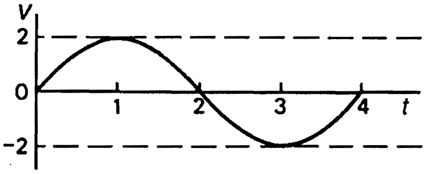
TOPIC 22 Electromagnetic Induction

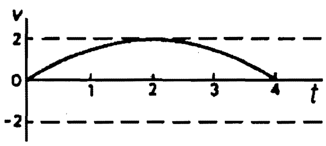
22.1 Principles of electromagnetic induction
22.2 The a.c. generator
22.3 The transformer

1 A simple a.c. generator produces a voltage which varies with time as shown in the diagram.



Which graph shows how the voltage varies with time when the speed of rotation is halved?

A



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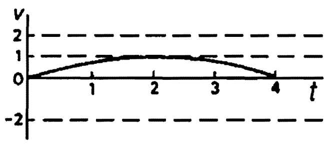

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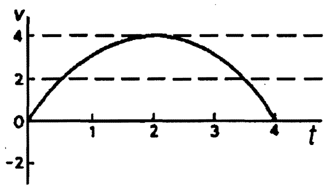

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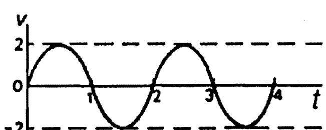

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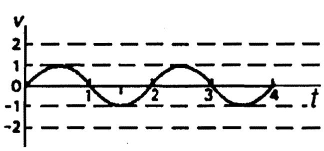


J90/I/34 ; N97/I/34

2 A transformer is needed to convert a mains 240 V supply into a 12 V supply.

If there are 2000 turns on the primary coil, how many turns should there be on the secondary coil?

A 100
B 120
C 200
D 24 000
E 90 000

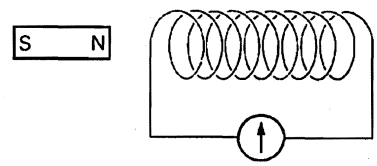
N90/I/32

3 What is the purpose of a step-down transformer?

A It makes the output current lower than the input current.
B It makes the output current the same as the input current.
C It makes the output voltage lower than the input voltage.
D It makes the output voltage higher than the input voltage.
E It makes the output voltage the same as the input voltage.

J91/I/33

4 When a magnet was pushed towards a solenoid, the sensitive meter connected to the solenoid deflected to the right.

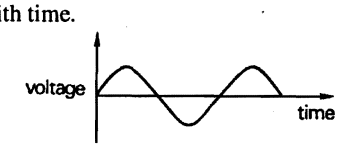


When the same magnet was pulled away from the solenoid at the same speed, what was the deflection on the meter?

A the same and to the right
B greater and to the right
C zero
D greater but to the left
E the same but to the left

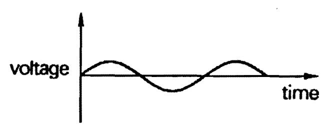
J92/I/31; J95/I/31

5 A transformer has more turns on the secondary coil than on the primary. The graph shows how the input voltage varies with time.



Which graph shows how the output voltage varies with time?

A



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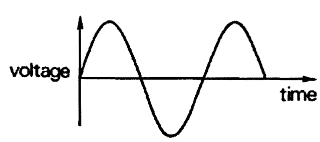

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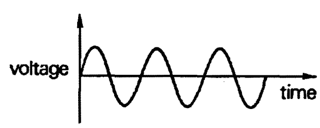

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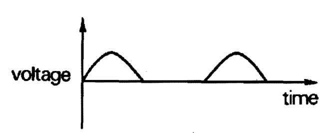

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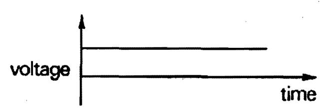


N92/I/32

6 In some countries, electricity is transmitted at very high voltages over large distances using overhead cables.

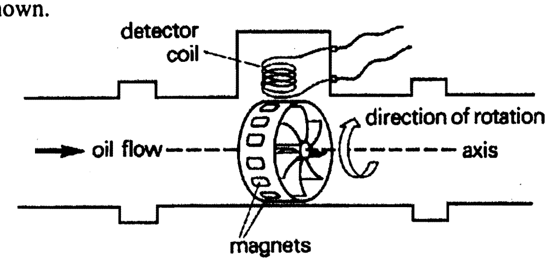
Why is this high voltage an advantage?

A Electricity can travel faster along the cables.
B It is safer for engineers to repair cables.
C It makes the cables stronger.
D There is less energy loss from the cables
E The cables do not need to be insulated N92/I/33

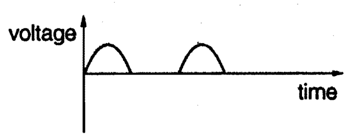
7 Why is electrical energy usually transmitted at high voltage?

A The resistance of the transmission cables is as small as possible.
B The transmission cables are safer to handle.
C As little energy as possible is wasted in the transmission cables.
D The transmission system does not require transformers.
E The current in the transmission cables is as large as possible. J93/I/31

8 The diagram shows the principle of a flowmeter used in the oil industry to measure the volume of oil passing along a pipe. When oil flows, the magnets rotate about the axis as shown.



Which graph best represents the voltage signal in the detector coil?

A


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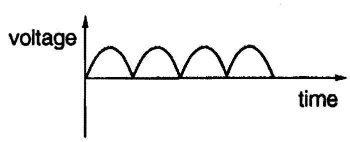

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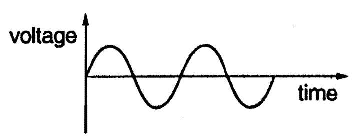

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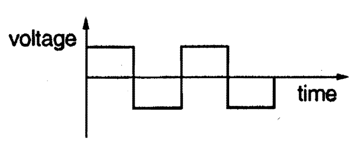

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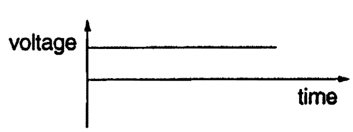


N93/I/32

9 There are 2000 turns in the secondary coil of a transformer and 500 turns in the primary coil.

What will be the voltage across the secondary coil if an alternating voltage of 240 V is applied across the primary coil?

A 60 V C 960 V
B 500 V D 2000 V J94/I/35

10 Electricity is transmitted at high voltage rather than at low voltage because

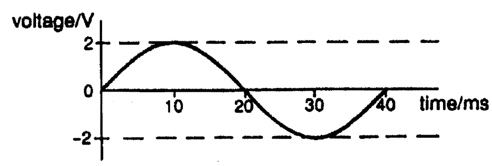
A it is generated at high voltage.
B it is safer.
C it requires less insulation.
D it wastes less energy. N94/I/32

11 A step-up transformer has a turns ratio of 1 : 100. An alternating supply of 20 V is connected across the primary coil.

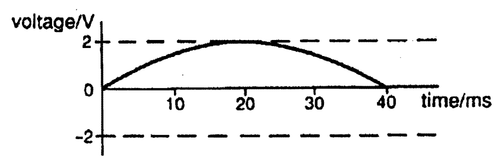
What is the secondary voltage?

A 0.2 V C 100 V
B 5 V D 2000 V N94/I/33

12 A simple a.c. generator, rotating at a certain speed, produces a voltage which varies with time as shown.



Which graph shows how the voltage varies with time when the generator rotates at half the original speed?

A


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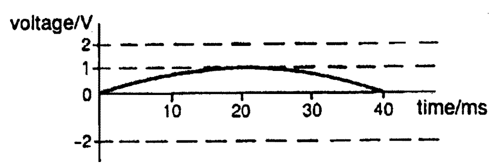

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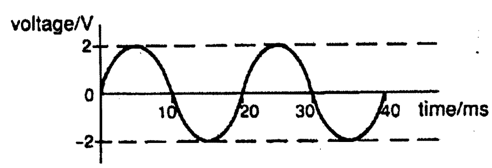

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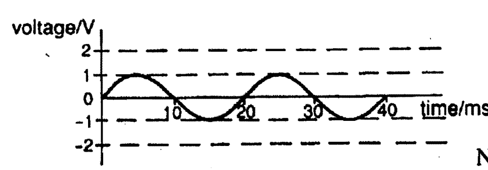
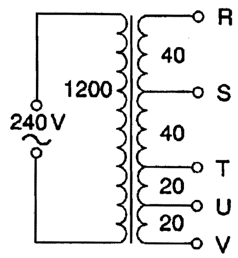


N95/I/32

13 A transformer consists of a coil of 1200 turns and another coil, with a total of 120 turns, which can be tapped at various places.

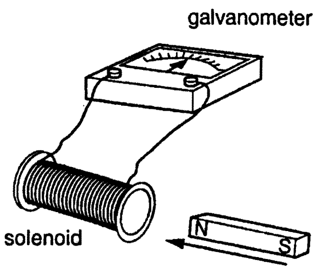
Which pair of terminals would you connect to a 12 V, 24 W lamp for it to be lit normally?



A RT
B RV
C SU
D TV

J96/I/33

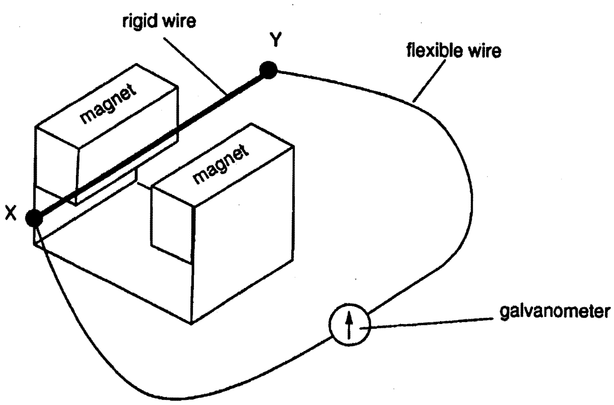
14 The N pole of a bar magnet is pushed into a solenoid, as shown in the diagram. An electromotive force is induced which moves the galvanometer needle to the left.



Which action, using the same end of the solenoid, would produce a deflection in the same direction?

A pulling a N pole out of the solenoid
B pushing a S pole into the solenoid
C pulling the solenoid away from a N pole
D pulling the solenoid away from a S pole N96/I/32

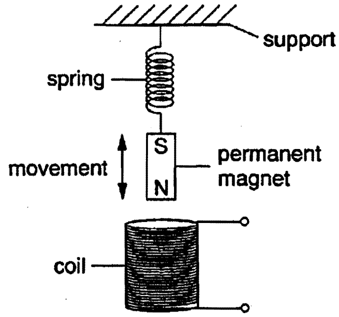
15 The rigid wire XY can be moved about in the space between the magnets as shown in the diagram.



Which of the following movements would produce the greatest reading on the galvanometer?

A downwards, quickly
B downwards, slowly
C sideways, quickly
D sideways, slowly N96/I/34

16 The diagram shows a permanent magnet moving up and down on the end of a spring. The movement of the magnet induces an e.m.f. in the coil.



Which factor, on its own, would **decrease** the maximum value of the induced e.m.f.?

A increasing the number of turns on the coil
B increasing the strength of the magnet
C raising the coil
D raising the support of the spring J97/I/30

17 Which statement about the action of a transformer is correct?

A An alternating current always flows in the secondary coil when an alternating voltage is applied to the primary coil.

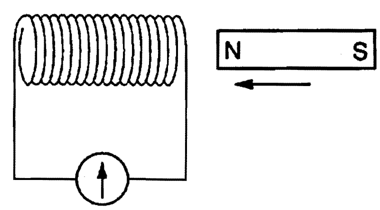
B The current in the secondary coil is always larger than the current in the primary coil.

C An e.m.f. is induced in the secondary coil when an alternating voltage is applied to the primary coil.

D An e.m.f. is induced in the secondary coil when a steady direct current flows in the primary coil.

J97/I/31

18 When a magnet is moved into the coil of wire shown, there is a small reading on the sensitive meter.



Which change would increase the size of the reading?

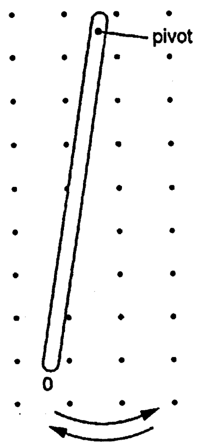
A moving the magnet faster
B pulling the magnet out
C pushing in the S-pole
D unwinding some of the turns of wire J98/I/32

19 A magnet is pushed horizontally towards a coil of insulated wire, inducing an e.m.f. in the coil.

In which direction does the coil try to move?

A downwards
B upwards
C away from the magnet
D towards the magnet N98/I/31

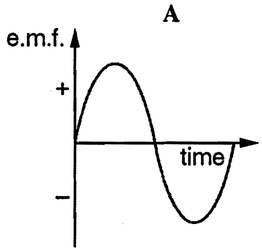
20 The diagram shows a metal bar swinging like a pendulum to and fro across a uniform magnetic field. The motion produces an induced e.m.f. in the bar.



(magnetic field)

Which graph could represent this e.m.f. during one complete to-and-fro oscillation of the bar, starting at 0?

A



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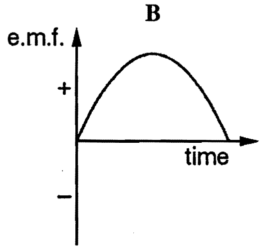

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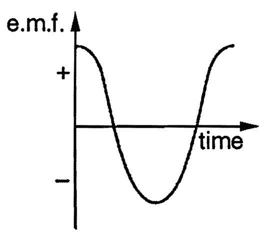

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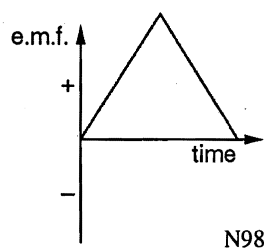
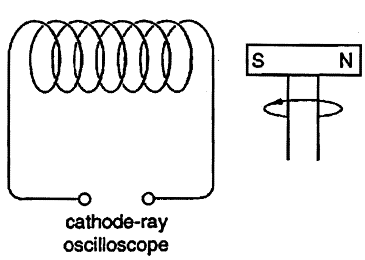


N98/I/32

21 Why does a transformer have a core made of iron?

A Iron has a high melting point.
B Iron is a conductor of electricity.
C Iron is a conductor of heat.
D Iron is a magnetic material. J99/I/31

22 A bar magnet is rotated on a shaft near to a coil as shown.



A cathode-ray oscilloscope connected to the coil indicates the induced e.m.f.

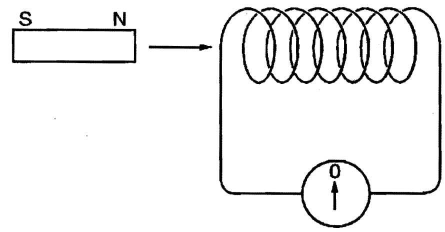
Which change does **not** increase the size of the induced e.m.f.?

A moving the magnet closer to the coil
B turning the magnet in the opposite direction at the same speed
C turning the magnet in the same direction at a greater speed
D using a coil with more turns J99/I/32

23 Why is the core of a transformer made of iron?

A Iron is a good electrical conductor.
B Iron is cheaper than copper.
C Iron is easily magnetised and demagnetised.
D Iron makes a good permanent magnet. N99/I/31

24 A small coil is connected to a meter as shown.

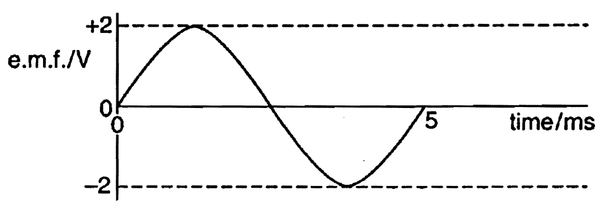


When a magnet is pushed into the coil, the pointer of the meter kicks to the right of zero.

What happens to the pointer of the meter when the magnet is pulled back from the coil?

A The pointer gives a continuous reading to the left.
B The pointer gives a continuous reading to the right.
C The pointer kicks to the left.
D The pointer kicks to the right. N99/I/32

25 The diagram shows how the e.m.f. of a simple generator varies with time.



What is the frequency and the maximum value of the e.m.f.?

	frequency /Hz	maximum e.m.f./V
A	200	2.0
B	200	4.0
C	400	2.0
D	400	4.0

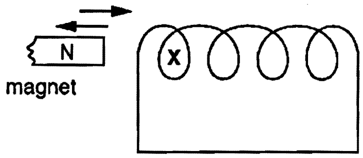
N99/I/34

26 For a step-down transformer, what are the relative numbers of turns on the two coils and the material of the core?

	primary turns	secondary turns	core material
A	few	many	hard steel
B	few	many	soft iron
C	many	few	hard steel
D	many	few	soft iron

J2000/I/31

27 The diagram shows a magnet moved into, and out of, a coil of wire.



What describes the poles produced in the coil at **X** by the movement of the magnet?

	north pole in	north pole out
A	N	N
B	N	S
C	S	N
D	S	S

N2000/I/33

28 Electrical energy is transmitted at high alternating voltages.

Which of the following is **not** a valid reason for doing this?

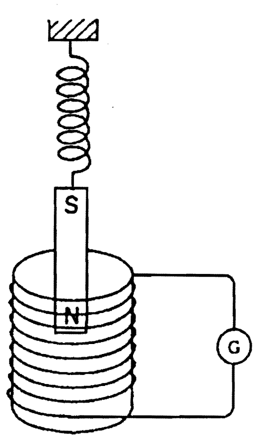
A At high voltage, a.c. is safer than d.c.

B For a given power, there is a lower current with a higher voltage.

C There is a smaller energy loss at higher voltage and lower current.

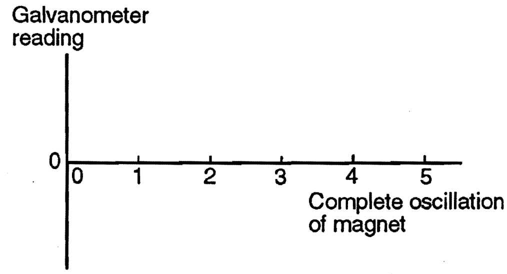
D The transmission lines can be thinner with a lower current. N2000/I/34

29



The diagram shows a bar magnet hanging from the end of a strong spring so that its N pole is stationary just inside a vertical coil whose ends are connected to a centre-zero galvanometer.

(a) The magnet is pushed down and released, so that the S pole stays well above the coil and only the N pole moves in and out of the coil. On the axes below draw a sketch graph of the expected readings of the galvanometer.



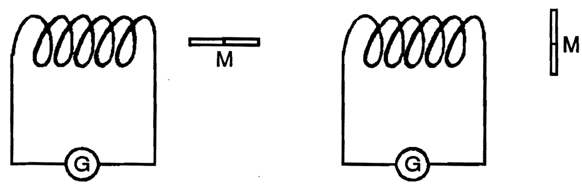
(b) Why is there a deflection of the galvanometer pointer when the magnet moves? J79/I/14

30 The voltage chosen for the *transmission* of electrical power over large distances is many times greater than the voltage of the domestic supply.

(a) State **two** reasons why electrical power is transmitted at high voltage.

(b) Why is the voltage used for the domestic supply much lower than the voltage at which the power is transmitted? N79/I/13

31



(a) *(b)*

The diagram shows a solenoid connected to a centre-zero galvanometer G and a strong magnet M which can rotate about an axis through its centre. Initially the solenoid and the magnet are in the positions shown in *(a)*. State what is observed on the galvanometer when the magnet is rotated quickly through 90° to the position shown in *(b)*.

Account for the observation you have described. N79/I/15

32

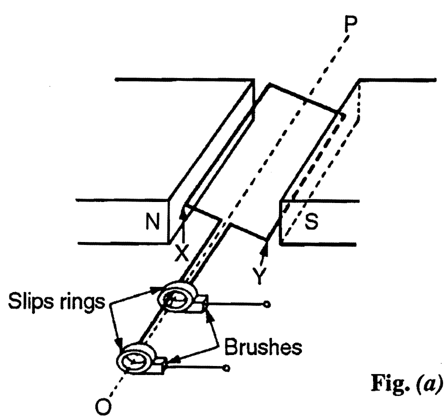


Fig. ***(a)***

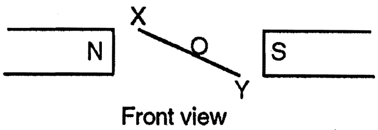


Fig. *(b)*

The diagrams Fig. *(a)* and Fig. *(b)* show a coil XY which can be rotated about an axis OP between the magnetic poles shown. The coil is connected to external circuit by the arrangement of slip rings and brushes shown.

Explain why a current flows in the external circuit when the coil is rotated.

Draw a line on Fig. *(b)* to show a position of the coil when the current produced has its maximum value. Label this line M.

Draw another line on the same Fig. *(b)* to show a position of the coil at which no current flows. Label this line Z.

J80/I/11

33 A mains supply is stated to be "240 V 50 Hz a.c."

With the aid of a labelled sketch graph, explain the meaning of a.c. and 50 Hz.

Describe with the aid of a labelled diagram a transformer which could be used to operate a lamp marked 12 V 36 W from the 240 V mains supply.

Assuming the transformer to be ideal (i.e. 100% efficient), calculate

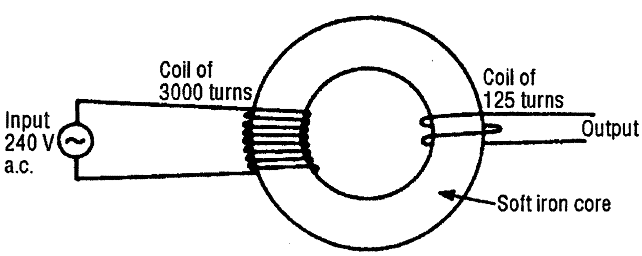
(i) the number of turns required in the secondary coil if there are 4000 turns in the primary,

(ii) the current in the primary circuit when the lamp is supplied with its normal operating current,

(iii) the energy given out in 300 s by the lamp under normal operating conditions.

J80/II/11

34 The diagram illustrates the structure of a simple ideal transformer.

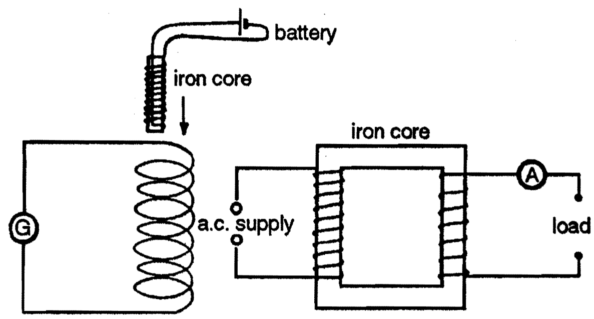


(a) If the input voltage to the transformer in the diagram is 240 V a.c., what is the output voltage?

(b) What is the purpose of the core?

N80/I/12

35 The diagrams, Fig. 1, illustrate two experiments *(a)* and *(b)*.



(a) *(b)*

In *(a)* a coil of wire wrapped around an iron core has a current passed through it from a battery. When this coil is moved into the larger coil the centre-zero galvanometer G deflects and then returns to zero.

In experiment *(b)* an a.c. supply is connected to the primary coil of a simple transformer. An a.c. ammeter A connected to the secondary coil of the transformer shows a steady deflection.

Explain in detail why the meters show a deflection in each case, and why the deflection is only for a short time in *(a)* but steady in *(b)*.

The transformer used in *(b)* is ideal and has an input voltage of 24 V and an input power of 48 W. Its primary coil has 900 turns and its secondary 600 turns.

Calculate (i) the input current,

(ii) the output power,

(iii) the output voltage,

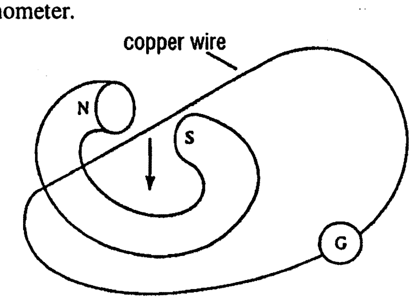
(iv) the output current.

Describe how a transformer can be designed to produce large increases in voltage.

State **two** advantages of using high voltage for long distance transmission.

J81/II/11

36 *(a)* The diagram shows an apparatus used to demonstrate electromagnetic induction. A length of copper wire is situated between the poles of a horseshoe magnet. The ends of the wire are connected to a centre-zero galvanometer.



The wire is now moved quickly in the direction indicated. The pointer of the galvanometer is observed to deflect momentarily to one side. Why does this deflection occur?

(b) Explain why the deflection of the pointer is larger when

(i) the magnet is stronger,

(ii) the galvanometer is more sensitive.

(c) State, with a brief explanation in each case, how the deflection observed would have been different if the wire had been moved at the same speed

(i) in the opposite direction,

(ii) at right angles to the indicated direction, i.e. directly towards one of the poles of the magnet.

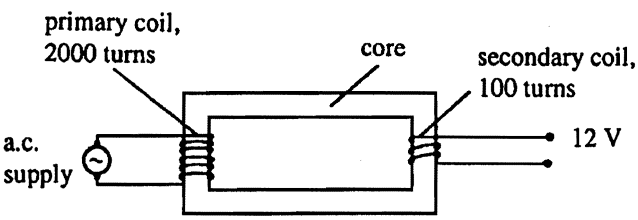
N81/II/5

37 Draw a labelled diagram showing the structure of a transformer. What is the turns ratio (the ratio of the number of primary turns to the number of secondary turns) of a transformer designed to step down the high voltage of a transmission line from 11 000 V to a domestic voltage of 250 V? (Assume that the transformer is ideal.)

It is found by experiment that the energy gained by the contents of an electric kettle in a given time is less than the energy taken from the electrical supply. Suggest reasons for this difference.

N81/II/11 (part)

38 The diagram illustrates the basic structure of a transformer.



(a) (i) Suggest a material suitable for use as the core.

Give a reason for your choice.

(ii) State the other usual feature of the design of the core.

(iii) What is the purpose of the core?

(iv) Why is it essential that the supply to the primary coil should be an a.c. supply?

(b) With the secondary coil connected across a resistor, the power dissipated in the secondary circuit is 30 W.

Calculate

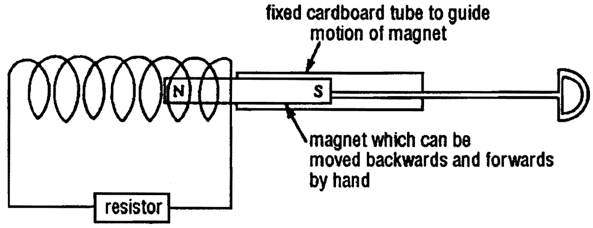
(i) the current then flowing in the secondary coil,

(ii) the voltage of the a.c. supply, assuming that the transformer is ideal, i.e. 100% efficient.

(c) Suggest **one** reason why, in a real transformer, the power drawn from the supply exceeds the power dissipated in the secondary circuit.

N82/II/6

39



The diagram shows a simple way of generating an e.m.f. by using the handle to move one end of the magnet repeatedly in and out of the coil. Explain why an e.m.f. is generated across the coil and how this causes a current in the resistor.

Draw a sketch graph to show the current in the coil against time during two complete in-and-out movements of the magnet. What happens to the frequency and amplitude of the e.m.f. when the magnet is moved to-and-fro more rapidly? Explain your answer.

A 12 V a.c. supply is connected to the primary turns of a transformer in order to rise the voltage to 240 V. Draw a labelled diagram of a suitable transformer (assumed ideal) and state the required turns ration.

Given that the current in the primary is 0.5 A and that the transformer is 100% efficient, calculate

(a) the current in the secondary,

(b) the power output of the transformer. J82/II/11

40 Draw a labelled diagram to show the structure of a simple a.c. generator.

Draw a sketch graph to illustrate how the output voltage of such a generator varies with time. What is the effect on the output voltage produced when the speed of rotation of the generator is increased?

Describe in outline how the output voltage of the generator could be displayed on the screen of an oscilloscope.

Explain the following observations.

(a) An electromagnet to which a 50 Hz alternating voltage is applied continuously attracts a piece of soft iron.

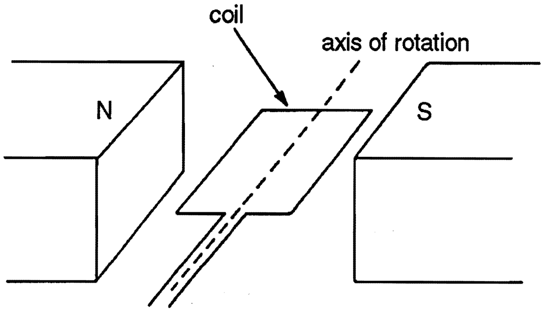
(b) There is no deflection of a moving-coil voltmeter to which a 50 Hz alternating voltage is applied.

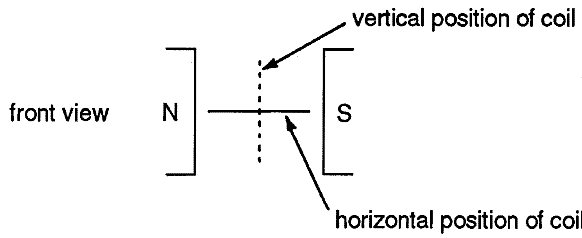
N82/II/11

41 A 40 kW electrical generator is used to supply power to a small factory. A cable resistance 2.0 Ω is used to transmit the energy. Calculate (i) the current, (ii) the power lost in the cable, when the voltage output at the generator is 5000 V.

Why is the power lost at this voltage less than the power lost when a different 40 kW generator with an output voltage of 500 V is used to transmit power to the factory through the same cables? J83/I/12

42 The diagrams show a coil rotating about the indicated axis between the poles of a permanent magnet. The coil rotates at a constant rate of 2 rev/s. On the axes below, sketch a graph to show how the e.m.f. produced varies with time. Show clearly the time scale on the time axis.

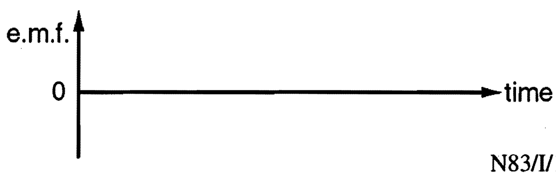




On the time axis of your graph, mark

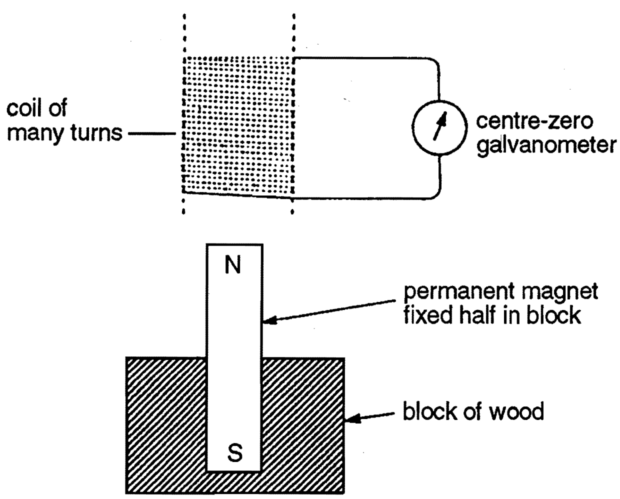
(a) the instant H when the coil is in a horizontal position,

(b) an instant V when the coil is in a vertical position.



N83/I/12

43 Draw a labelled diagram of the magnetic flux pattern inside and outside a solenoid carrying a direct current. Mark the direction (i) of the current, (ii) of the flux.



In the arrangement shown, the coil may be moved vertically down over the magnet until it rest on the block of wood.

Describe and explain what happens to the pointer of the galvanometer when

(a) the coil is moved down on to the block,

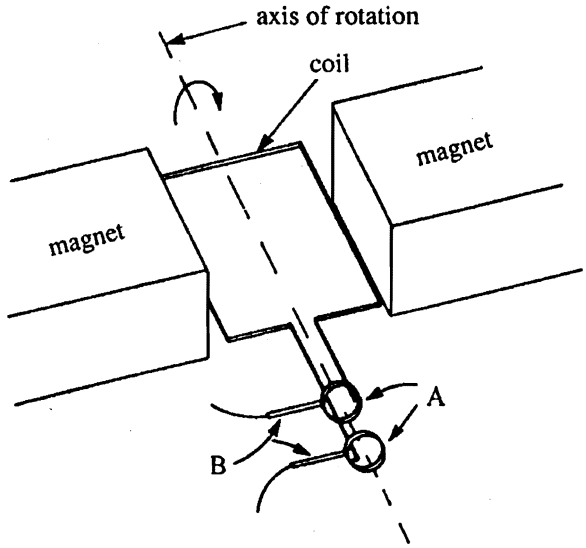
(b) the coil remains stationary resting on the block,

(c) the coil is alternately raised and lowered at regular intervals.

By modifying the apparatus, or otherwise, describe **three** ways in which the effect observed in *(a)* could be increased.

N83/II/11

44 The diagram shows the structure of a simple a.c. generator,

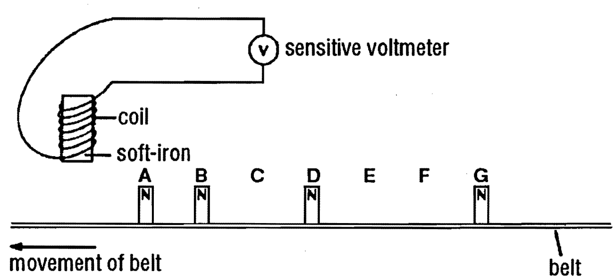


(a) Name the components A, and state their function.

Name the components B, and state their function.

(b) State *two* ways of increasing the peak voltage produced by such a generator. J84/I/13

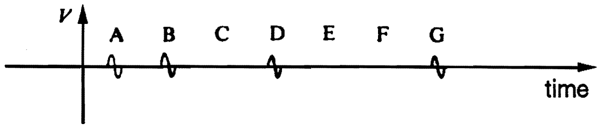
45 *(a)* The diagram shows an arrangement by which small permanent magnets, attached to a conveyor belt, are moved under a detecting device. This device consists of a coil of wire, wound on a soft-iron core, connected to a sensitive voltmeter.



As the conveyor belt moves along at constant speed, voltage pulses are recorded by the voltmeter.

(i) Explain why these pulses occur.

(ii) The graph of voltmeter reading against time is shown below, the letters corresponding to the positions on the belt as each magnet passes under the coil.



Explain why the pulse produced by each magnet has a positive and a negative part.

(iii) What is the purpose of the soft-iron core inside the coil?

(b) **Either** (i) Suggest similarities between the arrangement described in *(a)* above and the use of a magnetised tape for putting information into, for example, a computer.

Or (ii) State *two* ways in which the detecting device could be made more sensitive.

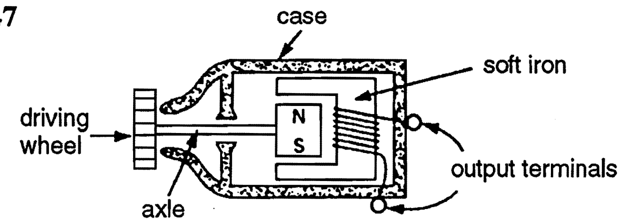
J84/II/4

46 Draw a labelled diagram to show the structure of a transformer which could be used to convert 240 V a.c. to 15 V a.c.

State and explain what would happen if a 240 V d.c. supply instead of the a.c. supply were connected to the transformer.

N84/II/11

47



The diagram above shows the structure of a bicycle dynamo. Explain briefly why the rotation of the magnet produces an e.m.f. across the output terminals. Account for the fact that the output voltage of the dynamo is alternating.

State *three* factors on which the magnitude of the e.m.f. depends. State the effect of *one* of these factors.

Why is it an advantage to make the core on which the coil is wound of laminated construction?

The power input to such a dynamo is 50 W. The voltage at the output terminals of the dynamo is 12.0 V. The currents flowing through two lamps connected in parallel to the output terminals are 1.5 A and 2.0 A respectively.

Calculate: $\dfrac{\text{the power output}}{\text{the power input}}$

Point out *two* reasons why the numerical value is less than one.

What is the source of the electrical energy produced by the dynamo?

J85/II/11

48 An electrical generator is supplying 80 kW of power at an output voltage of 5000 V. The generator is connected to a small factory by cables.

Calculate

(i) the current in the cables connecting the generator to the factory,

(ii) the power lost in the cables if they have a total resistance of 25 Ω.

N85/I/12

49 Draw a labelled diagram of a simple a.c. generator.

With reference to your diagram, explain why

(i) no e.m.f is obtained until the generator rotor is turned,

(ii) the e.m.f. varies with time even though the rotor is turned at a constant speed.

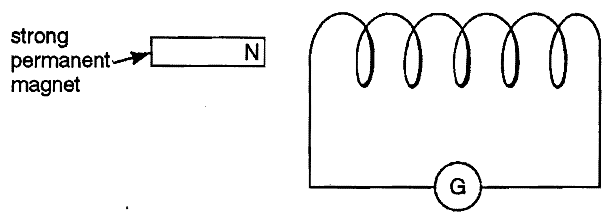
Draw a sketch graph showing how the e.m.f. of the generator varies with time. Label the axes of your graph.

The output of the generator is connected to the input terminals of a cathode ray oscilloscope. Indicate briefly any adjustments that may be necessary to obtain a suitable trace of the generator output on the screen.

Explain carefully the parts played by the Y-plates and the time-base.

N85/II/12

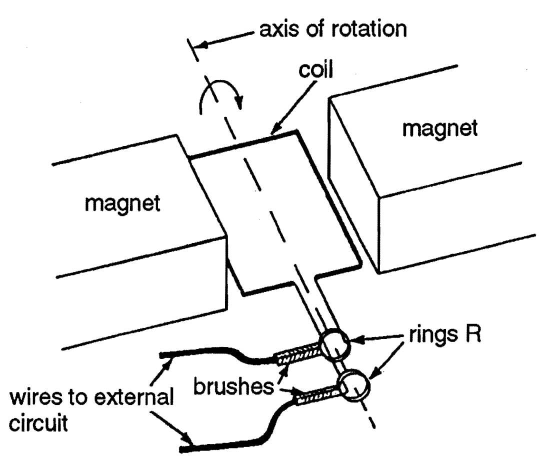
50 Describe how you could use the apparatus shown below to generate an e.m.f. by electromagnetic induction.



State *two* ways in which you would modify your method or the apparatus to increase the magnitude of the e.m.f. generated.

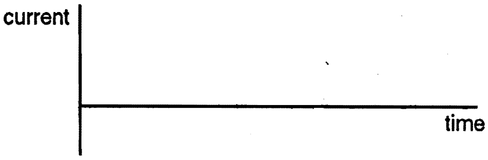
J86/I/12

51 The diagram below shows a simple a.c. generator in which a coil rotates in a magnetic field. Each end of the wire which forms the coil is connected to a metal ring R with which a brush B makes contact.



(a) State two ways in which the output of such a generator may be increased without altering the magnetic field.

(b) Sketch a graph of the form of the variation of current output with time for this type of generator.



(c) Suggest why the metal ring and brush arrangement is necessary to connect the coil to the external circuit.

N86/I/11

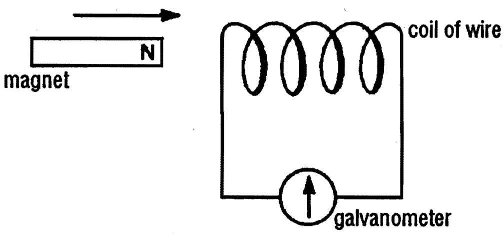
52 Electrical power may be transmitted through a system using high alternating voltages.

State the advantages gained by using

(a) *high voltages,*

(b) *alternating voltages.* J87/I/14

53 The diagram illustrates a simple experiment to demonstrate electromagnetic induction. In the diagram, the coil is wound clockwise when viewed from its left end.

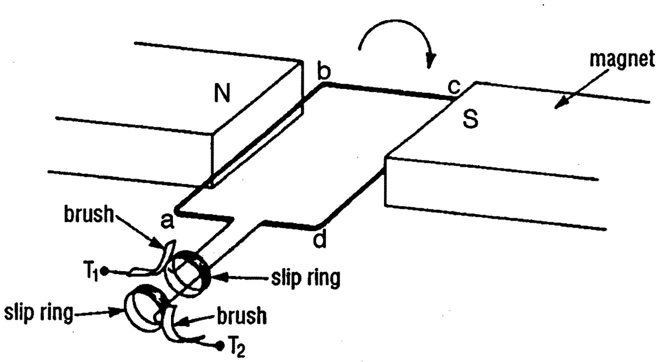


(a) Explain why the movement of the magnet into the coil induces an e.m.f. across the ends of the coil.

(b) Mark on the diagram the direction of the current induced in the coil when the magnet is moving in the direction indicated. Explain how you obtained your answer.

(c) State and briefly explain the effect, on the *magnitude* of the induced current, of moving the magnet more slowly.

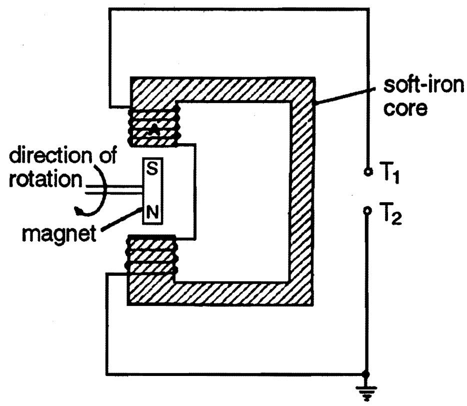
(d) The diagram illustrates a simple a.c. generator in which the coil is turned at a steady speed.



Explain the purpose of the slip ring and brush arrangement shown in the diagram.

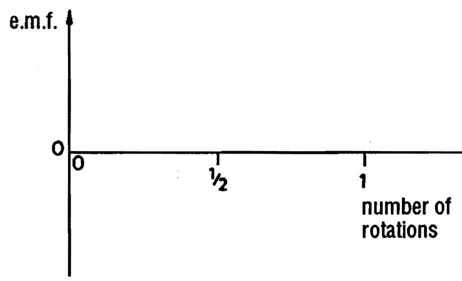
By considering the direction of the e.m.f. induced in the sections of wire ab and cd explain why, as the coil rotates, an alternating e.m.f. is obtained across the ends of the coil abcd. J87/II/4

54 The diagram shows a soft-iron core wound with two coils. The magnet is made to rotate as shown, the S-pole moving from this position up out of the plane of the paper and the N-pole moving down through the plane of the paper.



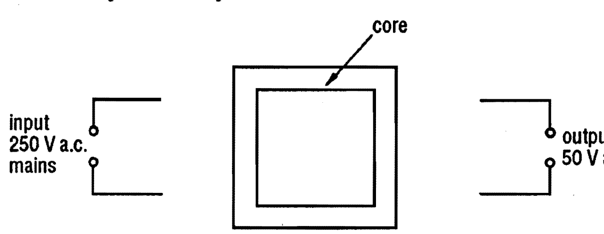
(a) Describe how the magnetic poles induced in part A of the core change during one rotation of the magnet.

(b) On the axes below, sketch the variation of the e.m.f. produced between terminals T_1 and T_2 during one rotation of the magnet. (Assume that T_2 is held at 0 V throughout the rotation.)



N87/I/12

55 *(a)* The diagram shows the core of a transformer and its input and output connections.



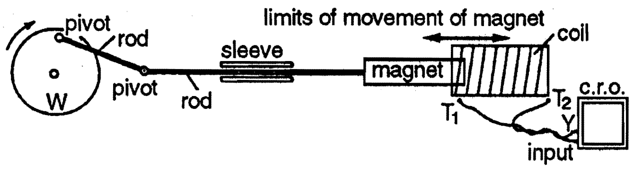
(i) State the material used for the core and describe the structure of the core. [2]

(ii) Use the figures given on the diagram to calculate the turns ratio for the transformer. (Assume the transformer to be ideal.) Hence complete the diagram of the transformer and connections, labelling all parts added to the diagram. [2]

(iii) If a current of 2 A is taken from the output, calculate the current in the input circuit. (Assume the transformer to be ideal.) [2]

N87/II/5(*a*)

56 (*a*) The diagram illustrates a form of a.c. generator.



As the wheel W is turned, one pole of the magnet moves in and out of the coil. The terminals T_1 and T_2 of the coil are connected to the Y-input of a cathode ray oscilloscope (c.r.o.) which has its controls set at suitable values to display the voltage across the coil.

(i) Explain carefully why a voltage is produced as the magnet is moved into the coil.

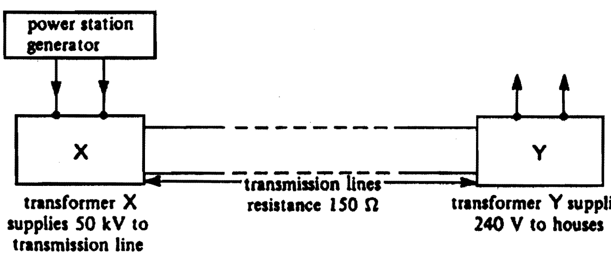
(ii) Why is a voltage produced when the magnet moves out of the coil?

(iii) State *one* way in which the two voltages are similar and *one* way in which they differ.

(iv) Sketch the pattern you would expect to see on the screen when the wheel is turned at a constant speed.

(v) State the differences you would expect to see when the wheel is rotated at twice the speed. [10]

(*b*) The diagram below represents, in simplified outline, an electrical supply system from a generating station to a house.



(i) Calculate the current passing through the element of a 3.0 kW electric kettle when used in a house in which the supply voltage is 240 V.

(ii) The distribution cable connecting transformer Y to the house has a resistance of 0.5 Ω. Calculate the rate at which heat is produced in the cable when the kettle is used.

(iii) The transmission lines have a resistance of 150 Ω and carry a current of 0.062 A. Calculate the rate at which heat is produced in the transmission lines.

(iv) Comment on the fact that the result for (ii) is much greater than that for (iii). [7]

J88/II/11

57 (*a*) Describe a simple experiment which demonstrates electromagnetic induction. Indicate how the apparatus or procedure could be modified in order to show how *each of three* different factors affect the magnitude of the e.m.f. induced. Also indicate how the direction of this e.m.f. could be reversed in your experiment. [7]

(*b*) (i) Draw a labelled diagram to illustrate the structure of a simple a.c. generator. Explain how the generator works. [6]

(ii) Suggest briefly how the generator could be modified to produce a d.c. output. [2]

(iii) A resistor is connected across the output terminals of the generator modified as in (ii). Draw a sketch graph to show the variation with time of the current in the resistor. [2]

N88/II/10

58 Fig. 2.1 shows a coil being rotated in the magnetic field between two magnets. Fig. 2.2 shows how the voltage between terminals $\mathbf{T_1}$ and $\mathbf{T_2}$ varies when the coil is rotated at a constant speed.

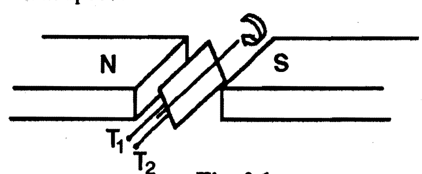


Fig. 2.1

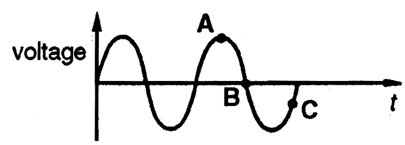


Fig. 2.2

(*a*) Which one of the points **A**, **B** or **C** could represent the voltage when the coil is passing through the position shown in Fig. 2.1? Explain how you arrived at your answer. [2]

(*b*) State two ways in which the graph in Fig. 2.2 would change if the speed of rotation of the coil was increased. [2]

J89/I/12

59

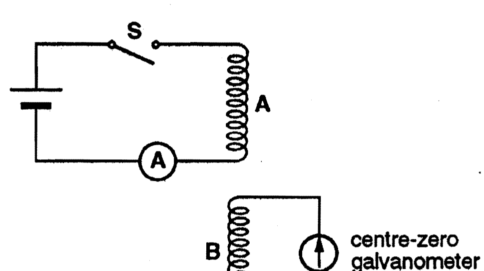


Fig. 3

(a) Fig. 3 shows an arrangement of apparatus which can be used to demonstrate electromagnetic induction. Coil **A** is connected to a battery as shown and coil **B** is connected to a sensitive centre-zero galvanometer. Coils **A** and **B** are placed close together.

State and explain what is observed

(i) when switch **S** is closed and remains closed,

(ii) when **S** is opened again. [7]

(b) (i) The experiment in *(a)* is repeated with a soft iron rod placed in both coils. State and explain one difference in the observations which would be made.

(ii) In what way, if any, would the observations change if the soft iron rod is removed and a large sheet of soft iron is placed between the coils at right angles to the line joining coils **A** and **B**? [3]

(c) (i) Draw a labelled diagram to illustrate the structure of a simple transformer.

(ii) State and explain one reason why the design of the transformer you have drawn is better than the arrangement of coils shown in Fig. 3. [4]

(d) An ideal transformer is to have an output of 12 V. Assuming that the input voltage is 240 V and that there are 3000 turns on the primary coil, calculate the number of turns required on the secondary coil. [3]

J89/II/12

60 Fig. 4 shows a rectangular coil **ABCD** placed between the poles of a magnet. The coil is rotated about the axis **XY** as shown.

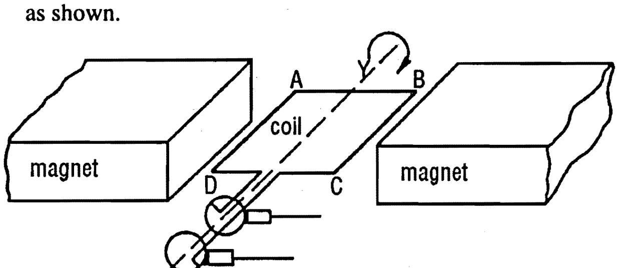


Fig. 4

(a) Explain why an e.m.f. is induced in the coil as it rotates. [2]

(b) The magnitude of the induced e.m.f. varies as the coil rotates. Show on Fig. 4 one of the positions of the coil when the e.m.f. has its maximum value. [1]

(c) Assuming that the coil and the magnet cannot be changed, describe one way in which the maximum value of the induced e.m.f. could be increased. [1]

N89/I/11

61 *(a)* Draw a labelled diagram to show the essential parts of a transformer which could be used to provide a 16 V output from a 240 V mains supply. [6]

(b) The transformer in *(a)* is to be used to charge a 12 V battery.

(i) Name two components which must be connected to the output if the transformer is to be used in this way.

(ii) Draw a circuit diagram to show how these components and the battery would be connected to the output of the transformer. [4]

N89/II/11*(a, b)*

62 The coil of the simple a.c. generator shown in Fig. 5.1 is wound on a rectangular wooden former and it rotates between the flat pole-pieces of a permanent magnet. Fig. 5.2 shows the trace obtained when the generator is connected to the input terminals of an oscilloscope.

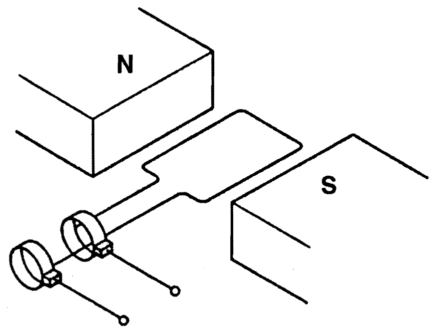


Fig. 5.1

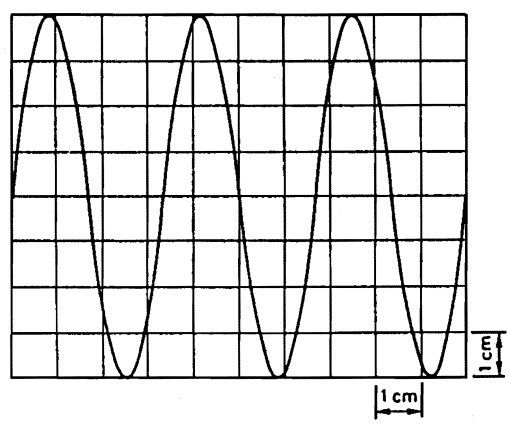


Fig. 5.2

(a) Assuming that the input sensitivity of the oscilloscope is 0.25 V/cm, what is the peak voltage output of the generator? [1]

(b) Calculate the speed of rotation of the generator coil, given that the time-base of the oscilloscope operates at 0.020 s/ cm. [2]

(c) Write down two changes to the generator design which would result in an increase in the voltage output at a given speed of rotation. [2]

J90/II/8

63 *(a)* Fig. 6 shows two insulated copper coils, **P** and **Q**, mounted close together on a wooden rod. Coil **P** is connected to switch **S** and a battery; coil **Q** is connected to a sensitive voltmeter **V**.

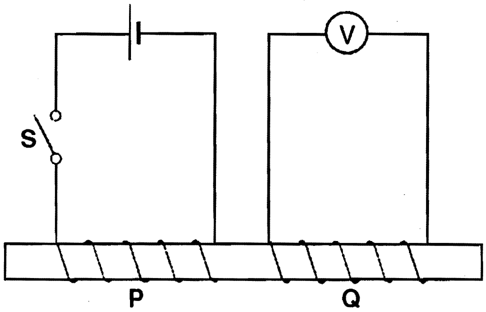


Fig. 6

When the switch S is closed a deflection is seen on the meter. This deflection lasts for a very short time.

(i) What name is given to this effect?

(ii) Does the current flow through the meter from left to right or from right to left? Justify your answer.

(iii) State and explain what will be observed as switch S is opened. [6]

(b) (i) Explain briefly how use is made of this effect in a transformer. Include in your answer a diagram and a short description of the structure of a transformer.

(ii) Explain why transformers can be used only with alternating current supplies. [6]

(c) Draw a labelled diagram of a simple a.c. generator. [3]

J91/II/11

64 Fig. 7 shows two coils of copper wire wound on a soft-iron rod. Each coil can slide easily on the rod. Coil **P** is connected in series to a battery and a switch S. Coil **Q** is connected to a sensitive centre-zero meter. As S is closed, a deflection is seen on the meter for a short time; during this time the coils slide apart a little.

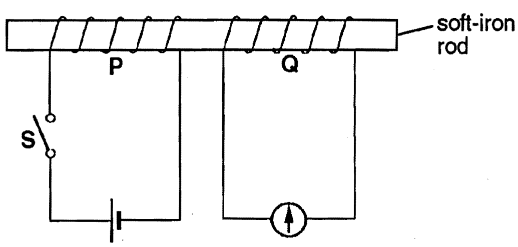


Fig. 7

(a) Explain briefly why there is a deflection on the meter.

(b) State and explain what you would expect to observe as S is opened.

(c) What would be the effect on the change you have described in *(a)* if the soft-iron rod were removed and a wooden rod put in its place. [6]

N91/II/6

65 Fig. 8 shows two coils of wire on a wooden core. Coil **P** is connected to a battery in series with a switch. Coil **Q** is connected to a sensitive ammeter. When the switch is closed there is a short-lived deflection on the ammeter.

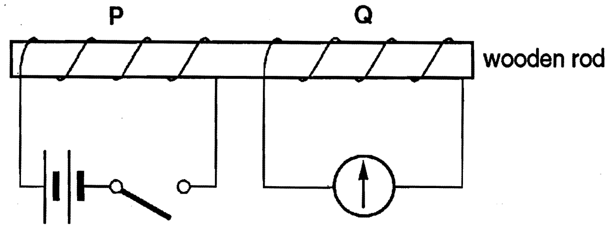


Fig. 8

(a) On Fig. 8 draw the magnetic field line pattern set up in and around coil **P** when there is a current in coil **P**. [3]

(b) What name is given to the effect which gives rise to a current in coil **Q** when the switch in the coil **P** circuit is closed? [1]

(c) Explain why the direction of the short-lived current in the coil **Q** circuit is from right to left through the coil. [2]

N92/II/7

66 Figure 9 represents a simple type of transformer. The coil on the left is connected to an a.c. power source. At the instant shown, the current is at its maximum positive value.

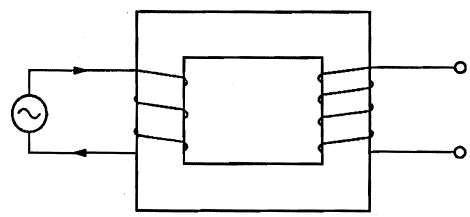


Fig. 9

(a) On Fig. 9, draw the magnetic field pattern set up by the current. [2]

(b) The current in the left-hand coil goes through one complete cycle. State briefly

(i) the changes in the current,

(ii) the changes in the magnetic field,

(iii) any possible effects on the right-hand coil. [5]

N93/II/5

67 *(a)* Figure 10.1 is a cross-section through a flat rectangular coil.

As shown, the current flows into arm **P** of the coil and out of arm **Q**.

On Fig.10.1, draw the magnetic field pattern due to the current in the coil.

P⊕ ⊙Q

Fig. 10.1 [3]

(b) Figure 10.2 shows a cross-section through the pole-pieces of a magnet. **On Fig. 10.2**, draw the magnetic field pattern between the two poles.

Fig. 10.2 [3]

(c) The coil of part *(a)* is rotating between the poles shown in Fig. 10.2 with its two ends connected together.

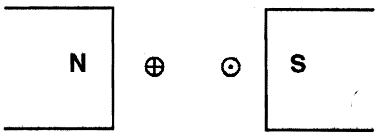


Fig. 10.3

The direction of the induced current is shown in Fig. 10.3.

State how we know that the direction of rotation is clockwise. [1]

N94/II/6

68 *(b)* Figure 11.1 shows an ideal step-down transformer. There are 1440 turns on the primary coil and 72 turns on the secondary coil. The primary coil is connected to the 240 V, 50 Hz mains supply. A resistor of resistance 600 Ω is connected across the secondary coil.

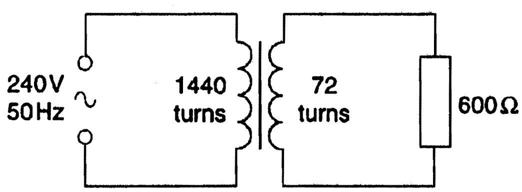


Fig. 11.1

Assuming that the transformer has an efficiency of 100%, determine

(i) the voltage across the 600 Ω resistor,

(ii) the current in the secondary coil,

(iii) the current in the primary coil. [6]

(c) Figure 11.2 shows the form of the variation with time t of the current I in the primary coil of the transformer in *(b)*.

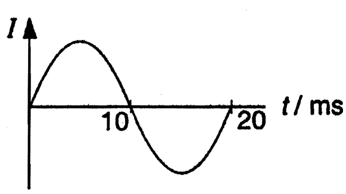


Fig. 11.2

Sketch graphs, with the same time axis as Fig. 11.2, to show possible forms of the variation of

(i) the strength of the magnetic field in the transformer core,

(ii) the e.m.f. induced in the secondary coil. [4]

N95/II/11*(b, c)*

69 *(b)* Fig. 12 shows the arrangement used in a further set of experiments in which coil **P** is connected to a 6 V alternating supply.

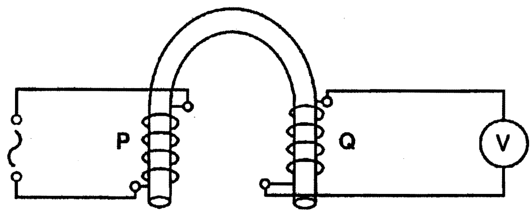


Fig. 12

(i) When coil **Q** is connected to an a.c. voltmeter, the voltmeter shows that there is a voltage across the output terminals of coil Q.

Explain why this happens.

(ii) State **two** changes which would increase the voltage across the output terminals of coil **Q**. [6]

J96/II/9*(b)*

70 Fig. 13 is a diagram of a simple a.c. generator.

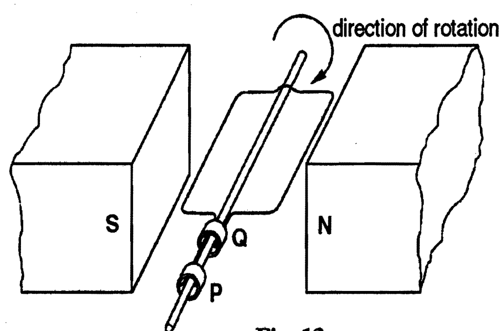


Fig. 13

(a) Explain

(i) why an e.m.f. is induced in the coil as it rotates,

(ii) how we know that at the instant shown in Fig. 13, the slip-ring **P** is positive,

(iii) why work has to be done to keep the coil rotating when the slip-rings **P** and **Q** are connected across a resistor. [5]

(b) The coil of the generator rotates 2.5 times in each second; at this speed, the maximum value of the induced e.m.f. is 20 mV. **On graph paper**, sketch a graph of e.m.f. against time for a time interval of 1 s from the instant shown in Fig. 13. [4]

(c) Explain briefly, with the aid of diagrams,

(i) how the electrons in a cathode-ray tube are produced,

(ii) how these electrons are given a high velocity,

(iii) how the beam of electrons in a cathode-ray tube can be made to move vertically by voltages such as the output of the generator shown in Fig. 13.

[6]

J97/II/9

71 Fig. 14.1 shows a transformer being used to step down a 240 V alternating supply, in order to operate a low voltage lamp.

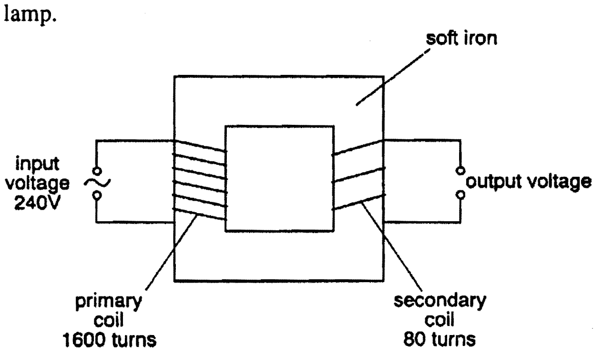


Fig. 14.1

(a) (i) Explain how the transformer works and how it is able to step down the input voltage.

(ii) The primary coil has 1600 turns and the secondary coil has 80 turns. Show that the output voltage across the secondary coil is 12 V. [7]

(b) A lamp is connected to the secondary coil of the transformer by long leads which have a resistance of 2.5 Ω, as shown in Fig. 14.2. (In this diagram, the resistance of the leads is shown as a single resistor of value 2.5 Ω.)

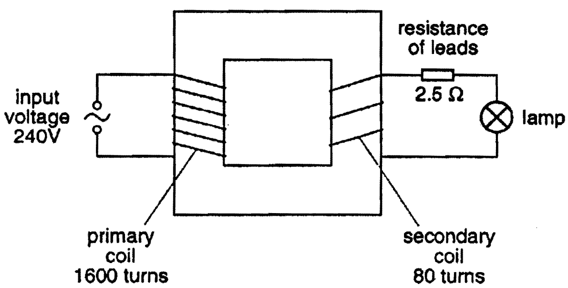


Fig. 14.2

The power input to the primary coil is 40 W, and the transformer is 100% efficient.

(i) Calculate the current in the secondary coil of the transformer.

(ii) Calculate the voltage across the resistance of the leads.

(iii) Calculate the electrical power dissipated in the lamp. [6]

(c) High voltages are used to transmit electrical energy through long-distance cables. Explain the advantage of using high voltages. [2]

N98/II/9

72 Fig. 15 shows a coil of wire wound on a piece of soft iron. A magnet is rotated in the gap in the soft iron as shown.

When the magnet rotates, the lamp connected to the coil glows. The magnet takes 0.20 s to make one complete revolution.

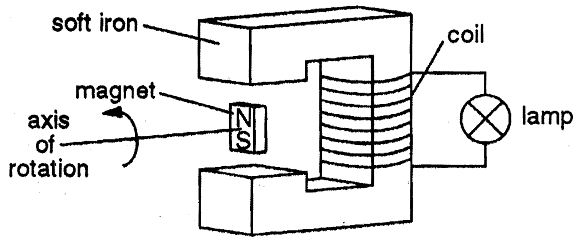
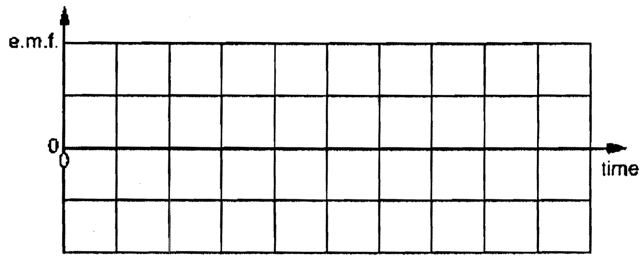


Fig. 15

(a) Explain why an e.m.f. is produced in the coil when the magnet rotates. [2]

(b) Using the axes provided, sketch a graph to show how the e.m.f. produced in the coil varies with time. Mark a scale along the time axis. [2]



(c) State two changes that increase the size of the e.m.f. produced. The parts of the apparatus shown in Fig. 15 may be altered. [2]

J2000/II/5

73 A lamp marked 6.0 V, 36 W is to be run from a power supply. The power supply can provide either direct current or alternating current.

(a) To operate at normal brightness, the lamp needs an effective potential difference across it of 6.0 V.

(i) Explain what is meant by *potential difference.*

(ii) Calculate the current through the lamp when it is operating normally.

(iii) Explain why the lamp should not be connected directly across a 10 V power supply. [6]

(b) Two students A and B suggest different ways to run the lamp at normal brightness using a 10 V power supply.

(i) Student A suggests that the lamp is used with a series resistor R, as shown in Fig. 9.1.

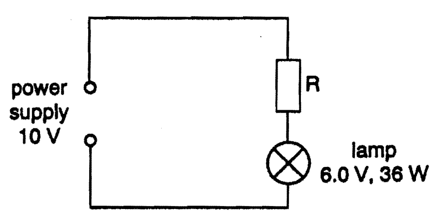


Fig. 9.1

State values for the potential difference across resistor R and the current through it, when the lamp is at normal brightness.

(ii) Student B suggests that a transformer is used to transform the power supply voltage down to 6 V.

1. Draw a labelled diagram of a transformer that could be used with a 10 V a.c. supply to operate the lamp normally. Suggest suitable values for the number of turns in each coil.
2. Explain how the transformer produces an output voltage.

(iii) Suggest and explain which student, A or B, has the better solution. [9]

Nov. 2000/II/9

ANSWERS

1. **B**	2. **A**	3. **C**	4. **E**	5. **B**
6. **D**	7. **C**	8. **C**	9. **C**	10. **D**
11. **D**	12. **B**	13. **C**	14. **C**	15. **A**
16. **B**	17. **C**	18. **A**	19. **C**	20. **A**
21. **D**	22. **B**	23. **C**	24. **C**	25. **A**
26. **D**	27. **B**	28. **A**		

33. (i) 200 (ii) 0.15 A
(iii) 10 800 J
34. *(a)* 10 V
35. (i) 2A (ii) 48 W
(iii) 16 W (iv) 3 A
37. 44
38. *(b)* (i) 2.5 A (ii) 240 V
39. $^1/_{20}$ *(a)* 0.025 A *(b)* 6 W
41. (i) 8.0 A (ii) 128 W
47. 0.84
48. (i) 16 A (ii) 640 W
55. *(a)* (ii) 5 (iii) 0.4 A
56. *(b)* (i) 12.5 A (ii) 75.125 W
(iii) 0.577 W
59. *(d)* 150
62. *(a)* 1 V *(b)* 15 Hz
68. *(b)* (i) 12 V (ii) 0.02 A
(iii) 0.001 A
71. *(b)* (i) 3.3 A (ii) 8.3 V
(iii) 12.2 W
73. *(a)* (ii) 6.0 A *(b)* (i) 4 V ; 6 A