## Checkpoints Chapter 13
## Generation Principles

### Question 503/504

As the magnet falls it will speed up, due to the effects of gravity. This means that the rate of change of flux will increase. This means that the graph will be steeper on the way out than on the way in. So the best option is B. It won't look like C or D because the direction of the field does not change.

**∴ B (ANS)**

### Question 505/506

The induced EMF is the negative gradient of the flux *v* time graph. It will start at zero, reach a maximum, and return to zero, (at the top of the graph); it will then reach another max, and then return to zero. The best answer is C.
(If on an exam you were asked this type of question, you would get marks for your working, even if you had picked the incorrect graph.)

**∴ C (ANS)**

### Question 507

The induced EMF is given by

$$\xi = -n \frac{\Delta\Phi}{\Delta t}$$

$\Delta\Phi = \Delta(BA) = 0.05 \times 0.2 = 0.01$.
$\Delta t = 0.15 - 0 = 0.15$ secs.

EMF = $100 \times 0.01/0.15$
**= 6.7 Volt (ANS)**

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### Question 508

The induced EMF is given by

$$\xi = -n \frac{\Delta\Phi}{\Delta t} \qquad \Delta\Phi = \Delta(BA)$$

So in this case the change in flux is due to the change in the strength of the field, not a change in the area under the field. So the rate of change of the flux is the Area × gradient of the magnetic field vs time graph.
So between time $t = 0$ and $t = t_1$ the magnetic field is constant, so the gradient is zero. From time $t = t_1$ to $t = t_2$ the gradient of the magnetic field graph is negative. So the induced EMF is a positive constant. As per the graph.

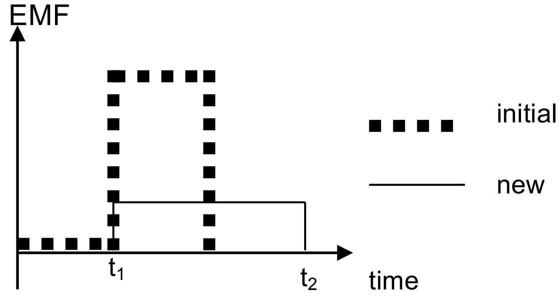
### Question 509

The induced EMF is given by

$$\xi = -n \frac{\Delta\Phi}{\Delta t}$$

$$\Delta\Phi = \Delta(BA)$$

As the field is only halved then the change in the flux is 1/2 of the original. It takes twice as long for the change to happen, this will halve the EMF again. So the induced EMF will be 1/4 of the original, and will be over twice the time.




### Question 510

The induced EMF is given by

$$\xi = -n \frac{\Delta\Phi}{\Delta t}$$

$$= -1 \times (200 \times 10^{-3} \times 0.15)/ 25 \times 10^{-3}$$

**= 1.2 volt (ANS)**

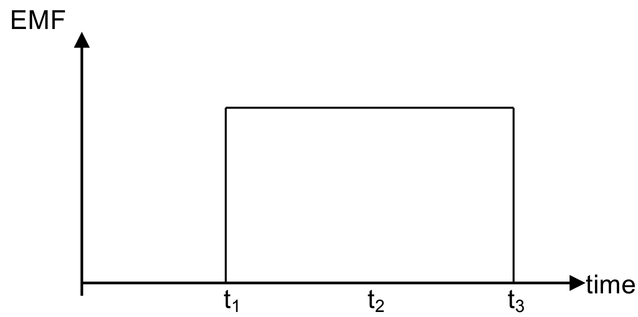
You need to assume that this question is based on the original set of data. This is a reasonable assumption. You can cover yourself by making sure that you show all your working and assumptions.

### Question 511

The induced EMF is given by

$$\xi = -n \frac{\Delta\Phi}{\Delta t}$$

The graph needs to reflect the negative gradient of the field vs time graph. From 0 to $t_1$ the gradient is zero. (so the EMF is zero) From $t_1$ to $t_2$ and from $t_2$ to $t_3$ the gradient is constant, so the EMF will be constant.




You also need to show that the induced EMF is zero between 0 and $t_1$ and after $t_3$.

### Question 512

To produce an AC voltage output, the output of the loop needs to be connected via split rings, so that the output from one side of the loop is always connected to the same side of the voltmeter. Then as the direction of the current flowing in the loop reverses every half cycle, we will get an AC output.

### Question 513

To get a DC output, we need to reverse the direction of the contacts every half cycle. We use a commutator to do this.

### Question 514

The magnetic flux is the product of the field (**B**) and the area (A) that is being cut by the field. Faradays law states that if the flux changes there is an induced EMF (or output voltage). In this case **B** is constant, because the magnets do not alter, but the area of the coil is spinning so the amount of flux cutting through this area changes.

**∴ A (ANS)**

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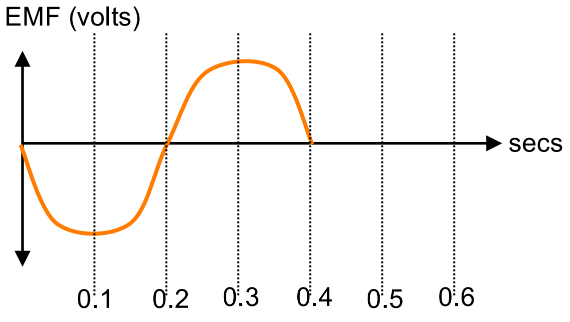
### Question 515

The induced EMF is given by

$$\xi = -n \frac{\Delta\Phi}{\Delta t}$$

So in this case the induced EMF is the negative gradient of the Flux *v* time graph. You need to assume that this is a stylised sine graph.
So at 0.1 secs the gradient was max, at 0.0 and 0.2 the gradient was zero, etc.




You don't need to worry about a scale on the vertical axis (because at this point you don't know how many turns are in the coil).

### Question 516

The induced EMF is given by

$$\xi = -n \frac{\Delta\Phi}{\Delta t}$$

Between 0.4 and 0.6 secs the flux changes from 0.01 to 0.024 Wb $m^{-2}$.
It takes 0.2 secs for this change to occur and there are 50 turns on the coil.

∴ EMF = 50 × (0.024 - 0.0)/0.2
**= 3.5 Volt (ANS)**

### Question 517

Assume that the total resistance of the circuit is 4.5 Ω.
Use V = iR
∴ I = 3.5/4.5
**∴ I = 0.78 Amp (ANS)**

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### Question 518 (2010 Q6, 2m, 75%)

When the flux is at a maximum, the gradient of the flux vs time graph is zero, therefore the induced voltage is zero. When the flux is zero, The gradient of the flux vs time graph is a maximum, therefore the induced voltage is a maximum. The slip rings ensure a AC output.

**∴ A (ANS)**

### Question 519 (2010 Q7, 3m, 63%)

With slip rings, each ring stays connected to either P or Q through-out the cycle. This produces an AC output.
A split ring swaps the connection to P and Q twice every cycle, i.e. reversing the direction of the current every half cycle. The split ring produces a DC output.
In general, slip rings are used in AC, whilst the split ring is used in DC.

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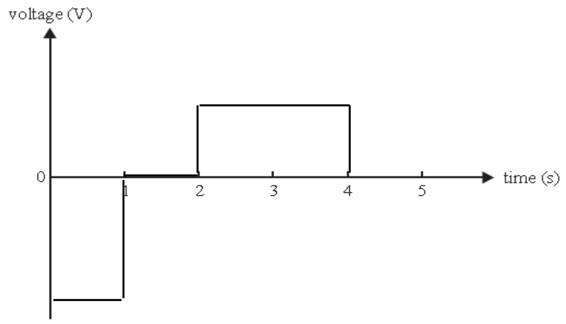
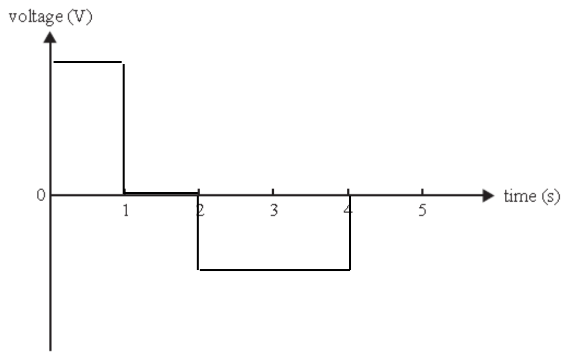
### Question 520 (2010 Q8, 2m, 40%)

Note the sentence under the graph in the question is misplaced
Using the graph as setting the direction, the gradient between 0-1 sec is a positive constant, therefore the induced EMF will be a negative constant. Between 1-2 sec, the gradient is zero, therefore the induced EMF is zero. Between 2-4 sec, the gradient is negative and half the original, therefore the induced EMF will be half the size and positive.

Therefore, you get




As the direction of positive is not defined the graph could also look like the one below.




**Question 521 (2010 Q9, 1m, 50%)**

Faraday's Law was used to determine the size of the relative voltages, and Lenz' law to give the relative directions.

**Question 522 (2010 Q10, 2m, 80%)**

To find the average emf use:

$$\varepsilon = -n\frac{\Delta\Phi}{\Delta t}$$

$$\varepsilon = -120 \times \frac{3.0\times10^{-4}}{0.012}$$

$\therefore$ **3.0 V (ANS)**

(You don't need to worry about the minus sign, as it is only giving the direction)

**Question 523 (2010 Q11, 2m, 50%)**

The original flux was from left to right. This flux was decreasing. To oppose this change in flux, the induced flux needed to try to reinforce the changing flux, by adding to it. A current was required from Q $\rightarrow$ P to do this.

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**Question 524 (2011 Q6, 2m, 63%)**

$\therefore$ **A (ANS)**

**Question 525 (2011 Q7, 2m, 50%)**

The coil is now operating as a generator. The split ring commutator is going to reverse the output every half cycle. Therefore the output will be DC, but varying with time.

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**Question 526 (2011 Q8, 2m, 35%)**

The maximum flux through the coil is given by

$\Phi_{max} = BA$

$\therefore \Phi_{max} = 2.0 \times 0.02$

$\therefore \Phi_{max} = 0.04$ Wb

The value in orientation C is less than the maximum value but greater than zero.

$\therefore$ **B (ANS)**

Remember that flux is the field through ONE loop. The answer 1.5 Wb was there for the people that didn't know this. Be careful!

**Question 527 (2011 Q9, 2m, 80%)**

To find the average emf use:

$$\varepsilon = -n\frac{\Delta\Phi}{\Delta t}$$

$$\varepsilon = -50 \times \frac{0.04}{0.15}$$

$\therefore$ **13.3 V (ANS)**

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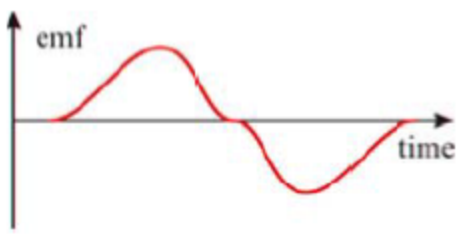
**Question 528 (2011 Q10, 2m, 70%)**

As the magnet moves closer to the loop the magnet field through the loop changes.
.: the magnetic flux through the loop changes.
This change in flux induces an EMF.
As the magnet leaves the loop the magnetic flux again changes and induces an emf.
It is important to state that the **change in flux** that induces the EMF.

**Question 529 (2011 Q11, 2m, 50%)**

The graph needed have this general shape. The flat section in the middle is an optional extra.



The rate at which the flux was changing was not constant, it reached a peak, and then dropped to zero. As the magnet was moving away from the loop the induced EMF was in the opposite direction. We would anticipate symmetry in the graph.

**Question 530 (2011 Q12, 3m, 43%)**

As the magnet moves away from the loop, the flux through the loop to the left, decreases. The loop finds the North field from the magnet decreasing. From Lenz's Law, the induced current will oppose the change in flux by creating a magnetic field to reinforce the decreasing North field. The induced current in the loop will try to strengthen the North field. Therefore viewed from the left, the current in the loop will be anticlockwise. Using the right hand grip rule gives a field pointing to the left.

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**Question 531 (2012 Q5a, 2m, 75%)**

The frequency = $\frac{1}{T}$

$= \frac{1}{100\times10^{-3}}$

**= 10 Hz (ANS)**

**Question 532 (2012 Q5b, 1m, 90%)**

The RMS voltage is the average voltage

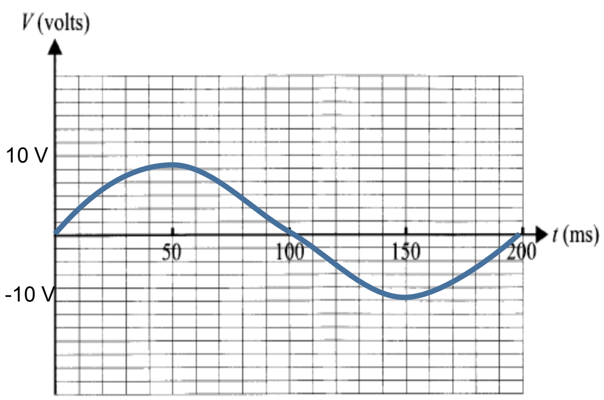
$V_{RMS} = \frac{V_{peak}}{\sqrt{2}}$

$= \frac{20}{\sqrt{2}}$

**= 14 V (ANS)**

**Question 533 (2012 Q5c, 3m, 77%)**

$Voltage_{max}$ = 10 V
Period = 200 ms

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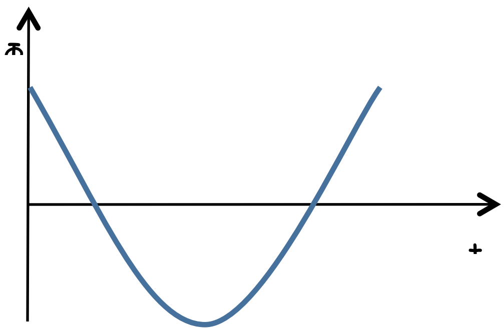
**Question 534 (2012 Q7a, 2m, 45%)**

The magnetic flux will vary sinusoidally as the loop rotates.
It will start at a maximum value and drop to zero ( a quarter of a cycle later) and then to an identical negative maximum value (half a cycle later). It will then return to zero and then back to its original maximum value. (One complete cycle)



**Question 535 (2012 Q7b, 3m, 60%)**

The induced EMF = -n $\frac{\Delta\phi}{\Delta T}$

$= -n\frac{\Delta BA}{\Delta T}$

$3.6 = -n\frac{0.030\times(0.30\times0.40)}{1/8}$

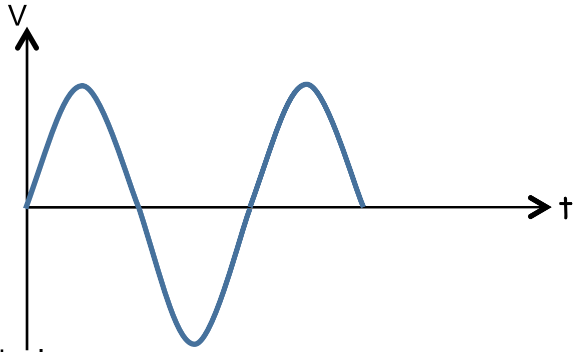
As the coil rotates at 2 rotations per second, it will take 0.5 seconds to complete on revolution. ∴ it will take 1/8 of a second to complete a ¼ cycle, which is how long it takes to change from maximum flux to zero flux.

∴ 3.6 = -n(0.030 x (0.3 x 0.4) x 8)

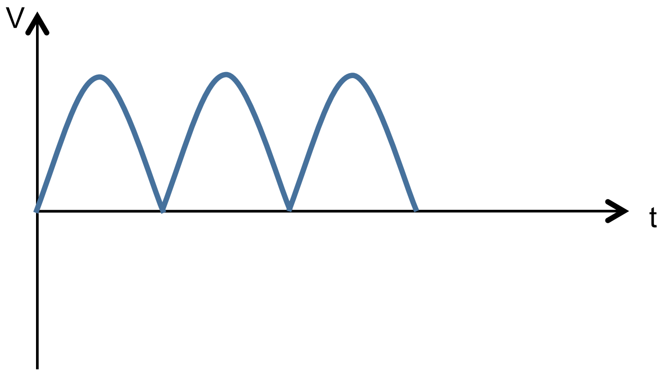
**∴ n = 125 turns (ANS)**

**Question 536 (2012 Q7c, 2m, 60%)**

Original




Final

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**Question 537 (2012 Q8a, 1m, 80%)**

The flux will start at zero, increase linearly to a maximum value, remain at the maximum for a while and then the flux will reduce linearly to zero. The gradient will be a positive constant, zero, and then the same (negative) gradient as initially.

∴ **A (ANS)**

**Question 538 (2012 Q8b, 1m, 80%)**

The induced EMF is the negative gradient of the flux vs time graph.
Would prefer a graph that was the negative of D, but D is by far the closest correct answer.
The direction of the EMF may be hard to justify in this scenario.

∴ **D (ANS)**

**Question 539 (2012 Q8c, 3m, 33%)**

As the loop moves from position 2 to position 3, the flux through it is decreasing. Therefore the induced EMF will generate a current to reinforce the flux.
As viewed from the South Pole, the current will go from X to Y in the square loop, so that the induced current is adding to the decreasing flux.

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**Question 540 (2013 Q17a, 2m, 57%)**

The induced EMF is given by

$$\text{EMF} = \frac{\Delta\Phi}{\Delta t}$$

$$= \frac{0.6 - 0.2}{0.5}$$

$$= 0.8 \text{ V}$$

THEN use V = iR

0.8 = i x 0.1

∴ **i = 8 A (ANS)**

**Question 541 (2013 Q17b, 2m, 45%)**

The EMF will be zero when the gradient of the flux vs time graph is zero.

After t = 0, and before t = 2.0 gives

**0.5, 1.0, 1.5 secs (ANS)**

**Question 542 (2013 Q17c, 4m, 27%)**

The current will be clockwise when viewed from above.
The induced current will oppose the changing flux that is creating it. The ring has increasing flux, therefore the current will be clockwise, to create a field downwards to oppose this increase in flux.
This is an application of Lenz's law.

**Question 543 (2013 Q17d, 2m, 24%)**

At point A: (0), 2.0
At point B: 1.0
At point C: 0.5, 1.5, (2.5)

The flux is lowest when the ring is furthest from the magnet, this is at positions A and B. The flux is a maximum at position C. The ring starts at A, and returns here at 2.0 s.

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**Question 544 (2014 Q12a, 1m, 40%)**

To create a current there needs to be an induced EMF. This occurs when the flux changes.
There will not be any change in flux in options A and B.
C and D will both result in a change in flux. As the loop in complete an induced current will flow.

∴ **C, D (ANS)**

**Question 545 (2014 Q12b, 3m, 60%)**

The induced EMF is given by

$$\xi = -n \frac{\Delta\Phi}{\Delta t}$$

$$= -n \times A \frac{\Delta B}{\Delta t}$$

$$= -1 \times 0.080 \times \frac{0.050}{10 \times 10^{-3}}$$

$$= -0.40 \text{ V}$$

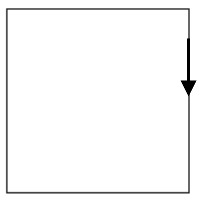
Use V = iR

$\therefore$ 0.40 = 0.020 × R

$\therefore$ **R = 20 Ω (ANS)**

**Question 546 (2014 Q12c, 3m, 37%)**

Initially the flux is down. As the magnetic field reduces to zero, the flux through the loop decreases. The induced EMF is going to create a field to oppose this change. Therefore the induced EMF is going to create its own field downwards.
In order for this to occur, the current in the loop needs to be clockwise. (From the right hand grip rule).



**Question 547 (2014 Q18a, 3m, 37%)**

The flux through the loop varies as the loop is rotated. The flux will vary sinusoidally. The induced EMF is given by: EMF = $-n \frac{\Delta\Phi}{\Delta t}$

Since the flux varies sinusoidally so will the induced EMF, as it is the gradient of the flux function.
Therefore the induced EMF will be AC.
The slip rings provide a constant connection, therefore the display on the CRO is AC.
If a split ring commutator was used the display would be DC.

**Question 548 (2014 Q18b, 2m, 55%)**

The loop will take 2 × 25 ms to complete a revolution.

$\therefore$ Period (T) = 50 ms.

The frequency is given by $f = \frac{1}{T}$

$$\therefore f = \frac{1}{50 \times 10^{-3}}$$

$\therefore$ **f = 20 Hz (ANS)**

**Question 549 (2014 Q18c, 2m, 60%)**

The magnitude of the induced EMF is given by

$$\xi = -n \frac{\Delta\Phi}{\Delta t}$$

If Δt is decreased (speed is increased), then the induced EMF will

**Increase (ANS)**