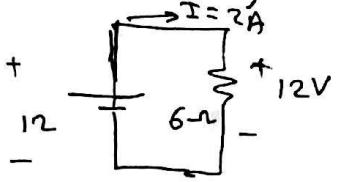
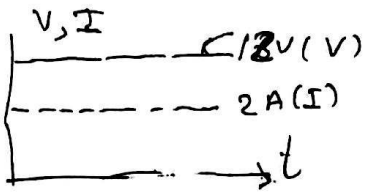
Lec (9)

(AC) alternating Current

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





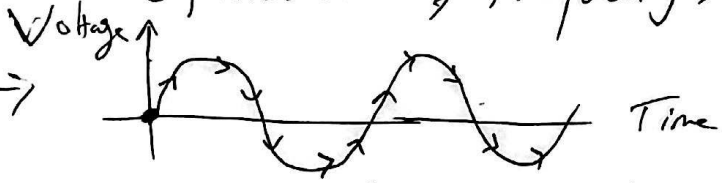
DC sowrce constant values with time (DC = Direct current)

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)

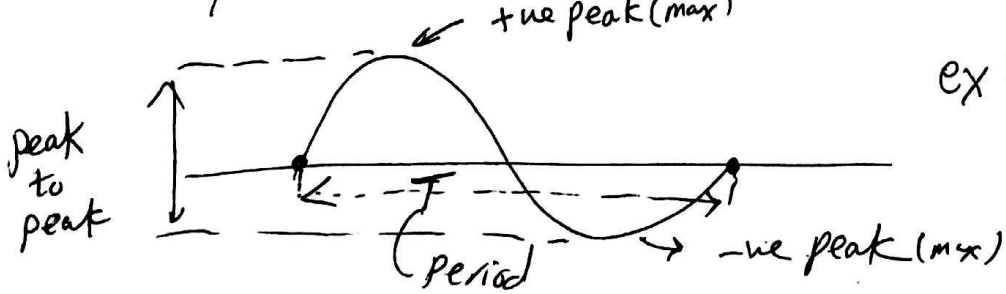
→



- 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)

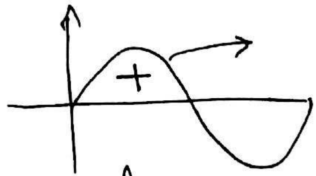
- The waveform (signal is called periodic) because every period it repeats itself.

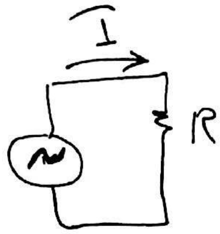
-- Symbol of Ac in Electrical circuit



ex signal with peak 5V

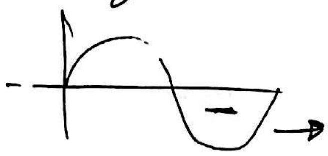
* Polarity of Sine wave

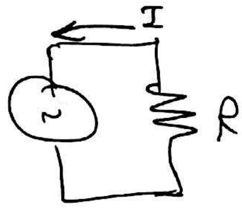




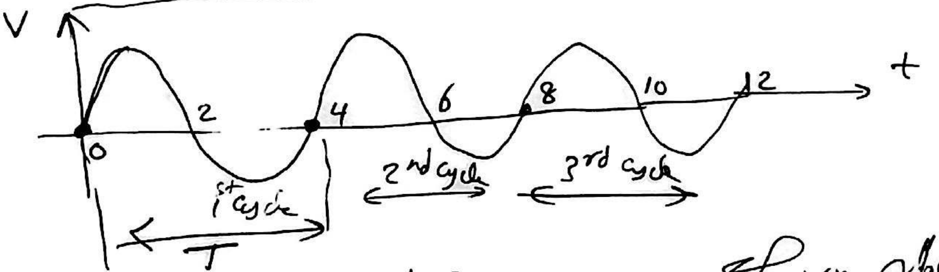
During (+ve half Cycle) → Voltage Source is positive & Current generates (clockwise)

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





* Period of Sine wave



(EX1)
Calculate the period of Sine wave Shown above ?

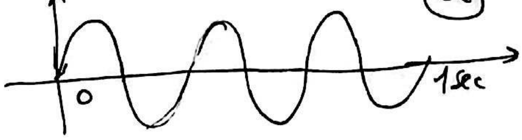
Sol $T = 4\ sec$ [عدد الـ cycle 8 ; زمن cycle واحدة = period]

* Frequency of Sine wave

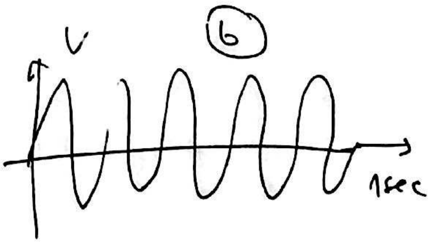
$f = \frac{1}{T}$ → تقاس بالهرتز HZ

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

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 $\frac{1}{T} = \frac{1}{\frac{1}{5} sec} = 5\ HZ$

∴ fig (b) more freq. than fig (a)

EX(3) If the Period of Certain Sine wave is 10ms, what is Freq?

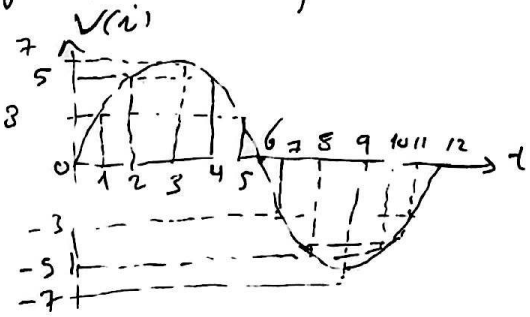
Sol $f = \frac{1}{T} = \frac{1}{10ms} = \frac{1}{10 \times 10^{-3}} = 100Hz$

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

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

Sinusoidal Voltage Values

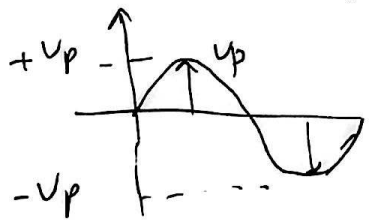
1- Find instantenous value at any time
2- Find peak
3- Peak-to-peak
4- RMS
5- Average



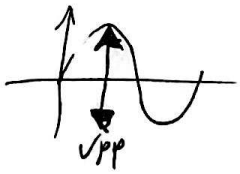
[1] Instantenous Value

i, v هي قيمة Time معين

[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

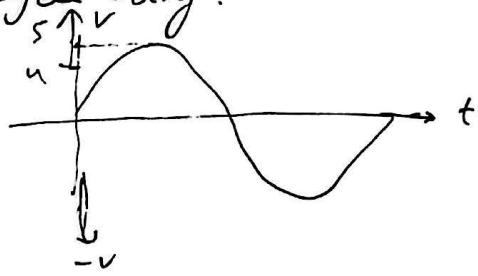
هي القيمة الناتج عند توصيل بطارية dc مع مقاومة وينتج عنها حرارة نفس الحرارة الناتجة عند توصيل AC مع نفس المقاومة.

$RMS = \frac{V_{max}}{\sqrt{2}}$ 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)) → $V_{avg} = \frac{2V_{max}}{\pi} = \frac{2V_p}{\pi}$

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 sine wave

radian ⟷ degree

$\frac{degree}{180^\circ} = \frac{rad}{\pi}$

So $degree = (\frac{180^\circ}{\pi}) \times rad$

$1\ rad = (\frac{\pi}{180^\circ}) \times degree$

Example $180^\circ = ?!\ rad$

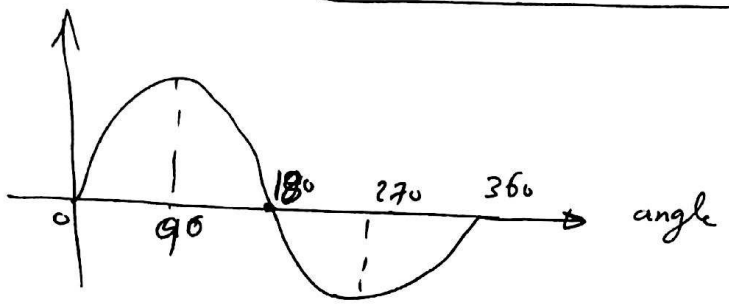
$\therefore rad = \frac{\pi}{180} \times 180 = \pi\ rad$

Ex(6)
Convert 60° to rad. & $\frac{\pi}{6}$ rad to degree

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

b- $deg \Rightarrow \frac{180}{\pi} \times (\frac{\pi}{6}) = 30^\circ$

Sine wave angles → (phase)



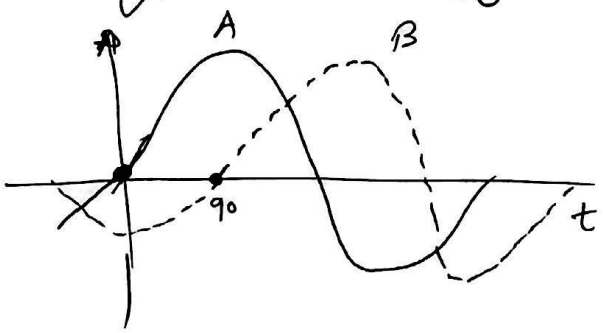
angle ⇒ angular frequency

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

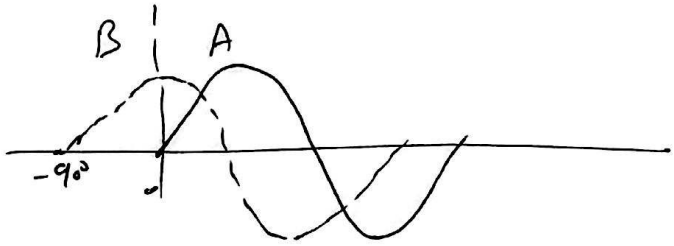
one cycle $= 2\pi = 360^\circ$

The phase of sine wave is [angular measurement of That specifies The position of that Sine wave].

* it is useful to identify which signals lead / or lag

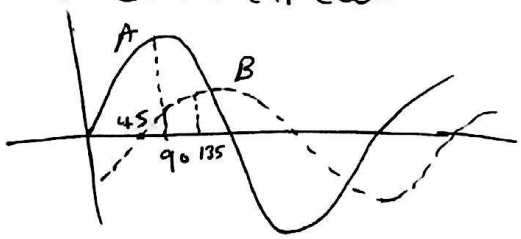


A lead B by 90°
or B lag A by 90°

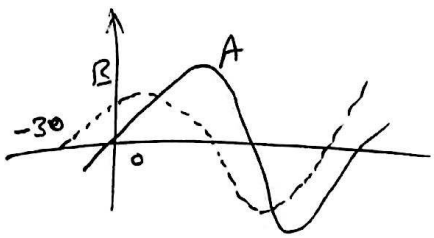


B lead A by 90°
or A lag B by 90°

EX(7) what is the phase angles between the two Sine waves in Both circuits

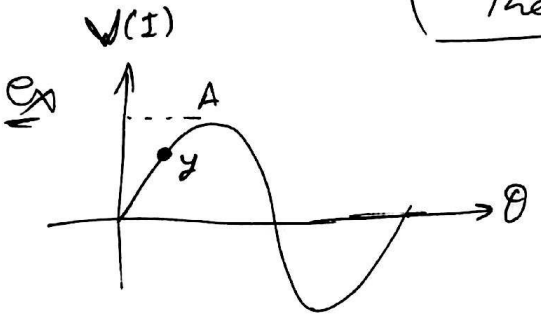


A lead B by 45°
Phase angle 45°



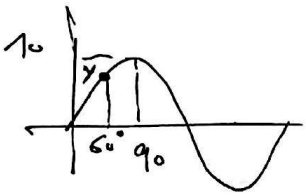
B lead A by 30°
Phase angle 30°

The Sinewave formula (instantenous wave)



$$y = A \sin\theta$$

$$V = V_p \sin\theta$$

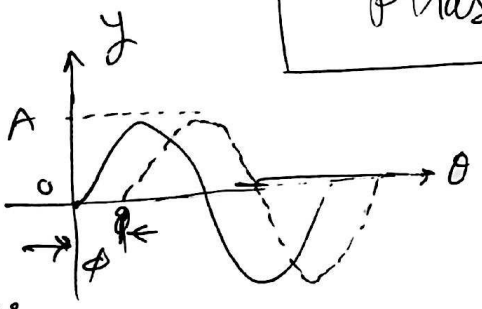


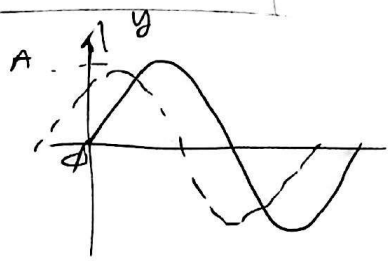
$$\rightarrow V = 10 \sin\theta$$

at $60^\circ \rightarrow V = 10 \sin 60 = 8.66V$

$\therefore y = 8.66V$

Phase shift sinewave

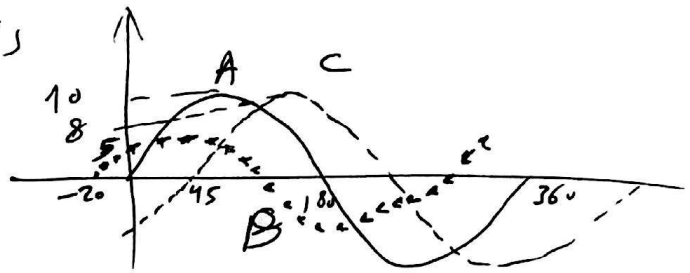




$y = A \sin(\theta - \Phi)$ — Reference ← solid

$y = A \sin(\theta + \Phi)$ — Ref. ← solid

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



$$V_A = A \sin\theta = 10 \sin\theta \Big|_{90^\circ} = 10 \sin 90 = 10\,V$$

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

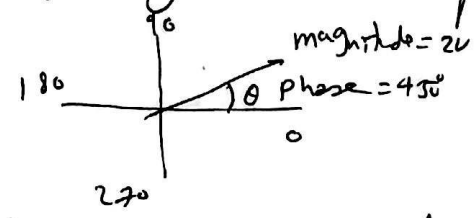
$90^\circ + 20$

$$V_C = 8 \sin(\theta - 45^\circ) = 8 \sin(90 - 45) = 5.66V$$

Phasor diagram

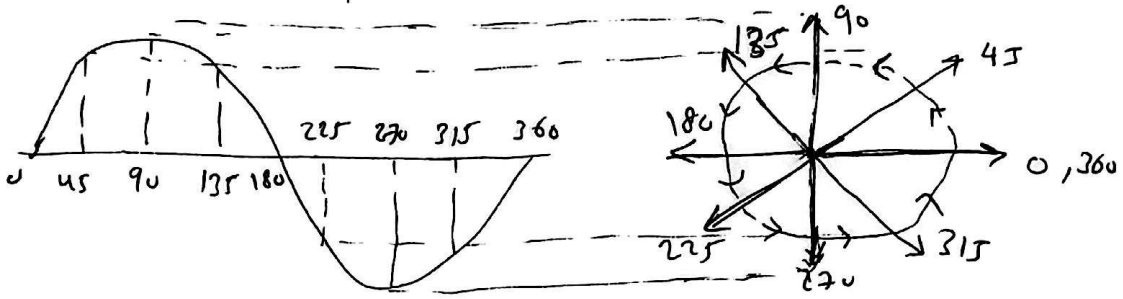
Quantity vary with time represented by a vector = phasor

ex)

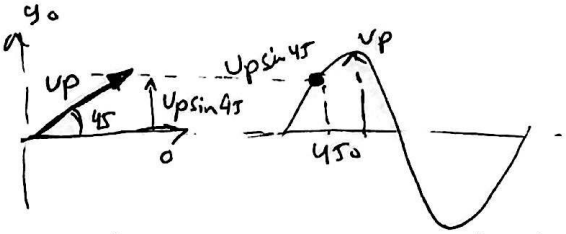


→ how to represent sine wave in a phasor ?!

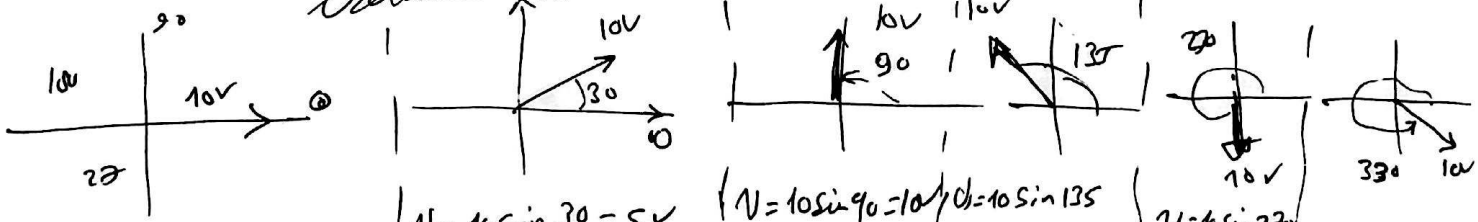
ex)



ex)



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



$V = 10 \sin 0 = 0V$

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

$V = 10 \sin 30 = 5V$

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

$V = 10 \sin 90 = 10$ / $\theta = 90 - 360 = -270$

$V = 10 \sin 135$ / $\theta' = 135 - 360 = -225$

$V = 10 \sin 270 = -10V$ / $\theta' = 270 - 360 = -90°$

$V = 10 \sin 330 = -5V$ / $\theta' = 330 - 360 = -30°$

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

angular velocity of a phasor

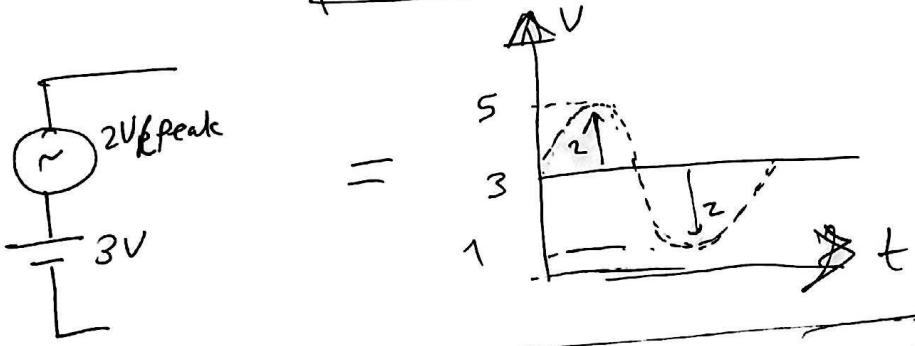
$\omega = 2\pi f$ (rad/sec)

1 cycle = 2π = 360° of phasor

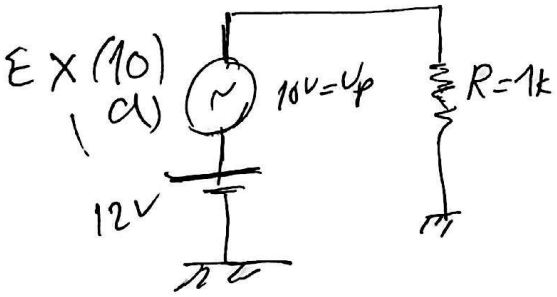
→ The velocity of rotation is called angular velocity = $\omega = 2\pi f$

So instantaneous voltage $v = V_p \sin \omega t$

Superimposed dc & Ac voltage



EX (10) (a)

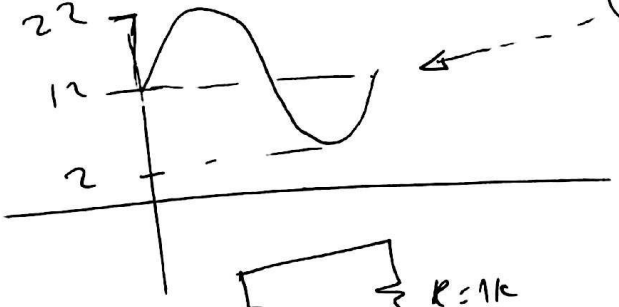


calc. voltage (max and min) across Resistor & draw

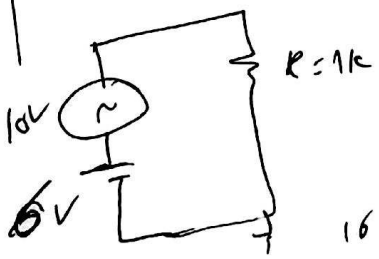
sol/

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

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

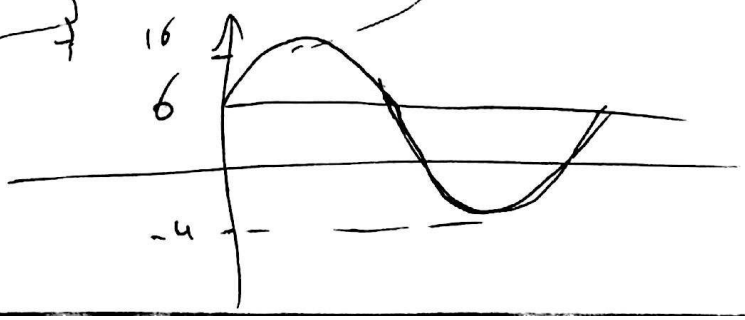


EX (6)



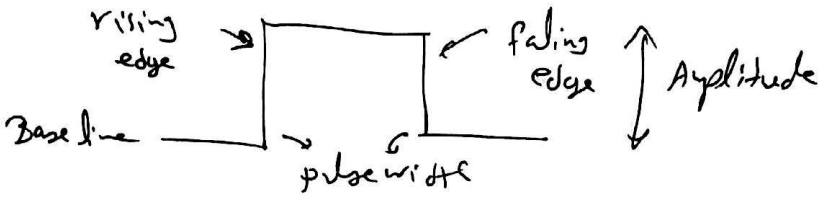
$V_{max} = (6) + 10 = 16V$

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

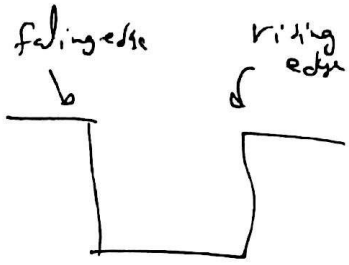


انواع أخرى من waves

pulse

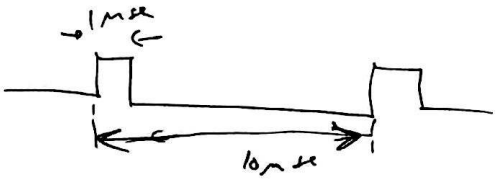


+ve pulse



-ve pulse

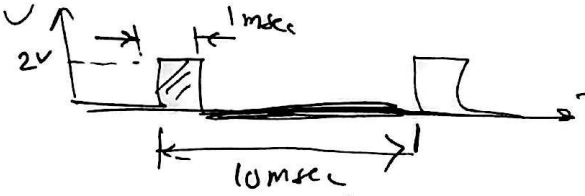
* duty cycle (percentage) = $\frac{T_{on}}{T_{on}+T_{off}}$ 100%

ex 

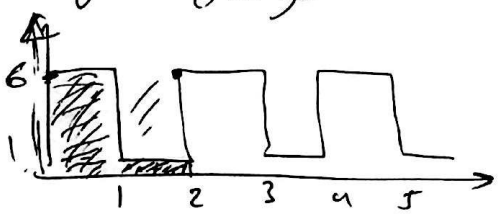
$\text{duty cycle} = \frac{1\mu}{10\mu} \times 100\ \% = 10\%$

* average value = area under curve for one cycle = $\frac{\text{مساحة الشكل الموجي لدورة كاملة}}{\text{الزمن لكل}}$

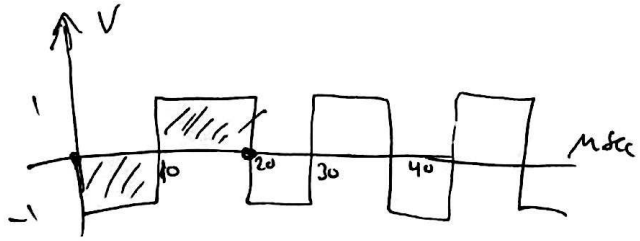
EX(1)

(a) 

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

(b) 

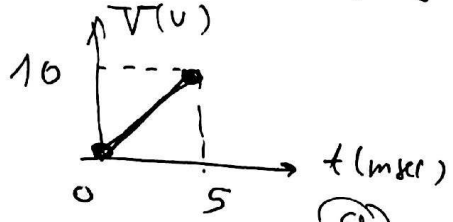
$= \frac{1 \times 6 + (1 \times 1)}{2} = \frac{6+1}{2} = 3.5\ V$

(c) 

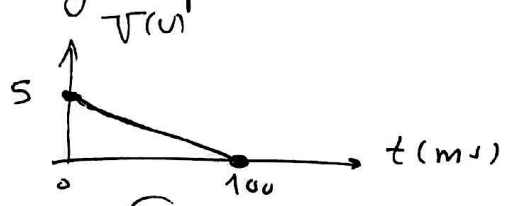
$= \frac{(10 \times -1) + (10 \times 1)}{20} = \text{Zero}\ V$

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), $x = t$ (msec)

$(x_2, y_2) = (5\text{ msec}, 10)$

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

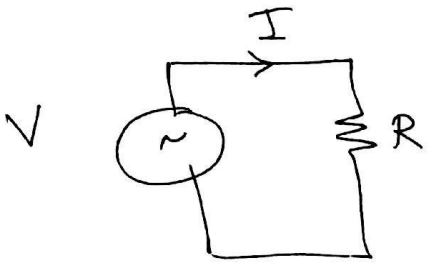
$V = 2t$ msec

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

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

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

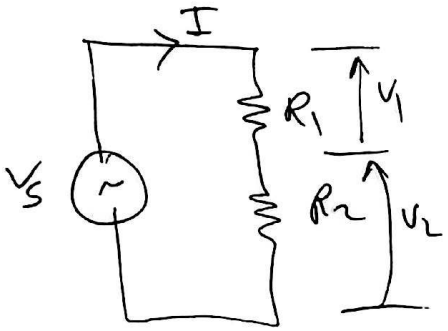
ohms law



$V_p = I_p R$

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

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



$V_S = V_1 + V_2$

$V_{S_{rms}} = V_{1rms} + V_{2rms}$

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

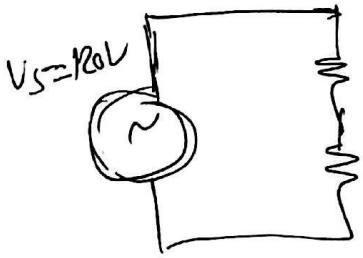
$V_{1(rms)} = I_{rms} R_1$

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

You can apply voltage divider and All other dc equations

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

EX(12)



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

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

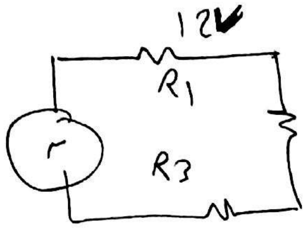
$V_{2(rms)} = \frac{V_{S(rms)} \times R_2}{R_1 + R_2} = \frac{120 \times 560}{560 + 1k} = 43.1V$

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

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

EX(13)

(a)



① find unkown peak Voltage drop

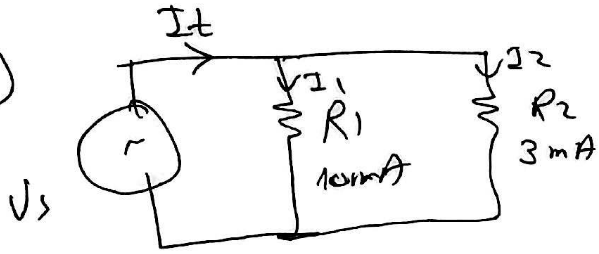
لاحظ لو لم يذكر الـ (peak/rms) source يعتبر RMS

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

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

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

(b)



find total Rms curnet & 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