Physics 12   Name:
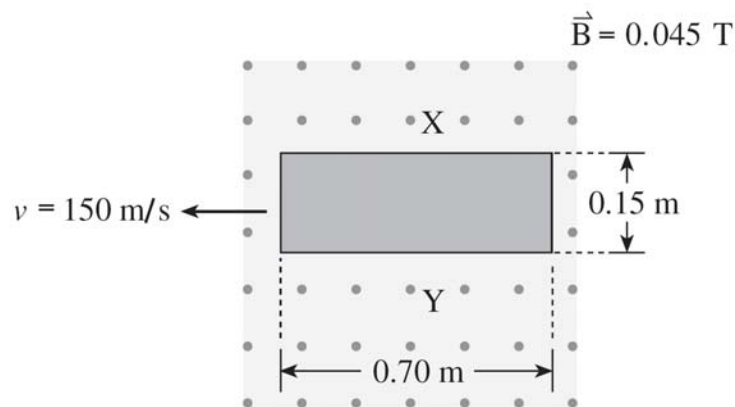
The Ultimate Electromagnetic Induction Assignment (9%)

Key Formulae:

$$\Phi = BA \qquad \varepsilon = -N\frac{\Delta\Phi}{\Delta t} \qquad V_{back} = \varepsilon - Ir \qquad \frac{V_s}{V_p} = \frac{N_s}{N_p} = \frac{I_p}{I_s}$$

0108

1.

A solid conductor travels at 150 m/s across a uniform 0.045 T magnetic field. Which side is positively charged and what is the emf across this block?

$\vec{B} = 0.045$ T

$v = 150$ m/s

0.15 m

0.70 m

Use RH Rule!

$\varepsilon = B\ell v$

$= (.045)(.15)(150)$

	POSITIVE SIDE	EMF
A.	X ✓	1.0 V ✓
B.	X ✓	4.7 V ✗
C.	Y ✗	1.0 V ✓
D.	Y ✗	4.7 V ➚

2.

A motor operating at full speed draws a current of 4.0 A when connected to a 110 V source. The motor has an armature resistance of 3.5 Ω. What is the back emf at full speed?
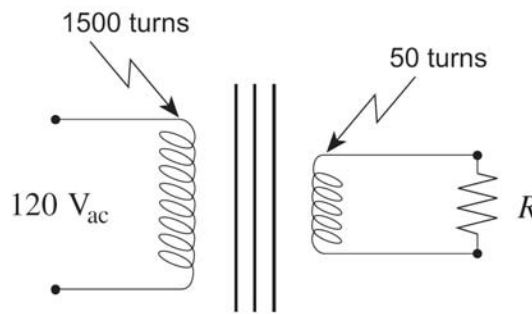
A. 14 V
B. 96 V
C. 110 V
D. 124 V

$V_{back} = \varepsilon - Ir = 110 - 4(3.5)$

$= 96 \checkmark$

3.

An ideal transformer with 120 V_{ac} on the primary coil supplies power to the resistor R. If this resistor dissipates 35 W, what is the current in the primary coil and in the secondary coil?
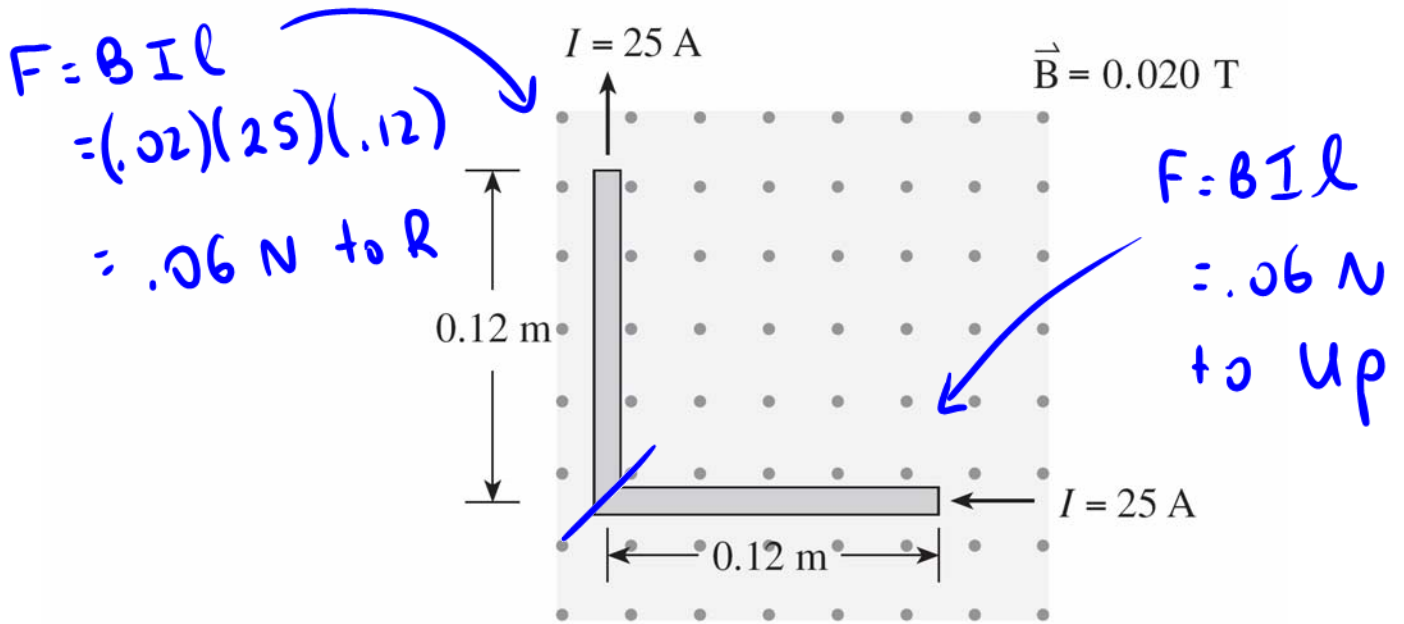
$P = VI$

$I = \dfrac{P}{V} = \dfrac{35}{120}$

1500 turns

50 turns

120 V_{ac}

R

$\dfrac{N_p}{N_s} = \dfrac{I_s}{I_p}$

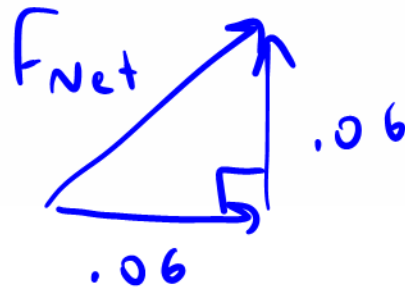|	CURRENT IN PRIMARY	CURRENT IN SECONDARY
A.	0.29 A ✔	0.29 A ✘
B.	0.29 A ✔	8.8 A ✔
C.	8.8 A ✘	0.29 A ✘
D.	8.8 A ✘	8.8 A ✔

$\dfrac{1500}{50} = \dfrac{I_s}{.29}$

$I_s = 8.8 \text{ A}$

4.

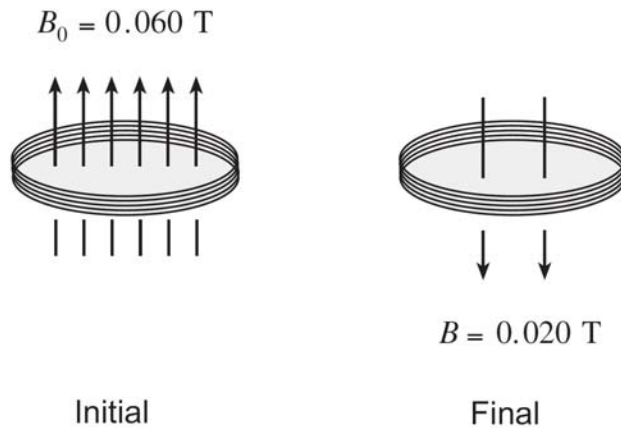What is the magnitude of the magnetic force on the L-shaped conductor?

$F = BI\ell$
$= (.02)(25)(.12)$
$= .06$ N to R

$I = 25$ A

$\vec{B} = 0.020$ T

$F = BI\ell$
$= .06$ N
to up

0.12 m

0.12 m

$I = 25$ A

A. 0 N
B. 6.0×10^{-2} N
C. 8.5×10^{-2} N
D. 1.2×10^{-1} N

F_{Net}

.06

.06

5.

A 500-turn circular coil with an area of 1.54×10^{-2} m^2 is perpendicular to a 0.060 T field. The magnetic field changes to 0.020 T in the opposite direction in 0.12 s.

$B_0 = 0.060$ T

$B = 0.020$ T

Initial   Final

What is the average emf induced in the coil?

A. 5.1×10^{-3} V
B. 1.0×10^{-2} V
C. 2.6 V
D. 5.1 V

$$\Delta \phi = BA_f - BA_i$$

$$= (.02)(1.54 \times 10^{-2}) - (-.06)(1.54 \times 10^{-2})$$

$$= .001232 \ wB$$

$$\varepsilon = -\frac{N \Delta \phi}{\Delta t} = -\frac{(500)(.001232)}{.12} = 5.1 \ v$$

6.

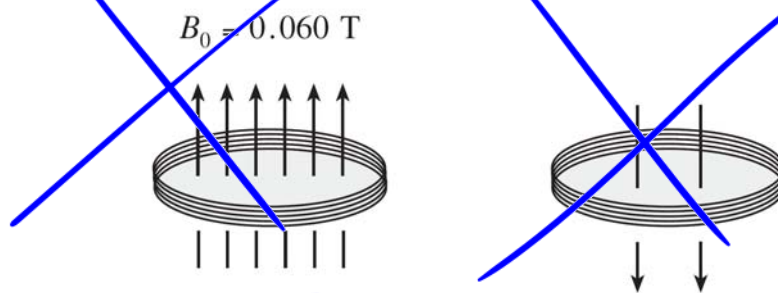A metal block moves with a constant speed in a uniform magnetic field.
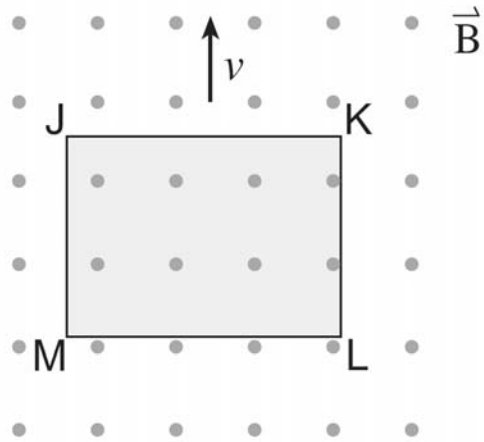
Which side of the block is positive?

A. JK
B. KL
C. LM
D. MJ

R H R.

7.

500-turn circular coil with an area of 1.54×10^{-2} m^2 is perpendicular to a 0.060 T field. The magnetic field changes to 0.020 T in the opposite direction in 0.12 s.

$B_0 = 0.060$ T

Omit

8.

A 0.75 m conducting rod is moved at 8.0 m/s across a 0.25 T magnetic field along metal rails.
The electrical resistance of the system is 5.0 Ω.

$\vec{B} = 0.25$ T   Use RHR

0.40 m   8.0 m/s   0.75 m   5.0 Ω

X

$\varepsilon = Blv$

$= (.25)(.4)(8) = .8v$
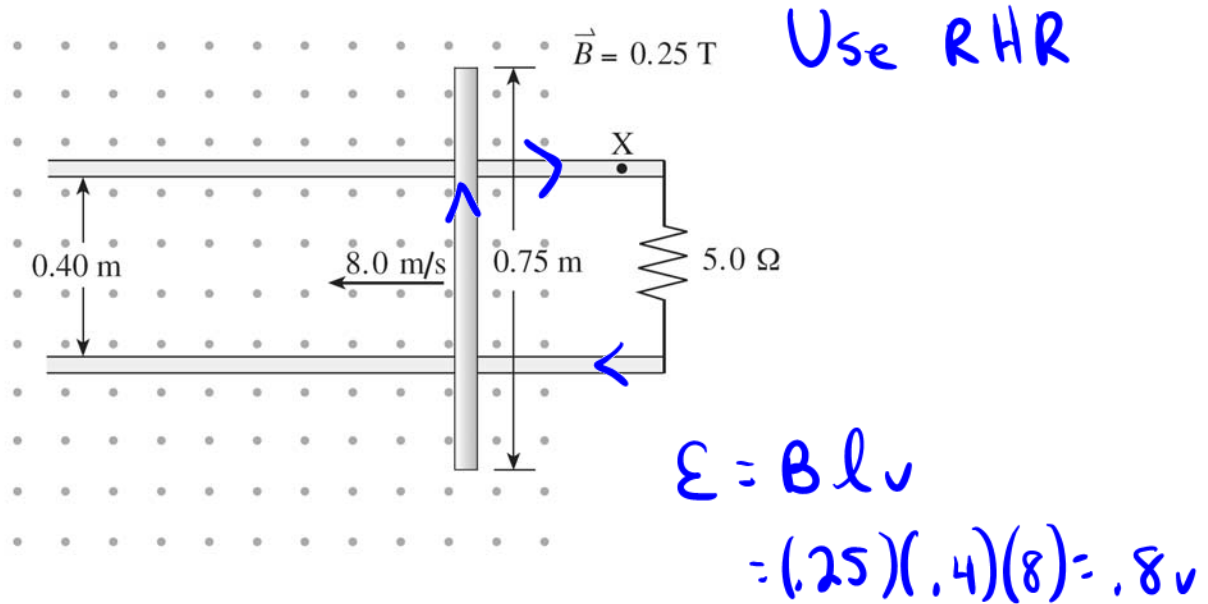
What are the magnitude and direction of the current through point X?

	MAGNITUDE OF CURRENT	DIRECTION OF CURRENT THROUGH X
A.	0.16 A ✓	Left ✗
B.	0.16 A ✓	Right ✓
C.	0.30 A ✗	Left ✗
D.	0.30 A ✗	Right ✓

$I = \dfrac{V}{R}$

$= \dfrac{.8}{5}$

9.

A bar magnet is moving toward a solenoid.
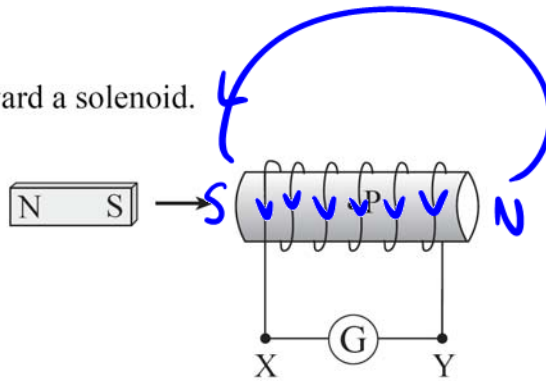
Use Lenz's Law

What is the direction of the current through the galvanometer and what is the direction of the magnetic field produced by this current at location P inside the solenoid?

	DIRECTION OF THE CURRENT THROUGH THE GALVANOMETER	DIRECTION OF THE MAGNETIC FIELD AT P
A.	From X to Y ✔	Right ✔
B.	From X to Y ✔	Left ✗
C.	From Y to X ✗	Right ✔
D.	From Y to X ✗	Left ✗

10.

A dc motor has a resistance of 2.0 Ω. When connected to a 12 V source, with the motor rotating at its operational speed, a back emf of 5.5 V is generated. What is the current in the motor at operational speed?

A. 2.8 A
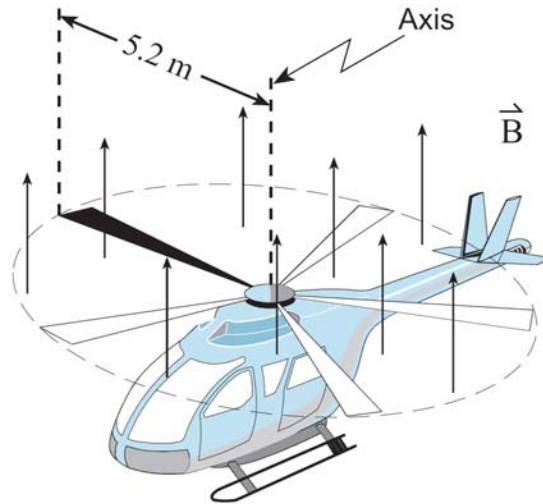B. 3.3 A
C. 6.0 A
D. 8.8 A

$$V_{back} = \varepsilon - Ir$$

$$5.5 = 12 - I(2)$$

$$-6.5 = -2I \qquad I = 3.25 \; A$$

11.

The 5.2 m long metal rotor blades of a helicopter spin at 6.0 revolutions per second perpendicular to the earth's magnetic field of 4.7×10^{-5} T.

$f = 6 \text{ revs}/s$

$t = \frac{1}{6}$ of a sec.

Axis

5.2 m

$\vec{B}$

$\phi = BA$

$= (4.7 \times 10^{-5}) \pi (5.2)^2$

$= 4.0 \times 10^{-3} \text{ Wb}$

$\varepsilon = -N \frac{\Delta\phi}{\Delta t} = -\frac{4.0 \times 10^{-3}}{\frac{1}{6}}$

$= 2.4 \times 10^{-2} \text{ v}$

What is the magnetic flux swept out by the rotor blades in one revolution and what is the emf induced between the axis and tip of a rotor blade?

	MAGNETIC FLUX	EMF INDUCED
A.	4.0×10^{-3} Wb ✔	2.4×10^{-2} V ✔
B.	4.0×10^{-3} Wb ✔	4.0×10^{-3} V ✗
C.	2.4×10^{-2} Wb ✗	2.4×10^{-2} V ✔
D.	2.4×10^{-2} Wb ✗	4.0×10^{-3} V ✗

12.

A coil having 150 turns and a cross-sectional area of 0.042 m^2 is oriented with its plane perpendicular to a 0.12 T magnetic field. If the field increases to 0.66 T in 0.25 s, what emf is induced in the coil?

A. 9.8 V
B. 14 V
C. 20 V
D. 320 V

$\Delta\phi = A\Delta B$

$= .042(.66 - .12)$

$= .02268 \text{ wb}$

$\mathcal{E} = \dfrac{-150(.02268)}{.25}$

$= 13.6 \text{ v}$

13.

An electric motor rotates at various speeds and the current through the armature changes accordingly. Which pair of conditions occurs when the motor generates the greatest back emf?

	SPEED	CURRENT THROUGH THE ARMATURE
A.	Fastest ✔	Largest ✘
B.	Fastest ✔	Smallest ✔
C.	Slowest ✘	Largest ✘
D.	Slowest ✘	Smallest ✔

$V_{AB} = \mathcal{E} - Ir$

14.

A transformer connected to a 120 V ac supply has 7 000 primary and 350 secondary windings. It delivers a secondary current of 2.4 A. Find the primary current and secondary voltage.

	PRIMARY CURRENT	SECONDARY VOLTAGE
A.	0.12 A ✔	6.0 V ✔
B.	0.12 A ✔	2 400 V ✘
C.	48 A ✘	6.0 V ✔
D.	48 A ✘	2 400 V ✘

$\dfrac{V_s}{V_p} = \dfrac{N_s}{N_p}$

$\dfrac{V_s}{120} = \dfrac{350}{7000}$

$\dfrac{N_s}{N_p} = \dfrac{I_p}{I_s} \rightarrow \dfrac{350}{7000} = \dfrac{I_p}{2.4}$

15.

The magnetic field at the centre of a solenoid of length 0.25 m is 1.2×10^{-2} T. The current in the windings is 7.5 A.

a) How many windings does the solenoid have? **(4 marks)**

b) If the cross-sectional area of the solenoid is 8.5×10^{-4} m^2, what is the flux through it? **(3 marks)**

a) $B = \mu_0 \dfrac{N}{\ell} I \Rightarrow N = \dfrac{\ell B}{\mu_0 I}$

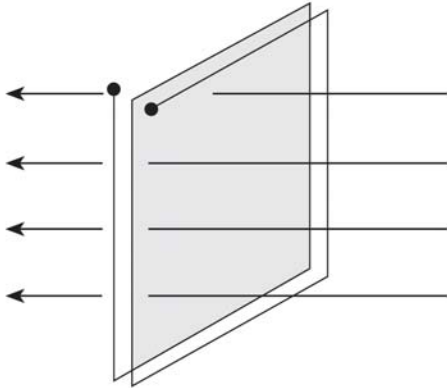$N = \dfrac{(.25)(1.2 \times 10^{-2})}{(4\pi \times 10^{-7})(7.5)} = 318$ windings

b) $\phi = BA = (1.2 \times 10^{-2})(8.5 \times 10^{-4})$
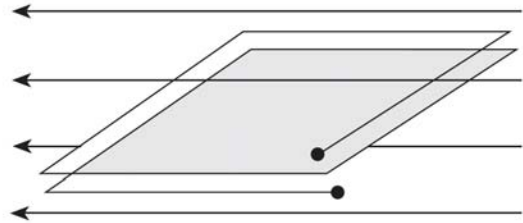
$= 1.02 \times 10^{-5}$ wb

16.

The diagram below shows two coils in a magnetic field.

Coils perpendicular to magnetic field   Coils parallel to magnetic field

An electric current can be induced in the coil oriented with its plane

A.   parallel to a constant magnetic field.
B.   parallel to a changing magnetic field.
C.   perpendicular to a constant magnetic field.
(D.) perpendicular to a changing magnetic field.

17.

An electric motor is connected to a 12.0 V power supply. When the armature is prevented from rotating, the current is 8.0 A. When the motor is running at normal speed, the current is 2.0 A. What is the back emf in each case?   Need r!
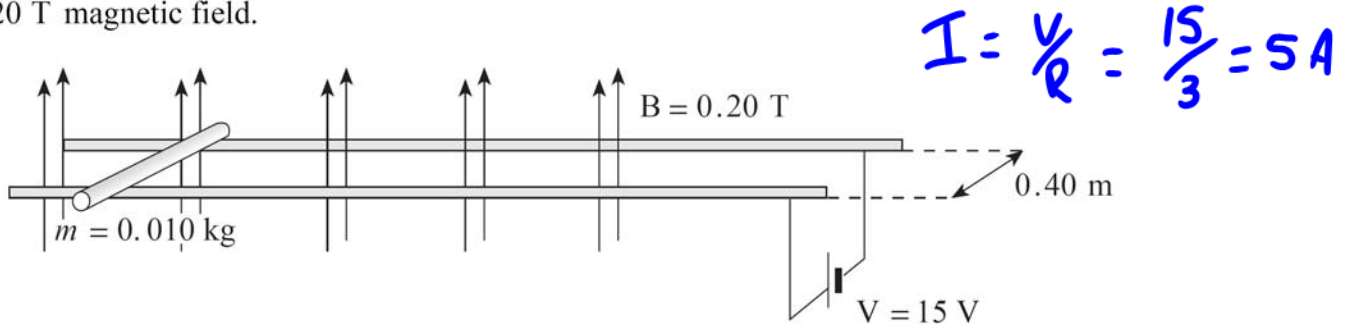
	BACK EMF WHEN STATIONARY	BACK EMF WHEN RUNNING
A.	0 V ✓	9.0 V ✓
B.	0 V ✓	3.0 V ✗
C.	12 V ✗	9.0 V ✓
D.	12 V ✗	3.0 V ✗

$$0 = 12 - 8r \quad \rightarrow \quad r = \frac{12}{8} = 1.5 \ \Omega$$

$$V_{back} = \mathcal{E} - I_r \rightarrow V_{back} = 12 - 2(1.5) = 9.0 \ \checkmark$$

18.

The diagram shows a 0.010 kg metal rod resting on two long horizontal frictionless rails which remain 0.40 m apart. The circuit has a resistance of 3.0 Ω and is located in a uniform 0.20 T magnetic field.

$$I = \frac{V}{R} = \frac{15}{3} = 5A$$

B = 0.20 T

0.40 m

m = 0.010 kg

V = 15 V

Find the initial acceleration and maximum velocity for the rod.

	INITIAL ACCELERATION	MAXIMUM VELOCITY
A.	40 m/s² ✓	190 m/s ✓
B.	40 m/s² ✓	300 m/s ✗
C.	120 m/s² ✗	190 m/s ✓
D.	120 m/s² ✗	300 m/s ✗

$$F = BI\ell$$
$$ma = BI\ell$$
$$a = \frac{BI\ell}{m}$$
$$a = \frac{(.20)(5)(.4)}{.01}$$
$$a = 40 \ m/s^2$$

at maximum velocity, $V_{back} = \mathcal{E}$

$$\mathcal{E} = B\ell v$$

$$v = \frac{\mathcal{E}}{B\ell} = \frac{15}{(.2)(.4)} = 188 \ m/s$$

19.

A transformer has 840 primary and 56 secondary windings. The primary coil is connected to a
110 V ac power supply which delivers a 0.30 A current to the transformer.

a) Find the secondary voltage. **(4 marks)**

b) Find the secondary current. **(3 marks)**

a) $\dfrac{V_s}{V_p} = \dfrac{N_s}{N_p} \rightarrow \dfrac{V_s}{110} = \dfrac{56}{840} \rightarrow V_s = 7.3 \text{ v}$

b) $\dfrac{N_s}{N_p} = \dfrac{I_p}{I_s} \rightarrow \dfrac{56}{840} = \dfrac{.3}{I_s} \rightarrow I_s = 4.5 \text{ A}$

20.

An aircraft with a wingspan of 24 m flies at 85 m/s perpendicular to a magnetic field. An emf of 0.19 V is induced across the wings of the aircraft. What is the magnitude of the magnetic field?

A. 9.3×10^{-5} T
B. 5.4×10^{-2} T
C. 6.7×10^{-1} T
D. 3.9×10^{2} T

$\mathcal{E} = B \ell v$

$B = \dfrac{\mathcal{E}}{\ell v} = \dfrac{.19}{(24)(85)} = 9.3 \times 10^{-5} \ T$

21.

As a carpenter drills into a beam, friction on the drill bit causes the armature of the drill to slow down. How will the back emf and the current through the armature change as the drill slows down?

|	BACK EMF	CURRENT
A.	Increase ✗	Increase ✓
B.	Increase ✗	Decrease ✗
C.	Decrease ✓	Increase ✓
D.	Decrease ✓	Decrease ✗

22.

The diagram shows a bar magnet falling through an aluminum pipe. Electric currents are induced in the pipe immediately above and below the falling magnet. In which direction do these currents flow?

Falling bar magnet

Aluminum pipe
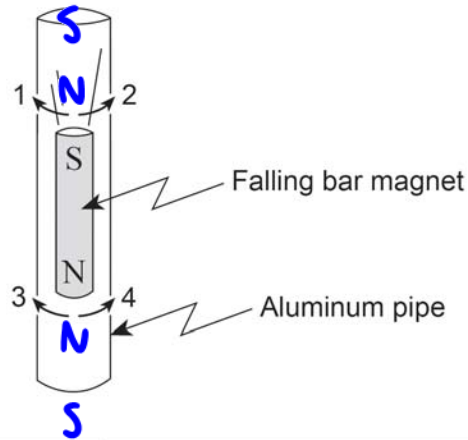
	ABOVE THE MAGNET	BELOW THE MAGNET
A.	1 ✓	3 ✗
B.	1 ✓	4 ✓
C.	2 ✗	3 ✗
D.	2 ✗	4 ✓

23.

The diagram shows a coil with 25 windings and dimensions 0.15 m by 0.20 m. Its plane is perpendicular to a magnetic field of magnitude 0.60 T.

Before

After

0.20 m

0.15 m

$\vec{B} = 0.60$ T
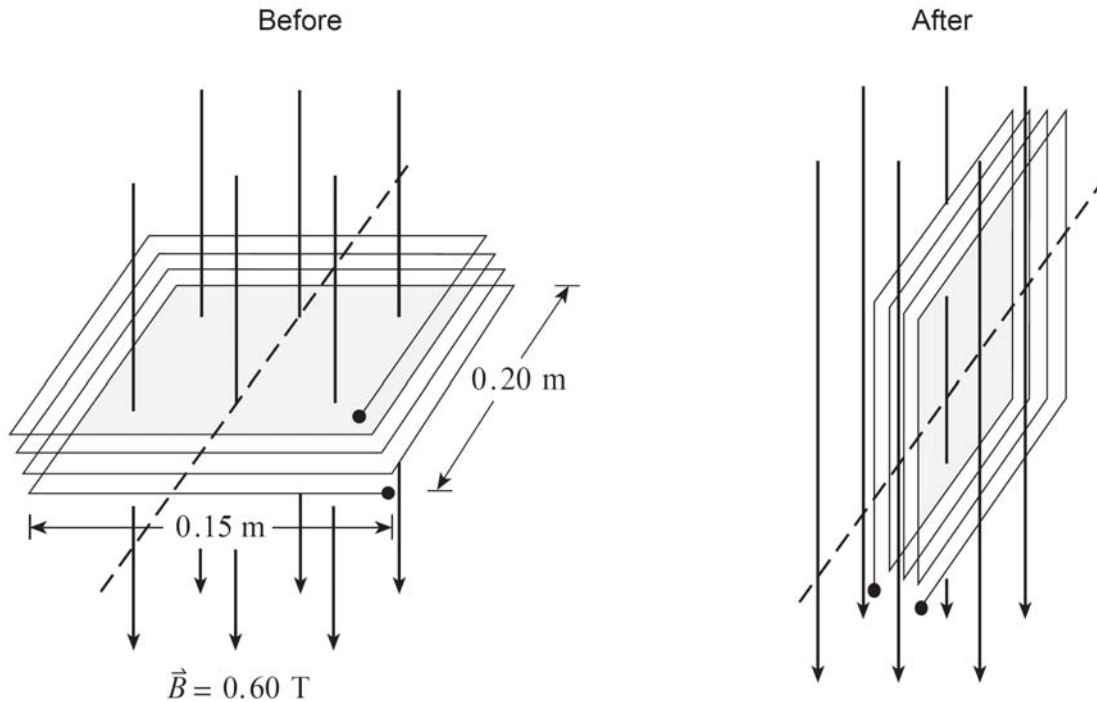
If the coil rotates 90° in 4.17×10^{-2} s so that its plane is now parallel to the magnetic field, what average emf is induced during this time? **(7 marks)**

$$\mathcal{E} = -\frac{N \Delta \phi}{\Delta t} \rightarrow \text{Need } \Delta \phi$$

$$\Delta \phi = BA_f - BA_i = 0 - (.6)(.2)(.15) = -.018 \text{ Wb}$$

$$\mathcal{E} = \frac{-25(-.018)}{4.17 \times 10^{-2}} = 10.8 \text{ v}$$

24.

The flux through a circular coil with a radius of 0.075 m is 0.013 Wb when placed perpendicular to a magnetic field. What is the strength of the magnetic field?
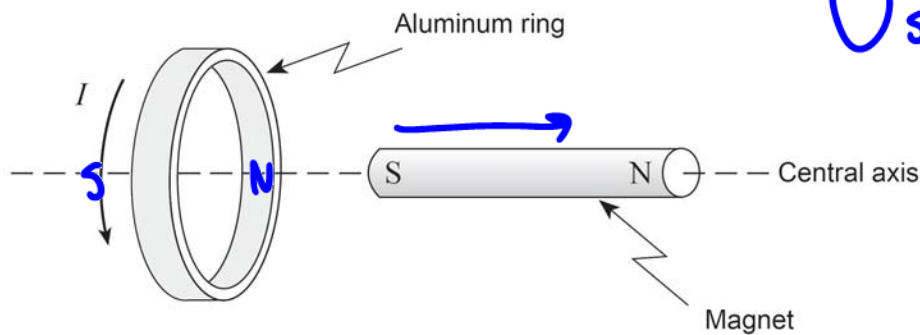
A.   0 T
B.   0.17 T
C.   0.74 T
D.   2.3 T

$$\phi = BA$$

$$B = \frac{\phi}{A} = \frac{\phi}{\pi r^2} = \frac{.013}{\pi (.075)^2} = .74 \text{ T}$$

25.

The diagram below shows an aluminum ring and the current induced in it by the nearby magnet that is free to move along its central axis.

Use Lenz' Law

The magnet must be

A.   stationary.
B.   moving to the left.
C.   moving to the right.
D.   spinning about its central axis.

26.

A computer adapter contains a transformer that converts 120 V ac across its primary windings to 24 V ac across its secondary windings. The primary current is 1.2 A. What is the secondary current and what is the type of transformer?

	MAGNITUDE OF CURRENT	DIRECTION OF CURRENT
A.	0.24 A ✗	Step-up ✗
B.	0.24 A ✗	Step-down ✓
C.	6.0 A ✓	Step-up ✗
D.	6.0 A ✓	Step-down ✓

$$\frac{V_p}{V_s} = \frac{I_s}{I_p} \rightarrow \frac{120}{24} = \frac{I_s}{1.2} \rightarrow I_s = 6.0 \text{ A}$$

27.

A loop of wire of area 0.32 m^2 is placed in a 0.75 T magnetic field as shown. The magnetic field is changed to 0.35 T in the opposite direction in 0.45 s.

Lenz' Law

Before

After
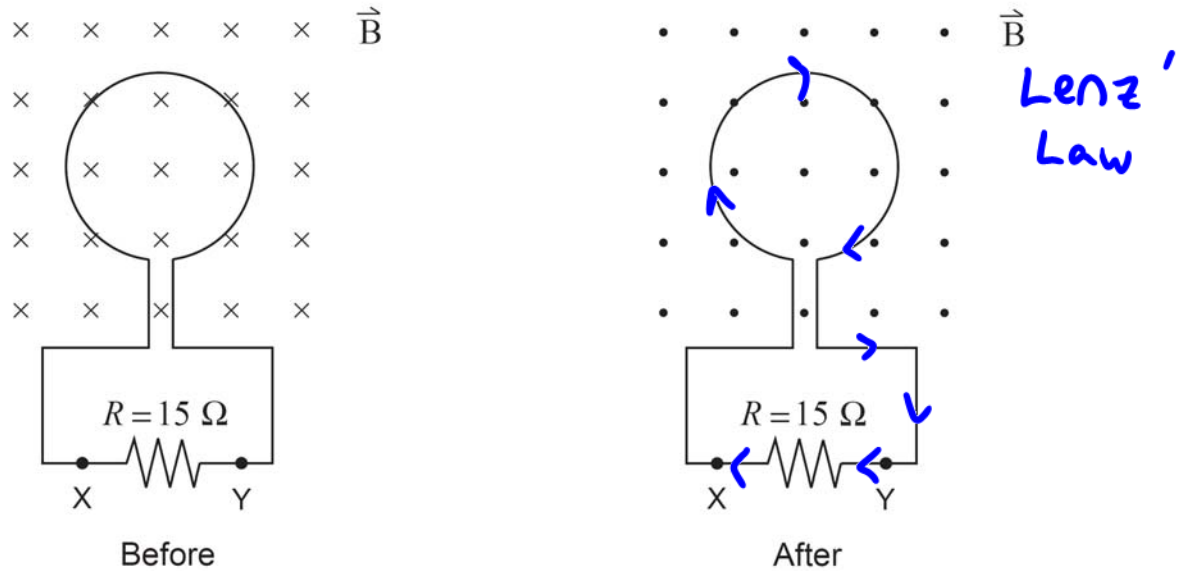
What are the magnitude and direction of the current through the $15 \text{ }\Omega$ resistor?

	MAGNITUDE OF CURRENT	DIRECTION OF CURRENT
A.	0.019 A ✗	X to Y ✗
B.	0.019 A ✗	Y to X ✓
C.	0.052 A ✓	X to Y ✗
D.	0.052 A ✓	Y to X ✓

$I = \dfrac{V}{R}$ Need V! $\Delta\phi = BA_f - BA_i$

$\Delta\phi = (-.35)(.32) - (.75)(.32)$

$\mathcal{E} = -\dfrac{N\Delta\phi}{\Delta t}$ ← $\Delta\phi = -.352$

$\mathcal{E} = \dfrac{-(1)(-.352)}{.45} = .78 v$ $I = \dfrac{.78}{15} = 0.052 \text{ A}$

28.

An automobile starter motor, connected to a 12.0 V battery, produces a back emf of 9.7 V when operating at normal speed. A malfunction prevents the starter motor from turning and the current increases to 180 A. What current does the starter motor draw when operating normally?   **(7 marks)**

when not turning, $V_{back} = 0$

$$0 = \varepsilon - Ir$$

$$\varepsilon = Ir \rightarrow 12 = 180r \rightarrow r = 6.67 \times 10^{-2} \, \Omega$$

When running:

$$V_{back} = \varepsilon - Ir$$

$$9.7 = 12 - I(6.67 \times 10^{-2})$$

$$-2.3 = -(6.67 \times 10^{-2})I$$

$$I = 34.5 \, A$$
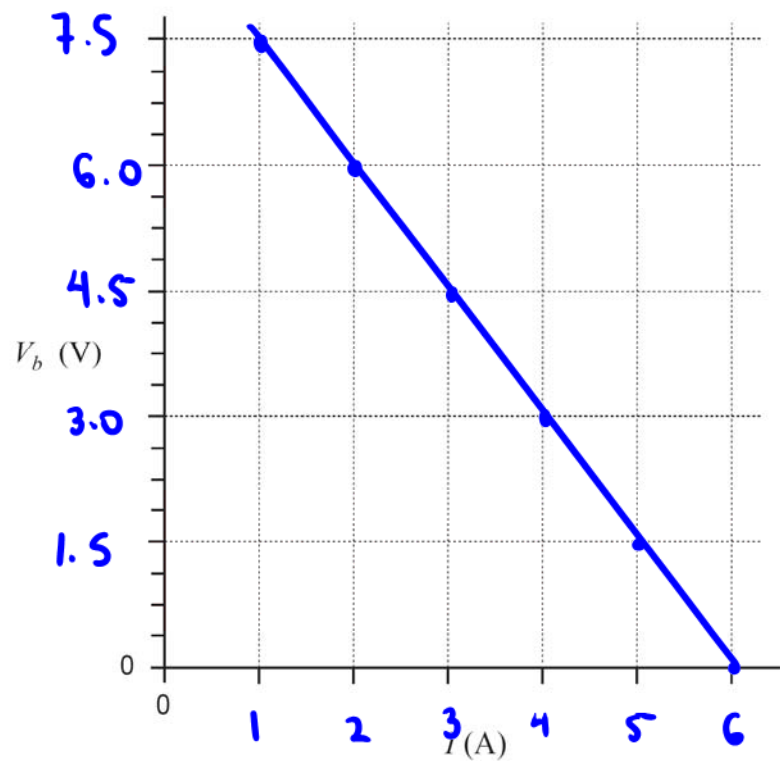
29.

An electric motor is connected to a 9.0 V power supply. The data table below shows how the back emf of the motor, V_{back}, varies with the current through the armature, I, as the mechanical load changes.

Back emf V_{back} (V)	7.5	6.0	4.5	3.0	1.5	0
Current I (A)	1.0	2.0	3.0	4.0	5.0	6.0

a) Plot this data on the graph below.   **(2 marks)**

b) Determine the slope of this graph.   (2 marks)

$$m = \frac{0 - 7.5}{6 - 1} = -1.5 \ V/_A$$

c) What property of the motor does the slope represent?   (1 mark)
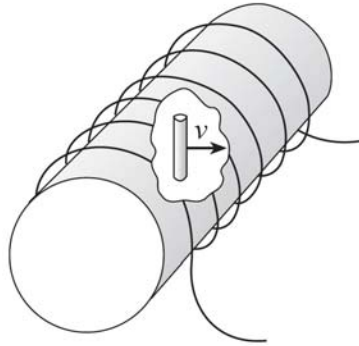
$$\frac{V}{I} = resistance$$

30.

A solenoid of length 0.75 m has a radius 0.092 m. A current of 25 A flows through its 4 700 turns. Within this solenoid a 0.10 m long conductor moves at 4.3 m/s perpendicular to the field in the solenoid.

Need B!

$B = \mu_0 \dfrac{N}{\ell} I$

$B = \dfrac{(4\pi \times 10^{-7})(4700)(25)}{.75}$

$B = .19687$ T

$\mathcal{E} = B\ell v$

$= (.19687)(.1)(4.3)$

What emf is induced between the ends of the conductor?

(A.) 0.085 V
B. 0.197 V
C. 0.430 V
D. 4.80 V

$\mathcal{E} = 0.085$ v

31.

A motor is connected to a 12 V dc supply and draws 5.0 A when it first starts up. What will be the back emf when the motor is operating at full speed and drawing 1.2 A?

A. 7.0 V
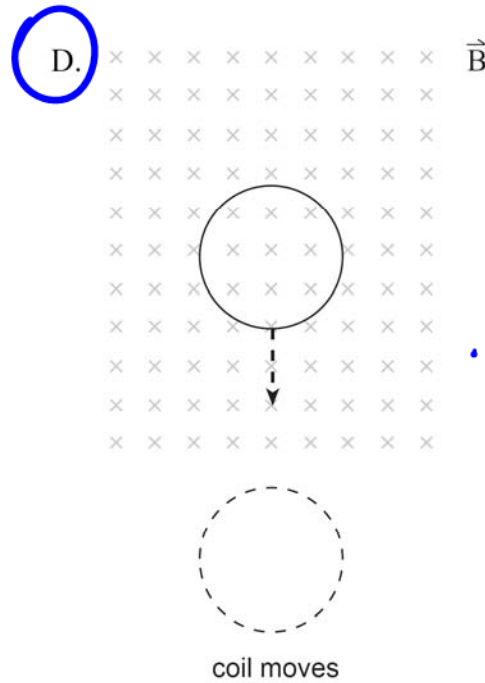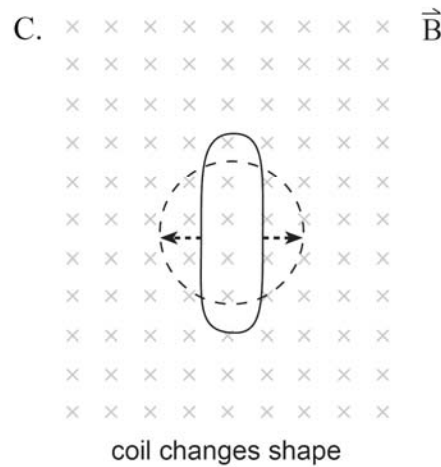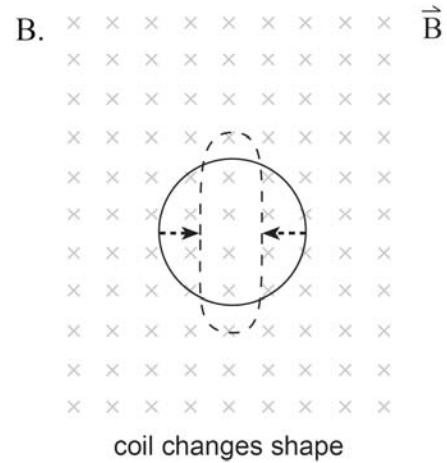B. 7.8 V
(C.) 9.1 V
D. 10.8 V

$V_{back} = \mathcal{E} - Ir$
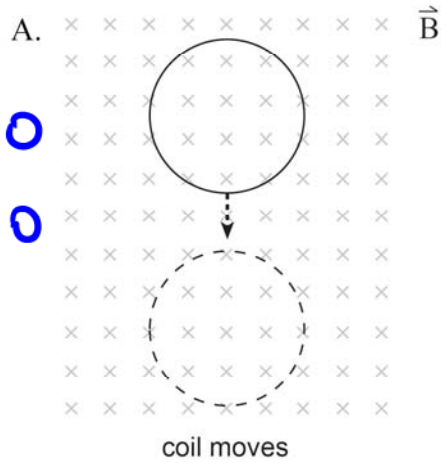
$0 = 12 - 5r \rightarrow r = 2.4 \, \Omega$

$V_{back} = 12 - (1.2)(2.4) = 9.12$ v

32.

In which of the following situations would the greatest emf be induced in the coil? All changes occur in the same time interval.

A. $\vec{B}$

coil moves

$\Delta \phi = 0$

$\therefore \mathcal{E} = 0$

B. $\vec{B}$

coil changes shape

C. $\vec{B}$

coil changes shape

D. $\vec{B}$

coil moves

biggest

$\Delta \phi$

$\therefore$ largest $\mathcal{E}$

33.

An ideal transformer has a potential difference of 130 V ac across the primary windings and a potential difference of 780 V ac across the secondary windings. There are 390 turns in the secondary. The secondary current is

A. twice the primary current.
B. one half the primary current.
C. six times the primary current.
D. one-sixth the primary current.

V_S is 6 times as large!

$\therefore I_S$ is 6 times as small!

34.

A rectangular coil of wire containing 250 loops is placed in a magnetic field. Each loop measures 0.075 m by 0.28 m. The magnetic field changes over a time interval of 0.36 s producing an average emf of 1.3 V. What is the change in the magnetic field strength?

(7 marks)

$$\varepsilon = -N\frac{\Delta\phi}{\Delta t} \rightarrow \varepsilon = -N\frac{(A)(\Delta\vec{B})}{\Delta t} \quad (\text{since } A = \ell w)$$

$$\Delta B = \frac{-\varepsilon\,\Delta t}{NA} = \frac{(-1.3)(.36)}{(250)(.075)(.28)} \quad \leftarrow \text{drop the negative!}$$
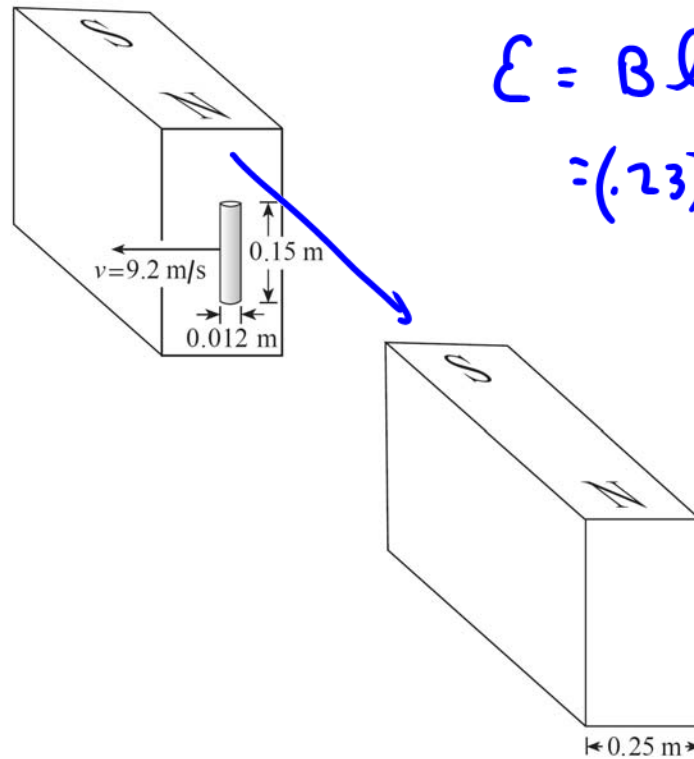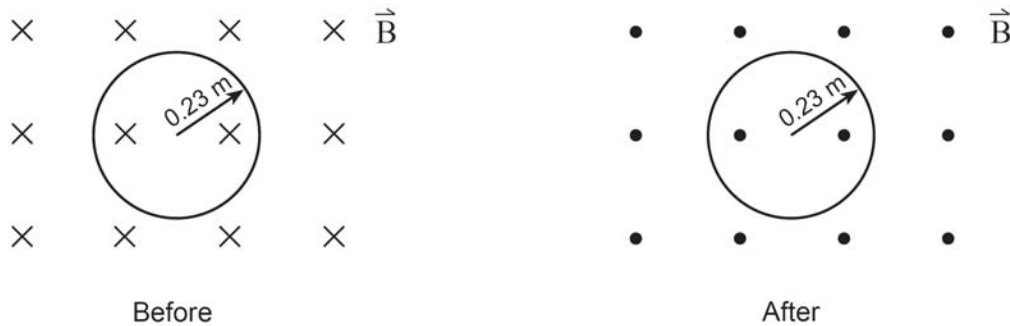
$$\Delta\vec{B} = 0.089 \text{ T}$$

35.

A conducting rod is moving perpendicular to a uniform magnetic field of 0.23 T at a velocity of 9.2 m/s. What emf is generated during this motion?

$$\mathcal{E} = B\ell v$$
$$= (.23)(.15)(9.2)$$

A. 0 V
B. 0.025 V
C. 0.32 V
D. 0.53 V

36.

A single loop of wire of radius 0.23 m is placed in a 0.75 T magnetic field as shown. The magnetic field is changed to a strength of 0.50 T in the opposite direction in 0.61 s.

Before

After

What is the average emf induced in the coil?

$$\Delta\phi = A(B_f - B_i) = \pi(.23)^2[-.5 - .75]$$

A. 0.068 V

$$\Delta\phi = -.2077$$

B. 0.094 V

C. 0.34 V

D. 0.47 V

$$\mathcal{E} = \frac{-N\Delta\phi}{\Delta t} = \frac{-(1)(-.2077)}{.61} = .34 \text{ v}$$

37.

A rectangular coil measuring 0.12 m by 0.080 m is placed perpendicular to a 0.85 T magnetic field as shown.
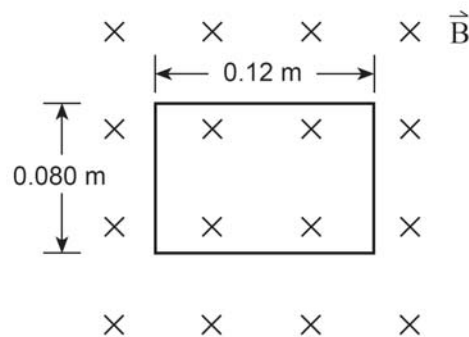
What is the magnetic flux through the coil?

A. 0 Wb

B. 8.2×10^{-3} Wb

C. 6.8×10^{-2} Wb

D. 1.0×10^{-1} Wb

$$\phi = BA = (.85)(.12)(.08)$$
$$= 8.16 \times 10^{-3} \text{ wb}$$

38.

An electric device operates on 9.0 V ac and has a total resistance of 21 Ω. An ideal transformer is used to change the incoming line voltage of 120 V ac to the operating voltage of 9.0 V ac.

a) Is the transformer a step-up or step-down transformer?   **(1 mark)**

$$\text{step-down}$$

b) What is the current in the primary side?   **(6 marks)**
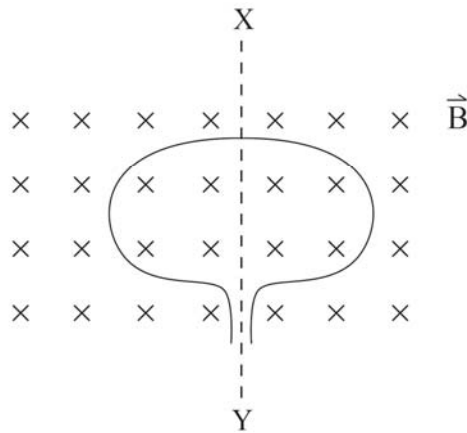
$$\frac{V_p}{V_s} = \frac{I_s}{I_p}$$

$$I_s = \frac{V_s}{R} = \frac{9}{21} = .4286 \text{ A}$$

$$\frac{120}{9.0} = \frac{.4286}{I_p} \rightarrow I_p = 0.032 \text{ A}$$

39.

A single coil of wire of area 6.0×10^{-3} m^2 is positioned in a uniform 0.18 T magnetic field as shown. The coil is rotated $90°$ about axis XY in 4.2×10^{-3} s. What average emf is induced by the coil?
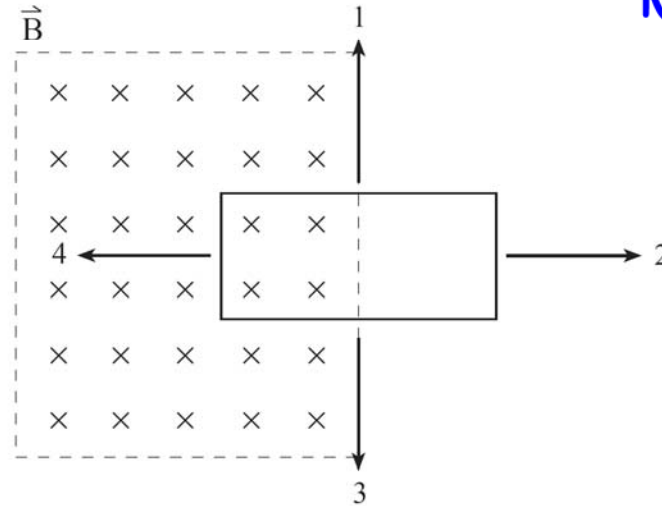

$$\Delta \phi = BA_f - BA_i$$

$$= 0 - (.18)(6 \times 10^{-3})$$

$$\Delta \phi = -0.00108 \text{ wb}$$

A. 0 V
B. 0.13 V
C. 0.26 V
D. 43 V

$$\mathcal{E} = \frac{-N \Delta \phi}{\Delta t} = \frac{-(1)(-.00108)}{4.2 \times 10^{-3}} = .26 \text{ v}$$

40.

A part of a coil of wire is placed in a uniform magnetic field as shown. Which two directions of motion would immediately induce an emf in the coil?

Need a $\Delta\phi$!

A. 1 and 2
B. 1 and 3
C. 2 and 3
D. 2 and 4

41.

An electric motor is connected to a constant source of potential. Considering back emf, which of the following observations is correct?

A. At full speed the applied voltage increases.
B. At full speed the armature resistance increases.
C. If the motor is kept from rotating at full speed, the armature heats up.
D. If the motor is kept from rotating at full speed, the armature temperature decreases.

42.

A motor is connected to a constant 120 V source and draws a current of 38.0 A when it first starts up. At its normal operating speed, the motor draws a current of 2.50 A.

a) What is the resistance of the armature coil?   **(3 marks)**

b) What is the back emf at normal speed?   **(4 marks)**
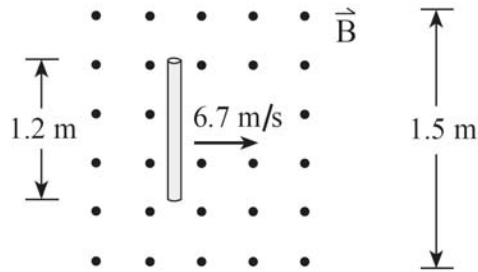
a) $V_{back} = \varepsilon - Ir$

$0 = 120 - 38r$ $r = \dfrac{120}{38} = 3.16 \, \Omega$

b) $V_{back} = 120 - 2.5(3.16) = 112 \, v$

43.

A 1.2 m length of wire is pulled through a uniform 0.045 T magnetic field at 6.7 m/s as shown. What emf is generated between the ends of the wire?

A. 0 V

B. 0.090 V

C. 0.36 V

D. 0.45 V

$$\mathcal{E} = B\ell v = (.045)(1.2)(6.7) = .362 \text{ v}$$

44.

A dc motor is connected to a 12.0 V power supply. When the armature is rotating, the current through it is 0.78 A and the back emf is 10.6 V. What is the resistance of the armature?

A. 1.4 Ω

B. 1.8 Ω

C. 14 Ω

D. 15 Ω

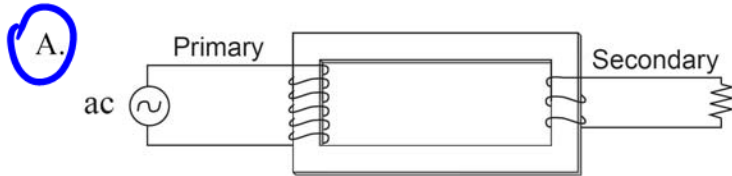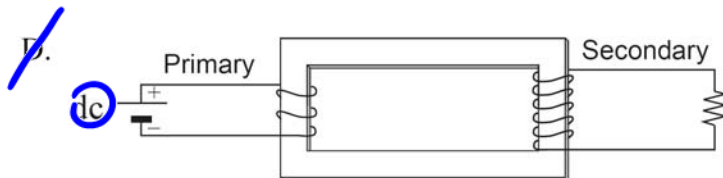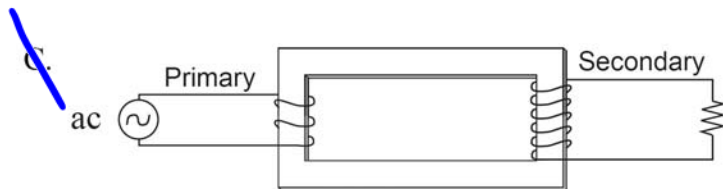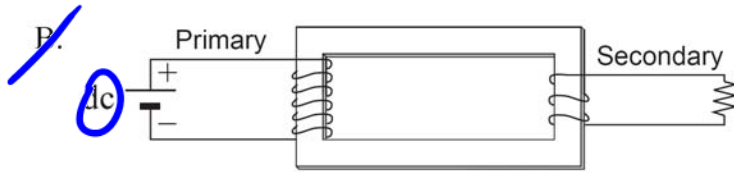$$V_{back} = \mathcal{E} - Ir$$

$$10.6 = 12 - .78r$$

$$-1.4 = -.78r$$

$$r = 1.8 \ \Omega$$

45.

In which of the following diagrams is the secondary **current** greater than the primary **current**?

A. Primary   Secondary
ac

step down transformer

B. Primary   Secondary
dc

C. Secondary   Primary
ac

D. Secondary   Primary
dc

46.

A single loop of wire of area 5.0×10^{-3} m^2 and resistance $1.8\ \Omega$ is perpendicular to a uniform magnetic field B. The field then decreases to zero in 1.2×10^{-3} s inducing an average current of 8.3×10^{-2} A in the loop. What was the initial value of the magnetic field B?   **(7 marks)**

$$V = IR = (8.3 \times 10^{-2})(1.8) = .1494 \checkmark$$

$$\mathcal{E} = \frac{-N \Delta \phi}{t} \rightarrow \mathcal{E} = \frac{-N(\phi_f - \phi_i)}{t} \qquad \boxed{\phi_f = 0}$$

$$\mathcal{E} = \frac{-N(-\phi_i)}{t} \rightarrow \phi_i = \frac{\mathcal{E}t}{N}$$

$$BA = \frac{\mathcal{E}t}{N} \rightarrow B = \frac{\mathcal{E}t}{NA} = \frac{(.1494)(1.2 \times 10^{-3})}{(1)(5 \times 10^{-3})}$$
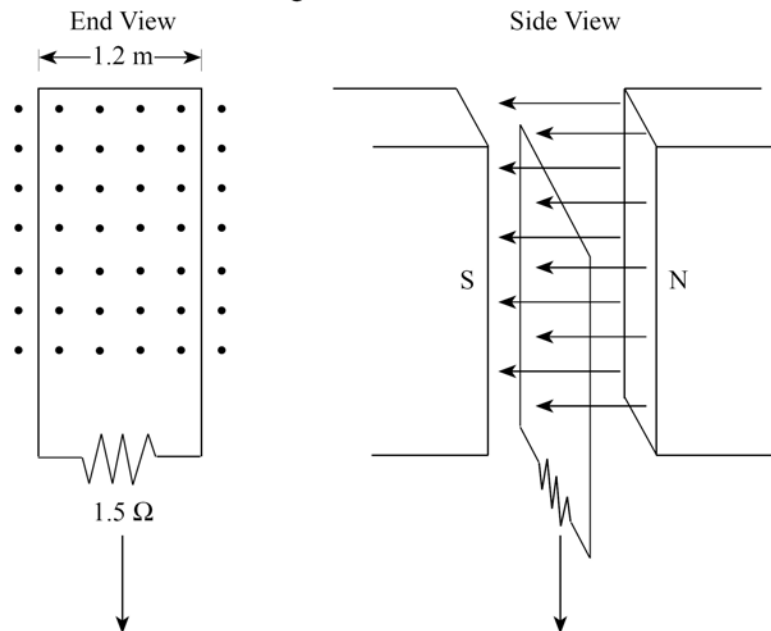
$$B = 0.036\ T$$

9401

47.

A rectangular conducting loop of mass 4.5 x 10^{-2} kg and resistance 1.5 Ω is dropped in the direction shown through a uniform horizontal magnetic field of 1.8 T.

End View

$\longleftarrow$1.2 m$\longrightarrow$

Side View

S   N

1.5 Ω

At what speed will this loop be falling through the magnetic field when it stops accelerating?

(10 marks)

$$F_g = F_B$$

$$mg = F_B \Rightarrow F_B = (4.5 \times 10^{-2})(9.8) = .441 \text{ N}$$

$$F_B = BI\ell$$

$$I = \frac{F_B}{B\ell} = \frac{.441}{(1.8)(1.2)} = .204 \text{ A} \Rightarrow V = IR = (.204)(1.5)$$
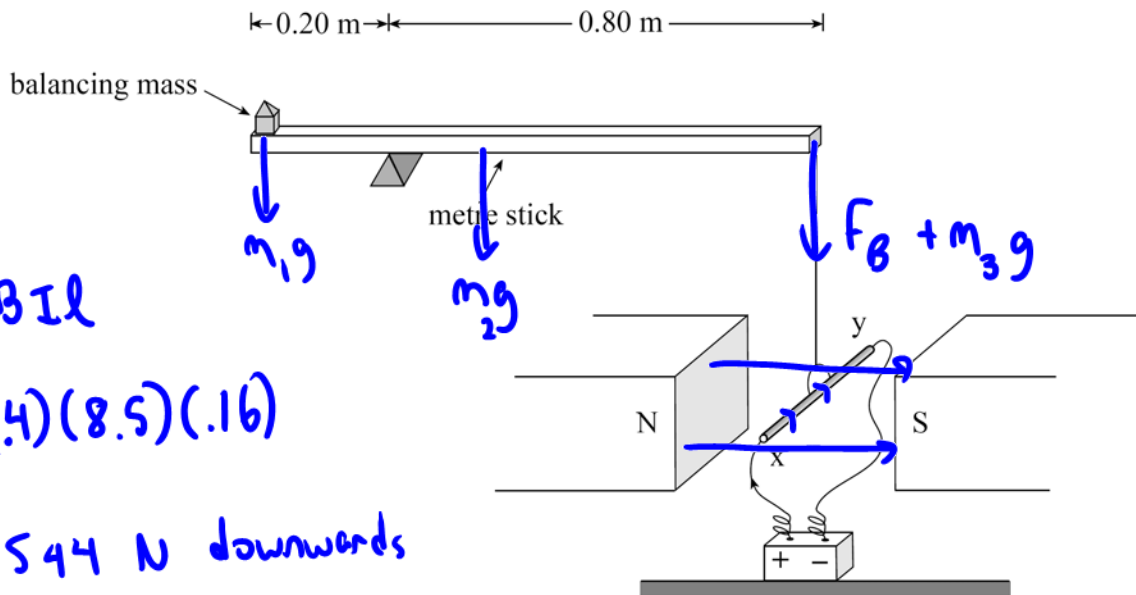
$$= .30625 \checkmark$$

$$\mathcal{E} = B\ell v \Rightarrow v = \frac{\mathcal{E}}{B\ell} = \frac{.30625}{(1.8)(1.2)} = .142 \text{ m/s}$$

48.

A uniform 0.125 kg metre stick is pivoted 0.20 m from its left end. A 0.250 kg conducting rod xy of length 0.16 m is suspended from the right end of the metre stick. An 8.5 A current flows through this rod. What balancing mass is needed to produce static equilibrium if the magnetic field is 0.40 T ?

(12 marks)

$$F_B = BIl$$

$$F_B = (.4)(8.5)(.16)$$

$$F_B = .544 \text{ N downwards}$$

$$\sum \tau_{cw} = \sum \tau_{ccw}$$

$$(m_2 g)(.3) + (F_B + m_3 g).8 = m_1 g (.2)$$

$$(.125)(9.8)(.3) + (.544 + (.25)(9.8))(.8) = m_1 (9.8)(.2)$$

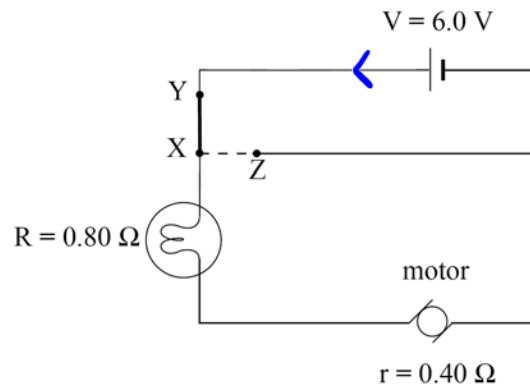$$m_1 = \frac{.3675 + 2.3952}{(.2)(9.8)} = \boxed{1.41 \text{ kg}}$$

49.

The circuit below shows a 6.0 V power supply connected to a 0.80 Ω light bulb in series with an electric motor whose internal resistance is 0.40 Ω. The power output of the bulb is 1.8 W when the switch is set in position XY, as shown.

$P = I^2 R$

$I = \sqrt{P/R} = 1.5 A$

V = 6.0 V

Y

X

Z

R = 0.80 Ω

motor

r = 0.40 Ω

a) Find the back emf (reverse voltage) of the motor. **(8 marks)**

b) When the switch is set to position XZ, the bulb instantly becomes brighter and then becomes dimmer as the armature of the motor slows down. Find the power output of the bulb when it is brightest. **(4 marks)**

a) $V_{back} = \mathcal{E} - Ir$

$V_{back} = 6 - I(.8 + .4) = 6 - 1.2 I \quad , \quad I = 1.5 A$

$V_{back} = 6 - 1.2(1.5) = 4.2 \checkmark$

b) $V_b = Ir$ (since $\mathcal{E}$ is no longer connected)

$4.2 = I(.8 + .4) \Rightarrow I = \dfrac{4.2}{1.2} = 3.5 A$

$P = I^2 R = (3.5^2)(.8) = 9.8 W$

Answers:

1. A

2. B

3. B

4. C

5. D

6. B

7. Omit

8. B

9. A

10. B

11. A

12. B

13. B

14. A

15. A) 3.2×10^2 m   b) 1.0×10^{-5} Wb

16. D

17. A

18. A

19. A) 7.3 v   b) 4.5 A

20. A

21. C

22. B

23. 11 v

24. C

25. C

26. D

27. D

28. 34 A

29. A) see solution key   b) -1.5 ohms
    c) internal resistance

30. A

31. C

32. D

33. D

34. ΔB=0.089 T

35. C

36. C

37. B

38. A) step down   b) 0.032 A

39. C

40. D

41. C

42. A) 3.16 ohms   b) 112 v

43. C

44. B

45. A

46. B=3.6×10^{-2} T

47. 0.142 m/s

48. M= 1.41 kg

49. A) 4.2 v   b) 9.8 W