Solutions for Topic 11 – Electromagnetic induction (AHL)

1. a) (i) M shown at peak or trough

(ii) Z shown on t-axis

b) by Lenz's law, emf (or current) must change direction as flux cutting changes direction as magnet oscillates, flux is cut in opposite directions

2. $BS \sin \phi$

3. a) induced e.m.f. proportional to rate of change of magnetic flux linkage as current increases, magnetic field in coil increases thus change in flux linkage and e.m.f. induced

b) direction of induced e.m.f. such as to tend to oppose the change producing it induced e.m.f. must oppose e.m.f. of battery / growth of current in circuit

c) energy is supplied by the battery in making charge move against the induced e.m.f.

4. a) magnetic flux through coil will change as the current changes

b) (i) sinusoidal and in phase with current

(ii) sinusoidal and same frequency with 90° phase difference to candidate's graph for ϕ

(iii) emf is reduced because B is smaller

c) advantage: no direct contact with cable required
disadvantage: distance to wire must be fixed

5. a) for e.m.f. to be induced in secondary, flux must be changing *in the core* changing flux is caused by varying current in primary

b) induced currents in core are kept small to reduce heating/energy losses

c) use of $\frac{N_s}{N_p} = \frac{V_s}{V_p}$

to give $N_P = 8600$ turns

and $I_p \left(= \frac{42}{230}\right) = 180$ mA

6. At 25 s pd has fallen to 4 V. Therefore $4 = 12e - \frac{t}{R \times 220\mu F}$

$\ln 0.333 = -\frac{t}{R \times 220\mu F}$ and $R = -\frac{25}{\ln 0.333 \times 2.2 \times 10^{-4}}$

$= 100$ kΩ

7. a) (i) 65 s – 70 s

(ii) $RC = 95$ s

$R = 470$ kΩ

(iii) $I = V/R$

$23.5 \rightarrow 26\ \mu$A

b) (i) $\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2}$

67μF

(ii) curve aiming for 12 V Ω

t value about 0.3 of original Ω

8. a) (i) 1 μC of charge per volt.

(ii) straight line through the origin
line up to (6, 1μC)

(iii) read charge and pd from the graph

energy $= \frac{1}{2} QV$

b) (i) use of $0.5\ CV^2 \Omega$

9.4 J Ω

(ii) energy output $= mgh = 0.25 \times 9.8 \times 0.90 = 2.2$ J

efficiency = useful power out / power input

efficiency $= \frac{2.2}{9.4} = 24\ \%$

9. charge stored = 20 μC

energy stored $= 0.5 \times 20\ \mu\text{C} \times 10^2 = 1$ mJ

10. a) correct curvature starting at 6 V at time = 0

points plotted correctly at 3 and 6 minutes with reasonable curve (2.2 V and 0.8 V)

b) time alarm rings read correctly from the graph at 3 V

c) $R = \frac{180}{2.2 \times 10^{-3}}$

82 kΩ

d) $3 = 9\ e^{\frac{-300}{CR}}$

120 kΩ

e) replace capacitor with one of higher value

11. a) the capacitance is smaller time constant is lower

b) (i) time to fall to $\frac{1}{e} = 29$ s

$t_{\frac{1}{2}} = 0.69\ C\ R$

132 kΩ

(ii) total $C = 68 - 74\ \mu$F

use of $\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2}$

99 – 111 μF

12. a) (i) $Q = CV$

33 μF

(ii) series combination = 15 μF

18 μF

(iii) uses ratio idea

9.0 V

b) (i) $\frac{V_0}{2} = V_0 e^{-\frac{t}{CR}}$

time to halve = 3.6 s

(ii) $V = V_0 e^{-\frac{t}{CR}}$

2.6 V

13. a) $C = \frac{\varepsilon_0 \varepsilon_r A}{d}$

$A = 4.7 \times 10^{-3}\ \text{m}^2$

76 mm

b) $E = \frac{1}{2} C\ V^2$

4.1×10^{-10} J