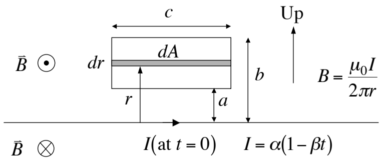
1992 #3



a.) the magnetic field is directed out of the page (RHR).

b.)

i.) $\Phi_B = \ ?$

$$\Phi_B = \int \vec B\cdot d\vec A = \int B\,dA = \int_a^b \frac{\mu_0 I}{2\pi r} c\,dr$$

$$\Phi_B = \frac{\mu_0 c I}{2\pi}\int_a^b \frac{dr}{r} = \frac{\mu_0 c I}{2\pi}\ln(r)\Big|_a^b = \frac{\mu_0 c I}{2\pi}\ln\left(\frac{b}{a}\right)$$

$$\boxed{\Phi_B = \frac{\mu_0 c\alpha}{2\pi}(1-\beta t)\ln\left(\frac{b}{a}\right)}$$

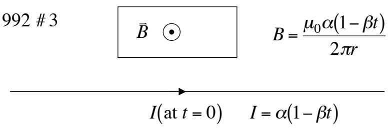
ii.) $\mathcal{E} = \ ?$

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

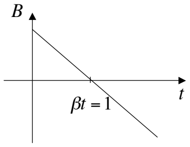
$$\mathcal{E} = -\frac{d}{dt}\left(\frac{\mu_0 c\alpha}{2\pi}(1-\beta t)\ln\left(\frac{b}{a}\right)\right)$$

$$\boxed{\mathcal{E} = \frac{\mu_0 c\alpha\beta}{2\pi}\ln\left(\frac{b}{a}\right)}$$

1992 #3

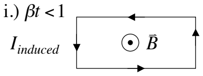


$$B = \frac{\mu_0\alpha(1-\beta t)}{2\pi r}$$



c.) direction of induced current in the loop for:

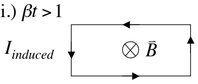
i.) $\beta t < 1$



$B$ is decreasing out of the page so induced current will create a $B$-field out of the page to oppose this change.

$B\downarrow$⊙ $\therefore B_{induced}$ $\circlearrowleft$ induced current is counterclockwise

ii.) $\beta t > 1$

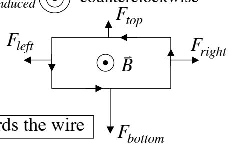


$B$ is increasing into the page so induced current will create a $B$-field out of the page to oppose this change.

$B\uparrow$⊗ $\therefore B_{induced}$ $\circlearrowleft$ counterclockwise

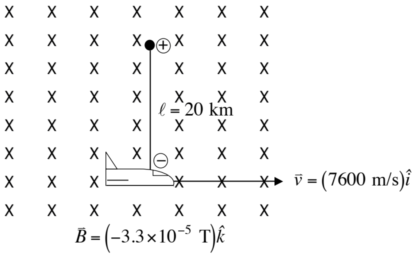
d.) direction of the force on the loop at $t = 0$?

$$\vec F = I_{induced}\vec\ell\times\vec B \qquad B = \frac{\mu_0 I}{2\pi r}$$



$\boxed{\text{net force on the loop is towards the wire}}$

1994 #2



a.)

i.) end of the tether that is negative?

$$\vec F = q\vec v\times\vec B = -e\vec v\times\vec B$$

direction of force on electrons in the tether is: $-(\hat i\times(-\hat k)) = -\hat j$

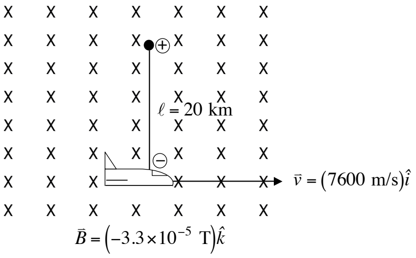
which is towards the shuttle

ii.) $\mathcal{E} = ?$ $\quad F = evB$ so $E = \frac{F}{q} = \frac{F}{e} = vB$

$$E = \frac{\Delta V}{\Delta x} = \frac{\mathcal{E}}{\ell} \quad \text{and} \quad \mathcal{E} = vB\ell = \left(7600\ \frac{\text{m}}{\text{s}}\right)\left(3.3\times10^{-5}\text{ T}\right)\left(20\times10^{3}\text{ m}\right)$$

$$\boxed{\mathcal{E} = 5016\text{ V}}$$

1994 #2



b.) $R = 10{,}000\ \Omega$, $I = ?$

$$I = \frac{\Delta V}{R} = \frac{\mathcal{E}}{R} = \frac{5016\text{ V}}{10{,}000\ \Omega} = \boxed{0.5016\text{ A}}$$

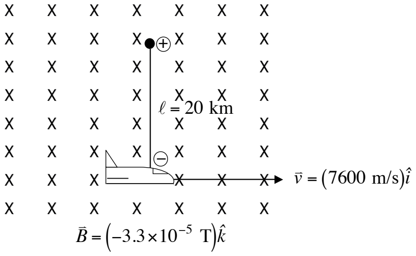
c.)

i.) $F = ?$

$$\vec F = I\vec\ell\times\vec B = (0.5016\text{ A})\left(20\times10^{3}\text{ m}\right)\hat j\times\left(-3.3\times10^{-5}\text{ T}\right)\hat k = \boxed{(-0.331\text{ N})\hat i}$$

ii.) The direction of the force is to the left.

1994 #2



d.) $t = 7$ days, $E = ?$

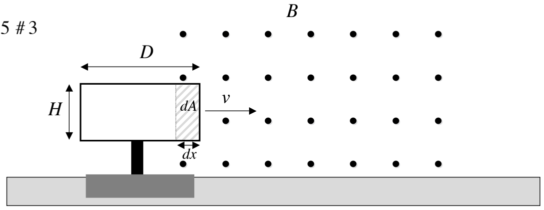
$$E = Pt = I^2Rt = (0.5016\text{ A})^2(10{,}000\ \Omega)(7\text{ days})\left(24\ \frac{\text{h}}{\text{day}}\right)\left(3600\ \frac{\text{s}}{\text{h}}\right)$$

$$\boxed{E = 1.52\times10^{9}\text{ J}}$$

e.) Effect of reversing current?

This would make the direction of the force go to the right speeding up the shuttle and boosting the shuttle into an orbit with a larger radius.

1995 #3



$dA = Hdx$

loop resistance $R$
glider and loop mass $m$

a.) Initial induced *emf* upon entering $B$-field?

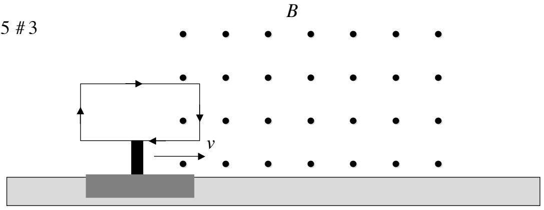
$$\mathcal{E} = \frac{d\Phi_B}{dt} = \frac{d(BA\cos\theta)}{dt} = B\frac{dA}{dt} = B\frac{Hdx}{dt} = BH\frac{dx}{dt} = BHv$$

$$\boxed{\mathcal{E} = BHv_0}$$

b.) $I_0 = ?$

$$I = \frac{\Delta V}{R} = \frac{\mathcal{E}}{R} \quad \text{so} \quad \boxed{I_0 = \frac{BHv_0}{R}}$$

1995 # 3



loop resistance $R$ and total mass of loop and glider $m$

c.) Direction of induced current entering $B$ - field?

$B$ is increasing out of the page so induced current will create a $B$ - field into the page to oppose this change.

$\boxed{B\uparrow\odot \therefore B_{induced}\otimes \text{ induced current is clockwise}}$

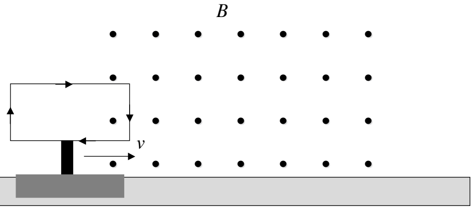
d.) $v(t) = ?$ as the loop enters $B$ - field

$$\vec{F}_{net} = m\vec{a}$$

---

1995 # 3

$I = \frac{BHv}{R}$



loop resistance $R$ and total mass of loop and glider $m$

d.) $v(t) = ?$ as the loop enters $B$ - field

$$\vec{F} = I\vec{\ell}\times\vec{B} = IH\left(-\hat{j}\right)\times B\left(\hat{k}\right) = -IHB\hat{i}$$

$$\vec{F}_{net} = ma = m\frac{dv}{dt}$$

$$-IHB = m\frac{dv}{dt}$$

$$-\frac{B^2H^2}{R}v = m\frac{dv}{dt} \qquad \left(I = \frac{BHv}{R}\right)$$

---

1995 # 3 d.) $v(t) = ?$ as the loop enters $B$ - field

$$-\frac{B^2H^2}{R}v = m\frac{dv}{dt}$$

$$-\frac{B^2H^2}{mR}dt = \frac{dv}{v}$$

$$\int_0^t -\frac{B^2H^2}{mR}dt = \int_{v_0}^{v}\frac{dv}{v}$$

$$-\frac{B^2H^2}{mR}t\Big|_0^t = \ln(v)\Big|_{v_0}^{v}$$

$$-\frac{B^2H^2}{mR}t - 0 = \ln(v) - \ln(v_0)$$

$$-\frac{B^2H^2}{mR}t = \ln\left(\frac{v}{v_0}\right)$$

$$-\frac{B^2H^2}{mR}t = \ln\left(\frac{v}{v_0}\right)$$

$$e^{-\frac{B^2H^2}{mR}t} = \frac{v}{v_0}$$

$$\boxed{v(t) = v_0e^{-\frac{B^2H^2}{mR}t}}$$

---

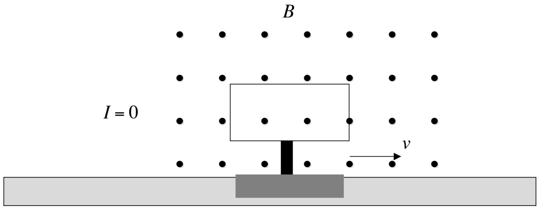
1995 # 3

e.) graph $v$ as it enters, travels through after completely entering, and exits $B$ - field

Entering the $B$ - field: $v(t) = v_0e^{-\frac{B^2H^2}{mR}t}$

Traveling through after completely entering the $B$ - field:

$I = 0$



$$\mathcal{E} = \frac{d\Phi_B}{dt} = \frac{d(BA\cos\theta)}{dt} = B\frac{dA}{dt} = 0 \text{ so } I = 0$$

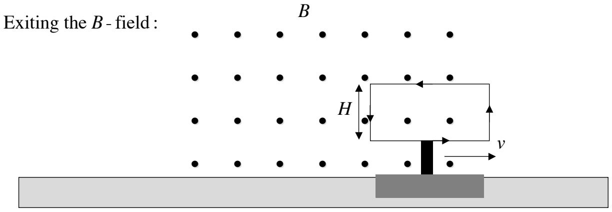
$\vec{F} = I\vec{\ell}\times\vec{B} = 0$ and $v(t)$ = constant

---

1995 # 3

e.) graph $v$ as it enters, travels through after completely entering, and exits $B$ - field

Exiting the $B$ - field:



$$\mathcal{E} = \frac{d\Phi_B}{dt} = \frac{d(BA\cos\theta)}{dt} = B\frac{dA}{dt} = B\frac{Hdx}{dt} = BH\frac{dx}{dt} = BHv$$

Direction of induced current exiting $B$ - field:

$B$ is decreasing out of the page so induced current will create a $B$ - field out of the page to oppose this change.

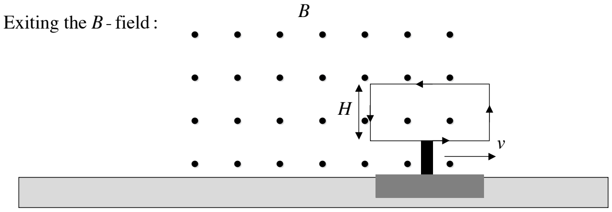
$B\downarrow\odot \therefore B_{induced}\odot$ induced current is counterclockwise

---

1995 # 3

e.) graph $v$ as it enters, travels through after completely entering, and exits $B$ - field

Exiting the $B$ - field:



$v(t) = ?$ as the loop exits $B$ - field

$$\vec{F} = I\vec{\ell}\times\vec{B} = IH\left(-\hat{j}\right)\times B\left(\hat{k}\right) = -IHB\hat{i}$$

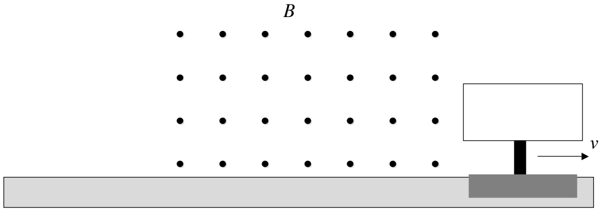
The same situation as when the loop is entering the $B$ - field and:

$$v(t) = ve^{-\frac{B^2H^2}{mR}t}$$

## 1995 # 3

e.) graph $v$ as it enters, travels through after completely entering, and exits $B$ - field

Completely out of the $B$ - field :



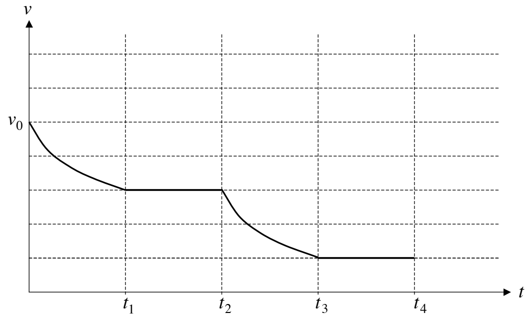
$$\mathcal{E} = \frac{d\Phi_B}{dt} = 0 \text{ so } I = 0$$

$$\vec{F} = I\vec{\ell} \times \vec{B} = 0 \text{ and } v(t) = \text{constant}$$

---

## 1995 # 3

e.) graph $v$ as it enters, travels through after completely entering, and exits $B$ - field



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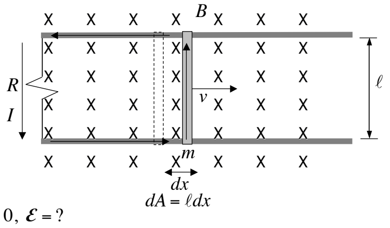
## 1991 # 3



$@\ t = 0,\ v = v_0$

a.) $@\ t = 0,\ \mathcal{E} = ?$

$$\mathcal{E} = \frac{d\Phi_B}{dt} = \frac{d(BA\cos\theta)}{dt} = B\frac{dA}{dt} = B\frac{\ell dx}{dt} = B\ell\frac{dx}{dt} = B\ell v$$

$$@\ t = 0, \boxed{\mathcal{E} = B\ell v_0}$$

b.) $@\ t = 0,\ \vec{F} = ?$

$\vec{F} = I\vec{\ell} \times \vec{B}$ direction of $F$ depends upon direction of $I$

$B$ is increasing into the page so induced current will create a $B$ - field out of the page to oppose this change.

$B\uparrow\otimes \therefore B_{induced}\ (\odot)$ induced current is counterclockwise

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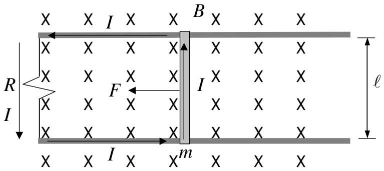
## 1991 # 3



$@\ t = 0,\ v = v_0$

b.) $@\ t = 0,\ \vec{F} = ?$

$$\vec{F} = I\vec{\ell} \times \vec{B} = I\ell(\hat{j}) \times B(-\hat{k}) = -I\ell B\hat{i}$$

$\boxed{\therefore \text{ the direction of the force is to the left}}$

the magnitude of the force is $F = I\ell B$

$$I = \frac{\Delta V}{R} = \frac{\mathcal{E}}{R} = \frac{B\ell v_0}{R}$$

$$F = I\ell B = \left(\frac{B\ell v_0}{R}\right)\ell B$$

$$\boxed{F = \frac{B^2\ell^2 v_0}{R}}$$

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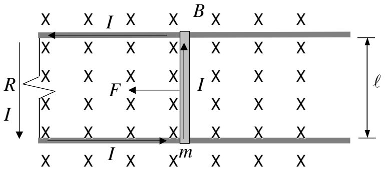
## 1991 # 3



$@\ t = 0,\ v = v_0$

$$F = \frac{B^2\ell^2 v_0}{R}$$

c.) $v(t) = ?$

$$\vec{F}_{net} = ma = m\frac{dv}{dt}$$

$$-\frac{B^2\ell^2}{R}v = m\frac{dv}{dt}$$

$$-\frac{B^2\ell^2}{mR}dt = \frac{dv}{v}$$

$$\int_0^t -\frac{B^2\ell^2}{mR}dt = \int_{v_0}^{v}\frac{dv}{v}$$

$$-\frac{B^2\ell^2}{mR}t\Big|_0^t = \ln(v)\Big|_{v_0}^{v}$$

$$-\frac{B^2\ell^2}{mR}t - 0 = \ln(v) - \ln(v_0)$$

$$-\frac{B^2\ell^2}{mR}t = \ln\left(\frac{v}{v_0}\right)$$

$$e^{-\frac{B^2\ell^2}{mR}t} = \frac{v}{v_0}$$

$$\boxed{v(t) = v_0 e^{-\frac{B^2\ell^2}{mR}t}}$$

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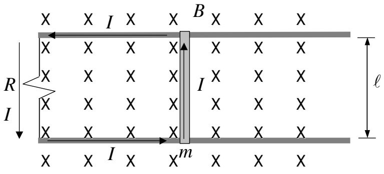
## 1991 # 3



$$i = \frac{B\ell v}{R}$$

$$i = \frac{B\ell}{R}v_0 e^{-\frac{B^2\ell^2}{mR}t}$$

d.) $E = ?\ (0 < t < \infty)$

$$E = \int Pdt = \int_0^\infty i^2 Rdt$$

$$E = \int_0^\infty \left(\frac{B\ell}{R}v_0 e^{-\frac{B^2\ell^2}{mR}t}\right)^2 Rdt$$

$$E = \int_0^\infty \frac{B^2\ell^2}{R^2}v_0^2 e^{-\frac{2B^2\ell^2}{mR}t}Rdt$$

$$E = \frac{-1}{2}mv_0^2\int_0^\infty e^{-\frac{2B^2\ell^2}{mR}t}\left(\frac{-2B^2\ell^2}{mR}\right)dt$$

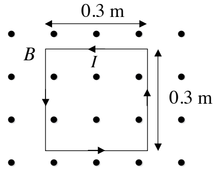
$$E = \frac{-1}{2}mv_0^2 e^{-\frac{2B^2\ell^2}{mR}t}\Big]_0^\infty$$

$$E = \frac{-1}{2}mv_0^2\left(e^{-\infty} - e^0\right)$$

$$E = \frac{-1}{2}mv_0^2(0 - 1)$$

$$\boxed{E = \frac{1}{2}mv_0^2}$$

1987 # 2



$R = 6\ \Omega$
$B_0 = 2\ \text{T}$
$B = 2e^{-4t}$

a.) $\Phi_B(t) = ?$

$$\Phi_B = \int \vec{B}\cdot d\vec{A} = BA = \left(2e^{-4t}\right)(0.3\ \text{m})^2$$

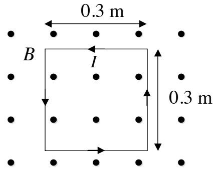
$$\boxed{\Phi_B = 0.18e^{-4t}}$$

b.) direction of induced current

$B$ is decreasing out of the page so induced current will create a $B$ - field out of the page to oppose this change.

$B\downarrow\odot\ \therefore B_{induced}\ \circlearrowleft\odot$ induced current is counterclockwise

1987 # 2



$R = 6\ \Omega$
$B_0 = 2\ \text{T}$
$B = 2e^{-4t}$
$\Phi_B = 0.18e^{-4t}$

c.) $I = ?$

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

$$\mathcal{E} = -\frac{d}{dt}\left(0.18e^{-4t}\right) = -(-4)\left(0.18e^{-4t}\right) = 0.72e^{-4t}$$

$$I = \frac{\mathcal{E}}{R} = \frac{0.72e^{-4t}}{6\ \Omega}$$

$$\boxed{I = 0.12e^{-4t}}$$

d.) $(0 < t < \infty)\ E = ?$

$$E = \int P dt = \int_0^\infty I^2 R dt$$

$$E = \int_0^\infty \left(0.12e^{-4t}\right)^2 (6) dt$$

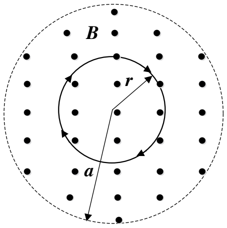
$$E = \int_0^\infty \frac{(0.12)^2(6)}{-8} e^{-8t}(-8)dt$$

$$E = -0.0108e^{-8t}\Big|_0^\infty = -0.0108\left(e^{-\infty} - e^{-0}\right)$$

$$E = -0.0108(0-1)$$

$$\boxed{E = 0.0108\ \text{J}}$$

1980 # 3



conducting loop resistance $R$

$B = B_0 + Ct$

a.) Direction of induced current in loop?

$B$ is increasing out of the page so induced current will create a $B$ - field into the page to oppose this change.

$B\uparrow\odot\ \therefore B_{induced}\ \circlearrowright\otimes$ induced current is clockwise

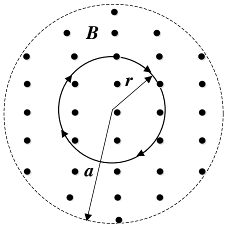
b.) $I = ?$ $\quad I = \frac{\mathcal{E}}{R}$ and $\mathcal{E} = -\frac{d\Phi_B}{dt}$

$$\mathcal{E} = \frac{d}{dt}(B_0 + Ct)\pi r^2 = \pi r^2 C$$

$$\Phi_B = \int \vec{B}\cdot d\vec{A} = BA = (B_0 + Ct)\pi r^2$$

$$\boxed{I = \frac{\pi r^2 C}{R}}$$

1980 # 3



conducting loop resistance $R$

$B = B_0 + Ct$

c.) $E$ induced for $r < a = ?$

$$\mathcal{E} = \pi r^2 C$$

$$\mathcal{E} = \oint \vec{E}\cdot d\vec{\ell} = -\frac{d\Phi_B}{dt}$$

$$E\oint d\vec{\ell} = \pi r^2 C$$

$$E(2\pi r) = \pi r^2 C$$

$$\boxed{E = \frac{rC}{2}}$$

d.) $E$ induced for $r > a = ?$

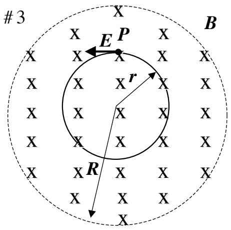
$$\mathcal{E} = \pi a^2 C$$

$$E\oint d\vec{\ell} = \pi a^2 C$$

$$E(2\pi r) = \pi a^2 C$$

$$\boxed{E = \frac{a^2 C}{2r}}$$

1985 # 3



$R = 0.75\ \text{m}$
$r = 0.5\ \text{m}$
$\frac{dB}{dt} = 60\ \frac{\text{T}}{\text{s}}$

a.) $\mathcal{E} = ?$

$$\Phi_B = \int \vec{B}\cdot d\vec{A} = BA$$

$$\mathcal{E} = -\frac{d\Phi_B}{dt} = -\frac{d(BA)}{dt} = -A\frac{dB}{dt}$$

$$\mathcal{E} = \pi(0.5\ \text{m})^2\left(60\ \frac{\text{T}}{\text{s}}\right)$$

$$\boxed{\mathcal{E} = 47\ \text{V}}$$

b.) $E$ induced at point $P = ?$

$$\mathcal{E} = \oint \vec{E}\cdot d\vec{\ell} = -\frac{d\Phi_B}{dt}$$

$$E\oint d\vec{\ell} = \mathcal{E}$$

$$E(2\pi r) = \mathcal{E}$$

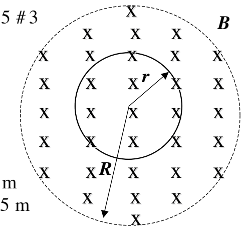
$$E = \frac{\mathcal{E}}{2\pi r} = \frac{47\ \text{V}}{2\pi(0.5\ \text{m})}$$

$$\boxed{E = 15\ \frac{\text{V}}{\text{m}}}$$

$B$ is increasing into the page so induced current will create a $B$ - field out of the page to oppose this change.

$B\uparrow\otimes\ \therefore B_{induced}\ \circlearrowleft\odot$ induced current is counterclockwise

1985 # 3



$r = 0.5\ \text{m}$
$R = 0.75\ \text{m}$

c.) electron, $B = 10^{-4}\ \text{T}$, $v = ?$

$$\vec{F}_M = q\vec{v}\times\vec{B}$$

$$F = ma$$

$$qvB = m\frac{v^2}{r}$$

$$v = \frac{qBr}{m} = \frac{\left(1.6\times10^{-19}\ \text{C}\right)\left(10^{-4}\ \text{T}\right)(0.5\ \text{m})}{9.11\times10^{-31}\ \text{kg}}$$

$$\boxed{v = 8.8\times10^{6}\ \frac{\text{m}}{\text{s}}}$$

d.) electron, $\frac{dB}{dt} = 60\ \frac{\text{T}}{\text{s}}$, $a = ?$

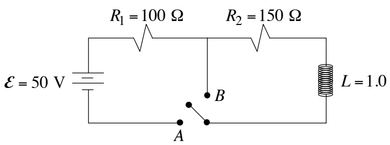
$$F = ma$$

$$qE = ma$$

$$a = \frac{qE}{m} = \frac{\left(1.6\times10^{-19}\ \text{C}\right)\left(15\ \frac{\text{V}}{\text{m}}\right)}{9.11\times10^{-31}\ \text{kg}}$$

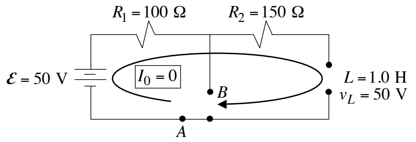
$$\boxed{a = 2.6\times10^{12}\ \frac{\text{m}}{\text{s}^2}}$$

1991 #2



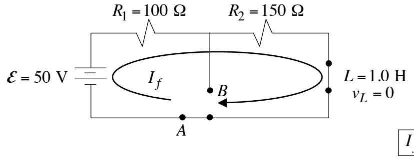
a.) $I_0 = ?$

@ $t = 0$



b.) $I_f = ?$

@ $t = \infty$



$$I = \frac{\mathcal{E}}{R}$$

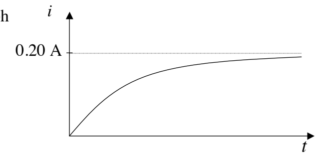
$$I_f = \frac{\mathcal{E}}{R_1 + R_2}$$

$$I_f = \frac{50\ \text{V}}{(100\ \Omega + 150\ \Omega)}$$

$$\boxed{I_f = 0.20\ \text{A}}$$

1991 #2

c.) graph

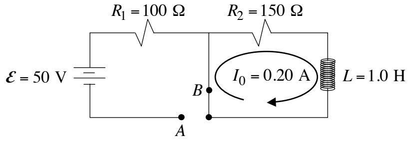


d.) $U_L = ?$

$$U_L = \frac{1}{2}LI^2$$

$$U_L = \frac{1}{2}(1.0\ \text{H})(0.2\ \text{A})^2$$

$$\boxed{U_L = 0.02\ \text{J}}$$



e.) $I_0 = ?$

$$\boxed{I_0 = 0.20\ \text{A}}$$

f.) $V_L = ?$

$$V_L = V_{R_2}$$

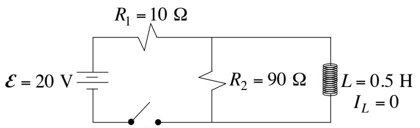
$$V_L = I_0 R_2 = (0.20\ \text{A})(150\ \Omega)$$

$$\boxed{V_L = 30\ \text{V}}$$

g.)

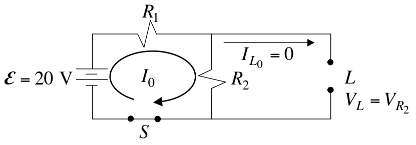
The energy stored in the inductor gets dissapated as heat in the resistor.

1987 # 3



a.) @ $t = 0$, $V_{R_2} = ?$

b.) @ $t = 0$, $\frac{dI_L}{dt} = ?$



$$I_0 = \frac{\mathcal{E}}{R_1 + R_2}$$

$$I_0 = \frac{20\ \text{V}}{10\ \Omega + 90\ \Omega} = 0.20\ \text{A}$$

$$V_{R_2} = I_0 R_2 = (0.20\ \text{A})(90\ \Omega)$$

$$\boxed{V_{R_2} = 18\ \text{V}}$$

$$\mathcal{E} = -L\frac{dI}{dt}$$

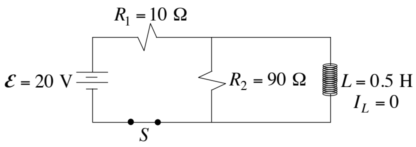
$$\frac{dI}{dt} = \frac{\mathcal{E}}{L}$$

$$\frac{dI_L}{dt} = \frac{V_L}{L} = \frac{V_{R_2}}{L}$$

$$\frac{dI_L}{dt} = \frac{18\ \text{V}}{0.5\ \text{H}}$$

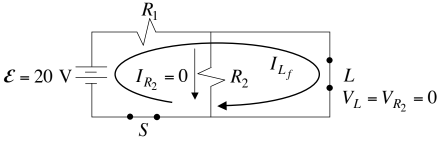
$$\boxed{\frac{dI_L}{dt} = 36\ \frac{\text{A}}{\text{s}}}$$

1987 # 3



c.) @ $t = \infty$, $I_{L_f} = ?$

d.) @ $t = \infty$, $U_L = ?$



$$I_{L_f} = \frac{\mathcal{E}}{R_1}$$

$$I_{L_f} = \frac{20\ \text{V}}{10\ \Omega}$$

$$\boxed{I_{L_f} = 2.0\ \text{A}}$$

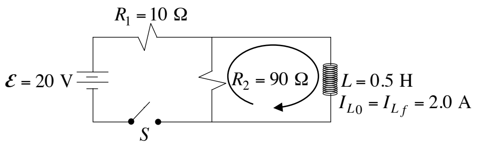
$$U_L = \frac{1}{2}LI^2$$

$$U_L = \frac{1}{2}LI_{L_f}^2$$

$$U_L = \frac{1}{2}(0.5\ \text{H})(2.0\ \text{A})^2$$

$$\boxed{U_L = 1.0\ \text{J}}$$

1987 # 3

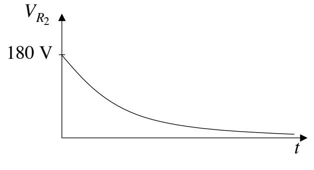


e.) @ $t = t_0$, switch reopened, $V_{R_2} = ?$

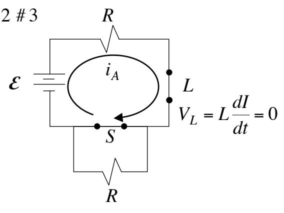
$$V_{R_2} = I_{L_0} R_2 = (2.0\ \text{A})(90\ \Omega)$$

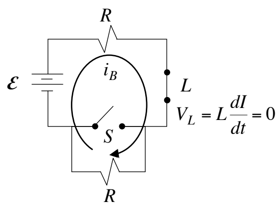
$$\boxed{V_{R_2} = 180\ \text{V}}$$

f.) graph $V_{R_2}$ vs $t$ for $t > t_0$



1982 # 3





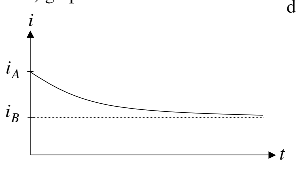
a.) @ $t = \infty$, $i_A = ?$

$$\boxed{i_A = \frac{\mathcal{E}}{R}}$$

b.) @ $t = \infty$, $i_B = ?$

$$\boxed{i_B = \frac{\mathcal{E}}{2R}}$$

c.) graph



d.) Differential Equation

$$\mathcal{E} = V_{2R} + V_L$$

$$\boxed{\mathcal{E} = 2Ri + L\frac{di}{dt}}$$

1982 # 3

e.) $i(t) = ?$

$$\mathcal{E} = 2Ri + L\frac{di}{dt}$$

$$\frac{\mathcal{E}}{2R} = i + \frac{L}{2R}\frac{di}{dt}$$

$$i - \frac{\mathcal{E}}{2R} = -\frac{L}{2R}\frac{di}{dt}$$

$$\int_{i_A}^{i}\frac{di}{i-\frac{\mathcal{E}}{2R}} = \int_0^t -\frac{2R}{L}dt$$

$$\ln\left(i-\frac{\mathcal{E}}{2R}\right)\Bigg|_{i_A}^{i} = -\frac{2R}{L}t\Bigg|_0^t$$

$$\ln\left(i-\frac{\mathcal{E}}{2R}\right) - \ln\left(i_A-\frac{\mathcal{E}}{2R}\right) = -\frac{2R}{L}t$$

$$\ln\left(\frac{i-\frac{\mathcal{E}}{2R}}{i_A-\frac{\mathcal{E}}{2R}}\right) = -\frac{2R}{L}t$$

$$\frac{i-\frac{\mathcal{E}}{2R}}{i_A-\frac{\mathcal{E}}{2R}} = e^{-\frac{2R}{L}t}$$

$$i-\frac{\mathcal{E}}{2R} = \left(i_A-\frac{\mathcal{E}}{2R}\right)e^{-\frac{2R}{L}t}$$

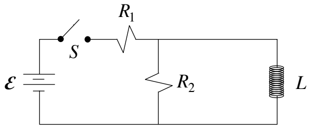
$$i = \frac{\mathcal{E}}{2R} + \left(\frac{\mathcal{E}}{R}-\frac{\mathcal{E}}{2R}\right)e^{-\frac{2R}{L}t}$$

$$i = \frac{\mathcal{E}}{2R} + \frac{\mathcal{E}}{2R}e^{-\frac{2R}{L}t}$$

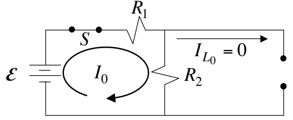
$$\boxed{i = \frac{\mathcal{E}}{2R}\left(1+e^{-\frac{2R}{L}t}\right)}$$

---

2005 # 2



a.) @ $t = 0$, switch closed, $I_{R_1} = ?$



$V_L = V_{R_2}$

$$\boxed{I_0 = \frac{\mathcal{E}}{R_1 + R_2}}$$

b.) @ $t = 0$, switch closed, $\left|\frac{dI_L}{dt}\right| = ?$

$$V_L = -L\frac{dI_L}{dt}$$

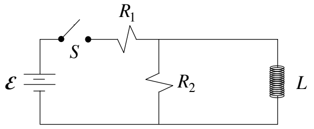
$$\left|\frac{dI_L}{dt}\right| = \frac{V_L}{L}$$

$$V_L = V_{R_2} = I_0R_2 = \frac{\mathcal{E}R_2}{R_1+R_2}$$

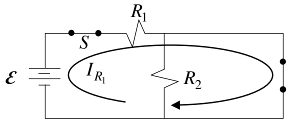
$$\boxed{\left|\frac{dI_L}{dt}\right| = \frac{\mathcal{E}R_2}{L(R_1+R_2)}}$$

---

2005 # 2



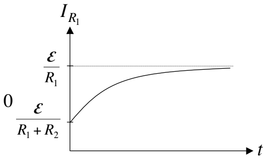
c.) @ $t = \infty$, switch closed, $I_{R_1} = ?$



$V_L = V_{R_2} = 0$

$$\boxed{I_{R_1} = \frac{\mathcal{E}}{R_1}}$$

d.) graph, $I_{R_1}(t) = ?$



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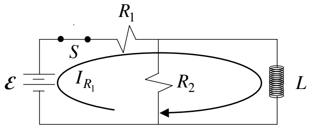
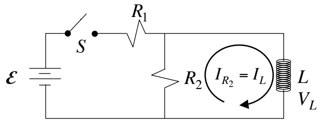
2005 # 2



$$I_{R_1} = \frac{\mathcal{E}}{R_1}$$

e.) @ $t = \infty$, switch opened, $V_{R_2} = ?$



$V_L = V_{R_2}$

$$I_{R_2} = I_L = \frac{\mathcal{E}}{R_1}$$

$$V_L = V_{R_2}$$

$$V_{R_2} = I_{R_2}R_2$$

$$\boxed{V_L = V_{R_2} = \frac{\mathcal{E}R_2}{R_1}}$$

---

1998 # 3

a.) $I = ?$ $(a = 0)$

$\sum F_x = 0$ (down the incline)

$F_{//} - F_B = 0$

$mg\sin\theta - I\ell B = 0$

$$\boxed{I = \frac{mg\sin\theta}{\ell B}}$$

b.) $v = ?$ $(a = 0)$

$$\mathcal{E} = \frac{d\Phi_B}{dt} = \frac{d(BA\cos\phi)}{dt} = B\frac{dA}{dt} = B\frac{\ell dx}{dt} = B\ell\frac{dx}{dt} = B\ell v$$

$\mathcal{E} = IR = B\ell v$ so $I = \frac{B\ell v}{R} = \frac{mg\sin\theta}{\ell B}$

$$\boxed{v = \frac{Rmg\sin\theta}{\ell^2B^2}}$$

c.) $P = ?$ $(a = 0)$

$$P = I^2R = \left(\frac{mg\sin\theta}{\ell B}\right)^2 R$$

$$\boxed{P = \frac{Rm^2g^2\sin^2\theta}{\ell^2B^2}}$$

---

1998 # 3

d.) $v(t) = ?$

$$F_{//} - F_B = ma$$

$$mg\sin\theta - I\ell B = m\frac{dv}{dt}$$

$$g\sin\theta - \frac{B\ell v}{R}\frac{\ell B}{m} = \frac{dv}{dt}$$

$$g\sin\theta - \frac{B^2\ell^2}{mR}v = \frac{dv}{dt}$$

$$-\frac{mgR\sin\theta}{B^2\ell^2} + v = -\frac{mR}{B^2\ell^2}\frac{dv}{dt}$$

$$-\frac{B^2\ell^2}{mR}dt = \frac{dv}{-\frac{mgR\sin\theta}{B^2\ell^2}+v}$$

$$\int_0^v \frac{dv}{-\frac{mgR\sin\theta}{B^2\ell^2}+v} = \int_0^t -\frac{B^2\ell^2}{mR}dt$$

$$\ln\left(-\frac{mgR\sin\theta}{B^2\ell^2}+v\right)\Bigg|_0^v = -\frac{B^2\ell^2}{mR}t\Bigg|_0^t$$

$$\ln\left(-\frac{mgR\sin\theta}{B^2\ell^2}+v\right) - \ln\left(-\frac{mgR\sin\theta}{B^2\ell^2}\right) = -\frac{B^2\ell^2}{mR}t$$

$$\ln\frac{\left(-\frac{mgR\sin\theta}{B^2\ell^2}+v\right)}{\left(-\frac{mgR\sin\theta}{B^2\ell^2}\right)} = -\frac{B^2\ell^2}{mR}t$$

$$\frac{\left(-\frac{mgR\sin\theta}{B^2\ell^2}+v\right)}{\left(-\frac{mgR\sin\theta}{B^2\ell^2}\right)} = \mathrm{e}^{-\frac{B^2\ell^2}{mR}t}$$