OXFORD
INTERNATIONAL
AQA EXAMINATIONS

OXFORD AQA INTERNATIONAL A-LEVEL
PHYSICS
(9630)

PAPER 3

Specimen 2019 Morning Time allowed: 2 hours

Materials
For this paper you must have:
- a pencil
- a ruler
- a calculator
- a data and formula booklet.

Instructions
- use black ink or ball-point pen
- answer **all** questions
- show all your working.

Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 80 marks.

Please write clearly in block capitals.

Centre number ☐☐☐☐☐ Candidate number ☐☐☐☐

Surname

Forename(s)

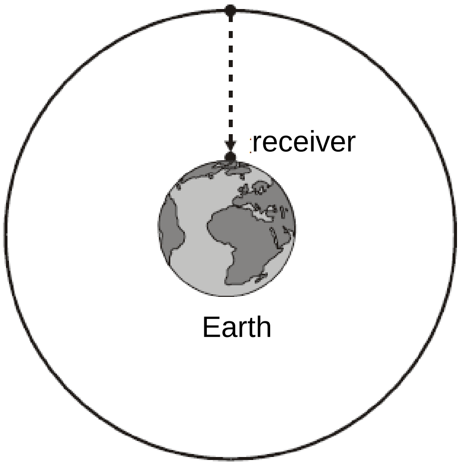
Candidate signature ______________________

V2.0

Section A

Answer **all** questions in this section.

0 1 The Global Positioning System (GPS) is a system of satellites that transmit radio signals which can be used to locate the position of a receiver anywhere on Earth.



A receiver at sea level detects a signal from a satellite in a circular orbit when it is passing directly overhead as shown in the diagram above. The satellite's orbit is 2.04×10^7 m above the Earth's surface.

0 1 . 1 Show that the gravitational field strength of the Earth at the position of the satellite is 0.56 N kg^{-1}.

mass of the Earth = 6.0×10^{24} kg
mean radius of the Earth = 6400 km

[3 marks]

0 1 . 2 Calculate the speed of the satellite in this orbit.

[2 marks]

speed = ________________ m s^{-1}

0 1 . 3 Calculate the time period of the satellite in this orbit.

[2 marks]

time period = ________________ s

Turn over for the next question

0 2 An ancient sealed flask contains a liquid, assumed to be water. An archaeologist asks a scientist to determine the volume of liquid in the flask without opening the flask. The scientist decides to use a radioactive isotope of sodium ($^{24}_{11}\text{Na}$) that decays with a half-life of 14.8 h.

0 2 . 1 The scientist first mixes a compound that contains 3.0×10^{-10} g of sodium-24 with 1500 cm^3 of water. The scientist then injects 15 cm^3 of the solution into the flask through the seal.
Show that initially about 7.5×10^{10} atoms of sodium-24 are injected into the flask.

[1 mark]

0 2 . 2 Show that the initial activity of the solution that is injected into the flask is about 1×10^6 Bq.

[3 marks]

activity = ________________ Bq

0 2 . 3 The scientist waits for 3.5 h to allow the injected solution to mix thoroughly with the liquid in the flask. The scientist then extracts 15 cm^3 of the liquid from the flask and measures its activity which is found to be 3600 Bq.

Calculate the total activity of the sodium-24 in the flask after 3.5 h and hence determine the volume of liquid in the flask.

[3 marks]

total activity = ________________ Bq

volume of liquid = ________________ m^3

0 2 . 4 The archaeologist obtained an estimate of the volume knowing that similar empty flasks have an average mass of 1.5 kg and that mass of the flask and liquid was 5.2 kg.

Compare the estimate that the archaeologist could obtain from these masses with the volume calculated in Question **02.3** and account for any difference.

[2 marks]

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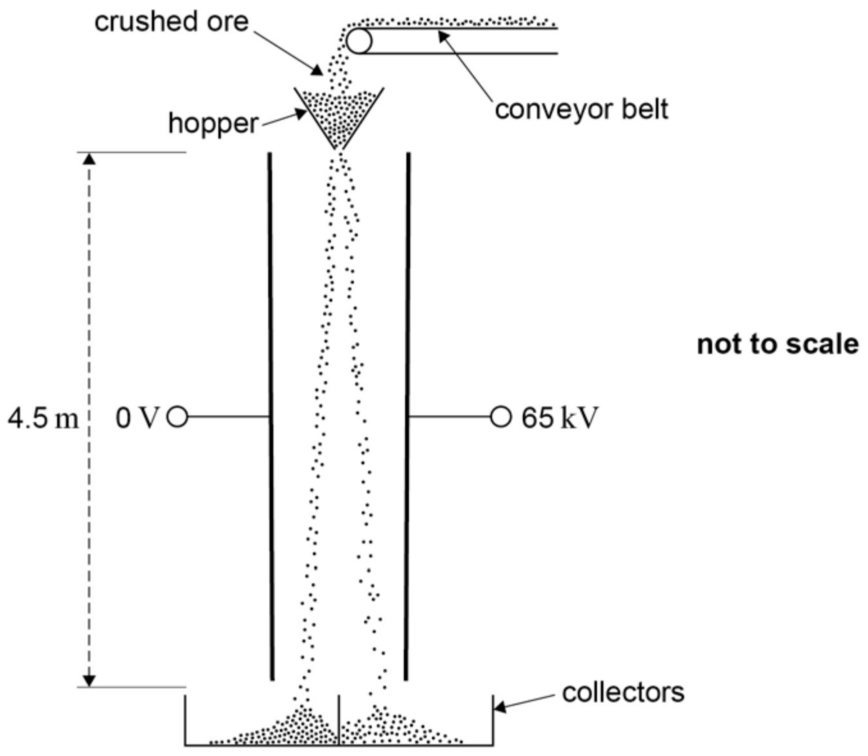
0 3 **Figure 1** shows a system that separates two minerals from the ore containing them using an electric field.

Figure 1



The crushed particles of the two different minerals gain opposite charges due to friction as they travel along the conveyor belt and through the hopper. When they leave the hopper they fall 4.5 m between two parallel plates that are separated by 0.35 m.

0 3 . 1 Assume that a particle has zero velocity when it leaves the hopper and enters the region between the plates.

Calculate the time taken for this particle to fall between the plates.

[2 marks]

time taken = ________________ s

0 3 . 2 A potential difference (pd) of 65 kV is applied between the plates.

Show that when a particle of specific charge 1.2×10^{-6} C kg^{-1} is between the plates its horizontal acceleration is about 0.2 m s^{-2}.

[3 marks]

0 3 . 3 Calculate the total horizontal deflection of the particle that occurs when falling between the plates.

[1 mark]

horizontal deflection = ______________ m

0 3 . 4 Explain why the time to fall vertically between the plates is independent of the mass of a particle.

[2 marks]

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0 3 . 5 State and explain **two** reasons, why the horizontal acceleration of a particle is different for each particle.

[3 marks]

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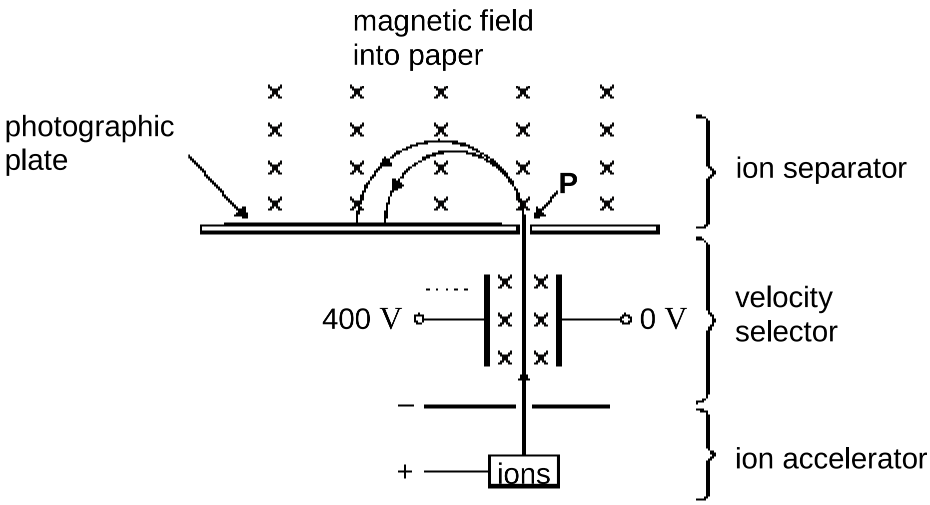
ANSWER IN THE SPACES PROVIDED

0 4 **Figure 2** shows a diagram of a mass spectrometer.

Figure 2



The magnetic field strength in the velocity selector is 0.14 T and the electric field strength is 20 000 V m^{-1}.

0 4 . 1 Define the unit for magnetic flux density, the tesla.

[2 marks]

0 4 . 2 Show that the velocity selected is independent of the charge on an ion.

[2 marks]

0 4 . 3 Show that the velocity selected is about 140 km s^{-1}.

[1 mark]

0 4 . 4 A sample of nickel is analysed in the spectrometer. The two most abundant isotopes of nickel are ${}^{58}_{28}\mathrm{Ni}$ and ${}^{60}_{28}\mathrm{Ni}$. Each ion carries a single charge of $+1.6 \times 10^{-19}$ C.

mass of a proton or neutron = 1.7×10^{-27} kg

The ${}^{58}_{28}\mathrm{Ni}$ ion strikes the photographic plate 0.28 m from the point **P** at which the ion beam enters the ion separator.

Calculate the magnetic flux density of the field in the ion separator.

[3 marks]

magnetic flux density = ______________________ T

0 4 . 5 Calculate the separation of the positions where the two isotopes hit the photographic plate.

[2 marks]

separation = ______________________ m

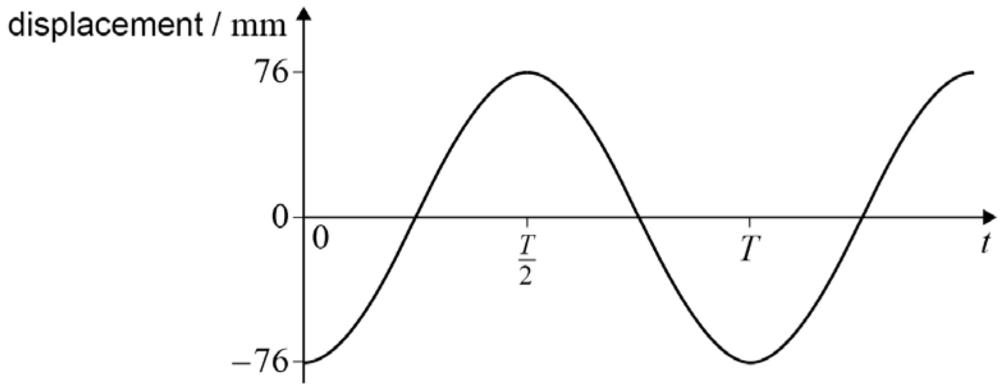
Turn over for the next question

0 5 Describe **two** causes of the energy losses in a transformer and discuss how these energy losses may be reduced by suitable design and choice of materials.

[6 marks]

0 6 A 200 g mass is suspended from a vertical spring. Initially, the mass–spring system is at rest. The mass is pulled 76 mm below its rest position and released. **Figure W** shows the displacement of the mass from its rest position with time t. The time period for one oscillation is T.

Figure W



0 6 . 1 State **two** conditions that must apply to the acceleration of the mass.

[2 marks]

condition 1 ____

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condition 2 ____

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Question 6 continues on the next page

0 6 . 2 The time taken for 25 oscillations is 23 s.

Show that the frequency of the oscillation is approximately 1.1 Hz.

[1 mark]

0 6 . 3 Calculate the maximum acceleration of the mass.

[2 marks]

maximum acceleration = ________________________ $m\ s^{-2}$

0 6 . 4 Calculate the magnitude of the displacement of the mass from its rest position 0.60 s after being released.

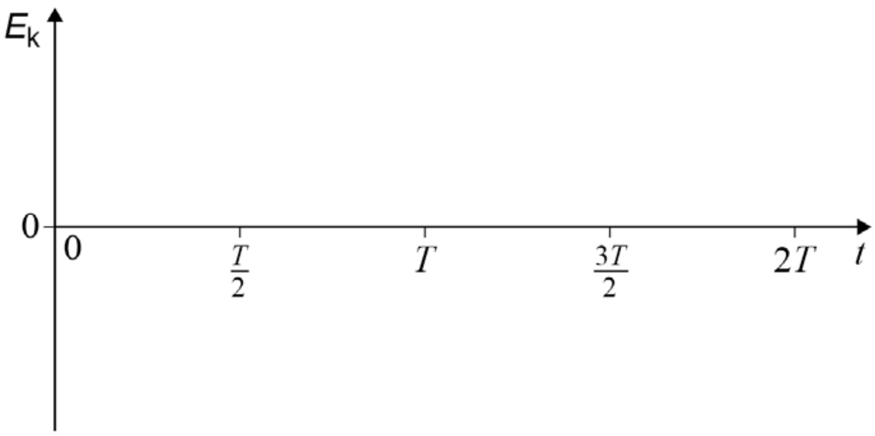
[2 marks]

displacement = ____________________________ mm

0 6 . 5 Sketch, on the axes in **Figure X**, the variation of kinetic energy E_k of the mass with time t for **two** complete oscillations of the mass–spring system. The mass is released from 76 mm below its rest position at $t = 0$

[2 marks]

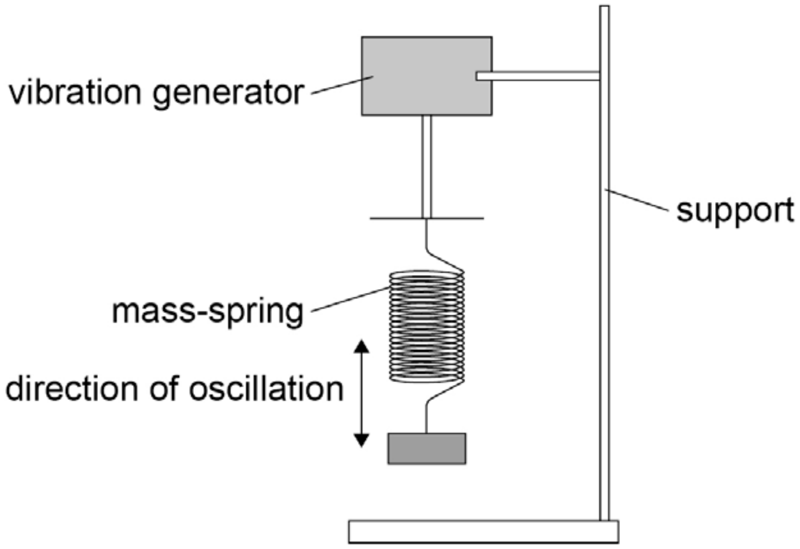
Figure X



Question 6 continues on the next page

0 6 . 6 **Figure Y** shows a vibration generator attached to the mass-spring system. The vibration generator vibrates with a small amplitude at a frequency of 1.1 Hz.

Figure Y



The small-amplitude vibrations of the generator force the mass-spring system to oscillate.

Describe and explain the oscillations of the mass–spring system.

[3 marks]

0 6 . 7 The mass is submerged in a beaker of water while the vibration generator continues to vibrate at a frequency of 1.1 Hz.

Explain why the amplitude of oscillation of the mass is reduced.

[2 marks]

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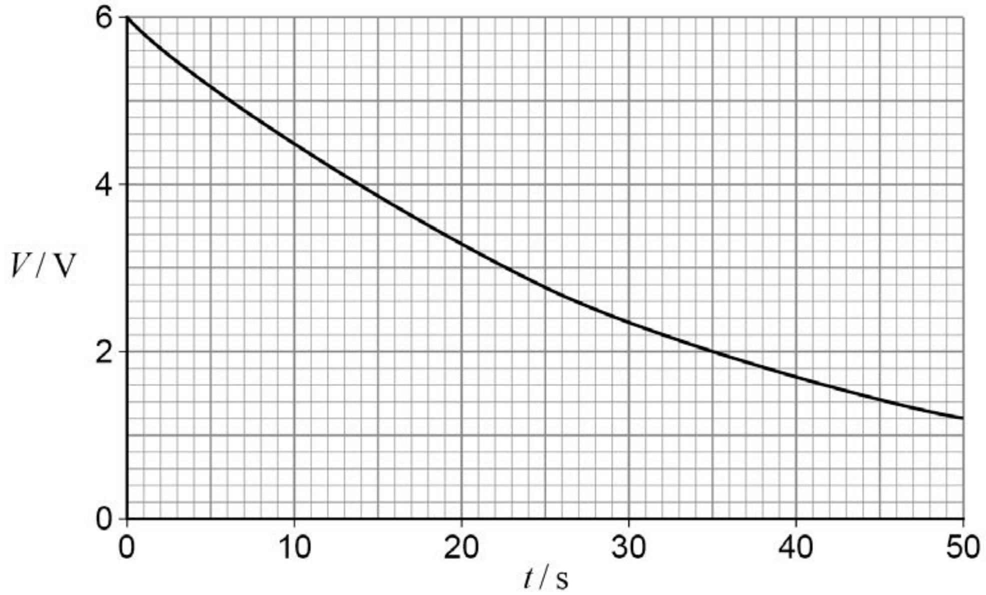
Turn over for the next question

0 7 . 0 A charged 4.7 μF capacitor initially stores 85 μJ of energy. The capacitor is discharged through a resistor **R**.

Figure Z shows the variation of potential difference *V* across the capacitor with discharge time *t*.

Figure Z



0 7 . 1 Calculate the charge on the capacitor when $t = 0$

[1 mark]

charge = ____________________ C

0 7 . 2 Calculate the energy transferred to **R** when the capacitor has been discharging for 50 s.

[3 marks]

energy transferred to **R** =_____________________ J

0 7 . 3 Calculate the resistance of **R**.

[4 marks]

resistance= ____________________________ Ω

Turn over for the next question

Section B

Each of the questions in this section is followed by four responses, **A**, **B**, **C**, and **D**. For each question select the best response.

Only **one** answer per question is allowed.

For each answer completely fill in the circle alongside the appropriate answer.

CORRECT METHOD ⬬ WRONG METHODS

If you want to change your answer you must cross out your original answer as shown.

If you wish to return to an answer previously crossed out, ring the answer you now wish to select as shown.

0 8 A coin of mass 35 g is placed on a turntable turning horizontally at 120 revolutions per minute.

If the maximum force of friction between the coin and the turntable is 0.4 N, calculate the maximum radius for the coin to stay in circular motion.

[1 mark]

A 7.2 cm ○

B 7.2 cm ○

C 4.6 cm ○

D 4.6 m ○

0 9 Which of these is an equivalent unit to the Volt?

[1 mark]

A N kg^{-1} ○

B J ○

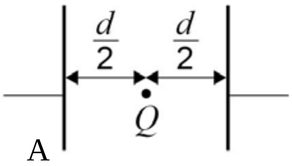
C J C^{-1} ○

D J kg^{-1} ○

1 0 Two parallel metal plates are separated by a distance d and have a potential difference V across them.

Which expression gives the magnitude of the electrostatic force acting on a charge Q placed midway between the plates?

[1 mark]



A $\frac{2VQ}{d}$ ⬭

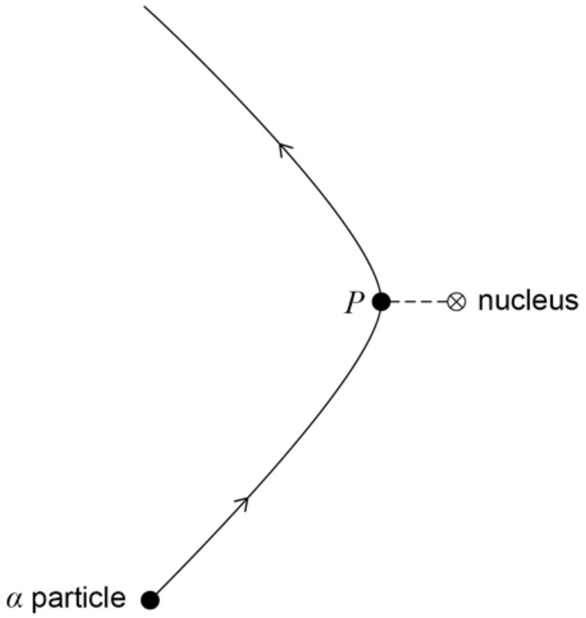
B $\frac{VQ}{d}$ ⬭

C $\frac{VQ}{2d}$ ⬭

D $\frac{Qd}{V}$ ⬭

Turn over for the next question

1 1 The diagram shows the path of an α particle deflected by the nucleus of an atom. Point P on the path is the point of closest approach of the α particle to the nucleus.



Which of the following statements about the α particle on this path is correct?

[1 mark]

A Its acceleration is zero at P.

B Its kinetic energy is greatest at P.

C Its potential energy is least at P.

D Its speed is least at P.

1 2 The electric potential at a distance *r* from a positive point charge is 45 V. The potential increases to 50 V when the distance from the point charge decreases by 1.5 m. What is the value of *r?*

[1 mark]

A 1.3 m

B 1.5 m

C 7.9 m

D 15 m

1 3 Charged particles, each of mass m and charge Q, travel at a constant speed in a circle of radius r in a uniform magnetic field of flux density B.
Which expression gives the frequency of rotation of a particle in the beam?

[1 mark]

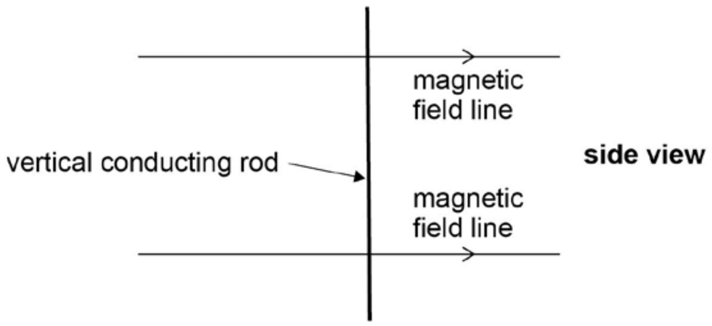
A $\frac{BQ}{2\pi m}$ ⬭

B $\frac{BQ}{m}$ ⬭

C $\frac{BQ}{\pi m}$ ⬭

D $\frac{2\pi BQ}{m}$ ⬭

1 4 A vertical conducting rod of length l is moved at a constant velocity v through a uniform horizontal magnetic field of flux density B.



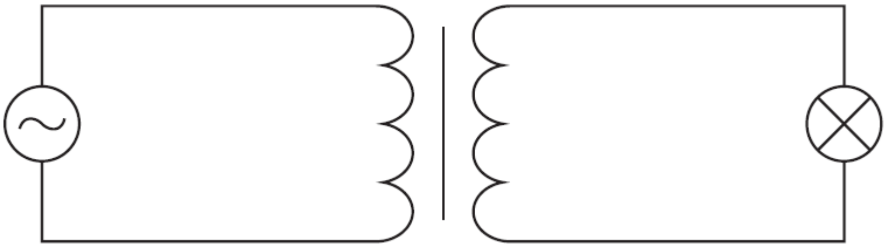
Which of the rows gives a correct expression for the induced emf between the ends of the rod for the stated direction of the motion of the rod?

[1 mark]

	Direction of motion	Induced emf	
A	Vertical	$\frac{B}{lv}$	⬭
B	Horizontal at right angles to the field	Blv	⬭
C	Vertical	Blv	⬭
D	Horizontal at right angles to the field	$\frac{B}{lv}$	⬭

1 5 A transformer with 3000 turns in its primary coil is used to change an alternating pd from an rms value of 240 V to an rms value of 12 V.

When a 60 W, 12 V lamp is connected to the secondary coil, the lamp lights at normal brightness and a rms current of 0.26 A passes through the primary coil.



Which line, **A** to **D**, in the table gives correct values for the number of turns on the secondary coil and for the transformer efficiency?

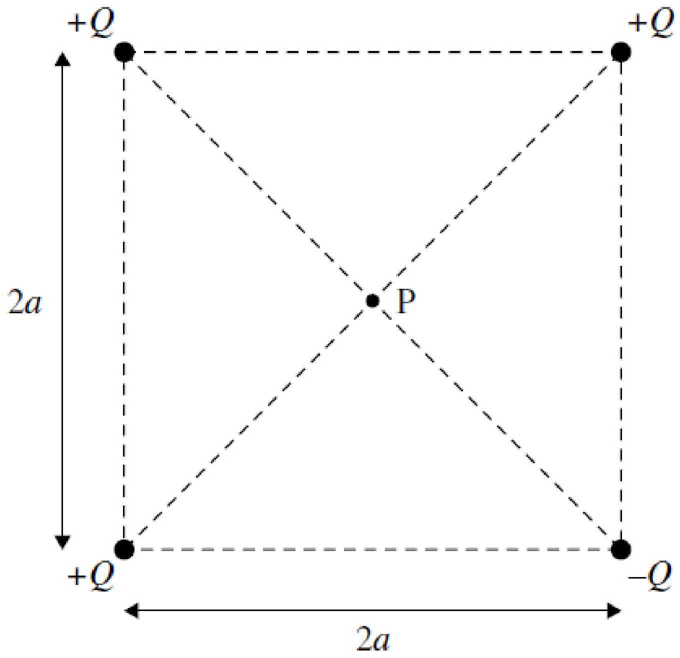
[1 mark]

	number of turns on the secondary coil	**efficiency**	
A	150	96%	⬭
B	60 000	96%	⬭
C	150	90%	⬭
D	60 000	90%	⬭

1 6 The diagram shows four point charges at the corners of a square of side $2a$.

What is the electric potential at P, the centre of the square?

[1 mark]



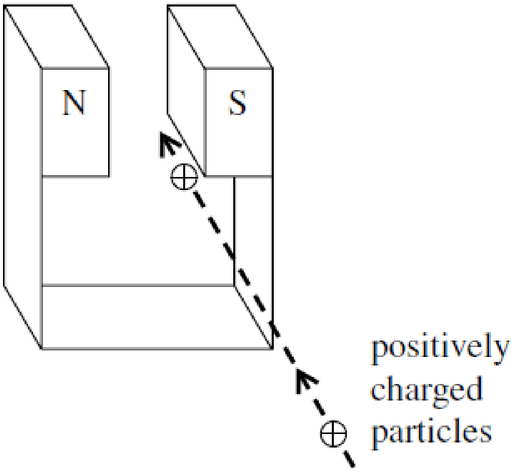
A $\frac{Q}{2\sqrt{2}\pi a\epsilon_0}$ ⬭

B $\frac{Q}{\sqrt{2}\pi a\epsilon_0}$ ⬭

C $\frac{Q}{2\pi a\epsilon_0}$ ⬭

D $\frac{Q}{4\pi a\epsilon_0}$ ⬭

1 7 A jet of air carrying positively charged particles is directed horizontally between the poles of a strong magnet, as shown in the diagram.



In which direction are the charged particles deflected?

[1 mark]

A upwards ⬭

B downwards ⬭

C towards the N pole of the magnet ⬭

D towards the S pole of the magnet ⬭

1 8 The half-life of a radioactive substance is 4.2 years. A freshly prepared sample of the substance contains 5.7×10^{24} nuclei.

Calculate the number of nuclei of the substance remaining after 500 days.

[1 mark]

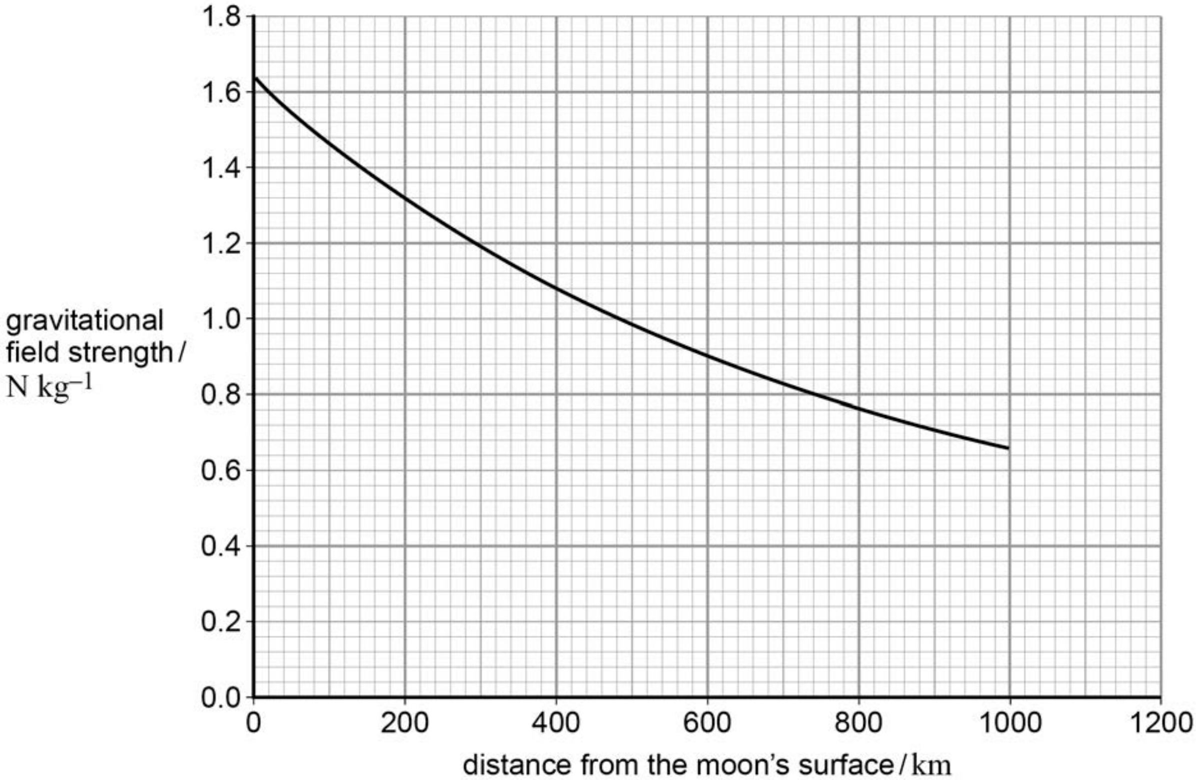
A 4.5×10^{24} ⬭

B 1.9×10^{24} ⬭

C 4.1×10^{24} ⬭

D 2.6×10^{23} ⬭

1 9 The graph shows the variation in gravitational field strength with distance in km from the moon's surface.



Estimate the energy needed to launch a 1 kg probe from the surface of the moon to a height of 400 km.

[1 mark]

A 67 J

B 536 000 J

C 536 J

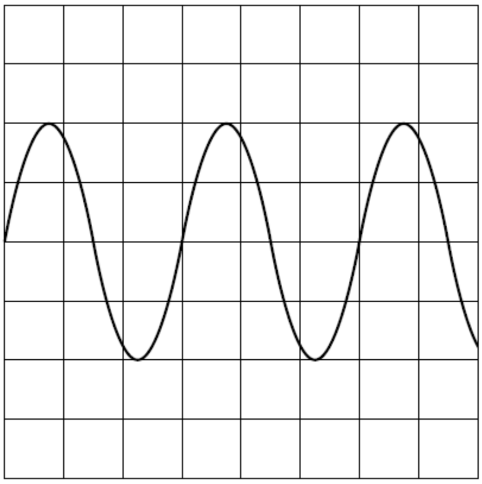
D 136 000 J

2 0

An alternating voltage supply is connected to the y-input of an oscilloscope and the following trace is obtained.

Calculate the frequency of the supply.

[1 mark]



The oscilloscope settings are: Y gain 5.0 V per division
time base 2.0 m s per division

A 10 Hz

B 3.3 Hz

C 63 Hz

D 170 Hz

2 1 A square coil with 50 turns is rotated through a magnetic field 25 times a second. The magnetic flux density of the field is 45 mT. The peak emf induced in the coil is 8.0 V.

Calculate the length of the sides of the coil.

[1 mark]

A 2.3 cm

B 38 cm

C 27 cm

D 15 cm

2 2

An artificial satellite of mass m is in a stable circular orbit of radius r around a planet of mass M. G is the universal gravitational constant.

Which of the following expressions gives the speed of the satellite?

[1 mark]

A $\left(\frac{GM}{r}\right)^{\frac{1}{2}}$ ⬭

B $\left(\frac{Gm}{r}\right)^{\frac{1}{2}}$ ⬭

C $\frac{Gm}{r}$ ⬭

D $\left(\frac{Gm}{r}\right)^{\frac{3}{2}}$ ⬭

END OF QUESTIONS

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