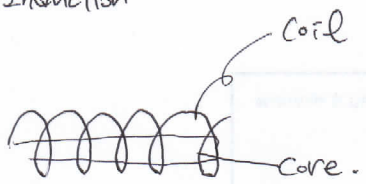
9/25. ①

"Induction"



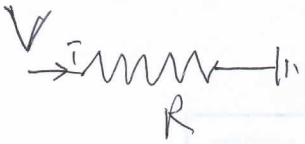
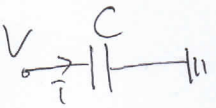
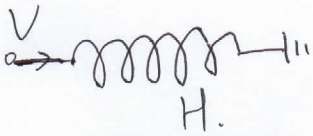
L[H].

: Voltage Potential (example).

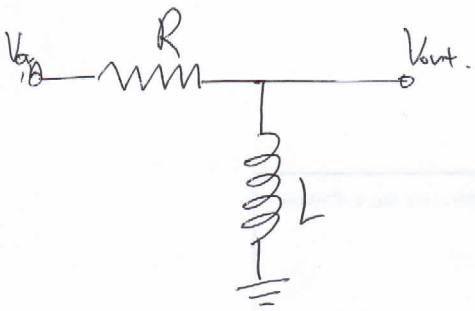
is stored in magnetic-field ~~of~~ Inductor.

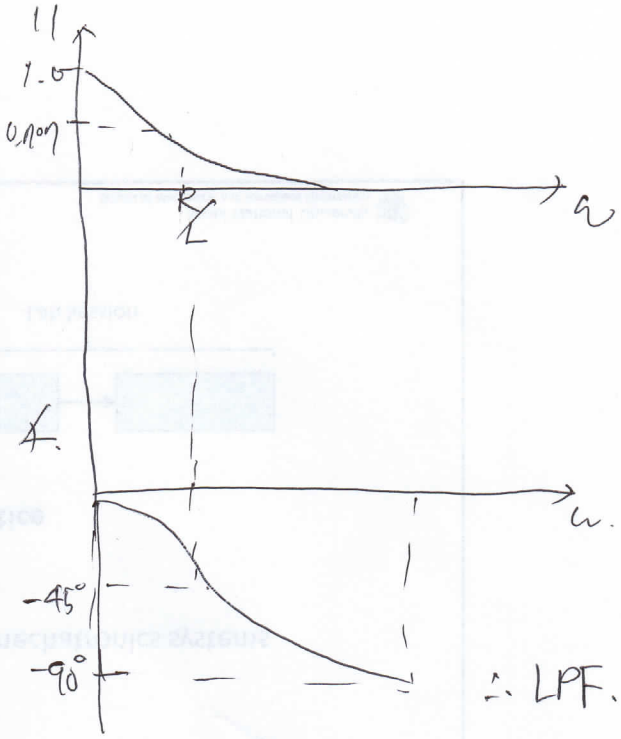
No energy dissipation.

Law: $V = L\frac{di}{dt}$. or $i = \frac{1}{L}\int V\,dt$.

Resistor	Capacitor	Inductor.
		
$i = \frac{V}{R}$.	$i = C\frac{dV}{dt}$.	$i = \frac{1}{L}\int V\,dt$.
energy consumed into "heat"	Storage into electrical field.	Storage into magnetic field.
$Z_R = R$.	$Z_C = \frac{1}{j\omega C}$	$Z_H = j\omega L$.

②





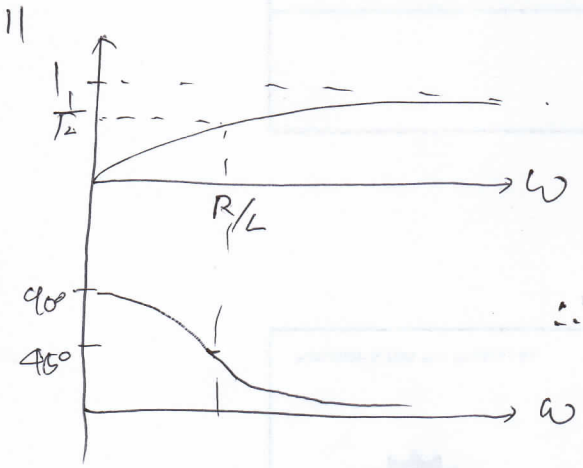
$$\frac{V_{out}}{V_{in}} = \frac{Z_L}{Z_R+Z_L} = \frac{j\omega L}{R+j\omega L}$$

$$\left|\frac{V_{out}}{V_{in}}\right| = \frac{\omega L}{\sqrt{R^2+\omega^2L^2}}, \quad \angle = 90^\circ - \tan^{-1}\frac{\omega L}{R}$$

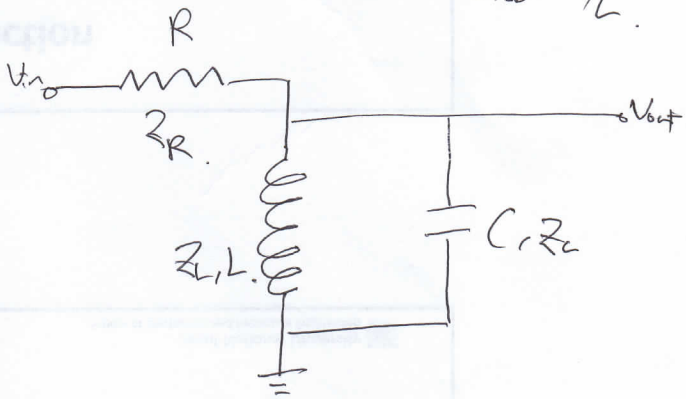
$$= \frac{1}{\sqrt{2}} \quad \text{when } \omega = \frac{R}{L} = \omega_{3dB}.$$

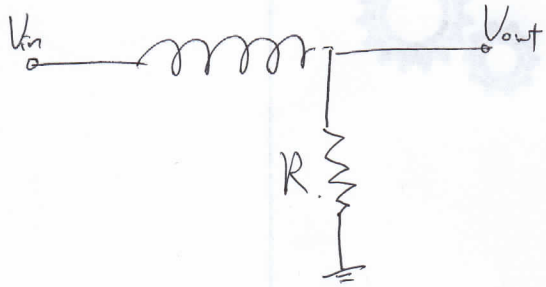
∴ LPF.

$\omega_{3dB} = R/L$.



∴ HPF.





$$\frac{V_{out}}{V_{in}} = \frac{Z_L//Z_C}{Z_R+Z_L//Z_C}.$$

$$Z_L//Z_C = \frac{Z_L \cdot Z_C}{Z_L+Z_C} = \frac{j\omega L \cdot \frac{1}{j\omega C}}{j\omega L + \frac{1}{j\omega C}}.$$

$$= \frac{L}{C} \cdot \frac{j\omega C}{1-\omega^2 LC}.$$

$$= \frac{j\omega L}{1-\omega^2 LC}.$$

$$\frac{V_{out}}{V_{in}} = \frac{Z_R}{Z_L+Z_R} = \frac{R}{j\omega L+R}.$$

$$|| = \frac{R}{\sqrt{(\omega L)^2+R^2}}, \quad \angle = -\tan^{-1}\omega L/R.$$

③

$$\therefore \frac{V_{out}}{V_{in}} = \frac{\dfrac{j\omega L}{1-\omega^2 LC}}{R + \dfrac{j\omega L}{1-\omega^2 LC}}$$

$$= \frac{j\omega L}{R(1-\omega^2 LC) + j\omega L}$$

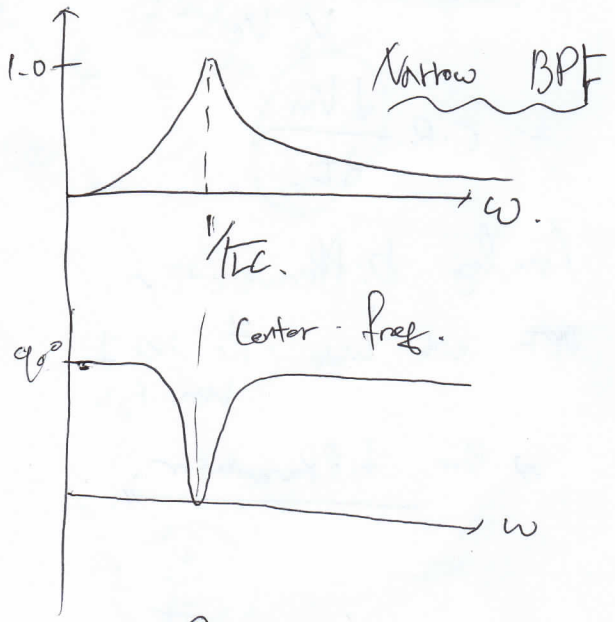
$$\left|\frac{V_{out}}{V_{in}}\right| = \frac{\omega L}{\underbrace{\sqrt{R^2(1-\omega^2 LC)^2 + \omega^2 L^2}}_{\omega_{3dB}}}$$

$$\angle = 90^\circ - \tan^{-1}\frac{\omega L}{R(1-\omega^2 LC)}$$

① $\omega \to 0$, $|| \to 0$, $\angle = 90^\circ$

② $\omega \to \infty$, $|| \to 0$, $\angle = 90^\circ$

③ $\omega \to 1/\sqrt{LC}$, $|| = 1$, $\angle = 0$.



$$Q = \frac{\omega_0}{\Delta\omega_{3dB}} = \text{Quality Factor.}$$

$$\frac{\omega^2 L^2}{R^2(1-\omega^2 LC)^2 + \omega^2 L^2} = \frac{1}{2}$$

$$\omega^2 L^2 = R^2(1-\omega^2 LC)^2$$

$$\pm \omega L = R(1-\omega^2 LC)$$

$$\therefore \omega = \frac{-(\pm L) \pm \sqrt{L^2 + 4R^2 LC}}{2RLC}.$$

quality -.

$\omega_1 =$ $-L + \sqrt{L^2+\sim}$ O

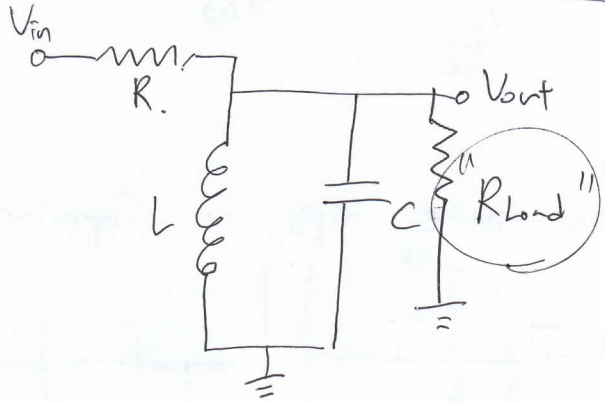
$-L - \sqrt{L^2+\sim}$ X

$\omega_2 =$ $+L + \sqrt{L^2+\sim}$ O

$+L - \sqrt{L^2+\sim}$. X.

$$\Delta\omega_{3dB} = \omega_2 - \omega_1 = \frac{2L}{2RLC} = \frac{1}{RC}.$$

$$Q = \omega_0 \cdot RC \quad \text{(by Design)}$$



3 Components to design.

① $\omega_0 = \frac{1}{\sqrt{LC}}$ (design)

② $Q = \omega_0 RC$ (design)

③ $R = \frac{1}{10} R_{load}$. (10X)