A2 PHYSICS PAST PAPER QUESTIONS

UNIT 5 – Fields and Forces

1. Using the usual symbols write down an equation for

(i) Newton's law of gravitation

....

(ii) Coulomb's law

....

(2)

State one difference and one similarity between gravitational and electric fields.

Difference ....

....

Similarity ....

(2)

A speck of dust has a mass of 1.0×10^{-18} kg and carries a charge equal to that of one electron. Near to the Earth's surface it experiences a uniform downward electric field of strength 100 N C^{-1} and a uniform gravitational field of strength 9.8 N kg^{-1}.

Draw a free-body force diagram for the speck of dust. Label the forces clearly.

Calculate the magnitude and direction of the resultant force on the speck of dust.

....

....

....

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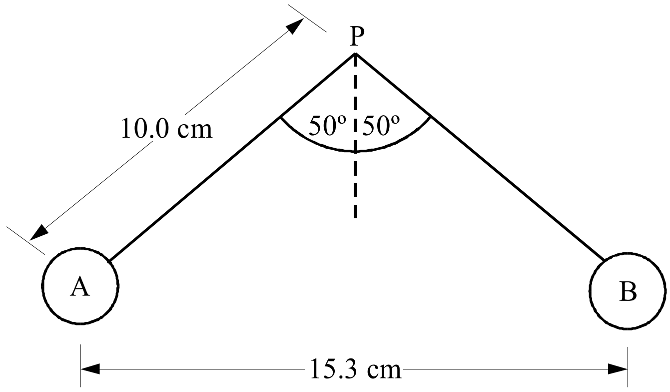
....

Force = ...

(6)

(Total 10 marks)

2. Two identical table tennis balls, A and B, each of mass 1.5g, are attached to non-conducting threads. The balls are charged to the same positive value. When the threads are fastened to a point P the balls hang as shown in the diagram. The distance from P to the centre of A or B is 10.0 cm.



Draw a labelled free-body force diagram for ball A.

(3)

Calculate the tension in one of the threads.

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....

....

Tension = ...

(3)

Show that the electrostatic force between the two balls is 1.8×10^{-2} N.

....

....

(1)

Calculate the charge on each ball.

....

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....

....

Charge = ...

(3)

How does the gravitational force between the two balls compare with the electrostatic force given above?

....

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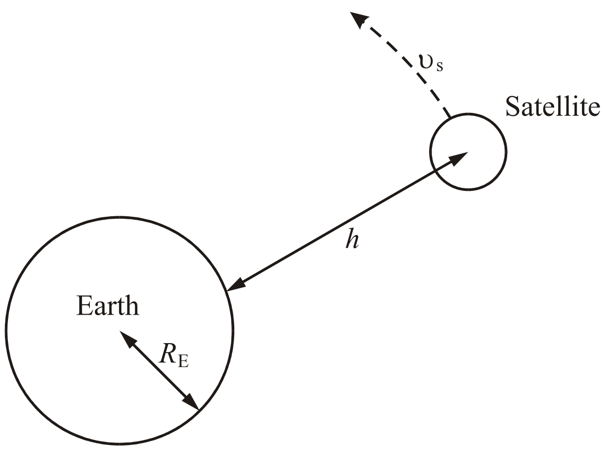
....

(2)
(Total 12 marks)

3. The diagram (not to scale) shows a satellite of mass m_s in circular orbit at speed υ_s around the Earth, mass M_E. The satellite is at a height h above the Earth's surface and the radius of the Earth is R_E.



Using the symbols above write down an expression for the centripetal force needed to maintain the satellite in this orbit.

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....

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(2)

Write down an expression for the gravitational field strength in the region of the satellite.

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State an appropriate unit for this quantity.

....

(3)

Use your two expressions to show that the greater the height of the satellite above the Earth, the smaller will be its orbital speed.

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(3)

Explain why, if a satellite slows down in its orbit, it nevertheless gradually spirals in towards the Earth's surface.

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(2)
(Total 10 marks)

4. Draw diagrams to represent

(i) the gravitational field near the surface of the Earth,

(ii) the electric field in the region of an isolated negative. point charge.

(4)

How does the electric field strength *E* vary with distance *r* from the point charge?

....

(1)

Give an example of a region in which you would expect to find a uniform electric field.

....

....

(1)
(Total 6 marks)

5. Write a word equation which states Newton's law of gravitation.

....

....

....

(2)

Mars may be assumed to be a spherical planet with the following properties:

Mass m_M of Mars	=	6.42×10^{23} kg
Radius r_M of Mars	=	3.40×10^{6} m

Calculate the force exerted on a body of mass 1.00 kg on the surface of Mars.

....

....

....

Force =...

(3)

For any planet the relationship between g (the free fall acceleration at the surface) the planet's density ρ and its radius R is

$$g = \frac{4}{3}\pi\rho GR$$

Has Mars a larger, smaller or similar radius to the Earth?

....

Explain your reasoning.

....

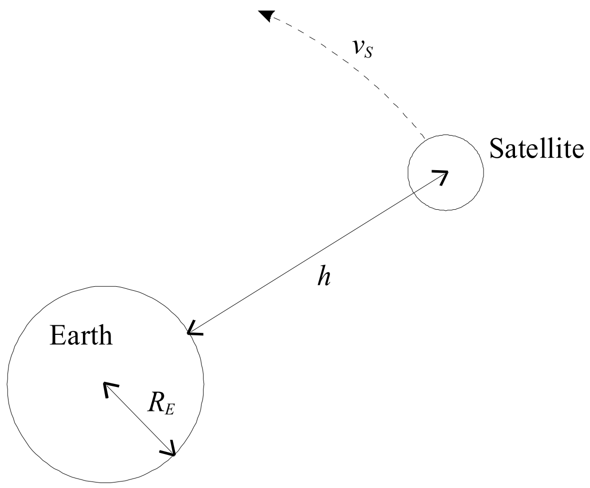
....

....

....

(2)
(Total 7 marks)

6. The diagram (not to scale) shows a satellite of mass m_s in circular orbit at speed υ_s around the Earth, mass M_E. The satellite is at a height h above the Earth's surface and the radius of the Earth is R_E.



Explain why, although the speed of the satellite is constant, its velocity varies.

....

....

(1)

Using the symbols above, write down an expression for the centripetal force needed to maintain the satellite in this orbit.

....

....

....

(2)

Write down an expression for the Earth's gravitational field strength in the region of the satellite.

....

....

State an appropriate unit for this quantity.

....

(3)

Use your two expressions to show that the greater the height of the satellite above the Earth, the smaller will be its orbital speed.

....

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....

(3)
(Total 9 marks)

1. A toroid is a conducting wire wound in the shape of a torus (a doughnut). A toroid could be made by bending a slinky spring into a torus. Figure 1 shows such a toroid. Figure 2 shows a plan view of this toroid with one magnetic field line added.

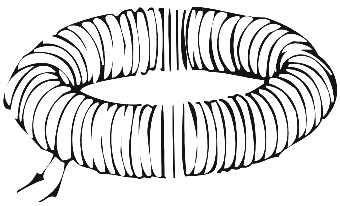

Figure 1

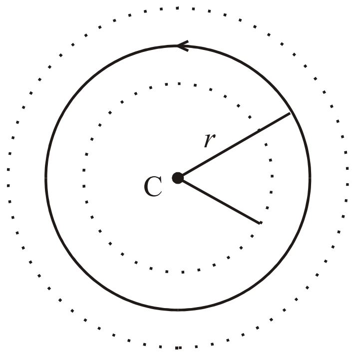

Figure 2

Theory suggests that for a toroid of N turns, the magnetic flux density B within the coils of the toroid at a distance r from the centre C of the toroid is given by

$$B = \frac{\mu_o NI}{2\pi r}$$

Describe how you would verify this relationship using a precalibrated Hall probe.

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(6)

For distances $r < r_o$, suggest how B might vary with r. Give a reason for your answer.

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(2)
(Total 8 marks)

2. State Coulomb's law for the electric force between two charged particles in free space.

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....

(2)

What are the base units of ε_0 (the permittivity of free space)?

....

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....

(2)
(Total 4 marks)

3. Using the usual symbols write down an equation for

(i) Newton's law of gravitation

....

(ii) Coulomb's law

....

(2)

State one difference and one similarity between gravitational and electric fields.

Difference ....

....

Similarity ....

(2)

A speck of dust has a mass of 1.0×10^{-18} kg and carries a charge equal to that of one electron. Near to the Earth's surface it experiences a uniform downward electric field of strength 100 N C^{-1} and a uniform gravitational field of strength 9.8 N kg^{-1}.

Draw a free-body force diagram for the speck of dust. Label the forces clearly.

Calculate the magnitude and direction of the resultant force on the speck of dust.

....

....

....

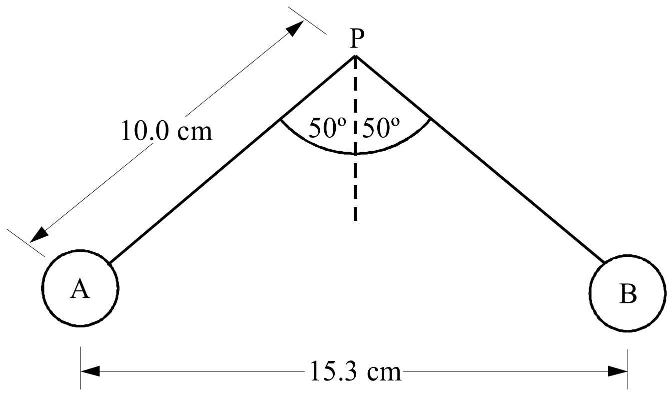
....

....

Force = ...

(6)
(Total 10 marks)

4. Two identical table tennis balls, A and B, each of mass 1.5g, are attached to non-conducting threads. The balls are charged to the same positive value. When the threads are fastened to a point P the balls hang as shown in the diagram. The distance from P to the centre of A or B is 10.0 cm.



Draw a labelled free-body force diagram for ball A.

(3)

Calculate the tension in one of the threads.

....

....

....

Tension = ...

(3)

Show that the electrostatic force between the two balls is 1.8×10^{-2} N.

....

....

(1)

Calculate the charge on each ball.

....

....

....

....

Charge = ...

(3)

How does the gravitational force between the two balls compare with the electrostatic force given above?

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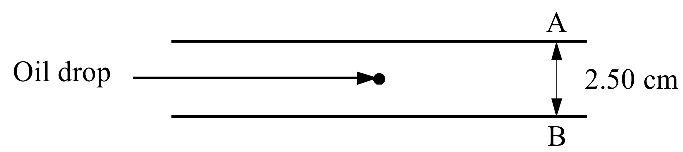
....

(2)
(Total 12 marks)

5. The diagram shows a positively charged oil drop held at rest between two parallel conducting plates A and B.



The oil drop has a mass 9.79×10^{-15} kg. The potential difference between the plates is 5000 V and plate B is at a potential of 0 V. Is plate A positive or negative?

……………………………………………………………………………………………

Draw a labelled free-body force diagram which shows the forces acting on the oil drop. (You may ignore upthrust).

(3)

Calculate the electric field strength between the plates.

…………………………………………………………………………………………

…………………………………………………………………………………………

Electric field strength =…………………………………

(2)

Calculate the magnitude of the charge Q on the oil drop.

…………………………………………………………………………………………

…………………………………………………………………………………………

Charge =……………………………………

How many electrons would have to be removed from a neutral oil drop for it to acquire this charge?

…………………………………………………………………………………………

(3)
(Total 8 marks)

6. Draw diagrams to represent

(i) the gravitational field near the surface of the Earth,

(ii) the electric field in the region of an isolated negative. point charge.

(4)

How does the electric field strength *E* vary with distance *r* from the point charge?

…………………………………………………………………………………………

(1)

Give an example of a region in which you would expect to find a uniform electric field.

....

....

(1)
(Total 6 marks)

7. Calculate the magnitude of the electric field strength at the surface of a nucleus $^{238}_{92}U$. Assume that the radius of this nucleus is 7.4×10^{-15} m.

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Magnitude of electric field strength =.......................................

State the direction of this electric field.

....

(4)

State one similarity and one difference between the electric field and the gravitational field produced by the nucleus.

Similarity ....

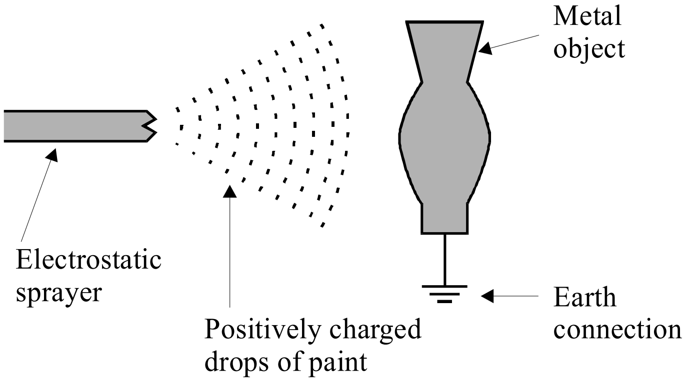
....

Difference ....

....

(2)
(Total 6 marks)

8. The diagram shows an electrostatic paint sprayer, used to obtain a uniform coat of paint on a metal object. The paint drops are charged positively by the sprayer. The metal object is connected to Earth.



Why does using identically charged paint drops help produce an evenly distributed spray of paint?

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....

(1)

Explain why the positive paint drops are attracted to the metal object.

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(3)

Why does the coat of paint become very patchy if the Earth connection is accidentally broken?

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(2)
(Total 6 marks)

9. A beam of electrons is directed at a target. They are accelerated from rest through 12 cm in a uniform electric field of strength 7.5×10^5 N C^{-1}.

Calculate the potential difference through which the electrons are accelerated.

....

....

Potential difference = ...

Calculate the maximum kinetic energy in joules of one of these electrons.

....

....

Maximum kinetic energy = ...

(4)

Calculate the maximum speed of one of these electrons.

....

....

....

Maximum speed = ...

(2)

Draw a diagram to represent the electric field close to an isolated electron.

(2)
(Total 8 marks)

10. Write down an equation for the force between two point charges, Q_1 and Q_2 , separated by a distance *r*

....

(1)

A speck of dust has a mass of 1.0×10^{-18} kg and carries a charge equal to that of one electron. Near to the Earth's surface it experiences a uniform downward electric field of strength 100 N C^{-1} and a uniform gravitational field of strength 9.8 N kg^{-1}.

Draw a free-body force diagram for the speck of dust. Label the forces clearly.

Calculate the magnitude and direction of the resultant force on the speck of dust.

....

....

....

....

Magnitude of force =…………………..

Direction of force =…………………….

(6)

(Total 7 marks)

1. A toroid is a conducting wire wound in the shape of a torus (a doughnut). A toroid could be made by bending a slinky spring into a torus. Figure 1 shows such a toroid. Figure 2 shows a plan view of this toroid with one magnetic field line added.

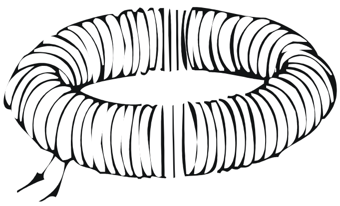

Figure 1

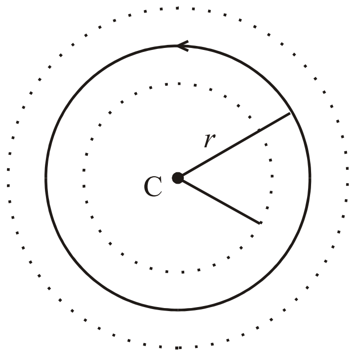

Figure 2

Theory suggests that for a toroid of N turns, the magnetic flux density B within the coils of the toroid at a distance r from the centre C of the toroid is given by

$$B = \frac{\mu_o NI}{2\pi\, r}$$

Describe how you would verify this relationship using a precalibrated Hall probe.

....

....

....

....

....

(6)

For distances $r < r_0$, suggest how B might vary with r. Give a reason for your answer.

....

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(2)
(Total 8 marks)

2. A child sleeps at an average distance of 30 cm from household wiring. The mains supply is 240 V r.m.s. Calculate the maximum possible magnetic flux density in the region of the child when the wire is transmitting 3.6 kW of power.

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....

Magnetic flux density = ...

(4)

Why might the magnetic field due to the current in the wire pose more of a health risk to the child than the Earth's magnetic field, given that they are of similar magnitudes?

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(2)
[6]

3. The magnitude of the force on a current-carrying conductor in a magnetic field is directly proportional to the magnitude of the current in the conductor. With the aid of a diagram describe how you could demonstrate this in a school laboratory.

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(4)

At a certain point on the Earth's surface the horizontal component of the Earth's magnetic field is 1.8×10^{-5} T. A straight piece of conducting wire 2.0m long, of mass 1.5g lies on a horizontal wooden bench in an east-west direction. When a very large current flows momentarily in the wire it is just sufficient to cause the wire to lift up off the surface of the bench.

State the direction of the current in the wire.

....

Calculate the current.

....

....

....

Current = ...

What other noticeable effect will this current produce?

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(4)
(Total 8 marks)

4. Explain what is meant by a neutral point in field.

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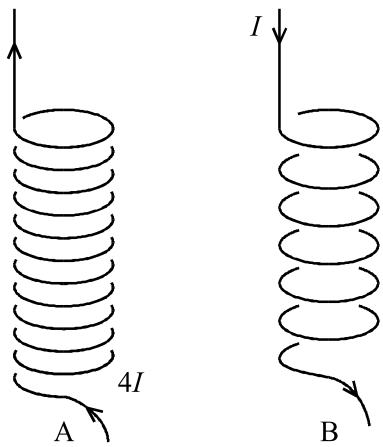
(2)

The diagram shows two similar solenoids A and B. Solenoid A has twice the number of turns per metre. Solenoid A carries four times the current as B.



Draw the magnetic field lines in, around and between the two solenoids.

(4)

If the distance between the centres of A and B is 1 m, estimate the position of the neutral point. Ignore the effect of the Earth's magnetic field.

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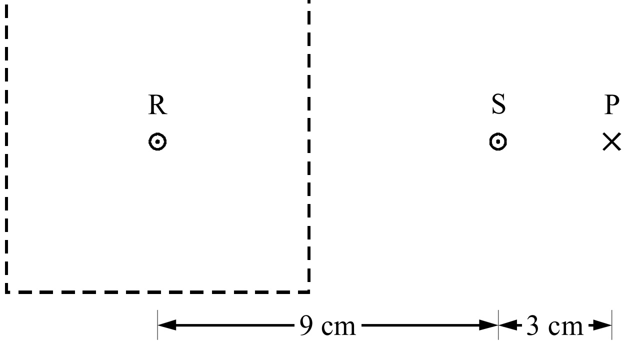
(3)
(Total 9 marks)

5. Two long parallel wires R and S carry steady currents I_1 and I_2 respectively in the same direction. The diagram is a plan view of this arrangement. The directions of the currents are out of the page.



In the region enclosed by the dotted lines, draw the magnetic field pattern due to the current in wire R alone.

(2)

The current I_1 is 4 A and I_2 is 2 A. Mark on the diagram a point N where the magnetic flux density due to the currents in the wires is zero.

(2)

Show on the diagram the direction of the magnetic field at P.

(1)

Calculate the magnitude of the magnetic flux density at P due to the currents in the wires.

………………………………………………………………………………………………

………………………………………………………………………………………………

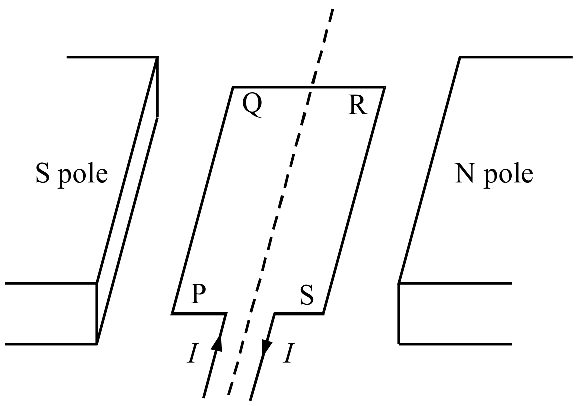
………………………………………………………………………………………………

Flux density = ……………………………………………

(3)

(Total 8 marks)

6. The diagram shows a rectangular coil PQRS which can rotate about an axis which is perpendicular to the magnetic field between two magnetic poles.



Explain why the coil begins to rotate when the direct current I is switched on.

....

....

....

....

Add to the diagram an arrow showing the direction of the force on PQ.

State *three* factors which would affect the magnitude of this force.

(1) ....

(2) ....

(3) ....

(7)

A student notices that as the coil rotates faster the current in it reduces. Explain this observation.

....

....

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....

(2)
(Total 9 marks)

7. **Figure 1** shows a simple moving coil loudspeaker. **Figure 2** is an end on view showing the position of the coil between the poles of the magnet.

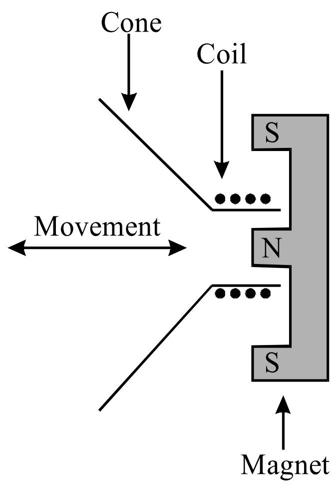


Figure 1

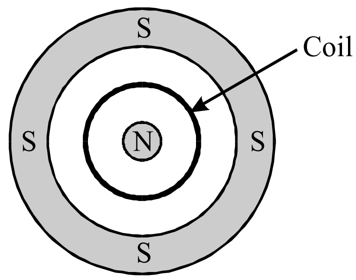


Figure 2

Explain how an alternating current in the coil causes the cone of the loudspeaker to move in and out as shown.

....

....

....

....

(2)

On **Figure 2** draw six magnetic field lines in the gap which contains the coil.

What is the advantage of having such an unusually shaped magnet?

....

....

Show on **Figure 2** the direction of the current in the coil that would cause the cone to move towards you out of the plane of the paper.

(3)

The magnetic flux density in the gap is 0.6 T. The coil has 300 turns of diameter 40 mm. What is the force on the coil when it carries a current of 20 mA?

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………

Force =……….........……..............

(3)
(Total 8 marks)

8. A solenoid is formed by winding 250 turns of wire on to a hollow plastic tube of length 0.14m.

Show that when a current of 0.08 A flows in the solenoid the magnetic flux density at its centre is 0.0018 T.

....

....

....

....

(2)

The solenoid has a cross-sectional area of $6.0 \times 10^{-3}m^2$. The magnetic flux emerging from one end of the solenoid is 5.4×10^{-6} Wb(Tm^2)

Calculate the magnetic flux density at the *end* of the solenoid.

....

....

....

Magnetic flux density = ...

(2)

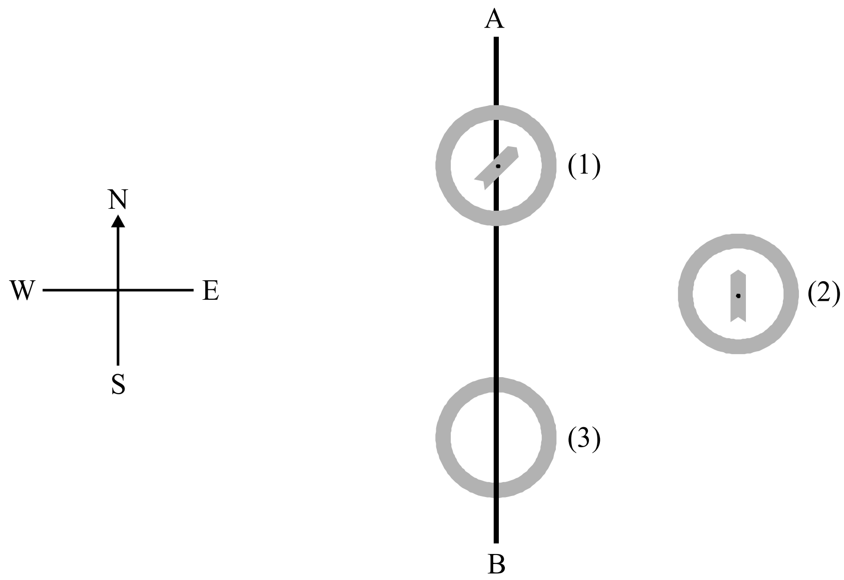
Why is the flux density at the end of the solenoid not equal to the flux density at the centre?

....

....

(1)
(Total 5 marks)

9. The diagram shows part of a long straight copper wire through which there is a direct current. Three plotting compasses are positioned as shown: (1) just above the wire, (2) alongside the wire, (3) just below the wire.



Deduce the direction of the current in the wire.

Direction of current ....

(1)

Complete the diagram by adding the pointer to compass (3).

(2)

Explain why the pointer in compass (2) settles in the direction shown.

....

....

....

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....

....

(2)
(Total 5 marks)

10. The magnitude of the force on a current-carrying conductor in a magnetic field is directly proportional to the magnitude of the current in the conductor. Draw a fully labelled diagram of the apparatus you would use to verify this relationship.

State what measurements you would make and how you would use your results. You may be awarded a mark for the clarity of your answer.

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(6)

At a certain point on the Earth's surface the horizontal component of the Earth's magnetic field is 1.8×10^{-5} T. A straight piece of conducting wire 2.0 m long, of mass 1.5 g , lies on a horizontal wooden bench in an East-West direction. When a very large current flows momentarily in the wire it is just sufficient to cause the wire to lift up off the surface of the bench.

Calculate the current.

....

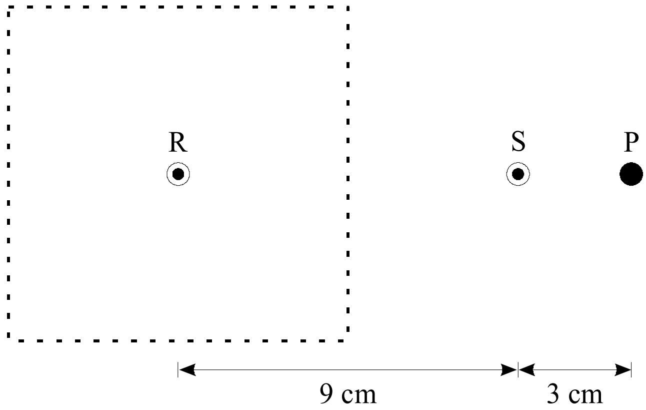
....

....

Current =………………………………...

(2)
(Total 8 marks)

11. Two long parallel wires R and S carry steady currents I_1 and I_2 respectively in the same direction. The diagram is a plan view of this arrangement. The directions of the currents are out of the page.



In the region enclosed by the dotted lines, draw the magnetic field pattern due to the current in wire R alone. Show at least three field lines.

(2)

The current I_1 is 4 A and I_2 is 2 A. Mark on the diagram a point N where the magnetic flux density due to the currents in the wires is zero.

(1)

Show on the diagram the direction of the magnetic field at P.

(1)
(Total 4 marks)

1. Define capacitance.

....

.... **(2)**

An uncharged capacitor of 200 μF is connected in series with a 470 kΩ resistor, a 1.50 V cell and a switch. Draw a circuit diagram of this arrangement.

(1)

Calculate the maximum current that flows.

....

....

Current .... **(2)**

Sketch a graph of voltage against charge for your capacitor as it charges. Indicate on the graph the energy stored when the capacitor is fully charged.

(4)

Calculate the energy stored in the fully-charged capacitor.

....

....

Energy = ... **(2)**

(Total 11 marks)

2. Derive a formula for the equivalent capacitance of two capacitors in series.

....

....

....

....

....

....

(4)

A 200 μF capacitor is connected in series with a 1000 μF capacitor and a battery of e.m.f. 9V. Calculate

(i) the total capacitance

....

....

Capacitance = ...

(2)

(ii) the charge that flows from the battery

....

....

Charge = ...

(2)

(iii) the final potential difference across each capacitor.

....

....

....

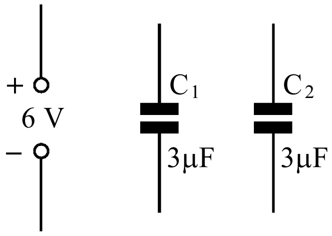
P.d. across 1000 μF = ...

P.d. across 200 μF = ...

(3)

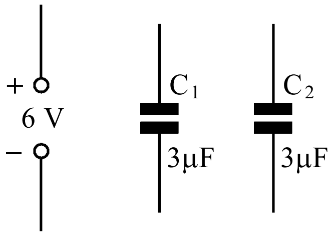
(Total 11 marks)

3. complete the circuit below to show the capacitors connected in parallel.



(1)

Complete the circuit below to show the capacitors connected in series.



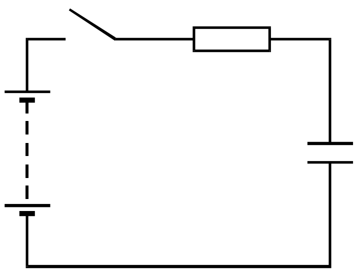
(1)

Use the information in the diagrams to complete the following table.

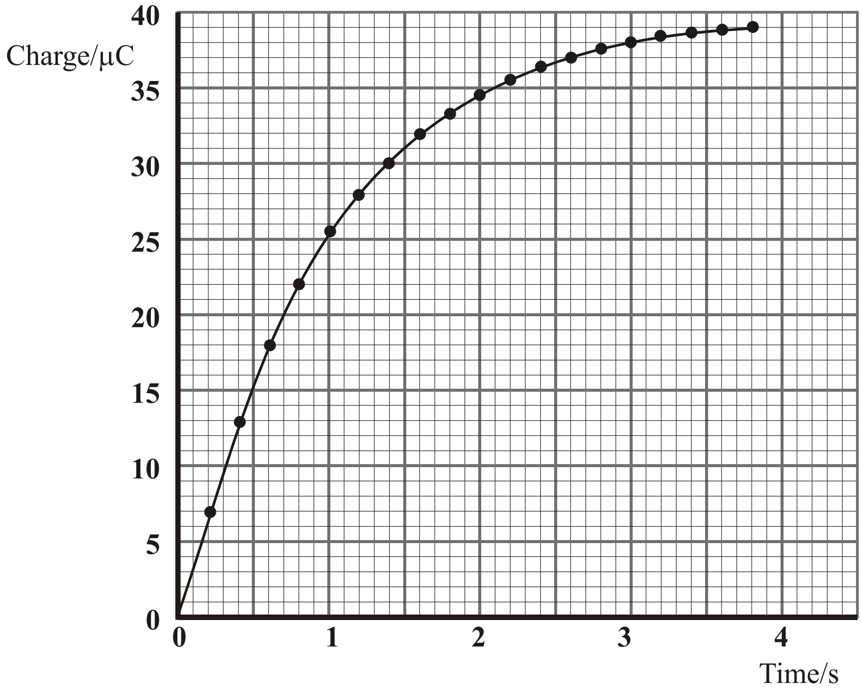
Capacitors in parallel	Charge on C_1	
	Energy stored in C_1 when fully charge	
Capacitors in series	Charge on C_2	
	Work done by power supply in charging both capacitors	

(4)
(Total 6 marks)

4. The circuit shown is used to charge a capacitor.



The graph shows the charge stored on the capacitor whilst it is being charged.



On the same axes, sketch as accurately as you can a graph of current against time.
Label the current axis with an appropriate scale.

(4)

The power supply is 3 V. Calculate the resistance of the charging circuit.

....

....

Resistance = ...

(2)
(Total 6 marks)

5. The permittivity of free space ε_0 has units F m^{-1}. The permeability of free space μ_0 has units N A^{-2}

Show that the units of $\frac{1}{\sqrt{\varepsilon_0 \mu_0}}$ are m s^{-1}

....

....

....

....

....

....

(3)

Calculate the magnitude of $\frac{1}{\sqrt{\varepsilon_0 \mu_0}}$.

....

....

Magnitude = ...

(1)

Comment on your answers.

....

....

(1)
(Total 5 marks)

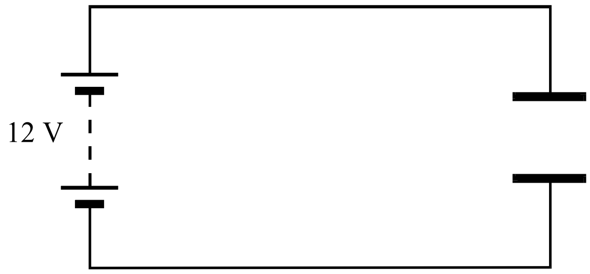
6. A 100 μF capacitor is connected to a 12V supply. Calculate the charge stored.

....

....

Charge stored = ...

Show on the diagram the arrangement and magnitude of charge on the capacitor.



(3)

This 100 μF charged capacitor is disconnected from the battery and is then connected across a 300 μF uncharged capacitor. What happens to the charge initially stored on the 100 μF capacitor?

....

....

....

Calculate the new voltage across the pair of capacitors.

....

....

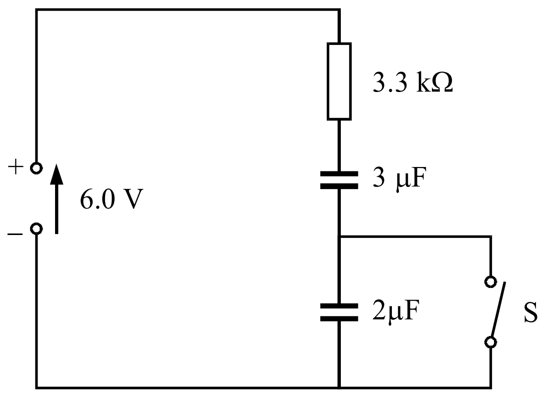
....

....

Voltage = ...

(4)
(Total 7 marks)

7.



Calculate the maximum energy stored in the 3 μ**F** capacitor in the circuit above

(i) with the switch S closed,

……..…………………………………………………………………………………

……..…………………………………………………………………………………

Maximum energy = ……………………..

(2)

(ii) with the switch S open.

……..…………………………………………………………………………………

……..…………………………………………………………………………………

……..…………………………………………………………………………………

……..…………………………………………………………………………………

Maximum energy = ………………………..

(4)

(Total 6 marks)

8. Define the term *capacitance*.

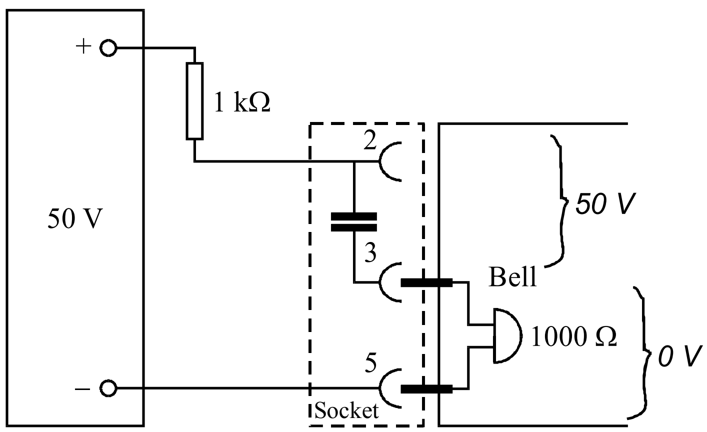
..............................…...…

..............................…...…

..............................…...…

(2)

The sockets of modern telephones have six pins. A power supply of 50 V in series with a resistance of about 1000 ? is connected to pins 2 and 5.



A capacitor of 2 ?F is connected between pins 2 and 3. In one installation, a bell of resistance 1000 ? is connected to pins 3 and 5.

Explain why there is a pulse of current through the bell when the circuit is first connected, but not after the bell has been connected for some time.

....

....

....

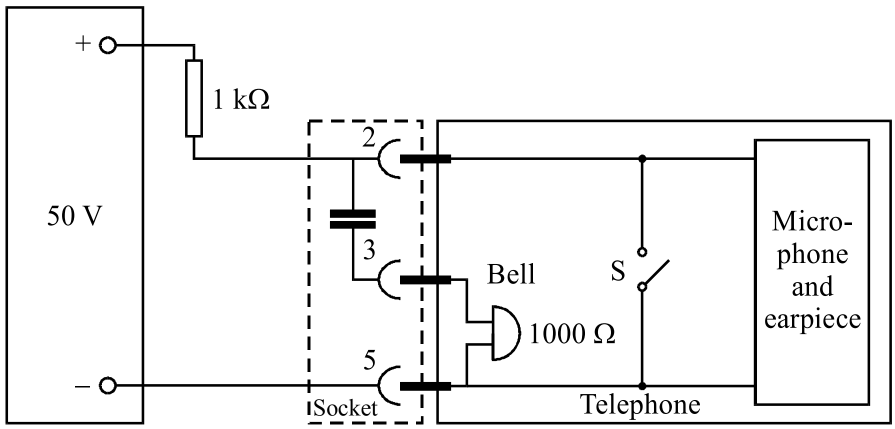
....

(2)

On the circuit diagram above, label the values of the voltages across the capacitor and across the bell when the circuit has been connected for some time.

(2)

To dial a number, e.g 7, switch S must be closed that number of times.



Explain why the bell sounds softly (tinkles) when the switch is closed and then opened again.

....

....

....

....

(2)

To avoid this tinkling, an "anti-tinkling switch is connected to short-circuit the bell during dialling. Draw this switch on the diagram.

(1)

Explain the operation of the anti-tinkling switch.

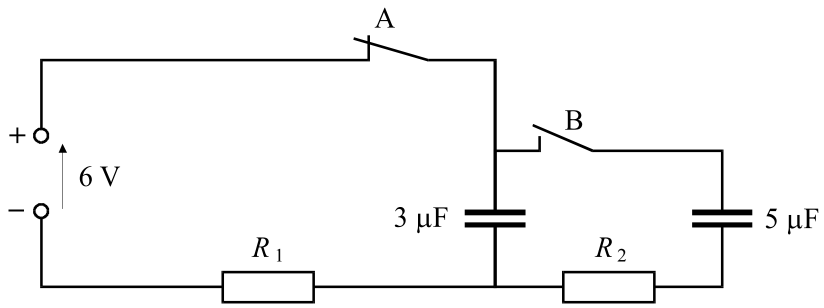
....

....

....

(1)
(Total 10 marks)

9. In the circuit below, switch A is initially closed and switch B is open. Calculate the energy stored in the 3 μF capacitor when it is fully charged.



....

....

....

....

Energy =...............................

(3)

Switch A is now opened and switch B is closed. Calculate the final value of the total energy stored in the two capacitors when the 5 μF capacitor is fully charged.

....

....

....

....

....

....

Total energy =..........................

(4)

State briefly how you would account for the decrease in stored energy.

...............................……...

...............................……...

...............................……...

(1)
(Total 8 marks)

10. Express the ohm and the farad in terms of SI *base* units.

Ohm ………………………………………………………………..…………………….

....

Farad ………………..…………………………………………………………..……..

....

Hence show that ohm x farad = second.

....

....

....

....

(4)

Most d.c. power supplies include a smoothing capacitor to minimise the variation in the output voltage by storing charge. In a particular power supply, a capacitor of 40 000 μF is used. It charges up quickly to 12.0 V, then discharges to 10.5 V over the next 10.0 ms, and then charges again to 12.0 V. The process then repeats continually.

Calculate the charge on the capacitor at the beginning and at the end of the 10.0 ms discharge period.

Beginning ……....…………………………………………………………………..

....

....

Charge ……………………………

....

....

End ……………………………………………….…………………………………

....

....

Charge ……………………………

(3)

What is the average current during the discharge?

....

....

....

Average current = ………………….………

(3)

The discharge times for the smoothing capacitors in modern computer power supplies are reduced to a minimum. Explain one advantage of this reduced discharge time.

....

....

....

(2)
(Total 12 marks)

11. A large solenoid is 45 cm long and has 72 turns. Calculate the magnetic flux density inside the solenoid when a current of 2.5 A flows in it.

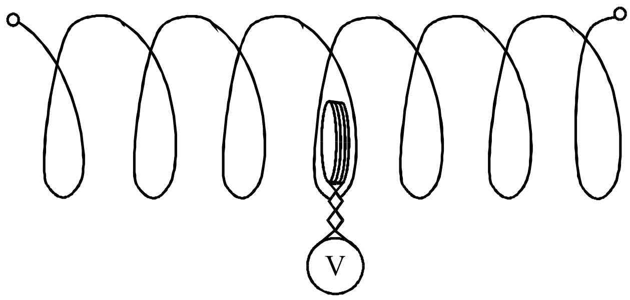
……………………………………………………………………………………………

……………………………………………………………………………………………

Flux density =……….......……...............

(2)

A small solenoid is placed at the centre of the large solenoid as shown. The small solenoid is connected to a digital voltmeter.



State what would be observed on the *voltmeter* when each of the following operations is carried out consecutively.

(a) A battery is connected across the large solenoid.

....

....

(b) The battery is disconnected.

....

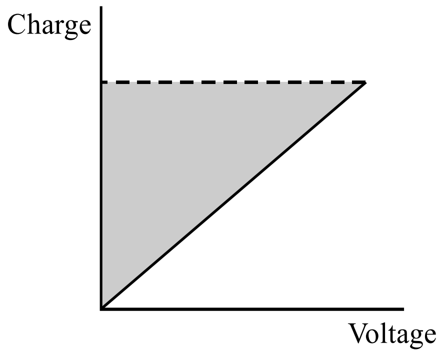
(c) A very low frequency alternating supply is connected across the large solenoid.

....

....

(5)
(Total 7 marks)

12. The diagram shows a graph of charge against voltage for a capacitor.



What quantity is represented by the slope of the graph?

....

What quantity is represented by the shaded area?

....

(2)

An electronic camera flash gun contains a capacitor of 100 μF which is charged to a voltage of

250 V. Show that the energy stored is 3.1 J.

....

....

....

....

....

(2)

The capacitor is charged by an electronic circuit that is powered by a 1.5 V cell. The current drawn from the cell is 0.20 A. Calculate the power from the cell and from this the minimum time for the cell to recharge the capacitor.

....

....

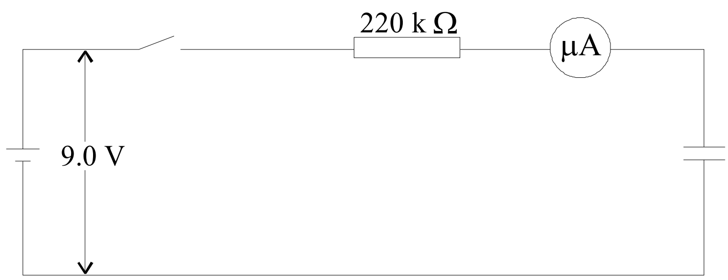
....

....

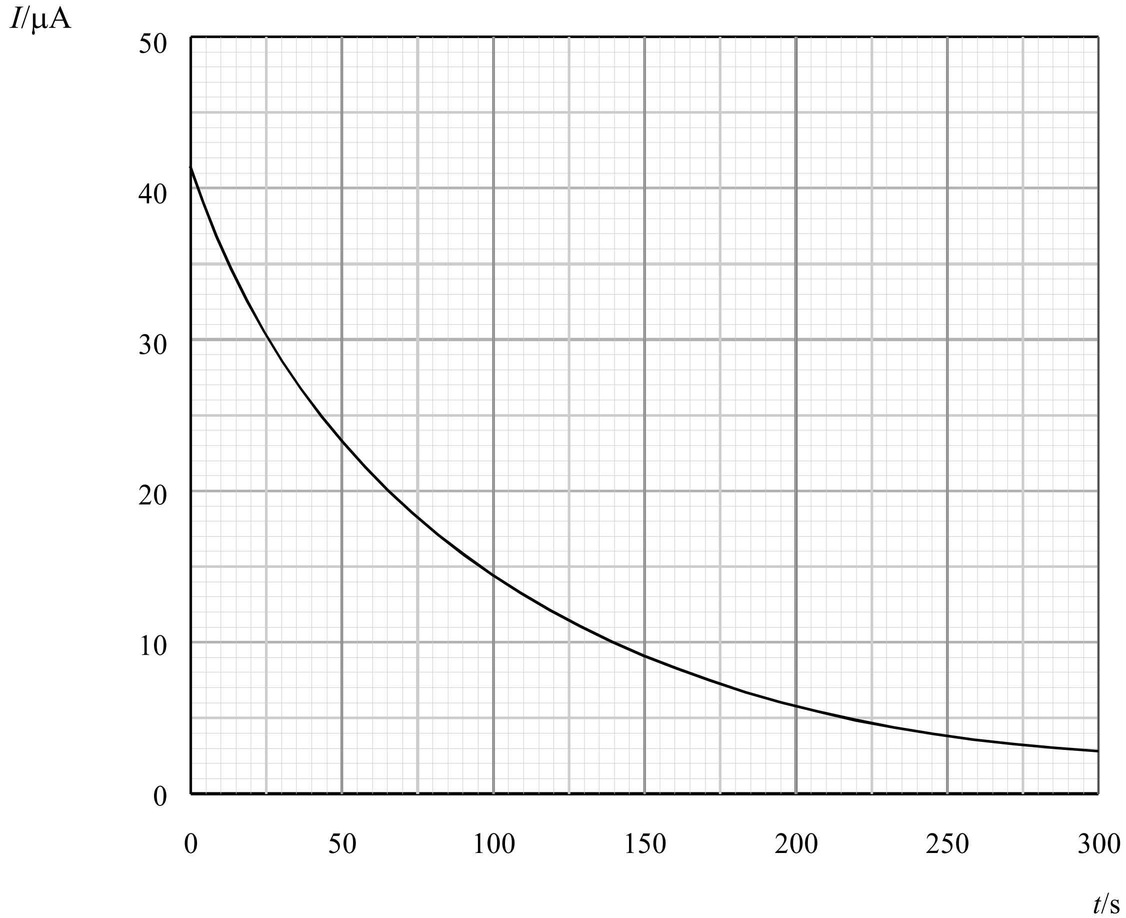
Minimum time = ...

(3)
(Total 7 marks)

13. A student assembles the circuit shown in which the switch is initially open and the capacitor uncharged.



He closes the switch and reads the microammeter at regular intervals of time. The battery maintains a steady p.d. of 9.0 V throughout. The graph shows how the current I varies with the time t since the switch was closed.



Use the graph to estimate the total charge delivered to the capacitor.

....

....

....

Charge =..

(3)

Estimate its capacitance.

....

....

Capacitance =.......................................

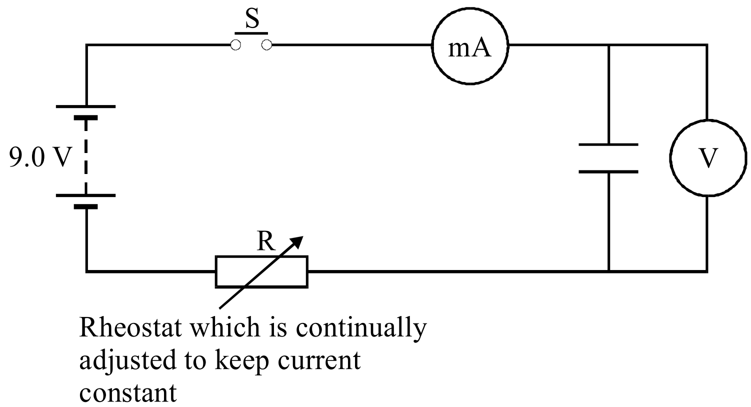
(2)
(Total 5 marks)

14. State the relationship between current and charge

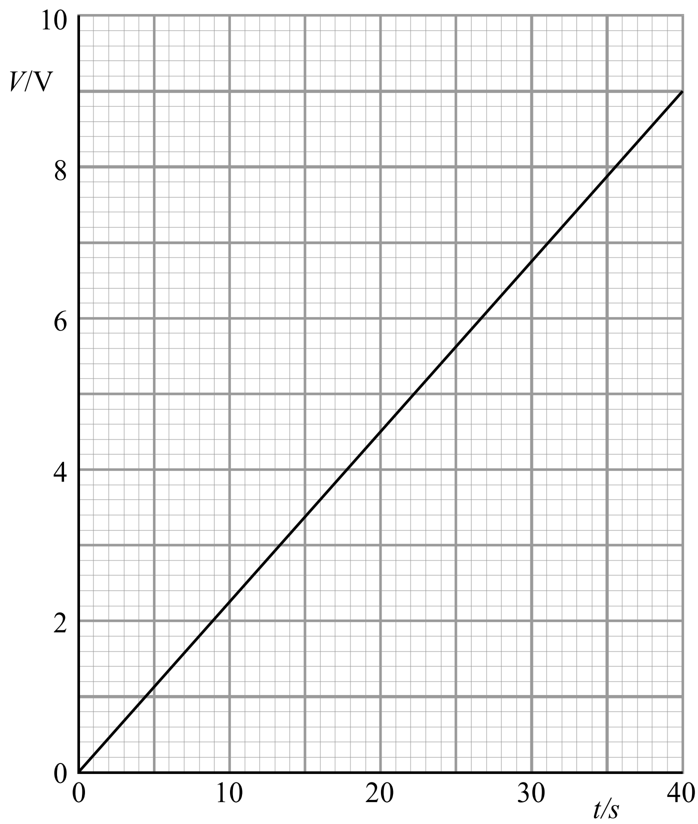
....

.... **(1)**

Two students are studying the charging of a capacitor using the circuit shown. The voltmeter has a very high resistance.



The capacitor is initially uncharged. At time zero, one student closes switch S. She watches the milliammeter and continually adjusts the rheostat R so that there is a constant current in the circuit. Her partner records the voltage across the capacitor at regular intervals of time. The graph below shows how this voltage changes with time.



Explain why the graph is a straight line.

....

....

....

....

....

....

(2)

The capacitance used was 4700 μF. Use the graph to determine the charging current.

....

....

....

....

Current =..

(3)

In order to keep the current constant, did the student have to increase or decrease the resistance of the rheostat as time passed? Explain your answer.

....

....

....

....

(3)

The students repeat the experiment, with the capacitor initially uncharged. The initial current is the same as before, but this time the first student forgets to adjust the rheostat and leaves it at a fixed value. Draw a second graph on the same axes to show qualitatively how the voltage across the capacitor will now change with time.

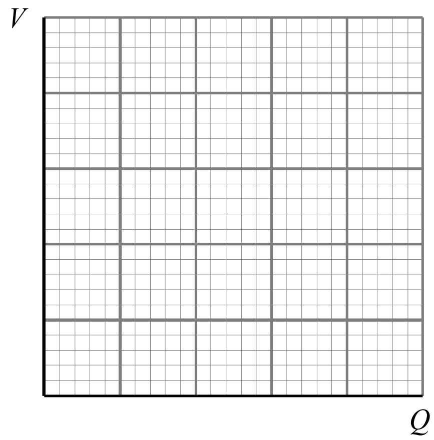
(2)
(Total 11 marks)

15. A 200 μF capacitor is connected in series with a 470 kΩ resistor, a switch and a 4.5 V battery.

Draw a circuit diagram of this arrangement.

(1)

On the axes below, draw a graph showing how the potential difference *V* across the capacitor varies as the charge *Q* stored in it increases. Add a scale to both axes.



(3)

Calculate the energy stored by the fully charged capacitor.

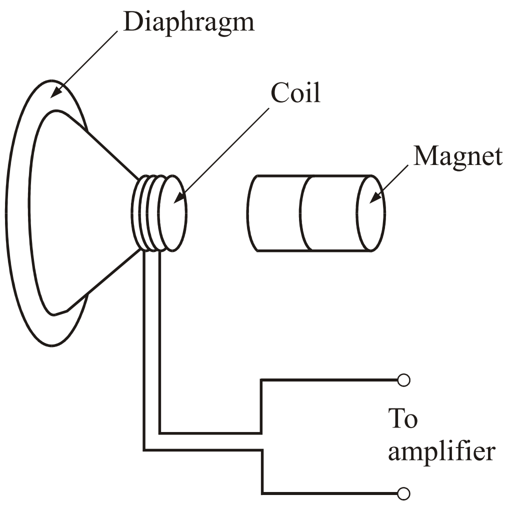
....

....

Energy =……………………………….

(2)
(Total 6 marks)

1. An induction microphone converts sound waves into electrical signals which can be amplified.



Describe the stages by which the sound waves are converted into electrical signals.
State whether the signals are a.c. or d.c.

....

....

....

....

(6)

If the alternating output from a signal generator were fed into the microphone, describe and explain what would happen to the diaphragm.

....

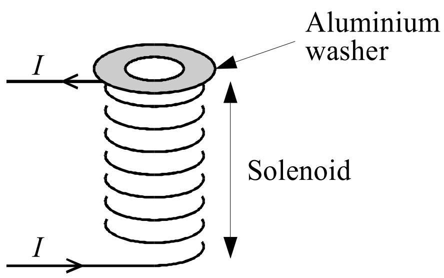
....

....

....

(3)
(Total 9 marks)

2. A light aluminium washer rests on the end of a solenoid as shown in the diagram.



A large direct current is switched on in the solenoid. Explain why the washer jumps and immediately falls back.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

(Total 5 marks)

3. What is meant by the term *electromagnetic induction*?

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

(3)

Describe an experiment you could perform in a school laboratory to demonstrate Faraday’s law of electromagnetic induction.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

(5)

An aircraft has a wing span of 54 m. It is flying horizontally at 860 km h^{-1} in a region where the vertical component of the Earth's magnetic field is 6.0 x 10^{-5} T. Calculate the potential difference induced between one wing tip and the other.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

Potential difference = ……………………………………

What extra information is necessary to establish which wing is positive and which negative?

……………………………………………………………………………………………

(3)
(Total 11 marks)

4. State Lenz's law of electromagnetic induction

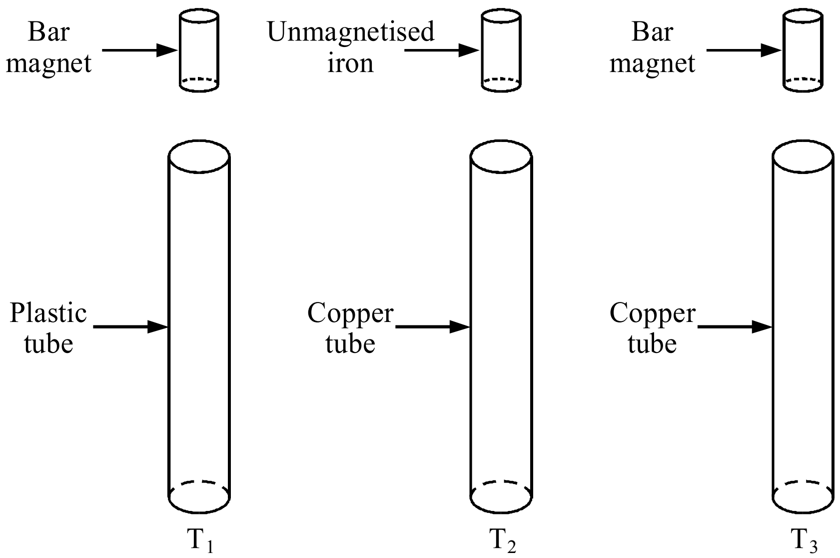
……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

(2)

An exhibit at a science centre consists of three apparently identical vertical tubes, T_1, T_2 and T_3, each about 2 m long. With the tubes are three apparently identical small cylinders, one to each tube.



When the cylinders are dropped down the tubes those in ~T, and ~T2 reach the bottom in less than I second, while that in ~T3 takes a few seconds.

Explain why the cylinder in T_3 takes longer to reach the bottom of the tube than the cylinder in T_1

....

....

....

....

....

(5)

Explain why the cylinder in T_2 takes the same time to reach the bottom as the cylinder in T_1

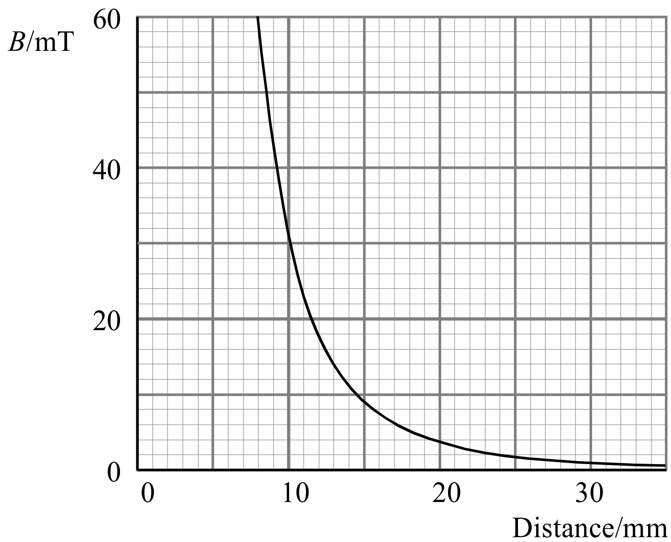
....

....

....

(2)
(Total 9 marks)

5. Magnetic flux density *B* varies with distance beyond one end of a large bar magnet as shown on the graph below.



A circular loop of wire of cross–sectional area 16 cm^2 is placed a few centimetres beyond the end of the bar magnet. The axis of the loop is aligned with the axis of the magnet.

Calculate the total magnetic flux through the loop when it is 30 mm from the end of the magnet.

....

....

....

Magnetic flux =..

Calculate the total magnetic flux through the loop when it is 10 mm from the end of the magnet.

....

....

....

Magnetic flux =..

(3)

The loop of wire is moved towards the magnet from the 30 mm position to the 10 mm position so that a steady e.m.f. of 15 μV is induced in it. Calculate the average speed of movement of the loop.

....

....

....

....

....

....

Speed =........................

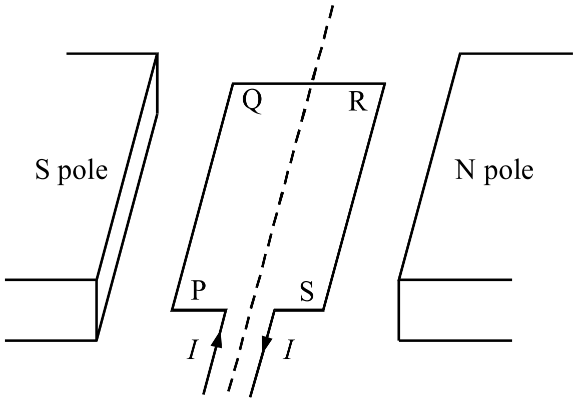
(3)

In what way would the speed of the loop have to be changed while moving towards the magnet between these two positions in order to maintain a steady e.m.f.?

....

(1)
(Total 7 marks)

6. The diagram shows a rectangular coil PQRS which can rotate about an axis which is perpendicular to the magnetic field between two magnetic poles.



Explain why the coil begins to rotate when the direct current *I* is switched on.

....

....

....

....

Add to the diagram an arrow showing the direction of the force on PQ.

State *three* factors which would affect the magnitude of this force.

(1) ....

(2) ....

(3) ....

(7)

A student notices that as the coil rotates faster the current in it reduces. Explain this observation.

....

....

....

....

....

(2)
(Total 9 marks)

7. A large solenoid is 45 cm long and has 72 turns. Calculate the magnetic flux density inside the solenoid when a current of 2.5 A flows in it.

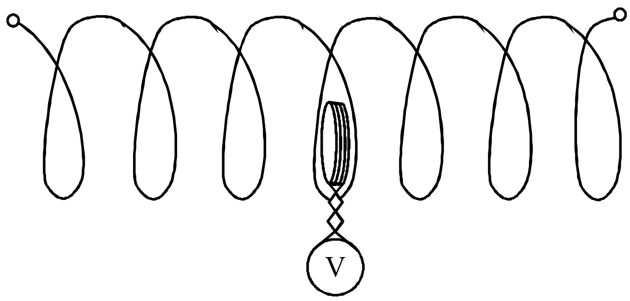
…………………………………………………………………………………………

…………………………………………………………………………………………

Flux density =…………........……..............

(2)

A small solenoid is placed at the centre of the large solenoid as shown. The small solenoid is connected to a digital voltmeter.



State what would be observed on the *voltmeter* when each of the following operations is carried out consecutively.

(a) A battery is connected across the large solenoid.

…………………………………………………………………………………………

…………………………………………………………………………………………

(b) The battery is disconnected.

…………………………………………………………………………………………

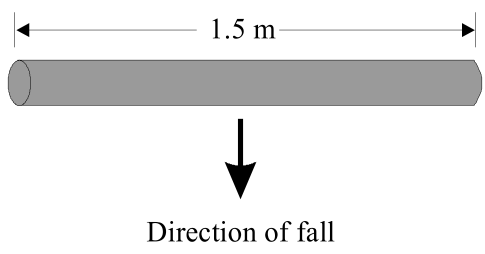
(c) A very low frequency alternating supply is connected across the large solenoid.

…………………………………………………………………………………………

…………………………………………………………………………………………

(5)
(Total 7 marks)

8. A horizontal metal rod, 1.5 m long, is aligned in an E ↔ W direction and dropped from rest from the top of a high building.



Calculate the e.m.f. induced across the falling rod 2.5 s after release. The horizontal component of the Earth's magnetic field = 2.0×10^{-5} T.

....

....

....

....

e.m.f. =....................................

(3)

Explain briefly why the magnitude of the vertical component of the Earth's magnetic field is not required in this calculation.

....

....

....

....

....

(2)
(Total 5 marks)

9. A metal framed window is 1.3 m high and 0.7 m wide. It pivots about a vertical edge and faces due south.

Calculate the magnetic flux through the closed window. (Horizontal component of the Earth's magnetic field = 20 μT. Vertical component of the Earth's magnetic field = 50 μT.)

....

....

....

Flux =.....................................

(2)

The window is opened through an angle of 90° in a time of 0.80 s. Calculate the average e.m.f. induced.

....

....

....

e.m.f. =...

(2)

State and explain the effect on the induced e.m.f. of converting the window to a sliding mechanism for opening.

....

....

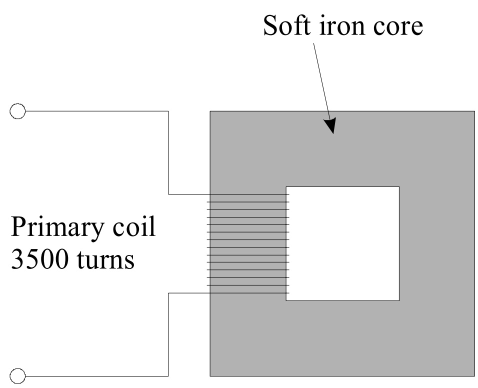
....

....

....

(2)
(Total 6 marks)

10. Complete the diagram below of a transformer designed to step down a potential difference of 11 kV to 415 V.



(2)

Explain why the transformer could not be used to step down the potential difference of a d.c. supply.

....

....

....

(1)

Show that for an ideal transformer (100% efficient)

$$\frac{I_{\text{primary}}}{I_{\text{secondary}}} = \frac{\text{number of secondary turns}}{\text{number of primary turns}}$$

....

....

....

....

(2)

Transformers are not 100%efficient. State one cause of energy loss in a transformer.

....

....

(1)
(Total 6 marks)