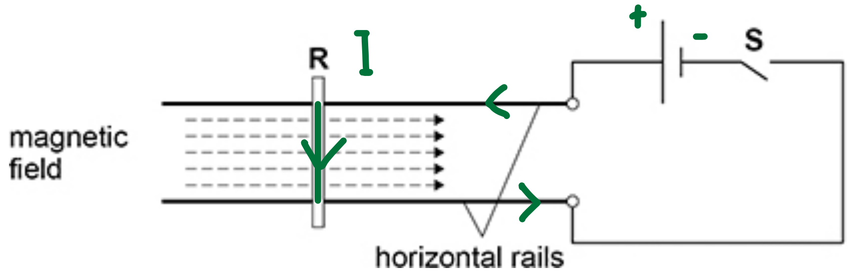
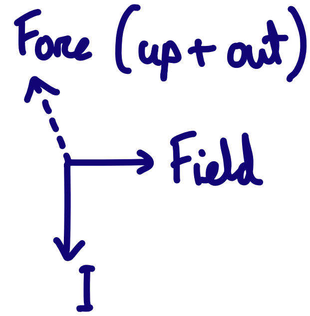
A LEVEL PHYSICS

WORKED SOLUTIONS

7.5. Magnetic Fields MCQ

1. A short copper rod **R** is placed on a pair of thick horizontal parallel copper rails.
A horizontal magnetic field exists in the direction shown by the dashed arrows.
The diagram shows the apparatus when viewed from directly above.





When switch **S** is closed, **R** will tend to

A lift upwards away from the rails. ☒

B move to the left. ☐

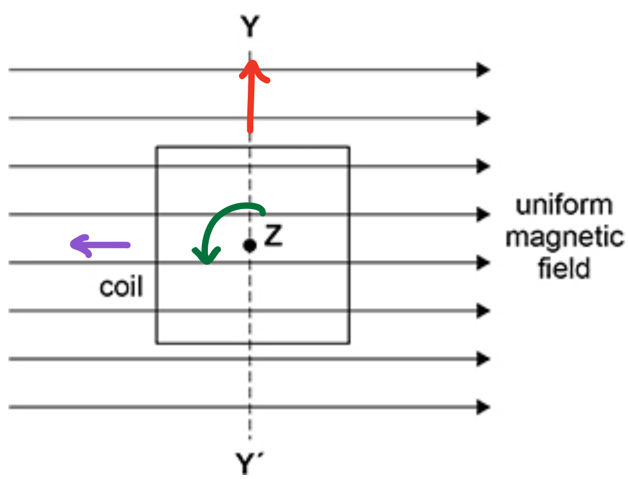
C move to the right. ☐

D be pressed downwards onto the rails. ☐

Use Fleming's left hand rule

(Total 1 mark)

2. The diagram shows a square coil with its plane parallel to a uniform magnetic field.



The coil always remains within the magnetic field.
There are four possible changes to the position of the coil:

- ✗ moving it to the left — No EMF (1)
- ✗ moving it towards **Y** — No EMF (2)
- ✓ rotating it about the axis **YY´**
- ✗ rotating it about an axis **Z** that is at its centre and perpendicular to the plane of the coil. — No EMF (4)

No change in number of field lines cut for 1, 2 and 4, so no change in the magnetic field ∴ EMF = 0

How many of these changes will result in an induced emf in the coil while the change occurs?

A one

B two

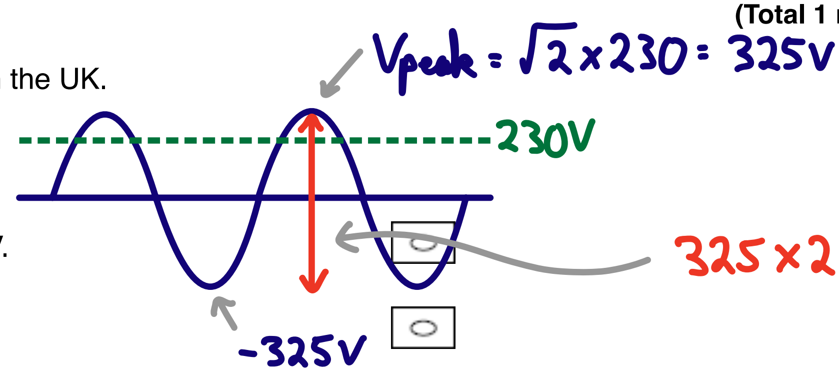
C three

D four

(Total 1 mark)

3. Mains electricity is rated 230 V in the UK.

Which is correct?



A The mean voltage is 163 V.

B The peak voltage is 230 V.

C The root mean square voltage is 325 V.

D The peak-to-peak voltage is 650 V.

(Total 1 mark)

4. In a resistor of resistance R, a steady current I dissipates a power P.

In a resistor of resistance $\frac{R}{2}$ there is an alternating current of root mean square value $3I$.

What is the mean power dissipated in the resistor of resistance $\frac{R}{2}$?

A $9P$

B $\frac{9}{2}P$

C $\frac{9}{4}P$

D $\frac{3}{2}P$

$P_1 = I^2R$

$P_2 = (3I)^2 \times \frac{R}{2} = \frac{9}{2} I^2R$

$P_2 = \frac{9}{2} P_1$

(Total 1 mark)

5. The primary winding of a transformer has 200 turns and the secondary winding has 1600 turns. A root mean square (rms) alternating voltage of 25 V is applied to the primary winding causing a primary rms current of 4.0 A. The transformer is 90% efficient.

What are the rms values of the secondary voltage and the secondary current?

$$\frac{V_p}{V_s} = \frac{n_p}{n_s} = \frac{I_s}{I_p}$$

	Secondary voltage / V	Secondary current / A	
A	200	~~0.50~~	○
B	200	0.45	●
C	~~180~~	~~0.50~~	○
D	~~3.1~~	~~29.0~~	○

$V_s = V_p \frac{n_s}{n_p} = 200V$

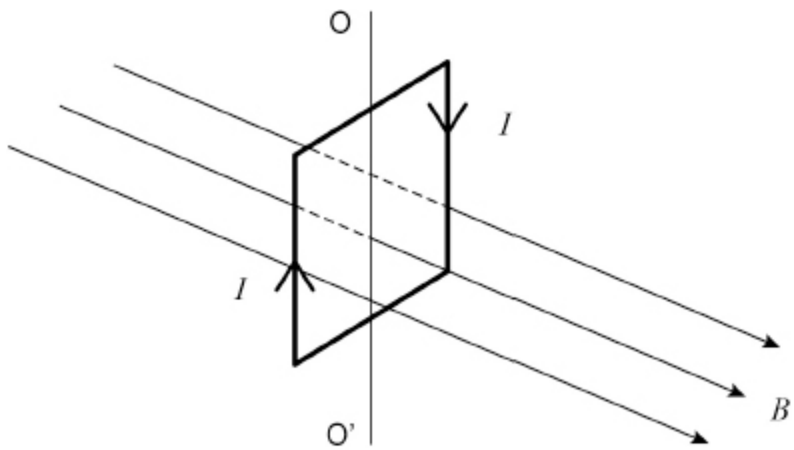
$I_s = I_p \frac{V_p}{V_s} \times 0.90$

V_s unaffected by efficiency I_s is affected

(Total 1 mark)

$I_s = 0.45A$

6. The diagram shows a current I in a vertical square coil.
The coil can rotate about an axis OO'.
The plane of the coil is at right angles to a uniform horizontal magnetic field of flux density B.



Which statement is correct?

A The forces on the vertical sides of the coil are equal in magnitude and opposite in direction. ●

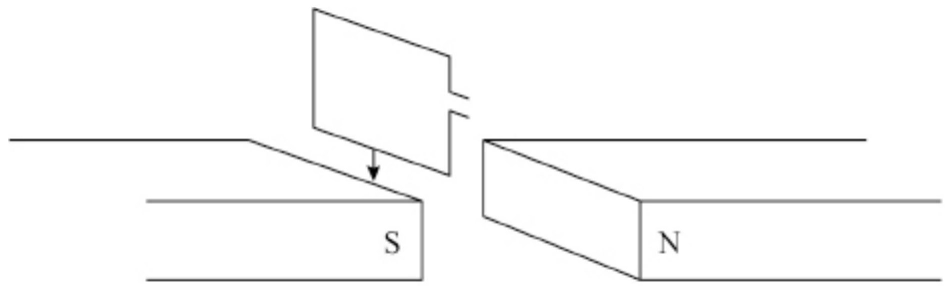
B ✗ A non-zero couple acts on the coil. Forces cancel, sum to 0 ○

C ✗ No forces act on the horizontal sides of the coil. Still a force on the horizontal ○

D ✗ The forces on all sides of the coil act toward the centre of the coil. No ○

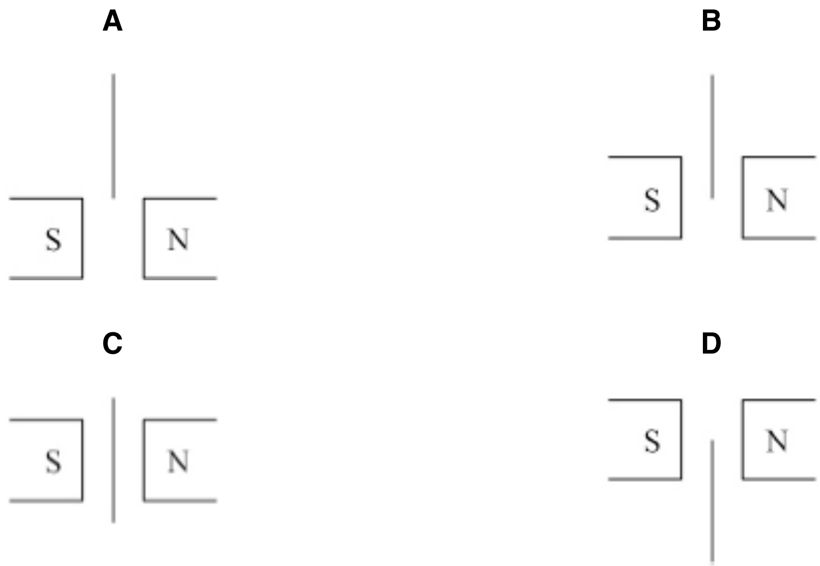
(Total 1 mark)

7. The diagram shows a small rectangular coil falling between two magnetic poles.



The coil is shown at four instants as it passes through the magnetic field.

At which instant will the induced emf be a maximum?



A ○

B ○

C ○

D ●

At D the speed is greatest

$\therefore \frac{\Delta \phi}{\Delta t}$ is greatest

(Total 1 mark)

8. An alternating emf is induced in a coil rotating in a magnetic field.

What is the phase difference between the magnetic flux linkage through the coil and the emf?

A 0

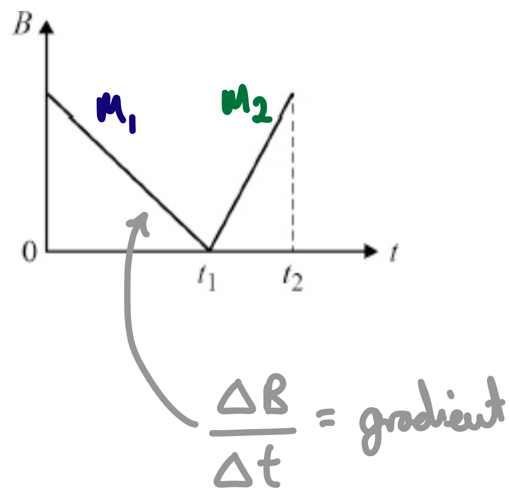
B $\frac{\pi}{3}$ rad

C $\frac{\pi}{2}$ rad (90°)

D π rad

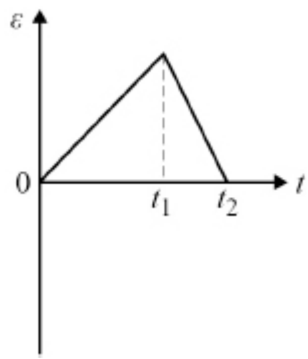
(Total 1 mark)

9. The diagram shows the variation with time t of the magnetic flux density B of the field linking a coil.

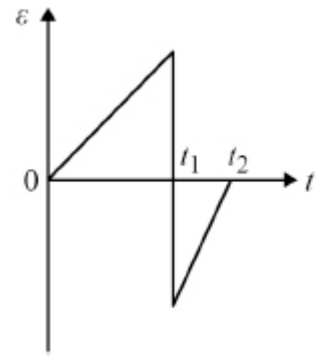


Which graph shows the variation of induced emf ε in the coil during this time interval?

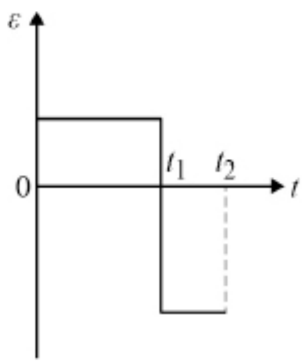
A



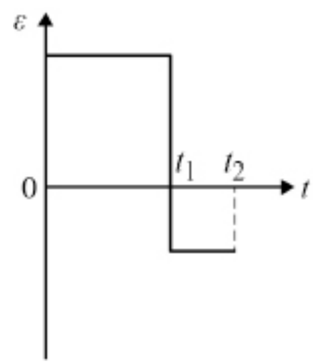
B



C



D



A ○

B ○

C ●

D ○

$$\varepsilon = -N\frac{\Delta\phi}{\Delta t}$$

$$= -AN\frac{\Delta B}{\Delta t}$$

$\frac{\Delta B}{\Delta t}$ = gradient

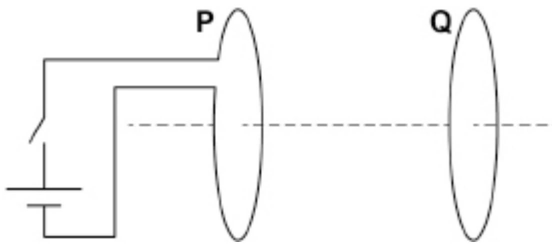
$0 \rightarrow t_1$ $\quad \frac{\Delta B}{\Delta t} = -m_1 \quad \therefore \varepsilon \propto +m_1$

(Total 1 mark)

$t_1 \rightarrow t_2$ $\quad \frac{\Delta B}{\Delta t} = +m_2 \quad \therefore \varepsilon \propto -m_2$

$$|m_1| < |m_2|$$

10. A coil **P** is connected to a cell and a switch.
A closed coil **Q** is parallel to **P** and is arranged on the same axis.



Change in B field occurs over a very short time, so it is short-lived.

Which describes the force acting on **Q** after the switch is closed?

Lenz's law: will oppose change that caused it, so to the right.

A ~~steady~~ and directed to the ~~left~~

B ~~steady~~ and directed to the right

C short-lived and directed to the ~~left~~

D short-lived and directed to the right ●

(You may have seen a jumping ring demo at school)

(Total 1 mark)

11. When an electron is moving at a speed v perpendicular to a uniform magnetic field of flux density B, it follows a path of radius R.

A second electron moves at a speed $\frac{v}{2}$ perpendicular to a uniform magnetic field of flux density $4B$.

What is the radius of the path of the second electron?

A $\frac{R}{8}$ ●

B $\frac{R}{4}$

C $2R$

D $8R$

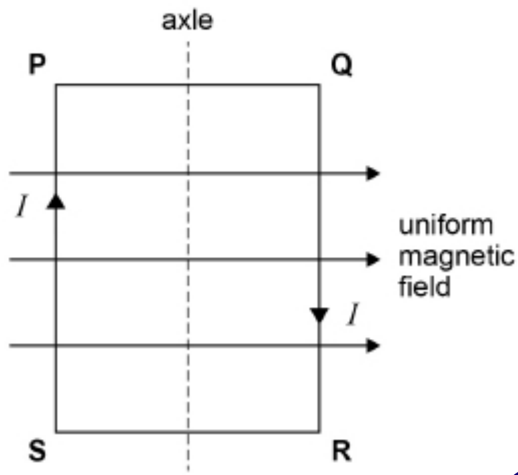
$$R_1 = \frac{mv}{BQ}$$

$$R_2 = \frac{m(v/2)}{4BQ}$$

$$R_2 = \frac{mv}{8BQ} = \frac{1}{8} \cdot R_1$$

(Total 1 mark)

12. The plane of coil **PQRS** is parallel to a uniform magnetic field.



These sides are parallel to the field ∴ no force

When a current I is in the coil

A ✗ there are no magnetic forces acting on **SP** and **QR**.

B ✓ there are no magnetic forces acting on **PQ** and **RS**. ●

C ✗ an attractive magnetic force acts between **SP** and **QR**.

D ✗ an attractive magnetic force acts between **PQ** and **RS**.

(Total 1 mark)

13. A horizontal wire of length 0.50 m and weight 1.0 N is placed in a uniform horizontal magnetic field of flux density 1.5 T directed at 90° to the wire.

What is the current that just supports the wire?

A 0.33 A

B 0.75 A

C 1.3 A ●

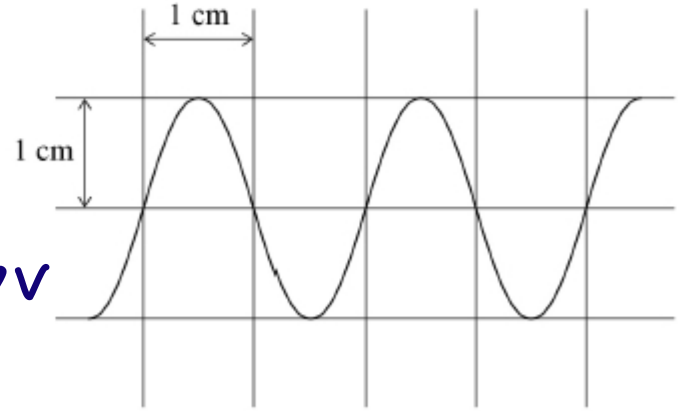
D 3.0 A

$F = BIL$

$I = \frac{F}{BL} = \frac{1.0}{1.5 \times 0.50} = 1.33\ A$

(Total 1 mark)

14. The figure shows an oscilloscope trace of a sinusoidal ac voltage.



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

$V_{rms} = \frac{10}{\sqrt{2}} = 7.07V$

$f = \frac{1}{T} = \frac{1}{2 \times 5 \times 10^{-3}}$

$f = 100 Hz$

The time base setting is 5 ms cm^{-1} and the Y-voltage gain is 10 V cm^{-1}.

Which row describes the ac voltage?

	rms voltage / V	Frequency / Hz
A	~~14~~	~~50~~
B	~~14~~	100
C	7	~~50~~
D	7	100

(Total 1 mark)

15. A steady current I dissipates power P in a resistor of resistance R.
An alternating current through a resistor of resistance $2R$ has a peak value of I.

What is the power dissipated in the second resistor?

A $\frac{P}{\sqrt{2}}$

B P

C $\sqrt{2}P$

D $2P$

$P_1 = I^2 R$

$P_2 = \left(\frac{I}{\sqrt{2}}\right)^2 \times 2R$

$P_2 = \frac{I^2}{2} \times 2R$

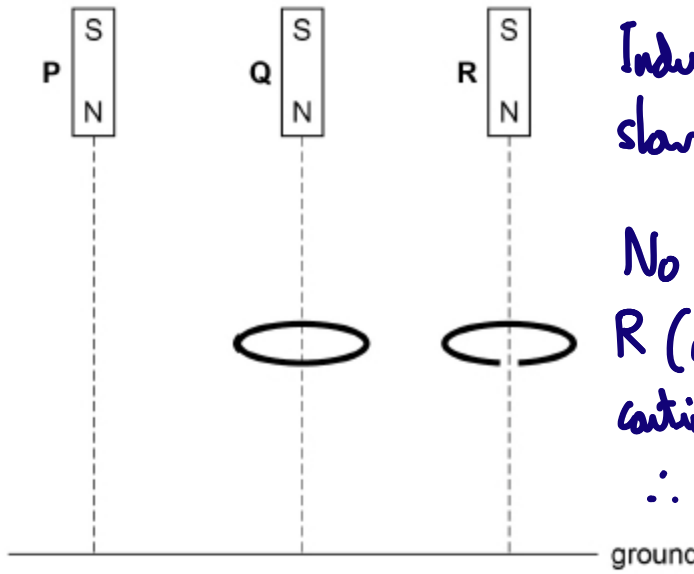
$P_2 = I^2 R = P_1$

$I_{rms} = \frac{I_{peak}}{\sqrt{2}}$

(Total 1 mark)

16. Three identical magnets **P**, **Q** and **R** are released simultaneously from rest and fall to the ground from the same height.

P falls directly to the ground.
Q falls through the centre of a thick horizontal conducting ring.
R falls through a similar ring that has a gap cut into it.



Lenz's law: Induced EMF in ring slows down Q.

No induced EMF in R (as it is not a continuous loop). ∴ R + P the same

In which order do the magnets reach the ground?

A **P** and **R** arrive together, followed by **Q**. ☒

B **P** and **Q** arrive together, followed by **R**. ☐

C **P** arrives first, followed by **Q** which is followed by **R**. ☐

D All three magnets arrive simultaneously. ☐

(Total 1 mark)

17. A transformer has an efficiency of 80%
It has 7000 turns on its primary coil and 175 turns on its secondary coil. When the primary of the transformer is connected to a 240 V ac supply, the secondary current is 8.0 A

What are the primary current and secondary voltage?

	Primary current / mA	Secondary voltage / V	
A	250	6.0	●
B	~~160~~	6.0	○
C	250	~~9600~~	○
D	~~160~~	~~9600~~	○

$$\frac{V_p}{V_s} = \frac{n_p}{n_s} = \frac{I_s}{I_p}$$

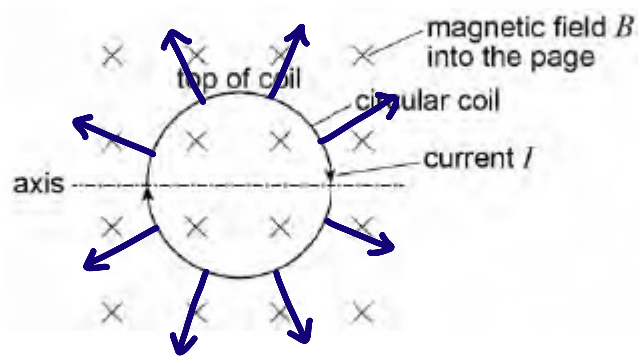
$$V_s = V_p \frac{n_s}{n_p} = 240 \times \frac{175}{7000}$$

$$V_s = 6.0\,V$$

$$I_p = I_s \frac{n_s}{n_p} \div 0.80 = 0.25\,A = 250\,mA$$

(Total 1 mark)

18. The diagram shows a clockwise current I in a circular coil placed in a uniform magnetic field B with the plane of the coil perpendicular to the magnetic field.



What is the effect on the coil of the interaction between the current and the magnetic field?

A It rotates about the axis with the top moving out of the page. ○

B It rotates about the axis with the top moving into the page. ○

C It causes an increase in the diameter of the coil. ●

D It causes a decrease in the diameter of the coil. ○

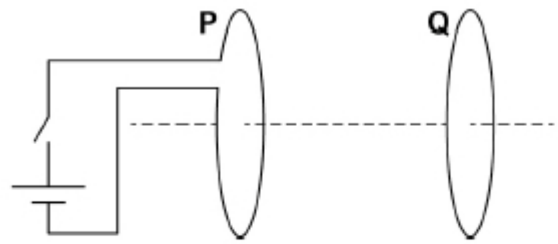
Fleming's LHR: Force always acts outwards from the centre ∴ coil gets larger

(Total 1 mark)

19. A coil **P** is connected to a cell and a switch.

A second closed coil **Q** is parallel to **P** and is arranged on the same axis.

Very similar to Q10



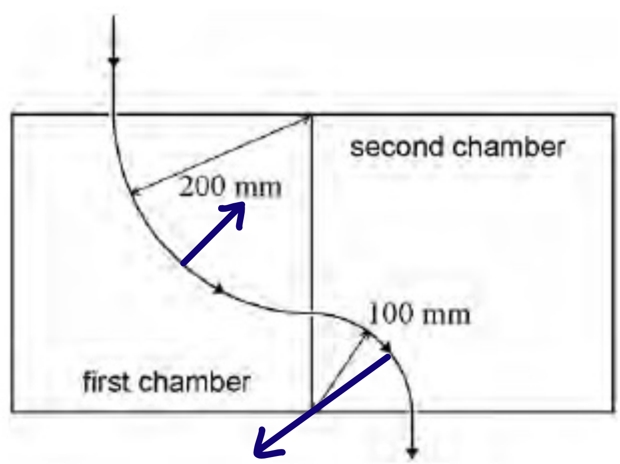
When the switch is closed, coil **Q** experiences a force.

Which row describes the force on **Q**?

	Force	Direction of force	
A	increases to constant value	to left	○
B	increases to constant value	to right	○
C	increases then decreases	to left	○
D	increases then decreases	to right	●

(Total 1 mark)

20. Different magnetic fields are present in the two chambers shown. A particle enters the first chamber at a velocity of 80 m s^{-1} and is deflected into a circular path of radius 200 mm
In the second chamber it follows a circular path of radius 100 mm



The particle leaves the second chamber at a speed of

A 20 m s^{-1} ☐

B 40 m s^{-1} ☐

C 80 m s^{-1} ■

D 160 m s^{-1} ☐

F at 90° to direction of motion ∴ v is constant

(Total 1 mark)

21. A coil with 20 circular turns each of diameter 60 mm is placed in a uniform magnetic field of flux density 90 mT.

Initially the plane of the coil is perpendicular to the magnetic field lines as shown in **Figure X**.

Figure X

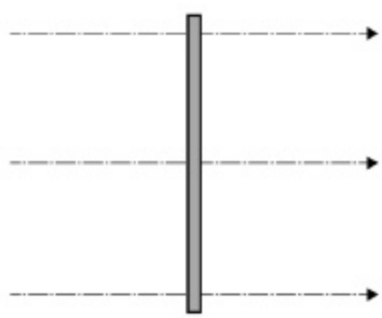
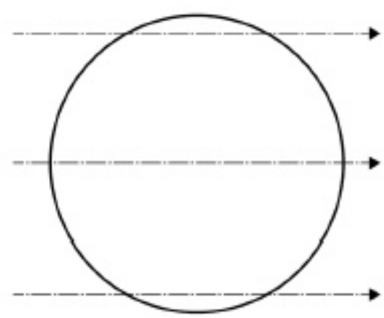


Figure Y



The coil is rotated about a vertical axis by 90° in a time of 0.20 s so that its plane becomes parallel to the field lines as shown in **Figure Y**.
Assume that the rate of change of flux linkage remains constant.

What is the emf induced in the coil?

$$\varepsilon = -N\frac{\Delta\phi}{\Delta t} = -N\frac{\Delta(BA\cos\theta)}{\Delta t}$$

A zero ☐

B 1.3 mV ☐

$$\varepsilon = \frac{-NBA}{\Delta t}\Delta\cos\theta$$

C 25 mV ■

D 100 mV ☐

$$\varepsilon = \frac{-NBA}{\Delta t}(\cos 90 - \cos 0) = \frac{-NBA}{\Delta t}(-1)$$

(Total 1 mark)

$$\varepsilon = \frac{NBA}{\Delta t} = \frac{20 \times 90\times10^{-3} \times \pi(30\times10^{-3})^2}{0.20} = 0.0254\ V$$

$$= 25\ mV$$

22. The mean power dissipated in a resistor is 47.5 μW when the root mean square (rms) voltage across the resistor is 150 mV.

What is the peak current in the resistor?

$$I_{rms} = \frac{P}{V} = \frac{47.5\times10^{-6}}{150\times10^{-3}} = 3.17\times10^{-4}\ A$$

A 2.3×10^{-4} A

B 4.5×10^{-4} A ●

C 2.3×10^{3} A

D 4.5×10^{3} A

$$I_{peak} = \sqrt{2}.\ I_{rms} = \sqrt{2} \times 3.17\times10^{-4}$$
$$= 4.48\times10^{-4}$$

(Total 1 mark)

23. The National Grid is used to transfer electrical energy from power stations to consumers.

What conditions for the transmission voltage and the transmission current give the most efficient transfer of energy through the National Grid?

	Transmission voltage	Transmission current	
A	High	~~High~~	
B	High	Low	●
C	~~Low~~	~~High~~	
D	~~Low~~	Low	

(Total 1 mark)

$P = IV$ and $P = I^2R$

High V ∴ Low I to reduce losses due to heating

24. A mains transformer has a primary coil of 2500 turns and a secondary coil of 130 turns.
The primary coil is connected to a mains supply where V_{rms} is 230 V.
The secondary coil is connected to a lamp of resistance 6.0 Ω.
The transformer is 100% efficient.

What is the peak power dissipated in the lamp?

A 12 W ○

B 24 W ○

C 48 W ●

D 96 W ○

$$\frac{V_p}{V_s} = \frac{n_p}{n_s}$$

V_{rms}

$$V_s = V_p \cdot \frac{n_s}{n_p} = 230 \times \frac{130}{2500} = 11.96\,V$$

(Total 1 mark)

$$V_{peak} = 11.96 \times \sqrt{2} = 16.91\,V$$

$$P = \frac{V^2}{R} = \frac{16.91^2}{6.0} = 47.7\,W$$