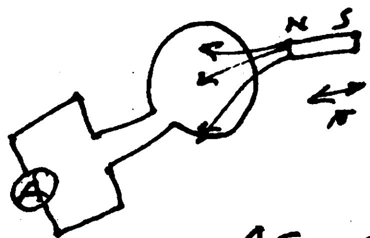
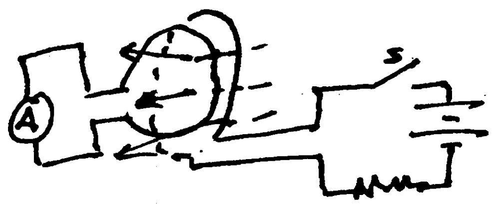




AS $\Phi_{\text{MAGNETIC FLUX}} = BA$ CHANGES THRU THE LOOPS CURRENT FLOWS

FARADAY'S LAW – AN emf is induced in A LOOP WHEN THE # OF MAGNETIC FIELD LINES (FLUX Φ) PASSING THRU THE LOOP CHANGES

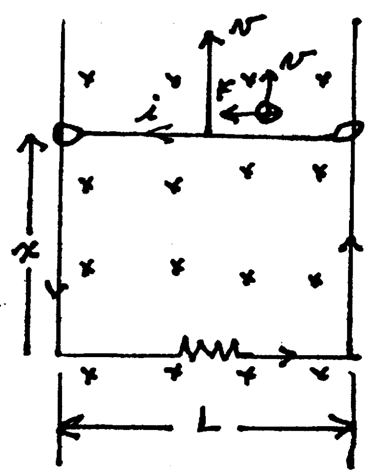
$$\mathcal{E} = -\frac{d\Phi_B}{dt} \quad \text{OR} \quad \mathcal{E} = -N\frac{d\Phi}{dt}$$

FLUX CHANGES IN 3 WAYS

$\Phi = BA\cos\theta$

$d\Phi = B\,dA + A\,dB$

1. CHANGE $|B|$ WITHIN THE COIL
2. CHANGE THE AREA OF THE COIL
3. CHANGE THE ∡ BETWEEN B & THE AREA NORMAL $A_\perp$



$$\Phi = BA = BLx$$

$$\mathcal{E} = \frac{d\Phi}{dt} = \frac{d}{dt}(BA) = BL\frac{dx}{dt} = BLv$$

$$\frac{\vec{F}}{q} = q\,\vec{v}\times\vec{B}$$

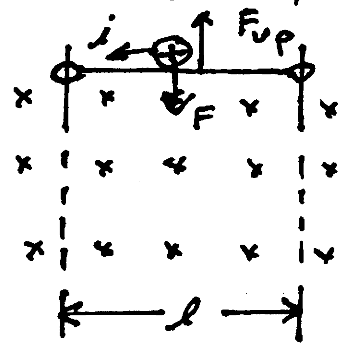
$$\mathcal{E} = i\,R_{loop} = BLv$$

$$i = \frac{BLv}{R}$$

EXAMPLE I $v = 10$ m/s $B = 0.1$ T $L = 3$ cm $R = 0.1\,\Omega$

$$i = \frac{vBL}{R} \quad \frac{10(0.1)(.03)}{0.1} = 0.3 \text{ Amps}$$

NOW THE FLOW OF CURRENT IN THE MOVING WIRE INDUCES A RESTRAINING FORCE ON THAT WIRE



$$F_{up} = F = i\vec{\ell}\times\vec{B} = i\ell B \sin\theta \underset{\theta=90^\circ}{=} i\ell B$$

$$P_{in} = \vec{F}_{up}\cdot\vec{v} = i\ell B v = \frac{(vB\ell)^2}{R}$$

$$i = \frac{vB\ell}{R}$$

POWER CONSUMED IN THE RESISTOR R } $P = i^2 R = \left(\frac{vB\ell}{R}\right)^2 R = \frac{(vB\ell)^2}{R}$

$$P_{\text{dissipated in } R} = P_{in}$$

EXAMPLE II

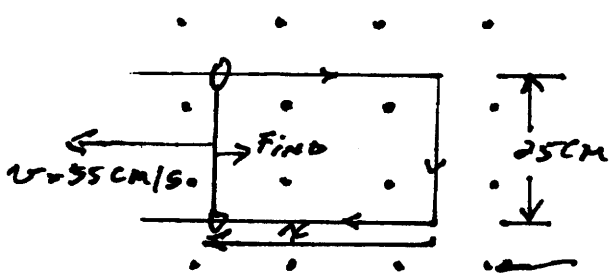
B INCREASES BY 0.1T IN 1 SEC

AREA = $10^{-3}\,m^2$

$$\mathcal{E} = -\frac{d\Phi}{dt} \approx \frac{\Delta(BA)}{\Delta t} = A\frac{\Delta B}{\Delta t} = \frac{1\times10^{-3}(0.1)}{1} = 1\times10^{-4}$$

$$\mathcal{E} = -10^{-4}\ \text{Volts}$$

EXAMPLE III



$$F_{IND} = i\vec{\ell}\times\vec{B}$$

a) find $\mathcal{E}_I = -\frac{d\Phi}{dt} = -B\frac{dA}{dt} = -BL\frac{dx}{dt} = -BLv$
$= -(.35)(.25)(.55) = -48\,mV$

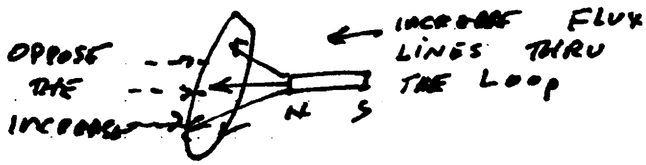
b) WHAT IS i IF THE CIRCUIT RESISTANCE IS 25 Ω $\quad i = \frac{\mathcal{E}}{R} = \frac{48\times10^{-3}}{25} = 1.92\ mA$

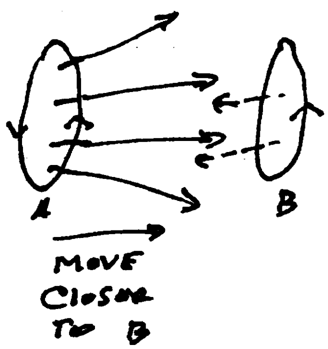
c) WHAT IS THE THERMAL POWER $\quad P = i^2 R = 9.2\times10^{-5}$ Watts

d) POWER TO MOVE THE SLIDER $\quad P = Fv = i\ell Bv = i^2 R = 9.2\times10^{-5}\,W$

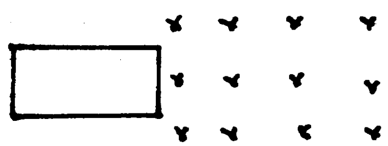
LENZ'S LAW

AN INDUCED CURRENT HAS A DIRECTION SUCH THAT THE MAGNETIC FIELD DUE TO THE CURRENT OPPOSES THE CHANGE IN THE MAGNETIC FIELD THAT INDUCES THE CURRENT

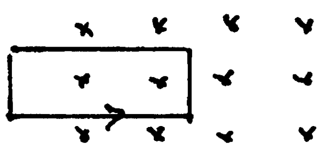




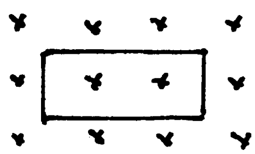
COIL MOVING INTO $\vec{B}$



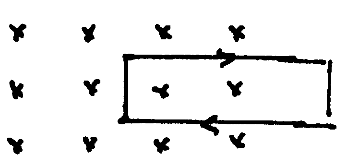
$\frac{\Delta\Phi}{\Delta t} = 0$ $\quad i = 0$



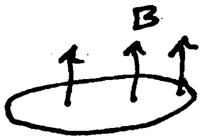
$\frac{\Delta\Phi}{\Delta t} > 0$ $\quad i$



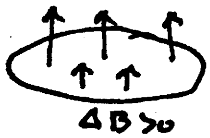
$\frac{\Delta\Phi}{\Delta t} = 0$ $\quad i = 0$



$\frac{\Delta\Phi}{\Delta t} < 0$ $\quad i$



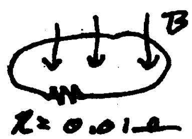
B IS A CONSTANT



$B + \Delta B$ INCREASING THE VALUE OF B

INDUCED B OPPOSES THE ORIGINAL INCREASE LEADING TO A ↻ CURRENT & $\mathcal{E}$

EXAMPLE IV



B GOES FROM 1T → 1.1T IN 2 SEC & RADIUS = 2CM OF THE LOOP

B INCREASES SO THE INDUCED B OPPOSES THE INCREASE

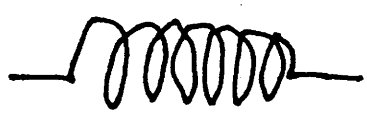
$$\frac{dB}{dt} = \frac{0.1}{2} = 0.05\,T/s \qquad \text{AREA} = \pi(.02)^2 = 1.25\times10^{-3}\,m^2$$

$$\frac{d\phi}{dt} = \frac{d}{dt}(AB) = A\frac{dB}{dt} = 1.25\times10^{-3}(.05) = 6.25\times10^{-5}$$

$$\mathcal{E} = -6.25\times10^{-5}\text{ Volts} \quad i = \frac{\mathcal{E}}{R} = \frac{6.25\times10^{-5}}{.01} = 6.25\,mA$$

EXAMPLE V

SOLENOID



$B = \mu_0 i n$

i - CURRENT
n - # OF TURNS/m
$\mu_0 = 1.26\times10^{-6}$ H/m
1H = 1T-m/A

THE SOLENOID HAS 1000 TURNS & B WITHIN IT GOES FROM 1T → −1T IN 1/120 SEC
THE COIL AREA = 3CM²

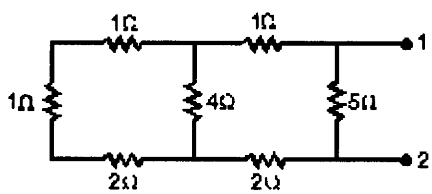
FIND THE INDUCED VOLTAGE

$$\frac{d\phi}{dt} = A\frac{dB}{dt} \simeq A\frac{\Delta B}{\Delta t} = 3CM^2\left(\frac{m}{100\,cm}\right)^2\left(\frac{-1-(+1)}{1/120}\right) = -0.072\,V$$

$$\mathcal{E} = -N\frac{d\phi}{dt} \qquad \mathcal{E} = -(1000)(-.072) = 72\text{ VOLTS}$$

PHYS 121 SAMPLE QUIZ 3

1. The equivalent resistance between points A and B of the circuit shown is:



A) 4 Ω
B) 4.5 Ω
C) 6 Ω
D) 3 Ω
E) 2.5 Ω

2. A battery with an emf of 12 V and an internal resistance of 1 Ω is used to charge a battery with an emf of 10 V and an internal resistance of 1 Ω. The current in the circuit is:
A) 1 A
B) 2 A
C) 4 A
D) 11 A
E) 22 A

3. In an antique automobile, a 6-V battery supplies a total of 48 W to two identical headlights in parallel. The resistance (in ohms) of each bulb is:
A) 0.67
B) 1.5
C) 3
D) 4
E) 8

4. Resistor 1 has twice the resistance of resistor 2. They are connected in parallel to a battery. The ratio of the thermal energy dissipation by 1 to that by 2 is:
   A) 1:4
   B) 1:2
   C) 1:1
   D) 2:1
   E) 4:1

5. A charged capacitor is being discharged through a resistor. At the end of one time constant the charge has been reduced by $(1 - 1/e) = 63\%$ of its initial value. At the end of two time constants the charge has been reduced by what percent of its initial value?
   A) 82%
   B) 86%
   C) 100%
   D) between 90% and 100%
   E) need to know more data to answer the question

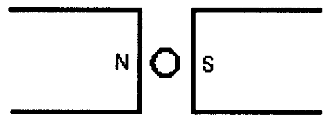
6. A certain capacitor, in series with a 720-Ω resistor, is being charged. At the end of 10 ms its charge is half the final value. The capacitance is about:
   A) 9.6 μF
   B) 14 μF
   C) 20 μF
   D) 7.2 F
   E) 10 F

7. An electron is moving north in a region where the magnetic field is south. The magnetic force exerted on the electron is:
   A) zero
   B) up
   C) down
   D) east
   E) west

8. An electron enters a region of uniform perpendicular $\vec{E}$ and $\vec{B}$ fields. It is observed that the velocity $\vec{v}$ of the electron is unaffected. A possible explanation is:
   A) $\vec{v}$ is parallel to $\vec{E}$ and has magnitude E/B
   B) $\vec{v}$ is parallel to $\vec{B}$
   C) $\vec{v}$ is perpendicular to both $\vec{E}$ and $\vec{B}$ and has magnitude B/E
   D) $\vec{v}$ is perpendicular to both $\vec{E}$ and $\vec{B}$ and has magnitude E/B
   E) the given situation is impossible

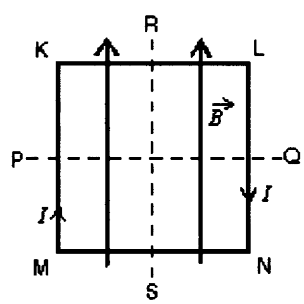
9. A proton is in a region where a uniform electric field of 5×10^4 V/m is perpendicular to a uniform magnetic field of 0.08 T. If its acceleration is zero then its speed must be:
   A) 0
   B) 1.6×10^4 m/s
   C) 4.0×10^5 m/s
   D) 6.3×10^5 m/s
   E) any value but 0

10. The diagram shows a straight wire carrying a flow of electrons into the page. The wire is between the poles of a permanent magnet. The direction of the magnetic force exerted on the wire is:



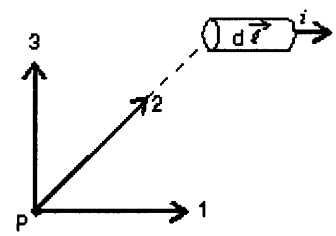
A) ↑
B) ↓
C) ←
D) →
E) into the page

11. A square loop of wire lies in the plane of the page and carries a current I as shown. There is a uniform magnetic field $\vec{B}$ parallel to the side MK as indicated. The loop will tend to rotate:



A) about PQ with KL coming out of the page
B) about PQ with KL going into the page
C) about RS with MK coming out of the page
D) about RS with MK going into the page
E) about an axis perpendicular to the page

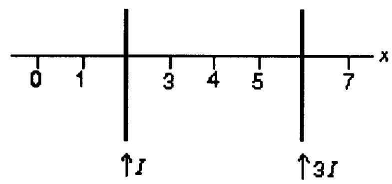
12. In the figure, the current element $i d\vec{\ell}$, the point P, and the three vectors (1, 2, 3) are all in the plane of the page. The direction of $d\vec{B}$, due to this current element, at the point P is:



A) in the direction marked "1"
B) in the direction marked "2"
C) in the direction marked "3"
D) out of the page
E) into the page

13. Two long parallel straight wires carry equal currents in opposite directions. At a point midway between the wires, the magnetic field they produce is:
A) zero
B) non-zero and along a line connecting the wires
C) non-zero and parallel to the wires
D) non-zero and perpendicular to the plane of the two wires
E) none of the above

14. Two long straight current-carrying parallel wires cross the x axis and carry currents I and $3I$ in the same direction, as shown. At what value of x is the net magnetic field zero?



A) 0
B) 1
C) 3
D) 5
E) 7

15. The magnetic field B inside a long ideal solenoid is independent of:
A) the current
B) the core material
C) the spacing of the windings
D) the cross-sectional area
E) the direction of the current

16. A solenoid is 3.0 cm long and has a radius of 0.50 cm. It is wrapped with 500 turns of wire carrying a current of 2.0 A. The magnetic field in tesla at the center of the solenoid is:
A) 9.9×10^{-8}
B) 1.3×10^{-3}
C) 4.2×10^{-2}
D) 16
E) none of these

Answer Key -- PHYS 121 -SAMPLE QUIZ 3

1. E
2. A
3. B
4. B
5. B
6. C
7. A
8. D
9. D
10. A
11. A
12. E
13. D
14. C
15. D
16. C