Answers to exam-style questions

Topic 11

Where appropriate, 1 ✓ = 1 mark

1 Constant and counter-clockwise. There is an error in the options for this question.

2 D

3 A

4 B

5 B

6 B

7 C

8 A

9 D

10 D

11 **a** As the magnet gets closer to the top of the coil the magnetic field at the coil increases. ✓
Hence the magnetic flux though the coil increases. ✓
By Faraday's law, a changing flux indices an emf. ✓

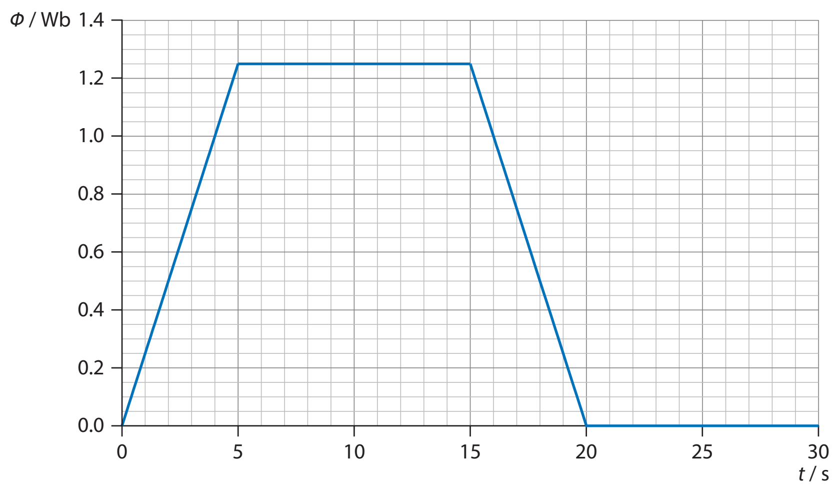
b **i** From C to D the magnet is moving faster than from A to B. ✓
Hence the rate of change of flux, and therefore emf, is higher. ✓

ii Since the magnet moves faster it takes less time to move past the magnet. ✓

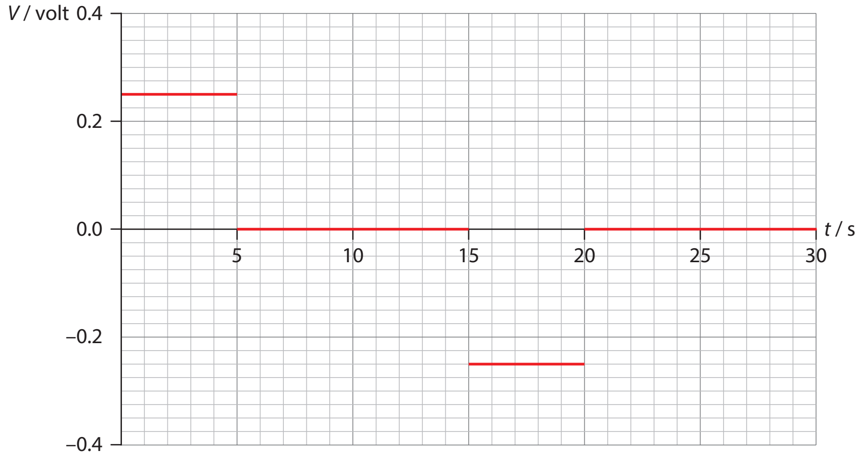
c **i** The graph is a graph of emf versus time, i.e. $\frac{d\Phi}{dt}$ versus time. ✓
So the area is the change in flux. ✓

ii The area from A to B is the change in flux from when the magnetic is very far away until it is essentially in the middle of the coil. ✓
The area from C to D is the exact opposite and so the areas are the same (in magnitude). ✓

12 **a** **i** Correct shape. ✓
Correct values of time. ✓
Correct values of flux. ✓



ii Correct shape. ✓
Correct values of time. ✓
Correct values of voltage. ✓



b i The induced current is $\frac{0.25}{0.75} = 0.333$ A. ✓

The magnetic force acting on the loop while entering or leaving the region of magnetic field is $F = NBIL = 50 \times 0.40 \times 0.333 \times 0.25 = 1.665$ N. ✓

Hence the power is pushing the loop through is $P = Fv = 1.665 \times 0.050 = 0.83$ W. ✓

ii This is power that is dissipated as thermal energy. ✓
In the cables of the coil. ✓

13 a i From $P = VI$ the current is he current is $I = \frac{P}{V} = \frac{120 \times 10^3}{240} = 500$ A. ✓

And so the power lost in the cables is $P = RI^2 = 0.80 \times 500^2 = 200$ kW. ✓

ii The power that must be supplied by the wind generator is 320 kW. ✓

And so the voltage is $V = \frac{P}{I} = \frac{320 \times 10^3}{500} = 640$ V. ✓

iii The efficiency is $e = \frac{\text{useful power}}{\text{input power}} = \frac{120}{320} = 0.375 \approx 0.38$. ✓

b The current would be 10 smaller. ✓
And so the power loss 100 times smaller i.e. 2.0 kW. ✓

c i The peak voltage is 340 V and so the rms voltage is $\frac{340}{\sqrt{2}} = 240.4 \approx 240$ V. ✓

ii $\overline{P} = V_{\text{rms}} I_{\text{rms}} = 18 \times 10^3$ W hence $I_{\text{rms}} = \frac{18 \times 10^3}{240} = 75$ A. ✓

Hence $I_{\text{peak}} = 75 \times \sqrt{2} = 106 \approx 110$ A. ✓

d i The alternating current in the primary coil produces an alternating magnetic field. ✓
The iron core confines the magnetic field lines within the core and hence into the secondary. ✓
Because the field is alternating the magnetic flux in the secondary coils varies with time. ✓
And hence by Faraday's law an emf is induced in the secondary coil. ✓

ii The magnetic field in the core creates small currents in the core by exerting magnetic forces on electrons. ✓
These currents dissipate energy as thermal energy in the core due to collisions with the core atoms. ✓

14 a i Capacitance is the charge per unit voltage that can be stored on one of the capacitor plates. ✓

ii Capacitors definitely store energy (which, for example, can be used to light up a light bulb connected to the capacitor as it discharges through the bulb). ✓

Whether it can store charge is a question of definition: the net charge is zero since the plates have equal and opposite charge so in that sense it does not store charge but it does store equal and opposite charges on <u>each</u> plate. ✓

b X and Y are in parallel so they correspond to a total capacitance of 360 pF. ✓

This and Z are in series so they correspond t an overall total of $\frac{1}{360}+\frac{1}{180}=\frac{3}{360}=\frac{1}{120}$, i.e. 120 pF. ✓

c i The charge on a plate of the total capacitor is $Q=C_{\text{total}}V=120\times10^{-12}\times12=1.44\times10^{-9}$ C. ✓

And this is the same as the charge on Z. ✓

ii $V=\frac{Q}{C_Z}=\frac{1.44\times10^{-9}}{180\times10^{-12}}=8.0$ V ✓

iii The potential difference across X is 4.0 V. ✓

And the charge is then $Q=C_XV=180\times10^{-12}\times4.0=7.2\times10^{-10}$ C. ✓

15 a An ideal voltmeter has infinite resistance. ✓

And so no charge can move through it, hence no current. ✓

b i $C=\varepsilon_0\frac{A}{d}=8.85\times10^{-12}\times\frac{0.68}{4.0\times10^{-3}}$ ✓

$C=1.5\times10^{-9}$ F ✓

ii $Q=CV=1.5\times10^{-9}\times9.0$ ✓

$Q=1.35\times10^{-8}$ C ✓

iii $E=\frac{1}{2}CV^2=\frac{1}{2}\times1.5\times10^{-9}\times9.0^2$ ✓

$E=6.1\times10^{-8}$ J ✓

c i The charge cannot change since the ideal voltmeter prevents any motion of charge in the circuit. ✓

ii The charge in the dielectric will separate. ✓

Creating a small electric field in the dielectric directed opposite to the original electric field. ✓

Since the net electric field in between the plates has decreased, the potential difference must also decrease. ✓

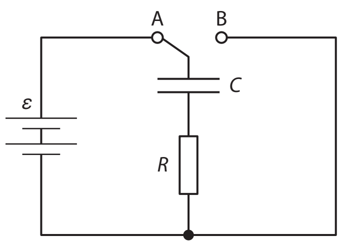
iii Since the potential difference decreased and the charge remained the same. ✓

The capacitance increased. ✓

16 a A circuit with 2 loops. ✓

C in series with R. ✓

Switch and battery in correct position. ✓



b 12 nC. ✓

c **i** $Q = CV \Rightarrow C = \frac{Q}{V}$ ✓

$C = \frac{12 \times 10^{-9}}{6.0} = 2.0 \times 10^{-9}$ F ✓

ii The work required to move deposit 12 nC on the capacitor plate is $W = qV = 12 \times 10^{-9} \times 3.0 = 3.6 \times 10^{-8}$ J. ✓

Since the average voltage is 3.0 V. ✓

iii $E = \frac{1}{2}CV^2 = \frac{1}{2} \times 2.0 \times 10^{-9} \times 6.0^2$ ✓

$E = 3.6 \times 10^{-8}$ J ✓

iv The two energies are the same. ✓

As they must be by energy conservation. ✓

d The time constant for the circuit is $\tau = RC = 2.5 \times 10^6 \times 2.0 \times 10^{-9} = 5.0 \times 10^{-3}$ s. ✓

From $q = q_0 e^{-\frac{t}{t}}$ we find $e^{-\frac{t}{t}} = \frac{q}{q_0} = \frac{8.0}{12} = 0.667$. ✓

$I = -\frac{q_0}{\tau} e^{-\frac{t}{t}} = -\frac{12 \times 10^{-9}}{5.0 \times 10^{-3}} \times 0.667$ ✓

$I = (-)1.6 \times 10^{-6}$ A ✓