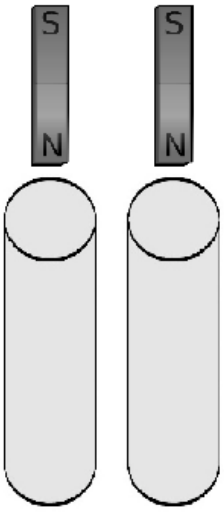
Question 1

(*d*) State Faraday's law of electromagnetic induction. (6)

Describe an experiment to demonstrate Faraday's law. (9)

A hollow copper pipe and a hollow glass pipe, with identical dimensions, were arranged as shown in the diagram. A student measured the time it took a strong magnet to fall through each cylinder. It took much longer for the magnet to fall through the copper pipe. Explain why. (13)



Question 2

(*b*) State the principle on which a moving-coil galvanometer is based. (6)

Draw labelled diagrams to show how a galvanometer may be converted to function as
(i) an ammeter
(ii) a voltmeter. (12)

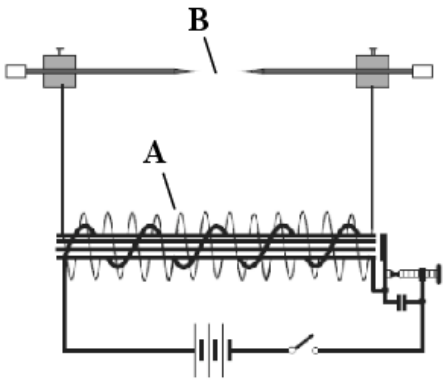
A galvanometer with a resistance of 100 Ω shows a full-scale deflection when a current of 2 mA passes through it. How can the galvanometer be converted to function as an ammeter reading up to 5 A? (15)

Name another device based on the same principle as the moving-coil galvanometer. (6)

The induction coil was invented by Dr Nicholas Callan, an Irishman. The diagram shows an induction coil that is used to produce a very high voltage from a low voltage source.

Explain the functions of the parts labelled **A** and **B** in the diagram. (12)

Give an application of the induction coil. (5)



Question 3

(b) In July 1898, at Dun Laoghaire, Guglielmo Marconi used an induction coil to send radio waves from a ship. The induction coil works on the principle of electromagnetic induction and had been invented earlier in Maynooth. He was reporting on the annual Kingstown regatta, and it was the first time that radio waves had been used in journalism. Over two days Marconi sent over 700 messages to shore using Morse code. The messages were then transmitted by telephone to the Dublin office of the *Daily Express* newspaper.

What is electromagnetic induction? Who invented the induction coil? (9)

What is the function of an induction coil? (6)

In an induction coil, a primary coil with a few turns of thick wire and a secondary coil with many turns of thin wire are wrapped on the same soft-iron core.

Why are there a large number of turns in the secondary coil?

Explain why the primary coil has thick wire.

Why are both coils wrapped on the same soft-iron core? (15)

Radio waves are much less energetic than light waves. List two other types of electromagnetic waves with energy less than that of light waves.

Give one property that is common to all types of electromagnetic waves. (8)

The telephone used to transmit the messages to Dublin contained a moving-coil loudspeaker. Describe, with the aid of a labelled diagram, how a loudspeaker operates. (18)

Question 4

(b) State the principle of conservation of energy.
What is the main energy conversion that takes place in an electric motor? (12)

What is the function of (i) the commutator, (ii) the carbon brushes, (iii) the magnet, in an electric motor? (15)

Why does the motor turn when current flows through the coil? (9)

The induction motor was invented by Nicholas Tesla.
Give an advantage of an induction motor over a dc motor. (5)

Describe an experiment to demonstrate the principle on which the induction motor operates. (15)

Question 5

(c) State Faraday's law of electromagnetic induction. (6)

Describe an experiment to demonstrate Faraday's law. (12)

A resistor is connected in series with an ammeter and an ac power supply. A current flows in the circuit. The resistor is then replaced with a coil. The resistance of the circuit does not change.
What is the effect on the current flowing in the circuit? Justify your answer. (10)

Question 6

11. *(b)* Read the following passage and answer the accompanying questions.

The scientist whose research would unite electricity and magnetism was Michael Faraday. He developed the first electric motor in 1821, showing that a current-carrying conductor could be made to revolve around a magnet. He went on to expand on Oersted's observation that an electric current produces a magnetic effect. Perhaps, Faraday thought, the opposite was also true: a moving magnetic field could generate an electric current. This was to be called electromagnetic induction. Soon he had created the first electric generator, and everyday life would never be the same again. His experiments with induced currents produced the transformer.

(Adapted from Milestones of Science; Curt Supple; 2000)

(i) List three factors that affect the force on a current-carrying conductor placed near a magnet. (7)

(ii) What energy transformation takes place in an electric motor? (7)

(iii) What is the function of a commutator in a dc motor? (7)

(iv) Draw a sketch of the output voltage from an ac generator. (7)

(v) How are the slip rings connected to an external circuit in an ac generator? (7)

(vi) A transformer and an induction coil can both be used to change a small voltage into a larger voltage. What is the basic difference in the operation of these two devices? (7)

(vii) Name the Irish physicist who invented the induction coil. (7)

(viii) Give two factors that affect the efficiency of a transformer. (7)

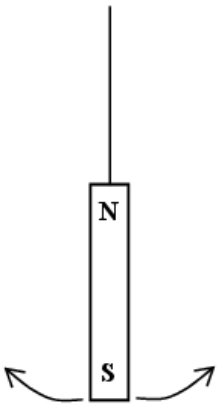
Question 7

(*h*) What is the average emf induced in a coil of 20 turns when the magnetic flux cutting it decreases from 2.3 Wb to 1.4 Wb in 0.4 s? (7)

Question 8

8. What is electromagnetic induction?
State the laws of electromagnetic induction. (18)

A bar magnet is attached to a string and allowed to swing as shown in the diagram. A copper sheet is then placed underneath the magnet. Explain why the amplitude of the swings decreases rapidly. (12)



What is the main energy conversion that takes place as the magnet slows down? (6)

A metal loop of wire in the shape of a square of side 5 cm enters a magnetic field of flux density 8 T.
The loop is perpendicular to the field and is travelling at a speed of 5 m s^{-1}.

(i) How long does it take the loop to completely enter the field?

(ii) What is the magnetic flux cutting the loop when it is completely in the magnetic field?

(iii) What is the average emf induced in the loop as it enters the magnetic field? (20)

Question 9

(b) Define magnetic flux. (6)

State Faraday's law of electromagnetic induction. (6)

A square coil of side 5 cm lies perpendicular to a magnetic field of flux density 4.0 T. The coil consists of 200 turns of wire.

(i) What is the magnetic flux cutting the coil? (9)

(ii) The coil is rotated through an angle of 90° in 0.2 seconds. Calculate the magnitude of the average e.m.f. induced in the coil while it is being rotated. (7)

Question 10

(g) Why does a magnet that is free to rotate point towards the North? (7)

Question 11

9. What is an electric current? Define the ampere, the SI unit of current. (12)

Describe an experiment to demonstrate the principle on which the definition of the ampere is based. (15)

Sketch a graph to show the relationship between current and time for

(i) alternating current;

(ii) direct current. (9)

The peak voltage of the mains electricity is 325 V. Calculate the rms voltage of the mains? (6)

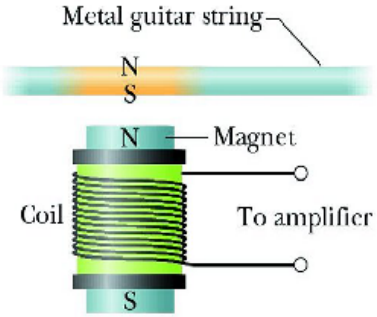
What is the resistance of the filament of a light bulb, rated 40 W, when it is connected to the mains? (9)

Explain why the resistance of the bulb is different when it is **not** connected to the mains. (5)

11. Read the following passage and answer the accompanying questions.

The growth of rock music in the 1960s was accompanied by a switch from acoustic guitars to electric guitars. The operation of each of these guitars is radically different.

The frequency of oscillation of the strings in both guitars can be adjusted by changing their tension. In the acoustic guitar the sound depends on the resonance produced in the hollow body of the instrument by the vibrations of the string. The electric guitar is a solid instrument and resonance does not occur.



Small bar magnets are placed under the steel strings of an electric guitar, as shown. Each magnet is placed inside a coil and it magnetises the steel guitar string immediately above it. When the string vibrates the magnetic flux cutting the coil changes, an emf is induced causing a varying current to flow in the coil. The signal is amplified and sent to a set of speakers.

Jimi Hendrix refined the electric guitar as an electronic instrument. He showed that further control over the music could be achieved by having coils of different turns.

(Adapted from Europhysics News (2001) Vol. 32 No. 4)

(a) How does resonance occur in an acoustic guitar? (7)

(b) What is the relationship between frequency and tension for a stretched string? (7)

(c) A stretched string of length 80 cm has a fundamental frequency of vibration of 400 Hz. What is the speed of the sound wave in the stretched string? (7)

(d) Why must the strings in the electric guitar be made of steel? (7)

(e) Define magnetic flux. (7)

(f) Why does the current produced in a coil of the electric guitar vary? (7)

(g) What is the effect on the sound produced when the number of turns in a coil is increased? (7)

(h) A coil has 5000 turns. What is the emf induced in the coil when the magnetic flux cutting the coil changes by 8×10^{-4} Wb in 0.1 s? (7)

Question 12

(f) Draw a sketch of the magnetic field due to a long straight current-carrying conductor. (7)