Questions on Electromagnetism MS

1. <u>How torch works and factors which affect brightness</u>

At least two lines leaving N and S pole, diverging and crossing wires **(1)**

Arrow leaving N pole/towards S pole **(1)**

Field/flux lines cut wires **(1)**

$\rightarrow$ changing B/ϕ OR $\frac{d\phi}{dt}$ OR Faraday's law causes *V or I* **(1)**

If causes *V* followed by causes *I* **(1)**

Any two of rotation, field strength, number of coils **(1)**

Appropriate direction e.g. faster rotation brighter/more *V*/*I* **(1)**

$R\downarrow \Rightarrow$ brighter **(1)**

[Max 6]

2. <u>How movement of magnet produces voltage shown on c.r.o screen</u>

Any 4 from:

- Boxes correct
- Mention of Faraday's law/equation/word description
- Flux max when magnet vertical / box 1 / box 3
- Flux zero when magnet horizontal / box 2 / box 4

When flux max, not changing, $V = 0$

When flux changing fastest, *V* max

Appropriate comment about sense of voltage, e.g.,
when poles reversed, V reversed 4

<u>Differences between figures (i) and (ii)</u>

Qualitative points: (max 2)

(Faster turning, giving) $\frac{d\phi}{dt}\uparrow$ **(1)**

$= V\uparrow$ and $f\uparrow$ OR $T\downarrow$ **(1)**

OR

Quantitative points: (max 3)

($f \times 2 =$) $\frac{d\phi}{dt}$ (max) $\times 2$ **(1)**

$= V \times 2$ **(1)**

$f \times 2$ (OR $T \div 2$) **(1)** 3

Flux at each end of magnet

Area 1 big square = 100 μ(Vs) or 100 × 10^{-6} (Vs)

OR area of 1 little square = 4 μ(Vs) or 4 × 10^{-6} (Vs)

OR area = 32 little squares (29 – 35)

OR area = 4/3 big squares (1.2 – 1.4) **(1)**

Area = 130 × 10^{-6} (Vs) (120 – 140) **(1)**

Φ = Area / 2 × 240

= 2.7 × 10^{-7} Wb (2.5 – 2.9) **(1)** 3

Magnetic flux density at end of bar magnet

$B = \Phi/A$ OR $\Phi = BA$ OR A = 0.01 × 0.005 OR A = 5 × 10^{-5} m^2 **(1)**

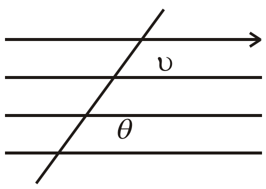
= 3.0 × 10^{-7} / 5.0 × 10^{-5}

= 6.0 × 10^{-3} T (accept Wb m^{-2}) **(1)** 2

[12]

3. Situation to which equation refers

F = force on particle **(1)**



B = (magnetic) flux density/field strength **(1)**

υ = velocity/speed of particle
q = charge of particle } **(1)**

θ = angle between *B* and υ/motion /current **(1)**

F is perpendicular to *B* and *υ* **(1)**

[Some of these may be shown by diagram] Max 4

Description of situation modelled by equation

Curved/circular motion of particle **(1)**

p = momentum **(1)** 2

Why path of a particle is curved

Charged particles **(1)**

with (component of) motion perpendicular to field **(1)**

Force perpendicular to motion/ Fleming's L.H. rule **(1)** Max 2

Why spiralling path decreases as it nears North Pole

Nearer pole → field stronger **(1)**

Reference to $r = p(m\upsilon)/Bq$ OR $r \propto 1/B$

OR B increasing → centripetal/inward *F* increases

Alternative: $\upsilon\downarrow$ due to resistive force **(1)**

Reference to $r = p(m\upsilon)/Bq$ OR $r \propto p/\upsilon$ 2

[10]

4. Use of device as either generator or motor

Motor:

B field + current (d.c.)	current (d.c.) + coil magnetised **(1)**
Forces on coil	magnetic fields interact **(1)**

Forces rotate coil **(1)**

Current reversed by commutator (when coil vertical) **(1)**

Continuous rotation (same direction) **(1)** — Max 4

Generator:

Coil rotated **(1)**

Coil cuts field lines/d φ/d*t* **(1)**

V induced (across ends of coil) **(1)**

d.c. **(1)**

Since connections change as cutting changes/due to commutator **(1)** — Max 4

Change:

e.g. magnets to wrap round more space/coil to be on iron cylinder/

more turns/stronger magnets (electromagnets)/

more coils set at angles **(1)** — 1

[7]

5. (a) The origin of the induced e.m.f:

Faraday's law **(1)**

As conductor cuts field lines **(1)**

Electrons experience force along wire **(1)**

⇒ move to one end ⇒ e.m.f. **(1)** — 3

b) Reduction in orbit height due to flow of current:

Current + field ⇒force OR Fleming L H rule **(1)**

Lenz's law: **(1)**

Force opposes motion **(1)**

Orbiting craft lose energy/speed **(1)** — 3

[Max 5]

6. Area = $l\upsilon\Delta t$ **(1)**

$\Delta \Phi = Bl\upsilon\Delta t$ **(1)** — 2

$E = \Delta\Phi/\Delta t = Bl\upsilon$ **(1)** — 1

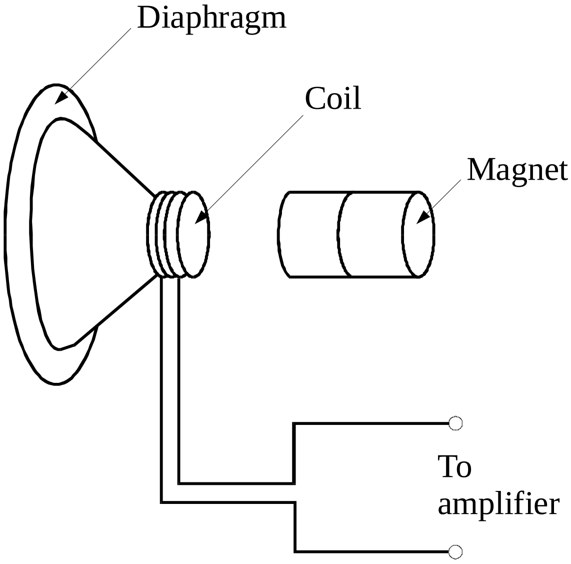
$\upsilon = E/Bl$ **(1)**

$= 5000 \text{ V}/((3.2 \times 10^{-5} \text{ T}) \times (20.7 \times 10^{3} \text{ m})$

$= 7.5 \times 10^{3} \text{ m s}^{-1}$ **(1)** — 2

[5]

7. An induction microphone converts sound waves into electrical signals which can be amplified.



Describe the stages by which the sound waves are converted into electrical signals.
State whether the signals are a.c. or d.c.

Some reference to the movement in the sound wave eg air molecules oscillate/compressions and rarefactions (1)

diaphragm vibrates/equivalent (1)

coil moves (1)

cuts field lines/change in flux linkage (1)

induction occurs (1)

a.c. signals (1)

(6 marks)

If the alternating output from a signal generator were fed into the microphone, describe and explain what would happen to the diaphragm.

diaphragm moves ↔ (1)

changing field in coil or

current in a conductor in a magnetic field (1)

interacts with magnet's field or

experiences a force at right angles/left hand rule/ equivalent (1)

(3 marks)
[Total 9 marks]

8. <u>Explanation</u>

AC/changing current in the primary **(1)**

Produces a changing *B* field **(1)**

B field carried through core (to secondary) **(1)**

Changing *B* field over secondary induces emf **(1)**

Rate of change of flux linkage is less through secondary OR emf induced across sec. is less because it has less turns than primary OR <u>explanation</u> in terms of the turns ratio formula **(1)**

Quality of written communication **(1)** 6

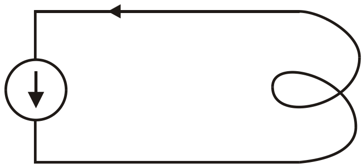
[6]

9. Lenz's law

The direction of an induced current/emf/voltage is such as **(1)**
to oppose the change (in flux) that produces it **(1)** 2

Polarity at top of coil

North **(1)**
Direction of current



Only ONE arrow required **(1)** 2

Graph

Magnet is moving faster / accelerating (under gravity) **(1)**

(Rate of) change/ cutting of flux is greater **(1)**

Induced emf is greater **(1)** Max 2

[6]

10. Action of transformer

Quality of written communication **(1)** 1

a.c. input/changing current **(1)**

Flux linkage to secondary through core/B field carried through core **(1)**

Induced e.m.f. (in secondary)

Any one from:

Varying magnetic field (in primary)

Changing B field acts over secondary

Flux linkage is greater **(1)** 5

Output voltage of the transformer

$\frac{100}{1200} \times 240\text{V}$ **(1)**

= 20V [Correct answer only] **(1)** 2

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11. Electrical property of blade

Resistance [Not resistivity] 1

Law of electromagnetic induction

The (magnitude of the) induced emf is equal to/proportional to 1

the rate of change of flux (linkage) 1

[Word equation can score two marks]

Explanation of damping

Quality of written communication — 1

E.m.f. induced (in blade) because flux linked (with blade) changes /
lines of force are cut (by blade) — 1

Large with reference to (induced) current or (induced) magnetic field — 1

Any one from:

- The two magnetic fields produce an opposing force (to motion)
- blade has low resistance current is induced
- current produces thermal energy
- kinetic energy/total energy is transferred to thermal energy — 1

Blade B

Smaller (eddy) currents (induced) in blade B / weaker field created around blade B — 1

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12. Why large voltage is generated in secondary circuit:

Faraday's Law in words including 'flux linkage'

Current flow in primary **(1)**

causes magnetic flux in core **(1)**

Flux links secondary **(1)**

Opening switch S causes flux to reduce **(1)**

Changing flux in. secondary induces e.m.f **(1)**

Many turns on secondary means large flux linkage **(1)**

Hence rate of change of flux linkage is large

reduction time is short **(1)**

Hence induced e.m.f. is large **(1)** — Max 6

[6]

13. How e.m.f is induced]

I in one coil $\rightarrow \phi$ linking other

Change in $I \rightarrow$ change in ϕ

V caused by $\frac{d\varphi}{dt}$ [OR quote Faraday] — 3

Function of transformer:

steps down **(1)**

by factor of $16\left(\frac{32}{512}\right)$ — 2

Explanation of current:

Power is same in both coils or $P = VI$ **(1)**

32-turn coil has lower V hence higher I — 2

Why coil is made with much thicker wire

Heat generated per second = RI^2 or need to reduce heating **(1)**

(Big *I*) needs low R OR lots of metal OR large cross-section (hence thicker wire) (accept last 2 only if linked to heating) 2

Why coil is made of thin laminated sheets of soft iron:

Any three of:

- Laminated - reduces eddy currents
- Thin - reduces them further
- Eddy currents lead to energy loss
- Soft iron - easily magnetised / demagnetised
- Soft iron - strengthens flux
- Eddy currents - caused by e.m.i 3

[12]

14. Explanation of why resultant flux in iron core is zero

Same current (in both coils) OR same turns **(1)**

Wound opposite ways **(1)** 2

OR leading to cancelling of magnetic effects

Explanation of how RCCB breaks circuit

Any five from:

Different currents give different (noncancelling) effects **(1)**

$\therefore$ net B OR ϕ/B $\neq 0$ **(1)**

Faraday/changing ϕ/B **(1)**

$\Rightarrow$ *V* induced in third coil ["*I* induced" is 4th **(1)** only] **(1)**

$\Rightarrow$ *I* in third coil/relay coil **(1)**

$\Rightarrow$ relay coil magnetized **(1)**

$\Rightarrow$ relay contact opens **(1)** Max 5

[7]

15. (a) Advantage of avoiding metal contacts

Any one from:

- makes possible a sealed unit
- avoids electrocution
- stops corrosion (by water)
- water cannot enter/short contacts **(1)** 1

(b) How arrangement is able to charge the battery

Any six from:

1. current (in X) produces magnetic field
2. field links second coil
3. metal = iron
4. metal core increases field

5. field changes/alternates
6. changing ϕ/B or $d\phi/dt$ or Faraday induces/causes V
7. V causes I
8. diode needed (or a.c. so won't charge)
9. field penetrates plastic
10. like a transformer / X is a primary and Y is a secondary
11. electromagnetic induction Max 6

[7]