Magnetic Induction Review

Multiple Choice

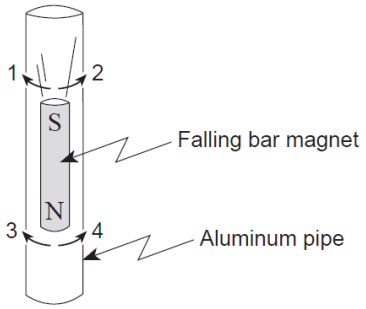
1. An aircraft with a wingspan of 24 m flies at 85 m/s perpendicular to a magnetic field. An emf of 0.19 V is induced across the wings of the aircraft. What is the magnitude of the magnetic field?

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

2. 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

3. 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?

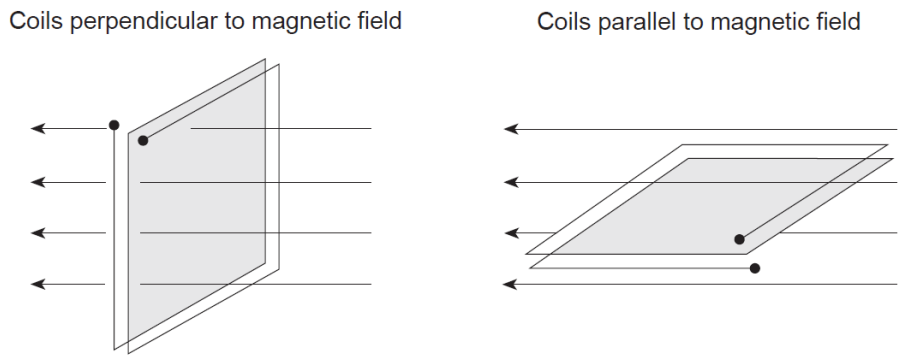


	ABOVE THE MAGNET	BELOW THE MAGNET
A.	1	3
B.	1	4
C.	2	3
D.	2	4

4. What are the units of magnetic flux?

   A. T
   B. Wb
   C. $\mathrm{T\cdot m/A}$
   D. $\mathrm{N\cdot m/C^2}$

5. The diagram below shows two coils in a magnetic field.



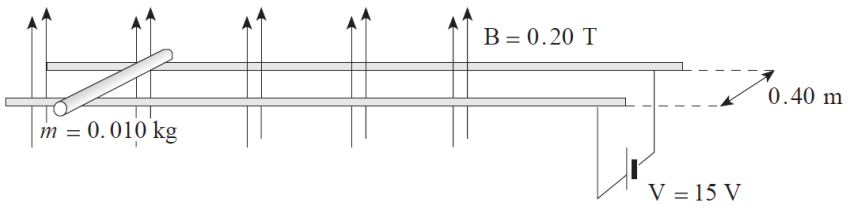
An electric current can be induced in the coil oriented with its plane

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.

6. 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?

	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

7. 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.



Find the initial acceleration and maximum velocity for the rod.

	INITIAL ACCELERATION	MAXIMUM VELOCITY
A.	40 m/s^2	190 m/s
B.	40 m/s^2	300 m/s
C.	120 m/s^2	190 m/s
D.	120 m/s^2	300 m/s

8. 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

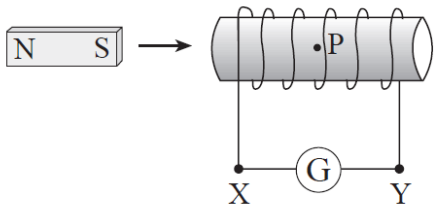
9. An electric motor rotates at various speeds and the current through the armature changes accordingly. Which pair of conditions occurs when the motor generates the greatest back emf?

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

10. 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

11. A bar magnet is moving toward a solenoid.



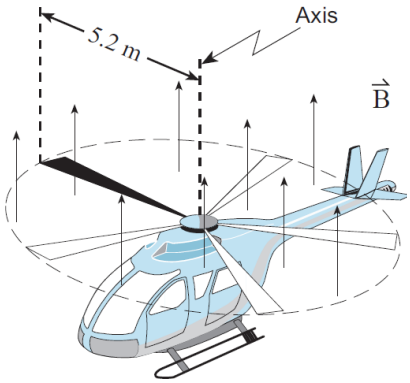
What is the direction of the current through the galvanometer and what is the direction of the magnetic field produced by this current at location P inside the solenoid?

	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

12. 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

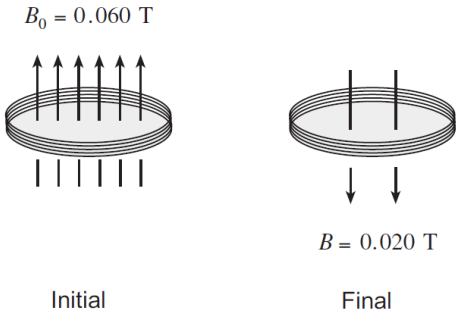
13. The 5.2 m long metal rotor blades of a helicopter spin at 6.0 revolutions per second perpendicular to the earth's magnetic field of 4.7×10^{-5} T.



	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

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?

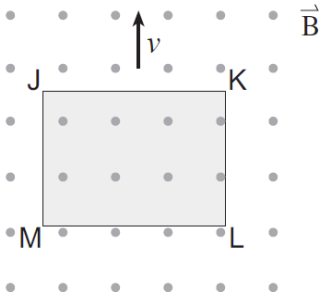
14. A 500-turn circular coil with an area of 1.54×10^{-2} m^2 is perpendicular to a 0.060 T field. The magnetic field changes to 0.020 T in the opposite direction in 0.12 s.



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

15. A metal block moves with a constant speed in a uniform magnetic field.



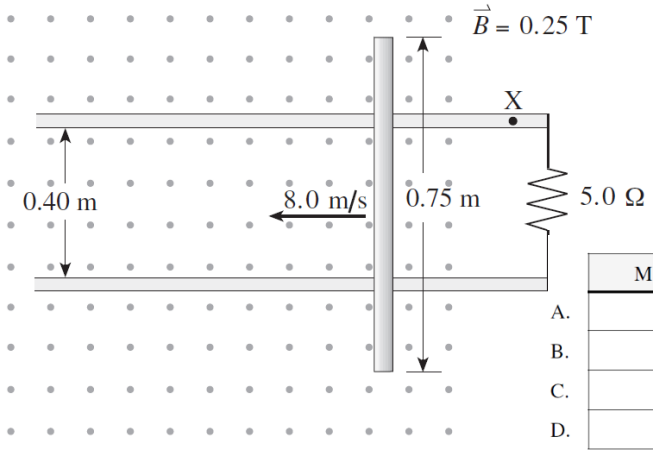
Which side of the block is positive?

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

16. A 120 V dc motor has an armature resistance of 5.0 Ω and draws 6.0 A when it is operating normally. What is the starting current of the motor and the back emf when it is operating?

	STARTING CURRENT	BACK EMF WHEN OPERATING
A.	6.0 A	30 V
B.	6.0 A	90 V
C.	24 A	30 V
D.	24 A	90 V

17. 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.



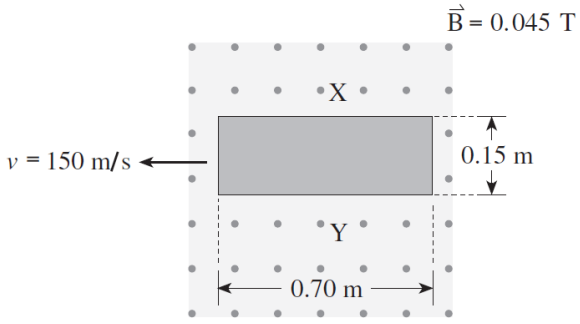
	MAGNITUDE OF CURRENT	DIRECTION OF CURRENT THROUGH X
A.	0.16 A	Left
B.	0.16 A	Right
C.	0.30 A	Left
D.	0.30 A	Right

What are the magnitude and direction of the current through point X?

18. Transformers are commonly used in which electrical device?

A. toaster
B. television set
C. electric kettle
D. incandescent bulb

19. 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?

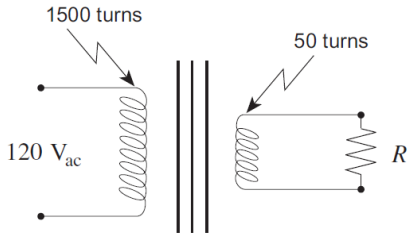


	POSITIVE SIDE	EMF
A.	X	1.0 V
B.	X	4.7 V
C.	Y	1.0 V
D.	Y	4.7 V

20. 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 $3.5\ \Omega$. What is the back emf at full speed?

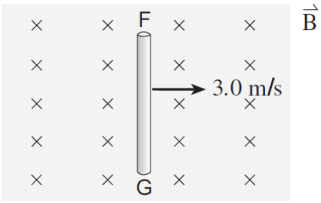
A. 14 V
B. 96 V
C. 110 V
D. 124 V

21. 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?



	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

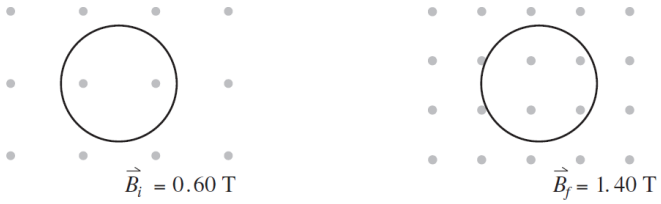
22. A 0.050 m long conducting wire is moved through a 1.5 T magnetic field as shown below.



What is the magnitude of the emf generated between its ends, and in what direction do the electrons in the conductor initially move?

	EMF (V)	DIRECTION OF ELECTRON MOVEMENT
A.	0.23 V	towards F
B.	0.23 V	towards G
C.	4.5 V	towards F
D.	4.5 V	towards G

23. The circular loop of wire shown below has an area of $0.40\ m^2$ and is in a 0.60 T magnetic field. This field is increased to 1.40 T in 0.25 s.



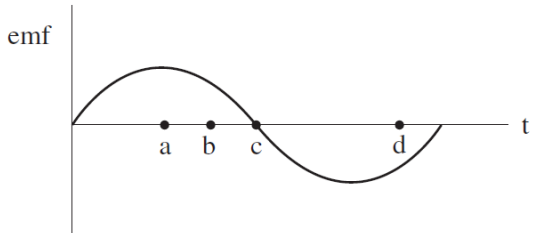
Determine the emf produced in the loop and the direction of current.

	EMF (V)	DIRECTION OF CURRENT
A.	1.3 V	clockwise
B.	1.3 V	counter-clockwise
C.	3.2 V	clockwise
D.	3.2 V	counter-clockwise

24. The load on an electric motor is gradually increased. Which one of the following quantities decreases? (Input voltage remains constant.)

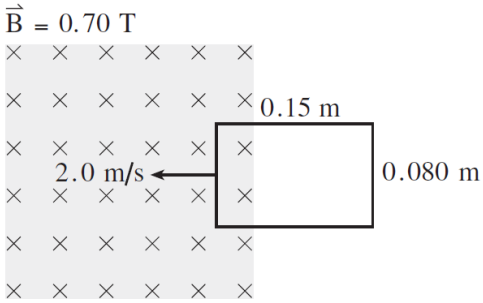
A. current
B. back emf
C. armature resistance
D. heat produced by armature

25. The graph below shows how the emf produced by an ac generator varies with time. At which point in time is the rate of flux change in the generator the greatest?



A. a
B. b
C. c
D. d

26. The single rectangular loop shown below is being pulled into the magnetic field at 2.0 m/s. Determine the emf developed in the loop.



A. 0.017 V
B. 0.11 V
C. 0.21 V
D. 0.64 V

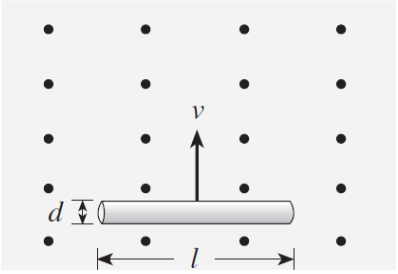
27. You are using an electric drill to put a hole in a piece of wood when it hits a tough spot. The drill slows down and its motor heats up. Which of the choices below describes what has happened to the back emf and current?

	BACK EMF	CURRENT
A.	increased	increased
B.	decreased	decreased
C.	increased	decreased
D.	decreased	increased

28. Which of the following combinations in the primary coil of an ideal transformer causes an emf to be developed in the secondary coil?

	CURRENT	MAGNETIC FIELD
A.	constant	constant
B.	constant	changing
C.	changing	constant
D.	changing	changing

29. A length of conducting wire is moving perpendicular to a magnetic field as shown below.



Which of the following does not affect the size of the emf produced between the ends of the wire?

A. speed of wire
B. length of wire
C. thickness of wire
D. magnetic field strength

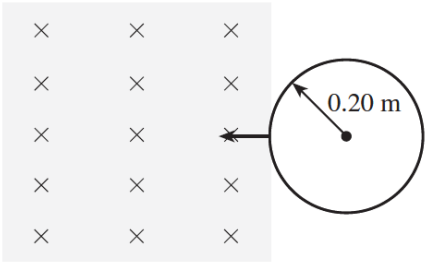
30. A refrigerator condenser motor draws a 10 A current at startup (armature not rotating) when attached to a 110 V source. When the motor is operating at normal speed the current is 0.20 A. What back emf is the motor producing at this normal speed?

A. 100 V
B. 108 V
C. 110 V
D. 112 V

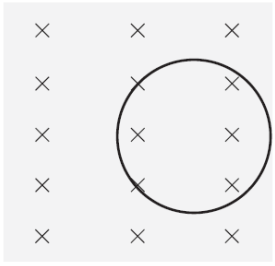
31. The secondary coil in an ideal transformer has 5 times as many windings as the primary. If the current in the primary is 0.40 A, determine the current in the secondary, and the type of the transformer.

	CURRENT IN SECONDARY	TYPE OF TRANSFORMER
A.	0.080 A	step-up
B.	0.080 A	step-down
C.	2.0 A	step-up
D.	2.0 A	step-down

32. A circular loop of resistance 1.2 Ω is pulled a distance of 0.40 m into a perpendicular magnetic field as shown below.



B = 0.80 T



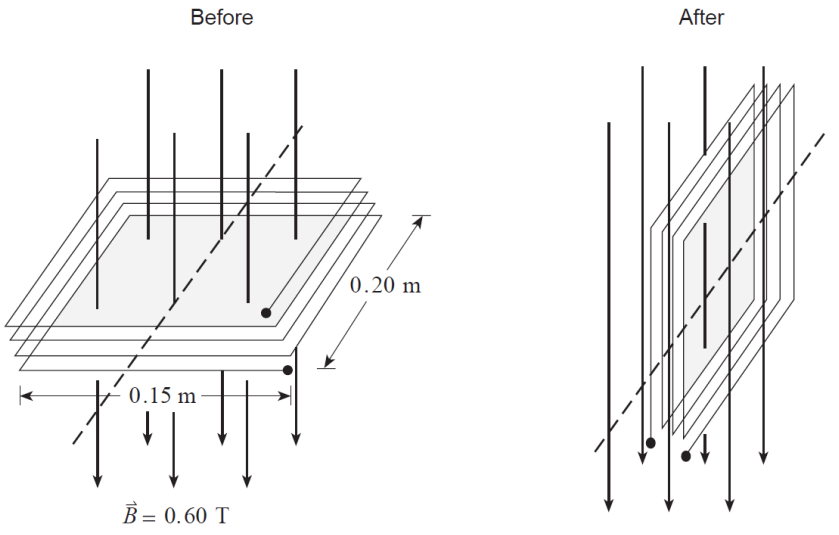
B = 0.80 T

A. 0.10 m/s
B. 0.75 m/s
C. 1.9 m/s
D. 2.4 m/s

An average current of 0.50 A is produced in the coil during this event. Calculate the constant speed with which the coil was pulled.

Written Response

1. 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.



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)**

2. 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)**

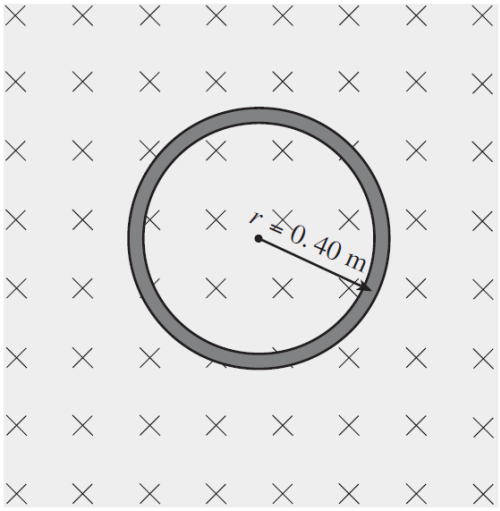
b) Find the secondary current. **(3 marks)**

3. 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)**

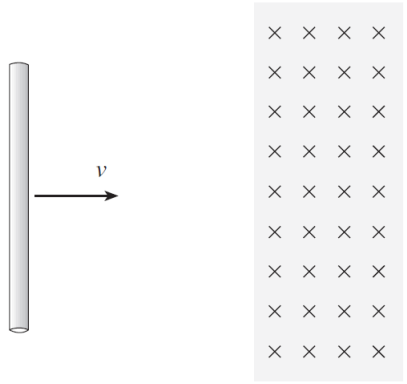
b) If the cross-sectional area of the solenoid is 8.5×10^{-4} m^2, what is the flux through it? **(3 marks)**

4. A coil of wire containing 50 loops is lying on a flat surface in a 0.60 T magnetic field pointing directly into the surface.



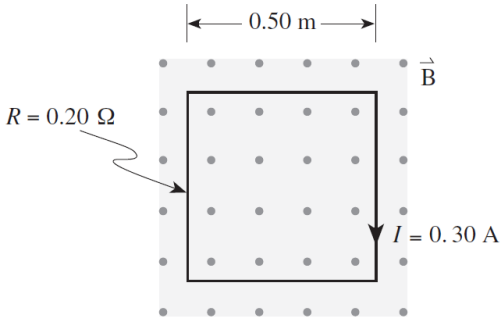
The magnetic field then changes to a value of 0.10 T in the opposite direction in 2.10 s. What is the average emf induced in the coil during the time that the magnetic field was changing? **(7 marks)**

5. A steel rod passes through a region where a magnetic field exists.



The rod slows as it passes through the magnetic field. Using principles of physics, explain why this happens. **(4 marks)**

6. The single square loop of copper wire with a resistance of 0.20 Ω has a current of 0.30 A due to a continuously increasing magnetic field.



At what rate, in T/s, is the magnetic field increasing? **(7 marks)**

Answers

MC

1. A	12. B	23. A
2. C	13. A	24. B
3. B	14. D	25. A
4. B	15. B	26. B
5. D	16. D	27. D
6. A	17. B	28. D
7. A	18. B	29. C
8. B	19. A	30. B
9. B	20. B	31. A
10. A	21. B	32. D
11. A	22. B	

WR

1.

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)**

$\mathcal{E} = -N\frac{\Delta\Phi}{\Delta t}$ (ignore direction term) ← **2 marks**

$$\mathcal{E} = \frac{N\times\Delta\Phi}{\Delta t}$$
$$= \frac{N\times(\Phi' - \Phi)}{\Delta t}$$
$$= \frac{N\times(0 - BA)}{\Delta t}$$
$$= \frac{25\times0.60\times0.15\times0.20}{4.17\times10^{-2}}$$ ← **4 marks**
$$= 10.8 \text{ V}$$
$$= 11 \text{ V}$$ ← **1 mark**

2.

a) Find the secondary voltage.

$$\frac{V_s}{V_p} = \frac{N_s}{N_p}$$
$$\frac{V_s}{110} = \frac{56}{840}$$
$$V_s = 7.3 \text{ V}$$

← **4 marks**

b) Find the secondary current.

$$\frac{I_p}{I_s} = \frac{N_s}{N_p}$$
$$\frac{0.30}{I_s} = \frac{56}{840}$$
$$I_s = 4.5 \text{ A}$$

← **3 marks**

3.

a) How many windings does the solenoid have?

$$B = \mu_0\left(\frac{N}{\ell}\right)I \qquad \leftarrow \textbf{1 mark}$$

$$N = \frac{B\ell}{\mu_0 \cdot I} = \frac{\left(1.2\times10^{-2}\right)(0.25)}{\left(4\pi\times10^{-7}\right)(7\cdot5)} = 318 \qquad \leftarrow \textbf{2 marks}$$

$$= 3.2\times10^{2} \qquad \leftarrow \textbf{1 mark}$$

b) If the cross-sectional area of the solenoid is

$$\Phi = BA \qquad \leftarrow \textbf{1 mark}$$

$$= \left(1.2\times10^{-2}\right)\left(8.5\times10^{-4}\right) \qquad \leftarrow \textbf{1 mark}$$

$$= 1.0\times10^{-5}\ \text{Wb} \qquad \leftarrow \textbf{1 mark}$$

4.

The magnetic field then changes to a value of 0.10 T in the opposite direction in 2.10 s. What is the average emf induced in the coil during the time that the magnetic field was changing? **(7 marks)**

$$\mathcal{E} = \frac{-N\Delta\Phi}{\Delta t} \qquad \leftarrow \textbf{1 mark}$$

$$= -50\cdot\frac{\pi(0.40)^2\left(0.10-(-0.60)\right)}{2.10} \qquad \leftarrow \textbf{5 marks}$$

$$= -50\cdot\frac{0.352}{2.10}$$

$$= 8.4\ \text{V} \qquad \leftarrow \textbf{1 mark}$$

5.

The rod slows as it passes through the magnetic field. Using principles of physics, explain why this happens. **(4 marks)**

As the rod passes through the magnetic field the free charges within it experience a magnetic force. ← 1 mark This force moves the charges along the rod . ← 1 mark As the charges begin to move along the rod they experience another magnetic force. ← 1 mark This second force is directed against the motion of the rod . ← 1 mark