KEY.

Physics 12 Electromagnetic Induction Worksheet #2

Name: ____________________

$4\pi \times 10^{-7} = 12{,}566 \times 10^{-7}$

Field Strength for a solenoid $$B = \mu_0 \frac{NI}{L}$$

Emf for a wire $$\mathcal{E} = B \cdot v \cdot l$$

Faraday's Law $$\mathcal{E} = -N \frac{\Delta \phi}{\Delta t}$$

Back EMF $$V_s = IR + V_{BACK}$$

Transformers $$\frac{V_s}{V_p} = \frac{N_s}{n_p} = \frac{I_p}{I_s}$$

Field Strength of a Solenoid

not needed.

A solenoid has a length of 0.30 m, a diameter of 0.040 m and 500 windings. The magnetic field at its centre is 0.045 T. What is the current in the windings?

A. 2.9 A
B. 3.0 A
[✓ C. 21 A]
D. 170 A

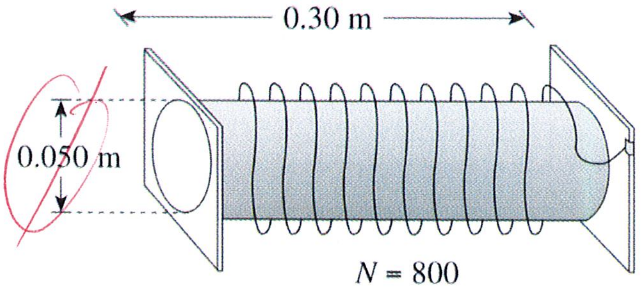
$$B = \mu_0 \frac{NI}{L}$$

$$.045 = \frac{(12.566\times10^{-7})(500)\,I}{.3}$$

$$I = 21.48 = 21A$$

Field Strength of a Solenoid

Consider the 800-turn solenoid shown in the diagram below.



What is the current in the windings that would produce a magnetic field of 0.060 T at the centre of this solenoid?

A. 3.0 A
B. 8.0 A
[✓ C. 18 A]
D. 290 A

$$B = \mu \frac{NI}{L}$$

$$0.06 = \frac{(12.566\times10^{-7})(800)\,I}{.3}$$

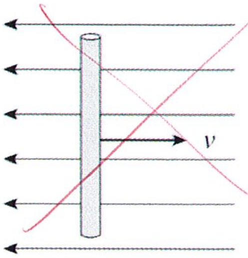
$$I = 17.9 A$$

Emf for a Wire

- **Emf = BvL, voltage generated by moving a wire through B fld.**
- **vel must cut across B field**
- **v must be perpendicular to L**

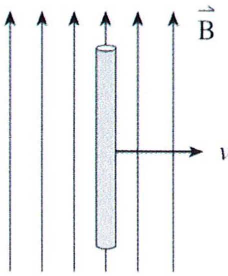
A conductor is moved to the right through four magnetic fields as shown below. In which case will the largest emf be generated?

A.



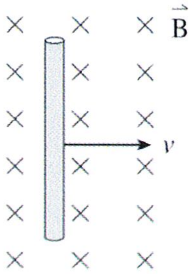
V is not ⊥ to B

B.

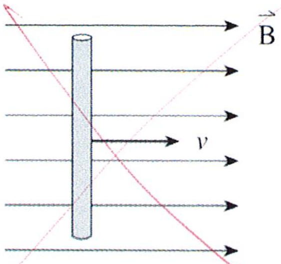


l, is not ⊥ to B

C.



D.



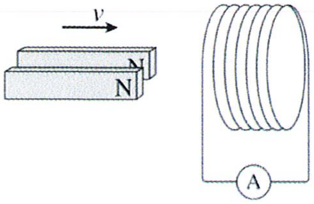
V is not ⊥ to B

Faraday's Law

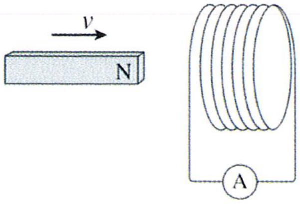
- $\mathcal{E} = -N\,\Delta\Phi/\Delta t$
- **voltage induced = number of turns x change in flux/time**

Which of the following situations induces the greatest current flow in the coil? (All magnets and coils are identical.)

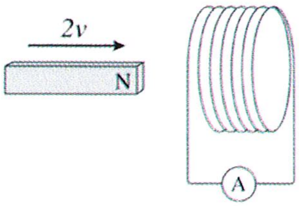
A.



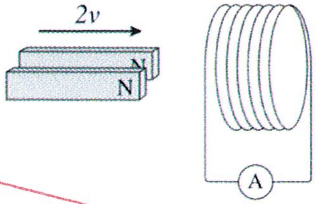
B.



C.



D.



a) and d) have greater ΔB

BA — area is const

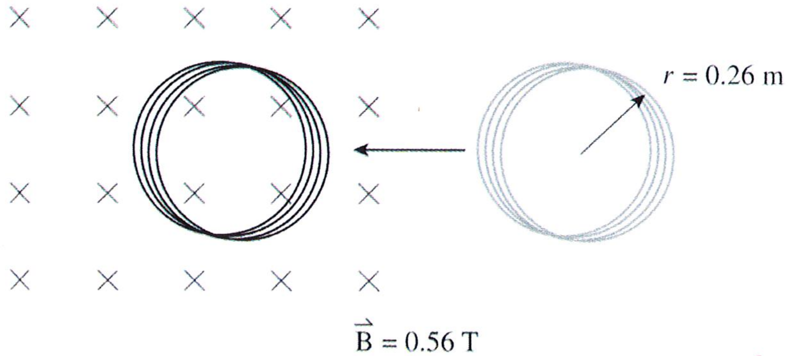
$-N\frac{\Delta\phi}{\Delta t}$

c) and d) have a higher vel, which means a quicker change.

Faraday's Law

- $\mathcal{E} = -N\,\Delta\Phi/\Delta t$
- **voltage induced = number of turns x change in flux/time**

A 520-turn circular coil of radius 0.26 m is initially outside a 0.56 T magnetic field. The coil is moved into the magnetic field, inducing an average emf of 47 V.



How much time does it take to move the coil to its new position?

A. 2.5×10^{-3} s
[✓ B. 1.3 s]
C. 1.6 s
D. 2.6 s

$.56T$ Area $= \pi r^2 = \pi(.26)^2 = .212$

zero

$$\mathcal{E} = -N\,\frac{(B_f A_f - B_i A)}{\Delta t}.$$

$$47 = \frac{-(520)(.56)(.21237)}{\Delta t}$$

$$\Delta t = \frac{(520)(.56)(.21237)}{47.} = 1.3$$

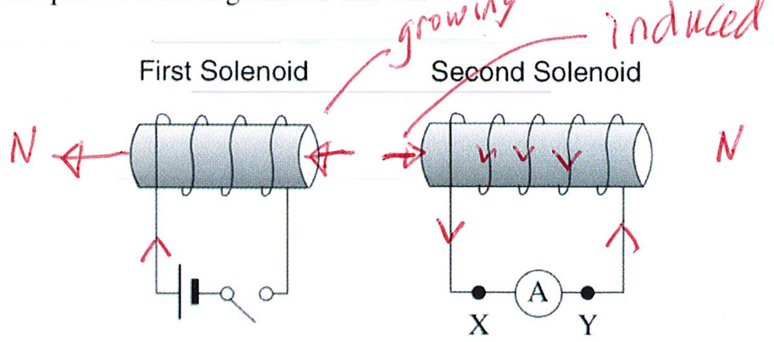
Lenz's Law

"The induced current will generate a B field that opposes the change in flux"

"The induced magnetic field will fight the change in B field"

"The induced magnetic field will oppose the motion of the moving magnet"

Two solenoids are placed close together as shown.



As the switch is closed, what is the direction of the current through the ammeter, and what is the direction of the induced magnetic field inside the second solenoid?

	DIRECTION OF CURRENT THROUGH AMMETER	DIRECTION OF INDUCED MAGNETIC FIELD INSIDE THE SECOND SOLENOID
A.	[✓ From X to Y]	Left
[✓ B.]	[✓ From X to Y]	[✓ Right]
C.	From Y to X	Left
D.	From Y to X	[✓ Right]

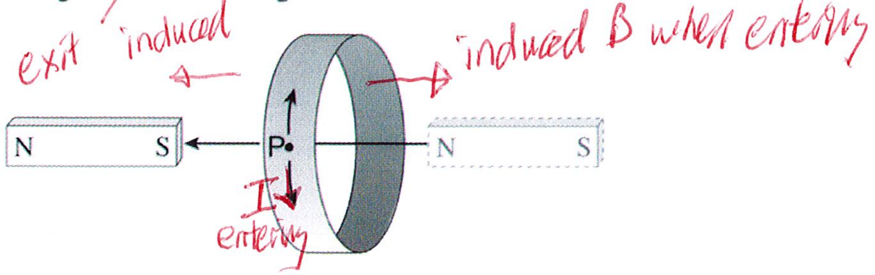
Lenz's Law

"The induced current will generate a B field that opposes the change in flux"

"The induced magnetic field will fight the change in B field"

"The induced magnetic field will oppose the motion of the moving magnet"

A magnet is passed through an aluminum ring as shown.



What is the direction of the induced current at point P on the ring as the north pole approaches the ring on the right side, and as the south pole leaves the ring on the left side?

	DIRECTION OF INDUCED CURRENT FOR NORTH POLE APPROACHING RING	DIRECTION OF INDUCED CURRENT FOR SOUTH POLE LEAVING RING
A.	Up	[✓ Up]
[✓ B.]	[✓ Down]	[✓ Up]
C.	Up	Down
D.	[✓ Down]	Down

entering → Field is increasing to left
so induced field will be to right

exiting - field is decreasing to left
so induced field is increasing
to left.

Back EMF

- **Electric motors that are spinning act like generators**
- **The EMF that they produce (as per Lenz's Law) acts like a voltage drop**
- **$V_{source} = IR + E_{back}$, this is just Total Gains = Total Drops**

Which of the following is correct for the back emf of an electric motor operating at a constant speed?

A. The back emf is zero.
B. The back emf is increasing.
C. The back emf is decreasing.
[✓ D.] The back emf remains constant.

The coil of a motor has a resistance of 4.1 Ω. The motor is plugged into a 120 V outlet, and the coil develops a back emf of 118 V when rotating at normal speeds. Find the current when the motor first starts up and the current when it is operating at normal speeds.

	CURRENT AT START UP	CURRENT AT NORMAL SPEEDS
A.	0.49 A	0.49 A
B.	0.49 A	29 A
[✓ C.]	29 A	0.49 A
D.	29 A	29 A

* You really do not even need to do the calc. We know @ start up current is high + @ speed it is low.

$V_s = IR + V_{BACK}$.

START UP $V_{BACK} = 0$

$I = \frac{V_s}{R} = \frac{120}{4.1} = 29A$.

$V_S = IR + V_{BACK}$

$120 = I(4.1) + 118$

$2 = I(4.1)$

$I = \frac{2}{4.1} = 0.49$

Transformers

- **Used to change AC voltage up and down**

In a step-down transformer, which of the following is greater in the secondary than in the primary?

A. power - const
[✓ B. current]
C. voltage - less
D. number of turns - less

step down voltage.

- if V↓, I↑ so that power is constant (P=VI)

- # of turns is ∝ voltage, more turns = more voltage, less turns = less voltage

An ideal 2.25 W transformer changes 120 V to 4.5 V for use in portable electronic devices. What is the current in the secondary windings and the ratio of primary coils to secondary coils in this transformer?

	Secondary Current	Ratio of **Primary** to **Secondary** Coils
[✓ A.]	0.50 A	27 to 1
B.	0.50 A	1 to 27
C.	2.0 A	27 to 1
D.	2.0 A	1 to 27

primary or IA
P=VI
2.25=(120)(I)
$I_p = 0.01875$ A.

This is a step down transformer, less coils on secondary side

100% efficient → $\frac{V_s}{V_p} = \frac{I_p}{I_s}$

$\frac{V_s}{V_p} = \frac{n_s}{n_p}$ or $\frac{V_p}{V_s} = \frac{n_p}{n_s}$.

~~4.5~~

$\frac{4.5}{120} = \frac{0.01875}{I_s}$

$I_s = 0.5$ A.

Transformers

- **Used to change AC voltage up and down**
- **Vp/Vs=Np/Ns=Is/Ip**

step down.

A transformer is made up of 200 turns in the primary windings and of 50 turns in the secondary windings. The primary voltage is 120 V and the secondary current is 0.12 A. What is the primary current and secondary voltage for this transformer?

	PRIMARY CURRENT	SECONDARY VOLTAGE
[✓ A.]	0.030 A	30 V
B.	0.030 A	480 V
C.	0.48 A	30 V
D.	0.48 A	480 V

4x less turns in secondary meant
4x less voltage. $\frac{120V}{4} = 30V$

4x more turns in primary meant
4x less current in primary.
$\frac{0.12A}{4} = 0.03A$ in primary