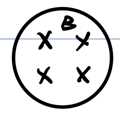
电磁感应.

一、法拉第电磁感应定律

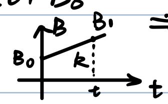
$$E = N\frac{\Delta\phi}{\Delta t}\begin{cases} N\frac{\Delta B}{\Delta t}\cdot S \text{ . 感生电动势} \\ N\cdot B\cdot\frac{\Delta S}{\Delta t} \text{ . 动生电动势} \end{cases}$$

1、感生电动势 (B变，S不变).



(1) $B=kt+B_0$

(2) B-t图:



$\Rightarrow E=N\cdot S\cdot\frac{\Delta B}{\Delta t}$

$=NSk$

(3) q(电荷): $q=It$, $I=\frac{E}{R_{总}}$.

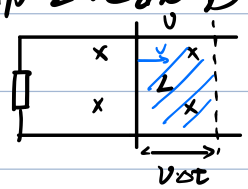
$q=I\Delta t=\frac{E}{R_{总}}\cdot\Delta t$

$=\frac{NS\frac{\Delta B}{\Delta t}\Delta t}{R_{总}}$

$$q = N\cdot\frac{\Delta\phi}{R_{总}}$$

2、动生电动势.

①



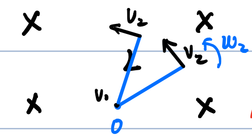
$\Delta\phi = B\Delta S = BLv\Delta t$

$E=\frac{\Delta\phi}{\Delta t}=\frac{BLv\Delta t}{\Delta t}=BLv$

电势高低：右手定则.

② 转动切割

①



$E_{动}=BLv$

But 导体棒上各点速度不相同，那么电动势 $E=BL\underline{\underline{v}}$ 速度应该带什么呢?

∵ 在匀速圆周运动中 $v=\omega r$

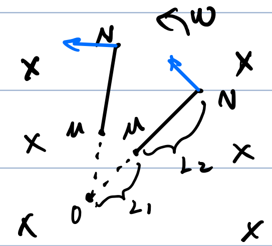
v与r是线性关系.

$\therefore E_{动} = BL\bar{v}$

$= BL\frac{v_1+v_2}{2} = BL\cdot\frac{0+\omega L}{2}$

$=\frac{1}{2}B\omega L^2$

②



$E=BL\bar{v} = BL_2\frac{v_M+v_N}{2}$

$=BL_2\frac{\omega L_1+\omega L_2}{2}$

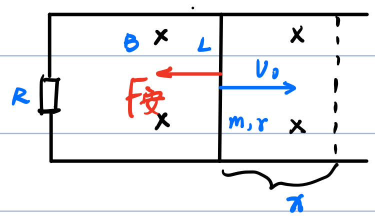
复习: $\begin{cases} F_{安}=BIL \\ f_{洛}=qvB \\ E_{动}=BLv \end{cases}$

单棒切割

$\left\{\begin{array}{l}\text{有初速}\\\text{有外力}\\\text{有电源}\\\text{有电容}\end{array}\right.$

前两类是比较基础的，要求一定要掌握，因此搞不明白也要多搞几遍!!!

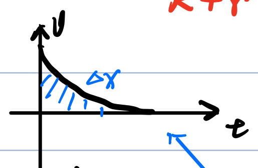
(1) 有初速(阻尼式)



① $E=BLv$

② $I=\frac{E}{R+r}=\frac{BLv}{R+r}$

③ $F_{安}=BIL=\frac{B^2L^2v}{R+r}$ ☆



加速度减小的减速运动.

④ $Q=\frac{1}{2}mv_0^2$

$Q_R=\frac{R}{R+r}Q$

曲线面积肯定不会算，所以要记住

题目让你求位移，本质上是求电荷量

⑤ q: $\left\{\begin{array}{l}1.\ q=N\frac{\Delta\phi}{R+r}=\frac{\boxed{BL\Delta x}}{R+r}\\2.\ I_{安}=F_{安}\cdot t=BIL\cdot t=BLq\end{array}\right.$

在一段较短的时间Δt内.

$-F_{安}\Delta t=m\Delta v$

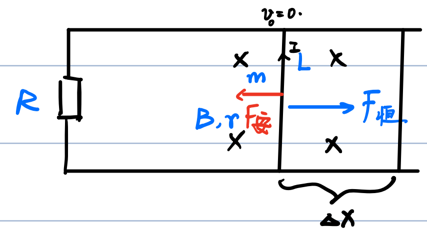
对整个时间求和: $-\Sigma BIL\Delta t=\Sigma m\Delta v$

$\therefore -BLq=0-mv_0$

$\therefore q=\frac{mv_0}{BL}=\frac{BL\Delta x}{R+r}$

(小q) 皮蛋就是一切!

(2) 有外力 (发电机式)

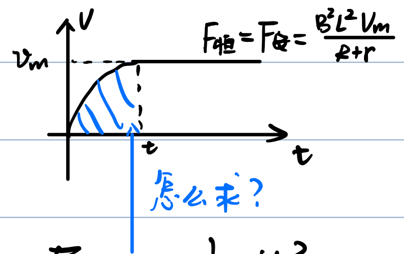


① $E=BLv$ ② $I=\frac{E}{R+r}$ ③ $F=\frac{B^2L^2v}{R+r}$

以上3个都一样，关键在后面.

※ $F_恒-F_安=ma$

$\therefore a=\frac{F_恒-\frac{B^2L^2v}{R+r}}{m}$ $v\uparrow \Rightarrow a\downarrow$



Q: $F_恒\Delta x=\frac{1}{2}mV_m^2+Q$

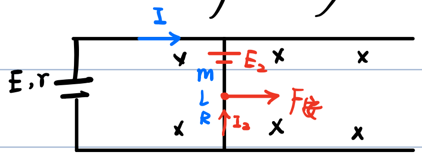
q: $q=\frac{\Delta\phi}{R+r}=\frac{BL\Delta x}{R+r}$

$\therefore F_恒t-F_安t=mV_m-0$

$\therefore F_恒t-BL\cdot\frac{BL\Delta x}{R+r}=mV_m$

※ Q、q、Δx、t · 知一求三.

含源单棒

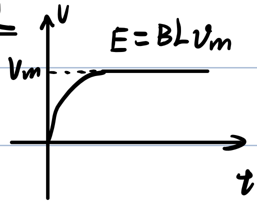


1. $E_0 = E - E_2\ (BLv)$

$I = \frac{E_0}{R+r} = \frac{E-BLv}{R+r}$

$F_安 = BIL = \frac{B(E-BLv)\cdot L}{R+r}$

$E = BLv_m$



$v\uparrow \to F_安\downarrow$

2. $v_m = \frac{E}{BL}$

3. $Q = ?$

$W_{电源} = E\cdot I t = E\cdot q$

$\therefore\ Q = W_{电源} - \frac{1}{2}mv_m^2$

$= Eq - \frac{1}{2}mv_m^2$

4. q:

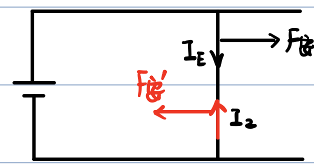
① $q = \frac{\Delta\Phi}{R+r} = \frac{BL\Delta x}{R+r}$ ×

② $BLq = mv_m$ √

$q = I\Delta t = \frac{\boxed{E}}{R+r}\Delta t = \boxed{\frac{\Delta\Phi}{\Delta t}}\frac{\Delta t}{R+r}$

含源单棒的电动势不是由电磁感应产生的，故不能使用 $q=\frac{\Delta\Phi}{R+r}$

5.



$F_安 = BIL \quad I\downarrow \to F_安\downarrow$

$I_E = \frac{E}{R+r} \quad I_2 = \frac{E_2}{R+r} = \frac{BLv}{R+r}$

$F_安\cdot t = mv_m - 0$

$BI_E L t - B\cdot I_2 L\cdot t = mv_m$

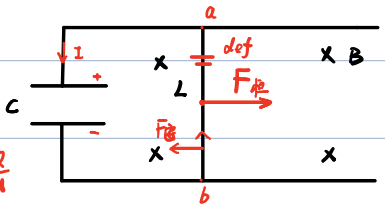
$B\frac{E}{R+r}\cdot Lt - \frac{B^2L^2v}{R+r}\boxed{t} = mv_m$

$\frac{BELt}{R+r} - \frac{B^2L^2\Delta x}{R+r} = mv_m$

Δx、t 知一求一.

含容单棒

1.



$C=\frac{Q}{U}$

$a=\frac{F-F_{安}}{m} \longleftarrow F_{安}=BIL$, $I=\frac{\Delta Q}{t}=\frac{\Delta UC}{t}$

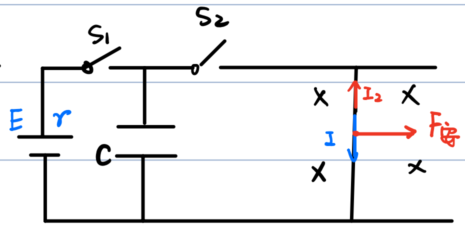
$=\frac{F-\frac{B^2L^2\Delta vC}{t}}{m}$ $\quad =\frac{B^2L^2\Delta vC}{t}$ $\quad =\frac{BL\Delta v\cdot C}{t}$

$=\frac{F-B^2L^2aC}{m}$

$\therefore a=\frac{F}{m+B^2L^2C}$ ⇒ a是常数

物体做匀加速直线..

2.

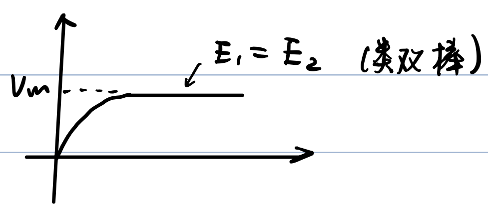


① S_1闭合，S_2断开.

② S_2断开，S_1闭合.

$F_{安}=BI_{总}L=B(I-I_2)\cdot L$, $\quad I_2=\frac{BLv}{R_{总}}$

$\therefore v\uparrow \quad F_{安}\downarrow$



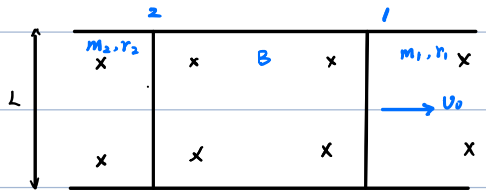
(3) $E_1=E-\Delta E \quad E_2=BLv_m$.

$\Delta E=\frac{\Delta q}{C} \quad q_0=EC \quad q_2=E_1C=E_2C$

$\Longrightarrow E-\frac{q_1-q_2}{C}=BLv_m$

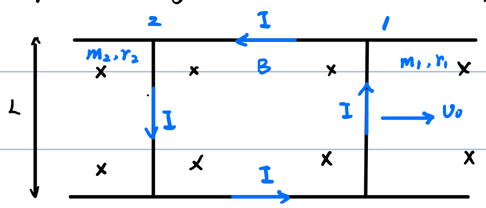
双棒切割

一、等长(无外力,有初速)

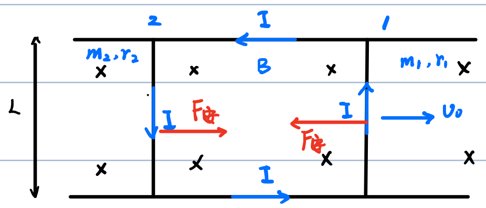


光滑导轨.两根导体棒都能移动.

初始时 m_2 静止, m_1 有向右的初速度 v_0



右侧导体棒切割磁感线.产生感应电动势.和感应电流,于是产生安培力 $F_{安}$



$F_{安}=BIL$,由于是串联电路,所以两棒所受 $F_{安}$ 大小相等.

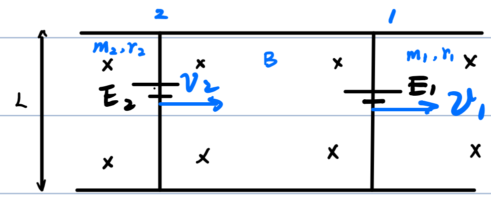
故:

棒1速度方向与受力方向相反.做减速运动.

棒2做加速运动.

那么棒1、2的加速度如何变化?

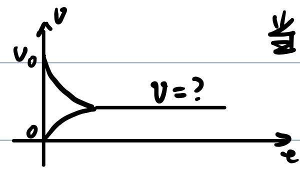
假设因为运动某时刻棒1棒2速度分别为 v_1、v_2



$$\begin{cases} F_{安}=BIL \\ I=\dfrac{E_1-E_2}{r_1+r_2} \Rightarrow F_{安}=\dfrac{B^2L^2(v_1-v_2)}{r_1+r_2} \\ E=BLv \end{cases}$$

$v_1\downarrow$、$v_2\uparrow$ $\therefore F_{安}\downarrow \Rightarrow a\downarrow$

故



当 $v_1=v_2$ 后 $a=0$.

※稳态: $I=0A$.

1.那么共速后 $v=?$

棒1、2看成一个整体.合力为0.故系统动量守恒.

$$m_1v_0=(m_1+m_2)v$$

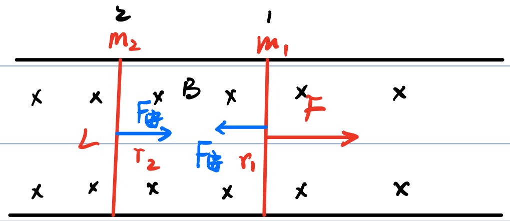
$$v=\frac{m_1}{m_1+m_2}v_0$$

2.回路产生的热量 $Q=?$

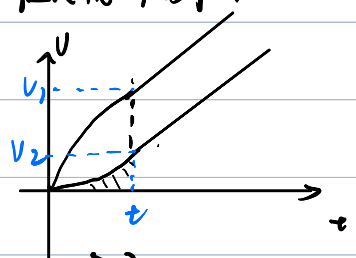
$$Q_{总}=\frac{1}{2}m_1v_0^2-\frac{1}{2}(m_1+m_2)v^2$$

$$Q_{r_1}=\frac{r_1}{r_1+r_2}Q_{总}.$$

二. 等长（无初速，有外力）.

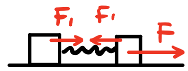


初始时，m_1、m_2无初速度，仅m_1受一个大小恒定的外力F.



$$F_安=\frac{B^2L^2(v_1-v_2)}{r_1+r_2}$$

※稳态：共 a. ← 类比



整体：$F=(m_1+m_2)\cdot a$ ①

对2：$F_安=\frac{B^2L^2(v_1-v_2)}{r_1+r_2}=m_2a$ ②

联立①，②.

$$\frac{B^2L^2(v_1-v_2)}{r_1+r_2}=\frac{m_2}{m_1+m_2}\cdot F \quad ③$$

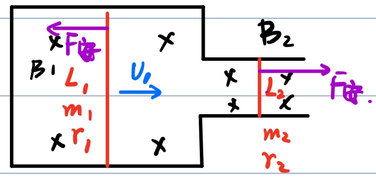
注意：事实上我们得到的不过是v_1、v_2的关系，即 $\frac{B^2L^2\Delta v}{r_1+r_2}=\frac{m_2}{m_1+m_2}F$.

回路通过的电量q.

$$\begin{cases} Ft-BLq=mv_1-0 & ④ \\ BLq=mv_2-0 & ⑤ \end{cases}$$

③、④、⑤三个方程. t、q、v_1、v_2四个未知数. 故t、q、v_1、v_2知一求三.

三. 不等长（有初速度，无外力）.

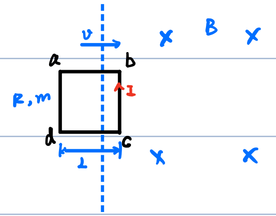


※稳态：$E_1=E_2$

$$\begin{cases} B_1L_1v_1'=B_2L_2v_2' \\ B_1L_1q=m_1v_1'-m_1v_1 \\ B_2L_2q=m_2v_2'-0 \end{cases}$$

线框切割.

(1)



$E=BLv$, $I=\frac{E}{R_{总}}=\frac{BLv}{R_{总}}$

$U_{ad}=?$ $U_{ab}=?$ $U_{cd}=?$ $U_{bc}=?$

$U_{ad}=\frac{1}{4}BLv$

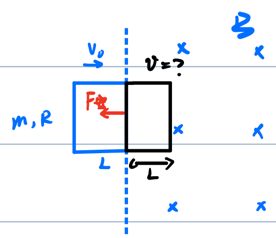
$U_{ab}=\frac{1}{4}E$

$U_{dc}=\frac{1}{4}E$

※ $U_{bc}=\frac{3}{4}E$ （路端电压）

易错

(2)



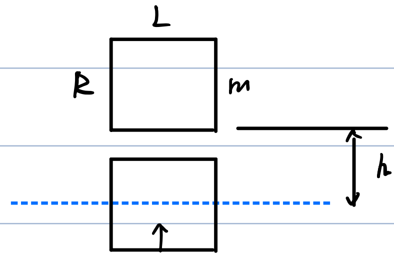
(1) $\frac{B^2L^2v}{R}t=m\Delta v$

$\therefore \frac{B^2L^3}{R}=mv_0-mv \Rightarrow v$

(2) $Q=\frac{1}{2}mv_0^2-\frac{1}{2}mv^2$

$Q_{ad}=\frac{1}{4}Q$ $Q_{bc}=\frac{1}{4}Q$

(3)



线框做自由落体运动，一段时间后匀速．恰好完全进入磁场中．求 Q：

① $mg=F_{安}=\frac{B^2L^2v_m}{R}$

$\Rightarrow v_m$

② $mg(h+L)-Q=\frac{1}{2}mv_m^2-0$

③ $t_1=\sqrt{\frac{2h}{g}}$

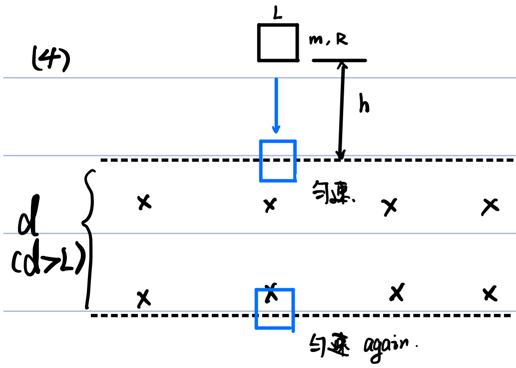
$mgt_2-BLq=mv_m-mv_1$

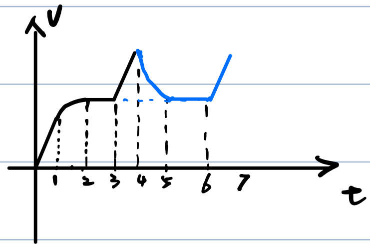
$q=\frac{BL^2}{R}$ $\sqrt{2gh}$

$\Rightarrow t_2$

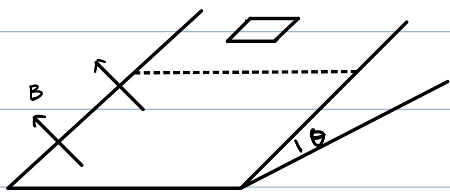
$\therefore t_{总}=t_1+t_2$.

(4)





(5)

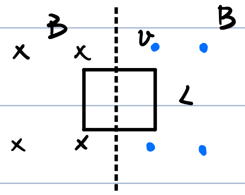


① $F = mg\sin\theta = \frac{B^2L^2v}{R}$ (光)

② $mg\sin\theta - \mu mg\cos\theta = \frac{B^2L^2v}{R}$ (粗).

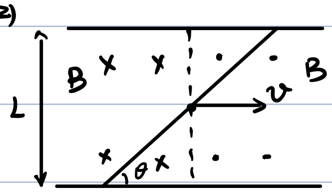
图象问题·(有效长度)

(1)

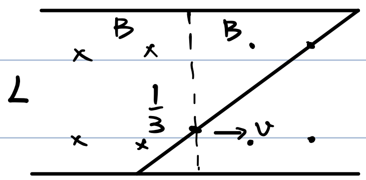


$E = 2BLv$

(2)

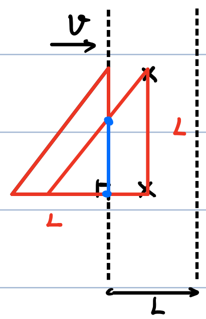


$E = 0$

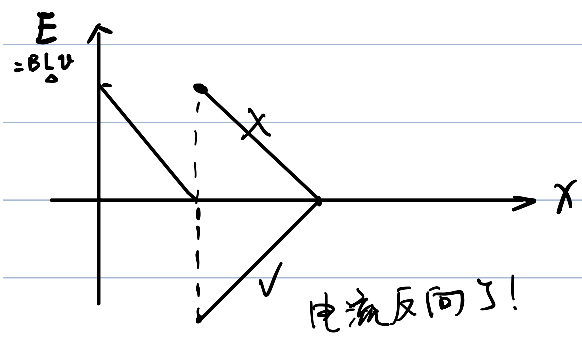


$E = \frac{1}{3}BLv$

(3)



$E = BLv$
↓
有效长度.



电流反向了!