ELECTROMAGNETISM
PROVINCIAL EXAMINATION ASSIGNMENT

ANSWER KEY / SCORING GUIDE

PART A: Multiple Choice (each question worth ONE mark)

Q	K	Q	K
1.	B	30.	B
2.	D	31.	C
3.	C	32.	D
4.	D	33.	A
5.	C	34.	A
6.	A	35.	C
7.	A	36.	A
8.	A	37.	D
9.	D	38.	C
10.	D	39.	C
11.	C	40.	D
12.	B	41.	C
13.	A	42.	C
14.	D	43.	D
15.	D	44.	B
16.	B	45.	D
17.	C	46.	C
18.	B	47.	D
19.	B	48.	B
20.	D	49.	C
21.	D	50.	A
22.	C	51.	A
23.	C	52.	C
24.	D	53.	B
25.	C	54.	B
26.	A	55.	C
27.	B	56.	A
28.	B	57.	B
29.	C	58.	A

1. 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)**

$$V = IR$$

$$= 8.3 \times 10^{-2}\ \text{A} \cdot 1.8\ \Omega$$

$$= 0.149\ \text{V}$$ ← **2 marks**

$$\varepsilon = \frac{N\Delta\Phi}{\Delta t}$$

$$0.149\ \text{V} = \frac{-(1)(\Delta\Phi)}{1.2 \times 10^{-3}\ \text{s}}$$

$$\Delta\Phi = -1.8 \times 10^{-4}\ \text{Wb}$$ ← **3 marks**

$$\Delta\Phi = (\Delta B)A$$

$$\Delta B = \frac{-1.8 \times 10^{-4}\ \text{Wb}}{5.0 \times 10^{-3}\ \text{m}^2}$$

$$\Delta B = B_{final} - B_{initial} = 0 - B_{initial}$$

$$B_{initial} = 3.6 \times 10^{-2}\ \text{T}$$

← **2 marks**

2. An electron is accelerated from rest through a potential difference of 750 V. It then enters a uniform 2.3×10^{-3} T magnetic field at right angles to the field.

a) What is the speed of the electron? **(3 marks)**

$$\Delta E_p = E_k$$

$$QV = \frac{1}{2}mv^2 \qquad \leftarrow \textbf{1 mark}$$

$$(1.60\times10^{-19}\ \text{C})(750\ \text{V}) = \frac{1}{2}(9.11\times10^{-31}\ \text{kg})v^2 \qquad \leftarrow \textbf{1}\tfrac{1}{2}\ \textbf{mark}$$

$$v = 1.62\times10^{7}\ \text{m/s} \qquad \leftarrow \tfrac{1}{2}\ \textbf{mark (for answer)}$$

b) What is the radius of its path in the magnetic field? **(4 marks)**

$$F_C = F_B \qquad \leftarrow \tfrac{1}{2}\ \textbf{mark}$$

$$\frac{mv^2}{r} = qvB \qquad \leftarrow \textbf{1 mark}$$

$$r = \frac{mv}{qB} \qquad \leftarrow \tfrac{1}{2}\ \textbf{mark}$$

$$r = \frac{(9.11\times10^{-31}\ \text{kg})(1.62\times10^{7}\ \text{m/s})}{(1.60\times10^{-19}\ \text{C})(2.3\times10^{-3}\ \text{T})} \qquad \leftarrow \textbf{1 mark}$$

$$r = 4.0\times10^{-2}\ \text{m} \qquad \leftarrow \textbf{1 mark}$$

3. An electric device operates on 9.0 V ac and has a total resistance of $21\,\Omega$. 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)**

Step-down

b) What is the current in the primary side? **(6 marks)**

$$I = \frac{V}{R} = \frac{9.0 \text{ V}}{21\,\Omega}$$ ← **1 mark**

$$= 0.43 \text{ A}$$ ← **1 mark**

$$P_1 = P_2$$ ← **1 mark**

$$V_1 I_1 = V_2 I_2$$ ← **1 mark**

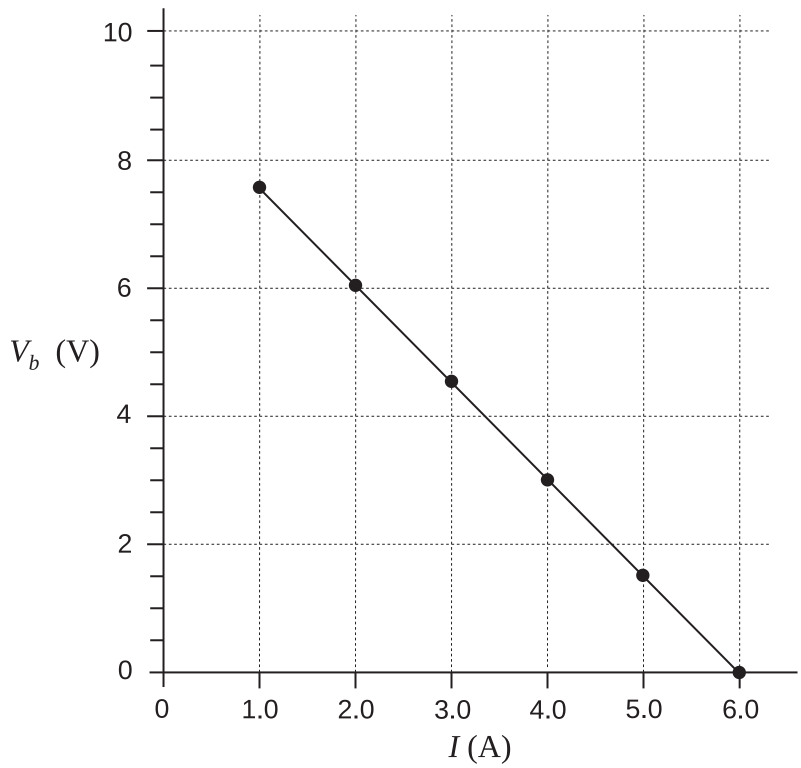
$$I_1 = \frac{9.0 \text{ V} \times 0.43\text{A}}{120 \text{ V}}$$ ← **1 mark**

$$= 0.032 \text{ A}$$ ← **1 mark**

4. 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)**



← 2 marks

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

$$slope = \frac{3.0 - 6.0 \text{ V}}{4.0 - 2.0 \text{ A}}$$

$$= -1.5 \frac{\text{V}}{\text{A}}$$

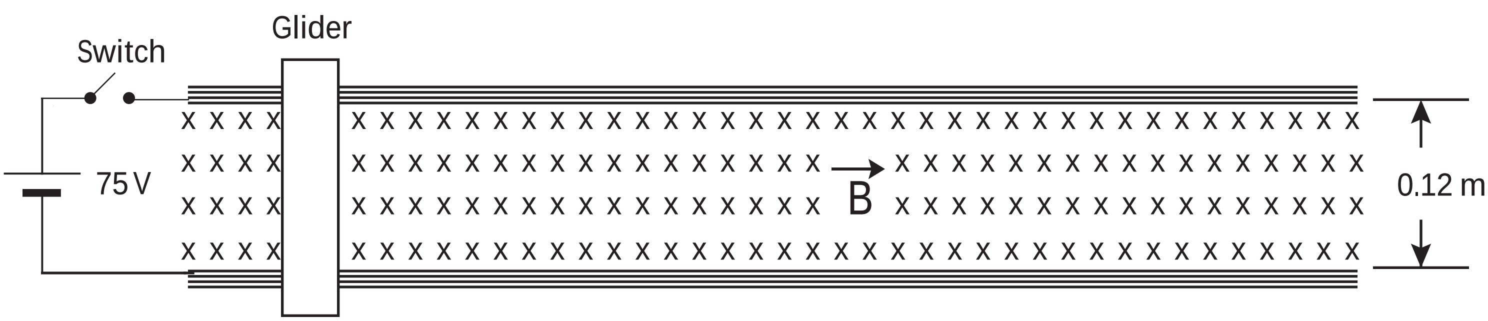
$$= -1.5\ \Omega$$

← 2 marks

c) What property of the motor does the slope of this graph represent? **(1 mark)**

internal resistance or resistance ← 1 mark

5. The diagram below shows a pair of horizontal parallel rails 0.12 m apart with a uniform magnetic field of 0.055 T directed vertically downward between the rails. There is a glider of mass $9.5 \quad 10^{\ 2}$ kg across the rails. the internal resistance of the 75 V power supply is 0.30 ohms and the electrical resistance of the rails and the glider is negligible. Assume friction is also negligible.



(a) When the switch is closed, what is the initial accleration of the glider? **(5 marks)**

$F = ma$ ⟵ **1/2 mark** $F = IlB$ ⟵ **1/2 mark**

$$a = \frac{IlB}{m} = \frac{\left(\frac{75\text{ V}}{0.30}\right)(0.12\text{ m})(0.055\text{ T})}{9.5 \quad 10^{\ 2}\text{ kg}}$$ ⟵ **3 marks**

$a = 17.9\text{ m/s}^2$ ⟵ **1 mark**

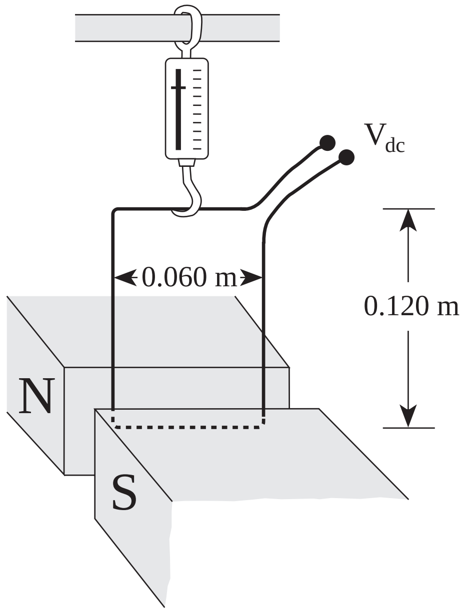
(b) What is the value of the terminal velocity as limited by the back emf produced by the moving glider? **(4 marks)**

$E = Blv$ ⟵ **1 mark**

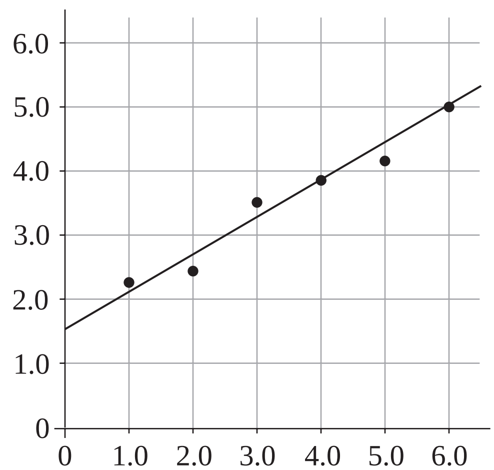
$75\text{ V} = (0.055\text{ T})(0.12\text{ m})(v)$ ⟵ **2 marks**

$v = 1.13 \quad 10^4\text{ m/s}$ ⟵ **1 mark**

6. A rectangular loop is suspended by a spring scale between magnetic poles. The loop is 0.60 m wide by 0.120 m high.



As the current in the loop is varied, the readings of the spring scale and current are plotted on a graph.



a) What is the weight, in newtons, of the loop? (1 mark)

1.5 N

b) What is the slope of the best fit line? **(2 marks)**

drawing a reasonable line through *y*-axis and to, or beyond, last point **(1 mark)**

$\frac{\Delta F}{\Delta I} \approx 0.58 \, \frac{\text{N}}{\text{A}}$ or $0.58 \, \text{T} \cdot \text{m}$ **(1 mark)**

c) What is the magnitude of the magnetic field? **(2 marks)**

Since the best fit line is described by

$$F_{scale} = F_{mag} + F_g$$

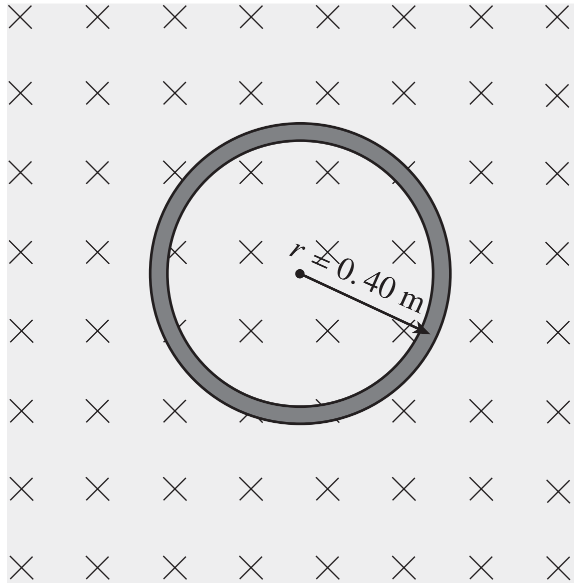
$$F_{scale} = B\ell(I) + F_g$$

the slope equals $B\ell$ ← **1 mark**

$\therefore 0.58 = B(0.060)$ ← **½ mark**

$B = 9.7 \text{ T}$ ← **½ mark**

7. 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)**

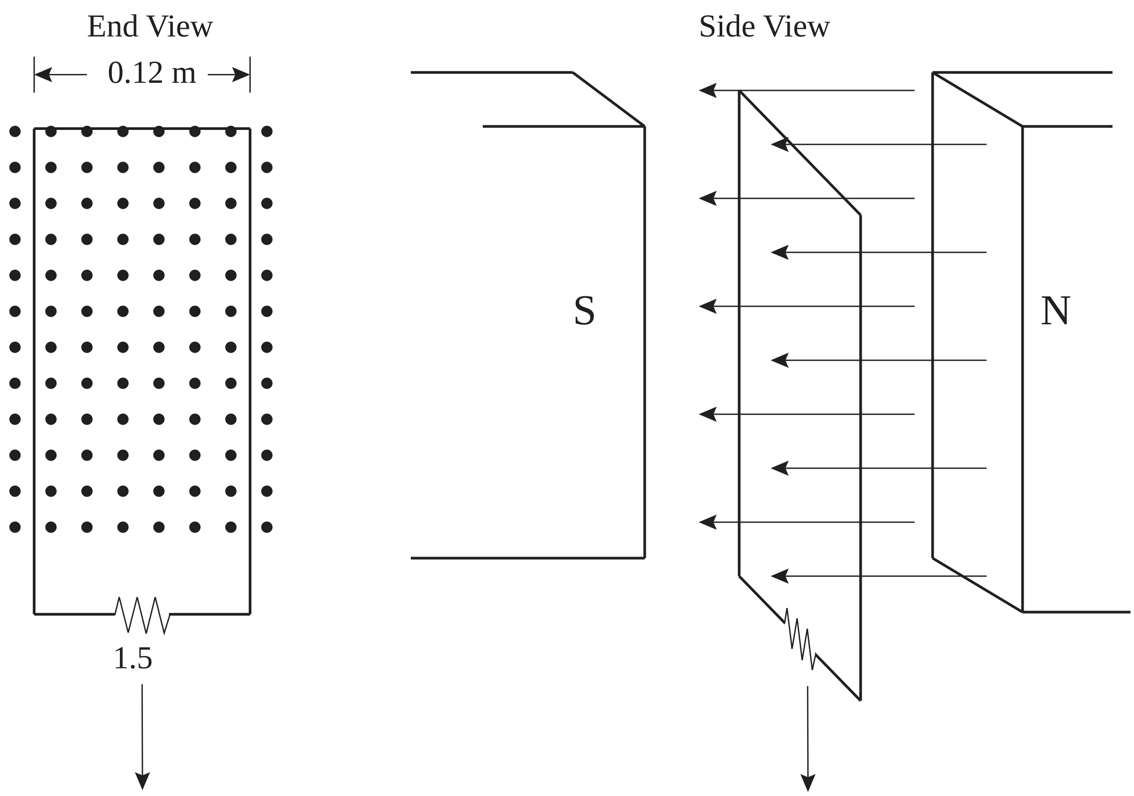
$$\varepsilon = \frac{-N\Delta\Phi}{\Delta t}$$ ← **1 mark**

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

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

$$= 8.4\ \text{V}$$ ← **1 mark**

8. A rectangular conducting loop of mass 4.5×10^{-2} kg and resistance 1.5 is dropped in the direction shown through a uniform horizontal magnetic field of 1.8 T. At what speed will this loop be falling through the magnetic field when it stops accelerating? **(7 marks)**



At what speed will this loop be falling through the magnetic field when it stops accelerating? **(7 marks)**

$a = 0$

$\therefore\ F_{net} = 0 \longrightarrow F_g = F_B$ ◄ **2 marks**

$mg = IlB$

$I = \dfrac{mg}{lB} = \dfrac{(4.5 \times 10^{-2}\ \text{kg})(9.8\ \text{m/s}^2)}{(0.12\ \text{m})(1.8\ \text{T})} = 2.04\ \text{A}$ ◄ **2 marks**

$\mathcal{E} = IR = (2.04\ \text{A})(1.5\ \Omega) = 3.06\ \text{V}$ ⟵ **1 mark**

$\mathcal{E} = Blv$ ► $v = \dfrac{\mathcal{E}}{Bl} = \dfrac{3.06\ \text{V}}{(1.8\ \text{T})(0.12\ \text{m})}$ ◄ **1 mark**

$= 14.2\ \text{m/s}$ ⟵ **1 mark**