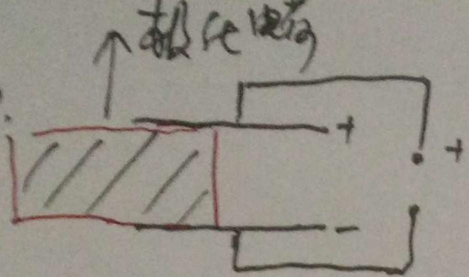
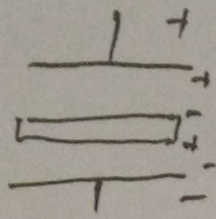
30.





$$\frac{1}{4\pi k}=\varepsilon_0$$

元功法 (虚位移)

电容器的初始值 $C_0=\dfrac{\varepsilon_0 b\cdot\frac{b}{2}}{d}+\dfrac{\varepsilon b\cdot\frac{b}{2}}{d}$

板进入x后 $C=\dfrac{\varepsilon_0 b(\frac{b}{2}-x)}{d}+\dfrac{\varepsilon b(\frac{b}{2}+x)}{d}$

电容改变 $\Delta C=C-C_0=\dfrac{bx(\varepsilon-\varepsilon_0)}{d}$

C↑ 电源对电容器充电

电源消耗的电能 = 电容器能量的增加 + 板动能

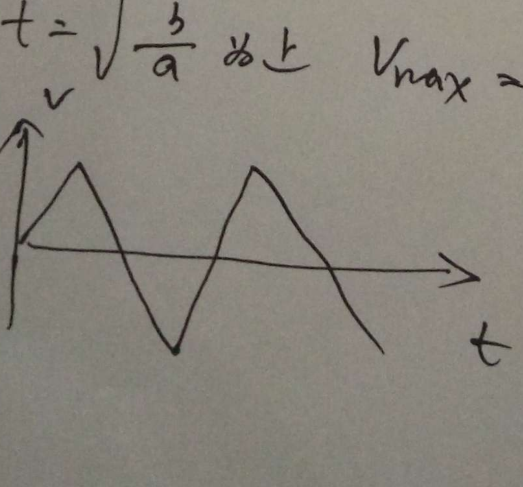
$$\Delta C U\cdot U=\frac{1}{2}\Delta C U^2+\frac{1}{2}mv^2$$

$$Fx=\frac{1}{2}mv^2,\quad F=ma$$

$$a=\frac{(\varepsilon-\varepsilon_0)U^2}{2bd^2\rho}\qquad \frac{b}{2}=\frac{1}{2}at^2$$

板运动速度 $v=at=\dfrac{(\varepsilon-\varepsilon_0)U^2}{2bd^2\rho}t$

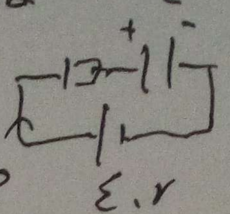
直到 $t=\sqrt{\frac{b}{a}}$ 为止 $v_{max}=\sqrt{ab}$

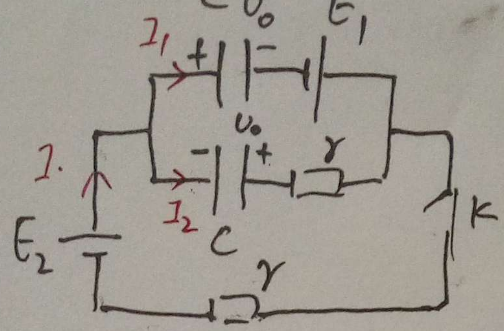


电路10.

闭合瞬间 电容器电量不变

稳定后 电容器→断开





K合上前 $U_0=\frac{E_1}{2}$, $q_0=\frac{1}{2}CE_1$

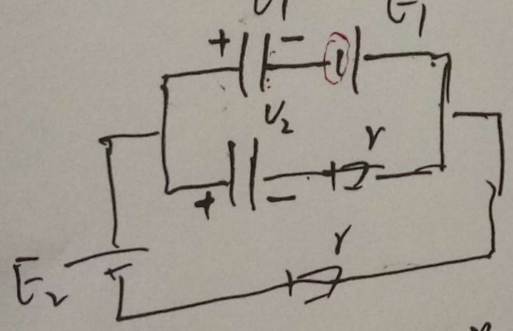
$$I=I_1+I_2$$

$$E_1+E_2-U_0=I\cdot r$$

$$I=\frac{E_2+E_1/2}{r}$$

$$E_2+U_0-I_2r-Ir=0 \Rightarrow I_2=0$$

$$I_1=I=\frac{2E_2+E_1}{2r}$$



$U_2=E_2 \Rightarrow q_2=CE_2$

$U_1=E_1+E_2 \Rightarrow q_1=C(E_1+E_2)$

末状态 $q=q_1+q_2=C(2E_2+E_1)$

(3) 流过E_2的电量为q. 电池E_2做功

$$W_2=qE_2=CE_2(2E_2+E_1)$$

(2) 初始时刻 $E_0=2\cdot\frac{1}{2}CU_0^2=\frac{1}{4}CE_1^2$

末态电场 $E=\frac{1}{2}CE_2^2+\frac{1}{2}C(E_1+E_2)^2$

$$\Delta E=E-E_0=\frac{C}{4}(E_1+2E_2)^2$$

流过E_1的电量 $\Delta q=CU_1-CU_0=C(E_2+\frac{1}{2}E_1)$

电池做功 $W_1=\Delta qE_1=\frac{C(2E_2+E_1)}{2}E_1$

热 $Q=W-\Delta E=\frac{1}{4}C(E_1+2E_2)^2$ 24-9 $W=W_1+W_2=\frac{1}{2}C(E_1+2E_2)^2$

磁场

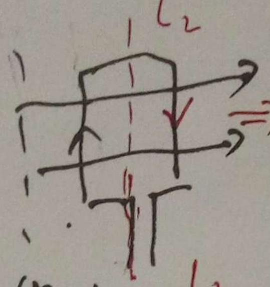
一、安培力和安培力矩

1. 磁场：毕奥—萨伐尔定律 ↑ $B=\frac{\mu_0 I}{2\pi r}$

螺线管 $B=\mu_0 n I$

2. 安培力

3. 安培力矩



⇒力偶

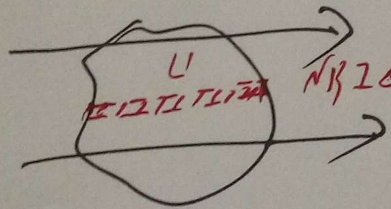
磁矩 $M=NBIS\cos\theta$

θ指B与线圈平面夹角

$M=2NBIl_1\cdot\frac{l_2}{2}$

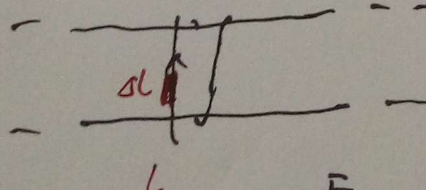
① M与转轴的具体位置无关（B⊥轴

② M与线圈的形状无关



$nBI\Delta l\cdot l'$

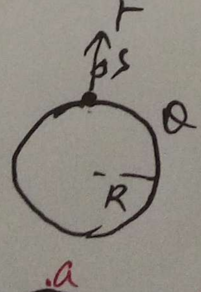
$$M=nBI\sum\Delta l\cdot l'$$
$$=nBI\sum\Delta S$$
$$=nBIS$$

1. 

⇒内部 $B=\mu_0\frac{N}{L}I$

$F=\frac{B}{2}\cdot I\cdot\Delta l$

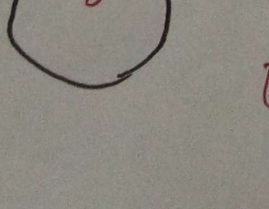
$\frac{L}{N}$

类比 

$E=k\frac{Q}{R^2}$

$E=\frac{k\Delta Q}{\Delta x^2}$

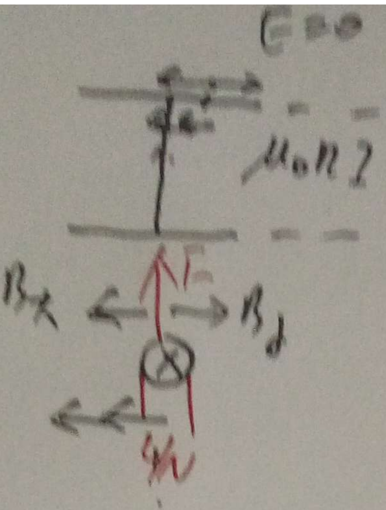
$F=\frac{Q}{4\pi R^2}\cdot\Delta S\cdot\frac{E}{2}$，$P=\frac{F}{\Delta S}$



$E_b=0=E_{大块}-E_{小块}$

$E_a=E_{大块}+E_{小块}$

$E_{大块}=\frac{kQ}{2R^2}$

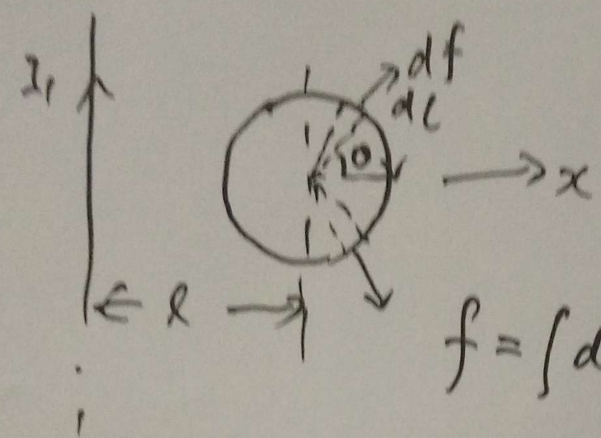


一大块 在一小块处 $B=\frac{1}{2}\mu_0\frac{N}{L}I$

$F=\frac{1}{2}\mu_0\cdot\frac{N}{L}I\cdot\Delta l$

$P=\dfrac{F}{\Delta l\cdot\frac{L}{N}}=\dfrac{\mu_0 N^2 I^2}{2L^2}$

3.



$B=\frac{\mu_0 I_1}{2\pi}\cdot\frac{1}{l+R\cos\theta}$

$df=BI_2\,dl=BI_2R\,d\theta$

$f=\int df_x=\int_0^{2\pi}BI_2R\cos\theta\cdot d\theta$

$=\mu_0 I_1 I_2\cdot\left(1-\frac{l}{\sqrt{l^2-R^2}}\right)$

二、粒子在磁场中的运动

1. 圆周运动 B 与 v_0 垂直. $Bqv_0=m\frac{v_0^2}{R}\Rightarrow R=\frac{mv_0}{Bq}$

$T=\frac{2\pi R}{v_0}=\frac{2\pi m}{Bq}$，与 v_0 无关

$m=\dfrac{m_0}{\sqrt{1-\frac{v^2}{c^2}}}$ $\Downarrow$ 应用 回旋加速器

考点 ① 磁场区域有限 $\Rightarrow$ 作图

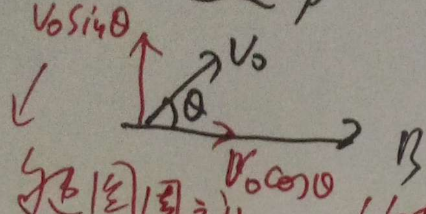
速度⊥半径 两个半径交点 $\Rightarrow$ 圆心

② 多个粒子 相遇. $\begin{cases}\text{往返}\\\text{对偏}\end{cases}$

二 1. $v_0=\dfrac{Bqa\sqrt{a^2+h^2}}{mh}$

$v_1=\dfrac{3Bqa\sqrt{a^2+h^2}}{4mh}$ $v_2=\dfrac{2Bqa\sqrt{a^2+h^2}}{3mh}$

2. 螺旋运动.



$R=\frac{mv_0\sin\theta}{Bq}$ $T=\frac{2\pi m}{Bq}$

互相垂直

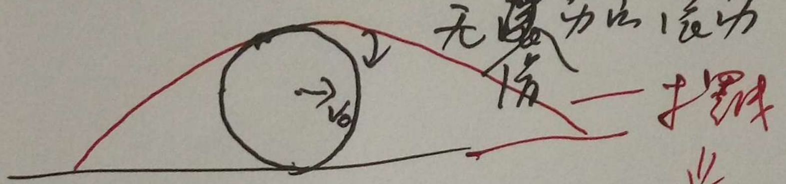
等距螺旋运动

螺距 $s=v_0\cos\theta\cdot\frac{2\pi m}{Bq}$

力 $\rightrightarrows$ B, E 不等距螺旋运动

$\rightarrow a=\frac{qE}{m}$

3. 摆线运动



无~~滚~~滑动的滚动 — 摆线

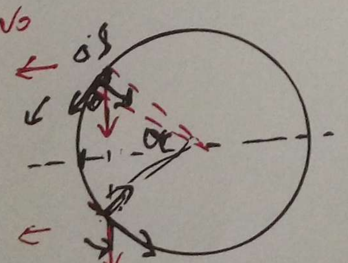
⇓

匀速直线运动和匀速圆周运动

在同一平面内的合成

4. 磁聚焦 → 某处重合

③



$F_{Bi}=B\cdot\sigma\Delta S\,v_i$ (v_i 平动速度)

切向分力

$F_{Bi切}=F_{Bi}\cos\theta$

由于转动速度 u $F_{Bi}'=B\cdot\sigma\Delta S\,u_i$

⇓ ⇓ 对转动无影响

$F_{切向力}=B\sigma v_i\,\Delta S\cos\theta$

由切割弦方向投影的长度

$M_i=F_{切向力}\cdot R=B\sigma v_i R\,l_i$

$M_i=mR^2\cdot\frac{\Delta\omega}{\Delta t}$ $u_i=\omega R$

$m\Delta u_i=B\sigma v_i l_i\Delta t$

同理 $Mu = B\sigma\pi R^2 \Rightarrow \sigma = \frac{Mu}{B\pi R^2}$

洛伦兹力总不做功 动能守恒

$$\frac{1}{2}Mv_0^2 = \frac{1}{2}Mu^2 + \frac{1}{2}Mu^2 \qquad u = \frac{v_0}{\sqrt{2}}$$

$$\sigma = \frac{Mv_0}{\sqrt{2}B\pi R^2}$$

故环的电荷量 $q = \sigma\cdot 2\pi R = \frac{\sqrt{2}Mv_0}{BR}$

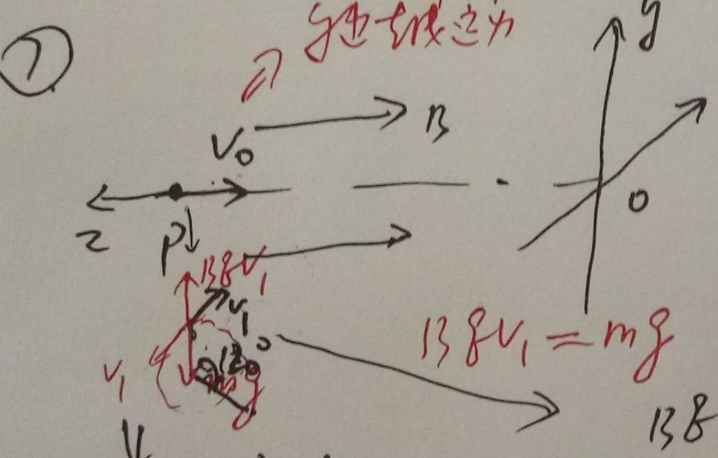
三、带电粒子在复合场中的运动

1、复合场包括重力场、电场、磁场

2、运动的形式多种多样

3、尽量运用能量关系（洛伦兹力总不做功）

①



小球（q、m）

$OP = \frac{2\pi m v_0}{3Bq}$

$$Bqv_1 = m\frac{v_1^2}{R} \qquad R = \frac{mv_1}{Bq} = \frac{m^2 g}{B^2 q^2}$$

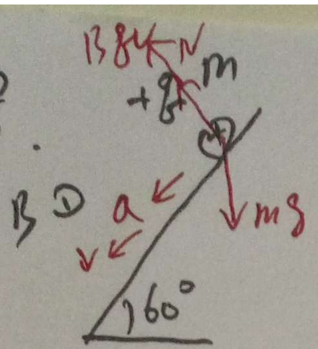
⇓ 对应摆线运动

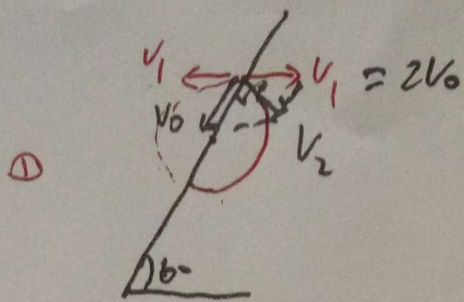
到屏的时间 $t = \frac{OP}{v_0} = \frac{2\pi m}{3Bq} = \frac{1}{3}T$

$$y = -(R + R\cos 60^\circ) = -\frac{3}{2}R = -\frac{3m^2 g}{2B^2 q^2}$$

$$x = -v_1 t + r\sin 60^\circ = -\frac{m^2 g}{B^2 q^2}\left(\frac{2}{3}\pi - \frac{\sqrt{3}}{2}\right)$$

8.





(1) N=0 物体会离开斜面 $Bqv_0=mg\cos 60°$

$$\Rightarrow v_0=\frac{mg}{2Bq}$$

(2) 引入向左 v_1 + 向右 v_1 $Bqv_1=mg$ $v_1=2v_0$

⇓ 匀速直线运动 以 v_2 速率 匀速圆周运动

$$v_2=\frac{\sqrt{3}mg}{2Bq}$$

$$v_{max}=v_1+v_2=(1+\frac{\sqrt{3}}{2})\frac{mg}{Bq}$$

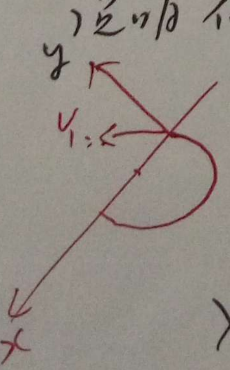
(3) 最大高度 ⇒ 对应速度最小

$$v_{min}=(v_1-v_2)=(1-\frac{\sqrt{3}}{2})\frac{mg}{Bq}$$

$$-mgh=\frac{1}{2}mv_{min}^2-\frac{1}{2}mv_0^2$$

$$h=\frac{\sqrt{3}-1.5}{2g}\left(\frac{mg}{Bq}\right)^2$$

说明不会撞到斜面



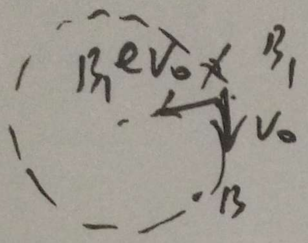
任意时刻 x, y

设撞上 y=0

$$x=\frac{-v_1t-2R\pm2\sqrt{R^2-v_1^2t^2}}{2}$$

x 无解 不撞

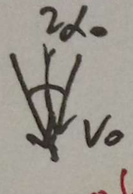
(1) $eV_0 = \frac{1}{2} m v_0^2$



$B_1 e v_0 = m \frac{v_0^2}{R}$

$\Rightarrow B_1 = 3.7 \times 10^{-3}\ T$

(2) — 磁聚焦



$\alpha_0 \ll 1$ $\quad v_{\parallel 0} = v_0 \cos\alpha = \underline{v_0}$ (一阶)

$v_{\perp 0} = v_0 \sin\alpha = v_0 \underline{\alpha}$

$v_{\perp 0} \rightarrow$ B 磁场 作用作圆周运动

$\rightarrow B$

$v_{\parallel 0} = v_0 \rightarrow$ B_1 磁场 作匀速圆周运动

$T = \frac{2\pi m}{Be}$

$b = v_{\parallel 0} \cdot T = \frac{2\pi R}{4}$

$\Rightarrow B = \frac{4}{R} \sqrt{\frac{2 m V_0}{e}} = 1.48 \times 10^{-2}\ T$

(3) 角动量守恒、能量守恒

~~计算~~ 结果 $b = 4m$， $r = 5.3m$

$= 1.11R$