Multiple choice solutions

Example 1 (2011 Question 6, 63%)

As the coil rotates at a constant speed the flux will change, therefore an emf will be induced. The split ring will reverse the output every half cycle, so the output will be DC

∴ A (ANS)

Example 2 (2008 Question 5, 75%)

When the oscilloscope is connected to the commutator, the output voltage is expected to be in the same direction and constantly changing like that shown in graph B.

∴ B (ANS)

Example 3 (2008 Question 6, 75%)

When the oscilloscope is connected to the slip rings, the output voltage is expected to be sinusoidal like that shown in graph D.

∴D (ANS)

Example 4 (2008 Question 8, 5%)

The emf graph will be produced from the change in flux that the loop experiences. This change only occurs as the loop enters the magnetic field and as it exits the field. The emf will be in the opposite direction as the loop exits the magnetic field compared to when it entered.

∴C (ANS)

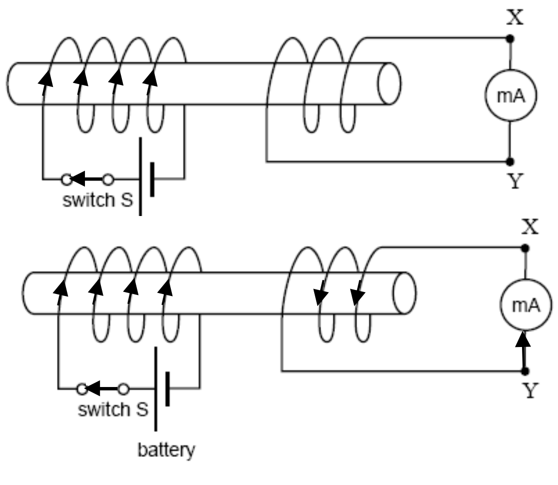
Example 5 (2007 Question 10, 65%)

The alternator gradually speeds up from stationary implies that the frequency increases, i.e. the period decreases. As the frequency increases the output voltage will also increase.

∴ C (ANS)

Example 6 (2007 Question 14, 45%)

When the switch is closed, there will be a current in the primary coil circuit. The current will change from zero to a constant value.
When the current is changing from zero to this constant value, it will create a changing magnetic field in the iron core.
This changing magnetic field will induce a momentary current in the secondary coil and hence in the milli-ammeter.
In the primary coil, the current is from right to left through the switch.



This will create a North pole at the left hand end of the iron core. To oppose this, the induced current will create a North pole at the extreme right hand end of the iron core. This will lead to a current as shown below.

Therefore the momentarily induced current will be from Y to X.

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

Example 7 (2006 Question 7, 65%)

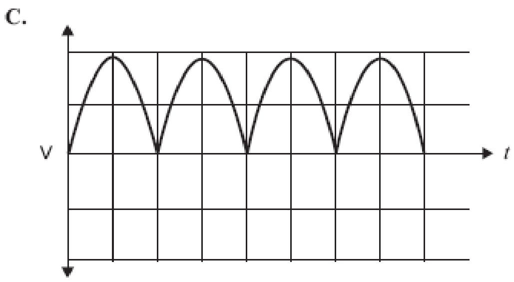
Initially the flux is zero, and constant, therefore the current is zero. As the loop enters the field there is a change of flux (for $\frac{1}{2}$sec). Then the flux is constant, therefore there isn't any induced current. As the loop leaves the field there is another change in flux. This time the flux is reducing, so the direction of the current will be the opposite to what happened before (it is constant for $\frac{1}{2}$sec).

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

Example 8 (2005 Question 8, 90%)

The graph shows that the voltage is always positive, therefore it is DC. (When the voltage is AC it varies from positive to negative). The fact that the voltage is varying does not alter the fact that it is DC.

∴ **C (ANS)**



Example 9 (2004 Question 10, 75%)

It is not clear from the diagram which wire end of the coil is connected to slip ring P.
The rate of change of area (and hence flux) is least when the plane of the coil is perpendicular to the field and greatest when it is parallel to the field.
Suppose the bottom wire is connected to P.
According to Lenz' law the induced current flows towards slip ring Q making its potential higher than slip ring P while the coil rotates to the horizontal position. $\xi = -n \frac{\Delta\Phi}{\Delta t}$,

Answer A. (Answer D for the reverse connection of the slip rings)

Example 10 (1999 Question 9, 45%)

The induced EMF is the negative gradient of the magnetic flux vs time graph.
Between t = 0 and t = 1,
the negative of the gradient of the line is zero
Between t= 1 and t = 2
the negative of the gradient of the line is a negative constant
Between t= 2 and t = 3
the negative of the gradient of the line is a positive constant
Between t = 3 and t = 4,
the negative of the gradient of the line is zero
Because the slope of the flux graph has the same gradient (magnitude), the two 'pulses' need to also have the same magnitude.

∴ **B (ANS)**

Example 11 (1994 Question 5)

The induced EMF is given by the negative gradient of the flux vs time graph.
Between 0 and 0.4, the gradient is zero. Between 0.4 and 0.6 the flux changes uniformly from a maximum value to zero. Therefore the induced EMF will be a positive constant. After 0.6 the flux is constant (zero) therefore the induced EMF is zero.

∴ **B (ANS)**

Example 12 (1984 Question 7l, 30%)

The flux starts at a maximum, and will reverse its direction halfway through the cycle.

∴ **B (ANS)**

(Make sure you didn't find the induced EMF)

Example 13 (1981 Question 70, 22%)

When we double 'f' we will get twice the amplitude but ½ the period

∴ **B (ANS)**

Example 14 (1981 Question 68, 47%)

The induced EMF is given by the negative gradient of the flux vs time graph.
Near t = 0, the gradient is a maximum in the negative.

∴ induced EMF will be maximum positive.
As t tends to t_1, the gradient remains negative but it is getting closer to zero.
∴ induced EMF is positive but close to zero

∴ Graph A (ANS)

For those of you with a mathematical mind, the original graph looks like $\frac{1}{r}$, so the negative gradient of this is $\frac{1}{r^2}$. ∴ A

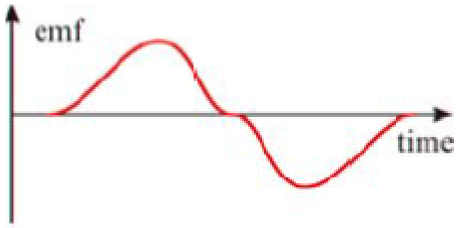
Extended response

Example 15 (2011 Question 10, 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.

Example 16 (2011 Question 11, 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.

Example 17 (2011 Question 12, 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.

Example 18 (2008 Question 7, 70%)

The V_{PEAK} would be 4.0 V, since the peak to peak voltage is 8.0 V.
From the supplied data sheet use:

$$V_{RMS} = \frac{1}{\sqrt{2}} V_{PEAK}$$

$$V_{RMS} = \frac{1}{\sqrt{2}} \times 4.0$$

$\therefore$ **V_{RMS} = 2.8 V (ANS)**

Example 19 (2008 Question 9, 60%)

First you need to calculate how much flux is in the coil:

$$\Phi = BA$$

$$\Phi = 4.0\times10^{-3}\times0.02\times0.02$$

$$\Phi = 1.6\times10^{-6}\,Wb$$

Now calculate the amount of time taken to exit the magnetic field.
The loop is 2.0 cm wide and travelling at a speed of 2.0 cm/s. So it will take the loop 1.0 seconds to exit the magnetic field.
To find the emf you now use:

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

$$\varepsilon = \frac{1.6\times10^{-6}}{1.0}$$

$$\varepsilon = 1.6\times10^{-6}\,V$$

$\therefore$ **1.6×10^{-6} V (ANS)**

Example 20 (2008 Question 10, 43%)

The direction of the current can be found by applying Lenz's law. The induced current in a loop will be in the direction that will create a flux that is in the opposite direction to the change in flux that created the current. Applying Lenz's law to the square loop, the change in flux the loop experiences is having the flux into the page being reduced. To oppose that change the loop will generate a current that puts some magnetic field back into the page. For the loop to generate a field into the page the current must flow from Q to P through the square loop.

Example 21 (2007 Question 6, 75%)

$$\Phi_B = B_\perp \times A$$

$$\therefore 3 \times 10^{-4} = B_\perp \times 0.20 \times 0.30.$$

$$\therefore B = \frac{3 \times 10^{-4}}{6 \times 10^{-2}}$$

$\therefore$ **B = 5 × 10⁻³ T (ANS)**

Example 22 (2007 Question 7, 70%)

In this quarter revolution, the flux goes from a maximum to zero.

$$\therefore \xi = -n\frac{\Delta\Phi_B}{\Delta t},$$

$$= 1000 \times \frac{3 \times 10^{-4}}{0.01}$$

= 30 V (ANS)

Example 23 (2007 Question 8, 75%)

From the graph, the time for one cycle is 80ms.

$$f = \frac{1}{T}$$

$$= \frac{1}{80 \times 10^{-3}}$$

$\therefore$ **12.5 Hz (ANS)**

Example 24 (2007 Question 9, 75%)

$$V_{RMS} = \frac{V_{PEAK}}{\sqrt{2}} = \frac{80}{\sqrt{2}}$$

= 57 V (ANS)

Example 25 (2007 Question 15, 40%)

This question required you to state Lenz's law and then apply it to this context.
Lenz's Law states that "the direction of the induced EMF is the same as that of a current whose magnetic action would <u>oppose</u> the flux change"
This means that the current in the secondary coil must be opposite to the current in the primary coil.
When the current in the primary coil is changing from zero to a constant value, it will create a changing magnetic flux to the left.
This will be opposed by the induced current in the secondary coil producing a changing magnetic flux to the right.
To do this the current in the secondary coil must be in the direction Y to X.

Example 26 (2006 Question 4, 80%)

The plane of the loop is parallel to the field so the flux is zero

$\therefore$ **0 Wb (ANS)**

(Don't forget to include the units, as they were specifically requested)

Example 27 (2006 Question 5, 60%)

$\Phi_B = B_\perp \times A$

$\therefore \Phi_B = 2.0 \times 10^{-4} \times 5 \times 10^{-4}$

$= 1.0 \times 10^{-7}$

$\therefore \Phi_B$ **= 1 × 10^{-7} Wb (ANS)**

(Remember to convert cm^2 to m^2 by multiplying by 10^{-4}). This should be on your cheat sheet.

Example 28 (2006 Question 6, 60%)

The role of the commutator is to change the direction of the current in a DC motor every half rotation. This keeps it rotating in the same direction.

Effie's idea would not work. The motor will just oscillate (about its rest position) and then eventually come to a stop.

Example 29 (2006 Question 8, 30%)

Using $\xi = -n\frac{\Delta\Phi_B}{\Delta t}$, here the flux changes from zero to a maximum in a $\frac{1}{2}$sec.

(The loop is travelling at 4 cms^{-1} and it is 2 cm wide, so it takes $\frac{1}{2}$sec to enter the field completely.)

The field strength is 3.7×10^{-3} T

The area is 2 cm × 2 cm which is 4×10^{-4} m^2

$$\therefore \xi = -n\frac{\Delta\Phi_B}{\Delta t},$$

$$= 1 \times \frac{3.7\times10^{-3}\times4\times10^{-4}}{0.5}$$

$$= 2.96 \times 10^{-6} \text{ V}$$

$= 3 \times 10^{-6}$ V (ANS)

Example 30 (2005 Question 2, 70%)

The flux through the coil is given by

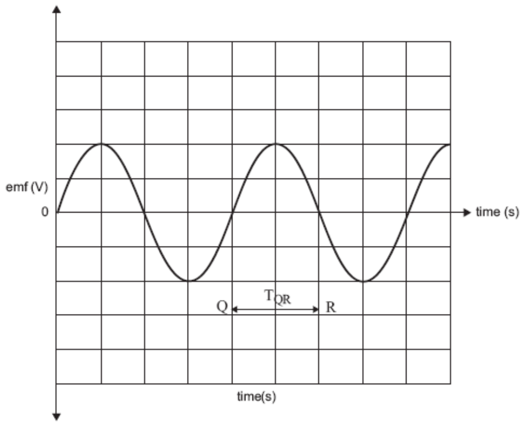
$$\Phi_B = B_\perp \times A$$

$$\therefore 8 \times 10^{-6} = 2.0 \times 10^{-2} \times A.$$

$$\therefore A = \frac{8\times10^{-6}}{2\times10^{-2}}$$

$\therefore A = 4 \times 10^{-4}$ m^2 (ANS)

Example 31 (2005 Question 3, 85%)



Since the loop is rotated at a rate of 10 revolutions per second, it must take 0.1 secs for each revolution.

There is half a cycle (revolution) between Q and R, so the time interval, T_{QR}, must be 0.05 secs.

Example 32 (2005 Question 4, 45%)

The induced emf is given by Lenz's law

$$\xi = - n\frac{\Delta\Phi_B}{\Delta t},$$

where n is the 'number of loops and $\frac{\Delta\Phi_B}{\Delta t}$ is the rate of change of flux. From the graph, it took 0.025 sec for the emf to change from a maximum value to zero. As the EMF graph is the negative gradient of the flux graph, then the time it takes for the flux to change from a maximum to zero must also be 0.025 secs.

$$\therefore \xi = 100 \times \frac{8\times10^{-6}}{0.025}$$

$\therefore$ **= 0.032 V (ANS)**

Example 33 (2005 Question 5, 60%)

When the rotation speed of the coil is increased to 20 revolutions per second, the output signal will change in two ways. The period will halve **and** the amplitude will double.

The doubling of the amplitude is because the emf is given by $\xi = - n\frac{\Delta\Phi_B}{\Delta t}$ and since Δt has halved, the ξ must double.

Example 34 (2005 Question 6, 90%)

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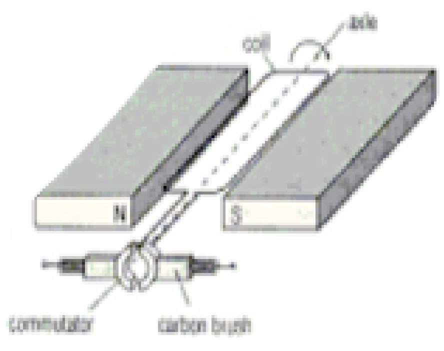
Example 35 (2005 Question 7, 40%)

A DC generator has a rotating coil in a magnetic field, or a rotating magnetic field positioned inside a coil. A commutator is used to keep contact with the brushes. The split-ring reverses the polarity of the output every half cycle. This allows the generator to produce a DC output.



Example 36 (2004 Question 9, 70%)

Use

$\varphi = BA$

$= 0.12 \times 0.40 \times 0.30$

$\mathbf{= 0.014\ Wb}$

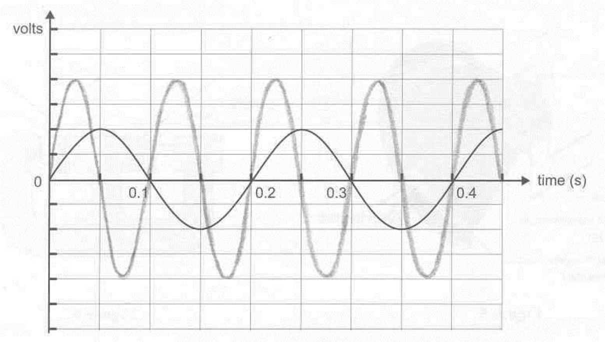
Example 37 (2004 Question 11, 52%)

Use $\xi = -n\dfrac{\Delta BA}{\Delta t}$,

$\therefore\ \xi = -1 \times \dfrac{0.12 \times (0.12 - 0)}{(0.15)}$

$\therefore \xi$ **= 0.096 V (ANS)**

Example 38 (2004 Question 12, 58%)



The induced EMF is related to the rate of change of magnetic flux by

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

Doubling the frequency of rotation halves the period of the rotation and so effectively halves the effective time for the change in magnetic flux. This doubles the induced voltage.

$\therefore$ When the frequency is doubled, the peak voltage is doubled and the period is halved.

Example 39 (1999 Question 7, 79%)

$\Phi = BA$

$\therefore\ \Phi = 5.0 \times 10^{-2} \times (0.020 \times 0.020)$

$= 0.00002$ Wb

$= 2 \times 10^{-5}$ Wb (ANS)

Example 40 (1999 Question 8, 74%)

The induced EMF is the rate of change of flux. In this case the flux changes from 2×10^{-5} Wb to zero in 0.040 secs.

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

n= 1, so $\xi = 2 \times 10^{-5} / 0.040$

$= 0.0005$ Volt

= 5×10^{-4} V (ANS)

Example 41 (1998 Question 9)

$\Phi = BA$

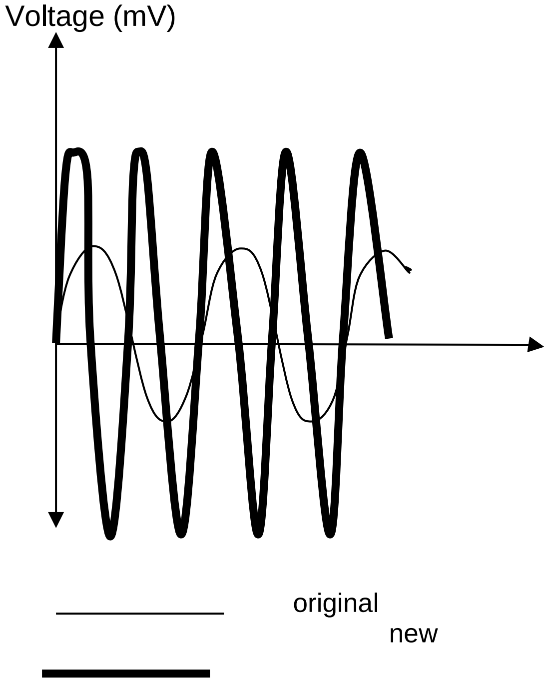
$\therefore\ \Phi = 0.12 \times (0.030 \times 0.020)$

$= 0.000072$ Wb

$= 7.2 \times 10^{-5}$ Wb

The first question in a set on an exam is **usually** a very straight forward question. Either, a simple concept or substitution into a basic formula. The next couple are generally more complex

Example 42 (1998 Question 10)



The graph remains a sine curve, but the **amplitude doubles** , the induced EMF is given by

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

if Δt is halved then ξ is doubled and the period is halved, because it is rotating twice as fast.

Example 43 (1997 Question 12, 20%)

The induced voltage is the negative gradient of the B vs t graph. This would give you a positive constant, but we do not know how the CRO has been wired. If we reversed the wiring on the CRO we would get a positive constant.

$\therefore$ B is by far the best answer.

Example 44 (1997 Question 13, 16%)

The induced EMF will depend on the change of flux. The area of the loop remains constant so the change in flux is related to the change in the magnetic field.
The gradient of the magnetic field is constant, ∴ the induced EMF is constant from time 0 to $t = t_2$. The only graph to show this is graph B. You might have expected the graph to have a positive value, but this depends entirely on the connections to the CRO. If you swapped the red and the black connections you would get a positive output from the CRO. The most important concept is the gradient of the flux vs time graph.

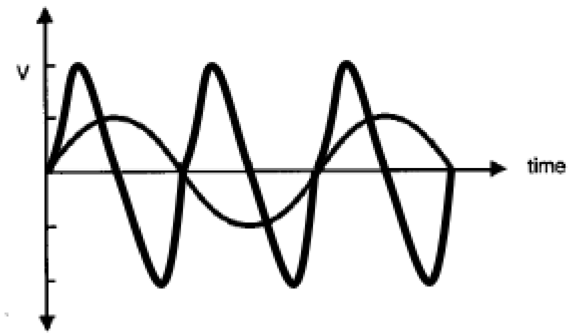
Example 45 (1994 Question 6)

Use $\xi = -n\frac{\Delta BA}{\Delta t}$,

$\therefore \xi = -200 \times \frac{0.080 \times (0.020 - 0)}{(0.6 - 0.4)}$

$\therefore$ **ξ = 1.6 V (ANS)**

Example 46 (1994 Question 7)



The new graph should have double the amplitude and half the period.

Example 47 (1984 Question 72, 26%)

The plane of the loop is perpendicular to the field at the beginning. The flux graph is B. The (negative) gradient of the line is zero, therefore the induced EMF = 0

∴ **0 V (ANS)**

Another way of looking at this is:
When the plane of the loop is perpendicular to the magnetic field, no lines of B are being cut.

∴ **0 V (ANS)**

Example 48 (1981 Question 69, 68%)

Using $\xi = -n \frac{\Delta\Phi}{\Delta t}$, we get

$\xi = -n \frac{\Delta BA}{\Delta t}$, but A is constant and n = 1

so we get

$$\xi = -A \frac{\Delta B}{\Delta t}$$

$$\therefore \xi = -0.040 \times \frac{0.60}{2}$$

$\therefore$ **ξ = 0.012 V (ANS)**