① SI ≡ MKS

meter kilogram second

② British system = flbs.

foot bound

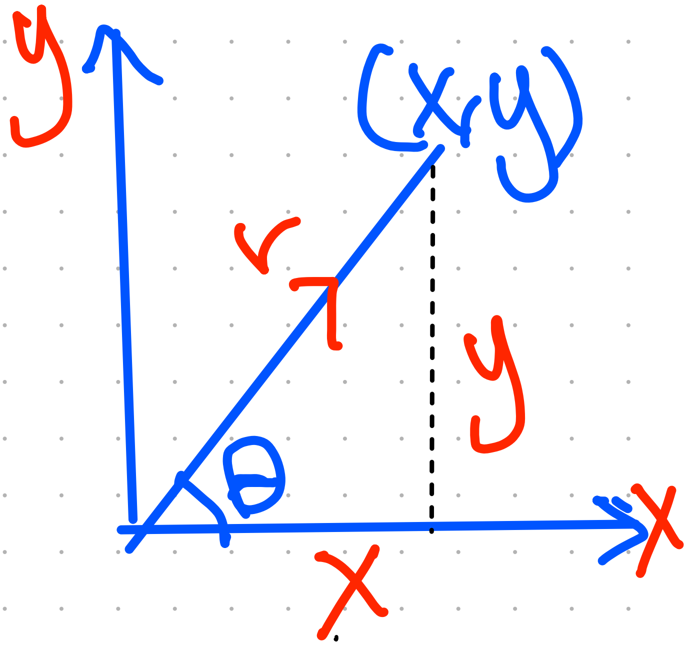
قدم

1 ft = 30.5 cm.

1 in = 2.54 cm.

1 mile = 1609 m.

1) Cartesian coords.
2) polar coords.




---

$$r^2 = x^2 + y^2$$

$$\cos\theta = \frac{x}{r} \Rightarrow x = r\cos\theta$$

$$\sin\theta = \frac{y}{r} \Rightarrow y = r\sin\theta$$

$$\theta = \tan^{-1}\left(\frac{y}{x}\right)$$

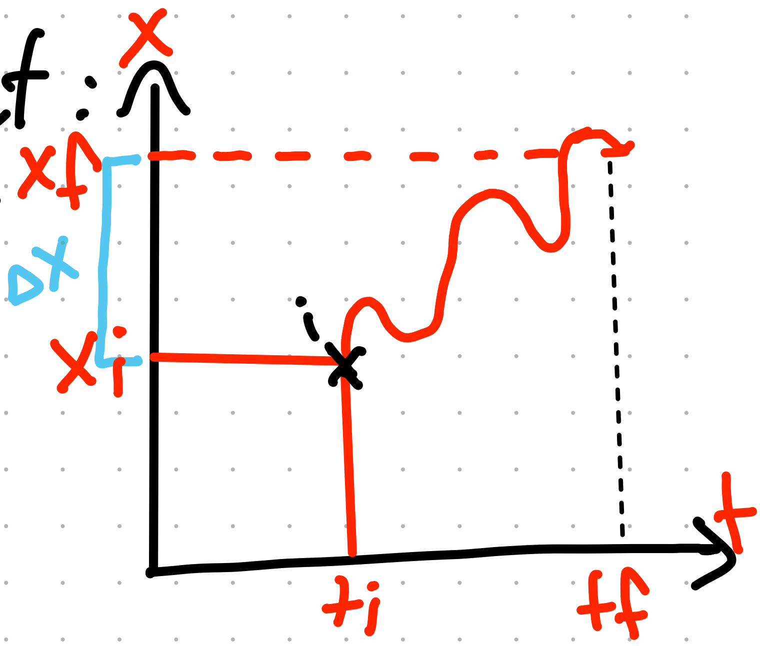
مطلوب

# Ch.2
# Motion in 1-Dim.

## 2-1 displacement:

$\Delta x = x_f - x_i$ (m)

$\Delta t = t_f - t_i$ (s)




## 2-2 velocity:

① av. $\bar{v} = \frac{\Delta x}{\Delta t}$ (m/s)

② inst. $v = \frac{dx}{dt}$ (m/s)

لها اتجاه

③ av. speed $= \frac{d}{t} = \frac{\text{total}(d)}{\text{total}(t)}$

صافي

وقت

مسافة   إزاحة

$d > \Delta x$

تساوي في حالة واحدة إذا مش في خط مستقيم.

The instantaneous velocity $v$ is the limit of the average velocity as the time interval $\Delta t$ becomes infinitesimally small:

$$v \equiv \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t}$$

مشتقة

**SI unit: meter per second (m/s)**

Ex: * $x = 3t^2 - 4t + 2$

find: (a) $\Delta x = ?$ * btwn $t_i = 0 \rightarrow t_f = 2$

(b) $\bar{v} = ?$

(c) $v = ?$ at $t = 2$ sec

حل:

(a) $\Delta x = x_f - x_i$

* عوضنا فوقه عشان نجيبهم ← $6 - 2 = 4m$

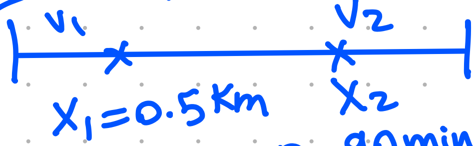
(b) $\bar{v} = \frac{\Delta x}{\Delta t} = \frac{4}{2-0} = 2 m/s$

(c) $v = \frac{dx}{dt} = 6t - 4 \Rightarrow v\Big|_{t=2} = 8 m/s$

# Ex : 2-1 ص28

$V_2 = 2V_1$
runs twice as fast

4 Km




nap = 90 min = 1.5 hr

ⓐ $\bar{V} = ?$ (speed)    ⓑ $V_1 = ?$

ⓐ $\bar{V} = \dfrac{total(d)}{total(t)} = \dfrac{4}{1.75} = 2.2$ Km/hr.

$t_{total} = 1.75$ hr
من السؤال

ⓑ $V_1 = \dfrac{X_1}{t_1}$    السرعه = المسافه / الزمن

$t = t_1 + nap + t_2$    زمن = المسافه / السرعه

$1.75 = t_1 + 1.5 + t_2$

$0.25 = t_1 + t_2$

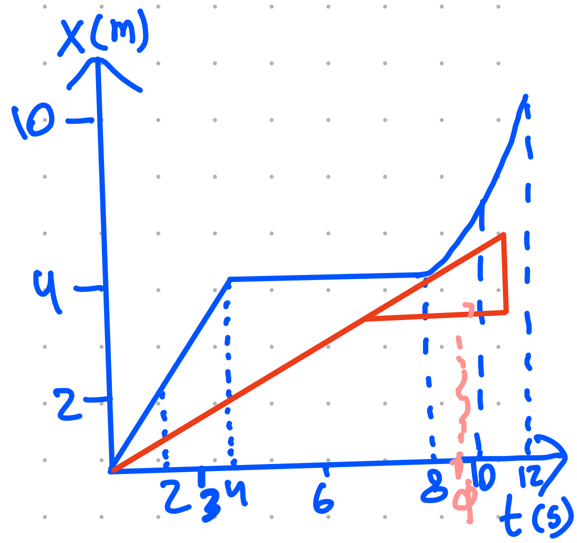
$= \dfrac{X_1}{V_1} + \dfrac{X_2}{V_2}$

$0.25 = \dfrac{0.5}{V_1} + \dfrac{3.5}{2V_1} = V_1 = 9$ Km/hr.

المسافه كلها 4km
$x_1 + x_2 = 4$ Km
$0.5 + x_2 = 4$
$x_2 = 3.5$ Km

---

# Ex 2-2 ص32




ⓐ $\bar{V} = \dfrac{d}{t} = \dfrac{10}{12} = 0.833$ m/s

ⓑ $\bar{V}_{0-4} = \dfrac{4-0}{4-0} = 1$ m/s

ⓒ $\bar{V}_{4-8} = 0$ ← خط مستقيم يوازي السينات

(d) $v|_{t=2} = \text{slop} = \frac{4-0}{4-0} = 1\,m/s$

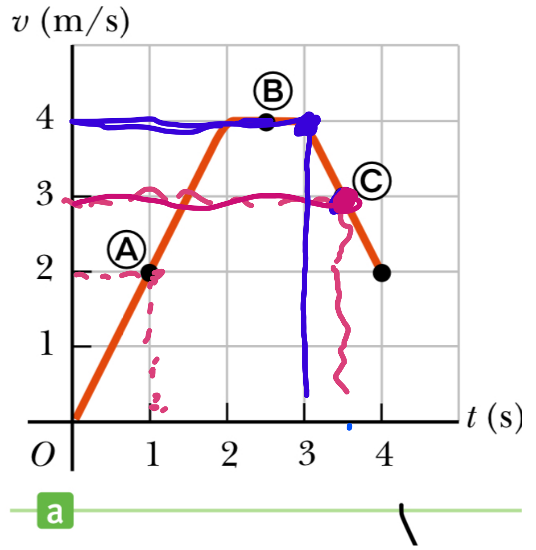
الميل

(e) $v|_{t=9} = \frac{4.5-0}{9-3} = 0.75\,m/s$

# 2-3 Acceleration:

$\bar{a} = \frac{\Delta v}{\Delta t}\ (m/s^2)$ , $a_{inst} = \frac{dv}{dt}\ (m/s^2) \rightarrow \lim_{\Delta t \to 0} \frac{\Delta v}{\Delta t}$

Ex 2-3 ص 35



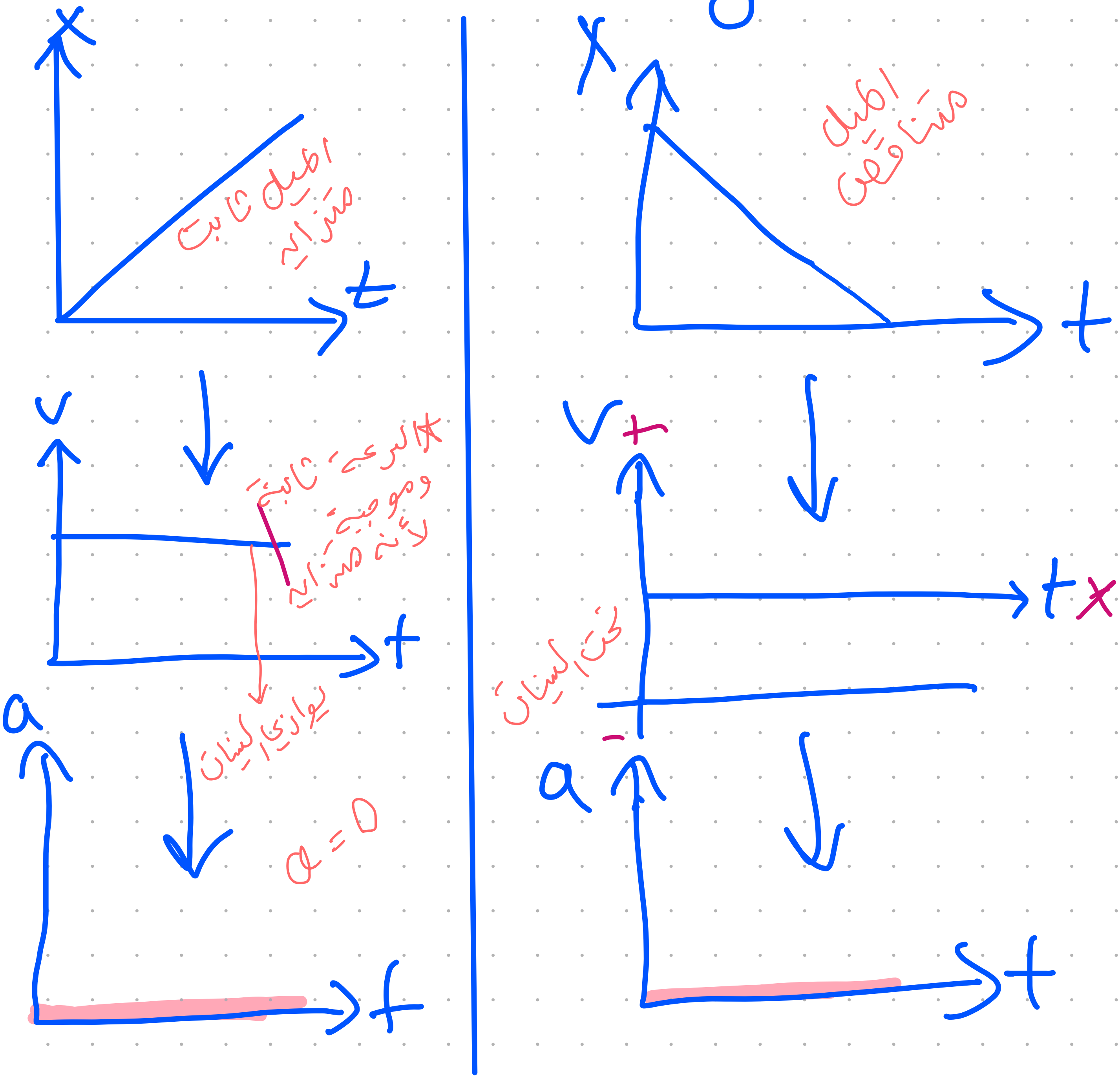

$a_A = ? = \frac{2-0}{1-0} = 2\,m/s^2$

$a_B = 0$

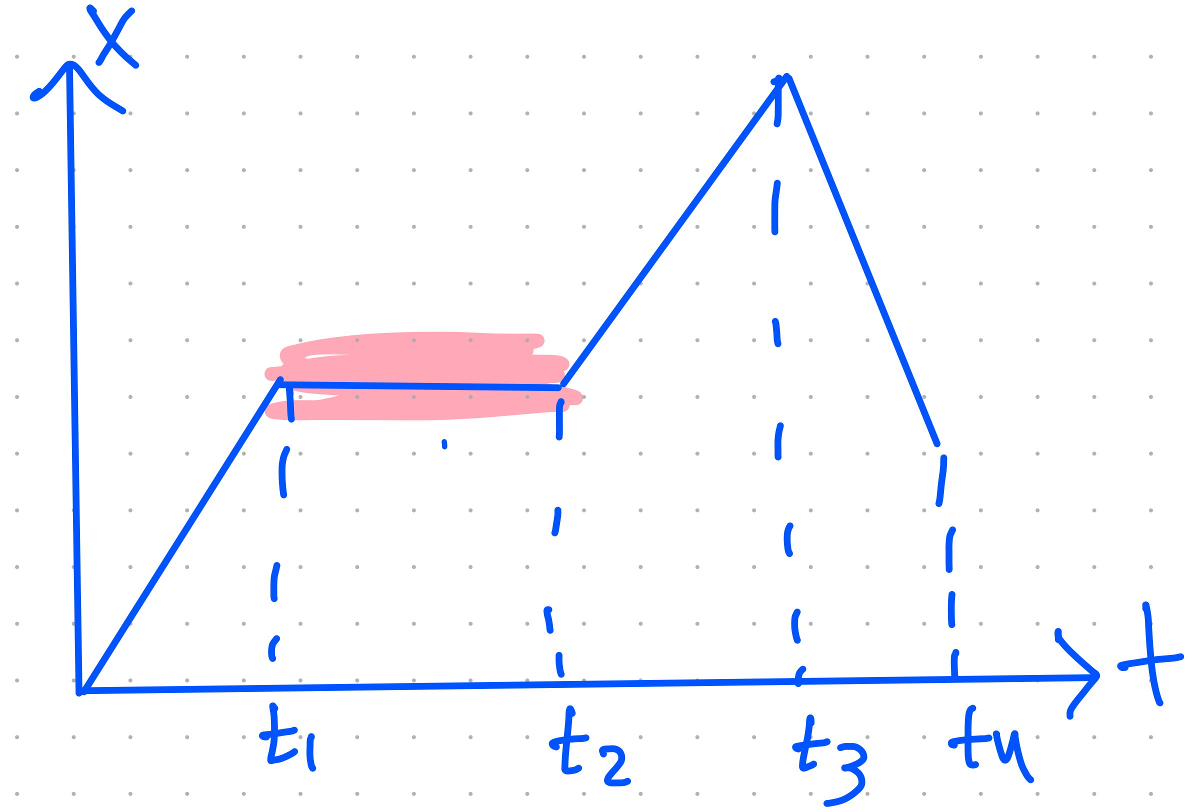
$a_C = \frac{3-4}{3.5-3} = -2\,m/s^2$

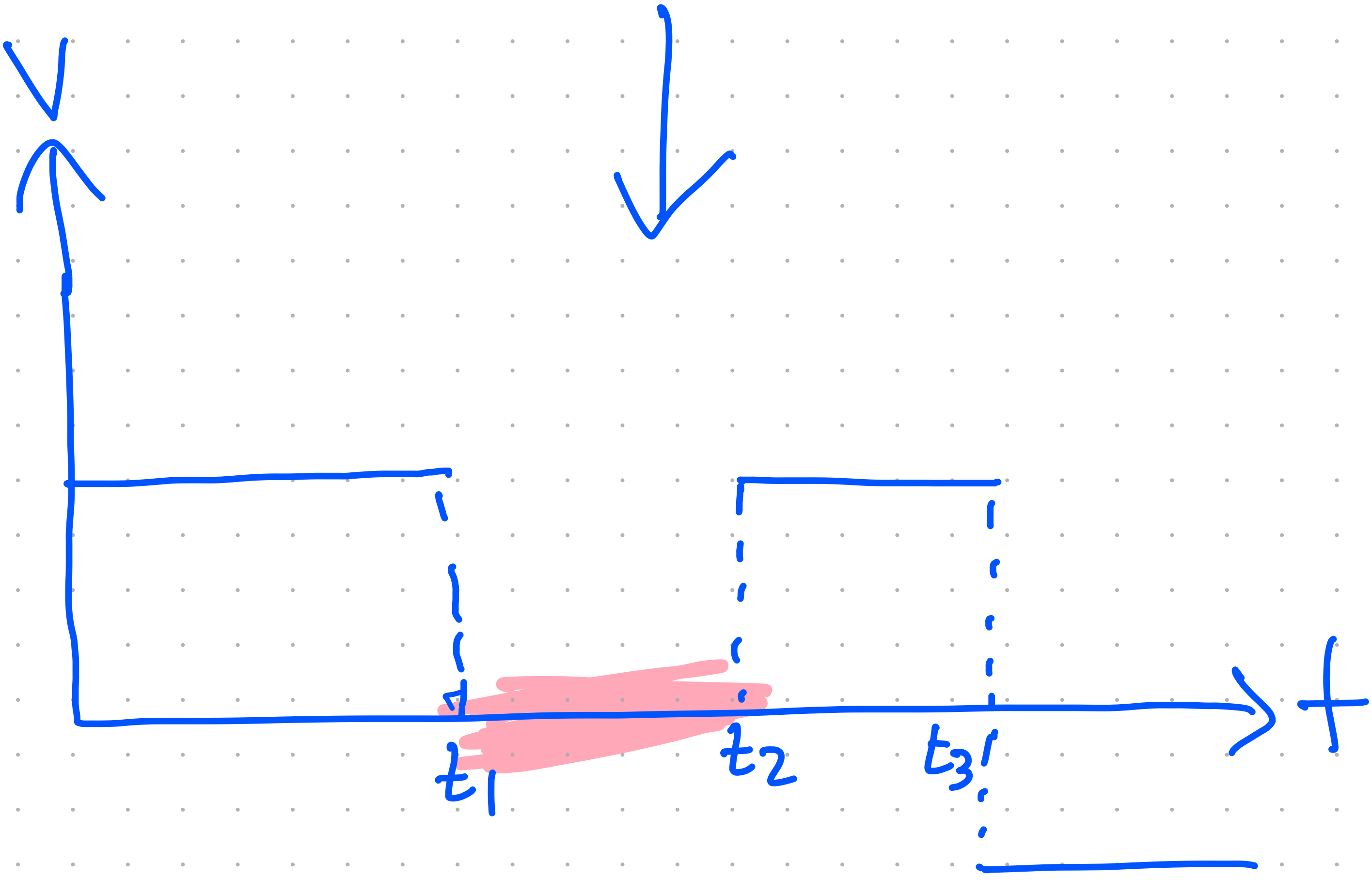
سالب إما بتباطؤ أو عكس اتجاه الحركة الأصلية.

# 2-4 Motion diagrams



*مثال :-




* في جميع المراحل التسارع = صفر
لأنها كلها خطوط مستقيمة .

# 2-5 Motion in 1-Dim with Const. accel.

$\bar{a} = a$

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

$$\Rightarrow a = \frac{\Delta v}{\Delta t} = \frac{v_f - v_i}{t_f - t_i}$$

$v_f = v$

$v_i = v_0$

$t_f = t$

$t_i = 0$

$$\Rightarrow a = \frac{v - v_0}{t}$$

$$\boxed{v = v_0 + at} \quad (1)$$

$$\boxed{x - x_0 = v_0 t + \frac{1}{2} a t^2} \quad (2)$$

$$\boxed{v^2 = v_0^2 + 2a\Delta x} \quad (3)$$

$$\boxed{\bar{v} = \left(\frac{v + v_0}{2}\right)t} \quad (4)$$

# Ex 2-5

$V_{car} = 24\ m/s$

$a_t = 3\ m/s^2$

$v_{o_t} = 0$

$t_{car} - t_{tmp} = 1\ sec$

$\Rightarrow \Delta X_{car} = V_o t + \frac{1}{2} a t^2$ سرعة ثابتة $a=0$

$x - 24 = 24t + 0$ — (1)

معادلتين

$\Rightarrow \Delta X_t = V_o t + \frac{1}{2} a t^2$ — (2)

$x - 0 = 0 + \frac{3}{2} t^2$

$x - 24 = 24t \Rightarrow x = 24 + 24t$

$1.5 t^2 = 24 + 24t$

$\Rightarrow t = 16.9\ sec$

$v = v_o + at$

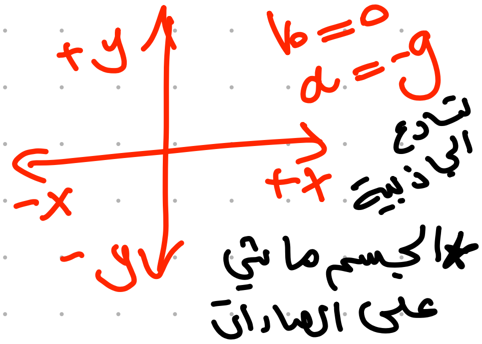
$= 0 + 3(16.9)$

$= 50.7\ m/s$

43p

# 2-6 Freely falling object

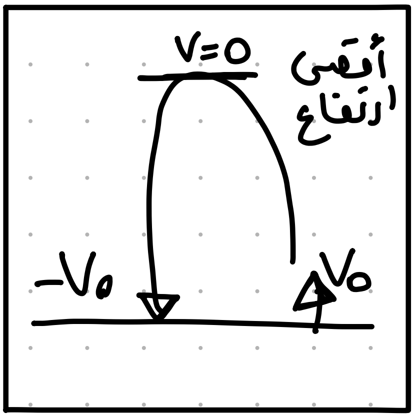
No air resistance




$\Rightarrow V = V_0 - gt$

$\Rightarrow \Delta y = V_0 t - \frac{1}{2} g t^2$

$\Rightarrow V^2 = V_0^2 - 2g \times \Delta y$




## ① time to reach the max heigh ($t_m$)

$V = V_0 - gt$

$0 = V_0 - g t_m$

$t_{max} = \frac{V_0}{g}$

زمن التحليق الكلي = 2 x زمن أقصى ارتفاع

## ② the max height ($y_m$)

$V^2 = V_0^2 - 2g\Delta y$

$0 = V_0^2 - 2g y_m$

$\Rightarrow y_m = \frac{V_0^2}{2g}$

## ③

$V = V_0 - gt$

$= V_0 - \cancel{g}\left(\frac{2V_0}{\cancel{g}}\right)$

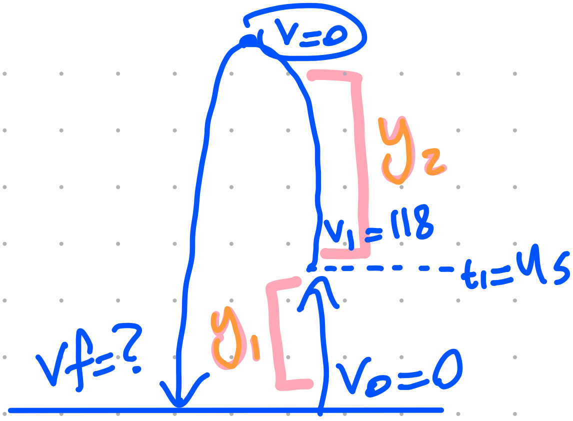
$= -V_0$

سرعة رجوعه لنفس المستوى نفسها سرعة العودة بس سالبة

Ex 2-10 ص 46

$V_0 = 0$

$a = 29.4\ m/s^2$




ⓐ $V_1 = ?\ /\ y_1 = ?$

$$V_1 = V_0 + at$$
$$= 0 + (29.4)(4) = 118\ m/s$$

$$y_1 = V_0 t + \frac{1}{2} a t^2$$
$$= 0 + \frac{1}{2}(29.4)(16) = 235\ m$$

ⓑ $y_m = ? = y_1 + y_2$

$$y_2 = \frac{V_0^2}{2g} = \frac{V_1^2}{2g} = 696\ m.$$

السرعة الابتدائية للمرحلة الثانية هي $V_1$ من الفرع العلوي.

$$y = y_1 + y_2 = 945\ m$$

ⓒ $V_f^2 = V_0^2 - 2g\,y_m$

$$= 0 - 2 * 10 * -945$$

لأنه نازل

$$\Rightarrow V_f = -136\ m/s$$

*Chapter 3: Vectors and motion in 2 - Dim

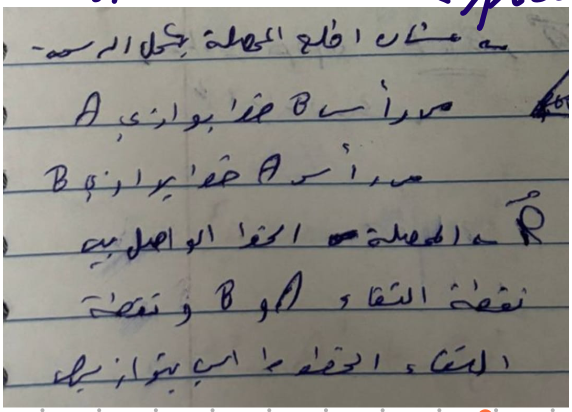
المتجهات

3-1 : Vectors and their properties:

ⓐ vectors : physical quantities which have magnitude (مقدار) + direction (اتجاه). (velocity, displacement, force)

ⓑ scalars (كمية قياسية) : // // // // // (speed, mass, distance)

الرمز → $\vec{A}$ أو **A** ≡ vectors.
B ≡ scalar.


بما ان اضلاع المثلث يمثل الرسم
مرورا بـ B نرسم خطا موازيا لـ A
مرورا بـ A نرسم خطا موازيا لـ B
R المحصلة هي الخط الواصل بين
نقطة التقاء A و B ونقطة
التقاء الخطين الموازيين

* Properties of vectors

① eqnality of vectors: → *خصائص المتجهات.

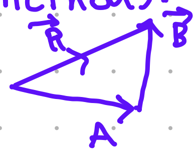
$\vec{A} = \vec{B} \Rightarrow$ They have the same magnitude and direction *نفس المقدار والاتجاه.

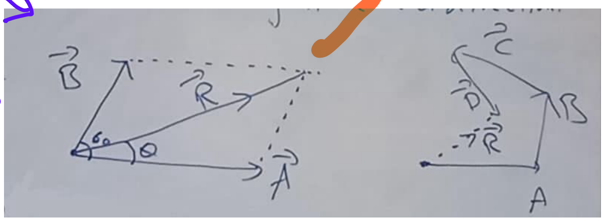
② addition of vectors (جمع) :-

ⓐ geometric method:-

ⓘ $\vec{R} = \vec{A} + \vec{B}$ (parallelogramm method).

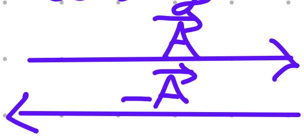
ⓘⓘ head - to - tail - method. (المحصلة) (أكثر من متجه)




③ negative of a vector. (سالب المتجه)

$-\vec{A} \equiv$ is a vector of the same magnitude of $\vec{A}$, But opposit direction.



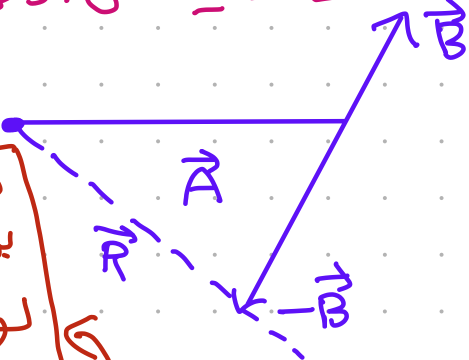

*فقط ينعكس الاتجاه.

④ subtraction of vectors (طرح) : →

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

لو ضربته في 2- نفس المقدار بيضو بس عكس الاتجاه.

لو ضرب x المتجه الصفري مقداره صفر واتجاهه غير معرف




⑤ multiplication of a vector by a scalar:

$2\vec{A}$ *الاتجاه زي ما هو بس المقدار بيكبر.

* scalar x vector = vector

الطريقة الجبرية.

## 3-2 Components of a vectors:

*مركبة سينية وصادية

$$A_x = A\cos\theta$$

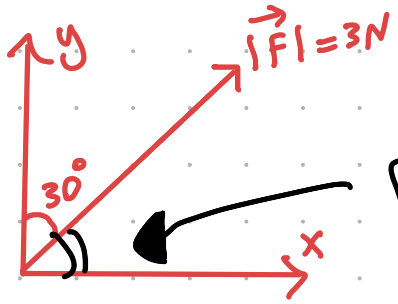
$$A_y = A\sin\theta$$

$$A^2 = A_x^2 + A_y^2$$

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

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

$$\tan\theta = \frac{A_y}{A_x}$$




* الزاوية لازم مع السينات.

**Ex:** Given $A_x = 3$, $A_y = 4$

$A = ?$

$\theta = ?$

$\rightarrow A = \sqrt{A_x^2 + A_y^2} = 5$

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

---

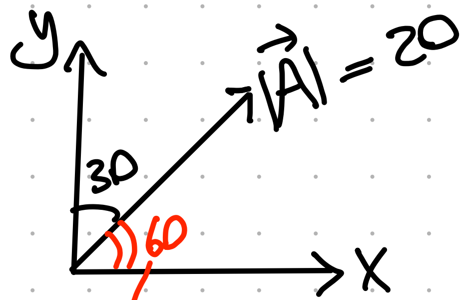
**Ex:** $A_x = ?$

$= A\cos 60$

$A_y = ?$

$= A\sin 60$

$A_x = 10$, $A_y = 17$



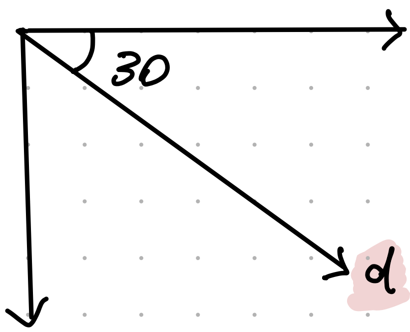

أنا بطلعها

**Ex:** Find the Horizontal and vertical components of $d = 1\times10^2\,m$ in the figure:

$\Rightarrow d_x = d\cos(-30) = 36.6\ m$

$d_y = d\sin(-30) = -50\ m$

سالبة لأنه تحت (X)



## * Adding Vectors algebraically:

*جمع المتجهات جبرياً

For $\vec{A} = \vec{A}_x + \vec{A}_y$ *مركبة سينية وصادية

$\vec{B} = \vec{B}_x + \vec{B}_y$

$$\vec{R} = \vec{A} + \vec{B} = (\overrightarrow{A_x + B_x}) + (\overrightarrow{A_y + B_y})$$

المركبة السينية للمحصلة — المركبة الصادية للمحصلة

*بالجمع الجبري بجمع السيني لحال والصادي لحال

### 3-3 Displacement, velocity & Accel. in 2-Dim.:

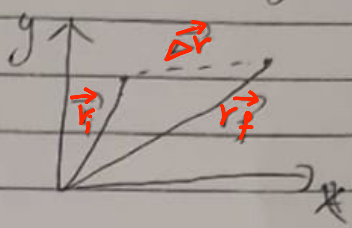
Here the vector concept is important to specify the direction of motion.

$\vec{r}$ is the position vector

& so $\Delta\vec{r} = \vec{r}_f - \vec{r}_i$

where $\vec{r}_i$ has two components $(x_i, y_i)$

& sim. $\vec{r}_f = (x_f, y_f)$.




### * velocity:-

av. $\vec{v} = \dfrac{\Delta r}{\Delta t}$ m/s

inst. $\vec{v} = \dfrac{d\vec{r}}{dt}$ m/s.

### * Acceleration:-

av. $\vec{a} = \dfrac{\Delta \vec{v}}{\Delta t}$ $m/s^2$

inst. $\vec{a} = \dfrac{d\vec{v}}{dt}$ $m/s^2$

# 3-4 Two Dim. Motion:

A particle moving in xy plane with const. accel. so its position & velocity components are:

$$\Delta x = v_{ox} t + \tfrac{1}{2} a_x t^2 \qquad \Delta y = v_{oy} t + \tfrac{1}{2} a_y t^2$$

$$v_x = v_{ox} + a_x t \qquad v_y = v_{oy} + a_y t$$

$$v_x^2 = v_{ox}^2 + 2 a_x \Delta x \qquad v_y^2 = v_{oy}^2 + 2 a_y \Delta y$$

ما حطينا إشارة المتجه لأنه اتجاه واحد

As asum:
$$\Delta \vec{r} = \vec{v}_o t + \tfrac{1}{2} \vec{a} t^2$$
$$\vec{v} = \vec{v}_o + \vec{a} t$$
$$v^2 = v_o^2 + 2 a \cdot \Delta r$$

*حطينا سهم المتجه لأنه إله مركبة سينية وصادية.

v.v

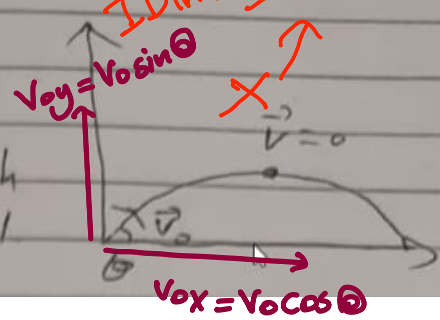
*ما في إشارة متجه لأنه الضرب نقطي. والضرب النقطي بيعطي كمية قياسية (scalars).

---

*فقط في 1Dim

## * Projectile Motion:

Here a particle is projected with $\vec{V}_o$ at angle $\theta$ above horizontal




*التسارع السيني = صفر فش قوة مأثرة غير الجاذبية وهي على (y).

① X - Motion:

No $a_x$, $V_{ox} = V_o \cos\theta = \text{const}$

صفر

السرعة السينية ثابتة

$$V_x = V_{ox} + a_x t \Rightarrow V_x = V_{ox} = V_o \cos\theta$$

$$\Delta x = V_{ox} t + \tfrac{1}{2} a_x t^2 \Rightarrow \Delta x = (V_o \cos\theta)\, t$$

*السرعة السينية = صفر

(2) y-motion:-

$a = -g$ , $V_{oy} = V_o \sin\theta$.

$V_y = V_{oy} + a_y t \Rightarrow V_y = V_{oy} - gt$

also $\Delta y = V_{oy}t - \frac{1}{2}gt^2$

$V_y^2 = V_{oy}^2 - 2g\Delta y$.

(3) Special cases:-

(a) max. height:- $V_y = 0$

موجبة من برة

$\Rightarrow V_y = V_{oy} - gt \Rightarrow \boxed{t_{max} = \frac{V_{oy}}{g}}$

$V_y^2 = V_{oy}^2 - 2g\Delta y \Rightarrow \boxed{\Delta y_{max} = V_{oy}^2 / 2g}$

(b) Range: $t_{total} = 2t_{max} = \frac{2V_{oy}}{g}$

الزمن الكلي × السرعة

$\Rightarrow X_{total} = R = V_{ox} * \frac{2V_{oy}}{g} = \frac{2 V_o \cos\theta * V_o \sin\theta}{g}$

or $\boxed{R = \frac{V_o^2 \sin 2\theta}{g}}$

المسافة الأفقية الكلية التي قطعها الجسم (المدى)

$R_{max} = \frac{V_o^2}{g}$ when $\theta = 45°$

أكبر قيمة عندما

## Ex: 3-6

A long jumber leaves the ground with $\theta = 20^\circ$ at a speed of $v_0 = 11$ m/s

(a) How long does it take him to reach max. height ($t_{max}$)

(b) $y_{max} = ?$

(c) $R = ?$

(a) $t_{max} = \dfrac{v_{oy}}{g} = \dfrac{v_0 \sin\theta}{g} = \dfrac{11 \sin 20}{9.8} = 0.384$ s.

(c) $R = \dfrac{v_0^2 \sin 2\theta}{g} = \dfrac{(11)^2 \sin 40}{9.8} = 7.94$ m.

(b) $y_{max} = \dfrac{v_{oy}^2}{2g} = \dfrac{v_0^2 \sin^2\theta}{2g} = \dfrac{(11)^2 \sin^2 20}{2 \times 9.8} = 0.722$ m

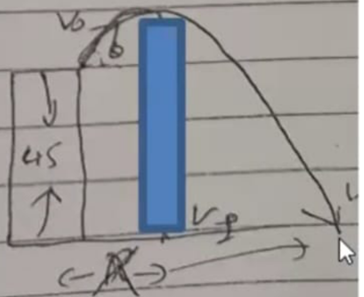
## Ex 3-8

A ball is thrown upward from the top of a building at $\theta = 30^\circ$ with $v_0 = 20$ m/s. The point of release is 45 m above earth.

(a) How long does it take the ball to hit the ground?

(b) Find $v$ at impact. ($v_f$)

(c) Find $x_R = ?$




*اما بنختم القوانين فوقه لانه نزل عن المستوى الي قذف منه .

5

Soln:

(a) $\Delta y = v_{oy} t - \frac{1}{2} g t^2$

بعوض على المعادلة المناسبة

$-45 = (20 \sin 30) t - \frac{1}{2} \times 9.8 \times t^2$

$\Rightarrow t = 4.22$ s.

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

$v_x = v_{0x} = v_0 \cos\theta = 17.3 \text{ m/s}$.

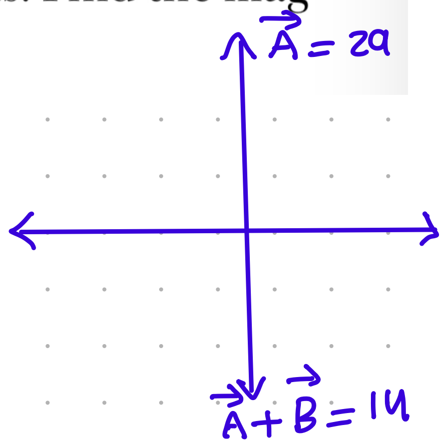
$v_y = v_{0y} - gt = 10 - 9.8 \times 4.22 = -31.4 \text{ m/s}$

$\Rightarrow v = \sqrt{(17.3)^2 + (-31.4)^2} = 35.9 \text{ m/s}$.

(c) $\Delta x = (v_0 \cos\theta)\, t$
$= (17.3)(4.22) = 73.1 \text{ m}$

* problems:

**1.** Vector $\vec{\mathbf{A}}$ has a magnitude of 29 units and points in the positive $y$-direction. When vector $\vec{\mathbf{B}}$ is added to $\vec{\mathbf{A}}$, the resultant vector $\vec{\mathbf{A}} + \vec{\mathbf{B}}$ points in the negative $y$-direction with a magnitude of 14 units. Find the magnitude and direction of $\vec{\mathbf{B}}$.



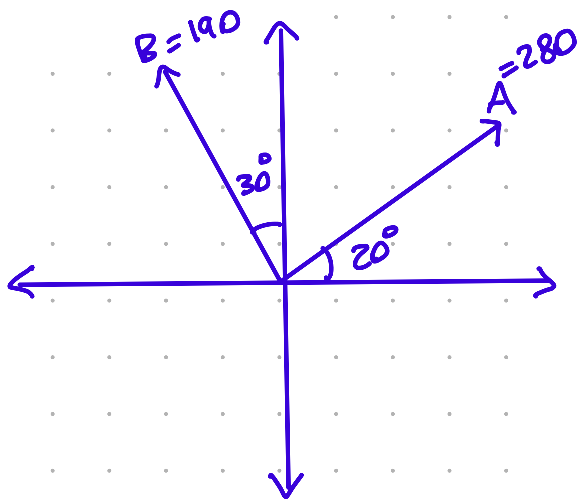

$\Rightarrow \quad A + \vec{B} = -14$ → لأنه (−y)

$29 + B = -14$

$B = -43 (-y)$

---

**7.** A plane flies from base camp to lake A, a distance of 280 km at a direction of 20.0° north of east. After dropping off supplies, the plane flies to lake B, which is 190 km and 30.0° west of north from lake A. Graphically determine the distance and direction from lake B to the base camp.




$(x)\,total = A_x + B_x$

$= A\cos\theta + B\sin\theta$ → (x−)

$= 280\cos 20 + -190\sin 30$

$= 168.11$ Km

$(y)\,total = A_y + B_y$

$= A\sin 20 + B\cos 30$

$= 280\sin 20 + 190\cos 30$

$= 260.3$ Km

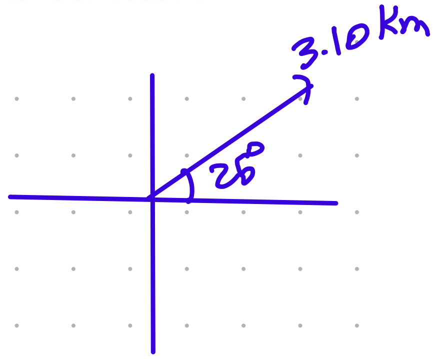
$R = \sqrt{(x)_t^2 + (y)_t^2}$

$= 310$ Km

$\theta = \tan^{-1}\dfrac{(y)_t}{(x)_t}$

$= 57.1$

**10.** A person walks 25.0° north of east for 3.10 km. How far due north and how far due east would she have to walk to arrive at the same location?




$r_x = r\cos 25$

$= 3.10 \cos 25$

$= 2.8$ Km

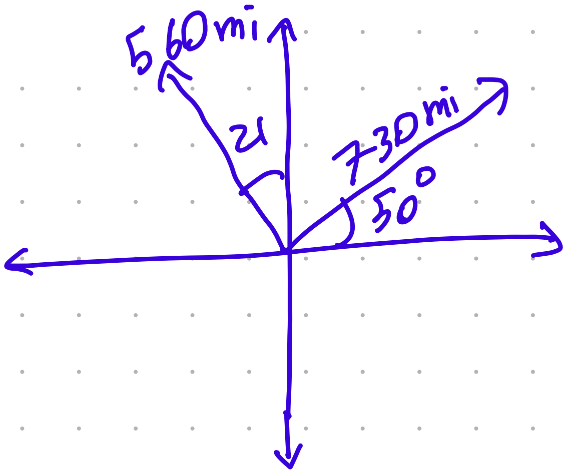
$r_y = r\sin 25$

$= 3.10 \sin 25$

$= 1.3$ Km

---

**18.** A map suggests that Atlanta is 730 miles in a direction 5.00° north of east from Dallas. The same map shows that Chicago is 560 miles in a direction 21.0° west of north from Atlanta. Figure P3.18 shows the location of these three cities. Modeling the Earth as flat, use this information to find the displacement from Dallas to Chicago.




$(X)_t = 730 \cos 5 - 560 \sin 21$

$= 526.5$ mi

$(Y)_t = 730 \sin 5 + 560 \cos 21$

$= 586.4$ mi

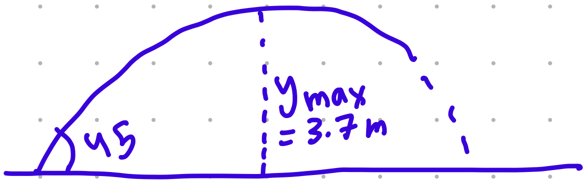
$R = \sqrt{(X)_t^2 + (Y)_t^2}$

$= 788.1$ mi

$\theta = \tan^{-1} \dfrac{(Y)_t}{(X)_t}$

$= 47.5$

**25.** The best leaper in the animal kingdom is the puma, which can jump to a height of 3.7 m when leaving the ground at an angle of 45°. With what speed must the animal leave the ground to reach that height?




$$y_{max} = \frac{(V_{oy})^2}{2g}$$

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

$$3.7 = \frac{(V_o \sin 45)^2}{2 \times 10}$$

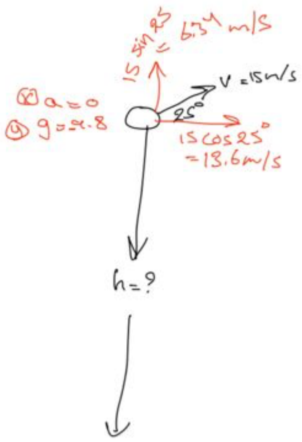
$$3.7 = \frac{\left(V_o \times \frac{\sqrt{2}}{2}\right)^2}{20}$$

$$74 = V_o^2 \times \frac{2}{4}$$

$$V_o = 12.1 \text{ m/s}$$

---

**29.** A brick is thrown upward from the top of a building at an angle of 25° to the horizontal and with an initial speed of 15 m/s. If the brick is in flight for 3.0 s, how tall is the building?




$V_o = 15$ m/s
$\theta = 25°$
$t = 3$ sec
$g = -9.8$ m/s

$* \; V_x = V \cos 25$
$= 15 \times 0.904$
$= 13.6$ m/s

$V_y = V \sin 25$
$= 15 \times 0.422$
$= 6.34$ m/s

$y = V_y \times t + \frac{1}{2} g t^2$
$y = 6.34 \times 3 + \frac{1}{2} \times (-9.8) \times 9$
$y = 19.04 - 44.1$
$y = -25.0$
$y \approx -25$

$h = x - y$
$h = 0 - -25$
$h = 25$ m

$$\Delta y = V_{oy} t - \frac{1}{2} g t^2$$

$$= V_o \sin \theta \times t - \frac{1}{2} g t^2$$

$$= 15 \sin 25 \times 3 - \frac{1}{2} \times 10 \times (3)^2$$

أو $= -25$ m

نزول

# * Ch. 4
# * Newton's Laws of Motion. ‏* قوانين نيوتن للحركة.
‏علهم بتعلقوا بالقوة.

## * Forces :-
‏قوى الاتصال

4-1 Those can be :-

a) contact forces:- result from physical Contact btwn two objects. ‏* تنشئ من اتصال فين ياني بين الجسمين. (دفع أو سحب)

‏القوى المجالية

b) Field forces: such as electromagnetic forces, gravitational forces. ‏قوى كهرومغناطيسية ‏قوى الجاذبية

* ($\vec{F}$) is a vector, measured in (Newtons)

## 4-2 Newton's 1st Law :
‏حفظ القصور الذاتي

‏* القصور الذاتي → Inertia

It is not the nature of an object to stop once set in motion, but rather to continue in its original state of motion, so Newton's 1st law statesmat:

[An object moves with a velocity that is const in magnitude and direction unless a non zero net force acts on it.]

* Mass and Inertia :- ‏* القصور الذاتي يتناسب طردياً مع كتلة الجسم

The tendency of an object to continue in its original state of Motion is called Inertia.

So mass is a measure of inertia. → ‏الكتلة مقياس القصور الذاتي.

## 4-3 Newton's 2ed law:-
‏* اذا أثرت قوة على جسم فإنها تكسبه تسارعاً يتناسب طردياً مع القوة وعكسياً مع الكتلة.

‏تناسب طردي

[The accel. of an object is directly proportional to the net force acting on it, and inversely propor. to the mass of the object.]

‏* كل ما زادت القوة يزداد التسارع بثبوت الكتلة والعكس صحيح.

‏تناسب عكسي.

$$\vec{a} = \frac{\sum \vec{F}}{m} \quad \text{or} \quad \sum \vec{F} = ma \quad (N)$$

Vectors القوة والتسارع متجهات

اذا في مركبات $(x, y, z)$

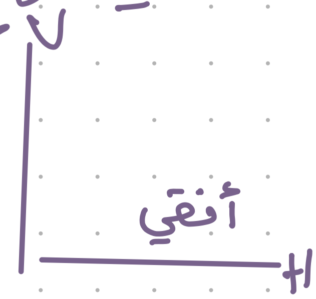
تحليل

This can be analyzed to:-

$$\sum F_x = m a_x$$
$$\sum F_y = m a_y$$
$$\sum F_z = m a_z$$

$(1N = 1kg \cdot m/s^2)$

$(1N = 0.225\ Lb)$




✓ Ex 4-1 An airboat of mass $3.5 \times 10^2$ kg has engine producing a horizontal force $F = 7.7 \times 10^2$ N.

a) Find $\vec{a}$ of the boat

b) Starting from rest how long does it take the boat to reach a speed of 12 m/s

c) After reaching that speed, the engine is put off & so the boat stops over a distance of 50 m. Find the resistance force

Soln.

(a) $F_{net} = ma \Rightarrow a = \frac{F_{net}}{m} = \frac{7.7 \times 10^2}{3.5 \times 10^2} = 2.2\ m/s^2$

(b) $v = v_0 + at$

$12 = 0 + (2.2)t \Rightarrow t = 5.45$ sec

(c) $v^2 = v_0^2 - 2a\Delta x \Rightarrow 0 = 12^2 - 2a(50) \Rightarrow a = -1.44\ m/s^2$

$F = ma = (3.5 \times 10^2)(-1.44) = -504\ N.$

## ★ Gravitational Force :

★ أي جسمين الهم كتلة وبينهم مسافة معينة بكونه بيهم قوى تجاذب.

⇒ This is a mutual force betwn 2-objects, where Newton's Law of gravitation is : (دايمًا تجاذب)

اختصار

$$F_g = G \frac{m_1 m_2}{r_2} \quad \text{always attraction.}$$

$G \equiv$ universal gravitation const. ثابت الجذب العام

$= 6.67 \times 10^{-11}\ N \cdot m^2/kg^2$

★ $r^2 =$ المسافة من مركز الجسم (1) لمركز الجسم (2).

## * Weight.

الوزن قوة أرض

$W = mg$ , $W = G\frac{M_E m}{r_e^2}$

كتلة الأرض

نق الأرض

$\Rightarrow g = G\frac{M_E}{r_e^2} \approx 9.8\ m/s^2$ near earth surface.

الكتلة نفسه
الوزن يختلف

$g_{moon} = 1.62\ m/s^2$ *يقل الوزن عالقمر / لأنه اقل كتلة من الأرض

$g_{sun} = 274\ m/s^2$ * أكبر من الأرض بكثير .

Ex 4-3

(a) Find the gravitational force exerted by the sun on a 70 Kg man at earth's equator at noon, [closest to the sun].

Soln. $F_{sun}^{noon} = \frac{m M_s G}{r^2} = \frac{m M_s G}{(r_s - R_E)^2} = \frac{70 \times 1.991\times10^{30}(6.67\times10^{-11})}{(1.496\times10^{11} - 6.38\times10^{6})^2}$

$= 0.41540\ N$.

b) Calculate the gravitational force of sun on a at midnight. (farthest from sun)

$F_{sun}^{mid} = \frac{G m M_s}{r^2}$

$= \frac{G m M_s}{(r_s + R_E)^2} = 0.41533\ N$

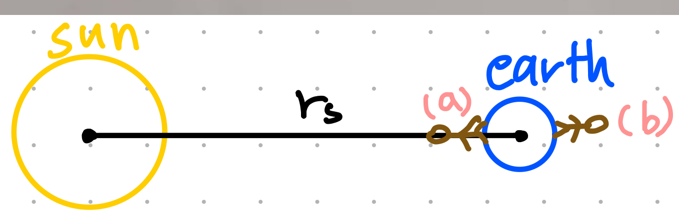
(c) Calculate the difference in man's accel. btw noon & ////.

midnight

$a = \frac{F_{sun}^{noon} - F_{sun}^{mid}}{m} = 1\times10^{-6}\ m/s^2$

نفس الكتلة

رسمة السؤال



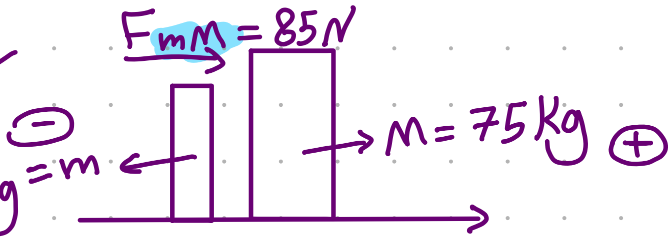
4-2

# Nwton's $3^{rd}$ law:

[At equil.] For each action, there is equal but opposite reaction.

$$\Rightarrow \vec{F}_{12} = -\vec{F}_{21} \qquad \Sigma \vec{F} = 0$$

Exe: (4-5) ص ١٥




a) $a = ?$

$$\Sigma F = M a_M$$
$$85 = 75 a_M$$
$$\Rightarrow a_M = 1.13 \, m/s^2$$

b) $F_{Mm} = -85N$

c) $a_m = ?$

$$\Sigma F = m a_m$$
$$-85 = 55 a_m$$
$$a_m = 1.55 \, m/s^2$$

## 4-5 Application of Newton's laws:

* objects in equil:

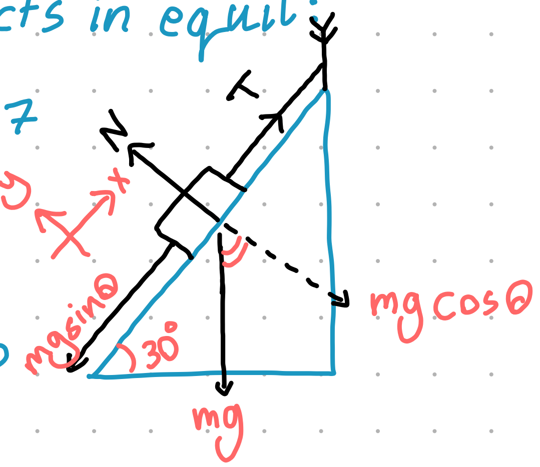
Ex 4-7

$N = ?$

$T = ?$

$\Sigma F_x = 0$

$\Sigma F_y = 0$

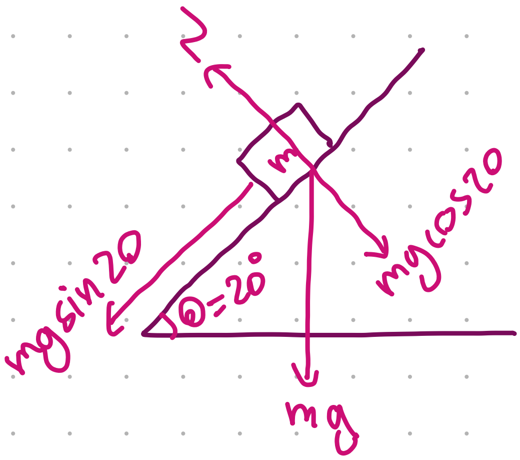



$$T - mg\sin\theta = 0$$
$$T = mg\sin\theta \quad (1)$$
$$= 38.5N$$

$$N - mg\cos\theta = 0$$
$$\Rightarrow N = mg\cos\theta$$
$$= 66.7N$$

## ★★ Accelerating objects:

Ex: 4-9




a) $a = ?$

$\Sigma F = ma$

$\cancel{m}g\sin\theta = \cancel{m}a$

$\Rightarrow a = 3.35\ m/s^2$

b) $\Delta X = 25\,m$

$V_0 = 0$

$t = ?$

$\Rightarrow \Delta X = V_0 t + \frac{1}{2} a t^2$

$25 = 0 + \frac{1}{2}(3.35)(t^2)$

$\Rightarrow t = 3.86\,s$

c) $V = ?$

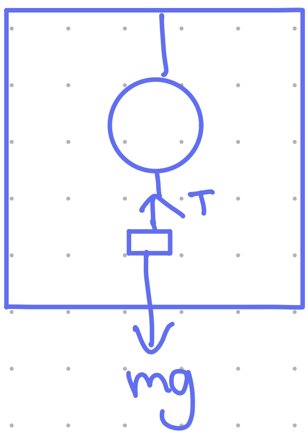
$V = V_0 + at$

$= 0 + (3.35)(3.86)$

$= 12.9\ m/s$

---

Ex 4-10




$mg = W_0 = 40N$

$W_1 = ?\ ,\ a = 2m/s^2$ up

$\Sigma F = ma$

$T - mg = ma$

$T = mg + ma$

$= 40 + (4*2) = 48N$

b) $W_2 = ?$ if $a = -2m/s^2$

$\Sigma F = ma$

$T - mg = ma$

$T = mg + ma$

$= 40 + (4)(-2)$

$= 32N$

## * The normal force and atmospheric pressure :-

* قوة رد الفعل العمودية تعاكس الضغط الجوي .

⇒ The normal force opposes the atmospheric pressure .

⇐ رد الفعل عمودي للخارج

⇐ الضغط عمودي للداخل .

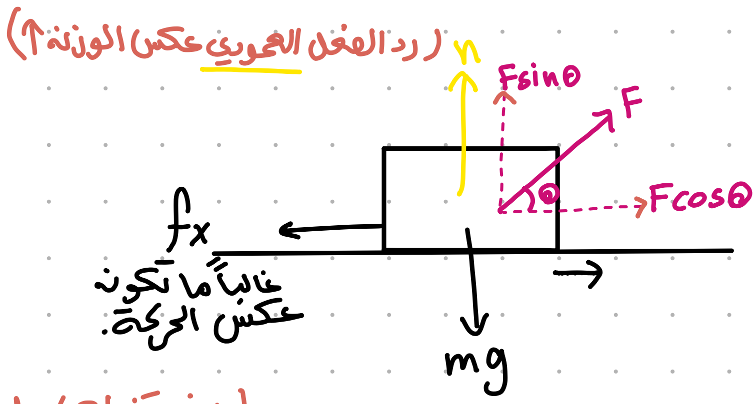
$\theta = 180$ : سطح مستوٍ

## 4-6 The forces of friction :

### 1) Force of Kinetic friction.

$f_k = \mu_k n$ when $\mu_k < 1$ Kinetic coefficient of friction.

For an object as shown :



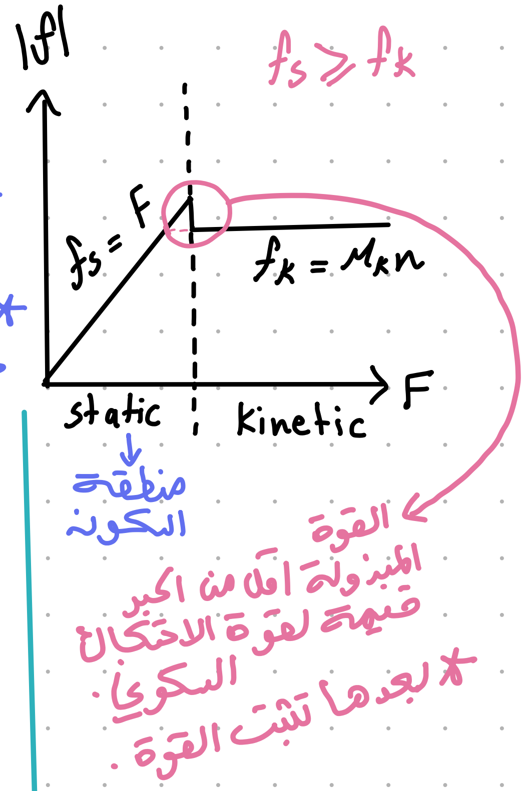

$$n + F\sin\theta = mg$$
$$\Rightarrow n = mg - F\sin\theta$$
متزنة عامودياً

* $F\cos\theta - f_k = ma$ ((نيوتن 2 على (x))
$$F\cos\theta - \mu_k n = ma$$
$$F\cos\theta - \mu_k(mg - F\sin\theta) = ma$$
$$\Rightarrow a = \dots\dots\dots$$

* كلما زدنا القوة تزداد قوة الاحتكاك .

الجسم لم يتحرك ⇐ قوة احتكاك سكوني .

* بعد بذل قوة كافية تتغلب على قوة الاحتكاك تنتقل من حالة السكون إلى الحركة.

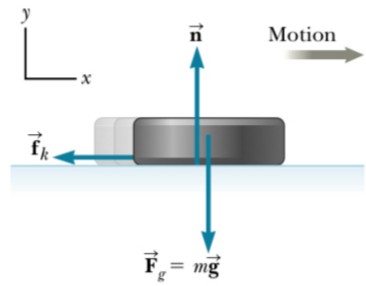



### 2) static friction forces :

$$f_{s_{max}} = \mu_s n \ , \quad 0 \leq f_s \leq f_{max}$$

## ■ EXAMPLE 4.13 The Sliding Hockey Puck

**GOAL** Apply the concept of kinetic friction.




**PROBLEM** The hockey puck in Figure 4.24, struck by a hockey stick, is given an initial speed of 20.0 m/s on a frozen pond. The puck remains on the ice and slides $1.20 \times 10^2$ m, slowing down steadily until it comes to rest. Determine the coefficient of kinetic friction between the puck and the ice.

$\downarrow$ $v_f = 0$

$v_0 = 20\,m/s, \quad v_f = 0, \quad \Delta x = 1.2\times10^2\,m$

$\Rightarrow v^2 = v_0^2 + 2a\Delta x$

$a = \frac{v^2 - v_0^2}{2\Delta x} = \frac{(0 - (20)^2)}{2\times(1.2\times10^2)} = 1.67\,m/s^2$

$n = mg$

$\Sigma F_x = ma \Rightarrow f_k = ma$

لأنه عكس اتجاه الحركة $\leftarrow$ $-\mu_k n = ma$

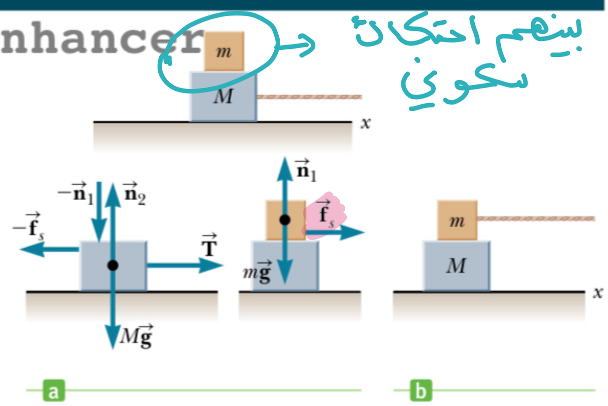
$-\mu_k mg = ma$

$\Rightarrow \mu_k = \frac{a}{g} = 0.17$ صح لأنه لازم يكونه اقل من (1)

## ■ EXAMPLE 4.15 Two Blocks and a Cord

**GOAL** Apply Newton's second law and static friction to a two-body system.






$\rightarrow$ بيفهم احتكاك سكوني

**PROBLEM** A block of mass $m = 5.00$ kg rides on top of a second block of mass $M = 10.0$ kg. A person attaches a string to the bottom block and pulls the system horizontally across a frictionless surface, as in Figure 4.26a. Friction between the two blocks keeps the 5.00-kg block from slipping off. If the coefficient of static friction is 0.350, **(a)** what maximum force can be exerted by the string on the 10.0-kg block without causing the 5.00-kg block to slip? **(b)** Use the system approach to calculate the acceleration.

* حسبت التسارع من F المؤثرة على m عشان ما فش اي مجهول.

a) $\Sigma F_x = ma \Rightarrow f_s = ma$

$\mu_s n_1 = ma$ تسارع الكبيرة والصغيرة

$\Sigma F_y = 0 \Rightarrow n_1 = mg$ $\uparrow$

$\Rightarrow \mu_s(mg) = ma \Rightarrow a = \mu_s g = 0.35 * 9.8 = 3.43\,m/s^2$

For The x-motion of the total system :-

$\Sigma F_x = Ma$

$T - f_s = Ma$ $\leftarrow$ التسارع يلزم

$T - \mu_s mg = Ma \Rightarrow T = Ma + \mu_s mg = 51.5\,N$

b) From the relation $T = (m+M)a$

$a = \frac{T}{m+M} = \frac{51.5}{15} = 3.43\,m/s^2$

**3.** A 6.0-kg object undergoes an acceleration of 2.0 m/s$^2$. (a) What is the magnitude of the resultant force acting on it? (b) If this same force is applied to a 4.0-kg object, what acceleration is produced?

a) $m = 6\,kg$ , $a = 2\,m/s^2$

$F = ma$
$= 6 * 2 = 12\,N$

b) $F = ma$
$\Rightarrow 12 = 4 * a$
$a = 3\,m/s^2$

**7.** A 75-kg man standing on a scale in an elevator notes that as the elevator rises, the scale reads 825 N. What is the acceleration of the elevator?

$\Sigma F = ma$
$T - mg = ma$
$825 - (75 * 9.8) = 75 * a$
$a = 1.2\,m/s^2$

* المصعد بسحب لفوق عكس الجاذبية

**18.** BIO A certain orthodontist uses a wire brace to align a patient's crooked tooth as in Figure P4.18. The tension in the wire is adjusted to have a magnitude of 18.0 N. Find the magnitude of the net force exerted by the wire on the crooked tooth.

Figure P4.17

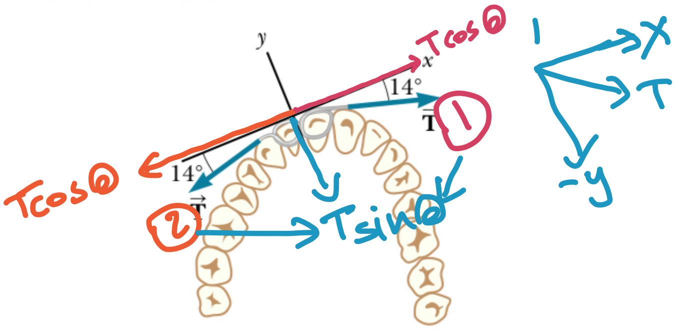



Figure P4.18

* القوى الأفقية تلغي بعضها

$\Rightarrow \Sigma F_x = 0$

$\Rightarrow T_y = -T\sin\theta$
$= -18\sin(14^\circ)$
$= 4.35\,N$

* بما أنه في قوتين Fy وبنفس الاتجاه بنضرب في ②

$\Rightarrow F_{net} = 2 \times T_y$
$= 2 \times 4.35 = 8.71\,N$

بس بدي نحطها لأنه سؤال جابي

**20.** BIO The leg and cast in Figure P4.20 weigh 220 N ($w_1$). Determine the weight $w_2$ and the angle $\alpha$ needed so that no force is exerted on the hip joint by the leg plus the cast.

$\Rightarrow F_{x1} = 110\cos(40^\circ)$
$= 84.2\ N$

$F_{y1} = 110\sin(40^\circ)$
$= 70.7\ N$

★ The sum of the horizontal forces should be zero.

$$\boxed{F_{x1} = F_{x2}}$$

★ The sum of the vertical forces should be zero:

$F_{y1} - w_1 = F_{y2}$

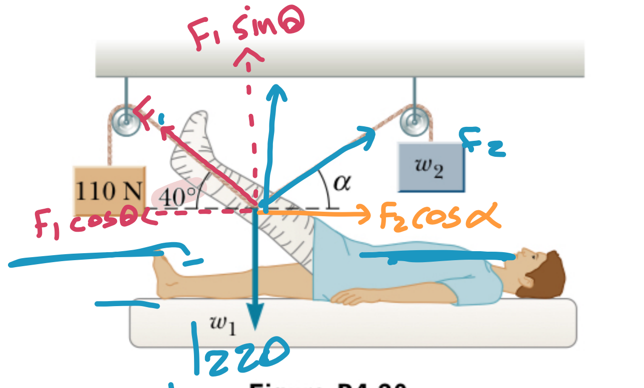



Figure P4.20

$\Sigma F_x = 0$

$F_{x1} = F_{x2} \rightarrow F_2\cos\theta$

$84.2 = w_2\cos\alpha$ — ①

$\Sigma F_y = 0$

$F_{y2} = w_1 - F_{y1}$ — ②

$w_2\sin\alpha = 220 - 70.7$

② ÷ ①

$$\frac{\cancel{w_2}\sin\alpha}{\cancel{w_2}\cos\alpha} = \frac{149.3}{84.2} \quad \tan^{-1}$$

$\alpha = 61^\circ$

نعوض في اي معادلة

$w_2 = 1.7 \times 10^2\ N$

**28.** Two packing crates of masses 10.0 kg and 5.00 kg are connected by a light string that passes over a frictionless pulley as in Figure P4.28. The 5.00-kg crate lies on a smooth incline of angle 40.0°. Find (a) the acceleration of the 5.00-kg crate and (b) the tension in the string.

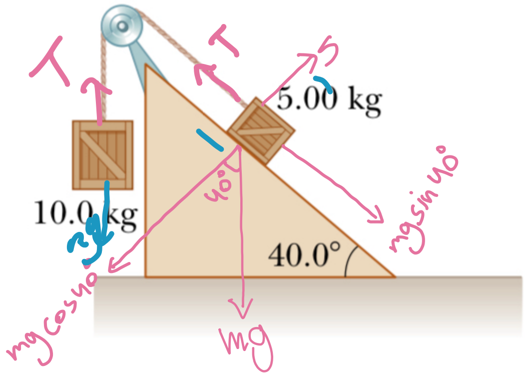



**Figure P4.28**

$m_1 = 5$ Kg
$m_2 = 10$ Kg
$\theta = 40°$

$$\Sigma F = ma$$

a) $\Rightarrow m_1 g - T = m_1 a$

$$98.1 - T = 10a \quad — ①$$

$\Rightarrow T - F_{down} = m_2 a$

$\Rightarrow m_2 g \sin\theta$

$\star\ F_{down} = 5 \times 9.81 \times \sin(40°) \approx 31.5N$

$$T - 31.5 = 5a$$

$$T = 5a + 31.5 \quad — ②$$

★ نعوض ② في ①

$\Rightarrow 98.1 - (5a + 31.5) = 10a$

$$a = 4.44 m/s^2$$

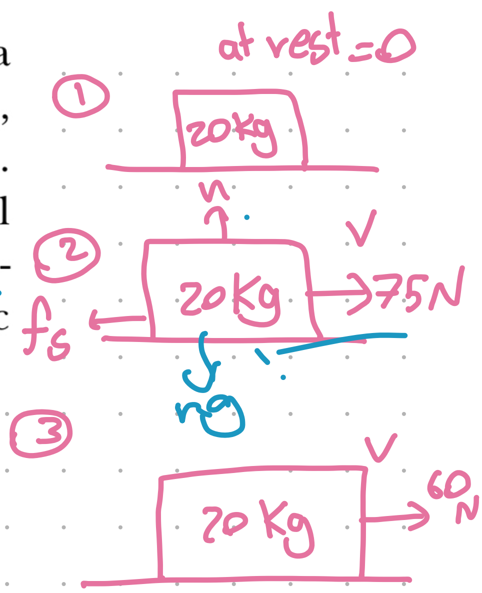
b) $T = 5a + 31.5$

$= 5(4.44) + 31.5$

$= 53.7 N$

**39.** A dockworker loading crates on a ship finds that a 20-kg crate, initially at rest on a horizontal surface, requires a 75-N horizontal force to set it in motion. However, after the crate is in motion, a horizontal force of 60 N is required to keep it moving with a constant speed. Find the coefficients of static and kinetic friction between crate and floor.






① $\Sigma F = ma$  $f_{s\,max} = 75N$

$f_s - F = ma$

$\mu_s n - F = ma$

$\mu_s(20\times9.81) - 75 = 20 * 3.75$

$\mu_s = 0.38$

$F = ma$

$75 = 20$

$= 3.75\ m/s^2$

② $\Sigma F = ma$

$f_k - F = ma$

$\mu_k n - F = ma$ → سرعة ثابتة يعني $a =$

$\mu_k(20\times9.81) - 60 = 0$

$\mu_k = 0.31$

---

$f_{s\,max} = \mu_s n$  $f_s = f_s(max)$  $n = mg$

$\mu_s = \dfrac{f_{s(max)}}{n} = \dfrac{75}{mg\,(20\times9.81)} = 0.38$

$f_k = \mu_k n$

$60 = \mu_k(mg)$

$\Sigma F_x = 0$

$60 - f_k = 0$

$f_k = 60$

$\mu_k = 0.31$

**41.** A 1 000-N crate is being pushed across a level floor at a constant speed by a force $\vec{\mathbf{F}}$ of 300 N at an angle of 20.0° below the horizontal, as shown in Figure P4.41a. (a) What is the coefficient of kinetic friction between the crate and the floor? (b) If the 300-N force is instead pulling the block at an angle of 20.0° above the horizontal, as shown in Figure P4.41b, what will be the acceleration of the crate? Assume that the coefficient of friction is the same as that found in part (a).

$W = 1000\,N\ (mg)$

$F = 300\,N$

$\theta = 20°$

* سرعة ثابتة = تسارع صفر

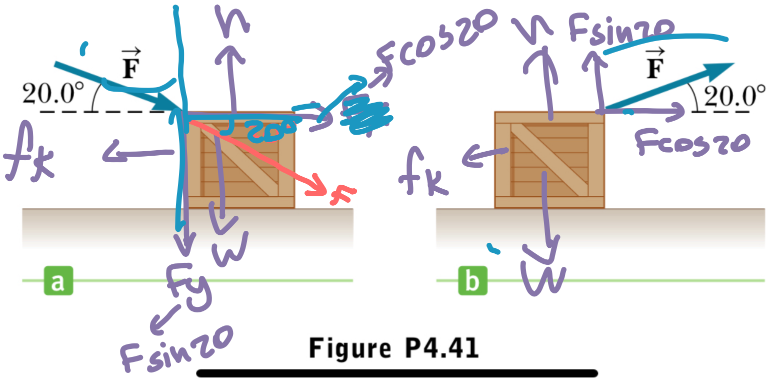



**Figure P4.41**

سرعة ثابتة

a)

$\Rightarrow F_x = F\cos\theta$
$= 300\cos 20$
$= 281.9\,N$

$\Sigma F_x = F\cos 20 - f_k = m a_x = 0$
$0 = 300\cos 20 - f_k$
$f_k$

$f_k = \mu_k n$
$282 = \mu_k\, 1.10 \times 10^3$
$\mu_k = 0.256$

$n = F\sin\theta + W$
$= 300\sin 20 + 1000$
$= 1.10 \times 10^3\,N$

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

b) $\Sigma F_x = F\cos 20 - f_k = ma$

$\Rightarrow 300\cos 20 - \mu_k n = m a$

$300\cos 20 - 0.256(W - F\sin\theta) = \frac{1000}{9.8}a$

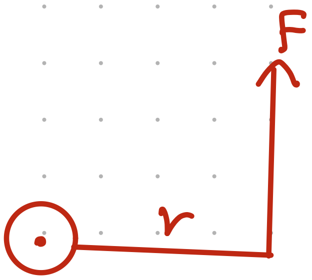
$300\cos 20 - 0.256(1000 - 300\sin 20) = \frac{1000}{9.81}$

$a = 0.509 \approx a = 0.51$

$n + F\sin 20 = W$

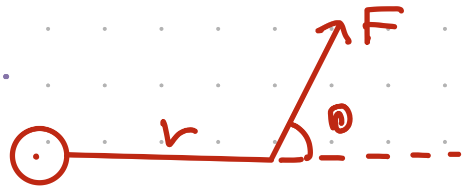
$n = W - F\sin 20$

# Ch. 8 Rotational equil
## 8-1 Torque:

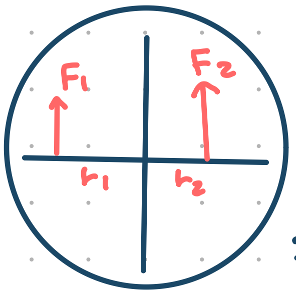



$\tau = rF$ (N.m)

$\tau = rF\sin\theta$ (N.m)




## Ex: 8-1




$F_1 = 625N$ / $F_2 = 850N$

$r_1 = 1.2\,m$ / $r_2 = 0.8$

$\Rightarrow \tau_1 = r_1 F_1$

$\ominus = 1.2 * 625 = 750$ (N.m)

$\Rightarrow \tau_2 = r_2 F_2 \oplus = (0.8)(850) = 680$ N.m

---

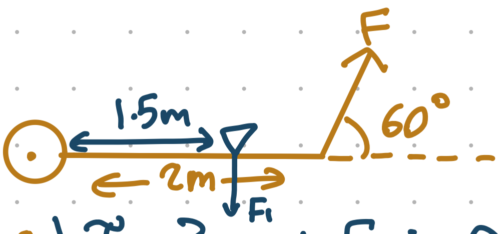
★ positive torque ⟹ if the object rotates counter clockwise and vice versa.

مع الساعة (-)

عكس الساعة (+)

## Ex 8-2

$F = 3 \times 10^2 N$




a) $\tau = ? = rF\sin\theta$

$= (2)(3 \times 10^2)\left(\frac{\sqrt{3}}{2}\right) = 5.2 \times 10^2$ (N.m)

b) $\tau_{net} = 0$

$\Rightarrow \tau_1 + \tau_2 = 0$

$\tau_1 = \tau_2$

$\rightarrow \tau_1 = r_1 F_1$

$5.2 \times 10^2 = 1.5 \times F_1$

$F_1 = 347\,N$

## 8-2 Torque and The 2- conditions of equil.

mechanical equil $\Rightarrow$ ① $\Sigma F = 0$
② $\Sigma \tau = 0$

* التوازن الميكانيكي :
$\Sigma F = 0 \quad \Sigma \tau = 0$

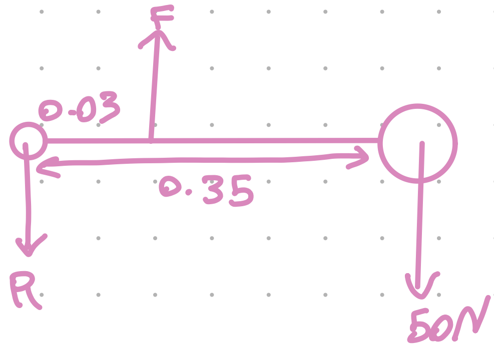
* التوازن الانتقالي :
$\Sigma F = 0$

* التوازن الدوراني :
$\Sigma \tau = 0$

### Ex 8-6

$mg = 50N$

$F = ? \quad R = ?$




$\Rightarrow \Sigma F = 0 \Rightarrow F - R - 50 = 0$

$F - R = 50$ — ①

$\Sigma \tau = 0 \Rightarrow \tau_{50} + \tau_R + \tau_F = 0$

$= -50(0.35) + 0 + F * 0.03 = 0$

$F = 583\ N$

$\Rightarrow$ نعوض في ①

$583 - R = 50$

$R = 533N$

---

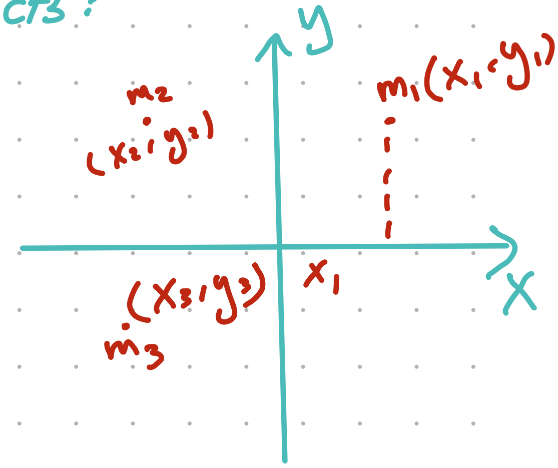
### 8-3 Ceneter of gravity

it is a point representing the whole object.

a) The center of mass of point objects:

$$X_{c.g} = X_{c.m} = \frac{m_1 x_1 + m_2 x_2 + \dots}{m_1 + m_2 + \dots}$$

$$y_{c.m} = y_{c.g} = \frac{m_1 y_1 + m_2 y_2 + \dots}{m_1 + m_2 + \dots}$$



★ العمود الفقري في حالة توازن دوراني وبالتالي $\sum\tau = 0$ عند النقطة (O).

★ لأنها على امتداد المحور $\tau_x = 0$ = صفر.

(عليهم فش $\tau$ $r=0$)

$$\sum \tau = 0$$

a) $+\tau_{T_y} - \tau_{350} - \tau_{200} = 0$

$$+T_y\left(\frac{2L}{3}\right) - \left(350 * \frac{L}{2} - 200 * L\right) = 0$$

$$T\sin 12^\circ\left(\frac{2\cancel{L}}{3}\right) = \cancel{350}\,\frac{\cancel{L}}{\cancel{2}} + 200\cancel{L}$$

★ (L) بعد توحيد المقامات بتروح

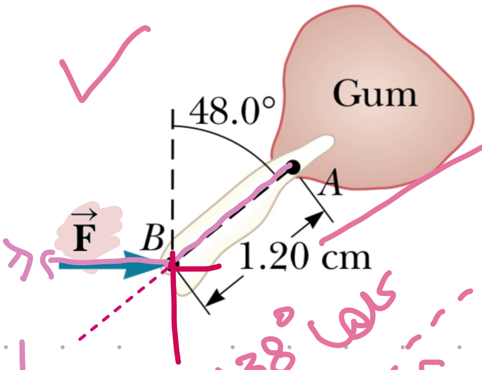
$$T\sin 12^\circ\left(\frac{2}{3}\right) = 175 + 200$$

$$T \approx 2706\,N$$

b) $\sum F_x = 0 \Rightarrow R_x - T_x = 0$

$$R_x = T_x = T\cos 12^\circ$$
$$= 2706\cos 12$$
$$= 2646.8\,N$$

**4.** **BIO** A dental bracket exerts a horizontal force of 80.0 N on a tooth at point *B* in Figure P8.4. What is the torque on the root of the tooth about point *A*?

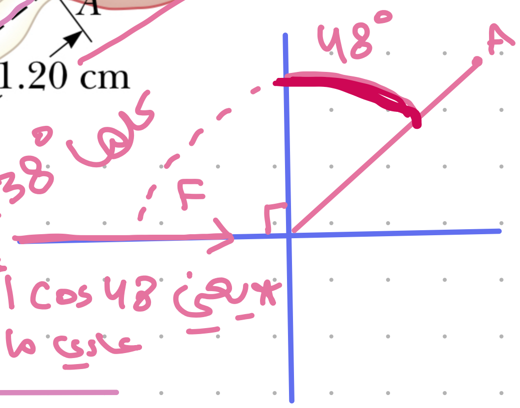



$\Rightarrow \tau = rF\sin\theta$ أو $\sin 138°$

$= 0.012 \times 80 \times \cos 48$

$= 0.642$ N.m (عكس الساعة)

كلها 138°




*يعني cos 48 أو sin 138 عادي ما بيفرقة

**6.** **S** Write the necessary equations of equilibrium of the object shown in Figure P8.6. Take the origin of the torque equation about an axis perpendicular to the page through the point *O*.

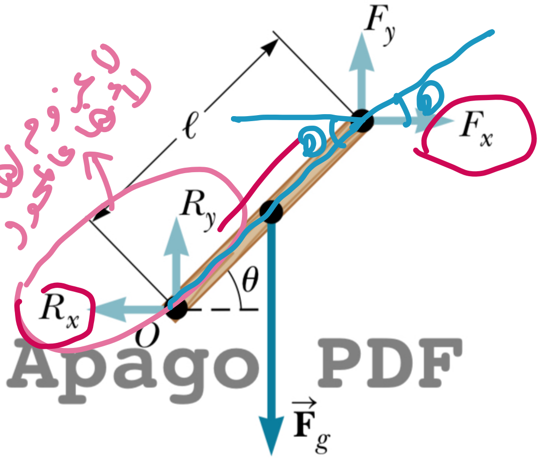




**Figure P8.6**

$\Sigma F_x = 0 \Rightarrow F_x - R_x = 0$

*حالة توازن انتقالي ودوراني.

$\Sigma F_y = 0 \Rightarrow F_y + R_y - F_g = 0$

$\Sigma \tau_o = 0 \Rightarrow F_y(L\cos\theta) - F_x(L\sin\theta) - F_g\left(\frac{L}{2}\cos\theta\right) = 0$

**9.** BIO A cook holds a 2.00-kg carton of milk at arm's length (Fig. P8.9). What force $\vec{F}_B$ must be exerted by the biceps muscle? (Ignore the weight of the forearm.)

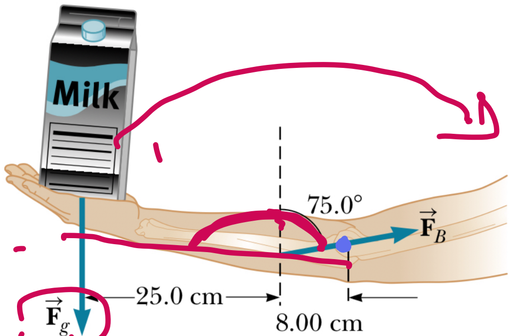
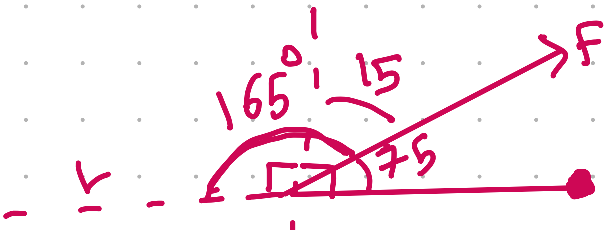



**Figure P8.9**




$90 - 75 = 15$

(F) $F_g$

$\tau_{F_g} = \tau_{F_B}$

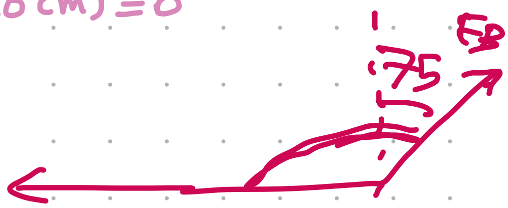
مطلوب انه تكون $(\Sigma\tau = 0)$ *

$\Sigma\tau = +[2 * 9.8](25\,cm + 8\,cm) - (F_B \cos 75°)(8\,cm) = 0$

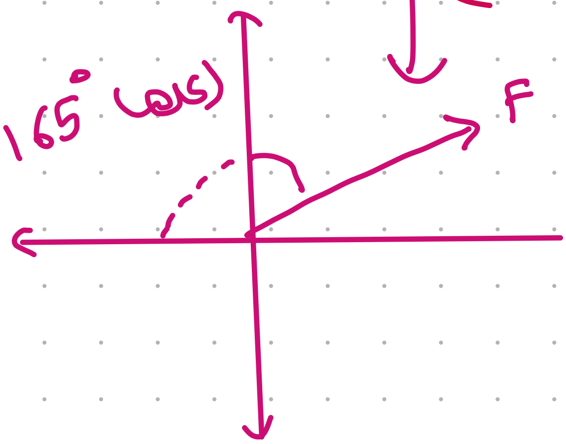
*$(\sin 90 = 1)$

$F_B = \frac{(19.6)(33)}{(8)\cos 75}$

$= 312\ N$




(165° عكس)




$\cos 75° = \sin 165°$

$\Sigma\tau = 0$

$F_g r \sin\theta + F_B \cos\theta = 0$

$(2 \times 10)(25+8)\sin 90 + F_B 8\cos 75$

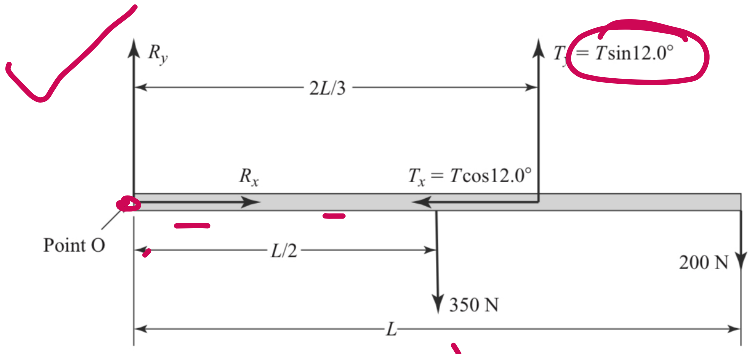
9.8 او

$660 + F_B * 8\cos 75$

$F_B = \frac{660}{8\cos 75}$

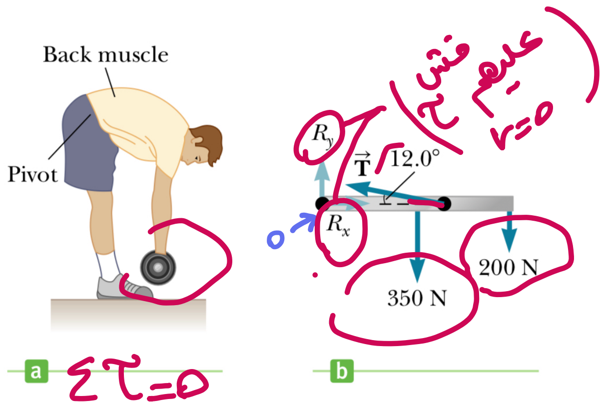
$= 318.7$

**17.** **BIO** A person bending forward to lift a load "with his back" (Fig. P8.17a) rather than "with his knees" can be injured by large forces exerted on the muscles and vertebrae. The spine pivots mainly at the fifth lumbar vertebra, with the principal supporting force provided by the erector spinalis muscle in the back. To see the magnitude of the forces involved, and to understand why back problems are common among humans, consider the model shown in Figure P8.17b of a person bending forward to lift a 200-N object. The spine and upper body are represented as a uniform horizontal rod of weight 350 N, pivoted at the base of the spine. The erector spinalis muscle, attached at a point two-thirds of the way up the spine, maintains the position of the back. The angle between the spine and this muscle is 12.0°. Find (a) the tension in the back muscle and (b) the compressional force in the spine.




★ العمود الفقري في حالة توازن دوراني
وبالتالي $\Sigma\tau = 0$ عند النقطة (O).

★ لأنها على امتداد $\tau_x = 0$ ★
المحور ⇒ صفر.




فش عليهم $\tau$
$r=0$

$\Sigma\tau = 0$

a) $+\tau_{T_y} - \tau_{350} - \tau_{200} = 0$

$+T_y\left(\frac{2L}{3}\right) - \left(350 * \frac{L}{2} - 200 * L\right) = 0$

$T\sin 12^\circ\left(\frac{2\cancel{L}}{3}\right) = \cancel{350}\frac{\cancel{L}}{\cancel{2}} + 200\cancel{L}$

★(L) بعد توحيد المقامات
بتروح

$T\sin 12^\circ\left(\frac{2}{3}\right) = 175 + 200$

$T \approx 2706\,N$

b) $\Sigma F_x = 0 \Rightarrow R_x - T_x = 0$

$R_x = T_x = T\cos 12^\circ$
$= 2706\cos 12$
$= 2646.8\,N$

**19.** **M** A 500-N uniform rectangular sign 4.00 m wide and 3.00 m high is suspended from a horizontal, 6.00-m-long, uniform, 100-N rod as indicated in Figure P8.19. The left end of the rod is supported by a hinge, and the right end is supported by a thin cable making a 30.0° angle with the vertical. (a) Find the tension $T$ in the cable. (b) Find the horizontal and vertical components of force exerted on the left end of the rod by the hinge.

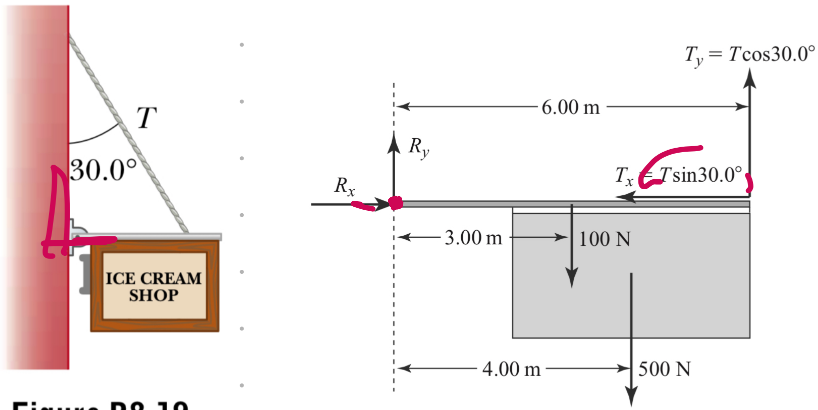



**Figure P8.19**

a) $\sum \tau = 0$ $\quad \tau_{T_y}$ $\quad \tau_{100\,N}$ $\quad \tau_{500\,N}$

$T_y\,(T * 6\cos 30) - 100 * 3 \sin 90 - 500 \times 4 \sin 90 = 0$ $\qquad \tau_{T_x} = 0 \to r = 0$

$T * 6\cos 30 = 300 + 2000$

$T = 443\,N$

أو بحلل (T)

b) $\sum F_x = 0 \to R_x = T_x$

$R_x = T\sin 30$

$= 443 \sin 30$

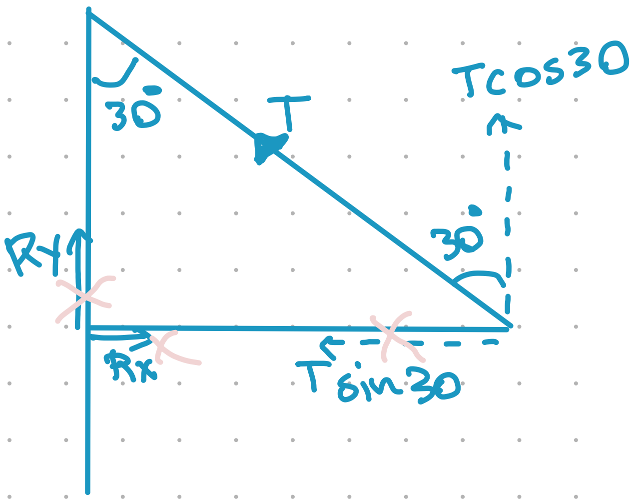
$= 222\,N$ (right)

$\sum F_y = 0$

$R_y + T\cos 30 - 100 - 500 = 0$

$R_y = 600 - 443\cos 30$

$= 216$ (upward)



# Ch. 9
# Solids and Fluids

## 9-1 states of matter. (الروابط بين الجزيئات قوية)

1) solid : has const. volume and shape.

2) Liquid : const. volume, but differ in shape.

3) gas : it has neither const. volume nor const. shape.

## 9-3

(إعادة تشكيل)

The deformation of solids.

1) young's modulus :

القوة على وحدة المساحة $\frac{F}{A}$ = stress → طردي مع القوة عكسي مع المساحة

* $\boxed{\text{strain}}$ is a measure of the stress

$\frac{F}{A} \propto \frac{\Delta L}{L_o}$

$\frac{F}{A} = Y \frac{\Delta L}{L_o}$

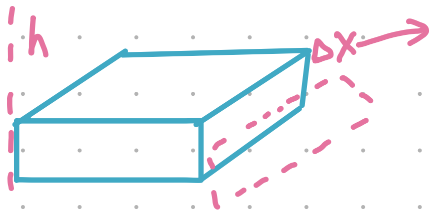
(الطول الأصلي)


(* table 9-3)

زيادة في الطول

$\star\ \Delta L = L_f - L_i$

2) shear modulus :




$\frac{F}{A} \propto \frac{\Delta X}{h}$

$\frac{F}{A} = S \frac{\Delta X}{h}$

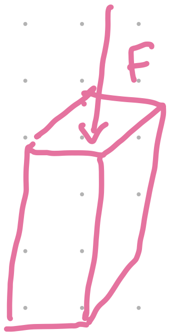
---

$Y = \frac{F}{A} \div \frac{\Delta L}{L_o} = \frac{F}{A} \times \frac{L_o (m)}{\Delta L (m)}$ $(N/m^2) \equiv Pa$ باسكال

★ كلما زاد معامل يونغ تزداد صعوبة كسر المادة إلى أجزاء.

## Ex 9-2

$F = 6 \times 10^4 \, N$




a) $L_o = 4m$

$A = 8 \times 10^{-2} m^2$

$$\Rightarrow \frac{F}{A} = Y \frac{\Delta L}{L_o}$$

$$\Delta L = \frac{F L_o}{A Y} = 1.5 \times 10^{-4} m$$

b) $F_{max} = ?$

$$\left(\frac{F}{A}\right)_{max} = 5 \times 10^8$$

$$F_{max} = \left(\frac{F}{A}\right)_{max} * A = 4 \times 10^6 N$$

$* \ \rho = \frac{m}{V}$

الكثافة = الكتلة / الحجم

---

## 9-2 Density of pressure.

$$\rho = \frac{m}{V} \quad \left(\frac{Kg}{m^3}\right)$$

V ← الحجم

$$1 g/cm^3 = \frac{10^{-3} kg}{10^{-6} m} = 10^3 kg/m^3$$

كثافة الماء

$$* \text{ specific gravity} = \frac{\rho_{material}}{\rho_{water}}$$

*(مالها وحدة زي $\mu_k$)

* pressure {P}

$P = \frac{F}{A}$ $\left[ \frac{N}{m^2} = Pa \right]$ ① ② باسكال

* كلما قلت المساحة يزداد الضغط .

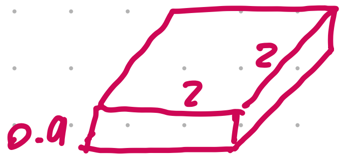
* mm Hg ③ or Atmosphere ④ .

Atmospheric pressure $P_0 = 1.013 \times 10^5$ Pas

---

طول عرض ارتفاع

Ex : a waterbed of sides $2 \times 2 \times 0.3$ is full of water.




a) $W = ?$

وزنة الماء .

$= mg$

$= \rho V g$

كثافة الماء معروفة وحجمه زي حجم ال Bed

$= 10^3 * (2 \times 2 \times 0.3)(9.8)$

$= 1.18 \times 10^4 N$

b) $P = ??$

$= \frac{F}{A}$ وزنة الماء

$= \frac{W}{A} = \frac{1.18 \times 10^4}{2 \times 2} = 2.95 \times 10^3 Pa$

مساحة القاعدة والقوة المؤثرة عليها نفسها Fg الماء .

## 9-4 Variation of pressure with depth:

(تغير الضغط مع العمق)

$P = \frac{F}{A}$

$\Rightarrow P_0 \equiv$ Atmospheric pressure.

$= 1.013 \times 10^5$ pas.

$= 760$ mmHg.

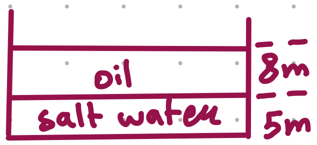
(الضغط المطلق)

$\boxed{* P = P_0 + \rho h g}$ *absolute pressure. → 2 *اذا الوعاء مفتوح

*الوعاء مغلق اذا لا يوجد $P_0$ ضغط جوي)

but if $P = \rho h g$ → gang pressure. (ضغط معياري)

### Ex 9-5




$*\rho_{oil} = 0.7 g/cm^3 = 0.7 \times 10^3 \, Kg/m^3$

$\rho_{s.w} = 1.025 g/m^3 = 1.025 \times 10^3 \, Kg/m^3$

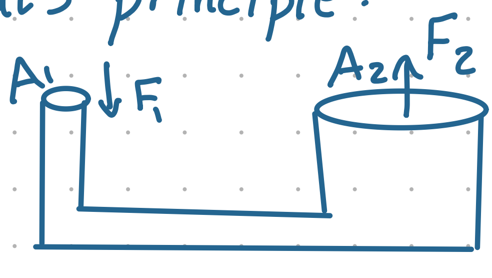
$\Rightarrow P = P_0 + P_{s.w} + P_{oil}$

$= 1 \times 10^5 + \rho_{s.w} * H_{s.w} * g + \rho_{oil} * H_{oil} * g$

$= 2.06 \times 10^5$ Pas

---

## * Pascal's principle.




$P_1 = P_2$

$\frac{F_1}{A_1} = \frac{F_2}{A_2}$

### Ex 9-7

$r_1 = 5cm$

$r_2 = 15 cm$

$F_2 = 13300 N$

$F_1 = ?$

a) $\frac{F_1}{\pi r_1^2} = \frac{F_2}{\pi r_2^2}$

$\frac{F_1}{\pi (5)^2} = \frac{13300}{\pi (15)^2} \Rightarrow F_1 = 1.48 \times 10^3 N$

*ما حولت لأنه ميلي ميلي بتروح.

تابع

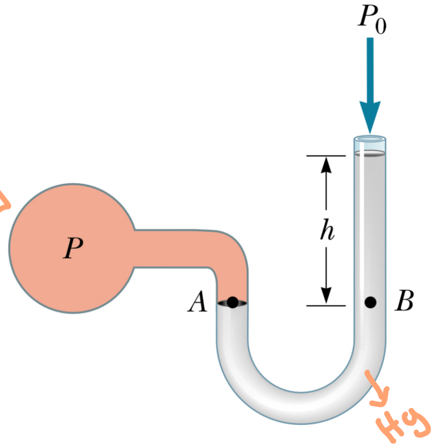
b) $P_1 = P_2 = \frac{F_1}{A_1} = \frac{F_2}{A_2}$

cm→m تحويل $= \frac{13300}{\pi(5\times10^{-2})^2} = 1.88\times10^{5}$ pas

---

## 9-5 pressure measurements.

1) open-tube-manometer.

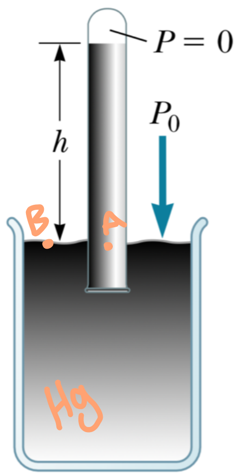



$P_A = P_B$

$P = P_0 + \rho h g$

---

2) Barometer




$P_A = P_B$

$P_A = P_0$

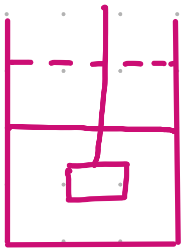
$\rho h g = P_0$

$(13.6\times10^{3})(0.76)(9.8) = 1.013\times10^{5}$ Pa

* الزئبق كثافته أكبر من الماء.
* لا يتبخر.
* سهل الرؤية.

(قوة الطفو)

## 9-6 Bouyant force and Archemides pripciple.



$V_o = V_{desplaced\ Liquid}$.   ★حجم الجسم = حجم السائل المزاح.

$W$ = weight of object in air.

$W'$ = " " " " Liquid.

$\Rightarrow B = W - W'$

$= \underset{\rho \times V}{mg}$ = weight of displaced Liquid.

$= \rho V g$

Liquid ← $\rho$ ; $V$ → object or displaced Liquid. متساويان

$\Rightarrow \frac{B}{W} = \frac{W-W'}{W}$   ($\div W$)

★ الكثافة هون أكبر من كثافة السائل.

$\frac{\rho_L \cancel{V_o} \cancel{g}}{\rho_o \cancel{V_o} \cancel{g}} = \frac{W-W'}{W}$

object ← $\rho_o$

★ اشتقاقه غير مطلوب.

$$\boxed{\frac{\rho_L}{\rho_o} = \frac{W-W'}{W}}$$ → for totally immersed objects.

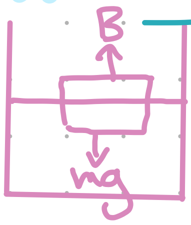
للأجسام المغمورة كلياً.

★ Partially immersed object.

$B = mg$

$\rho_L V_L g = \rho_o V_o g$

$\frac{\rho_L}{\rho_o} = \frac{V_o}{V_L}$




B → قوة الطفو

★ الجسم متزن.

★ الكثافة هون أقل من كثافة السائل.

★ حجم الجسم في هاي الحالة لا يساوي حجم الماء المزاح لأنه مغمور جزئياً.

## Ex-8

$W = 7.84\,N$

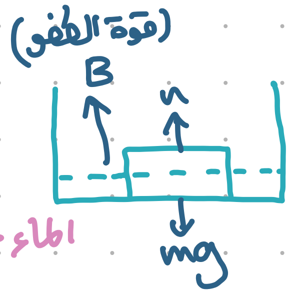
مغمور * $W_{in\ water} = W' = 6.86\,N$

$\rho_o = ??$

$$\Rightarrow \frac{\rho_L}{\rho_o} = \frac{W - W'}{W}$$

$$\frac{1000}{\rho_o} = \frac{7.84 - 6.86}{7.84} \Rightarrow \rho_o = 8 \times 10^3\ Kg/m^3.$$

## Ex-10




$m = 1 \times 10^3\ Kg$

الماء غطاه للنصف

a) $B + n = mg$

$$V = \frac{m}{\rho_{(AL)}} = 0.37\ m^3$$

$n = mg - B$

$= mg - \rho_L V_L g.$

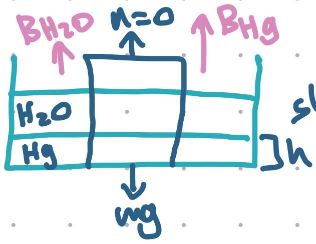
$= mg - \rho_L(\frac{1}{2}V_o)g.$

حجم الجسم الأصلي

$= 1 \times 10^3 \times 9.8 - 1 \times 10^3 (\frac{1}{2}(0.37)(9.8))$

$= 7.99 \times 10^3\ N$

b)




* مكعب

* قوتين طفو من الماء و الزئبق.

$mg = B_{Hg} + B_{H_2O}$

$= \rho_{Hg} V_{Hg} g + (B_{H_2O}) \longrightarrow$ من الفرع الأول

$= \rho_{Hg}(Ah)g + B_{H_2O}$

But $V_{AL} = L^3 \Rightarrow L = (V)^{\frac{1}{3}} = (0.37)^{\frac{1}{3}} = 0.718m$

$\Rightarrow A = L^2 = (0.718)^2$

$\Rightarrow h = 0.116m.$

## 9-7 Fluids in motion:

ideal Fluid: (مثالي)

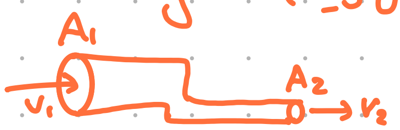
1. non viscous (عديم اللزوجة)
2. incompressible (غير قابل للانضغاط)
3. steady motion. (Laminar motion) (حركة ثابتة)
4. non turbulent. (سريان السائل يكون إنسيابي) (غير مضطرب)

★ equation of continuity: (معادلة الاستمرارية)

معدل التدفق

$AV = \frac{m^3}{s} \equiv$ flux rate

$A_1V_1 = A_2V_2$



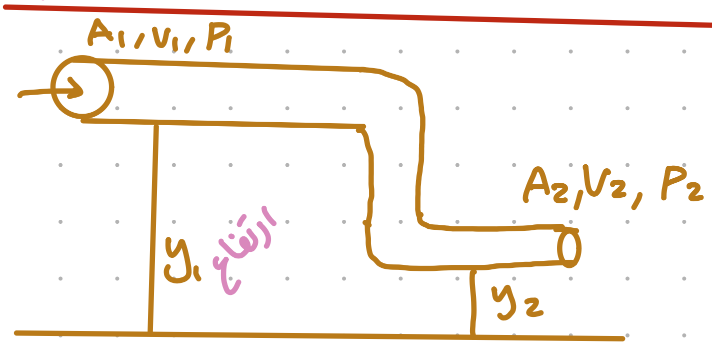

$A_1 > A_2$

$V_1 < V_2$

(Conservation of mass) (الكتلة)

★ تمثل حفظ كمية المادة.

(المادة إلي دخلت نفس كمية المادة إلي طلعت).




★ Bernoulli's equ :- معادلة برنولي (★حفظ الطاقة)

x الحجم

$$P_1 + \frac{1}{2}\rho v_1^2 + \rho g y_1 = P_2 + \frac{1}{2}\rho v_2^2 + \rho g y_2$$

$$P_1 V + \frac{1}{2}\rho V v_1^2 + \rho V g y_1 = \text{const.}$$

$$\underbrace{P \cdot A\Delta X}_{F \cdot \Delta X \,\to\, \text{work}} + \frac{1}{2}mv_1^2 + mgy_1 = \text{const.}$$

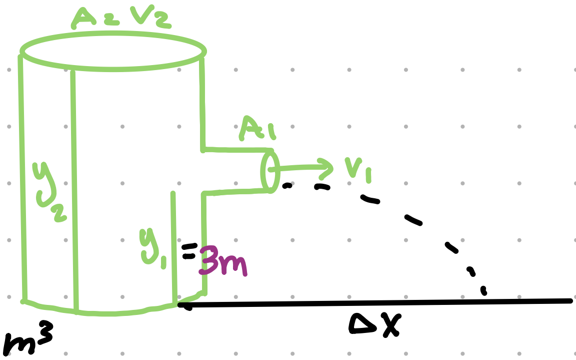
الشغل

طاقة حركة

طاقة وضع

## Ex 9-13

$y_2 - y_1 = h = 0.5m$




$V = 30$ liter $= 30 \times 10^{-3} m^3$

$\Delta t = 1$ min $= 60$ sec

$\Delta X = ??$

$y = v_{0y} t - \frac{1}{2} g t^2$

$-3 = 0 - 4.9 t^2 \Rightarrow t = 0.78 s.$

$X = v_{0x} t \quad , v_{0x} = v_1$

$$\cancel{P_1}^{P_0} + \frac{1}{2}\cancel{\rho} v_1^2 + \cancel{\rho} g y_1 = \cancel{P_2}^{P_0} + \frac{1}{2}\cancel{\rho} V_2^2 + \cancel{\rho} g y_2$$

$$\frac{1}{2} v_1^2 + g y_1 = \frac{1}{2} V_2^2 + g y_2 \quad \times 2$$

$$v_1^2 + 2g\underbrace{(y_1 - y_2)}_{(h)} = 0$$

since $V_2 = 0$

$\Rightarrow v_1 = 3.13 \, m/s$

$\Rightarrow \Delta X = (3.13)(0.782)$
$= 2.45 m$

---

## 9-8 Applications of fluid dynamics

1) Atomizer.

2) Vascular flutter.

3) Aircraft wings.

★السرعة والضغط تناسب عكسي.

**4.** **M** Calculate the mass of a solid gold rectangular bar that has dimensions of 4.50 cm × 11.0 cm × 26.0 cm.

$$\rho = \frac{m}{V} \rightarrow m = \rho V$$

$$V = (4.50 \times 10^{-2})(11 \times 10^{-2})(26 \times 10^{-2})$$
$$= 1.287 \times 10^{-3}\ m^3$$

$$\rho_{Gold} = 19.3 \times 10^3\ Kg/m^3$$

$$m = (19.3 \times 10^3)(1.287 \times 10^{-3})$$
$$= 24.8\ Kg$$

ρ نتحصل على النسبة بين m و V لذلك هي ثابتة عند ثبوت درجة الحرارة

---

**11.** A plank 2.00 cm thick and 15.0 cm wide is firmly attached to the railing of a ship by clamps so that the rest of the board extends 2.00 m horizontally over the sea below. A man of mass 80.0 kg is forced to stand on the very end. If the end of the board drops by 5.00 cm because of the man's weight, find the shear modulus of the wood.

$$F = mg = (80 \times 9.8)$$
$$h = 2m$$
$$A = (2 \times 15) = 30\ cm^2$$
$$= 3 \times 10^{-3}\ m^2$$
$$\Delta X = 5 \times 10^{-2}\ m$$

المساحة إلي بيتة

$$\Rightarrow \frac{F}{A} = S \frac{\Delta X}{h}$$

$$S = \frac{F \times h}{(\Delta X) A}$$

$$= \frac{80 \times 9.8 \times 2}{5 \times 10^{-2} \times 3 \times 10^{-3}} = 1.05 \times 10^7\ Pa$$

18. **BIO** The total cross-sectional area of the load-bearing calcified portion of the two forearm bones (radius and ulna) is approximately 2.4 $cm^2$. During a car crash, the forearm is slammed against the dashboard. The arm comes to rest from an initial speed of 80 km/h in 5.0 ms. If the arm has an effective mass of 3.0 kg and bone material can withstand a maximum compressional stress of $16 \times 10^7$ Pa, is the arm likely to withstand the crash?

$A = 2.4\ cm^2$
$\Rightarrow 2.4 \times 10^{-4}\ m^2$

$V_0 = 80\ Km/h$
$\Rightarrow \dfrac{80 \times 10^3}{3600}$

$t = 5\ ms$
$\Rightarrow 5 \times 10^{-3}\ s$

$m = 3\ Kg$

$stress = \dfrac{F}{A}$

* A معطى من السؤال
* F يجب ايجادها

$F = ma$
$= 3 \times 4.4 \times 10^3$
$= 13200\ N$

$a = \dfrac{\Delta V}{\Delta t} = \dfrac{22.22}{5 \times 10^{-3}} = -4.4 \times 10^3\ m/s$

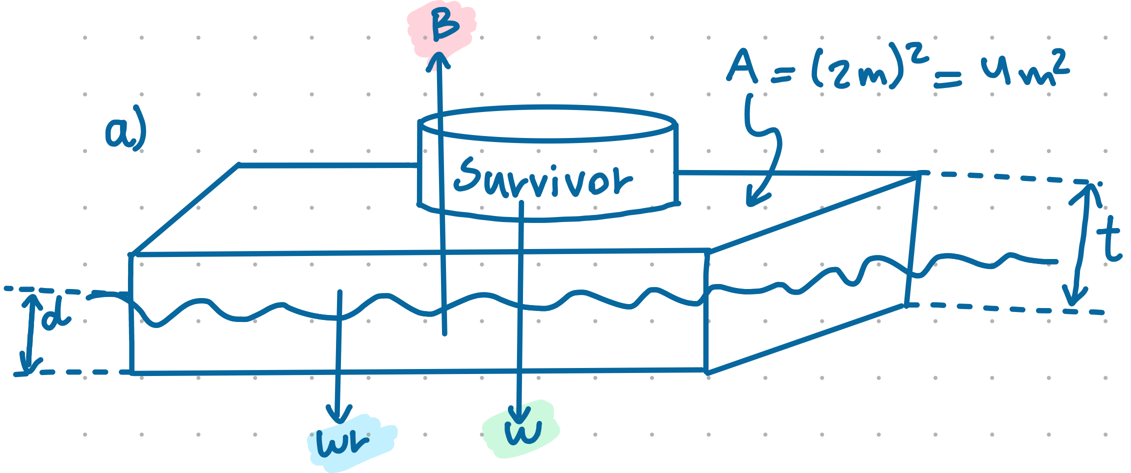
تباطؤ

* الضغط المحسوب اقل من اقصى ضغط يمكن أنه تتحمله الذراع اذاً ستبقى سليمة.

$Stress = \dfrac{13200}{2.4 \times 10^{-4}} = 5.5 \times 10^7\ Pa < 16 \times 10^7\ Pa$

**32.** **GP** A 62.0-kg survivor of a cruise line disaster rests atop a block of Styrofoam insulation, using it as a raft. The Styrofoam has dimensions 2.00 m × 2.00 m × 0.090 0 m. The bottom 0.024 m of the raft is submerged. (a) Draw a force diagram of the system consisting of the survivor and raft. (b) Write Newton's second law for the system in one dimension, using $B$ for buoyancy, $w$ for the weight of the survivor, and $w_r$ for the weight of the raft. (Set $a = 0$.) (c) Calculate the numeric value for the buoyancy, $B$. (Seawater has density 1 025 kg/m³.) (d) Using the value of $B$ and the weight $w$ of the survivor, calculate the weight $w_r$ of the Styrofoam. (e) What is the density of the Styrofoam? → (بوليستيرين) (f) What is the maximum buoyant force, corresponding to the raft being submerged up to its top surface? (g) What total mass of survivors can the raft support?

a)




b) $\Sigma F_y = B - w - w_r = 0$

c) $B = \rho_w g V_{submerged}$ (حجم الجزء المغمور) $(B = mg = \rho V g)$

$= \rho_w g (d \cdot A)$

$= (1025)(9.8)(0.024 * 4)$

$= 964\ N$

d) $\Sigma F_y = B - w - w_r = 0$ → mg

$w_r = B - w$

$= 964 - (62 * 9.8) = 356 N$

e) $\rho_{foam} = \dfrac{m}{V} = \dfrac{m}{A \cdot t}$

$= \dfrac{356/9.8}{4 \times 0.090} = 101\ kg/m^3$

f) * قوة الطفو القصوى لحتى تنغمس الطوافة كلها.

$B_{max} = \rho_w V_r g$

$= 1025 \times (4 * 0.09)(9.8)$

$= 3.62 \times 10^3 \, N$

* الارتفاع كامل مش بس المغمور

g) $w_{max} = m_{max} g = B_{max} - w_r$ (من $\Sigma F_y = B - w - w_r = 0$)

$\Rightarrow m_{max} = \dfrac{B_{max} - w_r}{g}$

$= \dfrac{3.62 \times 10^{3} - 356}{9.8} = 333 \, kg$

---

**43.** A 1.00-kg beaker containing 2.00 kg of oil (density = 916 kg/m³) rests on a scale. A 2.00-kg block of iron is suspended from a spring scale and is completely submerged in the oil (Fig. P9.43). Find the equilibrium readings of both scales.

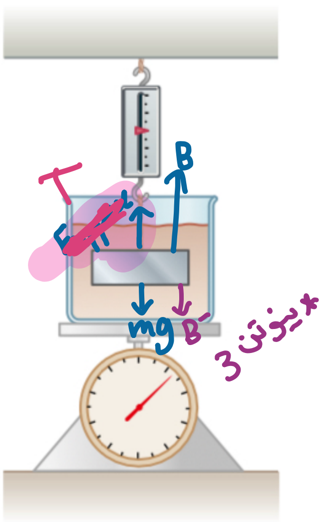



**Figure P9.43**

$\Sigma F_y = T + B - mg = 0$

$T = mg - B$

* Volume of the iron block:

$V = \dfrac{m}{\rho_{iron}} = \dfrac{2}{7.86 \times 10^3} = 2.24 \times 10^{-4} \, m^3$

* $B_{iron} = \rho_{oil} V_{iron} g$

$= 916 * 2.2 * 10^{-4} \times 9.8$

$= 2.28 \, N$

* $F$ = $m_{iron} g - B$ $(\Sigma F_y = 0)$ القوة المؤثرة من الميزان العلوي *

$= 19.6 - 2.28 = 17.3\,N$ (reading on the scale)

* $\Sigma F_y = 0$ (النظام المكون من الكأس والزيت)

$F_{lower} - B - (m_{oil} + m_{beaker})g = 0$

$F_{lower} = B + (m_{oil} + m_{beaker})g$

$= 2.28 + (2+1)(9.8)$

$= 31.7$ (Lower scale reading

# Ch. 10 (Thermal phisics)

## 10 - 1 Temp and the Zero law of Thermodynamics.

*مقياس كم في حرارة بالجسم.

* Temp. is a messure of how much Thermal Energy in the object.

اتصال حراري — *انتقال وتبادل حراري (من الساخن للبارد).

* Thermal contact :- when heat is exchanged btwn objects.

اتزان حراري — *بوقف التبادل الحرارة. (الجسمين نفس الحرارة).

* Thermal equilibrium :- is when no heat exchange.

*القانون الصفري في الديناميكا الحرارية.

* Zeroth law of Thermodynamics :-

→ 3 objects A, B, C where A is in thermal equil. with C, and B is in thermal equil with C, so ⇒ A and B are also in thermal equili.

*اساس تصنيع الثرمومير هذا القانون.

---

## 10 - 2 Thermometers and Temp. scales :-

*ثيرموميتر: أداة لقياس درجة الحرارة.

are device used to messure Temp. depending on some physical properties of materials such as:

1) expansion of solids liquid. (التمدد)
2) colour.
3) gas

* Temp. scales :

1) celsius (°C) depending on :

ice point or freez. point $0^{\circ}C$.

steam point $100^{\circ}C$.

boiling. *يغلي الماء على أي درجة فوق 0.

2) Fahrenhiet:

$T_F = \frac{9}{5} T_C + 32$

3) Kelvin:

$T_K = T_C + 273.15$

* 1 ، 5، 11 ، 21

36 ، 28,29

## Exe: (2)

عالم افترض هيك.

$0\,^{\circ}C \rightarrow -75\,^{\circ}E$ (* اوجد علاقة بين E و C°)

$100\,^{\circ}C \rightarrow 325\,^{\circ}E$

$\Delta T_C = 100 - 0 = 100\,^{\circ}C$

$\Delta T_E = 325 - (-75) = 400\,^{\circ}E$

$$\frac{\Delta T_E}{\Delta T_C} = 4 \Rightarrow \frac{T_E - (-75)}{T_C - 0} \cancel{=} \frac{4}{1}$$ (* نسبة ثابتة)

$\Rightarrow T_E + 75 = 4T_C \Rightarrow T_E = 4T_C - 75$

أو يربط كمانه

$$\frac{325 - T_E}{100 - T_C} = 4$$

$\Rightarrow 325 - T_E = 400 - 4T_C$

$\boxed{T_E = 4T_C - 75}$

---

## 10-3 Thermal expansion of solids and liqwids.

* الحرارة تزيد من حركة جزيئات الجسم وبالتالي يتمدد.
* العلاقة بين طول الجسم ودرجة حرارته..

1) $L - L_0 = \alpha L_0 (T - T_0)$

$\Delta L = \alpha L_0 (\Delta T)$

↳ Linear coefficient of expansion.

* ٣ اشكال للأجسام:
١) خطي
٢) مساحة.
٣) حجم.

2) Surface expansion :-

$\Delta A = \gamma A_0 \Delta T$ $(\gamma = 2\alpha)$

gama جاما

3) Volume expansion :-

$\Delta V = \beta V_0 \Delta T$ $(\beta = 3\alpha)$

---

Ex :-

a) $L_0 = 30\,m$ , $T_0 = 0\,^{\circ}C$ , $L = ?$ , $T = 40\,^{\circ}C$

$L - 30 = (11 \times 10^{-6})(30)(40 - 0)$

$L = 30.013\,m$

$= 1.3\,cm$

b) $\text{stress} = \frac{F}{A} = Y \frac{\Delta L}{L_0} = 8.67 * 10^{7}\,Pa$.

## Ex-5

a) $\frac{\Delta V}{V_o} = ?$   $\Delta T = 1C^\circ$

$$\Delta V = \beta V_o \Delta T$$

$$\frac{\Delta V}{V_o} = \beta \Delta T = 3\alpha \Delta T = 2\times10^{-4} \quad \text{(unitless)}$$

b) $L_o = 4000\,m$, $\Delta L = ?$ , $\Delta T = 1C^\circ$

$$\Delta L = \alpha L_o \Delta T = 0.3\,m$$

---

## 10-4

* الغاز المثالي: جزيئات بعيدة عن بعض وما بتفاعل مع بعض.

⇒ Macroscopic description of iedeal gases:-   * العلاقة بين الضغط والحرارة والحجم.

$$\underset{\substack{\text{pressure}\\ Pa}}{P}\ \underset{\substack{\text{Volume}\\ m^3}}{V} = \underset{\text{number of moles}}{n}\ \underset{\text{universal gas const. (J/K) or (J/K.mol) }(=8.31\,J/K.mol)}{R}\ \overset{\text{Temp (K)}}{T} \rightarrow \text{ideal gas equation}$$

number of moles ← كمية من المادة تحتوي على عدد أفجادرو من الجزيئات.

## Ex-6:

a) $T_1 = 20^\circ C$ , $P_1 = 1.5\times10^5\,Pa$ , $V_1 = 1L = 1\times10^{-3}\,m^3$

$$n = \frac{P_1 V_1}{T_1 R} = \frac{1.5\times10^5 * 1\times10^{-3}}{293 * 8.31} = 6.16\times10^{-3}\,\text{moles}$$

b) $V_2 = 2V_1$

$P_2 = 1\,atm = 1\times10^5\,Pa$ , $T_2 = ?$

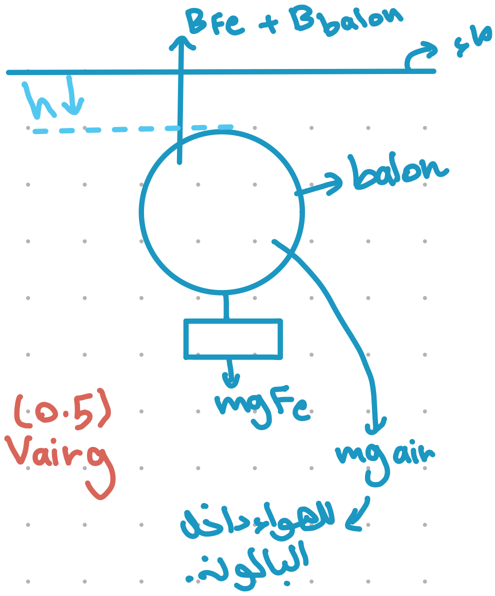
$$P_1V_1 = nRT_1$$
$$P_2V_2 = nRT_2$$

$$\Rightarrow \frac{P_2V_2}{P_1V_1} = \frac{T_2}{T_1} \Rightarrow \frac{1\times10^5(2V_1)}{1.5*10^5(V_1)} = \frac{T_2}{293} \Rightarrow T_2 = 395\,K$$

## Ex-8:

* كلما زاد الضغط يقل الحجم.

* البالونة تحت الماء قل حجمه.




a) $V_0 = 0.5\,m^3$ , $m_{Fe} = 2.5 * 10^2\,kg$ , $V_2 = ?$

$\rho_{air} = 1.29\,kg/m^3$

$\Rightarrow B_{Fe} + B_{balon} = mg_{Fe} + mg_{air}$

$\rho_{water} V_{Fe} g + \rho_{water} V_2 g = (2.5 * 10^2 \times g) + \rho_{air} V_{air} g$ (0.5)

$V_2 = 0.219\,m^3$

b) $T_2 = T_1 \leftarrow$ * حرارة الماء مثل حرارة الجو

$$\frac{P_2 V_2}{P_1 V_1} = \frac{T_2}{T_1}$$

$$\frac{P_2 (0.219)}{1 \times 10^5 (0.5)} = 1 \rightarrow P_2 = 2.31 * 10^5\,Pa.$$

* الضغط المطلق الكلي = ضغط عمود الماء + الضغط الجوي

c) $P = P_0 + \rho h g$

$2.31 \times 10^5 = 1 \times 10^5 + (1 \times 10^3 + 9.8 * h)$

$h = 13.3\,m$

---

**1.** For each of the following temperatures, find the equivalent temperature on the indicated scale: (a) $-273.15°C$ on the Fahrenheit scale, (b) $98.6°F$ on the Celsius scale, and (c) 100 K on the Fahrenheit scale.

a) $T_F = \frac{9}{5} T_C + 32$

$T_F = \frac{9}{5} * -273.15 + 32 = -460°F$

* انتبه بأي مقياس درجة حرارة.

b) $T_F = \frac{9}{5} T_C + 32$

$98.6 = \frac{9}{5} T_C + 32 \rightarrow T_C = 37°C$

c) $T_K = T_C + 273.15$

$100 = T_C + 273.15 \rightarrow T_C = -173.15°C$

* $T_F = \frac{9}{5} T_C + 32$

$= \frac{9}{5} * -173.15 + 32 = -279.6°F = -280°F$

**5.** Show that the temperature $-40°$ is unique in that it has the same numerical value on the Celsius and Fahrenheit scales.

$* \; T_F = \frac{9}{5} T_C + 32$

$-40 = \frac{9}{5} * T_C + 32 \Rightarrow T_C = -40C°$

$* \; T_F = \frac{9}{5} * T_C + 32$

$= \frac{9}{5} * -40 + 32 = -40C°$

* اوجد درجة الحرارة التي يتساوى عندها C, F ؟

$T_F = \frac{9}{5} T_F + 32$

$\frac{5}{5} T_F - \frac{9}{5} T_F = 32$

$-\frac{4}{5} T_F = 32 \Rightarrow T_F = -40 F$

**11.** The New River Gorge bridge in West Virginia is a 518-m-long steel arch. How much will its length change between temperature extremes of $-20°C$ and $35°C$?

$L_0 = 518m$ , $L = ?$ , $T_1 = -20°C$ , $T_2 = 35°C$

$\Delta L = \alpha L_0 \Delta T$

$\Delta L = 11 \times 10^{-6} * 518 * (35 - -20)$

$\Delta L = 0.31 m$

**21.** A hollow aluminum cylinder 20.0 cm deep has an internal capacity of 2.000 L at 20.0°C. It is completely filled with turpentine at 20.0°C. The turpentine and the aluminum cylinder are then slowly warmed together to 80.0°C. (a) How much turpentine overflows? (b) What is the volume of the turpentine remaining in the cylinder at 80.0°C? (c) If the combination with this amount of turpentine is then cooled back to 20.0°C, how far below the cylinder's rim does the turpentine's surface recede?

(يفيض ← زيادة ← $\Delta V$)

a) $\Delta V = B_c V_0 \Delta T$

$= 3\alpha V_0 \Delta T$

$= 3 * 24 \times 10^{-6} * 2 * 60$

$= 8.64 \times 10^{-3} L$

$= 8.64 \; cm^3$

للاسطوانة

$V = V_0 + \Delta V$

$= 2 + 8.64 \times 10^{-3}$

$= 2.008842\,L$

$= 2.0088 \times 10^{3}\,cm^3$

$\Delta V = \beta_T V_0 \Delta T$

$= 9 \times 10^{-4} * 2 * 60$

$= 0.108\,L$

$V_f = V_0 + \Delta V$

$= 2 + 0.108 = 2.108\,L.$

تربنتين

$\Delta V = V_T - V_c = 0.09936\,L. \rightarrow$ حجم ما تدفق فرق بين حجم تربنتين والإسطوانة.

b) $V_f = 2.00864\,L$

c) $\Delta V = \beta_T V_0 \Delta T$

$= 9 \times 10^{-4} * 2.00864 \times -60$

$= -0.108462$

$V_f = \underbrace{-0.10846}_{\Delta V} + \underbrace{2.00864}_{V_0}$

$= 1.9\,L$

$\frac{\Delta V}{V_0} = \frac{2 - 1.9}{2} = 0.05$ * نسبة ثابتة لكل شيء

$\frac{\Delta h}{h} = 0.05 \Rightarrow \Delta h = 0.05 * 0.2$

$h \rightarrow 0.2$

$= 0.01\,m = 1\,cm$

**28.** The concrete sections of a certain superhighway are designed to have a length of 25.0 m. The sections are poured and cured at 10.0°C. What minimum spacing should the engineer leave between the sections to eliminate buckling if the concrete is to reach a temperature of 50.0°C?

$\Delta L = \alpha L_0 \Delta T$

$\Delta L = 12 * 10^{-6} * 25 * (50 - 10)$

$L = 0.012\,m$

**29.** One mole of oxygen gas is at a pressure of 6.00 atm → $P$ and a temperature of 27.0°C. (a) If the gas is heated at constant volume until the pressure triples, what is the final temperature? (b) If the gas is heated so that both the pressure and volume are doubled, what is the final temperature?

$V_1 = V_2$
$P_2 = 3P_1$ → a

من معادلة الغاز المثالي

→ 16g/mol

$T = 27 + 273 = 300K$

Way 1: a) $T_f = T_i\left(\frac{P_f}{P_i}\right) = 300K\left(\frac{P_f}{P_i}\right) = 900K = 627°C$

b) $T_f = T_i\left(\frac{P_f V_f}{P_i V_i}\right) = T_i\left(\frac{2P_i * 2V_i}{P_i V_i}\right) = 4T_i = 4 \times 300K$
$= 1200K$
$= 927°C$

---

Way 2: a) $P_1 V = nRT_1 \Rightarrow P_1 = \frac{nRT_1}{V_1}$

$V_1 = V_2$

$P_2 = 3P_1$

$P_2 = \frac{nRT_2}{V_2}$

$* \; P_2 = 3P_1$

$\frac{\cancel{n}\cancel{R}T_2}{\cancel{V}} = 3 * \frac{\cancel{n}\cancel{R}T_1}{\cancel{V}}$

حولت إلى كلفن

$T_2 = 3 * 300 = 900k.$

b) $V_2 = 2V_1 \,/\, P_2 = 2P_1 \,/\, T_2 = ?$

$* \; P_2 = 2P_1$

$\frac{nRT_2}{V_2} = \frac{2nRT_1}{V_1}$

$\frac{T_2}{2\cancel{V}} = \frac{2 \times 300}{\cancel{V}}$

$T_2 = 4 \times 300 = 1200K$

**36.** The density of helium gas at 0°C is $\rho_0 = 0.179\ \text{kg/m}^3$. The temperature is then raised to $T = 100°\text{C}$, but the pressure is kept constant. Assuming the helium is an ideal gas, calculate the new density $\rho_f$ of the gas.

$373\text{K} = T_2 = 100°C$ حول لكلفن

$273\text{K} = T_1 = 0°C$

حجم ثابت

ضغط ثابت

$P_1 = P_2$

$\rho = ?$

Way 1: $m_1 = m_2 \leftarrow \frac{\rho_f}{\rho_i} = \frac{m/V_f}{m/V_i} = \frac{V_i}{V_f}$

from the ideal gas law with both n and P constant we find $\frac{V_i}{V_f} = \frac{T_i}{T_f}$ and now we have →

$$\rho_f = \rho_i \left(\frac{T_i}{T_f}\right) = 0.179 * \left(\frac{273\text{K}}{373}\right) = 0.131\ \text{kg/m}^2$$

---

Way 2: $PV = nRT$

$$P = \frac{m}{M.m} \frac{RT}{V} \rightarrow \rho$$

$$P = \frac{\rho RT}{M.m}$$

$$P * M = \rho RT \rightarrow \rho = \frac{PM}{RT} \rightarrow P = \frac{\rho RT}{M}$$

$$P_1 = P_2$$

$$\frac{\rho_1 \cancel{R} T_1}{\cancel{M}} = \frac{\rho_2 \cancel{R} T_2}{\cancel{M}}$$

$$\frac{\rho_1 T_1}{T_2} = \frac{\rho_2 \cancel{T_2}}{\cancel{T_2}}$$

$$\rho_2 = \frac{0.179 * 273.15}{373.15} = 0.131\ \text{kg/m}^3$$

---

$$m_1 = m_2$$

$$\rho_1 V_1 = \rho_2 V_2$$

$$0.179 V_1 = \rho_2 V_2$$

$$\frac{0.179}{\rho_2} = \frac{V_2}{V_1} \nearrow \frac{0.179}{\rho_2} = \frac{373}{273}$$

$$\rho_2 = 0.131\ \text{Kg/m}^3$$

# ch. 16 Electrial Energy

## 16-1 potential diff. (فرق الجهد) and Electrical pot.

* $W = F * \Delta X$ (N.m = Joule)

$F = q E$ — الشحنة ($q$); $E \rightarrow$ electric field (N/c)

$\Rightarrow W = q E \Delta X$

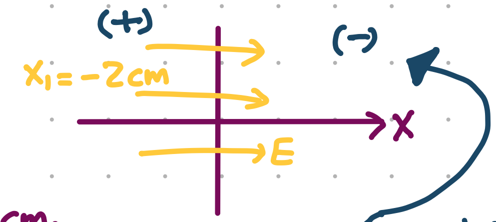
* $W = \Delta K.E = \frac{1}{2} m v_f^2 - \frac{1}{2} m v_i^2$

$= -\Delta P.E = mgy_1 - mgy_f$

طاقة الوضع

---

**Ex**




$V_0 = 0$

$E = 1.5 \times 10^3$ N/c

★ المجال من (+) ← (−)

★ البروتونة (+) تتنافر رح يروح للسالب

a) $\Delta p.E$ at $x_f = 5$ cm. (proton)

$\Delta X = 5 - (-2) = 7$cm

$\Delta P.E = -W = -q E \Delta X$

$= -1.6 \times 10^{-19} * 1.5 \times 10^3 * 7 \times 10^{-2}$

$= -1.68 \times 10^{-17}$ J

هو اعطى طاقة

b) $X_f = 12$cm ($\bar{e}$ — بعوض q سالبة)

$\Delta P.E = ??$

$= -q E \Delta X$

$= -(-1.6 \times 10^{-19} * 1.5 \times 10^3 * 14 \times 10^{-2})$

$= 3.36 \times 10^{-17}$ J

---

فرق الجهد

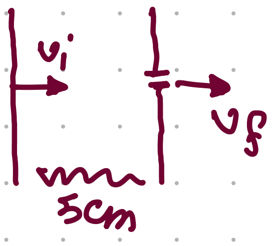
* $\Delta V = \frac{\Delta P.E}{q}$

$V_B - V_A = \frac{P.E_B - P.E_A}{q}$ (J/c) ≡ Volt

$= -\frac{W}{q} = \frac{-\cancel{q} E \Delta X}{\cancel{q}} = -E \Delta X$

* $E = -\frac{\Delta V}{\Delta X}$ (volt/m) (N/c)

## EX-3




$v = 1\times10^{6}$ m/s

ⓐ $\Delta V = ??$

$v_f = 3\times10^{6}$ m/s

$$\Delta V = -\frac{\Delta K.E}{q} = \frac{\frac{1}{2}mv_i^2 - \frac{1}{2}m\,v_f^2}{q} = -4.18\times10^{4}\ V.$$

ⓑ $E = ??$

$$E = \frac{-\Delta V}{\Delta x} = \frac{--4.18\times10^{4}}{5\times10^{-2}}$$

$$= 8.36\times10^{5}\ (V/m)$$

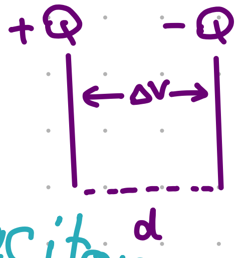
---

## 16-6 capacitors:

⇒ are devices used to store Electrical energy.

* Capacitance: (السعة)
is the ability to store electrical energy.

$C = \frac{Q}{\Delta V} = (C/V) \equiv F$ فاراد




* اللوحين لهم نفس المساحة .

## 16-7 parallel plate Capacitor.

* $C = \epsilon_0 \frac{A}{d}$

$A \rightarrow$ area of plate

$d \rightarrow$ distance btwn plate.

ثابت العزل في الفراغ

* $\epsilon_0 = 8.85\times10^{-12}$.

## * Ex8

$A = 2 \times 10^{-4}\ m^2$

$d = 1 \times 10^{-3}\ m$

a) $C = \epsilon_0 \frac{A}{d}$

$= \frac{8.85 \times 10^{-12} \times 2 \times 10^{-4}}{1 \times 10^{-3}} = 1.77 \times 10^{-12}\ f.$

b) $Q = ??$ , $\Delta V = 3V$ | $C = \frac{Q}{\Delta V} \rightarrow Q = C\Delta V$

$Q = C\,\Delta V = 5.31 \times 10^{-12}\ C.$

c) $\sigma = \frac{Q}{A} = 2.66 \times 10^{-16}$

الكثافة الشحنية

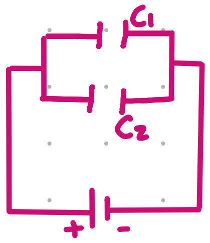
## 16-8 combination of capacitors :-

★ طرق توصيل المواسعات

★ عكس المقاومات.

1) Parellel توازي

$C_{eq} = C_1 + C_2$




★ الشحنة تتجزأ.

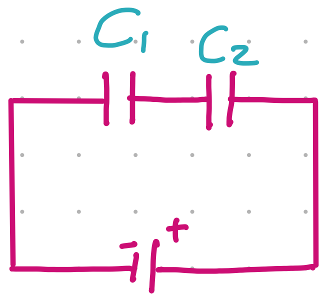
★ الجهد ثابت

2) Sereis توالي

$V = V_1 + V_2$

$Q_1 = Q_2$

$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} \Rightarrow C_{eq} = \frac{C_1 C_2}{C_1 + C_2}$ فقط ل (2)

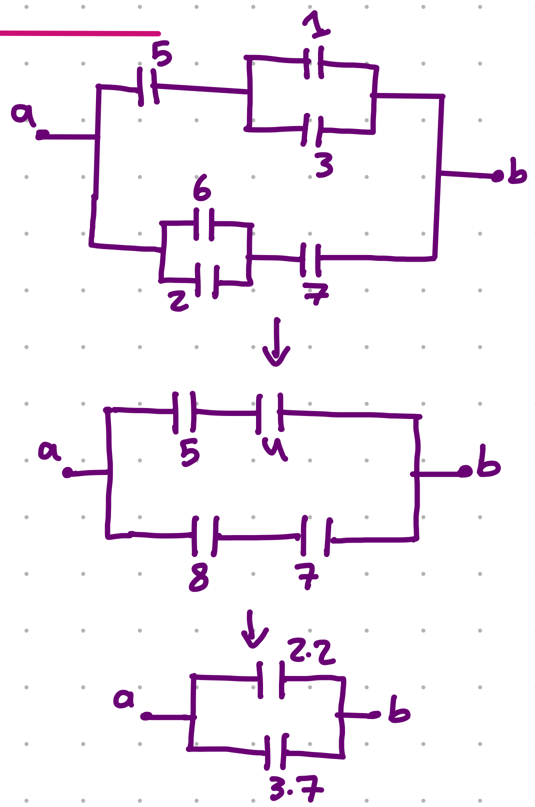



★ الشحنة لا تتجزأ نفس ماهي تضل.

★ الجهد متغير يتجزأ.

---

Ex:




a) $C_{eq} = ?$

$\frac{1}{C_{4,5}} = \frac{1}{4} + \frac{1}{5}$

$C_{4,5} = \frac{4 * 5}{4+5} = 2.2F$

$C_{8,7} = \frac{8 * 7}{8+7} = 3.7 F$

$C_{eq} = 2.2 + 3.7$

$= 5.9\ MF$

b) $V_{ab} = 12$ Volt

$V_5 = ?$ , $Q_5$ ?

$V_5 + V_4 = 12 \Rightarrow \frac{4}{5} V_4 + V_4 = 12$

$\frac{9}{5} V_4 = 12$

$V_4 = \frac{60}{9} = 6.6$ Volt

$V_5 = 12 - 6.6 = 5.4$ Volt

$Q_5 = C_5 V_5$

$= 5.4 * 5 = 22\ MF$

عوض

$Q_5 = Q_4$

$C_5 V_5 = C_4 V_4$

$5 V_5 = 4 V_4$

$V_5 = \frac{4}{5} V_4$

## 16-9 En. stored in capacitor:-

*الطاقة المخزنة في المواسع

طاقة الوضع

$U = \frac{1}{2} C V^2$

عوضنا مكان C ← $= \frac{1}{2} \frac{Q}{\cancel{V}} V^{\cancel{2}} = \frac{1}{2} Q V$

عوضنا مكان V ← $= \frac{1}{2} \cancel{C} \frac{Q^2}{C^{\cancel{2}}} = \frac{1}{2} \frac{Q^2}{C}$

* $C = \frac{Q}{V}$
* $V = \frac{Q}{C}$

**Ex:** $U = 1.2\ \text{KJ} = 1.2 * 10^{3}\ \text{J}$ / $C = 1 * 10^{-4}\ \text{F}$ / $U' = 6 \times 10^{2}\ \text{J}$

$t = 2.5\ \text{ms} = 2.5 \times 10^{-3}\ \text{s}$

فرق الجهد

a) $V = ?$ $\quad U = \frac{1}{2} C V^2$

$1.2 \times 10^{3} = \frac{1}{2} \times 1 \times 10^{-4} * V^2 \Rightarrow V = 4.67 \times 10^{3}$ Volts.

القدرة

b) $P = ?$ $\quad P = \frac{W}{t} = \frac{U'}{t} = \frac{6 \times 10^{2}}{2.5 \times 10^{-3}} = 2.4 \times 10^{5}\ \text{W}$ (watt)

*الشغل = طاقة الوضع (U)

الطاقة التي تم تفريغها مش الكلية.

---

## 16-10 Capacitors with dielectrics:-

عازل

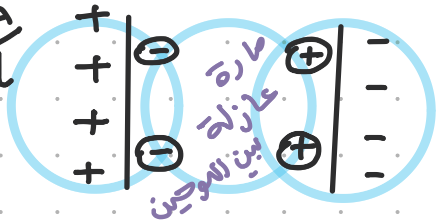
قبل المادة العازلة.

* call original voltage as $V_0$

بعد المادة العازلة

* call final Voltage as $V$

$C = \frac{\epsilon_0 A}{d}$




$V = \frac{V_0}{K}$ ثابت الاستقطاب

$K \rightarrow$ dielectric const.

$\Rightarrow C = K C_0$

$= K \frac{\epsilon_0 A}{d}$

* $K = 1$ هواء والفراغ
* $K \geq 1$

$E = \frac{V}{d}$

* dielectric strength: max. electric field btwn the plates.

$$C = \frac{Q}{V} = \frac{Q}{\frac{V_0}{K}} = \frac{Q \times K}{V_0} = K C_0$$

*تزداد المواسعة عند وجود مادة عازلة.

Ex: $A = 2 \times 3 = 6\,cm^2 = 6 \times 10^{-4}\,m^2$ / $d = 1\,mm = 1 \times 10^{-3}\,m$

* مليانة لدرجة
يعني في مادة عازلة.

a) $C = ?$ $\quad C = K\dfrac{\epsilon_0 A}{d} = \dfrac{3.7 * 8.85 * 10^{-12} * 6 \times 10^{-4}}{1 * 10^{-3}} = 2 \times 10^{-11}\,F$

b) $Q_{max} = ?$ $\quad Q = CV_{max}$

$= C\,E_{max}\,d$ — ثابت ما عطى max — من الجدول dielectric strength للورقة

$= 2 \times 10^{-11} * 16 \times 10^{6} * 1 \times 10^{-3}$

$= 0.32 * 10^{-6}\,C.$

* أزيل الورقة.
* فصلت عن البطارية.

c) $E = ?$ $\quad E = \dfrac{\sigma}{\epsilon_0} = \dfrac{Q/A}{\epsilon_0} = 6 \times 10^{7}\,(N/c)$

لأي صفيحة مشحونة (معدنية)

$E_{max\,(air)} = 3 \times 10^{6}\,(N/c) \Rightarrow E(paper) > E(air) \Rightarrow$ discharge.

من الجدول

تفريغ كهربائي

من (-) ← (+)

**2.** A proton is released from rest in a uniform electric field of magnitude 385 N/C. Find (a) the electric force on the proton, (b) the acceleration of the proton, and (c) the distance it travels in 2.00 $\mu$s.

$E = 385\,N/c$

$m_{proton} = 1.67 \times 10^{-27}$

a) $F = qE$

$= 1.6 \times 10^{-19} \times 385 = 6.16 \times 10^{-17}\,N$

b) $F = ma$

$a = \frac{F}{m} = \frac{6.16 \times 10^{-17}}{1.67 \times 10^{-27}} = 3.69 \times 10^{10}\,m/s^2$

c) $\Delta X = V_0 t + \frac{1}{2}at^2$

$= 0 + \frac{1}{2} \times 3.69 \times 10^{10} \times (2 \times 10^{-6})^2$

$= 7.38 \times 10^{-2}\,m$

$= 7.38\,cm$

---

**5.** The potential difference between the accelerating plates of a TV set is about 25 kV. If the distance between the plates is 1.5 cm, find the magnitude of the uniform electric field in the region between the plates.

في هذا السؤال، المطلوب هو حساب مقدار المجال

$\Delta V = 25\,Kv$ $\quad d = 1.5\,cm$

$E = \frac{|\Delta V|}{d}$

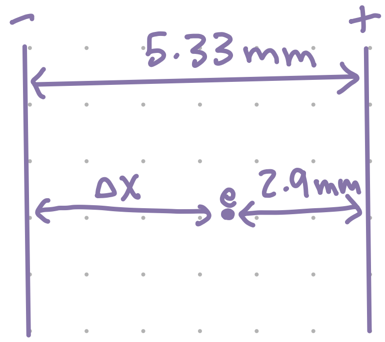
$= \frac{25 \times 10^{3}}{1.5 \times 10^{-2}} = 1.7 \times 10^{6}\,N/c$ أو $V/m$

---

**7.** **M** Oppositely charged parallel plates are separated by 5.33 mm. A potential difference of 600 V exists between the plates. (a) What is the magnitude of the electric field between the plates? (b) What is the magnitude of the force on an electron between the plates? (c) How much work must be done on the electron to move it to the negative plate if it is initially positioned 2.90 mm from the positive plate?

$d = 5.33\,mm \qquad \Delta V = 600\,V$

a) $E = \frac{|\Delta V|}{d} = \frac{600}{5.33 \times 10^{-3}} = 1.13 \times 10^{5}\ N/C$ أو $m/V$




b) $F = q|E| = -1.6 \times 10^{-19} \times 1.13 \times 10^{5} = 1.8 \times 10^{-14}\,N$

c) $W = F\Delta X$

$= 1.8 \times 10^{-14} \times ((5.33 - 2.9) \times 10^{-3})$

$= 4.37 \times 10^{-17}\,J$

---

**26.** (a) When a 9.00-V battery is connected to the plates of a capacitor, it stores a charge of 27.0 $\mu$C. What is the value of the capacitance? (b) If the same capacitor is connected to a 12.0-V battery, what charge is stored?

$Q = 27\,\mu C \qquad \mu C \rightarrow 10^{-6}\,C$

a) $C = \frac{q}{\Delta V} = \frac{27}{9} = 3\,\mu F \qquad \star F \equiv (V/C)$

b) $q = C\Delta V$

$= 3 \times 12$

$= 36\,\mu C$

---

**28.** Two conductors having net charges of +10.0 $\mu$C and −10.0 $\mu$C have a potential difference of 10.0 V between them. (a) Determine the capacitance of the system. (b) What is the potential difference between the two conductors if the charges on each are increased to +100 $\mu$C and −100 $\mu$C?

$\Delta V = 10V$

a) $C = \frac{Q}{V} = \frac{10}{10} = 1\,\mu F$

b) $V = \frac{Q}{C} = \frac{100}{1} = 100V$

ينشأ فرق الجهد () بين الموصلين عن فصل الشحنة هذا، ولا يتأثر بكون الشحنة موجبة أو سالبة — فقط كمية الشحنة هي المهمة.

**35.** Find (a) the equivalent capacitance of the capacitors in Figure P16.35, (b) the charge on each capacitor, and (c) the potential difference across each capacitor.

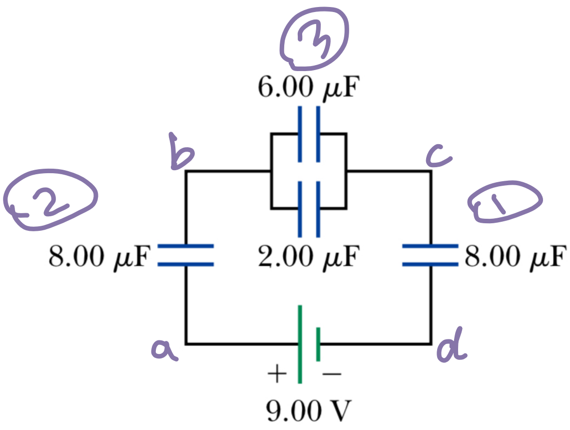



**Figure P16.35**

a) $C_{bc} = C_b + C_c$

$= 2 + 6 = 8\,\mu F$

$\frac{1}{C_{eq}} = \frac{1}{C_{ab}} + \frac{1}{C_{bc}} + \frac{1}{C_{cd}}$

$\frac{1}{C_{eq}} = \frac{1}{8} + \frac{1}{8} + \frac{1}{8}$

$C_{eq} = \frac{8}{3} = 2.67\,\mu F$

$Q_1 = Q_2$ توالي

$Q_1 \neq Q_2$ توازي

$\star\, C = \frac{Q}{V}$

b) in series:

$Q_{eq} = Q_{ab} = Q_{bc} = Q_{cd} = Q_{eq}\,\Delta V_{eq}$

$= 2.67 \times 9 = 24\,\mu F$

$\star\, \Delta V_{eq} = \Delta V_{ad}$.

$Q_{8(a \to b)} = 24\,\mu C$

$Q_{8(c \to d)} = 24\,\mu C$

$Q_2 = C_2\,\Delta V_2$

$= 2 \times 3 = 6\,\mu C$

$Q_6 = C_6\,\Delta V_6$

$= 6 \times 3 = 18\,\mu C$

c) $\Delta V_{ab} = \frac{Q_{ab}}{C_{ab}} = \frac{24}{8} = 3V$

$\Delta V_{bc} = 3V$

$\Delta_{cd} = \frac{Q_{cd}}{C_{cd}} = \frac{24}{8} = 3V$

**39.** Find the charge on each of the capacitors in Figure P16.39.

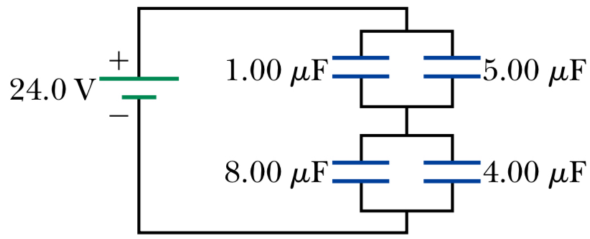



**Figure P16.39**

$a \rightarrow b \quad C_{eq} = 5 + 1 = 6\,\mu F$

$b \rightarrow c \quad C_{eq} = 8 + 4 = 12\,\mu F$

$a \rightarrow c \quad C_{eq} = \dfrac{12 \times 6}{12 + 6} = 4\,\mu F$

$Q_{a\rightarrow c} = C_{a\rightarrow c} \times \Delta V_{a\rightarrow c}$

$= 4 \times 24 = 96\,\mu C$

$Q_{a\rightarrow c} = Q_{a\rightarrow b} = Q_{b\rightarrow c} = 96\,\mu C$

$\Delta V_{a\rightarrow b} = \dfrac{Q_{a\rightarrow b}}{C_{a\rightarrow b}} = \dfrac{96}{6} = 16V$

$\therefore \Delta V_{b\rightarrow c} = 24 - 16 = 8V$

$Q_1 = C_1 \times \Delta V_1 = 1 \times 16 = 16\,\mu C$

$Q_5 = C_5 \, \Delta V_5$

$= 5 \times 16 = 80\,\mu C$

$Q_4 = C_4 \, \Delta V_4$

$= 4 \times 8 = 32\,\mu C$

$Q_8 = C_8 \, \Delta V_8$

$= 8 \times 8 = 64\,\mu C$

**47.** A parallel-plate capacitor has capacitance 3.00 μF. (a) How much energy is stored in the capacitor if it is connected to a 6.00-V battery? (b) If the battery is disconnected and the distance between the charged plates doubled, what is the energy stored? (c) The battery is subsequently reattached to the capacitor, but the plate separation remains as in part (b). How much energy is stored? (Answer each part in microjoules.)

a) $U = \frac{1}{2} C (\Delta V)^2$

$= \frac{1}{2} \times 3 \times (6)^2 = 54\ \mu J$

b) The capacitor disconnected from the battery → The charge constant at the value $Q_i$

$C_f = \cancel{\kappa}\ \kappa \epsilon_0 \frac{A}{2d}$

$2C_f = \kappa \epsilon_0 \frac{A}{d}$ but $C_i = \kappa \epsilon_0 \frac{A}{d}$

$\rightarrow 2C_f = C_i$

$C_f = \frac{C_i}{2}$

$U_f = \frac{1}{2} \frac{Q_i^2}{C_f}$

$= \frac{1}{2} \frac{Q_i^2}{\frac{C_i}{2}} \rightarrow \boxed{U_f = \frac{Q_i^2}{C_i}}$ but $\boxed{U_i = \frac{1}{2} \frac{Q_i^2}{C_i}}$

$U_i = \frac{1}{2} U_f$

$U_f = 2U_i$

$U_f = 2 \times 54$ من الفرع الاول

$= 108\ \mu J$

c) reconnected → $\Delta V = \Delta V_i = 6V$

$C_f = \frac{C_i}{2} = 1.5\ \mu F$ لأنه طلعناها نعوض

$U_f = \frac{1}{2} C_f (\Delta V_i)^2 = \frac{1}{2} \times 1.5 \times (6)^2$

$= 27\ \mu J$

**50.** (a) How much charge can be placed on a capacitor with air between the plates before it breaks down if the area of each plate is 5.00 $cm^2$? (b) Find the maximum charge if polystyrene is used between the plates instead of air. Assume the dielectric strength of air is $3.00 \times 10^6$ V/m and that of polystyrene is $24.0 \times 10^6$ V/m.

a) $Q_{max} = C(\Delta V_{max})$ but $\Delta V_{max} = E_{max} \cdot d$.

$= C(E_{max} \cdot d)$ but $C = K\epsilon_0 \frac{A}{d}$

$= K\epsilon_0 \frac{A}{\cancel{d}}(E_{max} \cdot \cancel{d})$

$= K\epsilon_0 A E_{max}$

$Q_{max} = 1 \times 8.85 \times 10^{-12} \times 5 \times 10^{-4} \times 3 \times 10^{6}$

$= 1.33 \times 10^{-8} C$

$= 13.3\ nC$

b) $Q_{max} = K\epsilon_0 A E_{max}$

$= 2.56 \times 8.85 \times 10^{-12} \times 5 \times 10^{-4} \times 24 \times 10^{6}$

$= 2.72 \times 10^{-7} C$

$= 272\ nC$

# Chapter 17

## Current and Resistance.

## ★ 17-1 electric current:

AVG $\vec{I} = \dfrac{\Delta Q}{\Delta T}$ $(C/s \equiv A)$

$I = \dfrac{dQ}{dt}$ (A)

★ Electro motive force: battaries, generations, photo cells.

**Ex:**

$\Delta Q = 1.68\,C$
$\Delta t = 2\ sec$

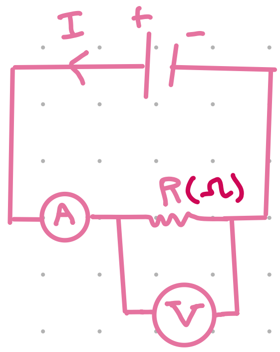
$\Rightarrow I = \dfrac{\Delta Q}{\Delta t} = 0.83\,A$

b) $\Delta t = 5$
عدد $N = ?$
$I = \dfrac{\Delta Q}{\Delta t} = \dfrac{Ne}{\Delta t}$
$N = \dfrac{I \Delta t}{e} = 2.61 \times 10^{19}$ electrons.

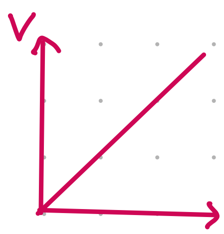
## 17-3

Current and Voltage measurements.

a) Ammeter.
b) Voltmeter.

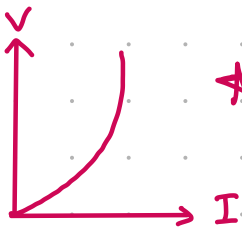



## 17-4 Resistance and Ohm's law:




$V \propto I$
$V = RI$

★ ohmmic material




★ nonohmmic material

## * Resistivity ($\rho$):-


$$R = \frac{\rho L}{A}$$

**Ex:**

a) $\frac{R}{L} = ? = \frac{\rho}{A} = \frac{\rho}{\pi r^2} = \frac{1.5 \times 10^{-6}}{\pi (0.32 \times 10^{-3})^2} = 4.6 \ (\Omega/m)$

$r = 0.321 mm$

b) $V = 10V$

$R = 4.6 \Omega$

$I = \frac{\Delta V}{R} = \frac{10}{4.6} = 2.2A$

c) $L_o$, $R_o$

$L_{new} = 2L_o$

$V_N = V_o$ الحجم ثابت *

$A_n L_n = A_o L_o$

$A_n (2\cancel{L_o}) = A_o \cancel{L_o}$

$A_N = \frac{A_o}{2}$

$R_o = \frac{\rho L_o}{A_o}$

$R_N = \frac{\rho L_N}{A_N}$

$= \frac{\rho 2L_o}{\left(\frac{A_o}{2}\right)} = 4 \frac{\rho L_o}{A} = 4R_o$

---

★ العلاقة بين R و درجة الحرارة.

★ $\underline{17-5}$

$$R = R_0(1+\alpha(T-T_0))$$

★ $R = \frac{\rho L}{A}$

$$\rho = \rho_0(1+\alpha(T-T_0))$$

$$= \rho_0 + \rho_0\alpha\underbrace{(T-T_0)}_{(\Delta T)}$$

★ علاقة خطية.

$\underline{17-6}$

$$\left.\begin{aligned} P &= IV \\ (W)\quad &= I^2R \\ &= \frac{V^2}{R} \end{aligned}\right\}$$

★ ٣ أشكال

واجب

★ 5, 11, 24, 34, 36, 42

★ $E = Pt$

$= IVt \quad (W/s) = J$

---

Ex: $R_0 = 50\Omega$ $\quad R = 76.8\Omega$

$T_0 = 20^\circ C$ $\quad T_{mp} = ??$

a) $T_{mp} = 157^\circ C$

b) $\rightarrow T = 235^\circ C$

$$\frac{I}{I_{mp}} = ??$$

$$I = \frac{\Delta V}{R}$$

$$I_{mp} = \frac{\Delta V}{R_{mp}}$$

$$\frac{I}{I_{mp}} = \frac{R_{mp}}{R} = 0.766$$

---

Ex:

$I = 20A$

$\Delta V = 1.2 \times 10^2 V$

a) $P_1 = 75 W$

$N P_1 = P_{Total}$

$N * 75 = IV$

$N * 75 = 20 * 1.2 \times 10^2$

$N = 32$ bulbs.

b) $1 kWh \approx 0.12 \$$

$t = 8 hrs.$

$E = Pt$

$= \frac{2.4 \times 10^3}{1000} \times 8 = 19.2 kWh$

$\Rightarrow$ Price $= 19.2 \times 0.12$

$= 2.5 \$$

---

Ex:6 $\Delta V = 50$ Volt

$R = 8 \Omega$

a) $I = ?, P = ?$

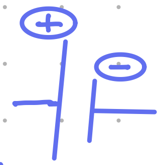
$I = \frac{\Delta V}{R} = \frac{50}{8} = 6.25 A.$

$P = IV = \frac{V^2}{R} = \frac{(50)^2}{8} = 313 W.$

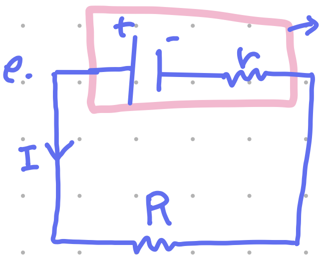
# ☆ Chapter 18 Direct current circuits.

## 18-1 Sources of emf ($\varepsilon$). * القوة الدافعة الكهربائية

batteries, generators, photocells are some sources of emf.




1) ideal battery → no internal resistance.
2) real // → with // //



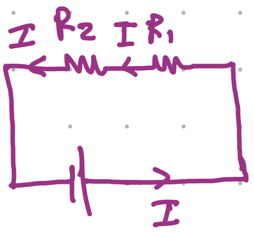

$$I = \frac{\varepsilon}{R+r}$$

* القدرة المعطاة = القدرة الخارجة.

(I×) $\varepsilon = IR + Ir$

(t×) $I\varepsilon = I^2R + I^2r$

## 18-2 resistors in series.




$\varepsilon = V_1 + V_2$

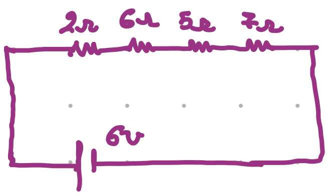
$= IR_1 + IR_2$

$= I(R_1 + R_2)$

$= IR_{eq}$

$\therefore R_{eq} = R_1 + R_2 + \cdots$

Ex 1:




a) $R_{eq} = 2 + 4 + 5 + 7 = 18\,\Omega$.

b) $I = \frac{V}{R_{eq}} = \frac{6}{18} = \frac{1}{3}\,A$.

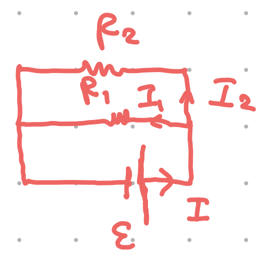
c) $P_5 = I^2 R_5$

$$= \left(\frac{1}{3}\right)^2 \times 5 = \frac{5}{9} \ \omega.$$

d) $P_{total} = I \mathcal{E}$

$$= \frac{1}{3} \times 6 = 2 \ \omega.$$

## 18-3 Resistors in Parallel :-



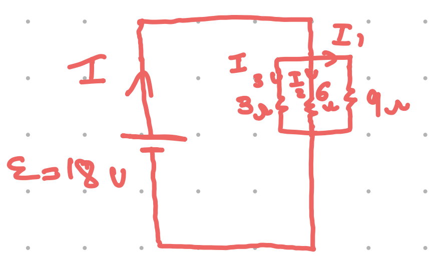

$I = I_1 + I_2$.

$\mathcal{E} = V_1 = V_2$.

$$\frac{\mathcal{E}}{R_{eq}} = \frac{V_1}{R_1} + \frac{V_2}{R_2}$$

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots\ldots$$

Ex 2 :-




a) $I_1 = \frac{18}{9} = 2\ A$

$I_2 = \frac{18}{6} = 3\ A$

$I_3 = \frac{18}{3} = 6A$.

b) $R_{eq} = ??$

$$\frac{1}{R_{eq}} = \frac{1}{3} + \frac{1}{6} + \frac{1}{9}$$

$$\Rightarrow R_{eq} = \frac{18}{11}\ \Omega$$

c) $I = I_1 + I_2 + I_3$

$= 11A$.

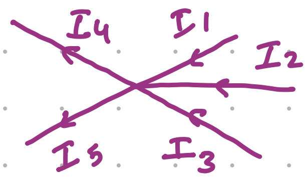
d) $P_3 = \frac{V^2}{R} = \frac{(18)^2}{3}$.

---

## 18-4 Kirchhoff's rules:

1) The sum of currents entering a junction is equal to the sum of currents leaving that junction.

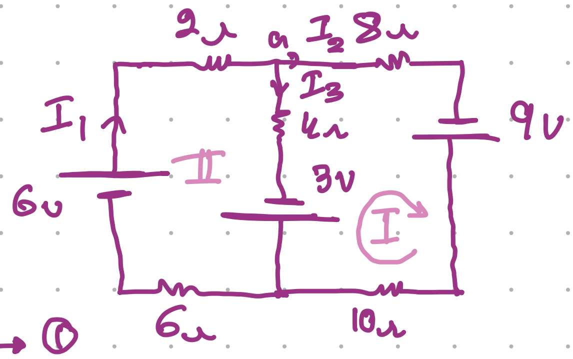
$I_1 + I_2 + I_3$




2) The sum of pot. diff. in a closed circuit is zero.

$$\Sigma V_{A-A} = 0$$

Ex:-



1 / 5 / 9 / 13 / 19
31 / 36 / 38

$I_1 = I_2 + I_3 \rightarrow (1)$

$-8I_2 + 9 - 10I_2 - 3 + 4I_3 = 0 \rightarrow (2)$

$-4I_3 + 3 - 6I_1 + 6 - 2I_1 = 0 \rightarrow (3)$

⋮

التكملة عليكي نوزو
(برتكن عليكي ياحلوة)

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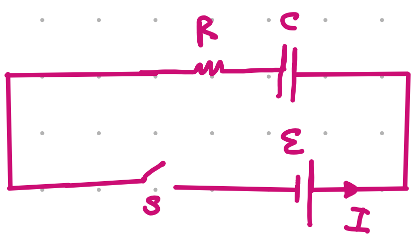
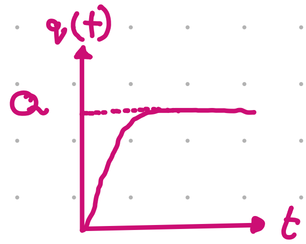
18-5 : Rc-circits:-



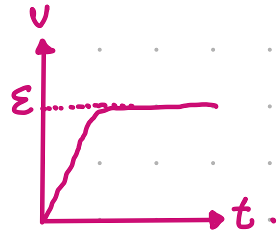
a) Charging process:

* charge is increasing.
* capasitance is const.
* $V_c$ is increasing.
* Current is decreasing.
* $q(t) = C\varepsilon(1 - e^{-t/RC})$.
* $q_{(t)} = Q(1 - e^{-t/RC})$.

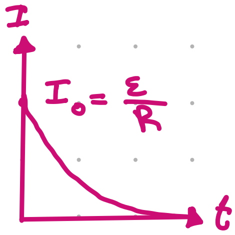


$\tau = RC \equiv$ time const. of the Circuit.

$V_c = \mathcal{E}(1 - e^{-t/\tau})$.




$* \; I = \frac{\mathcal{E}}{R} e^{-t/\tau}$

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Ex :

$R = 5\,M\Omega = 5\times10^{-6}\,\Omega$.
$C = 2\mu F = 2\times10^{-6}\,F$.
$\mathcal{E} = 12\,volt$.

$t = ??$
$q = \frac{1}{2}Q$.

$RC = 5\times10^{6} * 2\times10^{-6} = 10\,s$.

$q = Q(1 - e^{-t/\tau})$.

$\frac{1}{2}\cancel{Q} = \cancel{Q}(1 - e^{-t/10})$.

$\frac{1}{2} = 1 - e^{-t/10} \Longrightarrow \cancel{-}\frac{1}{2} = \cancel{-}e^{-t/10}$.

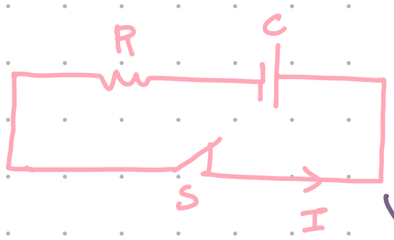
$\ln \frac{1}{2} = \ln(e^{-10/t}) \longrightarrow$ ($\ln$ على الآلة الحاسبة) $\quad * \; \ln e^{x} = x$

$\cancel{-}(0.69) = \frac{\cancel{-}t}{10}$

$t = 6.9\,sec$.

b) discharging process:

* charge is decreasing.
* capacitance is const.
* $V_c$ is decreasing.
* current is decreasing.




$C = \frac{Q}{V}$ ثابتة

*فش بطارية.


$q(t) = Q e^{-t/\tau}$

$I(t) = I_o e^{-t/\tau}$ $\left(I_o = \frac{\varepsilon}{R}\right)$

$V_c = V_o e^{-t/\tau}$

Ex-6

$R = 8 \times 10^{5} \Omega$

$C = 5 \times 10^{-6} F$

$\varepsilon = 12V$

a) $\tau = ? = RC = 4 sec$

b) $Q = C\varepsilon = 60 \times 10^{-6} C$.

$q_{max}$

c) $q(6) = ?$ $Q(1 - e^{-t/\tau})$

$= 60 \times 10^{-6}(1 - e^{-6/4}) = 4.6 \times 10^{-6} c$.

d) $V_R = ?? = IR = 2.68$ volts.

$I = \frac{\varepsilon}{R} e^{-t/\tau} = \dots$

e) $I(6) = 3.4 \times 10^{-6} A$

## 18-7 :- electrical Safety.

## 18-6 :- House hold circuits.

Ex :- $P_t = 1000W$

$P_{mw} = 800W$

$P_H = 1300W$ , $\mathcal{E} = 120V$

1) $I_t = \frac{P}{V} = \frac{1000}{120} = 8.33A$

$I_{mw} = \frac{P}{V} = 6.67A$

$I_H = \frac{P}{V} = 10.8A$

2) $I_T = ??$

$= 8.33 + 6.67 + 10.8 = 25.8A$