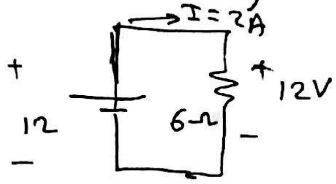
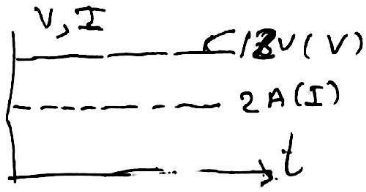
AC part (01)

(AC) alternating current التيار المتردد

1- Previously, we learned DC sources → dependent / independent



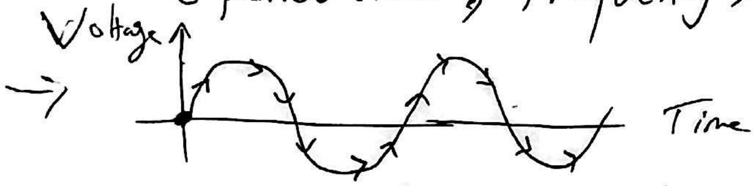


DC source constant values with time (DC = Direct current)

2- Ac (alternating current)

→ Voltage & current vary with time in Amplitude & direction

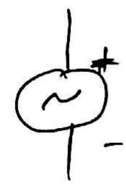
→ Sinusoidal wave (Example of Ac signals) has some characteristics (period (Time), Frequency, relation between period & Frequency)

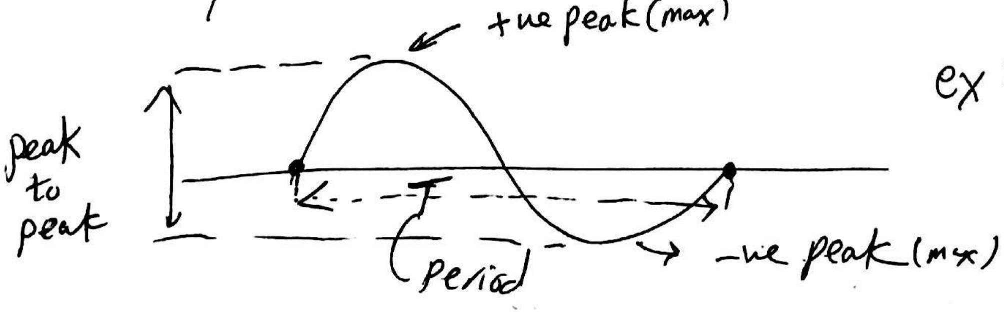
→ 

– The Sinusoidal wave starts from (0V), increase to maximum positive value (+ve peak) and then decreased to zero & continue to maximum negative value (−ve peak) & returns to zero again and so on (repeat cycles)

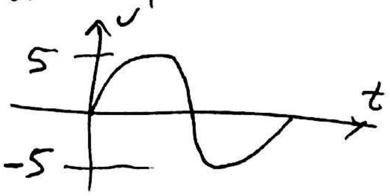
– The waveform (signal is called periodic) because every period it repeats itself.

– Symbol of AC in Electrical circuit

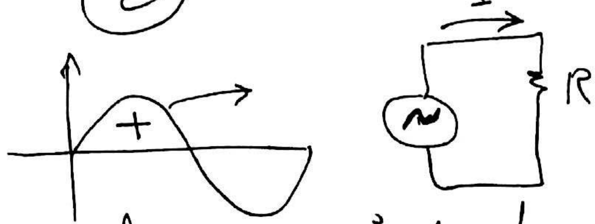




ex signal with peak 5V

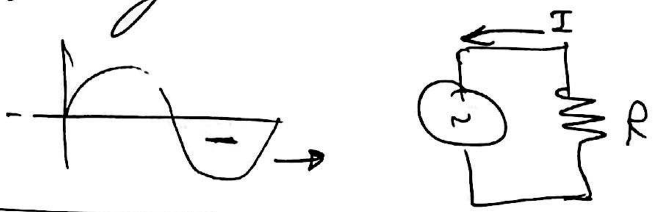


* Polarity of Sine wave

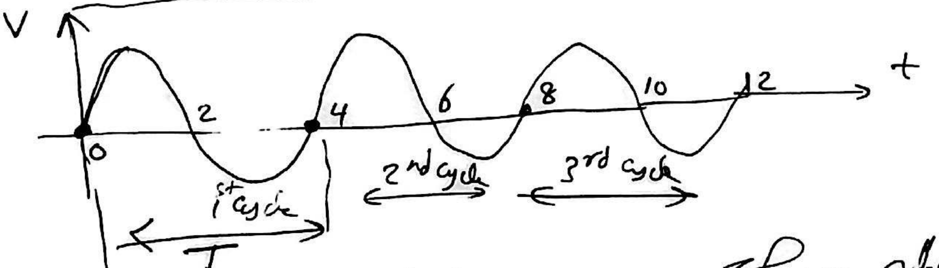


During (+ve half Cycle) → Voltage Source is positive & Current generate
(Clockwise)

During (-ve half Cycle) → Voltage sourse is -ve & current generate
(Counter clockwise)



* Period of Sine wave



(EX1)
Calculate The period of Sine wave shown above ?

Sol $T = 4$ sec

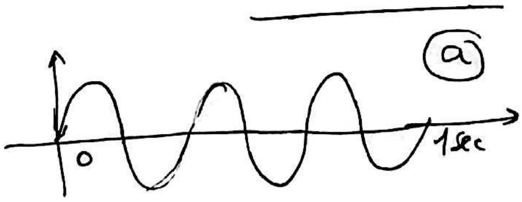
[∴ ت بعدد ال cycle
∴ period = زمن cycle واحدة]

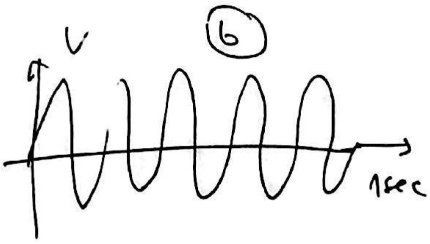
* Frequency of Sine wave

$f = \frac{1}{T}$ → تقاس بالهرتز HZ

$f = \frac{1}{4} = 0.25$ HZ

EX(2)





which of 2 Sine waves has more Frequency

fig (a) → 3 cycles (Sum of time = 1sec)
∴ one cycle period $= \frac{1}{3}$ sec
∴ freq $= \frac{1}{T} = 3$ HZ or [no. of cycles/sec = 3]

fig (b) → no. of cycles = 5 ∴ 5HZ or $\frac{1}{T} = \frac{1}{\frac{1}{5}\text{sec}} = 5$ HZ

∴ fig (b) more Freq. than fig (a)

EX(3) If the Period of certain Sine wave is 10ms, what is freq.?

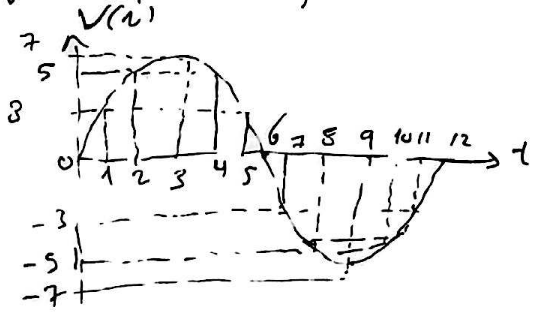
sol $f = \frac{1}{T} = \frac{1}{10ms} = \frac{1}{10 \times 10^{-3}} = 100 Hz$

EX(4) The Freq. of sine wave is 60Hz, what is period?

$T = \frac{1}{f} = \frac{1}{60} = 16.7 ms$

Sinusoidal Voltage Values

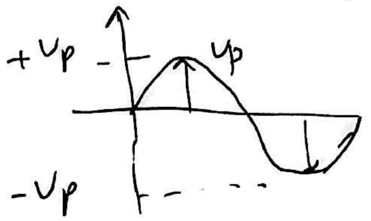
1- Find instantenous Value at any time
2- find peak
3- Peak-to-peak
4- RMS
5- Average



[1] instantenous Value

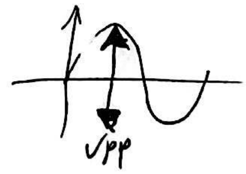
قصدكل Time في قيمة لـ V أو i

[2] Peak value (positive or negative maximum with respect to zero)



[3] peak to peak Value

$V_{pp} = 2V_p$



[4] RMS (root mean square Value) ⟹ AC voltmeter measured value

= effective value

هي نفس قيمة الجهد الناتج عند توصيل البطارية dc مع مقاومة وينتج عنها درجة حرارة تساوي نفس درجة الحرارة الناتجة من توصيل AC مع نفس المقاومة.

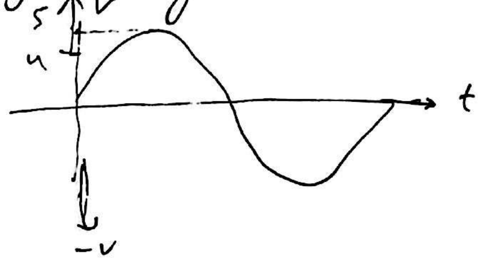
$RMS = \frac{V_{max}}{\sqrt{2}}$ ex $V_{max} = 5V$ ∴ $V_{RMS} = \frac{5}{\sqrt{2}}$, $V_{pp} = 10V$

5 Average value (DC value) (mean value) = read of DC Avometers

= total area under the half cycle curve divided By distance along horizontal axis (For complete cycle = zero)

(in (half) sine wave) → $V_{avg} = \frac{2V_{max}}{\pi} = \frac{2V_p}{\pi}$ ↑ نفس الكلام للسابق
لنصف موجة فقط
اما لموجة كاملة = صفر

Ex(5) find V_p, V_{pp}, V_{rms}, the half cycle V_{avg}.



$V_p = 4.5V$

$V_{pp} = 2 \times V_p = 9V$

$V_{rms} = V_p / \sqrt{2} = \frac{4.5}{\sqrt{2}} = 3.18V$

$V_{avg} = \frac{2V_p}{\pi} = \frac{2}{3.14} \times 4.5 = 2.87V$

angular Measurement of sinewave

radian ⟷ degree

$\frac{degree}{180°} = \frac{rad}{\pi}$

So 1 degree $= \left(\frac{180°}{\pi}\right) \times rad$

1 rad $= \left(\frac{\pi}{180°}\right) \times degree$

example $180° = ?!$ rad

$\therefore = \frac{\pi}{180} \times 180 = \pi$ rad

ex(6)

Convert 60° to rad. & $\frac{\pi}{6}$ rad to degrees

a- Rad $= \frac{\pi}{180} \times 60 = \pi/3$ rad

b- deg → $\frac{180}{\pi} \times \left(\frac{\pi}{6}\right) = 30°$

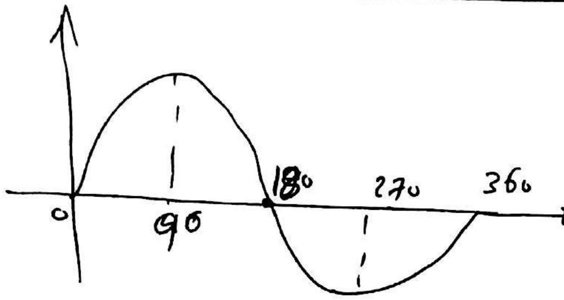
Sine wave angle → (phase)

كانه موتور يلف مع كل زاوية يتولد جهد

angle ⇒ angular frequency

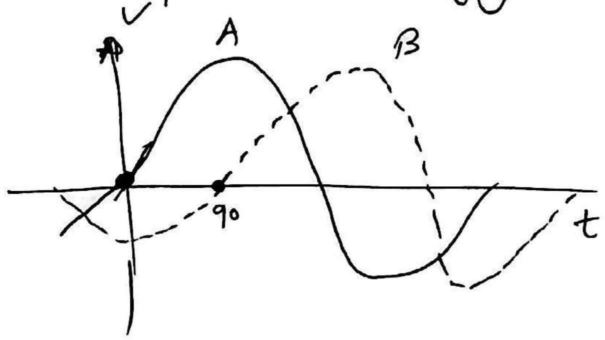
$= \omega t = 2\pi f t \Rightarrow 2\pi$

one cycle $= 2\pi = 360°$

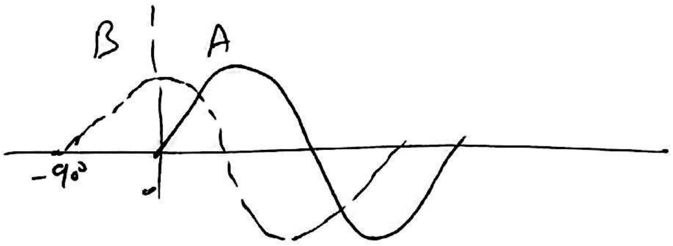


The phase of sine wave is [angular measurement that specifies the position of that sinewave].

* it is useful to identify which signals lead (متقدم) / or lag (متأخر)

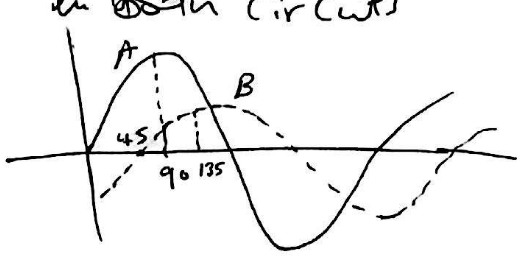


A lead B by 90°
or B lag A by 90°

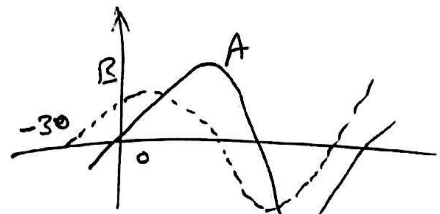


B lead A by 90°
or A lag B by 90°

EX(7) what is the phase angles between the two sine waves in both circuits



A lead B by 45°
Phase angle 45°

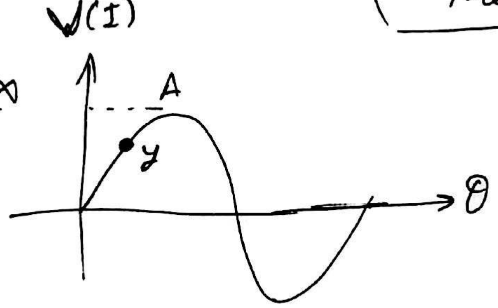


B lead A by 30°
Phase angle 30°

⑥

The Sine wave formula (instantenous wave)

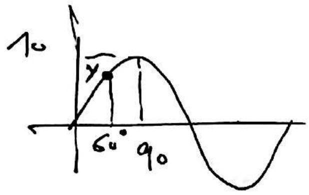
ex



$$y = A \sin\theta$$

متغير لحظي

$$V(t) = V_p \sin\theta$$

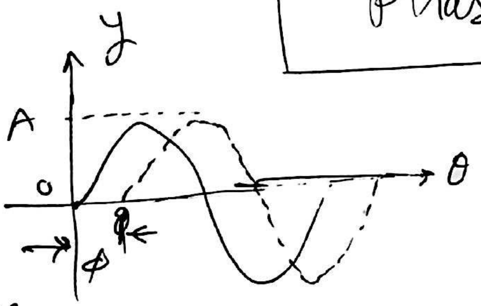


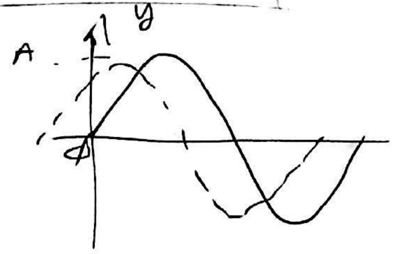
$\rightarrow V = 10 \sin\theta$

at 60° $\longrightarrow V = 10 \sin 60 = 8.66V$

$\therefore Y = 8.66V$

Phaseshift sinewave





متأخر

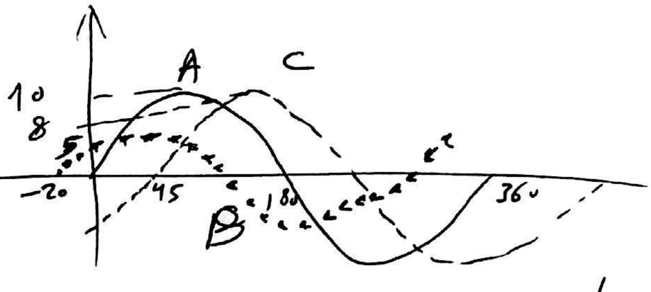
الموجة المتقطعة $y = A \sin(\theta - \phi)$

لو جعلنا الموجة solid reference

معادلة الموجة المتقطعة $y = A \sin(\theta + \phi)$

لو الموجة solid ← Ref.

EX (8) Determine instantenous value at 90° reference Point on horizontal axis



V_A (ref) الأكبر $= A \sin\theta = 10 \sin\theta \Big|_{90°} = 10 \sin 90 = 10V$

متقدم بـ 20 عن ref

V_B الصغيرة $= 5 \sin(\theta + 20)\Big|_{\theta = 90} = 5 \sin(110°) = 4.7V$ ($90 + 20$)

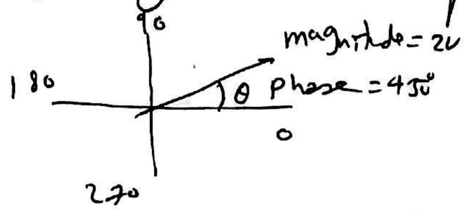
V_C المتوسط $= 8 \sin(\theta - 45°) = 8 \sin(90 - 45) = 5.66V$

Phasor diagram

معنى لتفسير ده كمية تتغير مع الزمن vector

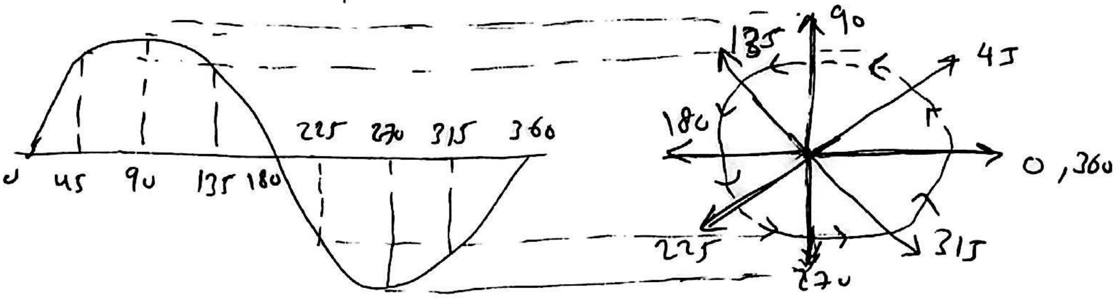
Quantity vary with time represented by a vector = phasor

ex)

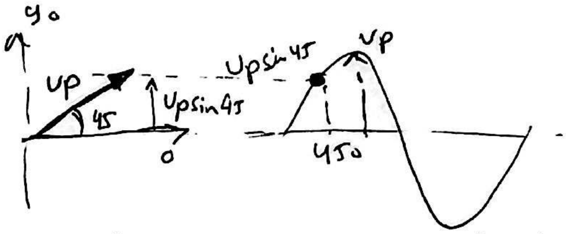


→ how to represent sine wave in a phasor ?!

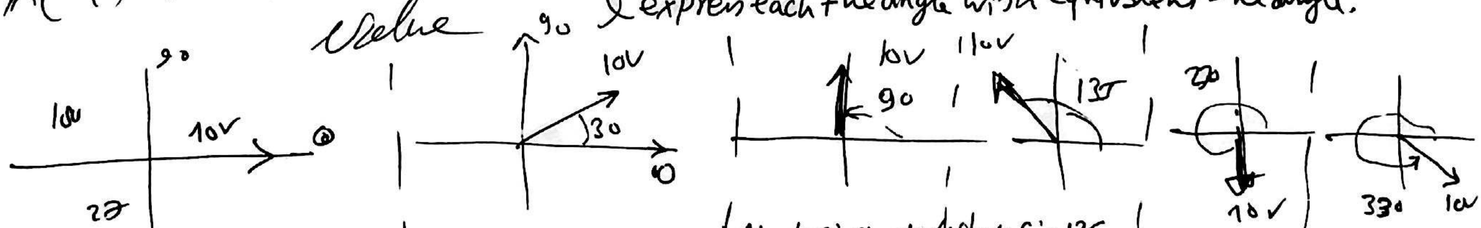
ex)



ex)



Ex(9) For phasors shown, determine the instantaneous voltage value & express each +ve angle with equivalent −ve angle.



$V = 10 \sin 0 = 0V$

θ' rewritten as $\theta - 360 = 0 - 360 = -360°$

$V = 10 \sin 30 = 5V$

$\theta' = \theta - 360 = 30 - 360 = -330°$

$V = 10 \sin 90 = 10V$

$\theta' = 90 - 360 = -270$

$V = 10 \sin 135$

$\theta' = 135 - 360 = -225$

$V = 10 \sin 270 = -10V$

$\theta' = 270 - 360 = -90°$

$V = 10 \sin 330 = -5V$

$\theta' = 330 - 360 = -30°$

$\theta' = \theta - 360$ → express each positive angle as equivalent negative angle

وعرفنا .

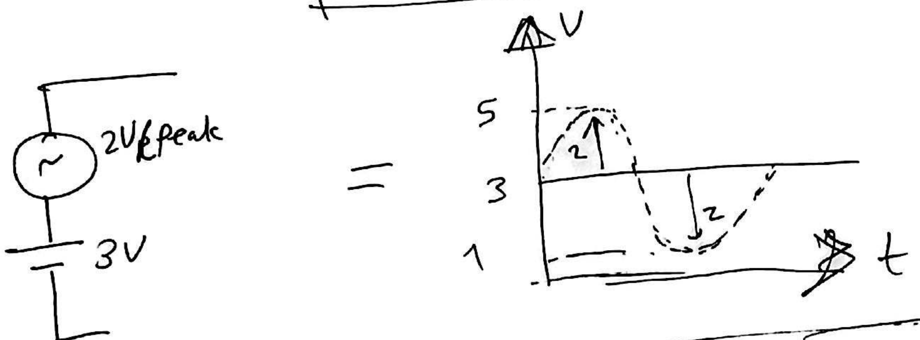
angular velocity of a phasor $\omega = 2\pi f$ (rad/sec)

معناها أن ال phasor يلف 360° (2π) يعني عمل 1 cycle

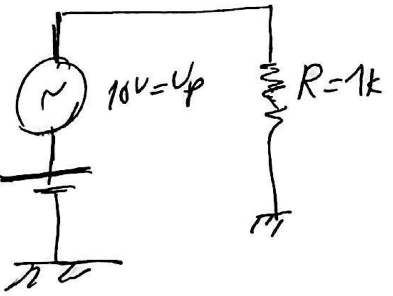
→ The velocity of rotation is called angular velocity $= \omega = 2\pi f$

So instantenous Voltage $\boxed{v = V_p \sin \omega t}$

Superimposed dc & Ac voltage



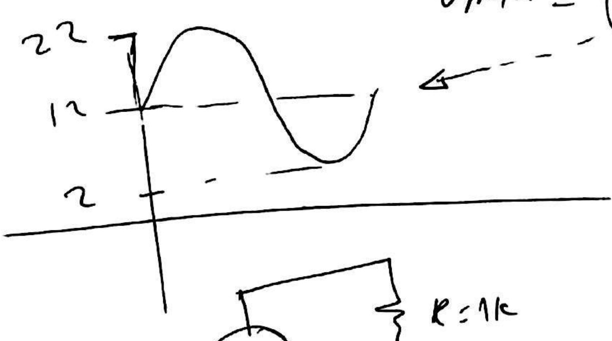
EX (10) calc. voltage (max and min) across Resistor & draw



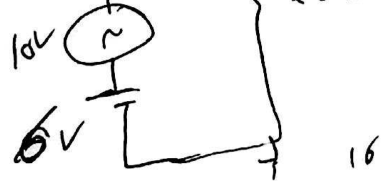
sol/

$V_{max} = \underset{dc}{12} + V_{max\,of\,ac} = 12 + 10 = 22V$

$V_{min} = 12 + V_{min\,of\,ac} = 12 - 10 = 2V$

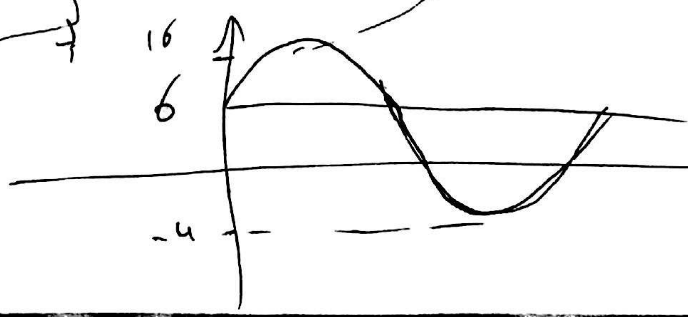


EX (6)



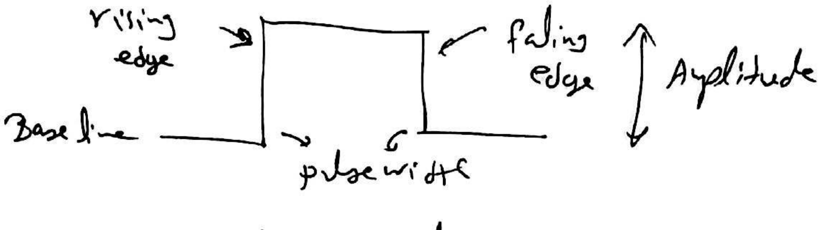
$V_{max} = 6 + 10 = 16V$

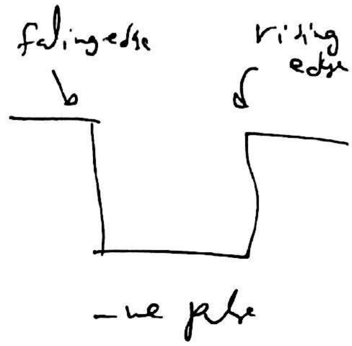
$V_{min} = 6 - 10 = -4V$



waves انواع أخرى من ال

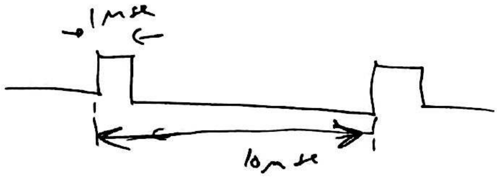
pulse





* duty cycle (percentage) = $\frac{T_{on}}{T_{on}+T_{off}}$ 100%

ex

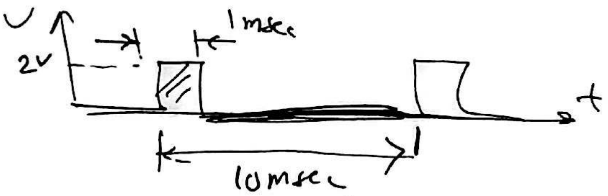


duty cycle = $\frac{1\mu}{10\mu} \times 100$ % = 10%

* average value = area under curve for one cycle = مساحة الشكل للزمن كامل / الزمن كامل

EX(1)

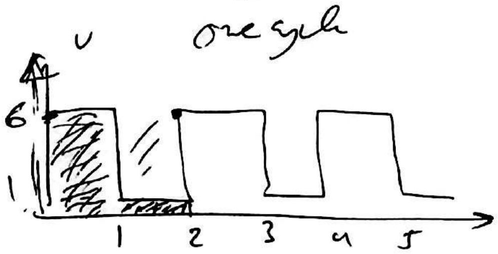
(a)



طول × عرض (مستطيل)

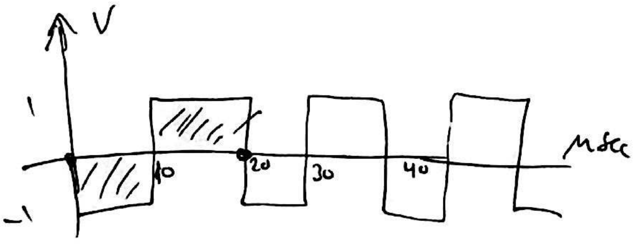
$= \frac{(1msec) \times 2 + 0}{10 msec} = 0.2V$

(b)



$= \frac{1\times 6 + (1\times 1)}{2} = \frac{6+1}{2} = 3.5V$

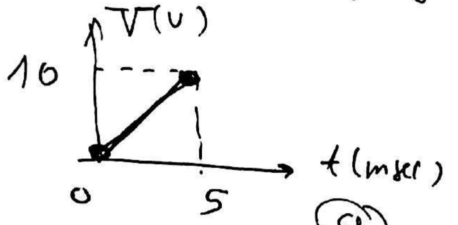
(c)



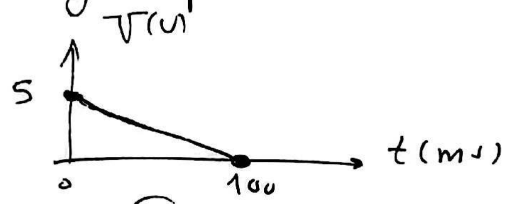
$= \frac{(10\times -1) + (10\times 1)}{20} = \text{zero } v$

Triangle wave / & / sawtooth (ramp)

ex) what is the slope of Voltage ramps shown



(a)



(b)

(a) $\frac{y-y_1}{x-x_1} = \frac{y_2-y_1}{x_2-x_1}$ let $(x_1, y_1) = (0, 0)$, $y = V$ (volt)

$(x_2, y_2) = (5, 10)$ $x = t$ (msec)

(5 → msec)

$\therefore \frac{V-0}{t-0} = \frac{10-0(V)}{(5-0)\,msec} = 2\ V/msec$ | slope

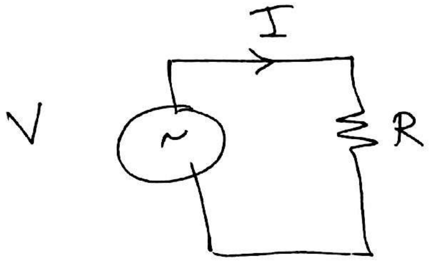
$V = 2t$ msec

(b) $(x_1, y_1) = (0, 5)$ → $x = t$ (msec)

$(x_2, y_2) = (100, 0)$ $y = V$ (volt)

$\therefore \frac{V-5}{t-0} = \frac{0-5}{100-0} = -0.05\ V/msec$ slope

Analysis of AC circuits

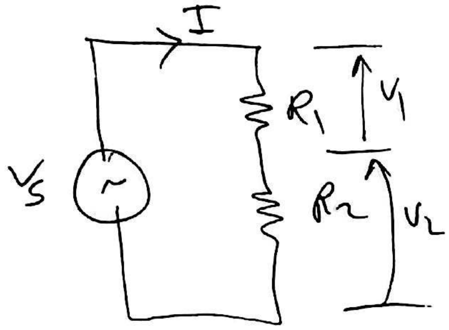


ohms law

$V_p = I_p R$

$V_{rms} = I_{rms} R$

$P = V_{rms} I_{rms} = \frac{V_{rms}^2}{R} = I_{rms}^2 R$



$V_S = V_1 + V_2$

$V_{S\,rms} = V_{1rms} + V_{2rms}$

$I_{rms} = \frac{V_{S\,rms}}{R_1 + R_2}$

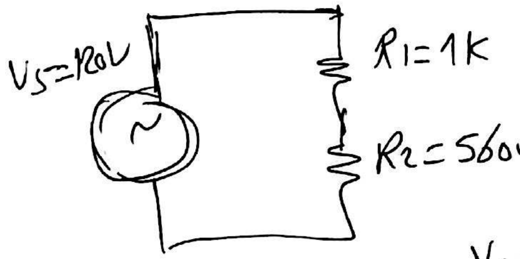
$V_{1(rms)} = I_{rms} R_1$

$V_{2(rms)} = I_{rms} R_2$

You can apply voltage divider and All other dc equations

or $V_{1(rms)} = \frac{V_{S(rms)} R_1}{R_1 + R_2}$ & $V_{2(rms)} = \frac{V_{S(rms)} R_2}{R_1 + R_2}$

EX(12)



determine rms voltage across each resistor & " current & total power

sol/ $V_{1rms} = \frac{V_{S(rms)} \times R_1}{R_1 + R_2} = \frac{120 \times 1k}{1k + 560\Omega} = 76.9V$

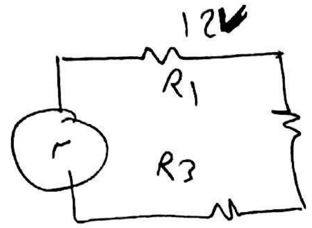
$V_{2(rms)} = \frac{V_{S(rms)} \times R_2}{R_1 + R_2} = \frac{120 \times 560}{560 + 1k} = 43.1V$

$I_{rms} = \frac{V_{S(rms)}}{R_1 + R_2} = \frac{120}{1K + 560} = 76.9mA$

$P_{tot} = I_{rms} V_{rms} = 120 \times 76.9mA = 9.23V$

EX(13)

(a)



① find unkown peak Voltage drop

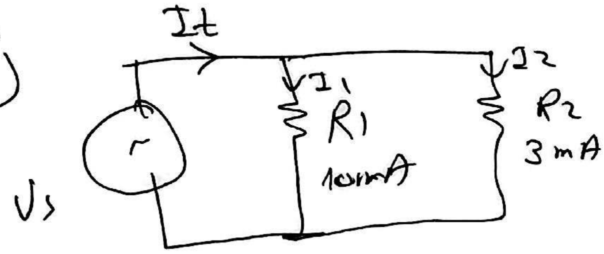
لاحظ لو لم يذكر إيه (peak/rms) source معتبره RMS

$\therefore V_{s(rms)} = V_{R_1(rms)} + V_{R_2(rms)} + V_{R_3(rms)}$

$24 = 12 + 8 + V_{R_3}$ $\quad \therefore V_{R_3} = 4V_{(rms)} = \frac{Peak}{\sqrt{2}}$

$V_{p(R_3)} = 4 \times \sqrt{2} = 5.66\,V$ (peak)

(b)



find total Rms current & total power of $V_{rms} = 24V$

Sol

$I_t = I_{R_1} + I_{R_2} = (10 + 3)\,mA = 13\,mA$

$P_t = I_t V_s = 24 \times 13 \times 10^{-3} = 312\,mW$

Good luck