11.1 Electromagnetic Induction

Question Paper

Course	DP IB Physics
Section	11. Electromagnetic Induction (HL only)
Topic	11.1 Electromagnetic Induction
Difficulty	Easy

Time allowed: 70

Score: /54

Percentage: /100

Question 1a

Faraday's law of electromagnetic induction can be written as:

$$\varepsilon = \frac{\Delta(N\phi)}{\Delta t}$$

(a)

(i)
Name the quantity represented by $\Delta(N\phi)$.

[1]

(ii)
State Faraday's law of electromagnetic induction in words.

[2]

[3 marks]

Question 1b

The table outlines the standard international (SI) units of the main quantities involved in electromagnetic induction.

Quantity	Symbol	SI unit
Magnetic flux	ϕ	
Magnetic flux linkage		Wb turns
Electromotive force		
Magnetic flux density	*B*	

(b)
Complete the table by filling in the missing symbols and SI units.

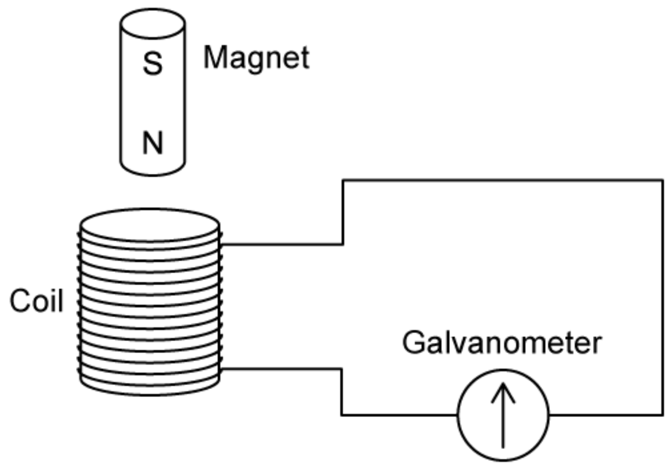
[4]

[4 marks]

Question 1c

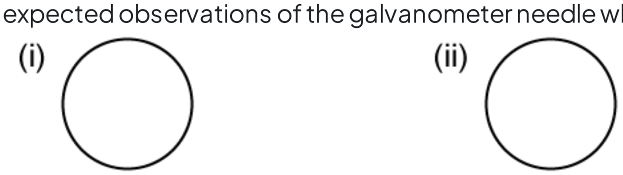
A galvanometer is an electromagnetic device that can measure small values of current by the deflection of a needle.

A coil is connected to a galvanometer centered at zero.



A magnet moves vertically into the coil so that the galvanometer deflects to the right as shown.

(c)
In the spaces provided, sketch the expected observations of the galvanometer needle when



(i)
The magnet is held at rest in the coil.

[1]

(ii)
The magnet is removed from the coil more quickly than it entered

[3]

[4 marks]

Question 1d

As the student removes the magnet from the coil, the galvanometer shows a constant value of 1.5 mV for 2.0 s.

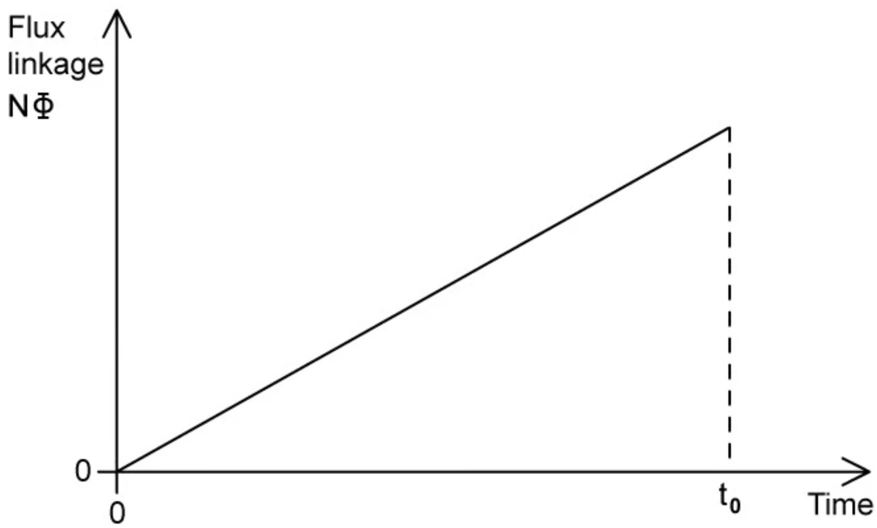
(d)
Calculate the change in magnetic flux linkage as the student removes the magnet from the coil.

[3]

[3 marks]

Question 2a

The graph shows how magnetic flux linkage $N\Phi$ passing through a coil of wire changes as time t progresses, as it moves into a uniform magnetic field.



(a)
State the quantity represented by the gradient of the graph.

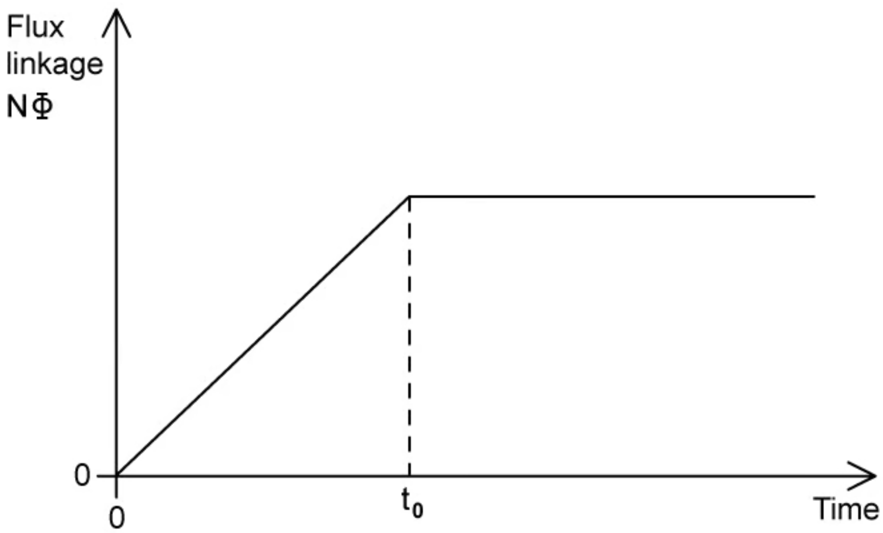
[1]

[1 mark]

Question 2b

After a certain amount of time the coil of wire in part (a) has fully entered the region of uniform magnetic field and moves normally to the flux density within it.

The graph in part (a) is continued so that the graph looks like:



(b)
State and explain the value of the induced emf in the coil of wire after time, t_0.

[2]

[2 marks]

Question 2c

The coil of wire in part (b) is made of 5000 turns of wire and has an area of 0.15 m^2. The uniform magnetic field has a field strength of 2.5 T and is perpendicular to the coil face, such that the angle between the normal line to the coil face and the flux lines is 0°.

(c)
Calculate the magnitude of the magnetic flux linkage through the coil in the uniform magnetic field.

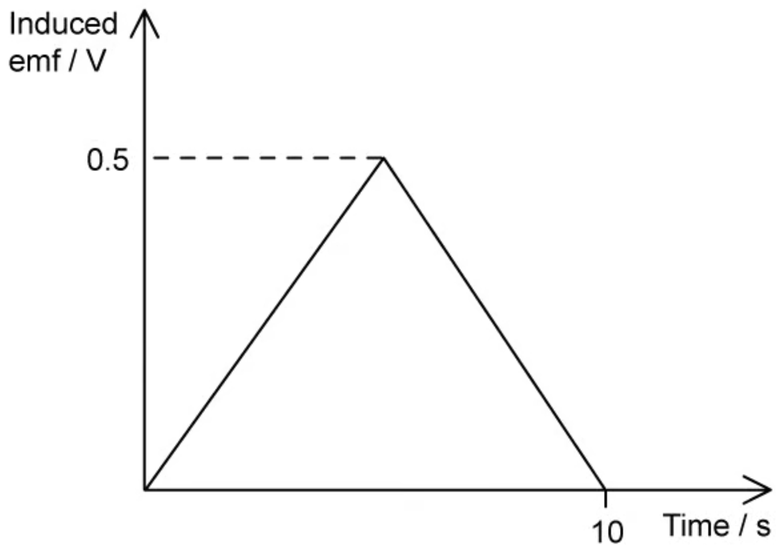
[2]

[2 marks]

Question 2d

(d)

The graph shows how the induced emf varies with time for a different coil of wire.



(i)

State the quantity represented by the area under the slope.

[1]

(ii)

Calculate the area under the slope, giving an appropriate unit with your answer.

[3]

[4 marks]

Question 3a

When a coil of wire rotates in a uniform magnetic field, the magnetic flux is given by the equation

$$\Phi = BA\cos(\theta)$$

(a)
State the meaning of the following symbols and an appropriate unit for each.

(i)
B

[1]

(ii)
A

[1]

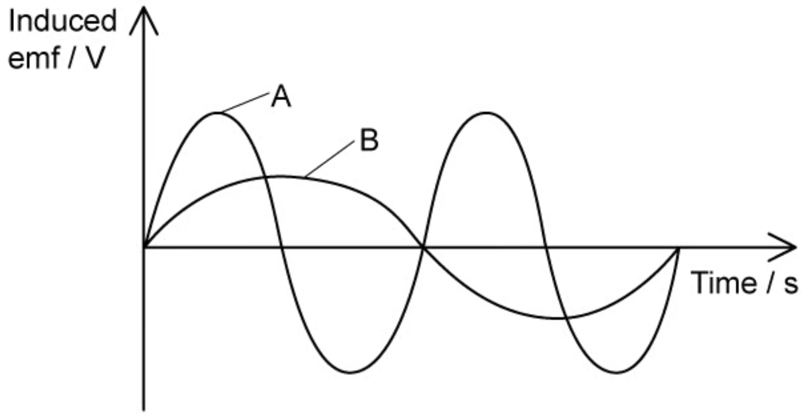
(iii) θ

[1]

[3 marks]

Question 3b

The graph represents the variation of induced emf over the progression of time for coils A and B which rotate in the same uniform magnetic field.



(a)
For coils A and B

(i)
State which of the two coils experiences the largest maximum induced emf.

[1]

(ii)
Hence, or otherwise, state which coil has a faster rate of rotation.

[1]

[2 marks]

Question 3c

Sometimes the equation $\Phi = BA\cos(\theta)$ is simplified to

$$\Phi = BA$$

(c)
State the relation between the coil and the magnetic field lines when the magnetic flux is simplified in this way.

[1]

[1 mark]

Question 3d

A rectangular coil with a magnetic flux of 0.15 mWb spins in a uniform magnetic field of flux density 0.50 mT.

(d)
Calculate the cross sectional area of the coil.

[4]

[4 marks]

Question 4a

Lenz's law is sometimes combined with Faraday's law in order to explain important electromagnetic effects.

(a)
Choose words from the list below to complete the sentence.

attract density direction linkage oppose

The ______ of an induced emf is always set up in such a way so as to ______ the change in magnetic flux ______ that causes it.

[3]

[3 marks]

Question 4b

Faraday's law can be combined with Lenz's law in the following mathematical equation

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

(a)
State which aspect(s) of the equation shown corresponds to

(i)
Faraday's law.

[1]

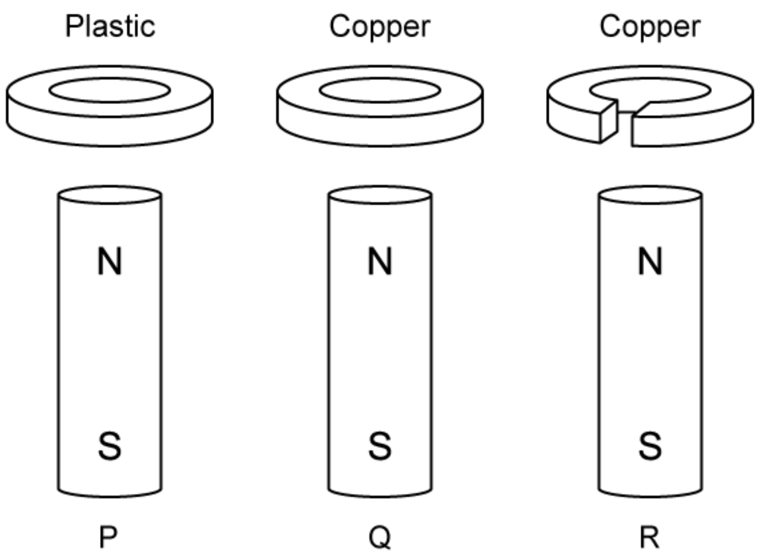
(ii)
Lenz's law.

[1]

[2 marks]

Question 4c

Bar magnets are arranged vertically, with each magnet having a ring of a different material suspended above it.



An analysis of the subsequent motion of each ring involves considering the type of material of each ring, how it is made, and how this affects any induced emfs or currents.

(c)
Respond with Y (yes) or N (no) in the table below to complete the analysis of the situation.

Ring	Conductor	Emf induced?	Current induced?
P	N	N	
Q	Y		
R	Y		

[5]

[5 marks]

Question 4d

Ring Q takes significantly longer to reach the bottom of the magnet compared to rings P and R.

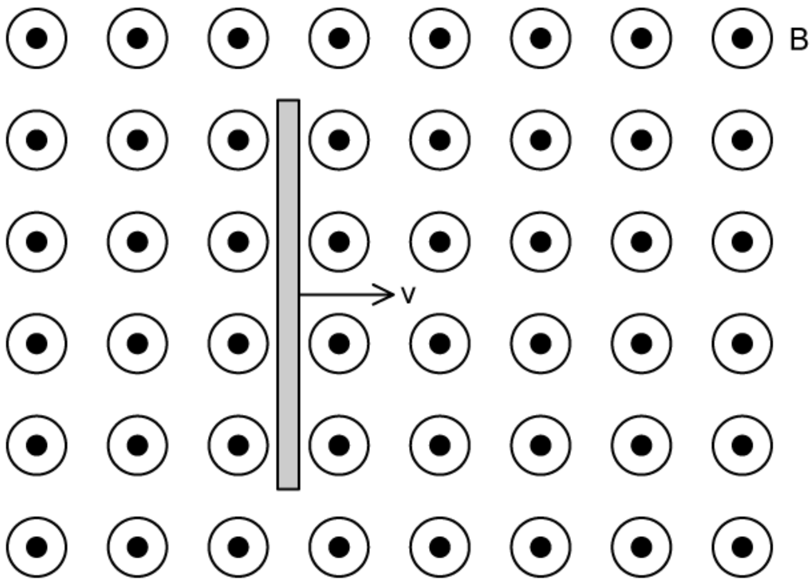
(d)
State the law of electromagnetic induction which explains this observation.

[1]

[1 mark]

Question 5a

A straight conductor of length l = 30 cm moves normally across a uniform magnetic field of flux density B = 2.0 T at a speed v.



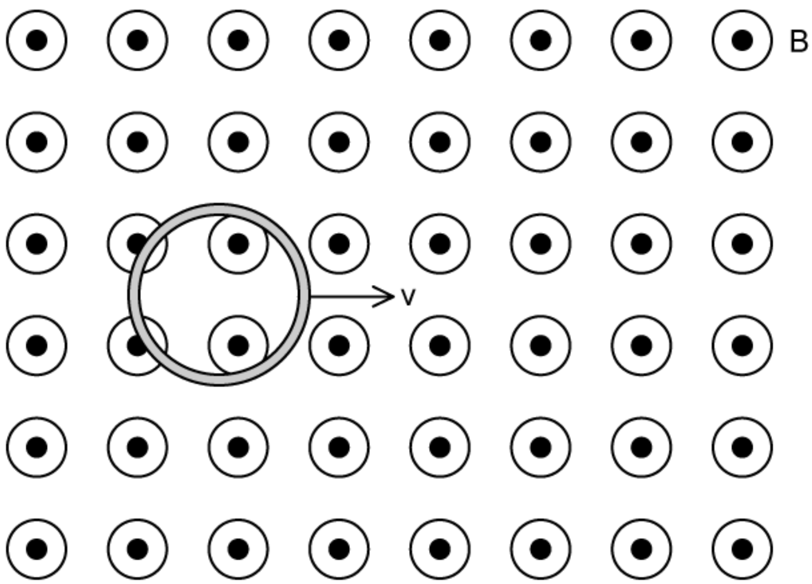
(a)
Calculate the speed v the conductor would need to have in order to induce an emf of magnitude 1.5 V.

[4]

[4 marks]

Question 5b

The conductor in the diagram is now bent into a single loop of wire and moves normally across the same uniform magnetic field at the same speed *v*, as shown.



The induced emf in the single loop of wire is now 0 V.

(b)
Explain why the induced emf in the single loop of wire is now 0 V.

[1]

[1 mark]

Question 5c

The single loop of wire shown in part (b) encloses an area of 7.2×10^{-3} m^2.

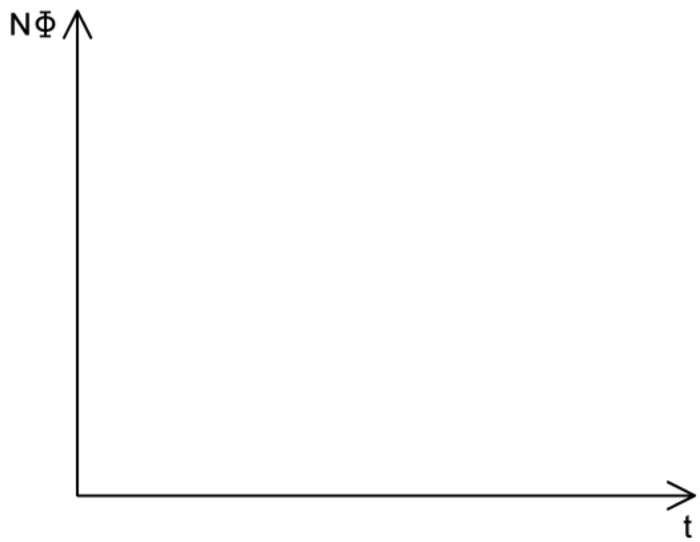
(c)
Calculate the magnetic flux through the single loop of wire.

[3]

[3 marks]

Question 5d

Sketch a graph on the axes provided below to show how the magnetic flux linkage $N\Phi$ varies with time t as the single loop of wire is removed entirely from the uniform magnetic field. Assume the speed v stays constant.



[2]

[2 marks]