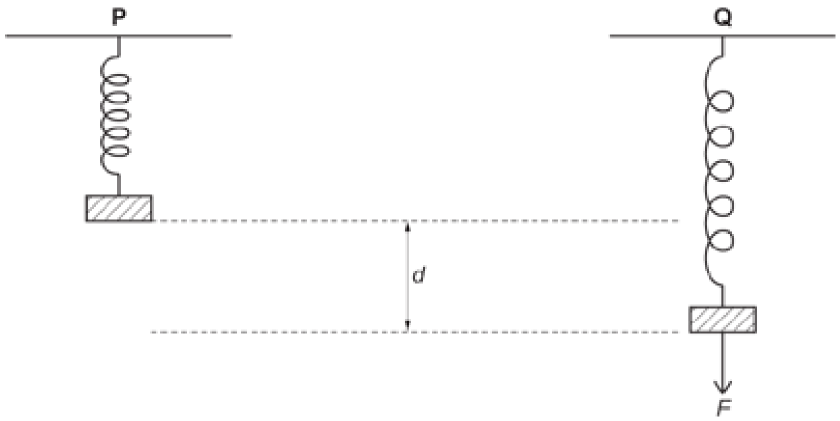
1(a). The length of an unloaded spring is approximately 4 cm.

The force constant *k* of the spring is 0.62 N cm^{-1}.

The figure below shows a block of mass 0.20 kg attached to one end of the spring. The other end of the spring is attached to a fixed support vertically above the block.

In position **P** the block rests in equilibrium. The extension of the spring is 3.2 cm.

In position **Q** a downwards force *F* has been applied to the block, so that it now rests a distance *d* below its position at **P**. The extension of the spring is now 8.5 cm.



The force *F* is removed.

i. Calculate the magnitude of the block's initial acceleration at the instant that the force *F* is removed.

Assume that the spring is not extended beyond its limit of proportionality.

acceleration = ... m s^{-2} **[3]**

ii. The block now moves with simple harmonic motion.

Calculate the frequency of this motion.

frequency = ... Hz **[3]**

(b). The block is replaced by a strong magnet **L** of slightly greater mass.

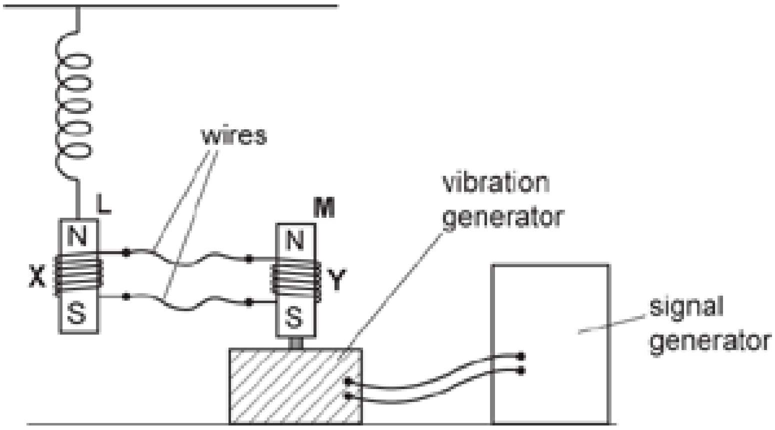
The oscillation frequency of this new arrangement is 2.5 Hz.

The magnet **L** is placed inside a coil **X** of insulated copper wire.

The coil **X** is connected with long wires to a second, identical coil **Y**.

A second strong magnet **M** is placed inside **Y** and attached to a vibration generator.

The vibration generator is then forced to oscillate with a frequency of approximately 2.5 Hz by adjusting the signal generator.



i. As magnet **M** oscillates, it moves in and out of coil **Y**.

The magnet **L** also begins to oscillate.

Explain why **L** oscillates.

____

____

____

____

____

____ **[3]**

ii. The frequency of the vibration generator is now varied between 0.5 Hz and 5.0 Hz.

Suggest how the amplitude and frequency of the oscillations of **L** will change as the frequency of the generator is varied.

You may draw a diagram to support your answer.

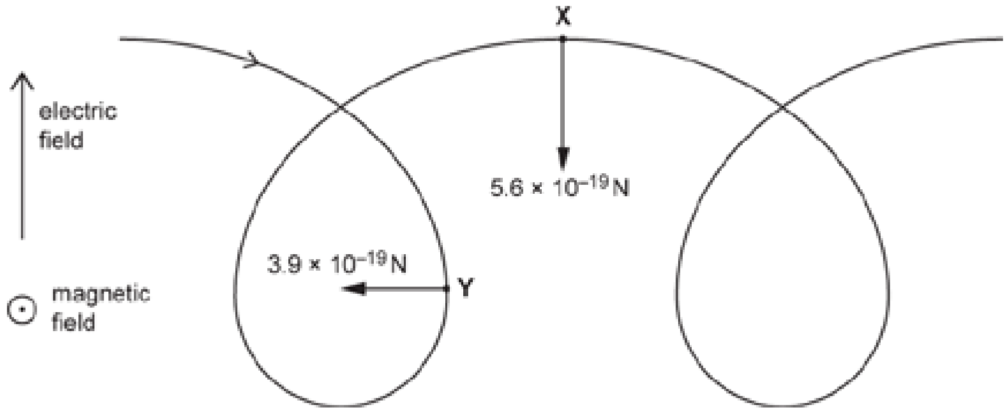
____

____

[3]

2(a). The figure below shows the path of a proton moving in a region occupied by both an electric field and a magnetic field.

The direction of the electric field lines is perpendicular to the direction of the magnetic field lines.



The uniform electric field is directed upwards, with electric field strength E = 0.90 N C^{-1}.

The uniform magnetic field is directed out of the plane of the paper, with magnetic flux density B = 5.0 × 10^{-5} T.

At point **X** the proton is moving horizontally to the right. The magnitude of the **magnetic** force at **X** is 5.6 × 10^{-19} N.

At point **Y** the proton is moving vertically downwards. The magnitude of the **magnetic** force at **Y** is 3.9 × 10^{-19} N.

The **electric** forces acting on the proton at **X** and **Y** are **not** shown in the figure.

Show that the magnitude of the constant **electric** force acting on the proton is about 10^{-19} N.

[1]

(b).

i. Suggest why the **magnetic** force acting on the proton has a different magnitude at **X** than at **Y**.

[1]

ii. At **X**, the motion of the proton is instantaneously equivalent to motion in a circle at a constant speed.

Calculate the radius of this circular motion.

radius = ... m **[4]**

iii. **1** Calculate the magnitude of the resultant force on the proton at **Y**.

resultant force = ... N **[2]**

2 Explain why the motion of the proton at **Y** is **not** instantaneously equivalent to motion in a circle at a constant speed.

[2]

3(a). Describe how an experiment can be conducted to determine how the output current of a step-up transformer depends on the number of turns on the secondary coil.

Explain how the data collected can be analysed to establish the relationship between the output current and the number of turns on the secondary coil.

You are provided with wire and a suitable core on which to wind the wire, as well as any other normal laboratory equipment.

Use the space below to draw a labelled circuit diagram.

[6]

(b). A simple laminated iron-core transformer takes mains voltage 230 V, 50 Hz into the primary coil. The output voltage from the secondary coil is 5.0 V. The primary coil has 920 turns.

i. State *Faraday's law*.

[1]

ii. Show that the number of turns on the secondary coil is 20.

[2]

iii. At one particular instant, the output voltage from the transformer is 3.4 V.

Calculate the change in magnetic flux experienced by the secondary coil in a short time interval of 1.2 ms and state its unit.

Assume that the output voltage from the transformer remains constant at 3.4 V over this time interval.

$\Delta\Phi$ = ... unit .... **[4]**

4. At the Earth's equator the magnetic flux density *B* is approximately 25 μT.

What is the magnitude of the force on an electron with velocity v = 100 km s^{-1} as it is moving perpendicular to the Earth's magnetic field at the equator?

A 4.0×10^{-25} N
B 4.0×10^{-22} N
C 4.0×10^{-19} N
D 4.0×10^{-16} N

Your answer ☐ **[1]**

5. A step-down transformer has an input potential difference of 200 V. There are 250 turns on the primary coil and 50 turns on the secondary coil. The secondary coil is connected to a 1.0 kΩ resistor.

What is the current through the resistor?

A 2×10^{-4}A
B 0.04A
C 1A
D 40A

Your answer ☐ **[1]**

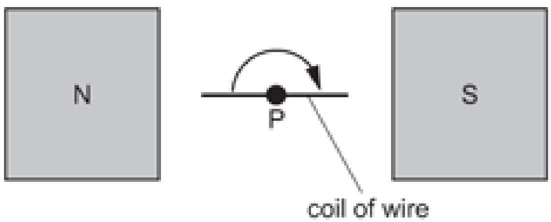
6. Which statement is Faraday's law?

A The direction of electric current induced by a changing magnetic field is such that the magnetic field created by the induced current opposes changes in the initial magnetic field.
B The magnitude of the electrostatic force between two point charges is directly proportional to the product of the magnitudes of charges and inversely proportional to the square of the separation.
C The magnitude of induced EMF is proportional to the rate of change of the magnetic flux linkage.
D The total energy of an isolated system remains constant.

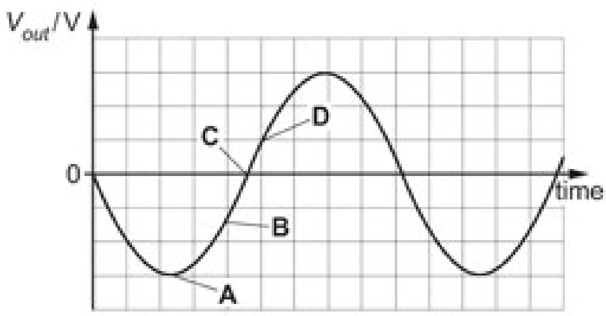
Your answer ☐ **[1]**

7. The diagram shows a coil of wire rotating between two permanent magnets in a model generator.

The coil is rotating clockwise about point P at constant angular velocity.

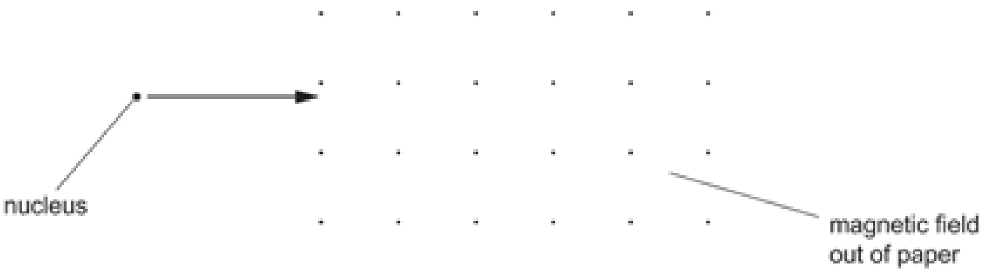


Which letter represents the output of the generator at the instant in the diagram?



Your answer ☐ **[1]**

8. The diagram shows the path of a nucleus entering a magnetic field.



In which direction does the force on the nucleus act as it enters the magnetic field?

A down the page
B into the page
C out of the page
D up the page

Your answer ☐ **[1]**

9.

*A student, supervised by their teacher, carries out an experiment with three unlabelled radioactive sources.

The student is told that each source emits only one type of radiation. One emits gamma rays, one emits beta-minus particles and one emits beta-plus particles.

The student has the following equipment:

- a selection of materials with different thicknesses
- a strong magnet
- a radiation counter (GM tube and counter).

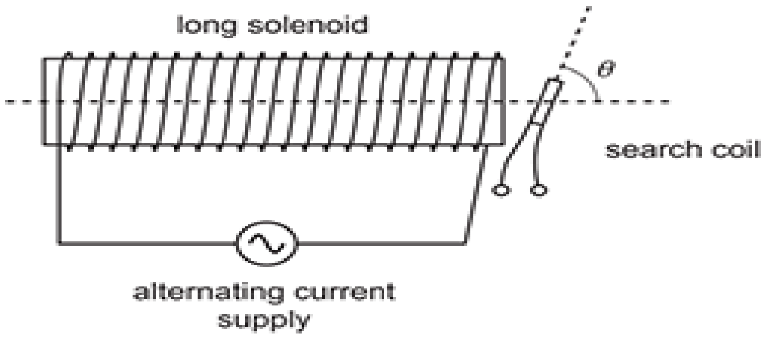
Explain how the student can use this equipment to determine safely which radiation each source emits.

You may use the space below to draw a diagram.

[6]

10(a).

A student is carrying out an experiment using a search coil.



A long solenoid is connected to an alternating current supply.

The search coil is placed at one end of the solenoid. The plane of the search coil is tilted such that it makes an angle θ with the central axis of the solenoid. The maximum alternating induced electromotive force (e.m.f.) across the ends of the search coil is E_0.

i. Name an instrument that can be used to determine E_0

[1]

ii. The equation for E_0 is:

$E_0 = KI_0 ANf \sin\theta$

where I_0 = maximum current in the solenoid, A = cross-sectional area of the search coil, N = number of turns of the search coil, f = frequency of the alternating current in the solenoid and $K = 4.0 \times 10^{-3}$ VA^{-1} m^{-2} s.

The magnitude of the induced e.m.f. in the search coil can be determined using Faraday's law of electromagnetic induction:

e.m.f. = rate of change of magnetic flux linkage

In the experiment, angle θ is changed and E_0 measured.

Suggest the quantity, or quantities, in the equation $E_0 = KI_0 ANf \sin\theta$ linked to

1 the 'rate' part of the law

______________________________ **[1]**

2 the 'change of magnetic flux linkage' part of the law.

______________________________ **[1]**

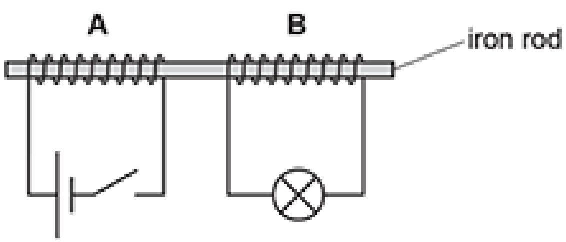
iii. The student plots a straight-line graph of E_0 against $\sin\theta$.

Determine f, including the absolute uncertainty. Write your value of f to **2** significant figures.

$I_0 = (8.0 \pm 0.2)$ A
$A = (7.8 \pm 0.1) \pm 10^{-5}$ m^2
$N = 5000$
gradient of line = $KI_0 ANf = (0.62 \pm 0.03)$ V

f = ... ± .... Hz **[4]**

(b). The diagram below shows two insulated-copper coils **A** and **B** connected in circuits.



Both coils are individually wrapped around the same iron rod.
Coil **A** is connected to a cell and a switch. Coil **B** is connected to a filament lamp.
The switch is initially closed and the lamp is off.
The switch is then opened. The lamp flashes on for a brief time, and then remains off.
Explain these observations in terms of magnetic flux.

[3]

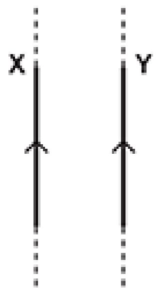
11. A particle is moving at right angles to a uniform magnetic field of flux density B. The particle has mass m, charge q and moves in a circular arc of radius r in the region of the magnetic field.

What quantities are required to determine the momentum of this particle?

A B, q and r
B B, q and m
C B, q, r and m
D q, r and m

Your answer **[1]**

12. The diagram below shows two long current-carrying conductors **X** and **Y**.



The conductors are parallel to each other.
Y experiences a force because it is in the magnetic field of **X**.

Which row gives the correct direction of the magnetic field at **Y** due to **X**, and the direction of the force experienced by **Y** due to this field?

	Direction of magnetic field	Direction of force
A	Down into the plane of paper	To the right
B	Up from the plane of paper	To the right
C	Down into the plane of paper	To the left
D	Up from the plane of paper	To the left

Your answer **[1]**

END OF QUESTION PAPER