1、磁场部分

magnetic energy density: $w = \frac{1}{2\mu_0} B^2$

$W = \frac{1}{2\mu_0}\int_V B^2 d\tau$ ($d\tau$为体积元) $= \frac{1}{2}\int_V \vec{A}\cdot\vec{J}\, d\tau$

$\nabla\cdot\vec{E} = \frac{\rho}{\varepsilon_0}$ $\nabla\times\vec{E} = -\frac{\partial\vec{B}}{\partial t}$ $-\nabla\varphi = \vec{E}$

$\nabla\cdot\vec{B} = 0$ $\nabla\times\vec{B} = \mu_0\vec{J} + \mu_0\varepsilon\frac{\partial\vec{E}}{\partial t}$ $\nabla\times\vec{A} = \vec{B}$ $\nabla\cdot\vec{J} = -\frac{d\rho}{dt}$ $\nabla^2\vec{A} = -\mu_0\vec{J}$

$\oint E\cdot d\vec{a} = \frac{Q_{total}}{\varepsilon_0}$ $\oint\vec{E}\cdot d\vec{l} = -\frac{\partial\phi}{\partial t}$

$\oint\vec{B}\cdot d\vec{a} = 0$ $\oint\vec{B}\cdot d\vec{l} = \mu_0 i + \mu_0\varepsilon_0\int_s\frac{\partial\vec{E}}{\partial t}\cdot d\vec{a}$

$\vec{A} = \int_V\frac{\mu_0}{4\pi}\frac{\vec{J}\,d\tau}{\eta}$

电流元: $d\vec{B} = \frac{\mu_0 I}{4\pi}\frac{d\vec{l}\times\hat{r}}{r^2}$

无限长直导线: $B = \frac{\mu_0 I}{2\pi r}$

$\oint\vec{B}\,d\vec{l} = \mu_0 I_{total}$

圆环电流圆心处: $B = \frac{\mu_0 I}{2\pi r}$

2、电感

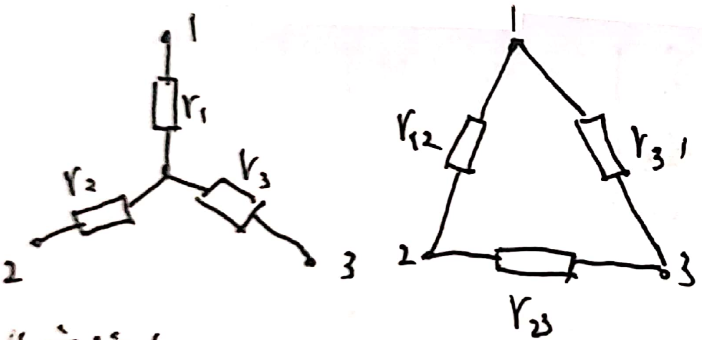
$L = \frac{\phi}{i}$ ($V = \frac{d\phi}{dt}$) $V = L\frac{di}{dt}$

$W = \frac{1}{2}Li^2$ (储存的能量)

串联: $L = L_1 + L_2 + 2M$ 并联: $L = \frac{L_1L_2 - M^2}{L_1 + L_2 + 2M}$

$W = \frac{1}{2}L_1 i_1^2 + \frac{1}{2}L_2 i_2^2 + M i_1 i_2$

3、星角变换



$r_{12} = r_1 + r_2 + \frac{r_1r_2}{r_3}$ $r_1 = \frac{r_{12}r_{31}}{r_{12}+r_{23}+r_{31}}$

$r_{23} = r_2 + r_3 + \frac{r_2r_3}{r_1}$ $r_2 = \frac{r_{12}r_{23}}{\cdots}$

$r_{31} = r_3 + r_1 + \frac{r_3r_1}{r_2}$ $r_3 = \frac{r_{23}r_{31}}{\cdots}$

4、交流电

$e^{j\omega t} = \cos\omega t + j\sin\omega t$

rms: $\frac{1}{\sqrt{2}}$ effective value: 产生和直流电相同功率的等效值

Reactance 电抗 (针对L和C)

$Z_L = \omega L$ $Z_C = -\frac{1}{\omega C}$

阻抗 Impedance (针对LRC一起)

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

$\tan\phi = \frac{\frac{1}{\omega C} - \omega L}{R}$

$i = \frac{V_0}{Z}\cos(\omega t + \phi)$

(电流领先电压ϕ)

计算电流用Z: $i = \frac{V}{Z}$

计算功率用R: $P = I_{rms}^2 R$

$I = \frac{V}{Z} = \frac{V}{R + i(\omega L - \frac{1}{\omega C})}$ (复数除法)

Resonance：电压大小相同，改变频率，使电流最大（在LRC中）

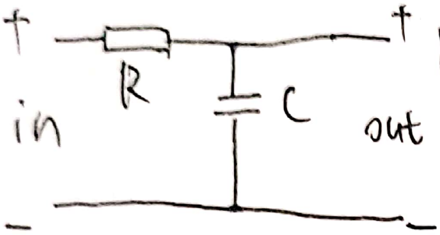
$\omega=\sqrt{\frac{1}{LC}}$（要求Z最小即 $\omega L-\frac{1}{\omega C}=0$）

5、

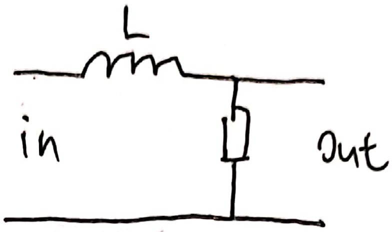
transformer：变压器。

$\frac{V_1}{V_2}=\frac{N_1}{N_2}$ $P=V_1I_1=V_2I_2$

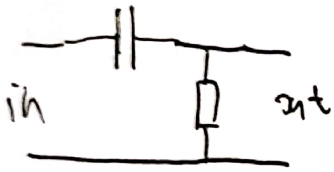
filter：滤波器



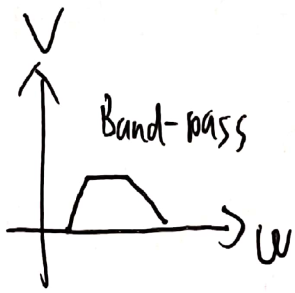
low-pass 指的是频率

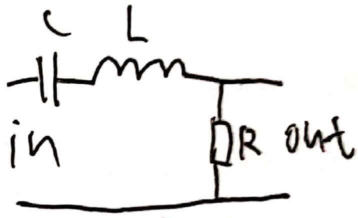


low-pass

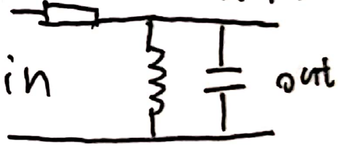


high-pass



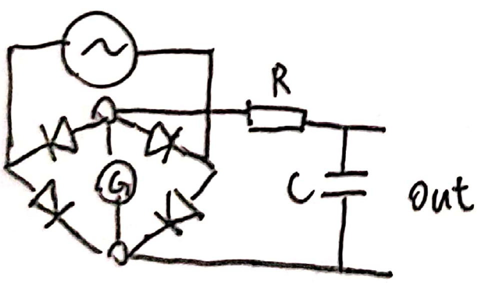


Band-pass



$H(j\omega)=\frac{V_{out}}{V_{in}}$

交流变直流：rectified DC output



6、电磁波

Maxwell equations: $\nabla\times\vec{D}=\rho_f$ $\nabla\times\vec{E}=-\frac{\partial\vec{B}}{\partial t}$ $\nabla\cdot\vec{B}=0$ $\nabla\times\vec{H}=J_f+\frac{\partial\vec{D}}{\partial t}$

$F(x,t)=F(x-vt)$

$F(x,t)=F(x+k\lambda,t)$

$F(x,t)=F(x+kT)$

$$\frac{\partial^2 y(x,t)}{\partial x^2}-\frac{1}{v^2}\frac{\partial^2 y(x,t)}{\partial t^2}=0$$

$v=\lambda f$

$v=\sqrt{\frac{F}{\mu}}$（F：拉力，μ：单位长度质量

$y(x,t)=A\cos[2\pi[\frac{x}{\lambda}-\frac{t}{T}]]=A\cos(kx-\omega t)$

$P_{max}=\sqrt{\mu F}\,\omega^2A^2$ $\bar{P}=\frac{1}{2}\sqrt{\mu F}\,\omega^2A^2$

2 $(k=\frac{2\pi}{\omega})$

$\vec{\nabla}\cdot\vec{E}=0 \quad \vec{\nabla}\cdot\vec{B}=0$

$\vec{\nabla}\times\vec{E}=-\frac{\partial \vec{B}}{\partial t} \quad \vec{\nabla}\times\vec{B}=\mu_0\varepsilon_0\frac{\partial E}{\partial t}$

$$\nabla\times(\nabla\times\vec{E})=-\frac{\partial\nabla\times\vec{B}}{\partial t}=-\mu_0\varepsilon_0\frac{\partial^2\vec{E}}{\partial t^2}$$

$\nabla\times(\nabla\times A)=\nabla(\nabla\cdot A)-\nabla^2 A$

$\nabla^2\vec{E}=\mu_0\varepsilon_0\frac{\partial^2\vec{E}}{\partial t^2}$ 同理 $\nabla^2\vec{B}=\mu_0\varepsilon_0\frac{\partial^2\vec{B}}{\partial t^2}$

speed $c=\frac{1}{\sqrt{\varepsilon_0\mu_0}}$ $\quad \vec{B}(r)=\vec{B}_0\cos(kr-\omega t)$

$B=\frac{E}{c}=\sqrt{\varepsilon_0\mu_0}\,E$ $\quad \vec{E}(r)=\vec{E}_0\cos(kr-\omega t)$

energy $u=\frac{1}{2}\varepsilon_0E^2+\frac{1}{2\mu_0}B^2=\varepsilon_0E^2$（体积密度）

$\vec{S}=\frac{1}{\mu_0}(\vec{E}\times\vec{B})$（方向为传播方向）（$W/m^2$）（poynting vector）

momentum density: $\vec{P}=\mu_0\varepsilon_0\vec{S}$

light pressure: $p_{rad}=\frac{S}{c}$（完全吸收，如果是反射要 ×2）

7、光学

折射率 $n=\sqrt{\varepsilon_r\mu_r}$

驻波：standing wave：两个波叠加后传播方向不移动

linear polarization: $\hat{x}E_0\cos(kz-\omega t)+\hat{y}E_0\cos(kz-\omega t)$

ellipse: $\hat{x}E_0\cos(kz-\omega t)+\hat{y}E_1\cos(kz-\omega t+\frac{\pi}{2})$

circle: $\hat{x}E_0\cos(kz-\omega t)+\hat{y}E_0\cos(kz-\omega t+\frac{\pi}{2})$

diffraction 衍射: $I=I_0\left[\frac{\sin[\pi a\sin\theta/\lambda]}{\pi a\sin\theta/\lambda}\right]^2$

双缝干涉间距: $\frac{\lambda x}{a}$ $\quad$ 圆盘衍射: $\sin\theta_1=1.22\cdot\frac{\lambda}{2r}$

（θ_1 为两道亮条纹与中心的夹角）

Laplace transform

$F(s) = \mathcal{L}\{f(t)\} = \int_0^\infty e^{-st} f(t)\,dt$

$\mathcal{L}\{f^{(n)}(t)\} = s^n \mathcal{L}\{f(t)\} - s^{n-1} f(0) - \cdots - f^{(n-1)}(0)\cdot s^0$

$f(t)$	$F(s)$
1	$\frac{1}{s}$
e^{at}	$\frac{1}{s-a}$
t^n	$\frac{n!}{s^{n+1}}$
$\sin(at)$	$\frac{a}{s^2+a^2}$
$\cos(at)$	$\frac{s}{s^2+a^2}$
$\sinh(at)$	$\frac{a}{s^2-a^2}$
$\cosh(at)$	$\frac{s}{s^2-a^2}$
$e^{at}\sin(bt)$	$\frac{b}{(s-a)^2+b^2}$
$e^{at}\cos(bt)$	$\frac{s-a}{(s-a)^2+b^2}$
$t^n e^{at}$	$\frac{n!}{(s-a)^{n+1}}$
$u_c(t)$	$\frac{e^{-cs}}{s}$
$u_c(t)f(t-c)$	$e^{-cs}F(s)$
$e^{ct}f(t)$	$F(s-c)$
$f(ct)$	$\frac{1}{c}F(\frac{s}{c})$
$\int_0^t f(t-\tau)g(\tau)\,d\tau$	$F(s)G(s)$
$\delta(t-c)$	e^{-cs}
$(-t)^n f(t)$	$F^{(n)}(s)$

∇算符

①作用于$f(\vec{r}) = (f_x(\vec{r}), f_y(\vec{r}), f_z(\vec{r}))$ $(f: R^3 \to R^3)$，输出常数

$\nabla \cdot f(\vec{r}) = \frac{\partial f_x(\vec{r})}{\partial x} + \frac{\partial f_y(\vec{r})}{\partial y} + \frac{\partial f_z(\vec{r})}{\partial z}$

②作用于$f(\vec{r}) = f(r_x, r_y, r_z) = C$ $(f: R^3 \to R)$，输出三维向量(R^3)

$\nabla f(\vec{r}) = \left(\frac{\partial f}{\partial x}, \frac{\partial f}{\partial y}, \frac{\partial f}{\partial z}\right)$

③叉乘，rot（作用于同①的函数）

$\nabla \times f(\vec{r}) = \left(\frac{\partial}{\partial x}, \frac{\partial}{\partial y}, \frac{\partial}{\partial z}\right) \times f(\vec{r})$

$$= \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ f_x & f_y & f_z \end{vmatrix}$$