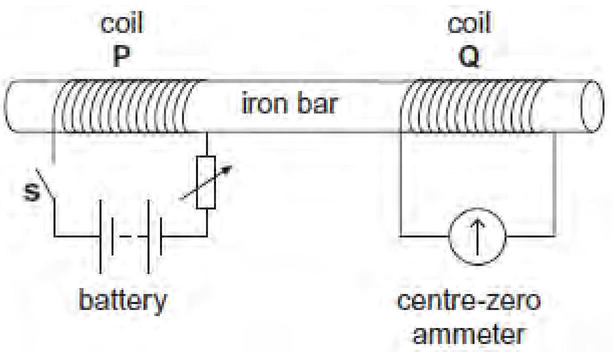
Q1.(a) **Figure 1** shows two coils, **P** and **Q**, linked by an iron bar. Coil **P** is connected to a battery through a variable resistor and a switch **S**. Coil **Q** is connected to a centre-zero ammeter.

Figure 1



(i) Initially the variable resistor is set to its minimum resistance and **S** is open. Describe and explain what is observed on the ammeter when **S** is closed.

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(3)

(ii) With **S** still closed, the resistance of the variable resistor is suddenly increased.
Compare what is now observed on the ammeter with what was observed in part (i).
Explain why this differs from what was observed in part (i).

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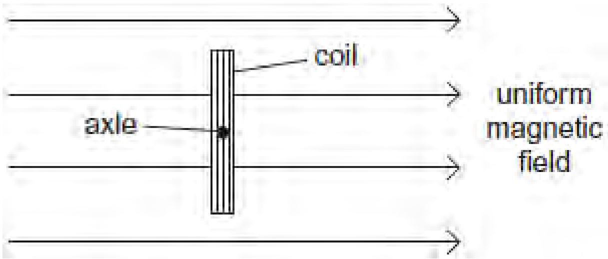
(2)

(b) **Figure 2** shows a 40-turn coil of cross-sectional area 3.6×10^{-3} m^2 with its plane set at right angles to a uniform magnetic field of flux density 0.42 T.

Figure 2



(i) Calculate the magnitude of the magnetic flux linkage for the coil.
State an appropriate unit for your answer.

flux linkage .... unit ....

(2)

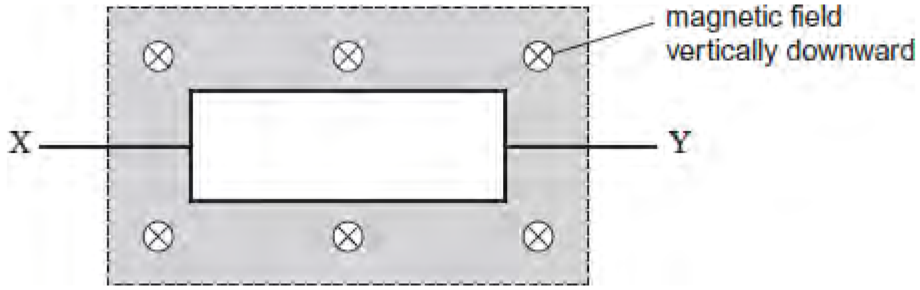
(ii) The coil is rotated through 90° in a time of 0.50 s.
Determine the mean emf in the coil.

mean emf V

(2)
(Total 9 marks)

Q2. A rectangular coil of area A has N turns of wire. The coil is in a uniform magnetic field, as shown in the diagram.

When the coil is rotated at a constant frequency f about its axis XY, an alternating emf of peak value ε_0 is induced in it.



What is the maximum value of the magnetic flux linkage through the coil?

A $\dfrac{\varepsilon_0}{2\pi f}$

B $\dfrac{\varepsilon_0}{\pi f}$

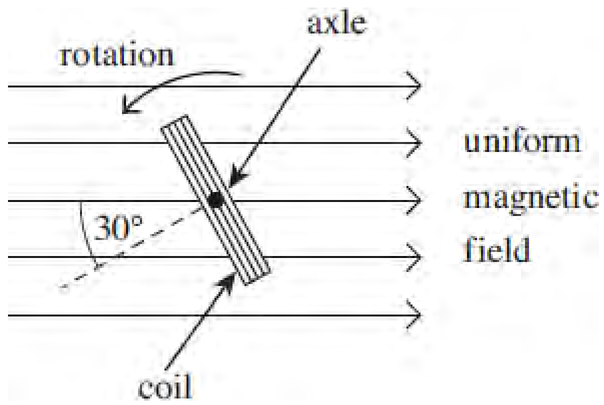
C $\pi f \varepsilon_0$

D $2\pi f \varepsilon_0$

(Total 1 mark)

Q3. A rectangular coil is rotating anticlockwise at constant angular speed with its axle at right angles to a uniform magnetic field. **Figure 1** shows an end-on view of the coil at a particular instant.

Figure 1



(a) At the instant shown in **Figure 1**, the angle between the normal to the plane of the coil and the direction of the magnetic field is 30°.

(i) State the minimum angle, in degrees, through which the coil must rotate from its position in **Figure 1** for the emf to reach its maximum value.

angle .... degrees

(1)

(ii) Calculate the minimum angle, in radians, through which the coil must rotate from its position in **Figure 1** for the flux linkage to reach its maximum value.

angle .... radians

(2)

(b) **Figure 2** shows how, starting in a different position, the flux linkage through the coil varies with time.

(i) What physical quantity is represented by the gradient of the graph shown in **Figure 2**?

....

(1)

(ii) Calculate the number of revolutions per minute made by the coil.

revolutions per minute ....

(2)

Figure 2

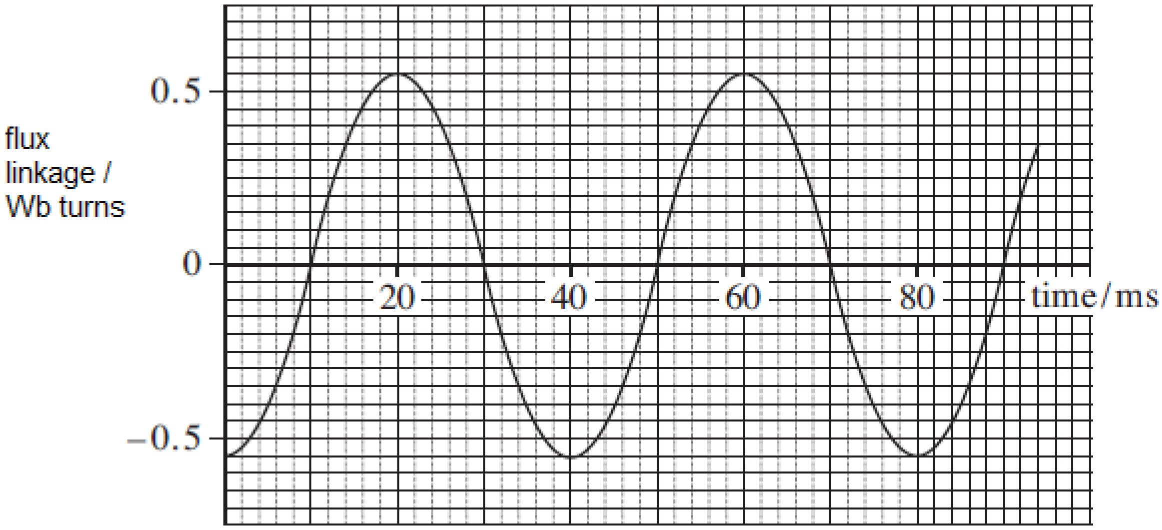
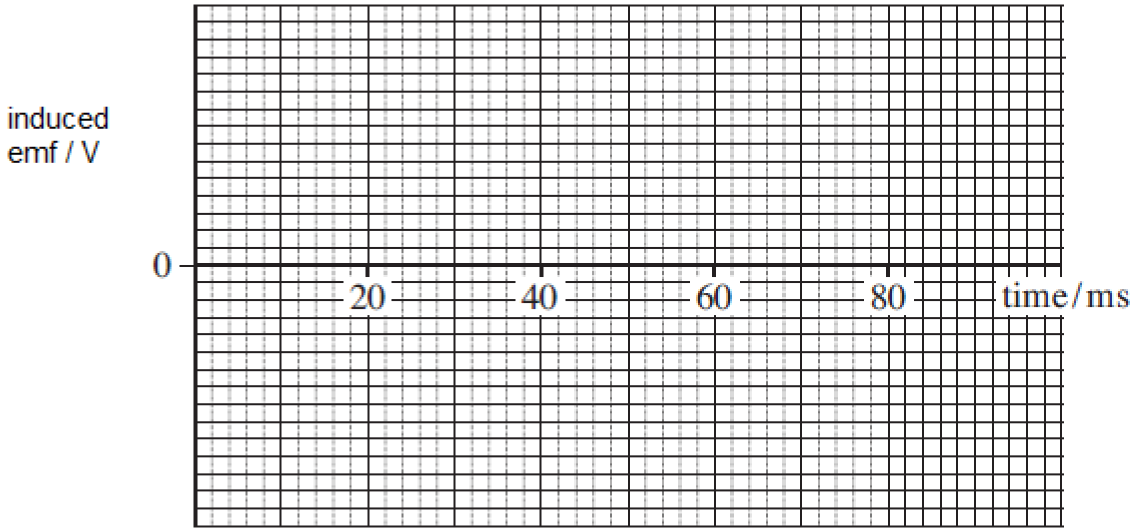


Figure 3



(iii) Calculate the peak value of the emf generated.

peak emf V

(3)

(c) Sketch a graph on the axes shown in **Figure 3** above to show how the induced emf varies with time over the time interval shown in **Figure 2**.

(2)

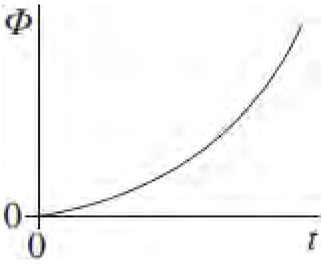
(d) The coil has 550 turns and a cross-sectional area of $4.0 \times 10^{-3} m^2$.

Calculate the flux density of the uniform magnetic field.

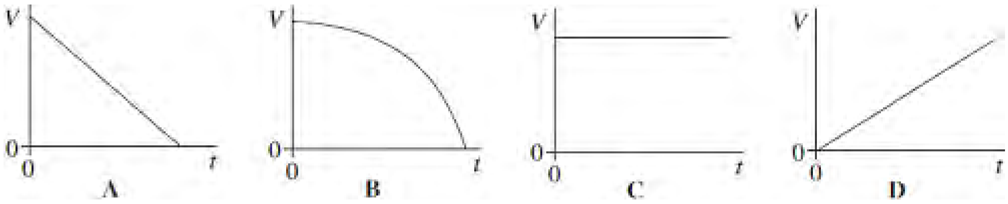
flux density .... T

(2)
(Total 13 marks)

Q4. The graph shows how the magnetic flux, Φ, passing through a coil changes with time, t.



Which one of the following graphs could show how the magnitude of the emf, V, induced in the coil varies with t?



(Total 1 mark)

Q5. The Large Hadron Collider (LHC) uses magnetic fields to confine fast-moving charged particles travelling repeatedly around a circular path. The LHC is installed in an underground circular tunnel of circumference 27 km.

(a) In the presence of a suitably directed uniform magnetic field, charged particles move at constant speed in a circular path of constant radius. By reference to the force acting on the particles, explain how this is achieved and why it happens.

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(4)

(b) (i) The charged particles travelling around the LHC may be protons. Calculate the centripetal force acting on a proton when travelling in a circular path of circumference 27 km at one-tenth of the speed of light. Ignore relativistic effects.

answer = ... N

(3)

(ii) Calculate the flux density of the uniform magnetic field that would be required to produce this force. State an appropriate unit.

answer = ... unit ....

(3)

(c) The speed of the protons gradually increases as their energy is increased by the LHC.
State and explain how the magnetic field in the LHC must change as the speed of the protons is increased.

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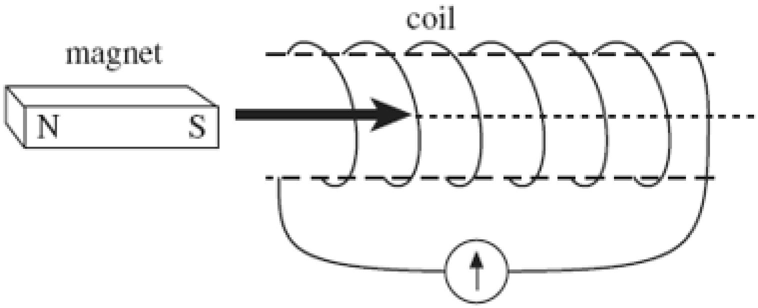
(2)
(Total 12 marks)

Q6. A 500 turn coil of cross-sectional area 4.0×10^{-3} m^2 is placed with its plane perpendicular to a magnetic field of flux density 7.5×10^{-4} T. What is the value of the flux linkage for this coil?

A 3.0×10^{-6} Wb turns
B 1.5×10^{-3} Wb turns
C 0.19 Wb turns
D 94 Wb turns

(Total 1 mark)

Q7. A bar magnet is pushed into a coil connected to a sensitive ammeter, as shown in the diagram, until it comes to rest inside the coil.



Why does the ammeter briefly show a non-zero reading?

A The magnetic flux linkage in the coil increases then decreases.

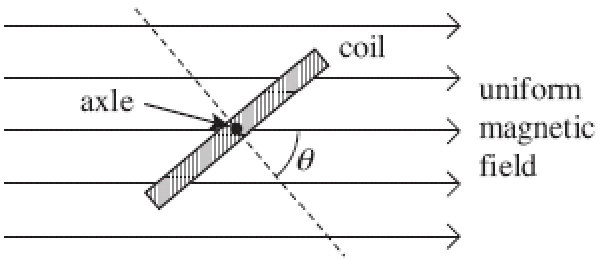
B The magnetic flux linkage in the coil increases then becomes constant.

C The magnetic flux linkage in the coil decreases then increases.

D The magnetic flux linkage in the coil decreases then becomes constant.

(Total 1 mark)

Q8.



A coil of 50 turns has a cross-sectional area of 4.2×10^{-3} m^2. It is placed at an angle to a uniform magnetic field of flux density 2.8×10^{-2} T, as shown in the diagram, so that angle $\theta = 50°$.

What is the change in flux linkage when the coil is rotated anticlockwise until $\theta = 0°$?

A The flux linkage decreases by 2.1×10^{-3} Wb turns.

B The flux linkage increases by 2.1×10^{-3} Wb turns.

C The flux linkage decreases by 3.8×10^{-3} Wb turns.

D The flux linkage increases by 3.8×10^{-3} Wb turns.

(Total 1 mark)

Q9. An aircraft, of wing span 60 m, flies horizontally at a speed of 150 m s^{-1}. If the vertical component of the Earth's magnetic field in the region of the plane is 1.0×10^{-5} T, what is the magnitude of the magnetic flux cut by the wings in 10 s?

A 1.0×10^{-5} Wb

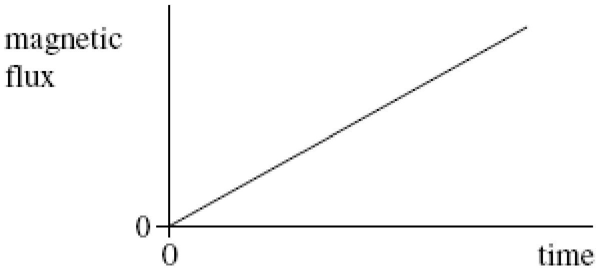
B 1.0×10^{-4} Wb

C 9.0×10^{-2} Wb

D 9.0×10^{-1} Wb

(Total 1 mark)

Q10. The graph shows how the magnetic flux passing through a loop of wire changes with time.



What feature of the graph represents the magnitude of the emf induced in the coil?

A the area enclosed between the graph line and the time axis

B the area enclosed between the graph line and the magnetic flux axis

C the inverse of the gradient of the graph

D the gradient of the graph

(Total 1 mark)

Q11. The magnetic flux through a coil of N turns is increased uniformly from zero to a maximum value in a time t. An emf, E, is induced across the coil.
What is the maximum value of the magnetic flux through the coil?

A $\frac{Et}{N}$

B $\frac{N}{Et}$

C $E\,t\,N$

D $\frac{E}{Nt}$

(Total 1 mark)