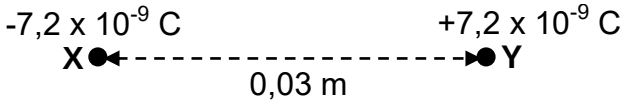
SA-STUDENT

To pass high school please visit us at:
https://sa-student.com/

QUESTION 7 (Start on a new page.)

Two point charges, **X** and **Y**, are held 0,03 m apart, as shown in the diagram below. The charge of **X** is -7,2 x 10^{-9} C, while the charge of **Y** is +7,2 x 10^{-9} C.

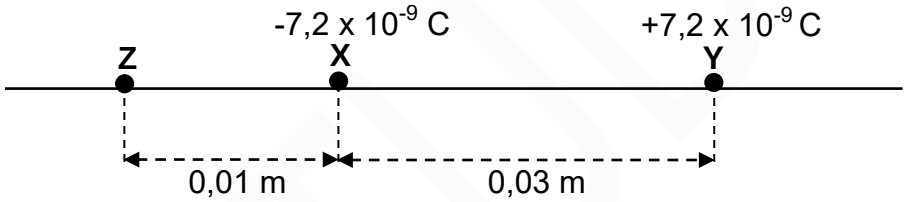


7.1 State Coulomb's law in words. (2)

7.2 Draw the net electric field pattern due to the two point charges. (3)

7.3 Calculate the magnitude of the electrostatic force that **Y** exerts on **X**. (3)

A third point charge, **Z**, of unknown positive charge, is positioned 0,01 m to the left of point charge **X** on the line joining point charges **X** and **Y**, as shown in the diagram below.



7.4 Draw a labelled vector diagram to show the directions of the electric fields at the point where **X** is positioned. (2)

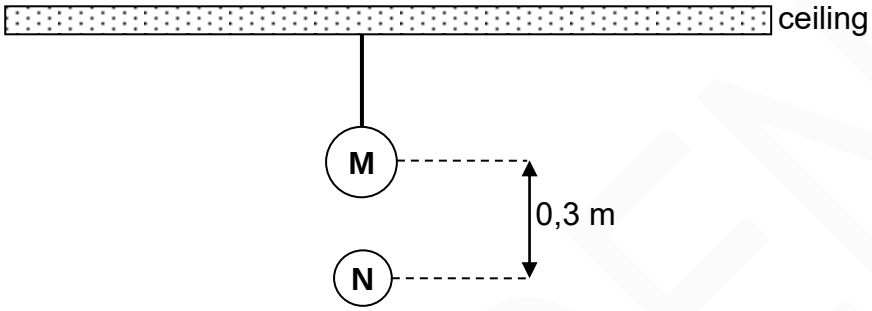
7.5 The magnitude of the resultant electric field at the point where **X** is positioned is 4,91 x 10^{5} N·C^{-1}.

Calculate the magnitude of charge **Z**. (5)
[15]

QUESTION 7 (Start on a new page.)

A charged sphere **M** is suspended from a ceiling by a light inextensible, insulated string.

Another charged sphere **N**, of mass 2,04 x 10^{-3} kg and carrying a charge of + 8,6 x 10^{-8} C, hangs STATIONARY vertically below sphere **M**. The centres of the spheres are 0,3 m apart, as shown in the diagram below.



7.1 State Coulomb's law in words. (2)

7.2 State whether the charge on sphere **M** is POSITIVE or NEGATIVE. (1)

7.3 Draw a labelled free-body diagram for sphere **N**. (2)

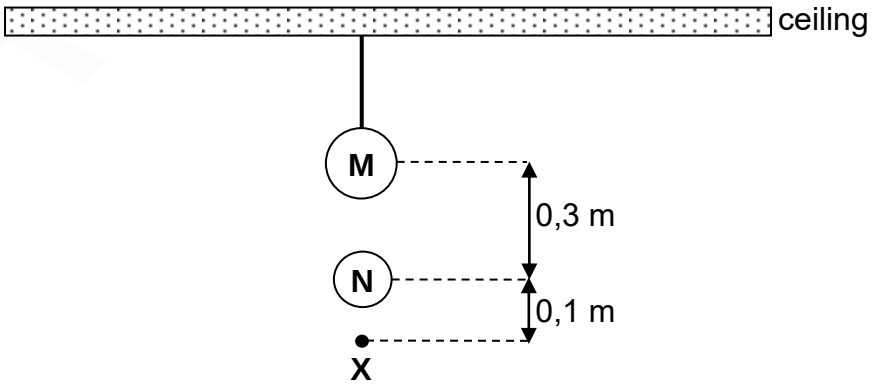
7.4 Calculate the magnitude of the charge on sphere **M**. (5)

7.5 How does the electrostatic force that sphere **M** exerts on sphere **N** compare to that exerted by sphere **N** on sphere **M** with respect to:

7.5.1 Magnitude (1)

7.5.2 Direction (1)

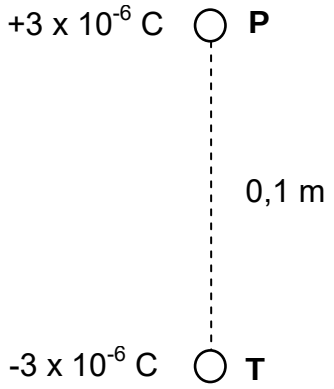
Point **X** is 0,1 m vertically below the centre of sphere **N**, as shown below.



7.6 Calculate the net electric field at point **X**. (5)
[17]

QUESTION 7 (Start on a new page.)

7.1 Two small, identical spheres, **P** and **T**, are placed a distance of 0,1 m apart, as shown in the diagram below. **P** carries a charge of +3 x 10^{-6} C and **T** carries a charge of -3 x 10^{-6} C.

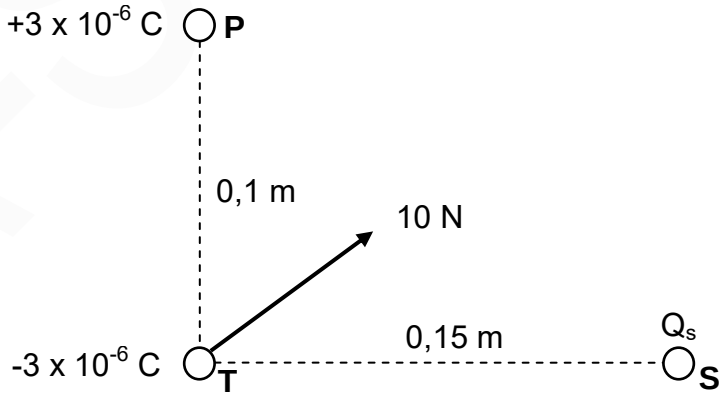


7.1.1 State Coulomb's law in words. (2)

7.1.2 Draw the resultant electric field pattern due to the charges on **P** and **T**. (3)

A third charged sphere **S** of unknown charge Q_s is placed a distance of 0,15 m from sphere **T** such that the three charged spheres are at the vertices of a right-angled triangle.

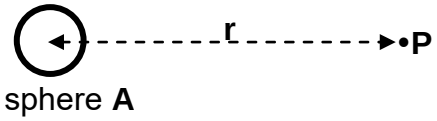
The net electrostatic force on sphere **T** due to the other two charged spheres has a magnitude of 10 N, as shown in the diagram below.



7.1.3 Is charge Q_s POSITIVE or NEGATIVE? (1)

7.1.4 Calculate the number of electrons added to or removed from sphere **S** to give it a charge of Q_s. (6)

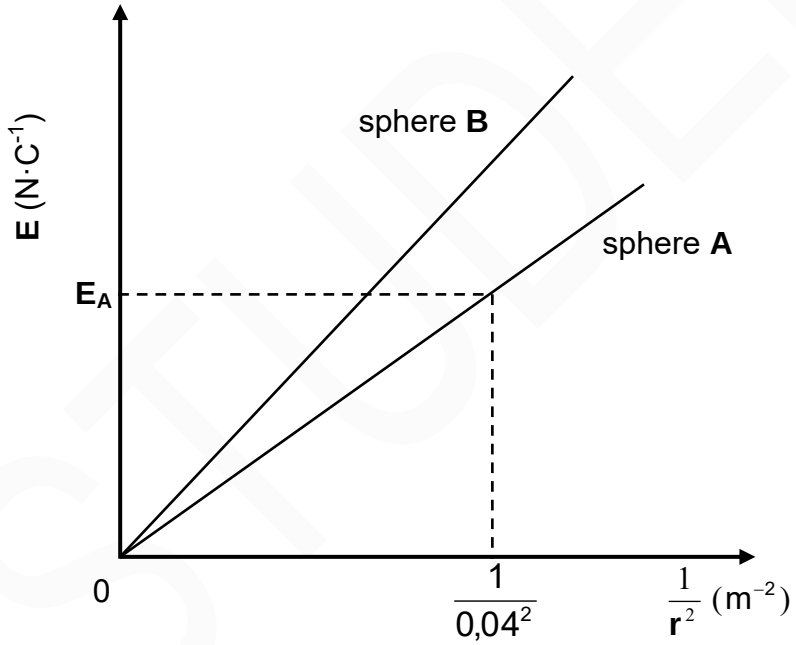
7.2 **P** is a variable point in the electric field of charged sphere **A** and **r** is the distance between point **P** and the centre of sphere **A**. See the diagram below.



A learner determines the magnitude of the electric field (**E**) at point **P** for different values of **r**.

Sphere **A** is then replaced by another sphere, **B**, of a different charge. Another set of results are obtained.

The graphs below are obtained from the results for sphere **A** and sphere **B**. $\mathbf{E_A}$ is the magnitude of the electric field at a distance of 0,04 m from the centre of charged sphere **A**.



Use the graphs to answer the following questions.

7.2.1 State the proportionality between the magnitude of electric field **E** at a point and $\frac{1}{\mathbf{r}^2}$. (1)

7.2.2 Calculate $\mathbf{E_A}$ if the numerical value of the gradient of the graph for sphere **A** is 680. (4)

7.2.3 How does the magnitude of the charge on sphere **B** compare to the magnitude of the charge on sphere **A**?

Choose from GREATER THAN, SMALLER THAN or EQUAL TO. Give a reason for the answer. (3)

[20]

QUESTION 7 (Start on a new page.)

7.1 A small neutral sphere acquires a charge of -1,95 x 10^{-6} C.

7.1.1 Were electrons ADDED TO or REMOVED FROM the sphere? (1)

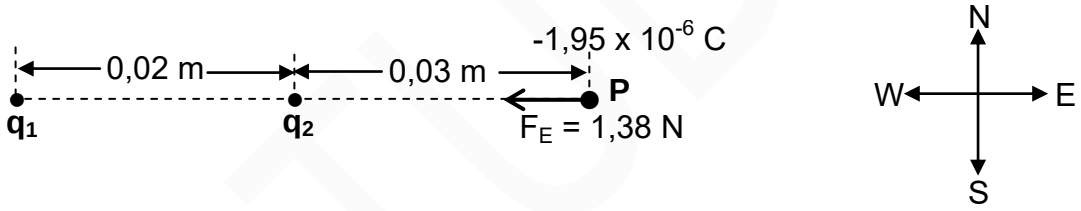
7.1.2 Calculate the number of electrons which were added or removed. (3)

7.1.3 Define the term *electric field at a point*. (2)

7.1.4 Calculate the magnitude of the electric field at a point 0,5 m from the centre of the charged sphere. (3)

7.2 Two point charges, $\mathbf{q_1}$ and $\mathbf{q_2}$, are fixed 0,02 m apart. The magnitude of charges $\mathbf{q_1}$ and $\mathbf{q_2}$ is the same and $\mathbf{q_1}$ is NEGATIVELY charged.

The small charged sphere with the charge of -1,95 x 10^{-6} C is placed at point **P**, 0,03 m east of charge $\mathbf{q_2}$, as shown in the diagram below. The sphere at point **P** experiences a net electrostatic force of 1,38 N west.



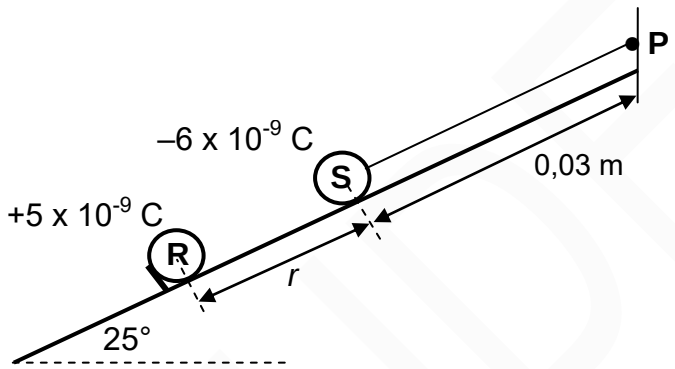
Calculate the magnitude of the charge on $\mathbf{q_2}$. (5)
[14]

QUESTION 7 (Start on a new page.)

Two charged spheres, **R** and **S**, are both stationary on a smooth, insulated surface inclined at an angle of 25° to the horizontal. Sphere **S**, of mass 0,01 kg and carrying a charge of -6×10^{-9} C, is connected to a 0,03 m long, light inextensible string attached to point **P** at the top of the incline.

Sphere **R**, carrying a charge of $+5 \times 10^{-9}$ C, is held such that the distance between the centres of the spheres is *r*, as shown in the diagram below.

Ignore the effects of friction.



Sphere **R** exerts an electrostatic force of magnitude $1,2 \times 10^{-3}$ N on sphere **S**.

7.1 State Coulomb's law in words. (2)

7.2 Calculate the distance *r* between the spheres. (3)

7.3 Draw a labelled free-body diagram for sphere **S**. (4)

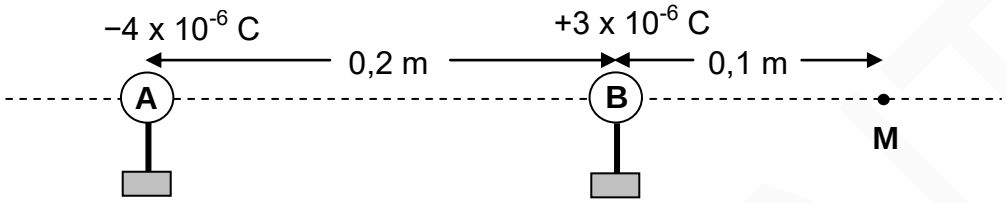
7.4 Calculate the:

7.4.1 Tension in the string (4)

7.4.2 Net electric field at point **P** (5)
[18]

QUESTION 7 (Start on a new page.)

Two small charged spheres, **A** and **B**, are placed on insulated stands, 0,2 m apart, as shown in the diagram below. They carry charges of -4×10^{-6} C and $+3 \times 10^{-6}$ C respectively.



M is a point that is a distance of 0,1 m to the right of sphere **B**.

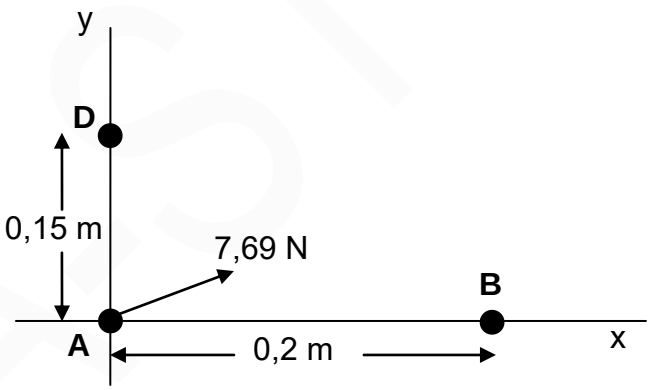
7.1 Calculate the number of electrons in excess on sphere **A**. (3)

7.2 Calculate the magnitude of the electrostatic force exerted by sphere **A** on sphere **B**. (3)

7.3 Describe the term *electric field*. (2)

7.4 Calculate the magnitude of the net electric field at point **M**. (5)

Charged spheres **A** and **B** and another charged sphere **D** are now arranged along a rectangular system of axes, as shown in the diagram below.



The net electrostatic force experienced by sphere **A** is 7,69 N in the direction as shown in the diagram above.

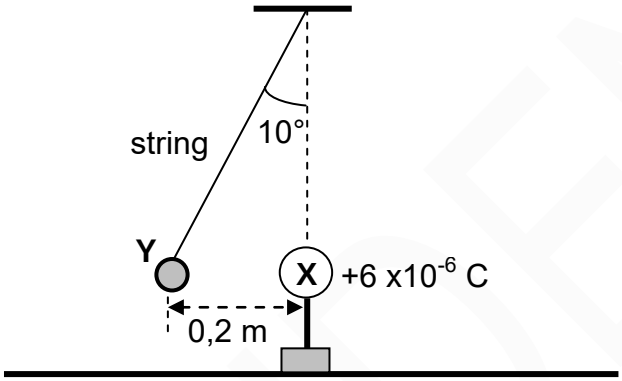
7.5 Is the charge on sphere **D** POSITIVE or NEGATIVE? (1)

7.6 Calculate the magnitude of the charge on sphere **D**. (3)
[17]

QUESTION 7 (Start on a new page.)

7.1 A small sphere, **Y**, carrying an unknown charge, is suspended at the end of a light inextensible string which is attached to a fixed point. Another sphere, **X**, carrying a charge of +6 x10^{-6} C, on an insulated stand is brought close to sphere **Y**.

Sphere **Y** experiences an electrostatic force and comes to rest 0,2 m away from sphere **X**, with the string at an angle of 10° with the vertical, as shown in the diagram below.



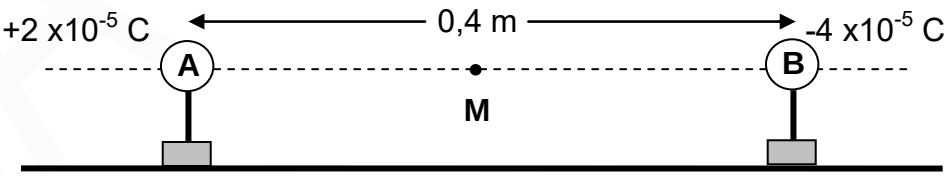
7.1.1 What is the nature of the charge on sphere **Y**? Choose from POSITIVE or NEGATIVE. (1)

7.1.2 Calculate the magnitude of the charge on sphere **Y** if the magnitude of the electrostatic force acting on it is 3,05 N. (3)

7.1.3 Draw a labelled free-body diagram for sphere **Y**. (3)

7.1.4 Calculate the magnitude of the tension in the string. (3)

7.2 Two small charged spheres, **A** and **B**, on insulated stands, with charges +2 x10^{-5} C and -4 x10^{-5} C respectively, are placed 0,4 m apart, as shown in the diagram below. **M** is the midpoint between spheres **A** and **B**.

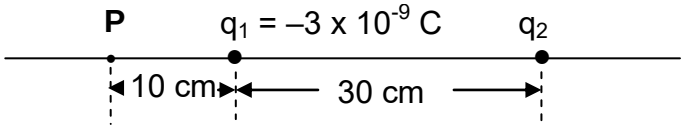


7.2.1 Define the term *electric field at a point*. (2)

7.2.2 Calculate the net electric field at point **M**. (6)
[18]

QUESTION 7 (Start on a new page.)

Two point charges, q_1 and q_2, are placed 30 cm apart along a straight line. Charge $q_1 = -3 \times 10^{-9}$ C. Point **P** is 10 cm to the left of q_1, as shown in the diagram below. The **net** electrostatic field at point **P** is **zero.**



7.1 Define the term *electric field at a point*. (2)

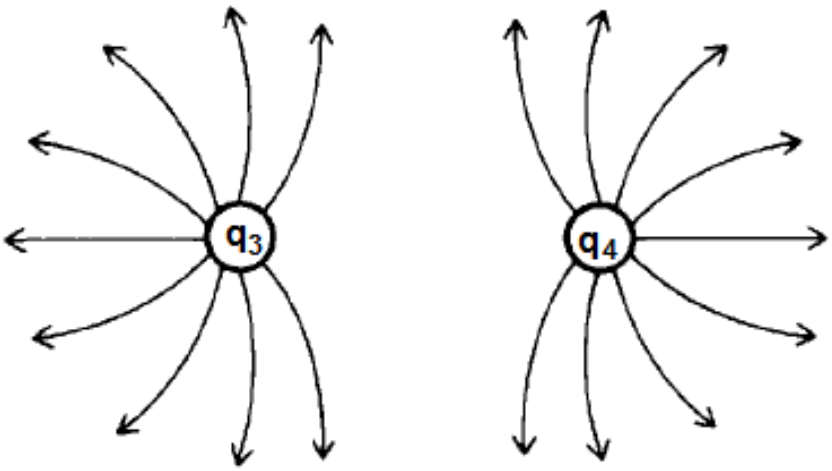
7.2 State, giving reasons, whether point charge q_2 is positive or negative. (3)

7.3 Calculate the magnitude of charge q_2. (4)

7.4 State Coulomb's law in words. (2)

7.5 Calculate the magnitude of the electrostatic force exerted by charge q_1 on charge q_2. (3)

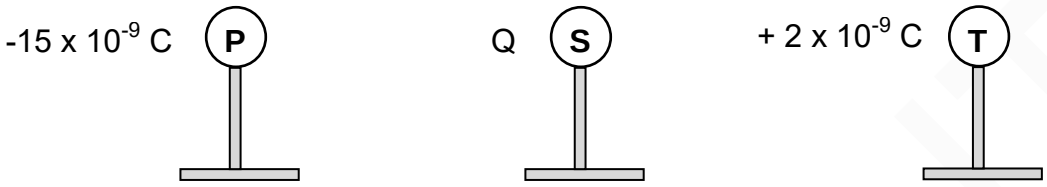
7.6 The two charges are now brought into contact with each other and are then separated. A learner draws the electric field pattern for the new charges q_3 and q_4 **after** contact, as shown below.



Is the diagram CORRECT? Give a reason for the answer. (2)
[16]

QUESTION 7 (Start on a new page.)

Three small identical metal spheres, **P**, **S** and **T**, on insulated stands, are **initially neutral**. They are then charged to carry charges of -15 x 10^{-9} C, Q and +2 x 10^{-9} C respectively, as shown below.

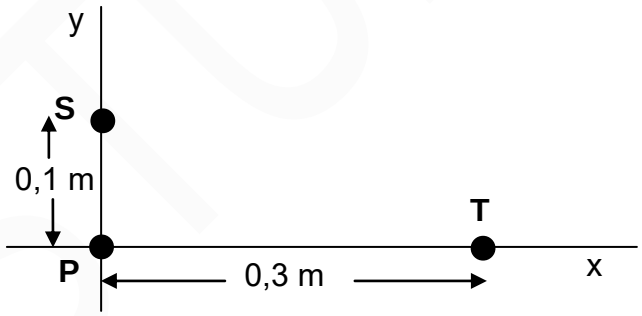


The charged spheres are brought together so that all three spheres touch each other at the same time, and are then separated. The charge on each sphere, after separation, is -3 x 10^{-9} C.

7.1 Determine the value of charge Q. (2)

7.2 Draw the electric field pattern associated with the charged spheres, **S** and **T**, **after they are separated** and returned to their original positions. (3)

The spheres, each with the **new charge** of -3 x 10^{-9} C, are now placed at points on the *x*-axis and the *y*-axis, as shown in the diagram below, with sphere **P** at the origin.



7.3 State Coulomb's law in words. (2)

Calculate the magnitude of the:

7.4 Net electrostatic force acting on sphere **P** (5)

7.5 Net electric field at the origin due to charges **S** and **T** (3)

7.6 ONE of the charged spheres, **P** and **T**, experienced a very small increase in mass **after it was charged initially**.

7.6.1 Which sphere, **P** or **T**, experienced this very small increase in mass? (1)

7.6.2 Calculate the increase in mass by the sphere in QUESTION 7.6.1. (3)

[19]

QUESTION 6 (Start on a new page.)

A sound source, moving at a constant speed of 240 $m \cdot s^{-1}$ towards a detector, emits sound at a constant frequency. The detector records a frequency of 5 100 Hz.

Take the speed of sound in air as 340 $m \cdot s^{-1}$.

6.1 State the Doppler effect. (2)

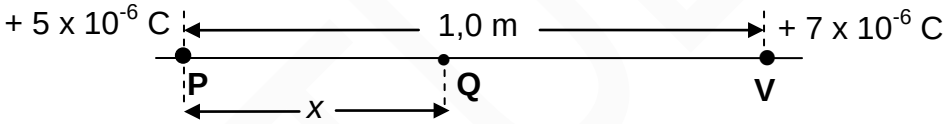
6.2 Calculate the wavelength of the sound emitted by the source. (7)

Some of the sound waves are reflected from the detector towards the approaching source.

6.3 Will the frequency of the reflected sound wave detected by the sound source be EQUAL TO, GREATER THAN or SMALLER THAN 5 100 Hz? (1)
[10]

QUESTION 7 (Start on a new page.)

A particle, **P**, with a charge of + 5 x 10^{-6} C, is located 1,0 m along a straight line from particle **V**, with a charge of +7 x 10^{-6} C. Refer to the diagram below.



A third charged particle, **Q**, at a point *x* metres away from **P**, as shown above, experiences a net electrostatic force of zero newton.

7.1 How do the electrostatic forces experienced by **Q** due to the charges on **P** and **V** respectively, compare with each other? (2)

7.2 State Coulomb's law in words. (2)

7.3 Calculate the distance *x*. (5)
[9]

QUESTION 8 (Start on a new page.)

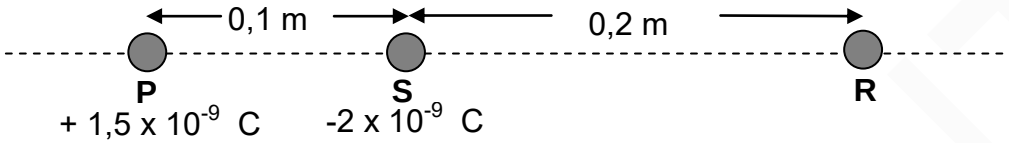
A small metal sphere **Y** carries a charge of + 6 x 10^{-6} C.

8.1 Draw the electric field pattern associated with sphere **Y**. (2)

8.2 If 8 x 10^{13} electrons are now transferred to sphere **Y**, calculate the electric field at a point 0,5 m from the sphere. (7)
[9]

QUESTION 7 (Start on a new page.)

Two point charges, **P** and **S**, are placed a distance 0,1 m apart. The charge on **P** is +1,5 x 10^{-9} C and that on **S** is -2 x 10^{-9} C.
A third point charge, **R**, with an unknown positive charge, is placed 0,2 m to the right of point charge **S**, as shown in the diagram below.



7.1 State Coulomb's law in words. (2)

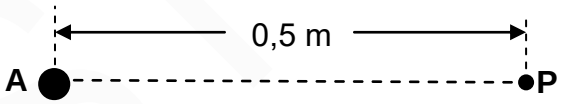
7.2 Draw a labelled force diagram showing the electrostatic forces acting on **R** due to **P** and **S**. (2)

7.3 Calculate the magnitude of the charge on **R**, if it experiences a net electrostatic force of 1,27 x 10^{-6} N to the left.

Take forces directed to the right as positive. (7)
[11]

QUESTION 8 (Start on a new page.)

P is a point 0,5 m from charged sphere **A**. The electric field at **P** is 3 x 10^{7} N·C^{-1} directed towards **A**. Refer to the diagram below.



8.1 Draw the electric field pattern due to charged sphere **A**. Indicate the sign of the charge on the sphere in your diagram. (2)

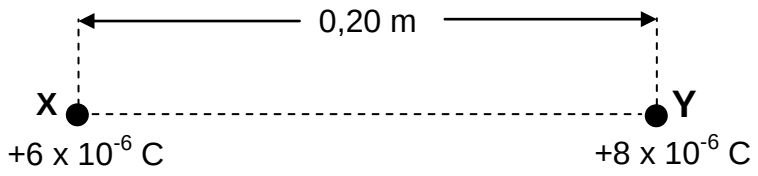
8.2 Calculate the magnitude of the charge on sphere **A**. (3)

Another charged sphere, **B**, having an excess of 10^{5} electrons, is now placed at point **P**.

8.3 Calculate the electrostatic force experienced by sphere **B**. (6)
[11]

QUESTION 7 (Start on a new page.)

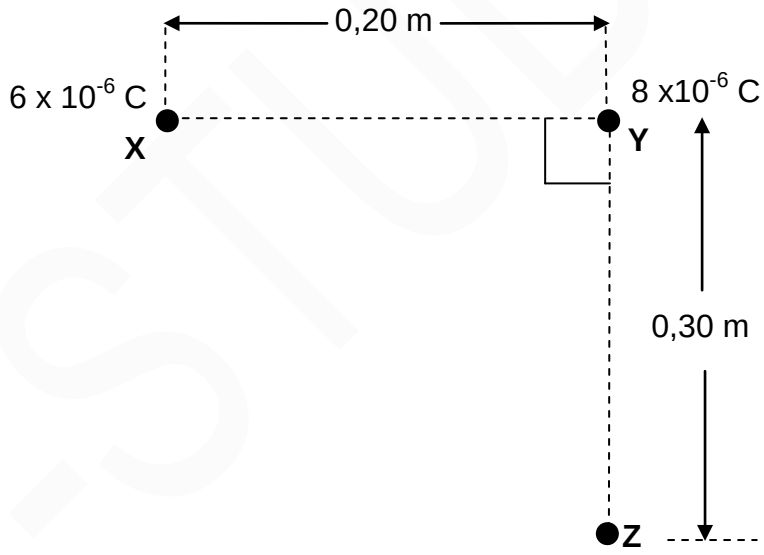
Two small spheres, **X** and **Y**, carrying charges of +6 x 10^{-6} C and +8 x 10^{-6} C respectively, are placed 0,20 m apart in air.



7.1 State Coulomb's law in words. (2)

7.2 Calculate the magnitude of the electrostatic force experienced by charged sphere **X**. (4)

A third sphere, **Z**, of unknown **negative** charge, is now placed at a distance of 0,30 m below sphere **Y**, in such a way that the line joining the charged spheres **X** and **Y** is perpendicular to the line joining the charged spheres **Y** and **Z**, as shown in the diagram below.

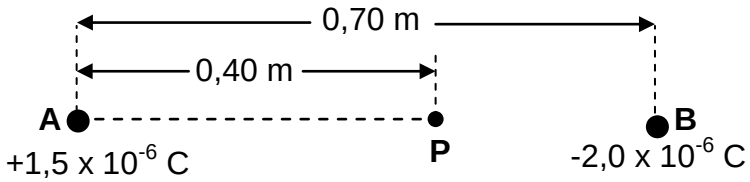


7.3 Draw a vector diagram showing the directions of the electrostatic forces **and** the net force experienced by charged sphere **Y** due to the presence of charged spheres **X** and **Z** respectively. (3)

7.4 The magnitude of the net electrostatic force experienced by charged sphere **Y** is 15,20 N. Calculate the charge on sphere **Z**. (4)
[13]

QUESTION 8 (Start on a new page.)

A and **B** are two small spheres separated by a distance of 0,70 m. Sphere **A** carries a charge of +1,5 x 10^{-6} C and sphere **B** carries a charge of -2,0 x 10^{-6} C.



P is a point between spheres **A** and **B** and is 0,40 m from sphere **A**, as shown in the diagram above.

8.1 Define the term *electric field at a point*. (2)

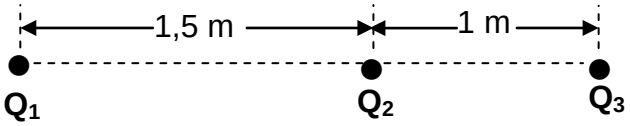
8.2 Calculate the magnitude of the net electric field at point **P**. (4)

8.3 A point charge of magnitude 3,0 x 10^{-9} C is now placed at point **P**.

Calculate the magnitude of the electrostatic force experienced by this charge. (3)
[9]

QUESTION 7 (Start on a new page.)

In the diagram below, Q_1, Q_2 and Q_3 are three stationary point charges placed along a straight line. The distance between Q_1 and Q_2 is 1,5 m and that between Q_2 and Q_3 is 1 m, as shown in the diagram below.



7.1 State Coulomb's law in words. (2)

7.2 The magnitude of charges Q_1 and Q_2 are unknown. The charge on Q_1 is positive. The charge on Q_3 is +2 x 10^{-6} C and it experiences a net electrostatic force of 0,3 N to the left.

7.2.1 Write down the sign (POSITIVE or NEGATIVE) of charge Q_2. (2)

Charge Q_2 is now removed. The magnitude of the electrostatic force experienced by charge Q_3 due to Q_1 now becomes 0,012 N.

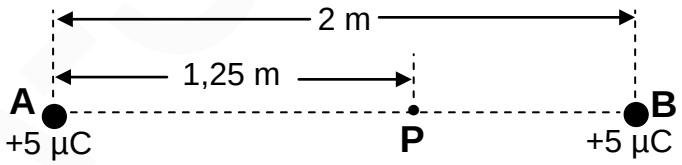
7.2.2 Calculate the magnitudes of the unknown charges Q_1 and Q_2. (7)
[11]

QUESTION 8 (Start on a new page.)

Two small identical spheres, **A** and **B**, each carrying a charge of +5 µC, are placed 2 m apart.

Point **P** is in the electric field due to the charged spheres and is located 1,25 m from sphere **A**.

Study the diagram below.



8.1 Describe the term *electric field*. (2)

8.2 Draw the resultant electric field pattern due to the two charged spheres. (3)

8.3 Calculate the magnitude of the net electric field at point **P**. (5)
[10]

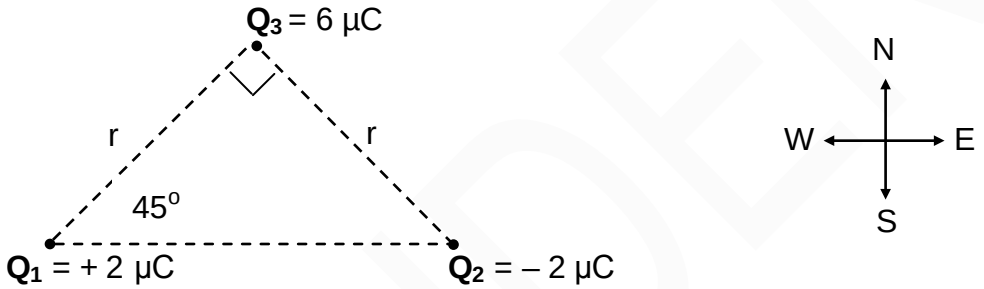
QUESTION 7 (Start on a new page.)

7.1 A metal sphere A, suspended from a wooden beam by means of a non-conducting string, has a charge of +6 µC.

7.1.1 Were electrons ADDED TO or REMOVED FROM the sphere to obtain this charge? Assume that the sphere was initially neutral. (1)

7.1.2 Calculate the number of electrons added to or removed from the sphere. (3)

7.2 Point charges $\mathbf{Q_1}$, $\mathbf{Q_2}$ and $\mathbf{Q_3}$ are arranged at the corners of a right-angled triangle, as shown in the diagram below.



The charges on $\mathbf{Q_1}$ and $\mathbf{Q_2}$ are + 2 µC and – 2 µC respectively and the magnitude of the charge on $\mathbf{Q_3}$ is 6 µC.

The distance between $\mathbf{Q_1}$ and $\mathbf{Q_3}$ is r. The distance between $\mathbf{Q_2}$ and $\mathbf{Q_3}$ is also r.

The charge $\mathbf{Q_3}$ experiences a resultant electrostatic force of 0,12 N to the west.

7.2.1 Without calculation, identify the sign (positive or negative) on the charge $\mathbf{Q_3}$. (1)

7.2.2 Draw a vector diagram to show the electrostatic forces acting on $\mathbf{Q_3}$ due to charges $\mathbf{Q_1}$ and $\mathbf{Q_2}$ respectively. (2)

7.2.3 Write down an expression, in terms of r, for the horizontal component of the electrostatic force exerted on $\mathbf{Q_3}$ by $\mathbf{Q_1}$. (3)

7.2.4 Calculate the distance r. (4)

7.3 The magnitude of the electric field is 100 $N \cdot C^{-1}$ at a point which is 0,6 m away from a point charge Q.

7.3.1 Define the term *electric field at a point* in words. (2)

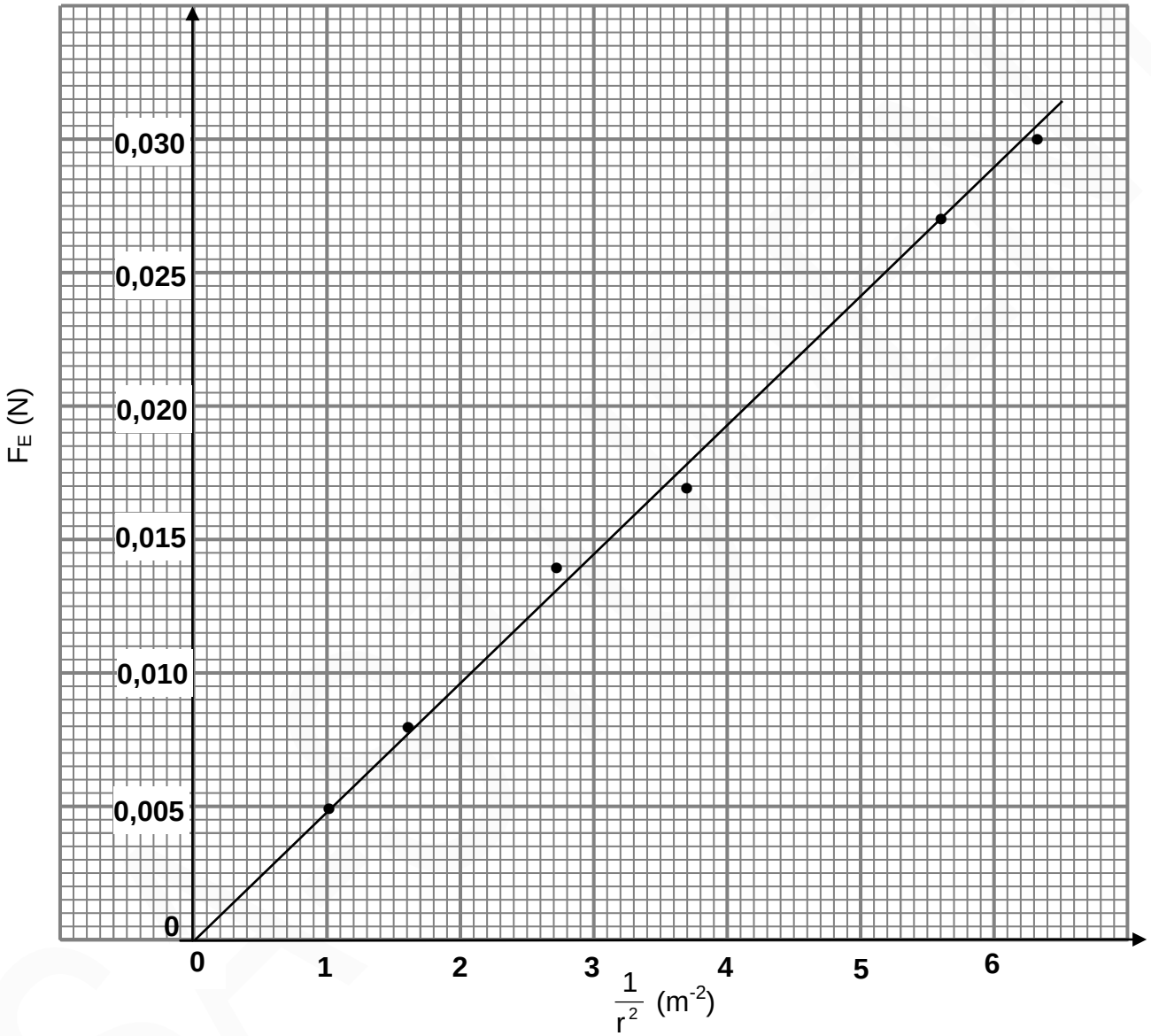
7.3.2 Calculate the distance from point charge Q at which the magnitude of the electric field is 50 $N \cdot C^{-1}$. (5)

[21]

QUESTION 7 (Start on a new page.)

7.1 In an experiment to verify the relationship between the electrostatic force, F_E, and distance, r, between two **identical**, positively charged spheres, the graph below was obtained.

GRAPH OF F_E VERSUS $\frac{1}{r^2}$



7.1.1 State Coulomb's law in words. (2)

7.1.2 Write down the dependent variable of the experiment. (1)

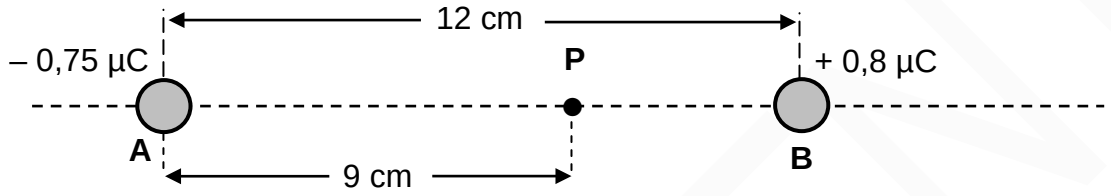
7.1.3 What relationship between the electrostatic force F_E and the square of the distance, r^2, between the charged spheres can be deduced from the graph? (1)

7.1.4 Use the information in the graph to calculate the charge on each sphere. (6)

7.2 A charged sphere, **A**, carries a charge of – 0,75 µC.

7.2.1 Draw a diagram showing the electric field lines surrounding sphere **A**. (2)

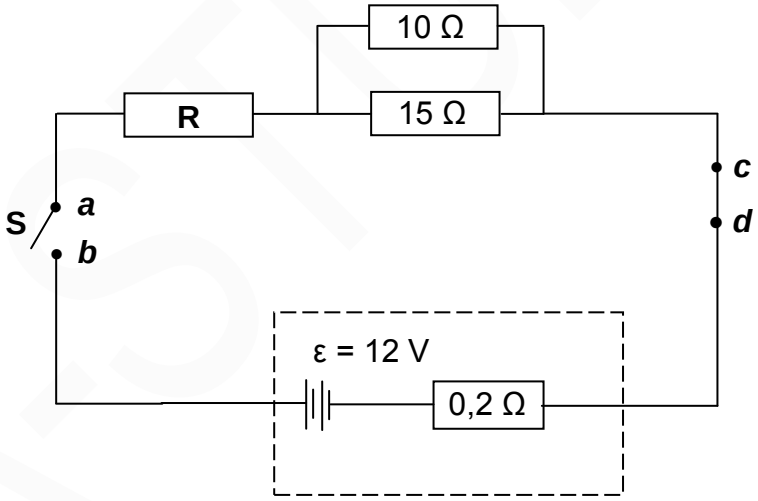
Sphere **A** is placed 12 cm away from another charged sphere, **B**, along a straight line in a vacuum, as shown below. Sphere **B** carries a charge of +0,8 µC. Point **P** is located 9 cm to the right of sphere **A**.



7.2.2 Calculate the magnitude of the net electric field at point **P**. (5)
[17]

QUESTION 8 (Start on a new page.)

8.1 In the circuit below the battery has an emf (ε) of 12 V and an internal resistance of 0,2 Ω. The resistances of the connecting wires are negligible.



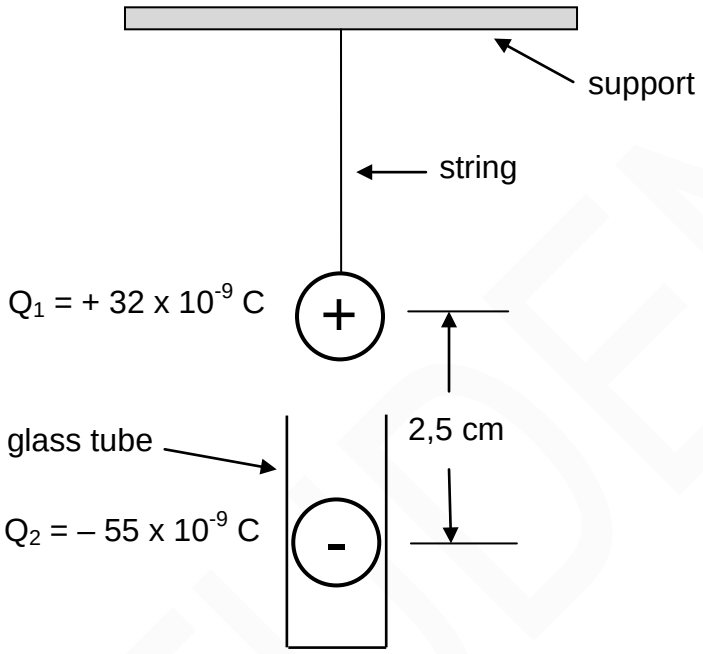
8.1.1 Define the term *emf of a battery.* (2)

8.1.2 Switch **S** is open. A high-resistance voltmeter is connected across points ***a*** and ***b***.
What will the reading on the voltmeter be? (1)

8.1.3 Switch **S** is now closed. The same voltmeter is now connected across points ***c*** and ***d.***
What will the reading on the voltmeter be? (1)

QUESTION 7 (Start on a new page.)

A small sphere, Q_1, with a charge of + 32 x 10^{-9} C, is suspended from a light string secured to a support. A second, identical sphere, Q_2, with a charge of – 55 x 10^{-9} C, is placed in a narrow, cylindrical glass tube vertically below Q_1. Each sphere has a mass of 7 g. Both spheres come to equilibrium when Q_2 is 2,5 cm from Q_1, as shown in the diagram. Ignore the effects of air friction.



7.1 Calculate the number of electrons that were removed from Q_1 to give it a charge of + 32 x 10^{-9} C. Assume that the sphere was neutral before being charged. (3)

7.2 Draw a labelled free-body diagram showing all the forces acting on sphere Q_1. (3)

7.3 Calculate the magnitude of the tension in the string. (5)

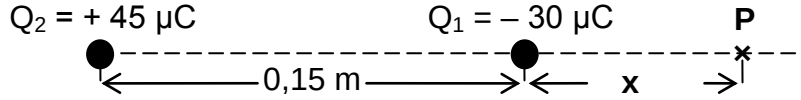
[11]

QUESTION 8 (Start on a new page.)

8.1 Define *electric field at a point* in words. (2)

8.2 Draw the electric field pattern for two identical positively charged spheres placed close to each other. (3)

8.3 A – 30 µC point charge, Q_1, is placed at a distance of 0,15 m from a + 45 µC point charge, Q_2, in space, as shown in the diagram below. The net electric field at point **P**, which is on the same line as the two charges, is zero.

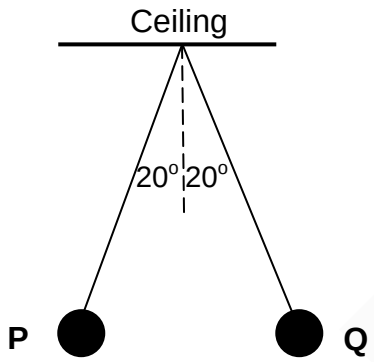


Calculate **x**, the distance of point **P** from charge Q_1. (5)

[10]

QUESTION 7 (Start on a new page.)

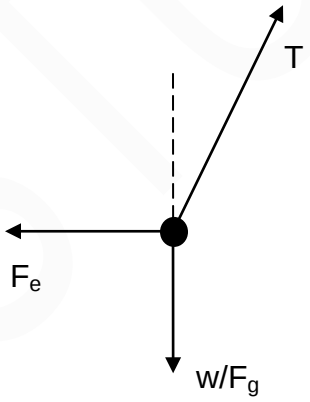
Two identical spherical balls, **P** and **Q**, each of mass 100 g, are suspended at the same point from a ceiling by means of identical light, inextensible insulating strings. Each ball carries a charge of +250 nC. The balls come to rest in the positions shown in the diagram below.



7.1 In the diagram, the angles between each string and the vertical are the same. Give a reason why the angles are the same. (1)

7.2 State Coulomb's law in words. (2)

7.3 The free-body diagram, not drawn to scale, of the forces acting on ball **P** is shown below.



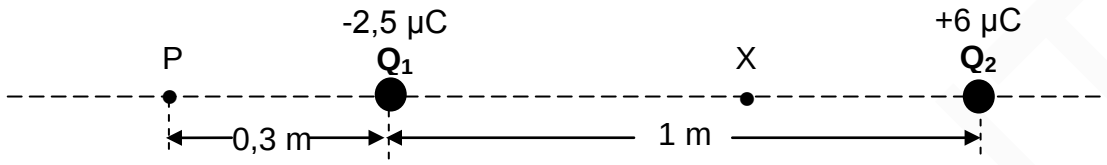
Calculate the:

7.3.1 Magnitude of the tension (T) in the string (3)

7.3.2 Distance between balls **P** and **Q** (5)
[11]

QUESTION 8 (Start on a new page.)

A sphere $\mathbf{Q_1}$, with a charge of -2,5 µC, is placed 1 m away from a second sphere $\mathbf{Q_2}$, with a charge +6 µC. The spheres lie along a straight line, as shown in the diagram below. Point **P** is located a distance of 0,3 m to the left of sphere $\mathbf{Q_1}$, while point **X** is located between $\mathbf{Q_1}$ and $\mathbf{Q_2}$. The diagram is not drawn to scale.

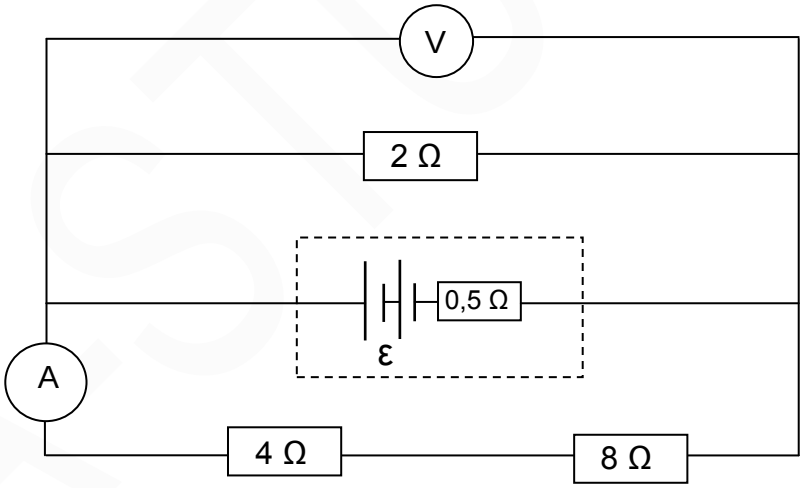


8.1 Show, with the aid of a VECTOR DIAGRAM, why the net electric field at point **X** *cannot be zero.* (4)

8.2 Calculate the net electric field at point **P**, due to the two charged spheres $\mathbf{Q_1}$ and $\mathbf{Q_2}$. (6)
[10]

QUESTION 9 (Start on a new page.)

A battery of an unknown emf and an internal resistance of 0,5 Ω is connected to three resistors, a high-resistance voltmeter and an ammeter of negligible resistance, as shown below.



The reading on the ammeter is 0,2 A.

9.1 Calculate the:

9.1.1 Reading on the voltmeter (3)

9.1.2 Total current supplied by the battery (4)

9.1.3 Emf of the battery (5)

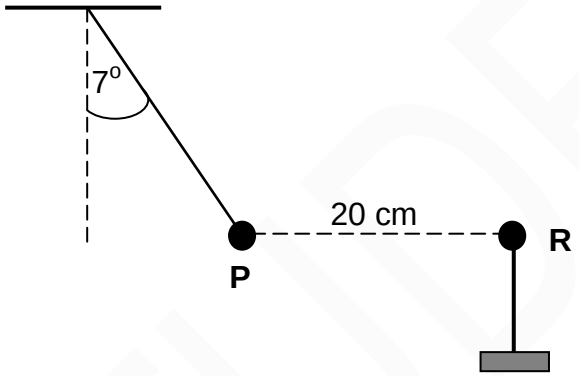
9.2 How would the voltmeter reading change if the 2 Ω resistor is removed from the circuit? Write down INCREASE, DECREASE or REMAIN THE SAME. Explain the answer. (3)
[15]

QUESTION 7 (Start on a new page.)

A very small graphite-coated sphere **P** is rubbed with a cloth. It is found that the sphere acquires a charge of + 0,5 µC.

7.1 Calculate the number of electrons removed from sphere **P** during the charging process. (3)

Now the charged sphere **P** is suspended from a light, inextensible string. Another sphere, **R**, with a charge of – 0,9 µC, on an insulated stand, is brought close to sphere **P**. As a result sphere **P** moves to a position where it is 20 cm from sphere **R**, as shown below. The system is in equilibrium and the angle between the string and the vertical is 7^o.



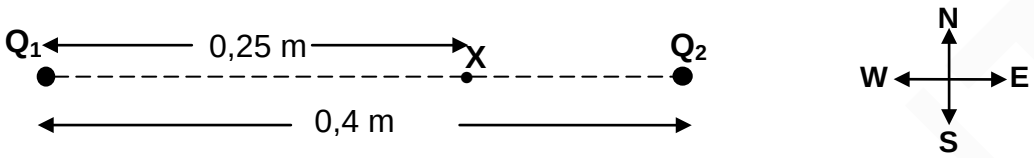
7.2 Draw a labelled free-body diagram showing ALL the forces acting on sphere **P**. (3)

7.3 State Coulomb's law in words. (2)

7.4 Calculate the magnitude of the tension in the string. (5)
[13]

QUESTION 8 (Start on a new page.)

Two charged particles, $\mathbf{Q_1}$ and $\mathbf{Q_2}$, are placed 0,4 m apart along a straight line. The charge on $\mathbf{Q_1}$ is + 2 x 10^{-5} C, and the charge on $\mathbf{Q_2}$ is – 8 x 10^{-6} C. Point **X** is 0,25 m **east** of $\mathbf{Q_1}$, as shown in the diagram below.



Calculate the:

8.1 Net electric field at point **X** due to the two charges (6)

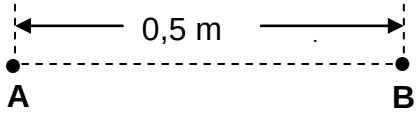
8.2 Electrostatic force that a – 2 x 10^{-9} C charge will experience at point **X** (4)

The – 2 x 10^{-9} C charge is replaced with a charge of – 4 x 10^{-9} C at point **X**.

8.3 **Without any further calculation**, determine the magnitude of the force that the – 4 x 10^{-9} C charge will experience at point **X**. (1)
[11]

QUESTION 7 (Start on a new page.)

Two identical negatively charged spheres, **A** and **B**, having charges of the **same magnitude**, are placed 0,5 m apart in vacuum. The magnitude of the electrostatic force that one sphere exerts on the other is $1,44 \times 10^{-1}$ N.



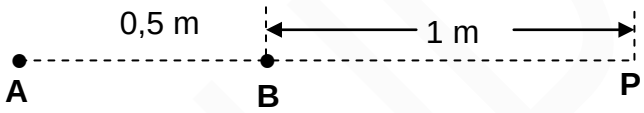
7.1 State Coulomb's law in words. (2)

7.2 Calculate the:

7.2.1 Magnitude of the charge on each sphere (4)

7.2.2 Excess number of electrons on sphere **B** (3)

7.3 **P** is a point at a distance of 1 m from sphere **B**.



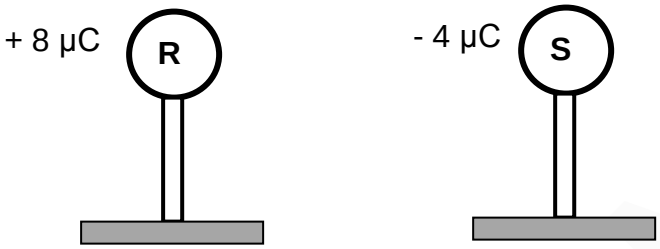
7.3.1 What is the direction of the net electric field at point **P**? (1)

7.3.2 Calculate the number of electrons that should be removed from sphere **B** so that the net electric field at point **P** is 3×10^{4} N·C^{-1} to the right. (8)

[18]

QUESTION 7 (Start on a new page.)

The diagram below shows two small identical metal spheres, **R** and **S**, each placed on a wooden stand. Spheres **R** and **S** carry charges of + 8 µC and - 4 µC respectively. Ignore the effects of air.



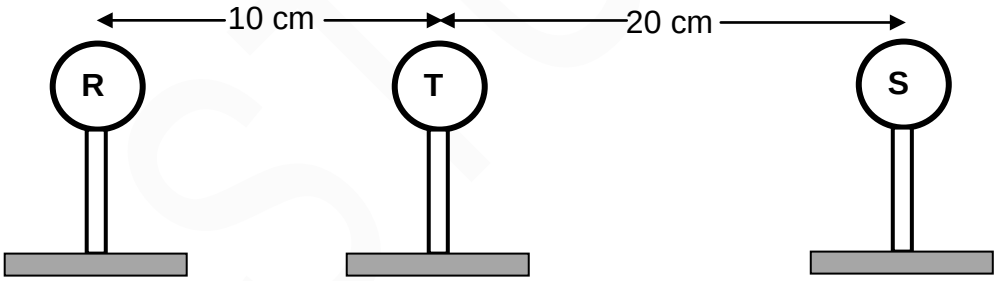
7.1 Explain why the spheres were placed on wooden stands. (1)

Spheres **R** and **S** are brought into contact for a while and then separated by a small distance.

7.2 Calculate the net charge on each of the spheres. (2)

7.3 Draw the electric field pattern due to the two spheres **R** and **S**. (3)

After **R** and **S** have been in contact and separated, a third sphere, **T**, of charge + 1 µC is now placed between them as shown in the diagram below.



7.4 Draw a free-body diagram showing the electrostatic forces experienced by sphere **T** due to spheres **R** and **S**. (2)

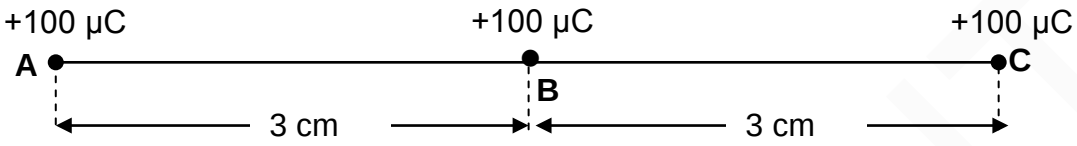
7.5 Calculate the net electrostatic force experienced by **T** due to **R** and **S**. (6)

7.6 Define the *electric field at a point*. (2)

7.7 Calculate the magnitude of the net electric field at the location of **T** due to **R** and **S**. (Treat the spheres as if they were point charges.) (3)
[19]

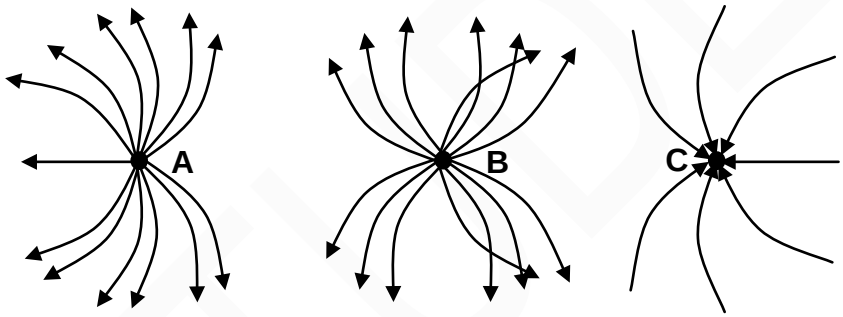
QUESTION 8 (Start on a new page.)

Three +100 µC point charges, **A**, **B** and **C**, are equally spaced on a straight line in a vacuum. The charges are a distance of 3 cm from each other as shown in the sketch below.



8.1 Name the law that describes the electrostatic force exerted by one point charge on another. (1)

8.2 A learner sketches the electric field pattern produced by the three charges as shown below.



Write down THREE mistakes the learner made. (3)

8.3 Calculate the net electrostatic force experienced by point charge **C**. (6)

8.4 Write down the net electrostatic force experienced by point charge **B**. Give a reason for the answer. (2)

[12]

QUESTION 6 (Start on a new page.)

The siren of a stationary police car emits sound waves of wavelength 0,55 m.

With its siren on, the police car now approaches a stationary listener at constant velocity on a straight road. Assume that the speed of sound in air is 345 $m \cdot s^{-1}$.

6.1 Will the wavelength of the sound waves observed by the listener be GREATER THAN, SMALLER THAN or EQUAL TO 0,55 m? (1)

6.2 Name the phenomenon observed in QUESTION 6.1. (1)

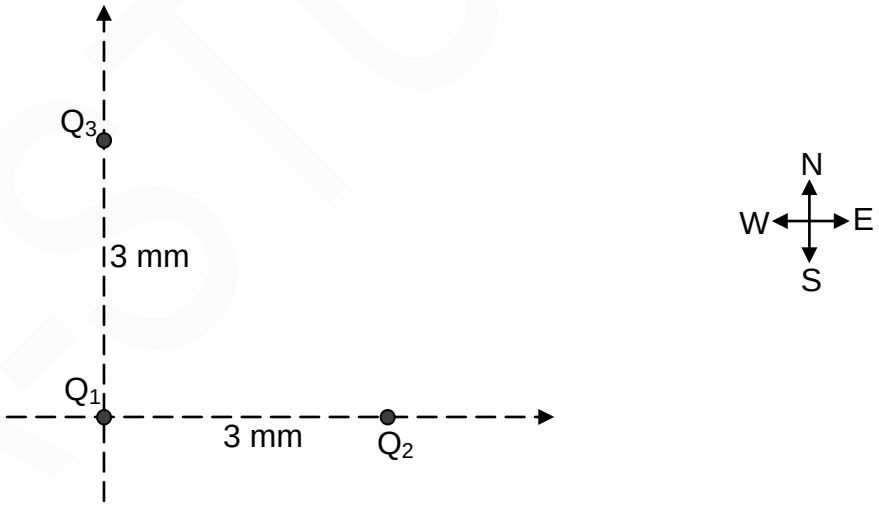
6.3 Calculate the frequency of the sound waves observed by the listener if the car approaches him at a speed of 120 $km \cdot h^{-1}$. (7)

6.4 How will the answer in QUESTION 6.3 change if the police car moves away from the listener at 120 $km \cdot h^{-1}$? Write down only INCREASES, DECREASES or REMAINS THE SAME. (1)

[10]

QUESTION 7 (Start on a new page.)

Three small, identical metal spheres, Q_1, Q_2 and Q_3, are placed in a vacuum. Each sphere carries a charge of – 4 µC. The spheres are arranged such that Q_2 and Q_3 are each 3 mm from Q_1 as shown in the diagram below.



7.1 State Coulomb's law in words. (2)

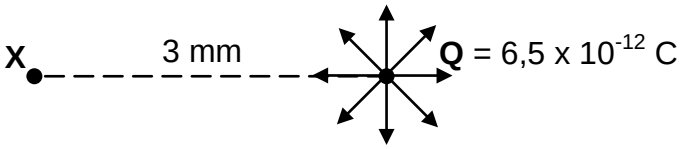
7.2 Draw a force diagram showing the electrostatic forces exerted on Q_1 by Q_2 and Q_3. (2)

7.3 Calculate the net force exerted on Q_1 by Q_2 and Q_3. (8)

[12]

QUESTION 8 (Start on a new page.)

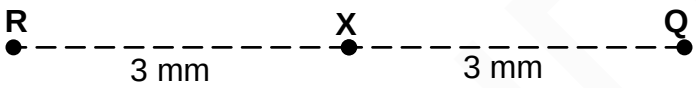
An isolated point charge **Q** is located in space as shown in the diagram below. Point charge **Q** contributes to an electric field as shown. Point **X** is located 3 mm away from point charge **Q**.

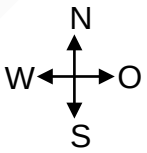


8.1 Define the term *electric field* at a point. (2)

8.2 Calculate the magnitude of the electric field at point **X**. (3)

8.3 Point charge **R** carrying a charge of + 6,5 x 10^{-12} C is placed 3 mm away from point **X** as shown in the diagram below.

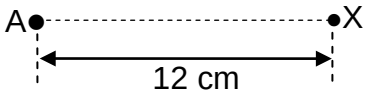


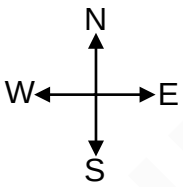


Calculate the net electric field at point **X**. (4)
[9]

QUESTION 8 (Start on a new page.)

In the diagram below, point charge **A** has a charge of +16 µC. **X** is a point 12 cm from point charge **A**.



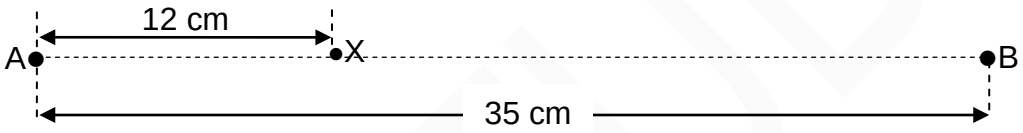


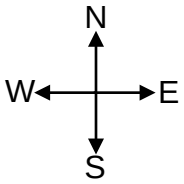
8.1 Draw the electric field pattern produced by point charge **A**. (2)

8.2 Is the electric field in QUESTION 8.1 UNIFORM or NON-UNIFORM? (1)

8.3 Calculate the magnitude and direction of the electric field at point **X** due to point charge **A**. (5)

Another point charge **B** is now placed at a distance of 35 cm from point charge **A** as shown below. The NET electric field at point **X** due to point charges **A** and **B** is 1 x 10^7 $N \cdot C^{-1}$ west.





8.4 Is point charge **B** POSITIVE or NEGATIVE? (1)

8.5 Calculate the magnitude of point charge **B**. (5)
[14]

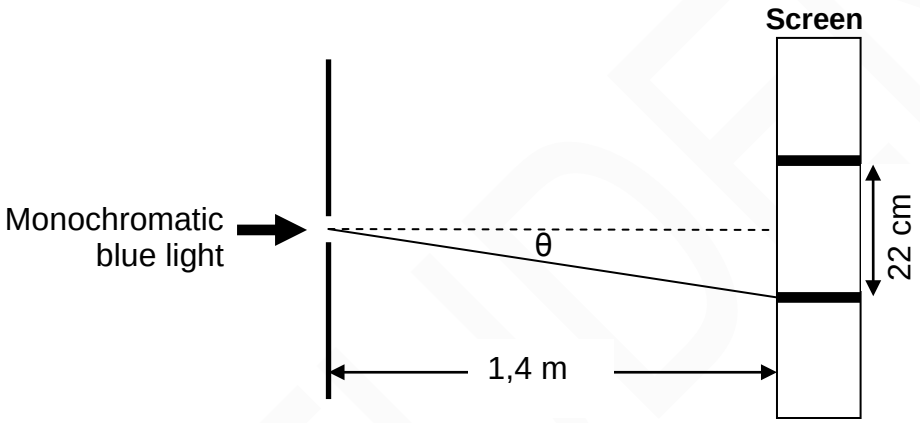
QUESTION 7 (Start on a new page.)

Learners use monochromatic blue light to investigate the difference between an interference pattern and a diffraction pattern.

7.1 Apart from the blue light and a screen, write down the name of ONE item that the learners will need to obtain an interference pattern. (1)

7.2 Briefly describe the interference pattern that will be observed on the screen. (2)

7.3 In one of their experiments they place the screen at a distance of 1,4 m from a single slit and observe a pattern on the screen. The width of the central bright band is measured as 22 cm.



Calculate the:

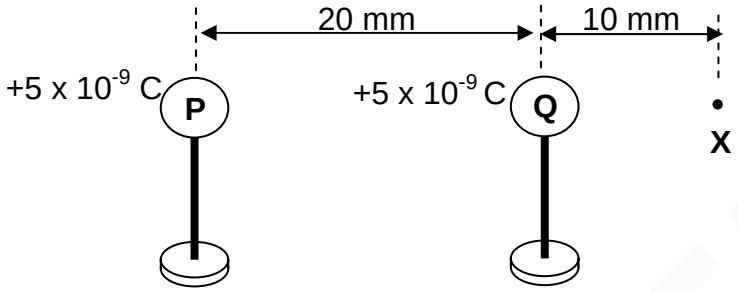
7.3.1 Angle θ at which the first minimum will be observed on the screen (3)

7.3.2 The width of the slit used if the wavelength of the blue light is 470 nm (5)

7.4 The width of the central band INCREASES when the blue light is replaced with monochromatic red light. Explain this observation. (2)
[13]

QUESTION 8 (Start on a new page.)

Two metal spheres, **P** and **Q**, on insulated stands, carrying charges of +5 x 10^{-9} C and +5 x 10^{-9} C respectively, are placed with their centres 20 mm apart. **X** is a point at a distance of 10 mm from sphere **Q**, as shown below.



8.1 Define the term *electric field.* (2)

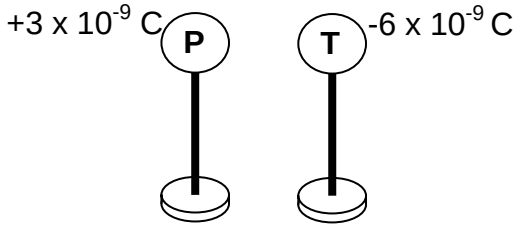
8.2 Sketch the net electric field pattern for the two charges. (3)

8.3 Calculate the net electric field at point **X** due to the presence of **P** and **Q**. (6)

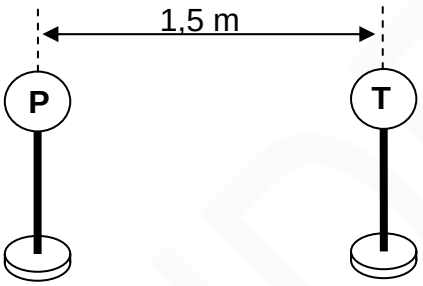
8.4 Use your answer to QUESTION 8.3 to calculate the magnitude of the electrostatic force that an electron will experience when placed at point **X**. (3)
[14]

QUESTION 8 (Start on a new page.)

Two metal spheres, **P** and **T**, on insulated stands, carry charges of $+3 \times 10^{-9}$ C and -6×10^{-9} C respectively.



The spheres are allowed to touch each other and are then placed 1,5 m apart as shown below.



8.1 In which direction will electrons flow while spheres **P** and **T** are in contact? Write down only FROM **P** TO **T** or FROM **T** TO **P**. (1)

8.2 Calculate the net charge gained or lost by sphere **P** after the spheres have been in contact. (3)

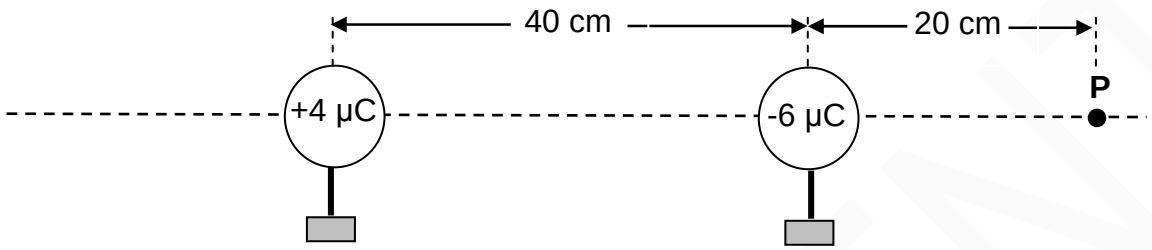
8.3 Calculate the number of electrons transferred during the process in QUESTION 8.2. (2)

8.4 A third sphere **R,** carrying a charge of -3×10^{-9} C, is NOW placed between **P** and **T** at a distance of 1 m from **T**.

Calculate the net force experienced by sphere **R** as a result of its interaction with **P** and **T**. (6)
[12]

QUESTION 10 (Start on a new page.)

Two metal spheres on insulated stands carry charges of +4 µC and -6 µC respectively. The spheres are arranged with their centres 40 cm apart, as shown below.



10.1 Calculate the magnitude of the force exerted by each sphere on the other. (4)

10.2 By what factor will the magnitude of the force in QUESTION 10.1 change if the distance between the spheres is halved? (Do not calculate the new value of the force.) (1)

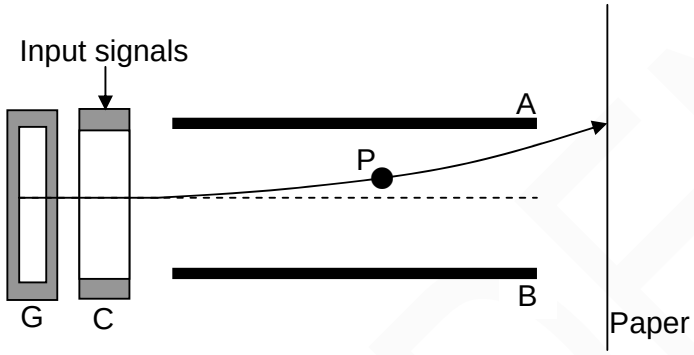
10.3 Calculate the net electric field at point P as shown in the diagram above. (6)

10.4 The spheres are now brought into contact with each other and then returned to their original positions. Now calculate the potential energy of the system of two charges. (5)
[16]

QUESTION 10

An ink-jet printer makes use of the electric field between two oppositely charged parallel plates to control the position of an ink drop on paper.

In the diagram below, the generator (G) of the printer shoots out ink drops that are charged in the charging unit C. The input signal from a computer controls the charge given to each ink drop. **P is a negatively charged ink drop.**



10.1 Define the electric field at a point in space. (2)

10.2 Is plate B negatively or positively charged? Give a reason for your answer. (2)

10.3 Sketch the electric field pattern between plates A and B. (2)

The plates A and B are $6,4 \times 10^{-4}$ m apart and ink drop P has a charge of magnitude $1,5 \times 10^{-13}$ C. When the ink drop enters the field it experiences an electrical force of $2,1 \times 10^{-7}$ N.

10.4 Calculate the potential difference across the parallel plates. (5)
[11]