8.6 Gauss's Law

Name: _____ Class: _____ Date: _____ **Total: 10 marks**

Objective

Build the skills to answer exam questions on **Gauss's law**.

You must be able to:

- state **Gauss's law** 高斯定律, $\oint \vec{E} \cdot d\vec{A} = \dfrac{Q_{\text{enc}}}{\varepsilon_0}$
- choose a **Gaussian surface** 高斯面 whose symmetry makes $\vec{E}$ constant and perpendicular
- apply Gauss's law to spherical, cylindrical, and planar distributions
- explain why $\vec{E} = 0$ inside a conductor in electrostatic equilibrium

1 Worked examples

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

Gauss's law

$\oint \vec{E} \cdot d\vec{A} = \dfrac{Q_{\text{enc}}}{\varepsilon_0}$: the net flux through a closed surface equals the enclosed charge divided by ε_0.

Choose the symmetry

Pick a Gaussian surface (sphere, cylinder, box) on which E is constant and either perpendicular or parallel to the surface, so the integral becomes $E \times A$.

A point charge

For a sphere of radius r around charge q: $E(4\pi r^2) = \dfrac{q}{\varepsilon_0}$, giving $E = \dfrac{kq}{r^2}$. Inside a conductor at equilibrium, no charge is enclosed, so $E = 0$.

2 Practice

2.1 State Gauss's law. [1]

2.2 State the electric field inside a conductor in electrostatic equilibrium. [1]

2.3 A charge of 5.0×10^{-9} C is enclosed by a closed surface ($\varepsilon_0 = 8.85 \times 10^{-12}$). Find the flux through it. [2]

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3 Exam-style questions

3.1 Gauss's law relates the flux through a closed surface to the [1]

- **A** total field everywhere
- **B** charge enclosed
- **C** surface area
- **D** current

3.2 Inside a charged conducting sphere in equilibrium, the electric field is [1]

- **A** kq/r^2
- **B** zero
- **C** at its maximum
- **D** infinite

3.3 A point charge $+8.0 \times 10^{-9}$ C sits at the centre of a spherical surface of radius 0.20 m ($\varepsilon_0 = 8.85 \times 10^{-12}$, $k = 8.99 \times 10^9$).

(a) Find the flux through the sphere. [2]

(b) Find the field at the surface. [2]

4 Go further

- work through the **8.6 Gauss's Law** lesson on the **Learn** page;
- read the **Electrostatics** section of the AP Physics C: E&M handout on the **Know** page.

Solutions

2.1 the net electric flux through a closed surface equals the enclosed charge divided by ε_0.

2.2 zero.

2.3 $\Phi_E = \dfrac{Q_{\text{enc}}}{\varepsilon_0} = \dfrac{5.0 \times 10^{-9}}{8.85 \times 10^{-12}} = 565 \text{ N m}^2 \text{ C}^{-1}$.

3.1 **B**.

3.2 **B**.

3.3 (a) $\Phi_E = \dfrac{Q}{\varepsilon_0} = \dfrac{8.0 \times 10^{-9}}{8.85 \times 10^{-12}} = 904 \text{ N m}^2 \text{ C}^{-1}$. (b) $E = \dfrac{kq}{r^2} = \dfrac{8.99 \times 10^9 \times 8.0 \times 10^{-9}}{(0.20)^2} = 1.8 \times 10^3 \text{ N C}^{-1}$.