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29.11

$\times \vec{B}$

2cm

0.6Ω

$t=0$ $B=3T$, $B(t)=B_0 e^{-t/\tau}$

$\tau=0.5s$

(a) $I=\frac{\varepsilon}{R}$ $\varepsilon=-\frac{d\Phi}{dt}$

$\Phi=B\cdot A$ $d\Phi=dBA$

A is constent, only B change

$\frac{d\Phi}{dt}=\frac{B_0 e^{-\frac{t}{\tau}}}{dt}A=-\frac{1}{\tau}B_0 e^{-\frac{t}{\tau}}A$

$I=\frac{\varepsilon}{R}=-\left(-\frac{1}{\tau}B_0 e^{-\frac{t}{\tau}}\right)A\times\frac{1}{R}$

$=\frac{B_0 e^{-\frac{t}{\tau}}A}{\tau R}$

Maximum $= e^{-\frac{t}{\tau}}$ max, $\frac{t}{\tau}=0$ $t=0$

$I_{Max}=\frac{3\times(\frac{2}{100})^2\pi}{0.5\times0.6}\times e^0=\underline{1.26\times10^{-2}A}$

(b) $t=1.5$

$I=\frac{3\times(\frac{2}{100})^2\pi}{0.5\times0.6}\times e^{-\frac{1.5}{0.5}}$

$=\underline{6.26\times10^{-4}A}$

29.36

$N=900/m$ $R=2.5cm$ $\frac{dI}{dt}=36A/s$ $\varepsilon_{Ind}=?$

(a) $B=\mu_0 nI$ $\varepsilon_{Ind}=\oint\vec{E}\cdot d\vec{l}=-\frac{d\Phi_B}{dt}$ calculated

$\Phi=AB=\pi r^2 B$ $\oint\vec{E}\cdot d\vec{l}=E(2\pi r)=\pi r^2\left|\frac{dB}{dt}\right|$

$E=\frac{1}{2}r\left|\frac{dB}{dt}\right|$ $\frac{dB}{dt}=\mu_0 n\frac{dI}{dt}$

$=\frac{1}{2}r\mu_0 n\frac{dI}{dt}=\frac{1}{2}\times0.5\times4\pi\times10^{-7}\times900\times36$

$=1.02\times10^{-4}$ V/m

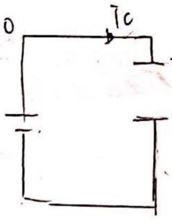
(b) $E=\frac{1}{2}r\left|\frac{dB}{dt}\right|$ $r=1cm$

$=\frac{1}{2}r\mu_0 n\frac{dI}{dt}$

$=\frac{1}{2}\times\frac{1}{100}\times4\pi\times10^{-7}\times900\times36$

$=2.04\times10^{-4}$ V/m

2.40



I_c

$A=5cm^2$

$d=2mm$

$I_c=1.8mA$

$t=0$, charge $=0$

(a) $q=\int I_c dt=q_0+I_c t$

$t=0$, $q_0=0$

$t=0.5\mu s$

$q=0+1.8\times10^{-3}\times0.5\times10^{-6}$

$=\underline{9\times10^{-10}}$

(a) $E(t)=\frac{q(t)}{C}=\frac{I_c t}{\epsilon_0 A}$ $t=0.5\mu s$

$=\frac{1.8\times10^{-3}\times0.5\times10^{-6}}{8.85\times10^{-12}\times5\times10^{-4}}$

$=\underline{2.03\times10^5}$ N/C

$V(t)=E(t)d=2.03\cdot10^5\times2\times10^{-3}$

$=4.06\times10^2$ V

(b)

$\frac{dE}{dt}=?$ $\frac{dE}{dt}$ is constent or not?

$E(t)=\frac{q(t)}{C}=\frac{I_c t}{\epsilon_0 A}$ $\frac{dE(t)}{dt}=\frac{I_c}{\epsilon_0 A}=\underline{4.07\times10^{11}}$

$\frac{dE}{dt}$ doesn't vary in time.

(c) $j_D=\epsilon_0\frac{dE}{dt}=\epsilon_0\left(\frac{I_C}{\epsilon_0 A}\right)=\frac{I_c}{A}$

$=\underline{3.6A/m^2}$

$i_D=j_D A=\left(\frac{I_c}{A}\right)A=i_c=\underline{1.8\times10^{-3}A}$

I_c and i_D are equal

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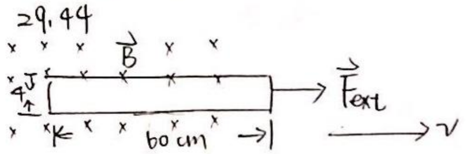
29.44



$B = 2.9\,T$ 24g

$R = 5\times10^{-3}\,\Omega$ $F_{ext} = 0.18\,N$

(a) $v = 3\,cm/s$, $a = ?$

$F_{mag} = ILB$ $I = \frac{\mathcal{E}}{R}$

$I = \frac{vBL}{R}$ $F_{mag} = \frac{v(BL)^2}{R}$

$\Sigma F = F_{ext} - F_{mag} = ma$

$ma = F_{ext} - \frac{v(BL)^2}{R}$

(a) $\frac{24}{1000}a = \left(0.18 - \frac{3\cdot10^{-2}\cdot(2.9\cdot0.04)^2}{5\times10^{-3}}\right)$

$a = 4.14\,m/s^2$

(b) when $F_{mag} = F_{ext}$, it will be the loop's terminal speed

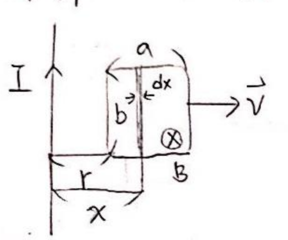
$\frac{v(BL)^2}{R} = 0.18$ $v = \frac{0.18R}{(BL)^2}$

$a = 0$ $= 6.69\cdot10^{-2}$

(c) out of magnetic field, $F_{mag} = 0$

$\Sigma F = F_{ext} = ma$ $a = 7.5\,m/s^2$

29.49



(a) i. $d\Phi_B = B\cdot dA$

$B = \frac{\mu_0 I}{2\pi x}$

$dA = b\,dx$

$d\Phi_B = \frac{\mu_0 I b}{2\pi}\frac{dx}{x}$

$\Phi_B = \int d\Phi_B =$

$= \int_r^{r+a}\frac{\mu_0 I b}{2\pi}\frac{dx}{x}$

$\Phi_B = \frac{\mu_0 I b}{2\pi}\ln\left(\frac{r+a}{r}\right)$

$\frac{d\Phi_B}{dt} = \frac{d\Phi_B}{dr}\frac{dr}{dt}$ $\frac{dr}{dt} = v$

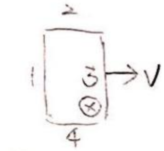
$\frac{d\Phi_B}{dt} = \frac{d\,\frac{\mu_0 I b}{2\pi}\ln\left(\frac{r+a}{r}\right)}{dr}\cdot v$

$= \frac{\mu_0 I b}{2\pi}\left(-\frac{a}{r(r+a)}\right)v$

$= \frac{\mu_0 I b a v}{2\pi r(r+a)}$

$\mathcal{E} = \frac{\mu_0 I b a v}{2\pi r(r+a)}$

ii. $\mathcal{E}_1 = \left(\frac{\mu_0 I}{2\pi r}\right)vb$



$\mathcal{E}_3 = \left(\frac{\mu_0 I}{2\pi(r+a)}\right)vb$

$\mathcal{E}_2 = \mathcal{E}_4 = 0$

$\mathcal{E} = \mathcal{E}_1 - \mathcal{E}_3 = \frac{\mu_0 I}{2\pi}vb\left(\frac{1}{r} - \frac{1}{r+a}\right)$

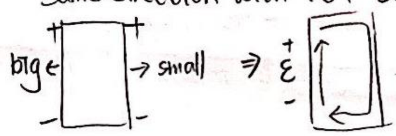
$= \frac{\mu_0 I}{2\pi}vb\,\frac{a}{r(r+a)}$

$= \frac{\mu_0 I v a b}{2\pi r(r+a)}$

(b)

(i) as the loop moves to the right, the magnetic field decrease. According to Lenz's law, a current must flow in to the loop so the magnetic field opposes the external magnetic field, in our case, the direction of the induced must point in the same direction of the external magnetic field "Into the page." Therefore, the direction of the induced current is Clockwise

(ii) we have free charge in each side, each experience a force $\vec{F}_1 = q\vec{v}\times\vec{B}$ positive charge will go up, this causing a potential difference between the ends of each one of sides. Since the left side is closer to the wire, it have a higher induced emf, the direction of the induced emf will have the same direction with it. So it is clockwise

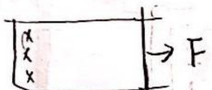


(c) i. loop is stationary, $v = 0$ Since $v = 0$, $\mathcal{E} = 0$

ii. $a \to 0$, The magnetic flux is zero the enduced emf $\mathcal{E} = 0$

iii. $B \to 0$, $\Phi_B \to 0$, the induced emf, the formula in part (a) gives same answer, $\mathcal{E} = 0$

29.52



$B = 1.5\,T$ $F = 1.9\,N$

$m = 0.12\,kg$ $R = 80\,\Omega$

$t = ?$ when speed $= 25\,m/s$

$L = 0.2$

$\Sigma\vec{F} = \vec{F}_{ext} - \vec{F}_B$

$\vec{F}_B = I\,l\,\vec{B}$

$I = \frac{\mathcal{E}}{R}$ $\mathcal{E} = \frac{d\Phi_B}{dt}$

$\Phi_B = B\,dA = B\cdot L\,dx$

$\mathcal{E} = B\frac{L\,dx}{dt} = LBv$

$I = \frac{vBL}{R}$ $\vec{F}_B = \frac{v(BL)^2}{R}$

$F - \frac{v(BL)^2}{R} = ma$

$F - \frac{v(BL)^2}{R} = m\frac{dv}{dt}$

$\frac{F}{m}dt = \frac{dv}{1 - \frac{v(BL)^2}{FR}}$

$\frac{F}{m}\int_0^t dt = \int_0^{25}\frac{dv}{1 - \frac{v(BL)^2}{FR}}$

$t = 1.59\,s$ (only t unknown)

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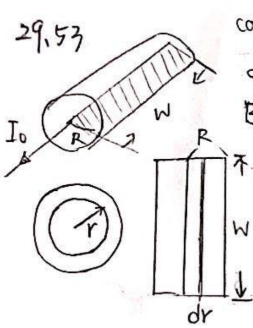


calculate Φ_B

$d\Phi_B = B \cdot dA$

$B(r) = \frac{\mu_0 I r}{2\pi R^2}$

$dA = W dr$

$d\Phi_B = \frac{\mu_0 I W}{2\pi R^2} r dr$

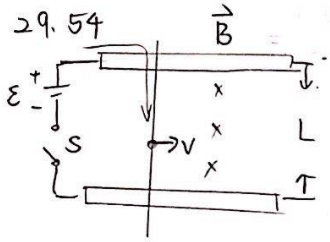
$\Phi_B = \int d\Phi_B$

$$\Phi_B = \int_0^R \frac{\mu_0 I_0 W}{2\pi R^2} r dr$$

$$= \frac{\mu_0 I_0 W}{2\pi R^2} \times \frac{1}{2} R^2$$

$$= \frac{\mu_0 I_0 W}{4\pi}$$

29.54



$L = 0.36m$

$B = 2.4T$

$\mathcal{E} = 12V$

bar $m = 0.9kg$

$R = 5\Omega$

(a) since the bar will have current, it will have magnetic force, which direction : →, and when it move to right it will have induced emf since $\mathcal{E}$ is change.

(b) switch closed $I = \frac{\mathcal{E}}{R} = \frac{12}{5}$

$F_B = ILB = \frac{12}{5} \cdot 0.36 \cdot 2.4$

$\Sigma F = F_B = ma$ $\quad a = 2.304 m/s^2$

(c) $v = 2.0 m/s$ $\quad a = \frac{\mathcal{E} - BLv}{mR} BL$

$a = 1.97 m/s^2$

(d) terminal speed, by the graph, we could know

$v_T = 13.89 m/s$

(a) $I = I_{bar} - I_{ind}$ $\quad I_{bar} = \frac{\mathcal{E}}{R}$ $\quad I_{end} = \frac{\mathcal{E}_{ind}}{R}$

$= \frac{\mathcal{E} - \mathcal{E}_{ind}}{R}$ $\quad \mathcal{E}_{ind} = vLB$

$= \frac{\mathcal{E} - BLv}{R}$

$F_{bar} = ILB = \frac{\mathcal{E} - BLv}{R} LB$

$a: F_{bar} = ma$

$a = \frac{(\mathcal{E} - BLv)}{mR} BL = \frac{dv}{dt}$

$\frac{BL}{mR} dt = \frac{dv}{(\mathcal{E} - BLv)}$

$\frac{BL}{mR}\int_0^t dt = \int_0^v \frac{dv}{\mathcal{E} - BLv}$

$-\frac{\ln(\mathcal{E} - BLv)}{BL}\Big|_0^v = \frac{LBt}{mR}$

$\frac{\ln\mathcal{E} - \ln(\mathcal{E} - BLv)}{BL} = \frac{LBt}{mR}$

$\ln\left(\frac{\mathcal{E}}{\mathcal{E} - BLv}\right) = \frac{(BL)^2 t}{mR}$

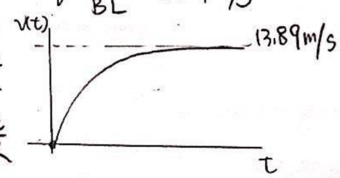
$v = \frac{\mathcal{E}}{BL}\left(1 - e^{-\frac{B^2L^2t}{mR}}\right)$

when $t = 0$

$v = 0$

$t \to \infty$

$v = \frac{\mathcal{E}}{BL} = 13.89 m/s$



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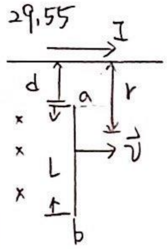

$B = \frac{\mu_0 I}{2\pi r}$

$d\mathcal{E} = \vec{v} \times \vec{B} \cdot d\vec{l}$

$d\vec{l} = dr$

$d\mathcal{E} = \frac{-v\mu_0 I}{2\pi} \frac{dr}{r}$

$V_{ba} = \int_a^b d\mathcal{E}$

$V_{ba} = -\int_d^{d+L} \frac{v\mu_0 I}{2\pi} \frac{dr}{r}$

$= -\frac{\mu_0 I v}{2\pi} (\ln(d+L) - \ln d)$

$= -\frac{\mu_0 I v}{2\pi} \ln\left(1 + \frac{L}{d}\right)$

(b) The $\vec{F_B}$ dir is ↑

this would make positive charge go up, point a will be higher

(c)

$\mathcal{E} = -\frac{d\Phi_B}{dt}$

$d\Phi_B = B \cdot dA = 0$

$\mathcal{E} = 0$

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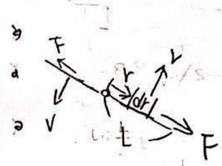


$B = 0.65T$

(a) $v = \omega r$

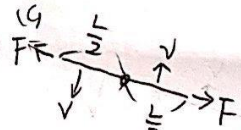
$d\mathcal{E} = \omega B r dr$

$\mathcal{E} = \int_0^L \omega B r dr$

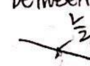
$= \frac{1}{2}\omega B L^2 = 0.165V$

(b) The potential difference between the rod's end = the magnitude of the emf induced in the rod. That is $V = |\mathcal{E}| = 0.165V$

(c)



the potential difference between the ends = 0



$\mathcal{E} = \int_0^{\frac{L}{2}} \omega B r dr$

$= \frac{1}{2}\omega B\left(\frac{L}{2}\right)^2 = 4.13 \times 10^{-2} V$