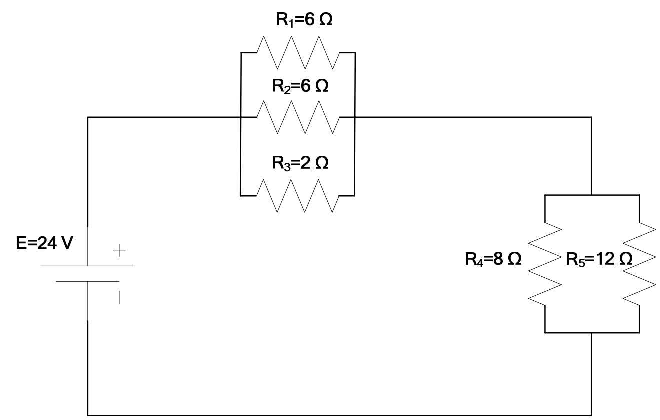
Sheet (1)

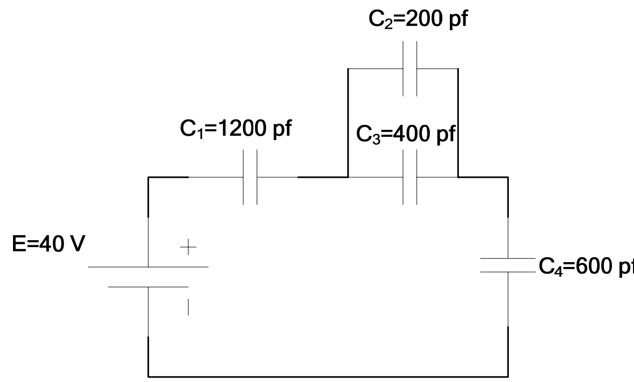
1. What is the diameter of a copper wire with a resistance of 0.5 Ω and a length of 45 m. knowing that the resistivity of copper is 1.72×10^{-8} Ω.m.

2. For the circuit shown in Fig. (1) find:
   a) The current in each branch
   b) The power consumed in each resistance.



3. Find the capacitance of a parallel plate capacitor if the area of each plate is 0.075 m^2 and the distance between the plates is 1.77 mm. The dielectric is air with relative permittivity of 1.0006.

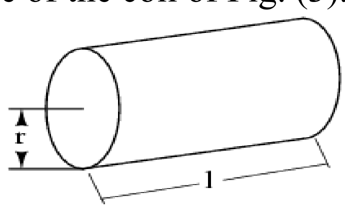
4. Find the voltage across and charge on each capacitor for the circuit shown in Fig. (2).



5. Find the inductance of the coil of Fig. (3).

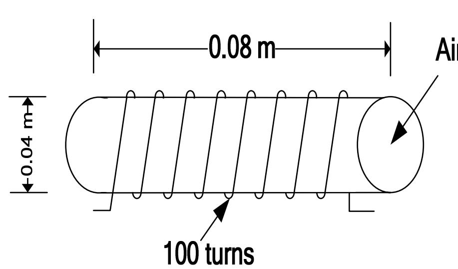
$$L = \frac{N^2 \mu A}{l}$$

$$\mu = \mu_r \mu_o$$

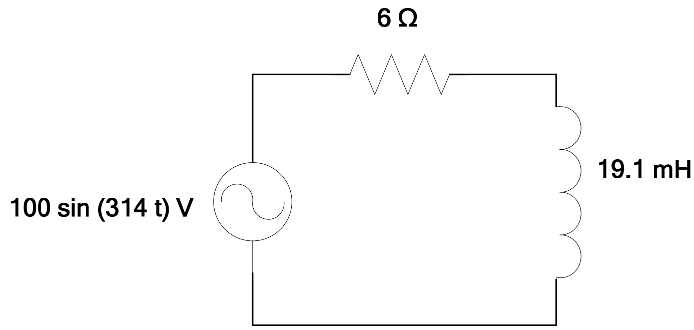


Where,

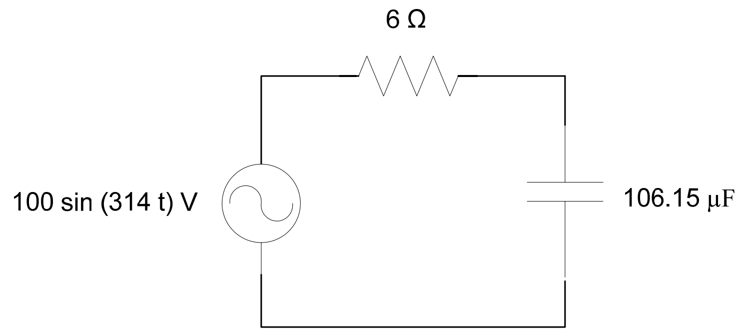
L = Inductance of coil in Henrys
N = Number of turns in wire coil (straight wire = 1)
μ = Permeability of core material (absolute, not relative)
μ_r = Relative permeability, dimensionless (μ_o=1 for air)
μ_o = 1.26 x 10^{-6} T-m/At permeability of free space
A = Area of coil in square meters = πr^2
l = Average length of coil in meters



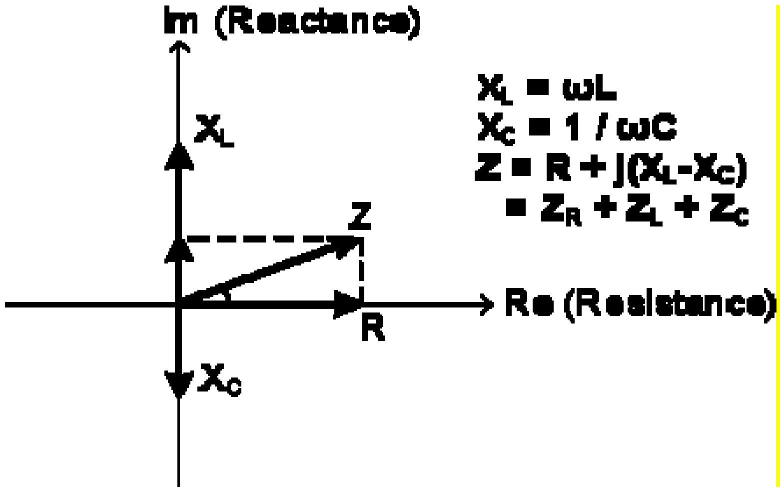
6. For the Circuit of Fig. (4):
   a) Find the total impedance.
   b) Draw the impedance diagram.
   c) Find the supply current and the voltages across the resistor and inductor.
   d) Draw the phasor diagram of the voltages and current.
   e) Find the apparent, active and reactive powers.
   f) Find the power factor of the circuit and indicate whether it is leading or lagging.

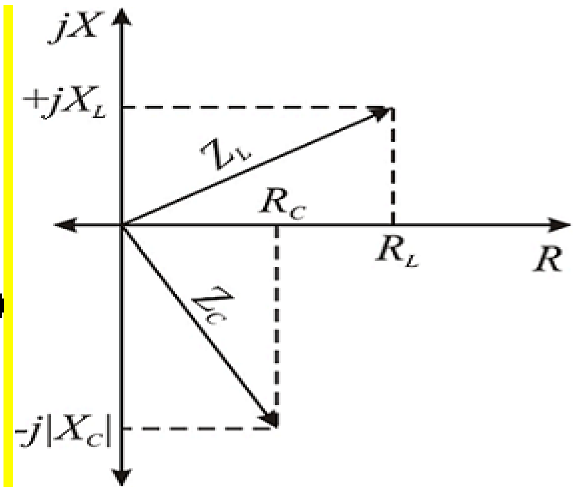


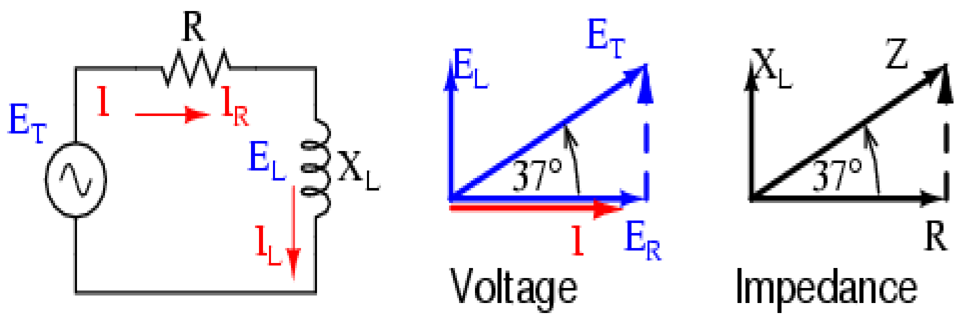
7. Repeat problem (6) for the circuit of Fig. (5) Replacing inductor by capacitor in part (c).

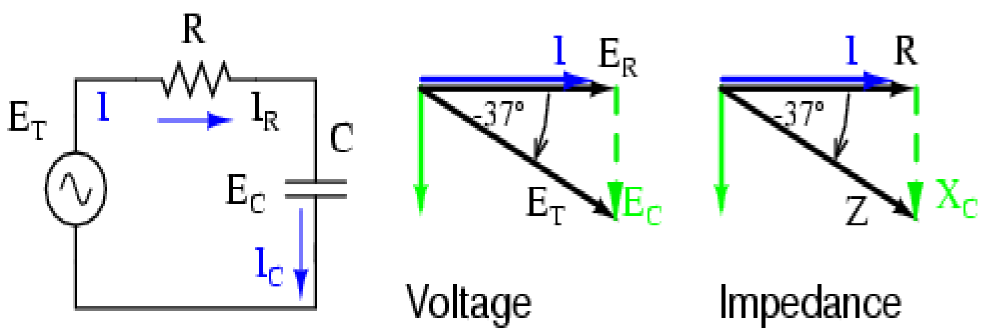


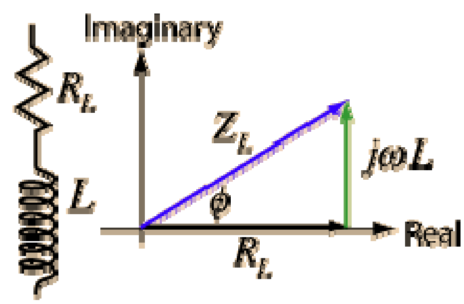
8. A single-phase transformer has a ratio of 1:10 and a secondary winding of 1000 turns. The primary winding is connected to a 25 V sinusoidal supply. If the maximum core flux is 2.25 mWb, determine:
    a) The secondary voltage.
    b) The number of primary turns.
    c) The frequency of the supply.









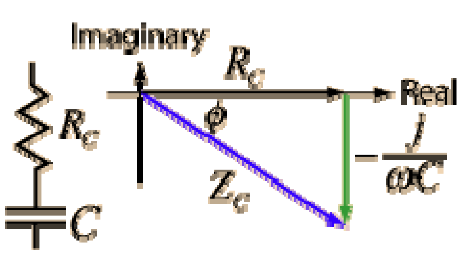


Cartesian form: $Z_L = R_L + j\omega L$

Polar form: $Z_L = |Z_L| e^{j\phi}$

where $|Z_L| = \sqrt{R_L^2 + \omega^2 L^2}$

$\phi = \tan^{-1} \frac{\omega L}{R_L}$

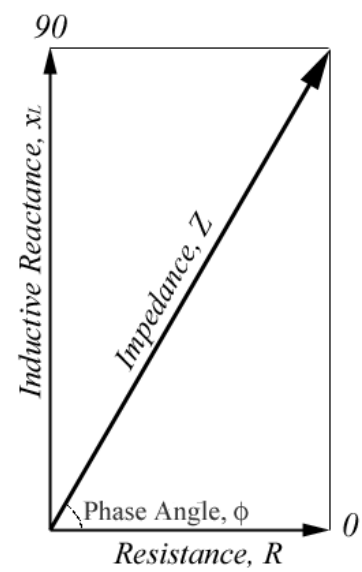


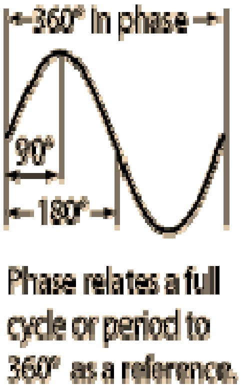
Cartesian form: $Z_C = R_C - \frac{j}{\omega C}$

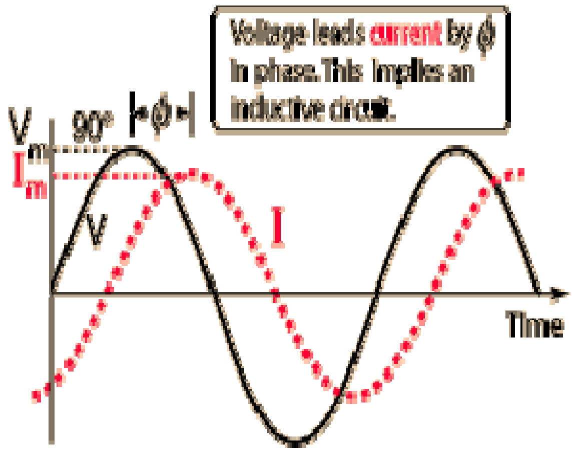
Polar form: $Z_C = |Z_C| e^{j\phi}$

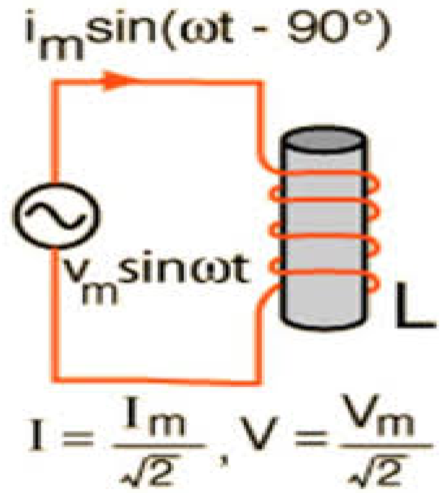
where $|Z_C| = \sqrt{R_C^2 + \frac{-1}{\omega C R_C}}$

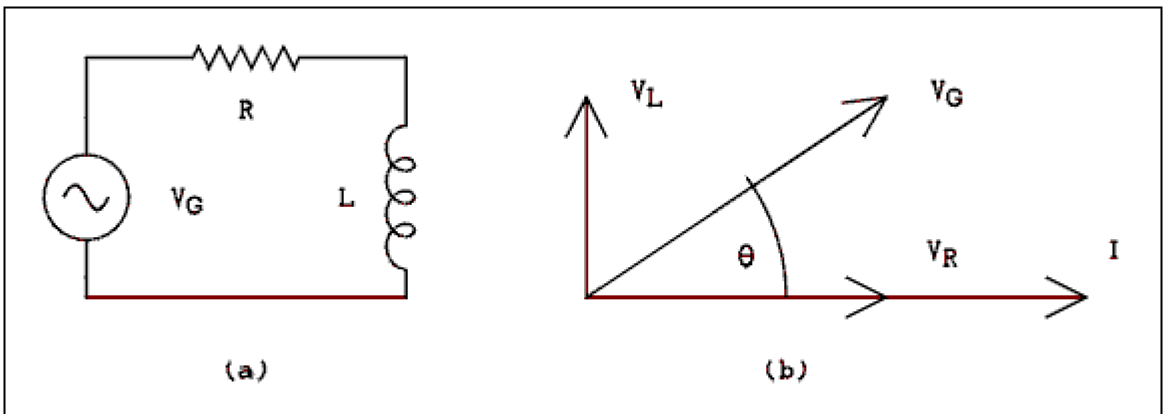
$\phi = \tan^{-1} \frac{-1}{\omega C R_C}$




360° In phase
90°
180°
Phase relates a full cycle or period to 360° as a reference.


Voltage leads current by φ In phase. This implies an inductive circuit.
Vm
Im
90°
φ
V
I
Time


imsin(ωt - 90°)
vmsinωt
L
I = Im/√2 , V = Vm/√2


R
VG
L
VL
VG
θ
VR
I
(a)
(b)

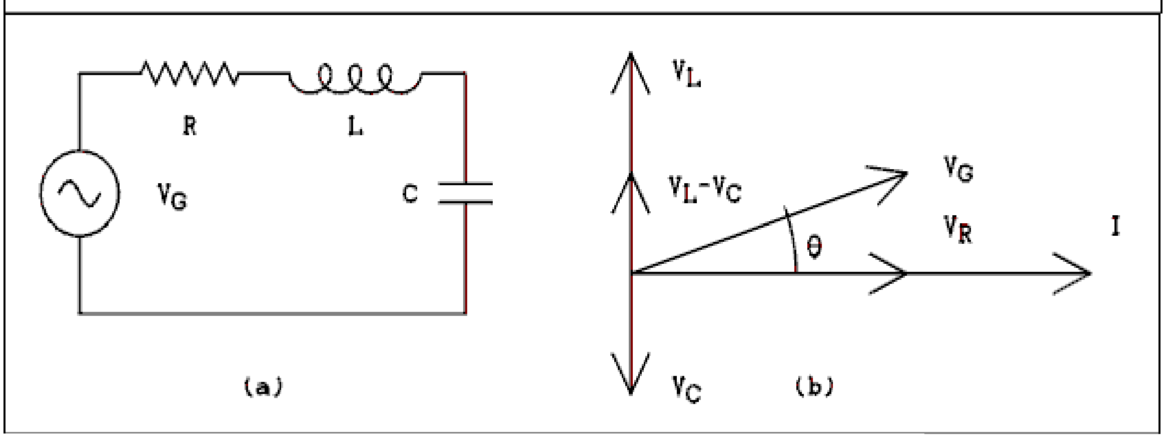
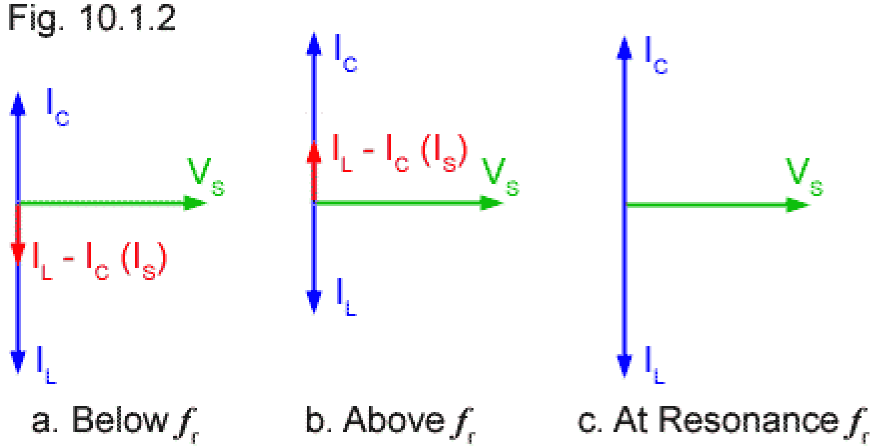

R
L
VG
C
VL
VL-VC
VG
θ
VR
I
VC
(a)
(b)

Fig. 10.1.2


IC
VS
IL - IC (IS)
IL
a. Below fr
b. Above fr
c. At Resonance fr

There are three options in a circuit for current. It can be **leading**, **lagging**, or in phase with voltage. These can all be seen when one maps current and voltage of alternating (AC) circuits against time. The only time that the voltage and current are in phase together is when the load is resistive.

Lagging Current

Lagging current can be formally defined as "an alternating current that reaches its maximum value up to 90° behind the voltage that produces it".[6] This can also be stated as the voltage and current being out of phase. In an inductive circuit, current will be at its maximum phase shift and lagging the voltage.

Leading Current

Leading current can be formally defined as "an alternating current that reaches its maximum value up to 90° ahead of the voltage that produces it".[7] They are both out of phase from each other. In a purely capacitive circuit, current will be at its maximum phase shift and leading the voltage.

Inductor current lags voltage

Capacitor voltage lags current

Example 3 : A single phase transformer has 350 primary and 1050 secondary turns. The primary is connected to 400 V, 50 Hz a.c. supply. If the net cross-sectional area of the core is 50 cm^2, calculate i) The maximum value of the flux density in the core ii) The induced e.m.f. in the secondary winding.

Solution

The given value are,

N_1 = 350 turns, N_2 = 1050 turns

V_1 = 400 V , A = 50 cm^2 = 50 x 10^{-4} m^2

The e.m.f. of the transformer is,

$E_1 = 4.44 f \Phi_m N_1$

$E_1 = 4.44 B_m A f N_1$ as $\Phi_m = B_m A$

Flux density $B_m = E_1 / (4.44 A f N_1)$

$= 400 / (4.44 \times 50 \times 10^{-4} \times 50 \times 350)$ assume $E_1 = V_1$

$= 1.0296$ Wb/m^2

$K = N_2 / N_1 = 1050/350 = 3$

And $K = E_2 / E_1 = 3$

$\therefore$ $E_2 = 3 \times E_1 = 3 \times 400 = 1200$ V

Consider a transformer shown in Fig.1 indicating various voltages and currents.

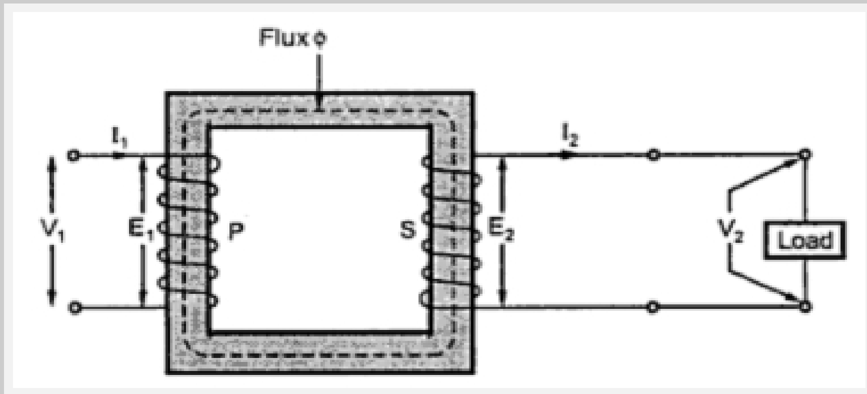


Fig. 1 Ratios of transformer

1. Voltage Ratio

We known from the e.m.f. equations of a transformer that

$$E_1 = 4.44\, f\, \Phi_m\, N_1 \quad \text{and} \quad E_2 = 4.44\, f\, \Phi_m\, N_2$$

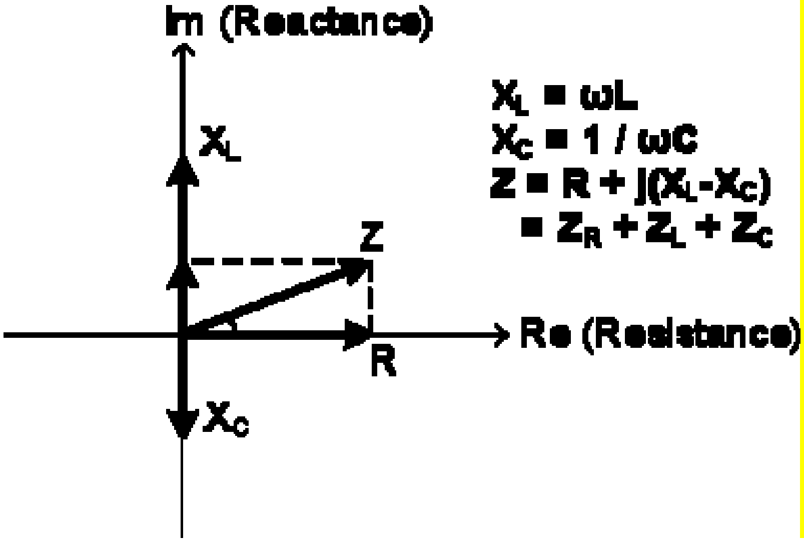
Taking ratio of the two equations we get,

$$\frac{E_2}{E_1} = \frac{N_2}{N_1} = K$$

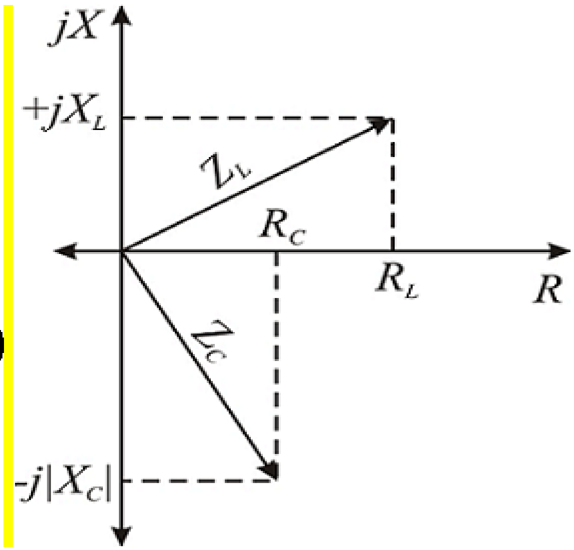
This ratio of secondary induced e.m.f. to primary induced e.m.f. is known as voltage transformation ratio denoted as K,

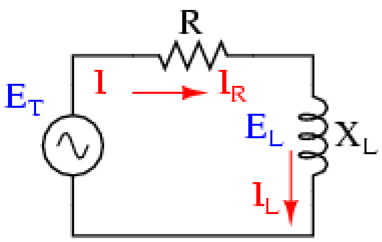
Thus,

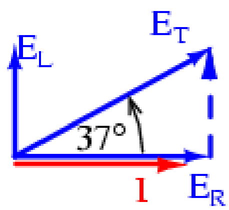
$$E_2 = K\, E_1 \quad \text{where} \quad K = \frac{N_2}{N_1}$$



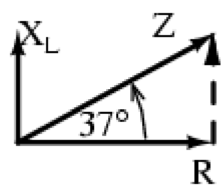
$X_L = \omega L$
$X_C = 1 / \omega C$
$Z = R + j(X_L - X_C)$
$= Z_R + Z_L + Z_C$



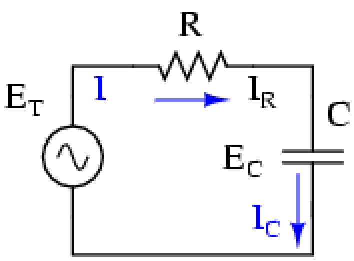


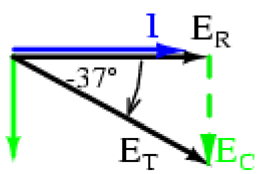


Voltage

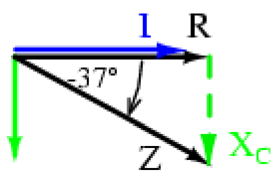


Impedance

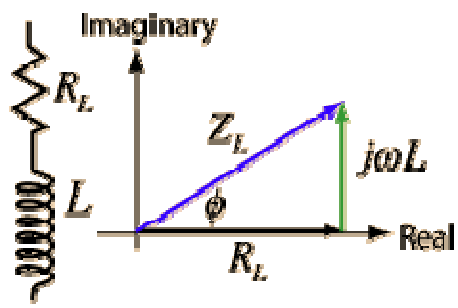




Voltage



Impedance



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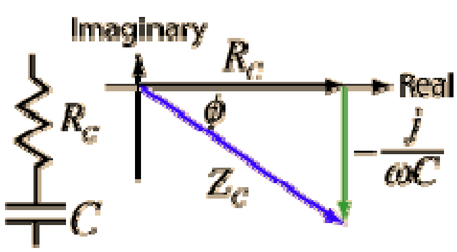

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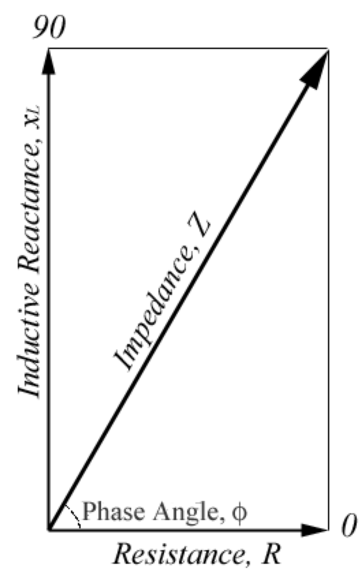
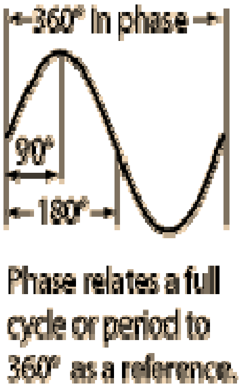
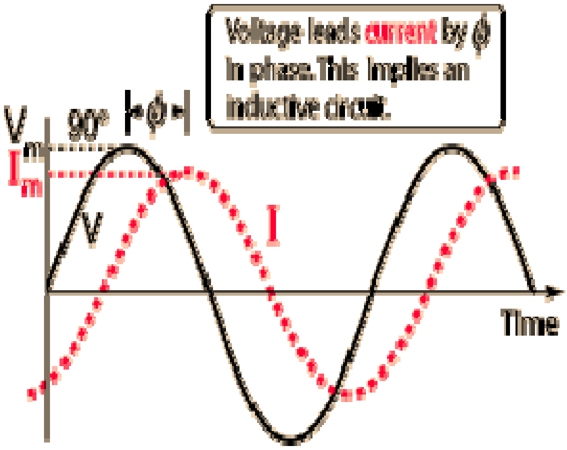
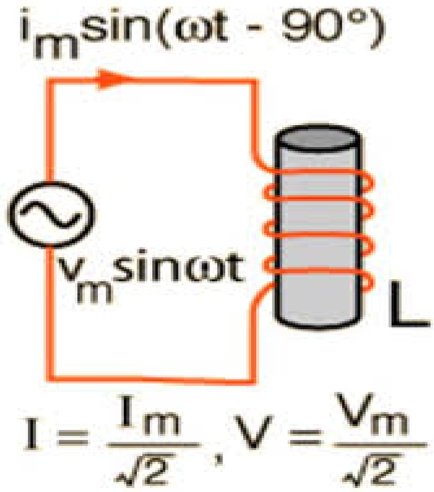
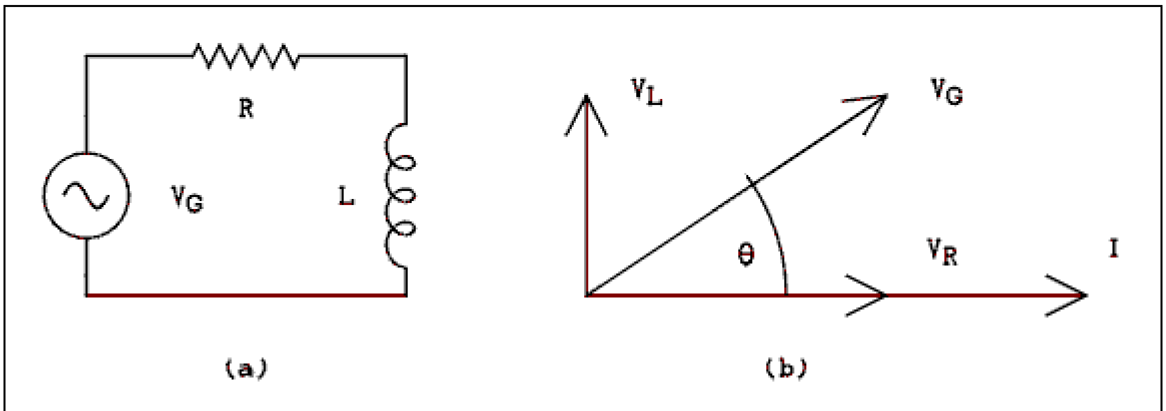










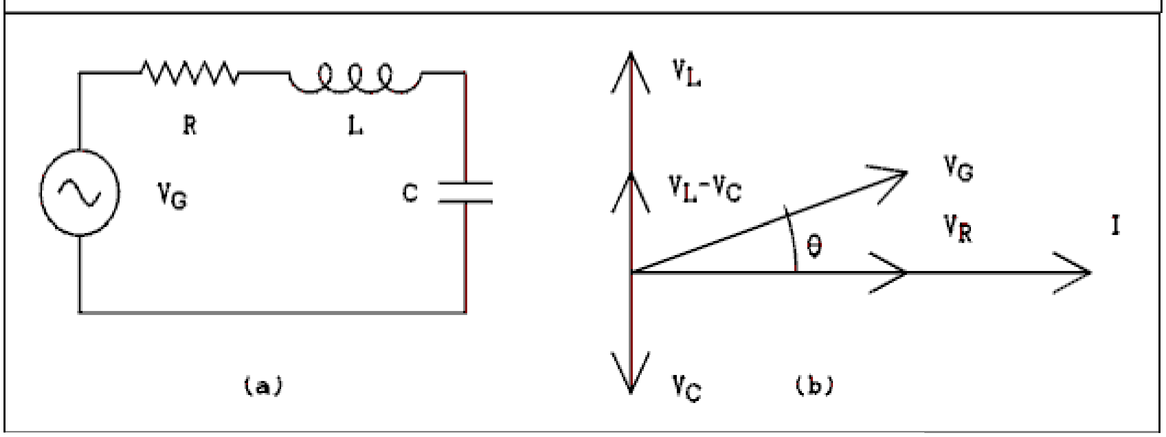
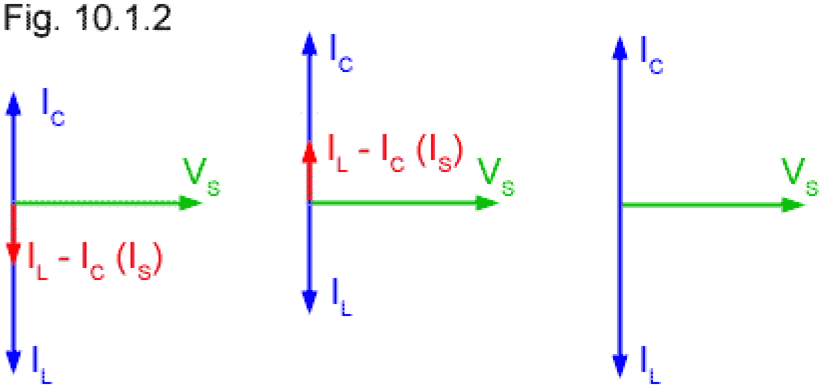


Fig. 10.1.2



a. Below f_r b. Above f_r c. At Resonance f_r

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Inductor current lags voltage

Capacitor voltage lags current