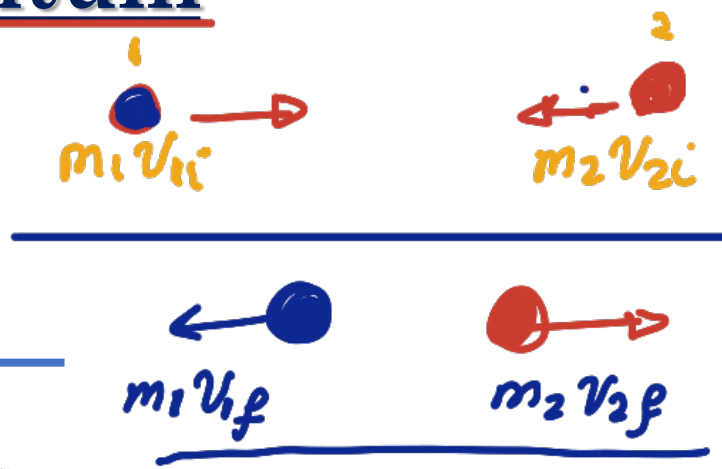
$$\vec{J} = \vec{F}\Delta t$$

$J = F\Delta t$

$F\Delta t = \Delta P$

Conservation of Linear Momentum

في جميع التصادمات
يكون الزخم محفوظ



بعد التصادم — قبل التصادم

$$m_1 v_{f1} + m_2 v_{f2} = m_1 v_{i1} + m_2 v_{i2}$$

$$\sum P_{\text{بعد}} = \sum P_{\text{قبل}}$$

Conservation of Linear Momentum

انواع التصادمات

المرن :- الزخم محفوظ و الطاقه محفوظة
غيرمرن :- الزخم محفوظ الطاقه غير محفوظة
عديم المرونة :- الزخم محفوظ الطاقه غير محفوظة
الاجسام تتدمج ببعضها بعد التصادم

- **Types of collision:**
  - Elastic collision
  - Inelastic collision
  - Totally inelastic collision

مرن ⇒ غيرمرن
عديم المرونة

- **Conservation of Linear Momentum**

The sum of the momentum after collision is the same as the sum of momentum before collision.

$$\vec{p}_{f1} + \vec{p}_{f2} = \vec{p}_{i1} + \vec{p}_{i2}$$

For one dimension:

$$m_1 v_{f1} + m_2 v_{f2} = m_1 v_{i1} + m_2 v_{i2}$$

قانون حفظ الزخم :: مجموع الزخم قبل التصادم يساوي مجموع الزخم بعد التصادم