Exercise walk-through

Capacitors and capacitance ▪ 19.1

eXercise

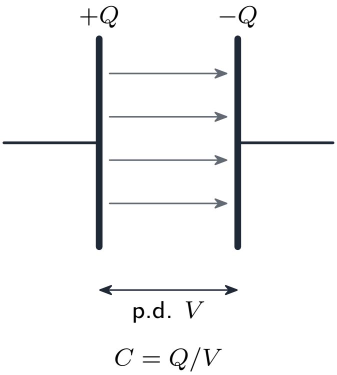
You must be able to

- define **capacitance** and use $C = Q/V$
- combine capacitors in **series** and **parallel**

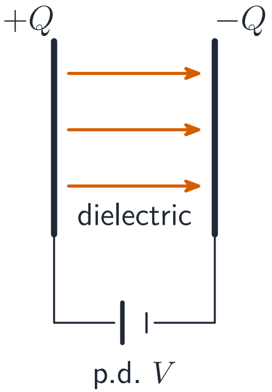
Method — Capacitance

A **capacitor** stores charge: $+Q$ on one plate, $-Q$ on the other, with p.d. V across the gap:

$$C = \frac{Q}{V} \quad (\text{farad, F} = \text{C V}^{-1}).$$



Method — Capacitance



$$C = \frac{Q}{V}$$

A parallel-plate capacitor

Method — Combining capacitors (opposite to resistors)

- **parallel:** $C = C_1 + C_2 + \dots$
- **series:** $\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \dots$

Practice 2.1 ▪ 1 mark

Define **capacitance**.

Solution 2.1

Method: Capacitance

Worked steps

The **charge stored per unit potential difference** $(C = Q/V)$ B1.

Practice 2.2 ▪ 1 mark

State the **unit** of capacitance.

Solution 2.2

Method: Capacitance

Worked steps

The **farad** (F) B1.

Practice 2.3 ▪ 2 marks

A capacitor holds 60 μC of charge at 12 V. Find its **capacitance**.

Solution 2.3

Method: Capacitance

Worked steps

$C = Q/V = (60 \times 10^{-6})/12 = 5.0\ \mu\mathrm{F}$ M1 A1.

Practice 2.4 ▪ 1 mark

Write the formula for capacitors in **parallel**.

Solution 2.4

Worked steps

$C = C_1 + C_2 + \ldots$ **B1**.

Exam-style 3.1 ▪ 1 mark

The unit of capacitance is the:

A coulomb

B farad

C volt

D ohm

Solution 3.1

Method: Capacitance

A coulomb

B farad ✓

C volt

D ohm

Worked steps

B — farad.

Exam-style 3.2 ▪ 2 marks

A $100\ \mu$F capacitor is charged to 9.0 V. Calculate the **charge** stored.

Solution 3.2

Method: Capacitance

Worked steps

$Q = CV = (100 \times 10^{-6})(9.0) = 9.0 \times 10^{-4}$ C **M1** **A1**.

Exam-style 3.3 ▪ 3 marks

A $4.0\ \mu$F and a $2.0\ \mu$F capacitor are connected in **series**. Calculate the combined capacitance.

Solution 3.3

Method: Capacitance

Worked steps

$\dfrac{1}{C} = \dfrac{1}{4.0} + \dfrac{1}{2.0} = \dfrac{3}{4.0}$ **M1** **M1**; $C = 1.3\ \mu\text{F}$ **A1**.

Exam-style 3.4 ▪ 1 mark

Write the formula for capacitors in **series**.

Solution 3.4

Method: Combining capacitors (opposite to resistors)

Worked steps

$$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \ldots \quad \textbf{B1}.$$

Exam-style 3.5 ▪ 2 marks

Three capacitors are available: $C_1 = 120\ \mu$F, $C_2 = 180\ \mu$F and $C_3 = 220\ \mu$F.
(a) C_1 and C_2 are connected in **series** across a supply. **Complete** the table to show how the charge on each and the p.d. across each relate to the total charge Q_S and the supply p.d. V_S.

quantity	**relationship**
charges Q_1, Q_2 and Q_S	______________________
p.d.s V_1, V_2 and V_S	______________________

Exam-style 3.5 ▪ 2 marks

(b) **Determine** the combined capacitance of C_1 and C_2 in series.
(c) The supply provides 12 V. **Calculate** the charge stored by that series combination, and the p.d. across C_1.
(d) C_3 is now connected in **parallel** with the series pair. **Determine** the total capacitance of the whole network, and the total charge it now stores at 12 V.
(e) **State and explain** which single capacitor in the network stores the **most** charge.

Solution 3.5

Method: Capacitance

Worked steps

(a) Charges: $Q_1 = Q_2 = Q_S$ — the same charge passes through every capacitor in a series chain **B1**. P.d.s: $V_1 + V_2 = V_S$ **B1**.

(b) $\dfrac{1}{C} = \dfrac{1}{120} + \dfrac{1}{180}$ **M1**, so $C = \dfrac{120 \times 180}{300} = 72\ \mu\text{F}$ **A1**.

(c) $Q = CV = 72 \times 10^{-6} \times 12 = 8.6 \times 10^{-4}$ C **M1** **A1**;

$V_1 = \dfrac{Q}{C_1} = \dfrac{8.64 \times 10^{-4}}{120 \times 10^{-6}} = 7.2$ V **A1**. (The **smaller** capacitor takes the larger share of the p.d.)

(d) Capacitors in parallel add: $C_{\text{total}} = 72 + 220 = 292\ \mu\text{F}$ **M1** **A1**;

Solution 3.5

$Q_{\text{total}} = 292 \times 10^{-6} \times 12 = 3.5 \times 10^{-3}$ C **A1**.
(e) C_3 **B1** — it has the full 12 V across it and the largest capacitance, so $Q = CV$ is largest; the series pair shares the same p.d. between two capacitors and behaves as only 72 μF **B1**.