

# 10.3 Capacitors

Name: \_\_\_\_\_ Class: \_\_\_\_\_ Date: \_\_\_\_\_

**Total: 11 marks**

## Objective

Build the skills to answer exam questions on **capacitors**.**You must be able to:**

- define **capacitance** 电容 as  $C = \frac{Q}{V}$
- use the parallel-plate result  $C = \frac{\epsilon_0 A}{d}$
- calculate the **energy stored**,  $U = \frac{1}{2}CV^2 = \frac{1}{2}\frac{Q^2}{C}$
- combine capacitors in **series and parallel** 串联和并联

## 1 Worked examples

Study these first. Each one shows the method for a question type used later.

### ■ Capacitance

$C = \frac{Q}{V}$  (farads). For parallel plates,  $C = \frac{\epsilon_0 A}{d}$  —larger area or smaller gap gives more capacitance.

### ■ Energy stored

$U = \frac{1}{2}CV^2 = \frac{1}{2}\frac{Q^2}{C}$ , stored in the field (energy density  $u = \frac{1}{2}\epsilon_0 E^2$ ).

### ■ Combining capacitors

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

## 2 Practice

**2.1** A parallel-plate capacitor has area  $0.020 \text{ m}^2$  and separation  $1.0 \text{ mm}$  ( $\epsilon_0 = 8.85 \times 10^{-12}$ ). Find its capacitance. [2]

**2.2** Two  $4.0 \mu\text{F}$  capacitors are connected in parallel. Find the total capacitance. [1]

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**2.3** Find the energy stored in a  $10 \mu\text{F}$  capacitor at  $12 \text{ V}$ . [2]

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### 3 Exam-style questions

**3.1** The capacitance of a parallel-plate capacitor is [1]

- **A**  $\frac{\epsilon_0 d}{A}$
- **B**  $\frac{\epsilon_0 A}{d}$
- **C**  $\epsilon_0 A d$
- **D**  $\frac{A}{\epsilon_0 d}$

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**3.2** Two capacitors in series have a total capacitance that is [1]

- **A** the sum of the two
- **B** less than either one
- **C** the larger of the two
- **D** zero

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**3.3** A  $5.0 \mu\text{F}$  capacitor is charged to  $100 \text{ V}$ .

(a) Find the charge stored. [2]

(b) Find the energy stored. [2]

## 4 Go further

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- work through the **10.3 Capacitors** lesson on the **Learn** page;
- read the **Conductors and Capacitors** section of the AP Physics C: E&M handout on the **Know** page.

## Solutions

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$$\mathbf{2.1} \quad C = \frac{\epsilon_0 A}{d} = \frac{(8.85 \times 10^{-12})(0.020)}{1.0 \times 10^{-3}} = 1.8 \times 10^{-10} \text{ F.}$$

$$\mathbf{2.2} \quad C = 4.0 + 4.0 = 8.0 \text{ } \mu\text{F.}$$

$$\mathbf{2.3} \quad U = \frac{1}{2}CV^2 = \frac{1}{2}(10 \times 10^{-6})(12)^2 = 7.2 \times 10^{-4} \text{ J.}$$

**3.1 B.**

**3.2 B.**

$$\mathbf{3.3} \quad \text{(a) } Q = CV = (5.0 \times 10^{-6})(100) = 5.0 \times 10^{-4} \text{ C.} \quad \text{(b) } U = \frac{1}{2}CV^2 = \frac{1}{2}(5.0 \times 10^{-6})(100)^2 = 0.025 \text{ J.}$$