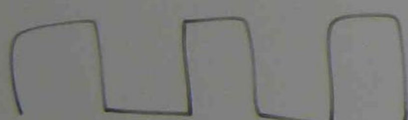
HARMONICS AND FOURIER ANALYSIS

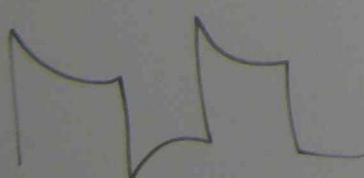
HALF WAVE RECTIFIER SINE WAVE

FULL WAVE RECTIFIER SINE WAVE



SQUARE WAVE

PULSE WAVE



SQUARE WAVE WITH DISTORTION

EXPONENTIAL WAVE

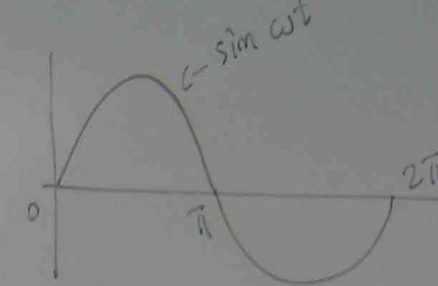
SAW TOOTH WAVE

TRIGULAR WAVE

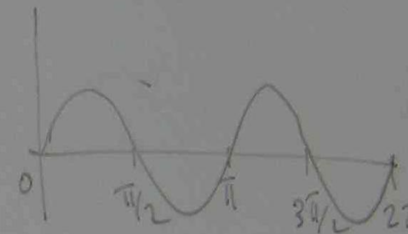
DISTORTED SINE WAVE

FOURIER SERIES →

FUNDAMENTAL = BASE FREQUENCY ($\sin \omega t$)



2nd HARMONIC = 2x BASE FREQUENCY ($\sin 2\omega t$)



3rd HARMONIC = 3 x BASE FREQUENCY ($\sin 3\omega t$)

n^{th} HARMONIC = n x BASE FREQUENCY ($\sin n\omega t$)

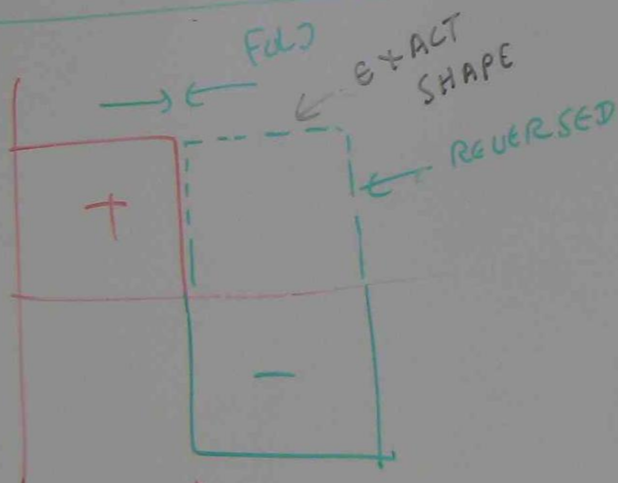
FUNDAMENTAL + HARMONIC = DISTORTED WAVE

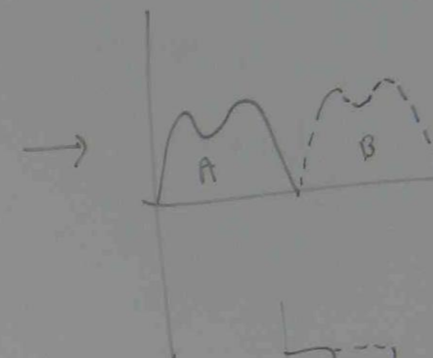
GENERALIZED MATHEMATICAL EQUATION FOR FUNDAMENTAL & HARMONIC WAVES

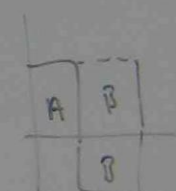
$$f(t) = \frac{1}{2}a_0 + a_1 \cos \omega t + a_2 \cos 2\omega t + a_3 \cos 3\omega t + \cdots + b_1 \sin \omega t + b_2 \sin 2\omega t + b_3 \sin 3\omega$$

FOURIER SERIES SIMPLIFICATION USING WAVEFORM SYMMETRY

CONDITION (1) HALF WAVE SYMMETRY

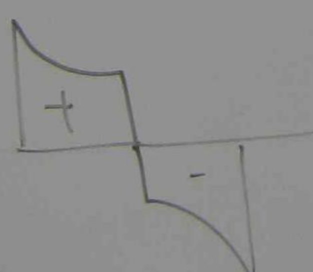






$\omega t + - - -$

NOT HALF WAVE SYMMETRY



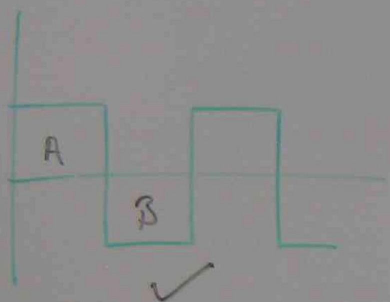
SELF ASSESSMENT (1)

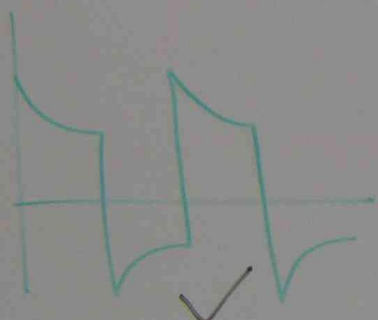
INDICATE WHETHER THE FOLLOWING WAVES ARE HALF WAVE SYMMETRIC

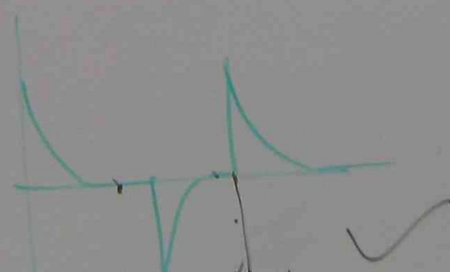
→ 3 pm - UEENEEE
6032H

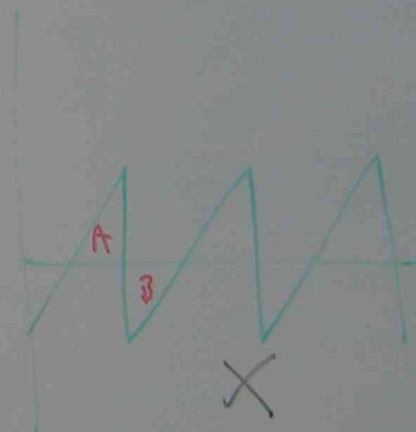
3 → 5 pm UEENEEE
UEENEE H

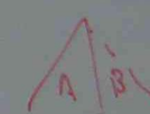
5:30 → 9:30 UEENEE H
UEENEE

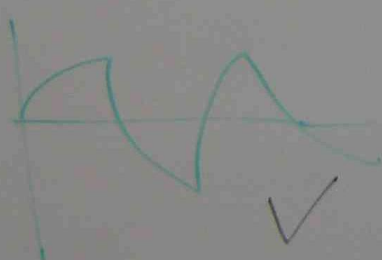






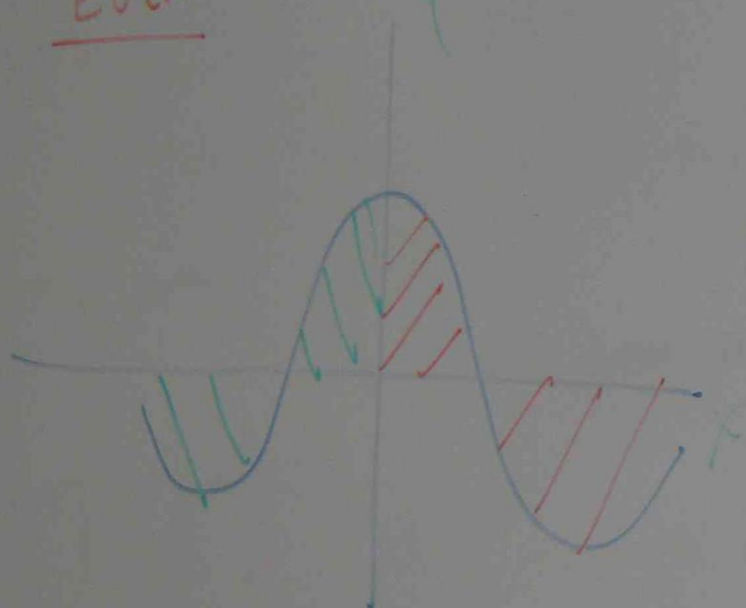


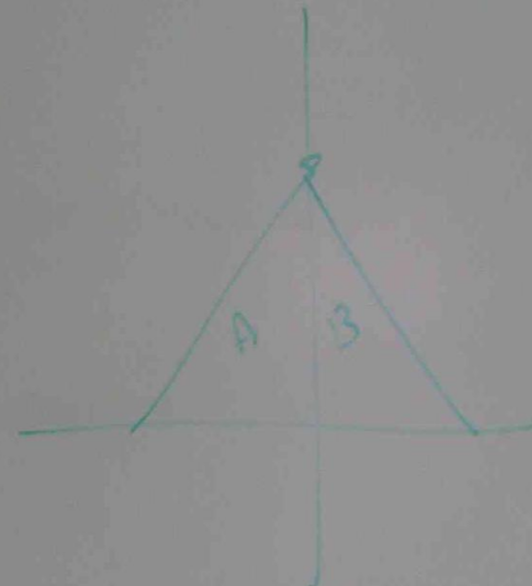


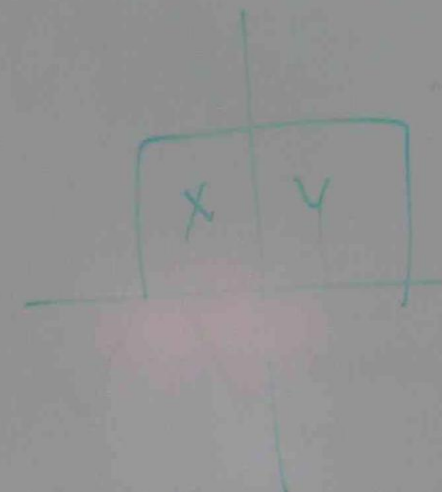


ODD AND EVEN FUNCTIONS

EVEN

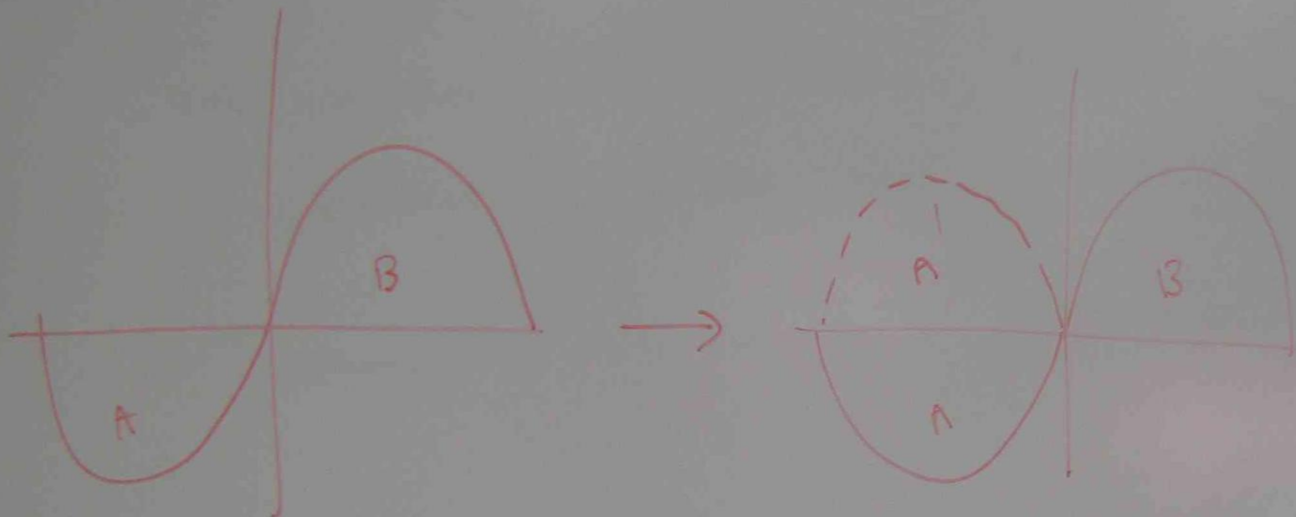






DIRECT FOLD → EVEN

ODD



REVERSED & FOLD → ODD

$$f(t) = \frac{1}{2}A_0 + a_1\cos\omega t + a_2\cos 2\omega t + a_3\cos 3\omega t + \cdots + b_1\sin\omega t + b_2\sin 2\omega t + b_3\sin 3\omega t + \cdots$$

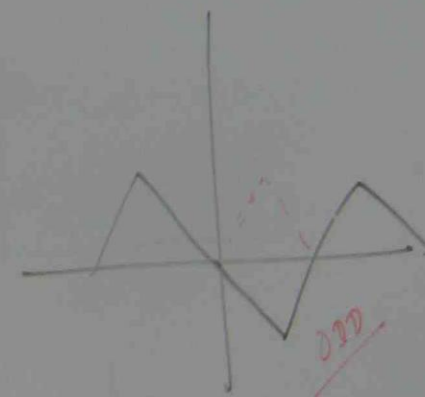
GENERALIZED FOURIER EQUATION FOR ALL WAVE FORMS.

EVEN FUNCTION

$$f(t) = a_0 + a_1 \cos \omega t + a_2 \cos 2\omega t + a_3 \cos 3\omega t \cdots$$

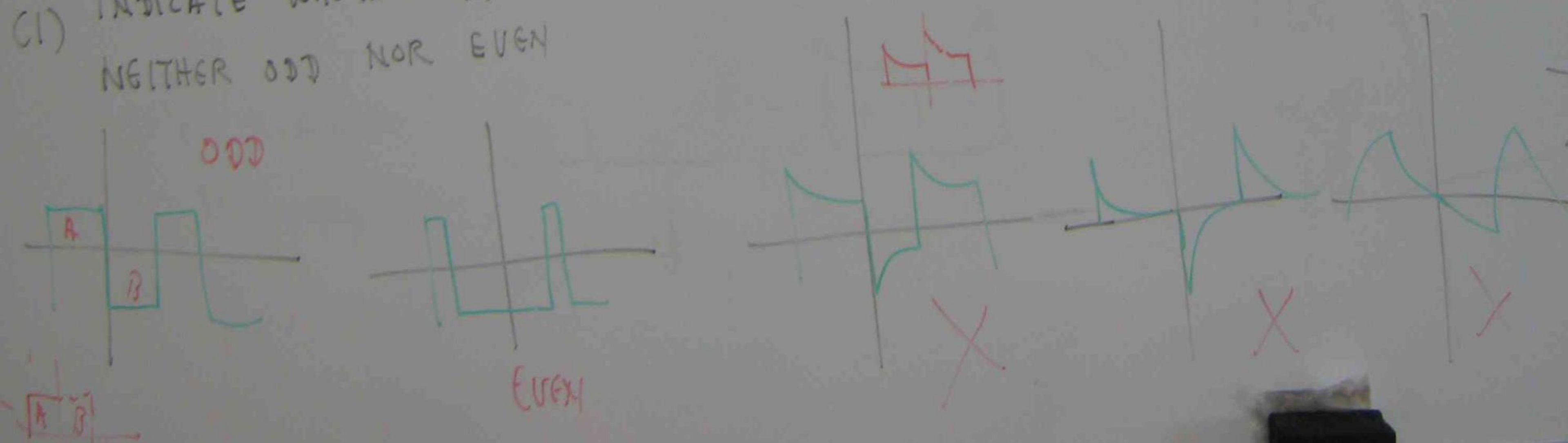
ODD FUNCTION

$$f(t) = b_1 \sin \omega t + b_2 \sin 2\omega t + b_3 \sin 3\omega t + \cdots$$



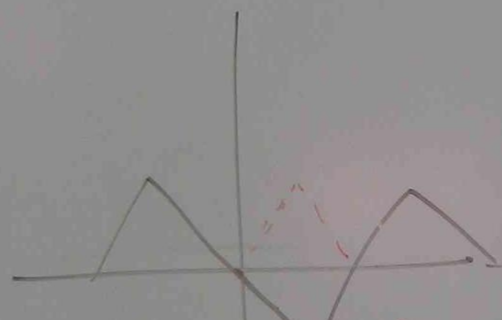
EXERCISE (2)

(1) INDICATE WHETHER THE FOLLOWING WAVES ARE ODD, EVEN (OR) NEITHER ODD NOR EVEN



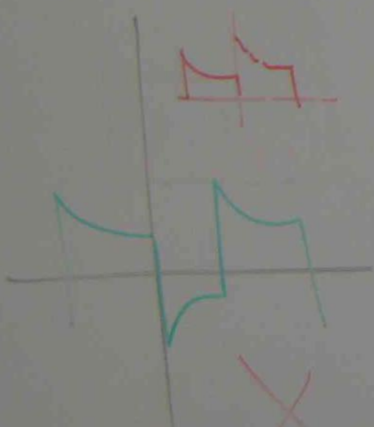
$a_2 \cos 2\omega t + a_3 \cos 3\omega t - - - -$

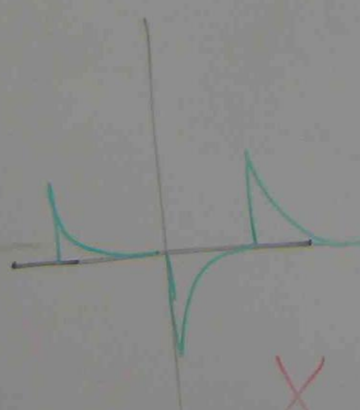
$\omega t + b_3 \sin 3\omega t + - - - -$



ODD

G WAVES ARE ODD, EVEN (OR)





(2) INDICATE WHETHER THE

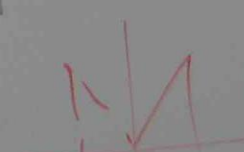
ARE EVEN (OR) ODD

ODD (a) $f(t) = \frac{2}{\pi} \sin \omega t +$

(b) $f(t) = 70 \sin \omega t + 20 s$

$+ 10 \sin$

(c) $f(t) = 3$



ODD

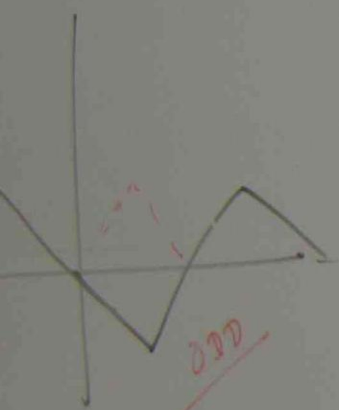
(2) INDICATE WHETHER THE FOLLOWING SERIES ARE EVEN (OR) ODD

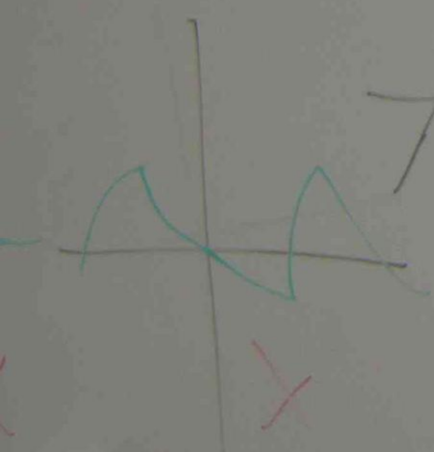
ODD (a) $f(t) = \frac{2}{\pi} \sin \omega t + \frac{3}{2\pi} \sin 3\omega t + \cdots$

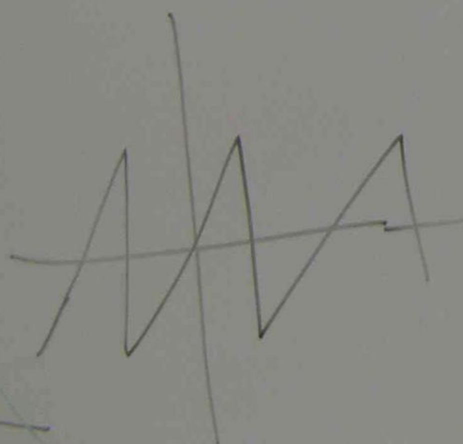
X (b) $f(t) = 70 \sin \omega t + 20 \sin 2\omega t + 10 \sin 3\omega t + 40 \cos \omega t + 10 \cos 2\omega t$

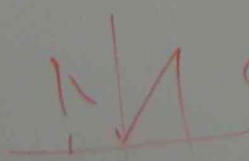
(c) $f(t) = 35 - \frac{10}{\pi} \sin \omega t - \frac{10}{2\pi} \sin 2\omega t$ ODD

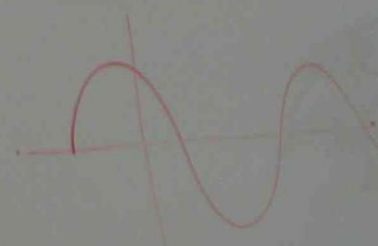
DC COMPONENT

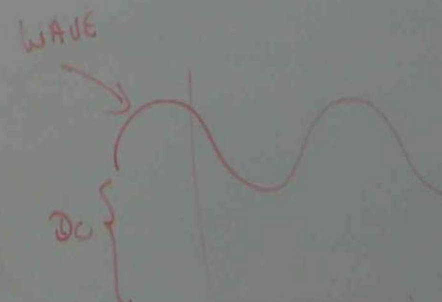












→ 3 pm - UEENEEE[...] 6032A

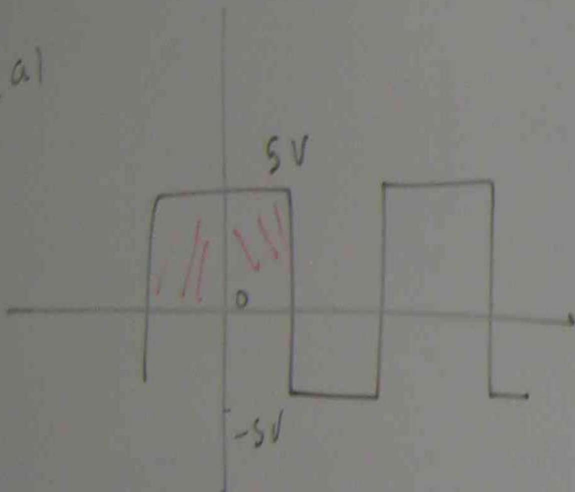
3 → 5 pm UEENEEE[...] UEENEEH[...]

9:30 → 9:30 UEENEEH[...]

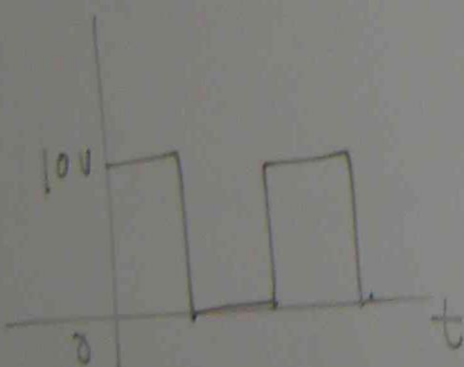
UEENEE[...]

pb - CONSTRUCT BASIC FOURIER SERIES FOR THE FOLLOWING WAVE SHAPES.

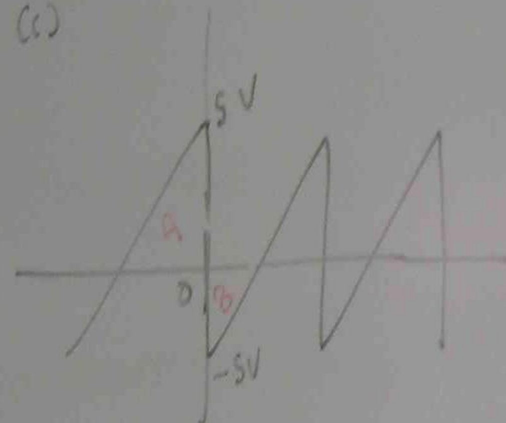
(a)



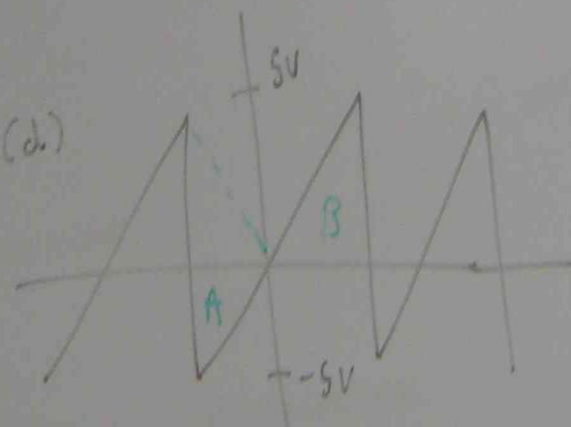
(b)



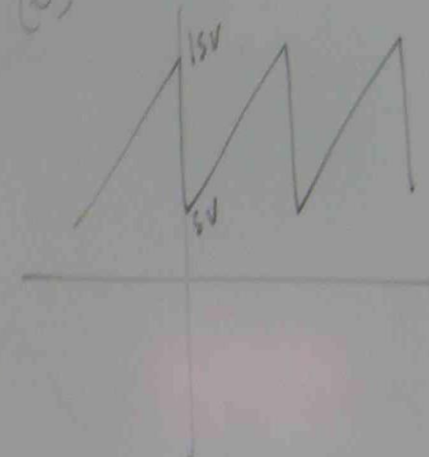
(c)



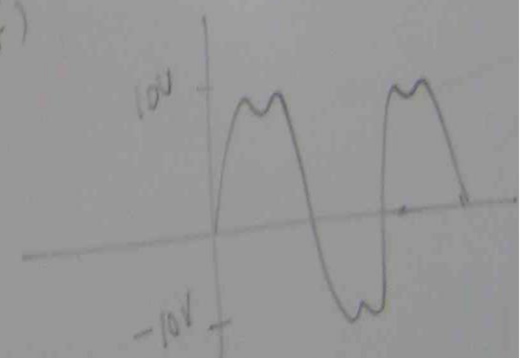
(d)



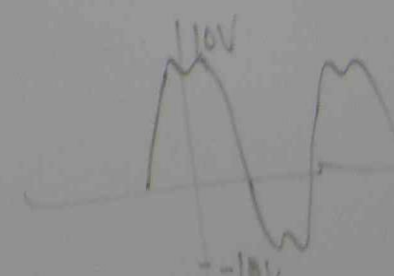
(e)



(f)



(g)



(a)(g) EVEN, NO DC

$$e(t) = \cancel{a_0} + a_1 \cos \omega t + a_2 \cos 2\omega t + a_3 \cos 3\omega t + \cdots$$

(b) NO EVEN, NO ODD, NO DC

$$e(t) = \cancel{a_0} + a_1 \cos \omega t + a_2 \cos 2\omega t + a_3 \cos 3\omega t + \cdots + b_1 \sin \omega t + b_2 \sin 2\omega t + b_3 \sin 3\omega t + \cdots$$

(c)(d)(f) ODD, NO DC

$$e(t) = b_1 \sin \omega t + b_2 \sin 2\omega t + b_3 \sin 3\omega t + \cdots$$

(e) NO EVEN, NO ODD WITH DC

$$e(t) = a_0 + a_1 \cos \omega t + a_2 \cos 2\omega t + a_3 \cos 3\omega t + \cdots + b_1 \sin \omega t + b_2 \sin 2\omega t + b_3 \sin 3\omega t \cdots$$

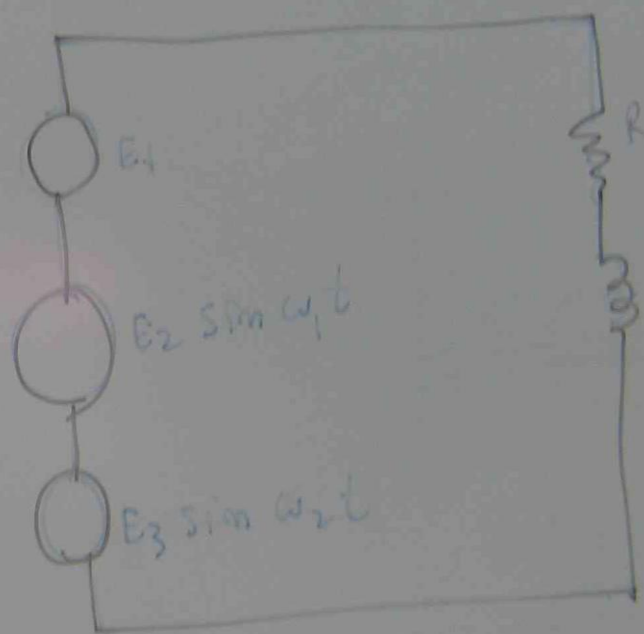
MATHEMATICAL FUNCTION EXPRESSION OF EVEN AND ODD FUNCTION

EVEN $f(t) = f(-t)$

ODD $f(t) = -f(-t)$

REVERSED

HARMONICS IN CIRCUIT ANALYSIS

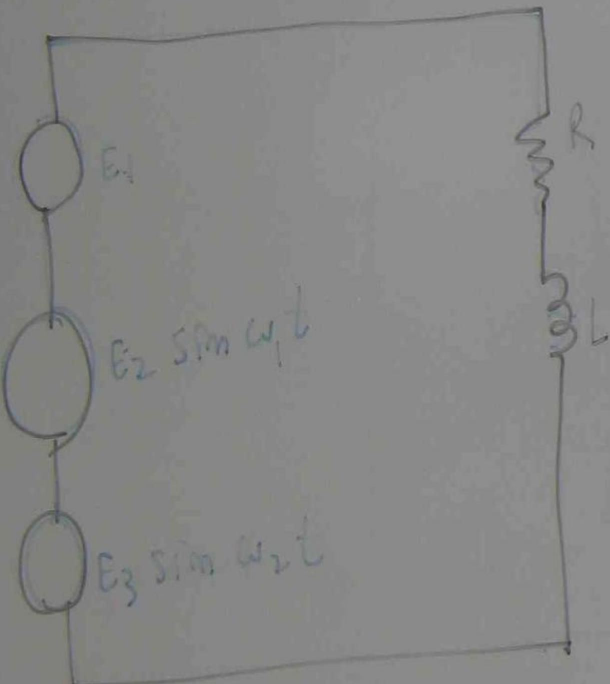


$= \sqrt{1.25^2 + 1.49^2 + 0.132^2}$

E_2 IS LEFT

$E_2 \sin \omega_1 t$

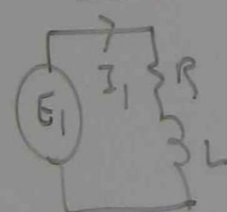
MONICS IN CIRCUIT ANALYSIS



$$E_{rms\ TOTAL} = \sqrt{E_1^2 + E_2^2 + E_3^2}$$

$$I_{rms} = \sqrt{I_1^2 + I_2^2 + I_3^2}$$

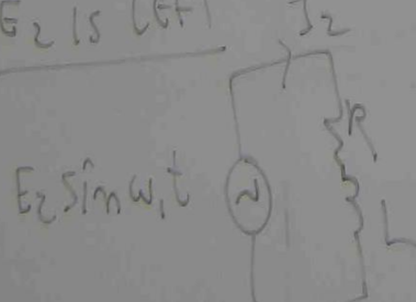
E1 IS LEFT



$$I_1 = \frac{E_1}{\sqrt{R^2 + \omega^2 L^2}} = \frac{E_1}{R}.$$

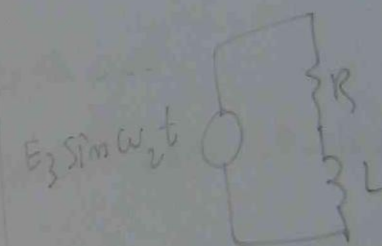
$\omega = 0$

E2 IS LEFT



$$I_2 = \frac{E_2}{\sqrt{R^2 + (\omega_1 L)^2}}$$

E3 IS LEFT



$$I_3 = \frac{E_3}{\sqrt{R^2 + (\omega_2 L)^2}}$$

Q6

A SERIES R-L CIRCUIT HAS A RESISTANCE OF 20 Ω AND AN INDUCTANCE OF 0.2 HENRY. THE APPLIED VOLTAGE IS

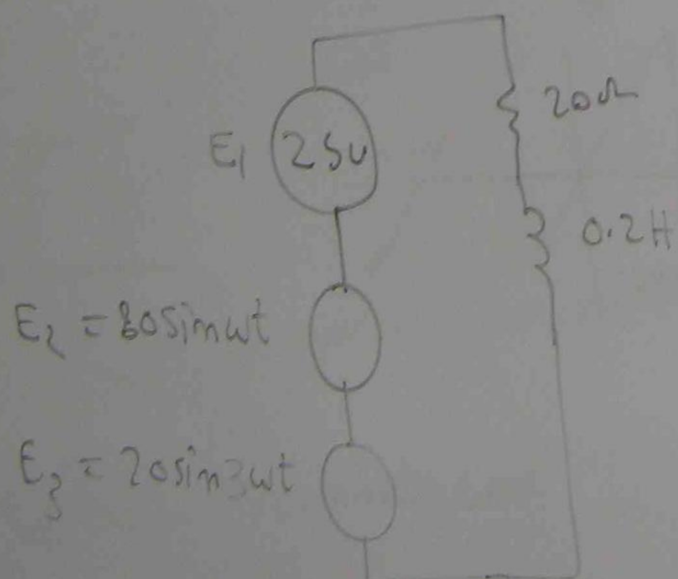
$$v(t) = 25 + 80\sin\omega t + 20\sin 3\omega t \quad \text{WHERE} \quad \omega = 250 \text{ rad/sec.}$$

FIND

(a) THE INSTANTANEOUS CURRENT

(b) RMS VOLTAGE AND CURRENT

(c) AVERAGE POWER SUPPLIED TO CIRCUIT.



$E_1 = 25V$

$E_2 = 80V$

$E_3 = 20V$

$$E_{rms} = \sqrt{25^2 + 80^2 + 20^2}$$

$=$

E_1

$$I_1 = \frac{E_1}{\sqrt{R^2+\omega^2 L^2}} = \frac{25}{20} = 1.25 \text{ Amp.}$$

20

$E_2 = 80 \sin \omega t$ $\qquad \omega = 250$

$$I_2 = \frac{80}{\sqrt{20^2+(250\times 0.2)^2}}$$

$$= \frac{80}{\sqrt{20^2+50^2}\ \angle \tan^{-1}\frac{50}{20}} \qquad \angle 68.2^\circ$$

$$= 1.49 \angle -68.2 \text{ Amp.}$$

$E_3 = 20 \sin 3\omega t$

$$I_3 = \frac{20}{\sqrt{20^2+(3\times 250\times 0.2)^2}}$$

$$= \frac{20}{151.3\ \angle \tan^{-1}\frac{3\times 250\times 0.2}{20}}$$

$$= 0.132 \angle -82.4^\circ$$

$$I_{rms} = \sqrt{I_1^2+I_2^2+I_3^2}$$