# Electromagnetic Induction

## Mark Scheme 1

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|---|---|
| **Level** | International A Level |
| **Subject** | Physics |
| **Exam Board** | CIE |
| **Topic** | Electromagnetic Induction |
| **Sub Topic** | |
| **Paper Type** | Theory |
| **Booklet** | Mark Scheme 1 |

**Time Allowed:** **69 minutes**

**Score:** **/57**

**Percentage:** **/100**



| A* | A | B | C | D | E | U |
|---|---|---|---|---|---|---|
| >85% | '77.5% | 70% | 62.5% | 57.5% | 45% | <45% |

1 **(a) (i)** field shown as right to left — B1 [1]

**(ii)** lines are more spaced out at ends — B1 [1]

**(b)** Hall voltage depends on angle — M1
*either* between field and plane of probe
*or* maximum when field normal to plane of probe
*or* zero when field parallel to plane of probe — A1 [2]

**(c) (i)** (induced) e.m.f. proportional to rate — M1
of change of (magnetic) flux (linkage) — A1 [2]
(*allow rate of cutting of flux*)

**(ii)** e.g. move coil towards/away from solenoid
rotate coil
vary current in solenoid
insert iron core into solenoid
(*any three sensible suggestions, 1 each*) — B [3]

2 **(a) (i)** region (of space)
*either* where a moving charge (may) experience a force
*or* around a magnet where another magnet experiences a force — B1 [1]

**(ii)** ($\Phi$ =) $BA \sin\theta$ — A1 [1]

**(b) (i)** plane of frame is always parallel to $B_V$ / flux linkage always zero — B1 [1]

**(ii)** $\Delta\Phi = 1.8 \times 10^{-5} \times 52 \times 10^{-2} \times 95 \times 10^{-2}$ — C1
$= 8.9 \times 10^{-6}$ Wb — A1 [2]

**(c) (** (induced) e.m.f. proportional to rate of — M1
change of (magnetic) flux (linkage) — A1 [2]
(*allow rate of cutting of flux*)

**(ii)** e.m.f. $= (8.9 \times 10^{-6}) / 0.30$
$= 3.0 \times 10^{-5}$ V — A1 [1]

**(iii)** This question part was removed from the assessment. All candidates were awarded 1 mark. — B1 [1]

| | | | | | |
|---|---|---|---|---|---|
| 3 | **(a** | (uniform magnetic) flux normal to long (straight) wire carrying a current of 1 A<br>(creates) force per unit length of $1\,N\,m^{-1}$ | | M1<br>A1 | [2] |
| | **(b)** | **(** flux density $= 4\pi \times 10^{-7} \times 1.5 \times 10^{3} \times 3.5$<br>$= 6.6 \times 10^{-3}\,T$ | | C1<br>A | [2] |
| | | **(ii)** flux linkage $= 6.6 \times 10^{-3} \times 28 \times 10^{-4} \times 160$<br>$= 3.0 \times 10^{-3}\,Wb$ | | C1 | [2] |
| | **(c)** | **(** (induced) e.m.f. proportional to rate of<br>change of (magnetic) flux (linkage) | | M1<br>A1 | [2] |
| | | **(ii)** e.m.f. $= (2 \times 3.0 \times 10^{-3}) / 0.80$<br>$= 7.4 \times 10^{-3}\,V$ | | C1<br>A | [2] |
| 4 | **(a** | *either* $\phi = BA \sin\theta$<br>where $A$ is the area (through which flux passes)<br>$\theta$ is the angle between $B$ and (plane of) $A$<br>*or*<br>$\phi = BA$<br>where $A$ is area normal to $B$ | | M1<br>A1<br>(M1)<br>(A1) | [2] |
| | **(b)** | graph: $V_H$ constant and non zero between the poles and zero outside<br>sharp increase/decrease at ends of magnet | | M1<br>A1 | [2] |
| | **(c)** | **(i)** (induced) e.m.f. proportional to<br>rate of change of (magnetic) flux (linkage) | | M1<br>A1 | [2] |
| | | **(ii)** short pulse on entering and on leaving region between poles<br>pulses approximately the same shape but opposite polarities<br>e.m.f. zero between poles and outsi | | M1<br>A1<br>A1 | [3] |

5 (a) (i) (induced) e.m.f. proportional to — M1
rate of change of (magnetic) flux (linkage)/ rate of flux cutting — A1 [2]

(ii) 1. moving magnet causes change of flux linkage — B1 [1]
2. speed of magnet varies so varying rate of change of flux — B1 [1]
3. magnet changes direction of motion (so current changes direction) — B1 [1]

(b) period= 0.75s — C1
frequency= 1.33 Hz — A1 [2]

(c) graph: smooth correctly shaped curve with peak at f₀ — M1
*A* never zero — A1 [2]

(d) (i) resonance — B1 [1]

(ii) e.g. quartz crystal for timing/ production of ultrasound — A1 [1]

6 **(a** magnetic flux = $BA$
$= 89 \times 10^{-3} \times 5.0 \times 10^{-2} \times 2.4 \times 10^{-2}$ — C1
$= 1.07 \times 10^{-4}$ Wb — A1 [2]

**(b) (i)** e.m.f. = $\Delta\phi / \Delta t$ — C1
(for $\Delta\phi$ = $1.07 \times 10^{-4}$ Wb), $\Delta t = 2.4 \times 10^{-2} / 1.8 = 1.33 \times 10^{-2}$ s — C1
e.m.f. = $(1.07 \times 10^{-4}) / (1.33 \times 10^{-2})$
$= 8.0 \times 10^{-3}$ V — A1 [3]

**(ii)** current = $8.0 \times 10^{-3} / 0.12$ — M1
$\approx$ 70 mA — A0 [1]

**(c)** force on wire = $BIL$
$= 89 \times 10^{-3} \times 70 \times 10^{-3} \times 5.0 \times 10^{-2}$ — C1
$\approx 3 \times 10^{-4}$ (N) — M1
suitable comment e.g. this force is too / very small (to be felt) — A1 [3]