10 Marking scheme: Worksheet

1 a i Magnetic flux, $\phi = BA$ [1]

ii Flux linkage = $N\phi = NBA$ [1]

b Flux linkage = $N(B \cos \theta)A = NBA \cos \theta$ [1]

(The component of B normal to the plane of the coil is $B\cos \theta$.)

2 Area A of coil = x^2 [1]

flux linkage = $NBA = NBx^2$ [1]

3 a There is no change to the magnetic flux linking the coil, hence according to Faraday's law, there is no induced e.m.f. [1]

b The magnetic flux density B increases as the magnet moves towards the coil. [1]

There is an increase in the magnetic flux linking the coil, hence an e.m.f. is induced across the ends of the coil. [1]

4 a Flux linkage = NBA so $B = \dfrac{\text{flux linkage}}{NA}$ [1]

$B = \dfrac{1.4 \times 10^{-4}}{70 \times 4.0 \times 10^{-4}}$ [1]

$B = 5.0 \times 10^{-3}$ T [1]

b Flux linkage = $NBA \cos \theta$ [1]

flux linkage = $70 \times 0.050 \times 4.0 \times 10^{-4} \times \cos 60°$ [1]

flux linkage = 7.0×10^{-4} Wb [1]

5 a i Magnetic flux, $\phi = BA = 40 \times 10^{-3} \times (0.03 \times 0.03)$ [1]

$\phi = 3.6 \times 10^{-5}$ Wb [1]

ii Flux linkage = $N\phi = 200 \times 3.6 \times 10^{-5}$ [1]

flux linkage = 7.2×10^{-3} Wb [1]

b Final flux linkage = 0, initial flux linkage = 7.2×10^{-3} Wb [1]

Hence, change in magnetic flux linkage is 7.2×10^{-3} Wb. [1]

6 a Initial magnetic flux = $BA = 0.15 \times (\pi \times [8.0 \times 10^{-3}]^2)$ [1]

initial magnetic flux = 3.02×10^{-5} Wb [1]

final magnetic flux = 0 [1]

average magnitude of induced e.m.f. = rate of change of magnetic flux linkage

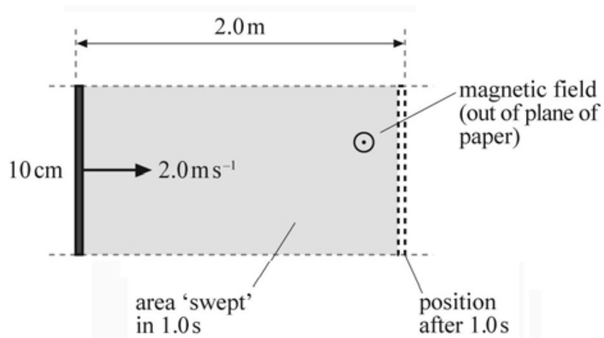
$E = N\dfrac{\Delta\phi}{\Delta t}$, so $E = 1200 \times \dfrac{0 - 3.02 \times 10^{-5}}{0.020}$ [1]

$E = 1.81\text{ V} \approx 1.8\text{ V}$ (magnitude only) [1]

b Average current = $\dfrac{\text{e.m.f.}}{\text{resistance}} = \dfrac{1.81}{6.3}$ [1]

$I = 0.287\text{ A} \approx 0.29\text{ A}$ [1]

7 a Distance = speed × time = 2.0 × 1.0 = 2.0 m [1]



b Area swept = length × distance travelled = 0.10 × 2.0 = 0.20 m^2 [1]

c Change in magnetic flux = area swept × magnetic flux density [1]
change in magnetic flux = 0.20 × 0.050 = 1.0×10^{-2} Wb [1]

d Magnitude of e.m.f. = rate of change of magnetic flux linkage [1]

$$E = \frac{\Delta(N\phi)}{\Delta t} \quad (N = 1)$$

$$E = \frac{1.0\times10^{-2}}{1.0} = 1.0 \times 10^{-2}\text{ V} \quad (1\text{ Wb s}^{-1} = 1\text{ V})$$ [1]

e $E = BvL = 0.050 \times 2.0 \times 0.10 = 1.0 \times 10^{-2}$ V [1]

8 Initial magnetic flux = $BA = 0.060 \times \pi \times (1.2 \times 10^{-2})^2$ [1]
initial magnetic flux = 2.72×10^{-5} Wb [1]
final magnetic flux = -2.72×10^{-5} Wb (since the field is reversed) [1]
average magnitude of induced e.m.f. = rate of change of magnetic flux linkage

$$E = N\frac{\Delta\phi}{\Delta t}\text{, so } E = 2000 \times \frac{-2.72\times10^{-5} - 2.72\times10^{-5}}{0.030}$$ [1]

$E = 3.62$ V ≈ 3.6 V (magnitude only) [1]

9 **a** There is a current in the primary coil when the switch is closed. This current creates a magnetic flux in the primary coil. [1]
Due to the soft iron ring, the magnetic flux created by the primary coil also links the secondary coil. With the switch closed, there is no change in the magnetic flux linkage at the secondary and hence the lamp is not lit. [1]
When the switch is opened, the magnetic flux decreases to zero in a short period.
The rapid change in magnetic flux at the secondary coil creates an e.m.f. and the lamp illuminates for a short period. [1]
Eventually there is no magnetic flux at the primary or secondary coils and hence there is no e.m.f. induced – the lamp stays off. [1]

b **i** $P = VI$ [1]

$$I = \frac{P}{V} = \frac{24}{6.0} = 4.0\text{ A}$$ [1]

ii According to the turns-ratio equation: $\frac{6.0}{V_p} = \frac{30}{1150}$ [1]

$$V_p = 6.0 \times \frac{1150}{30} \approx 230\text{ V}$$ [1]

10 **a** **i** Time taken = $\frac{\text{distance}}{\text{speed}} = \frac{0.02}{0.50} = 4.0 \times 10^{-2}$ s [1]

ii Flux linkage = $NBA = 150 \times 0.30 \times (0.02 \times 0.02)$ [1]
flux linkage = 1.8×10^{-2} Wb [1]

b The rate of change of magnetic flux is constant. [1]

c Initial flux linkage = 0 and final flux linkage = 1.8×10^{-2} Wb [1]
magnitude of induced e.m.f. = rate of change of magnetic flux linkage [1]

$$E = \frac{1.8\times10^{-2} - 0}{4.0\times10^{-2}}$$ [1]

$E = 0.45$ V (magnitude only) [1]

d When the coil is completely within the field, the induced e.m.f. is zero. [1]
The reason for this is that there is no change in the magnetic flux linkage. [1]

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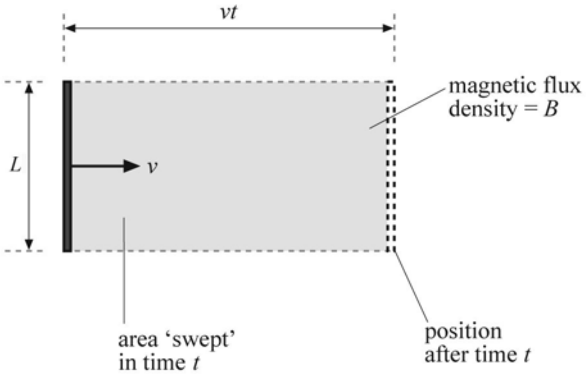

Distance = speed × time = vt	[1]
area swept = length × distance travelled = Lvt	[1]
change in magnetic flux = area swept × magnetic flux density	[1]
change in magnetic flux = $(Lvt) \times B = BLvt$	[1]
magnitude of e.m.f. = rate of change of magnetic flux linkage	[1]
$E = \frac{BLvt}{t} = BLv$	[1]
$E = BLv = 40 \times 10^{-6} \times 0.20 \times 0.30$	[1]
$E = 2.4 \times 10^{-6}$ V (2.4 μV)	[1]