

Charges, coulomb's law and electric potential

Physics grades 11-12 (A Level · IB · Class 11-12) · Worksheet

Name: _____ Date: _____ Class: _____

These twenty problems start with field strength, Coulomb's law and electronvolts, then move to droplets, potentials and charged particles in plates. They suit A Level, IB Physics and CBSE Class 12 students. Problems 16 to 20 combine several ideas, including equilibrium, projectile-style motion and conservation of energy.

Level: Physics grades 11-12 (A Level · IB · Class 11-12) · **Curriculum:** IB D.2

Problem 1 Field from a measured force (easy)

In a school lab in Kampala, a 2.0 nC test charge feels a force of 6.0×10^{-5} N at a point near a charged dome.

1. Calculate the field strength at that point.
2. Calculate the force on a 5.0 nC charge placed at the same point.

Problem 2 Distance and force (easy)

Two small spheres carry charges of +1.0 μC and +2.0 μC and are 30 cm apart in air.

1. Calculate the force between them and state whether it attracts or repels.
2. State the force when the spheres are moved to 60 cm apart.

Problem 3 Capacitor-style plates (easy)

Class 12 student Aarav in Pune connects a 12 V supply across two parallel metal plates separated by 3.0 mm. Calculate the electric field strength between the plates in V/m.

Problem 4 Electronvolts (easy)

An electron is accelerated through a potential difference of 200 V.

1. State the kinetic energy gained in electronvolts.
2. Convert that energy to joules.

Problem 5 Direction of field and force (easy)

1. State the direction of the electric field lines near a positive charge and near a negative charge.
2. A small negative charge is placed in a field that points east. State the direction of the force on it.

3. Explain what it means when field lines are close together.

Problem 6 Field of a point charge (easy)

A small sphere carries a charge of $+4.0 \text{ nC}$. Calculate the field strength at a point 0.30 m from its centre and state its direction.

Problem 7 Proton in a field (medium)

In a vacuum chamber a proton is placed in a uniform field of $2.5 \times 10^4 \text{ N/C}$.

1. Calculate the electric force on it.
2. Calculate its acceleration.
3. Show that its weight is negligible by comparing it with the electric force.

Problem 8 Work against a charge (medium)

A fixed sphere carries $+6.0 \text{ nC}$. Wanjiru's demonstration moves a $+2.0 \text{ nC}$ test charge from 0.15 m to 0.060 m from the sphere's centre.

1. Calculate the potential at each position.
2. Calculate the work done on the test charge.

Problem 9 Suspended droplet (medium)

A charged oil droplet of mass $2.0 \times 10^{-15} \text{ kg}$ hangs motionless between horizontal plates 1.0 cm apart, with 600 V across them.

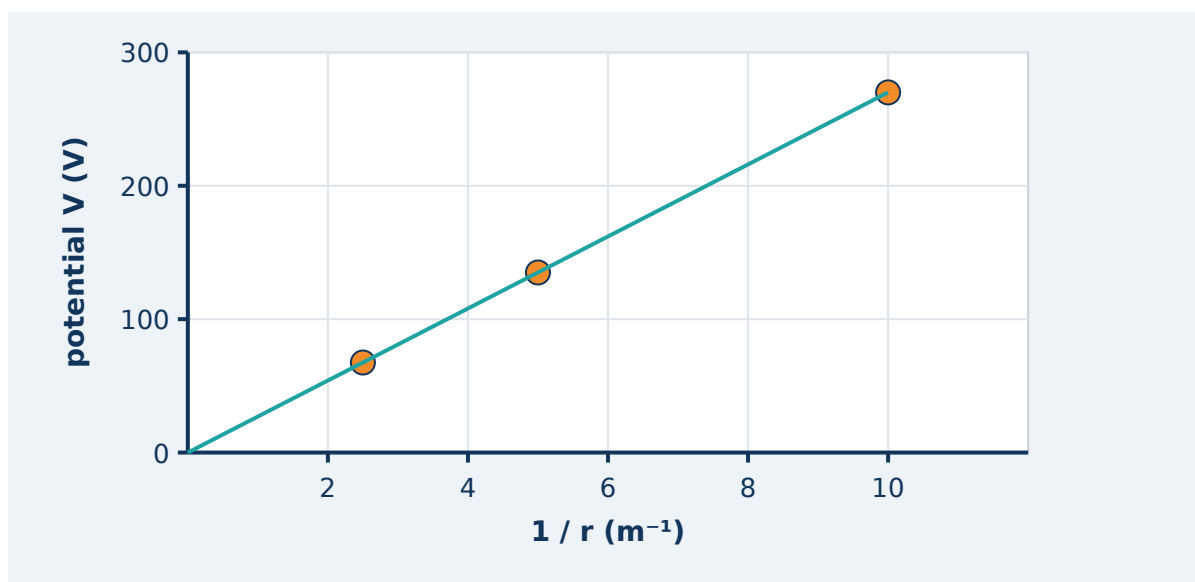
1. Calculate the electric field between the plates.
2. Calculate the charge on the droplet.
3. Calculate the number of excess electrons and say which plate is positive if the droplet is negative.

Problem 10 Midpoint of two charges (medium)

A $+4.0 \text{ nC}$ charge and a -4.0 nC charge are fixed 0.20 m apart in air. Calculate the magnitude and direction of the field at the midpoint.

Problem 11 Reading a potential graph (medium)

A student measures the potential V at three distances r from a small charged sphere: 270 V at 0.10 m , 135 V at 0.20 m and 67.5 V at 0.40 m . The graph of V against $1/r$ is shown.



Potential V of an unknown point charge plotted against $1/r$.

1. Explain why the graph is a straight line through the origin.
2. Calculate its gradient.
3. Use the gradient to find the charge on the sphere.

Problem 12 Accelerating through a gun (medium)

An electron in an old display tube is accelerated from rest through 1500 V.

1. Calculate its kinetic energy in joules.
2. Calculate its final speed.
3. Calculate the final speed of a proton accelerated through the same voltage.

Problem 13 Electric against gravity (medium)

Two protons are 1.0 nm apart.

1. Calculate the electric force between them.
2. Calculate the gravitational force between them ($G = 6.67 \times 10^{-11} \text{ N m}^2/\text{kg}^2$).
3. Calculate the ratio of the two forces and say how it changes if the protons move further apart.

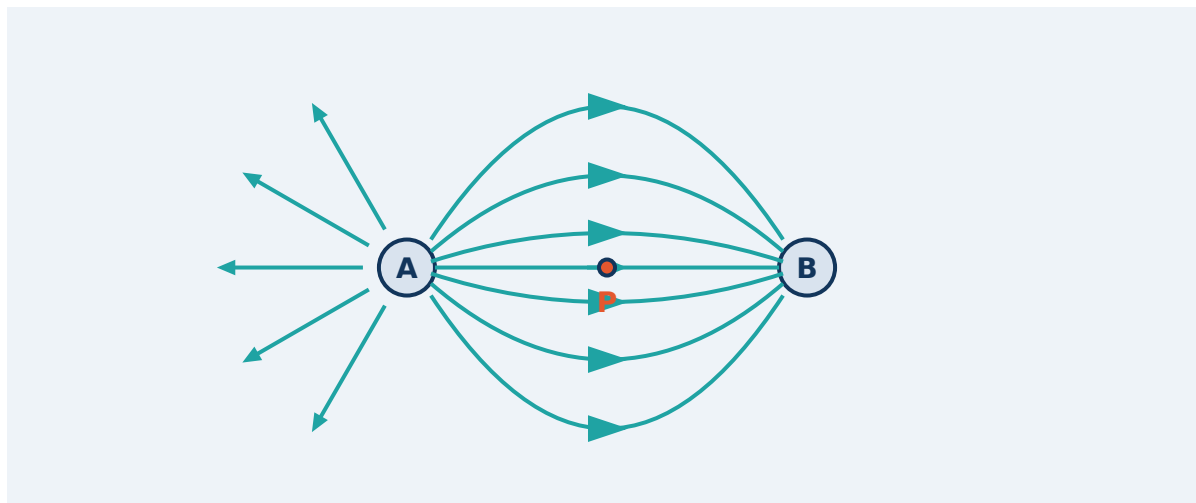
Problem 14 Spot the error (medium)

A student calculates the force between two +5.0 nC charges 5.0 cm apart as $F = (8.99 \times 10^9 \times 5.0 \times 10^{-9} \times 5.0 \times 10^{-9}) / 5.0 = 4.5 \times 10^{-8} \text{ N}$, and says that at 10 cm the force would be half as large.

1. Identify the two errors.
2. Calculate the correct force at 5.0 cm.
3. State the correct force at 10 cm.

Problem 15 Reading a field pattern (medium)

The diagram shows the electric field lines of two small charged spheres A and B.

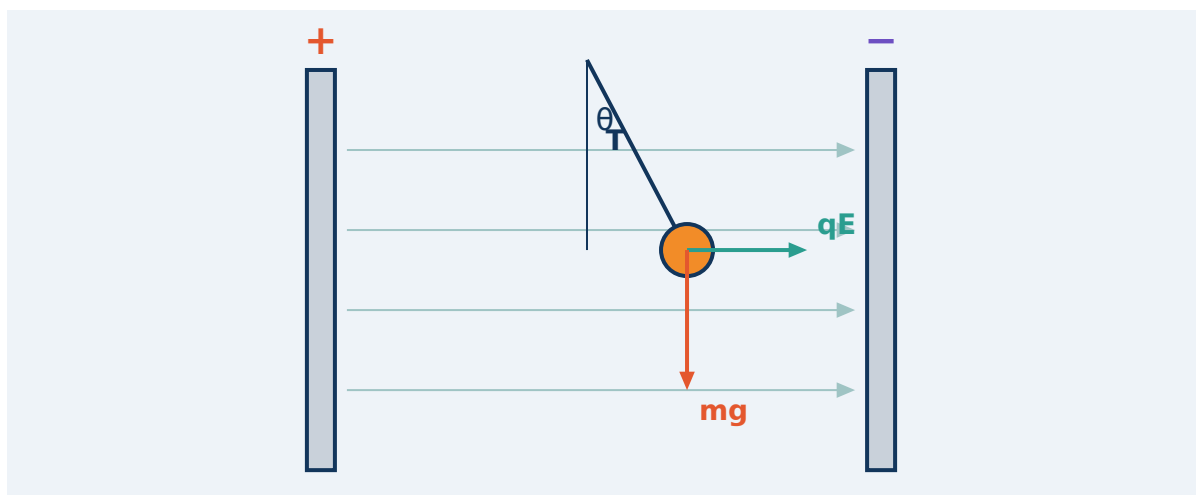


Field lines of two charges A and B. P is the midpoint.

1. State the sign of each charge.
2. State which charge is larger and give the evidence.
3. State the direction of the force on an electron placed at P.

Problem 16 Ball on a thread (hard)

A small ball of mass 1.0 g carries a charge of $+2.0 \mu\text{C}$ and hangs from an insulating thread in a horizontal uniform field. At rest the thread makes 20° with the vertical ($g = 9.81 \text{ N/kg}$).



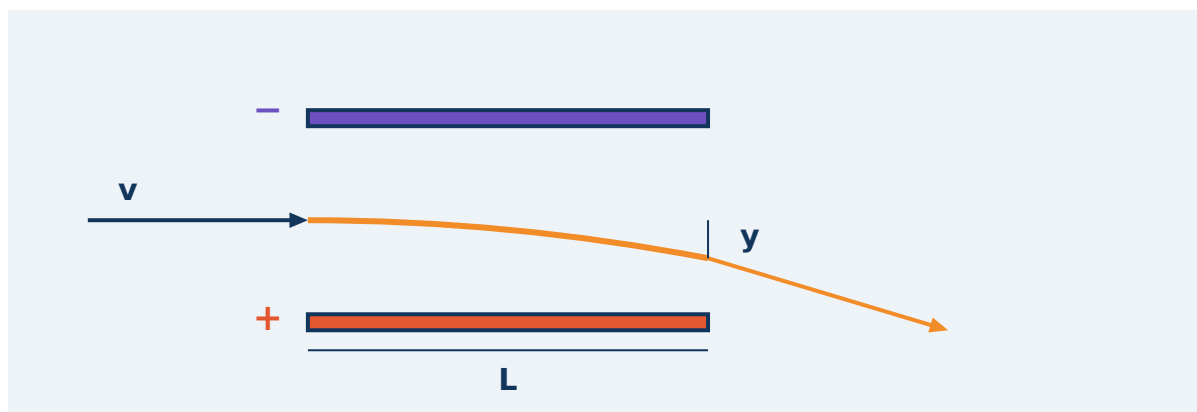
Charged ball in a horizontal uniform field. Forces: weight mg , electric force qE and tension T .

1. Draw and name the three forces on the ball.
2. Calculate the field strength.
3. Calculate the tension in the thread.

Problem 17 Beam between plates (hard)

Mei in Singapore fires an electron horizontally at $3.0 \times 10^7 \text{ m/s}$ into the gap between two plates of length 4.0 cm, separated by 2.0 cm, with 400 V across them. The upper plate is

negative and the lower plate is positive.



Beam entering the plates horizontally; y is the sideways displacement on leaving.

1. Calculate the field strength between the plates.
2. Calculate the time the electron spends between the plates.
3. Calculate its deflection on leaving the plates and the angle of its path to the horizontal.

Problem 18 Alpha particle and gold nucleus (hard)

In a scattering experiment, an alpha particle (charge $+2e$) of kinetic energy 5.0 MeV is fired directly at a gold nucleus (charge $+79e$). Treat the nucleus as fixed and use $1 \text{ MeV} = 1.60 \times 10^{-13} \text{ J}$.

1. Convert the kinetic energy to joules.
2. Write the electric potential energy of the pair at distance r .
3. Calculate the distance of closest approach.

Problem 19 Zero potential but not zero field (hard)

A $+6.0 \text{ nC}$ charge and a -2.0 nC charge are 0.40 m apart. Find the point between them on the line joining them where the potential is zero, and calculate the field strength there.

Problem 20 Spark from a metal sphere (hard)

Air breaks down and sparks when the field exceeds about $3.0 \times 10^6 \text{ V/m}$.

1. Calculate the potential difference that makes a spark jump a 2.0 mm gap between flat plates.
2. A Van de Graaff dome is a sphere of radius 5.0 cm . Calculate the charge that makes the field at its surface reach $3.0 \times 10^6 \text{ V/m}$.
3. Calculate the potential of the dome at that moment.