Exercise walk-through

Capacitors ▪ 10.3

eXercise

You must be able to

- define **capacitance 电容** as $C = \dfrac{Q}{V}$
- use the parallel-plate result $C = \dfrac{\varepsilon_0 A}{d}$
- calculate the **energy stored**, $U = \frac{1}{2}CV^2 = \frac{1}{2}\dfrac{Q^2}{C}$
- combine capacitors in **series and parallel 串联和并联**

Method — Capacitance

$C = \dfrac{Q}{V}$ (farads). For parallel plates, $C = \dfrac{\varepsilon_0 A}{d}$ — larger area or smaller gap gives more capacitance.

Method — Energy stored

$U = \frac{1}{2}CV^2 = \frac{1}{2}\frac{Q^2}{C}$, stored in the field (energy density $u = \frac{1}{2}\varepsilon_0 E^2$).

Method — Combining capacitors

- **Parallel:** $C = C_1 + C_2 + \ldots$
- **Series:** $\dfrac{1}{C} = \dfrac{1}{C_1} + \dfrac{1}{C_2} + \ldots$ (less than the smallest).

Practice 2.1 ▪ 2 marks

A parallel-plate capacitor has area 0.020 m^2 and separation 1.0 mm ($\varepsilon_0 = 8.85 \times 10^{-12}$). Find its capacitance.

Solution 2.1

Method: Capacitance

Worked steps

$$C = \frac{\varepsilon_0 A}{d} = \frac{(8.85 \times 10^{-12})(0.020)}{1.0 \times 10^{-3}} = 1.8 \times 10^{-10}\ \text{F}$$ M1 A1.

Practice 2.2 ▪ 1 mark

Two 4.0 μF capacitors are connected in parallel. Find the total capacitance.

Solution 2.2

Worked steps

$C = 4.0 + 4.0 = 8.0\ \mu\text{F}$ B1.

Practice 2.3 ▪ 2 marks

Find the energy stored in a $10\ \mu$F capacitor at 12 V.

Solution 2.3

Method: Energy stored

Worked steps

$U = \frac{1}{2}CV^2 = \frac{1}{2}(10 \times 10^{-6})(12)^2 = 7.2 \times 10^{-4}$ J M1 A1.

Exam-style 3.1 ▪ 1 mark

The capacitance of a parallel-plate capacitor is

A $\dfrac{\varepsilon_0 d}{A}$

B $\dfrac{\varepsilon_0 A}{d}$

C $\varepsilon_0 A d$

D $\dfrac{A}{\varepsilon_0 d}$

Solution 3.1

Method: Capacitance

A $\frac{\varepsilon_0 d}{A}$

B $\frac{\varepsilon_0 A}{d}$ ✓

C $\varepsilon_0 A d$

D $\frac{A}{\varepsilon_0 d}$

Worked steps

B.

Exam-style 3.2 ▪ 1 mark

Two capacitors in series have a total capacitance that is

A the sum of the two

B less than either one

C the larger of the two

D zero

Solution 3.2

Method: Combining capacitors

A the sum of the two

B less than either one ✓

C the larger of the two

D zero

Worked steps

B.

Exam-style 3.3 ▪ 2 marks

A 5.0 μF capacitor is charged to 100 V.
(a) Find the charge stored.
(b) Find the energy stored.

Solution 3.3

Method: Energy stored

Worked steps

(a) $Q = CV = (5.0 \times 10^{-6})(100) = 5.0 \times 10^{-4}$ C M1 A1. (b) $U = \frac{1}{2}CV^2 = \frac{1}{2}(5.0 \times 10^{-6})(100)^2 = 0.025$ J M1 A1.