

Exercise walk-through

# 8.6

## Gauss's Law

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AP Physics C: Electricity and Magnetism

# Gauss's law

One of Maxwell's equations – flux out of a closed surface reveals the charge inside:

## Gauss's law

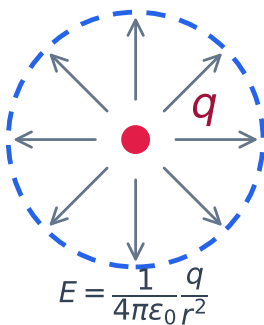
$$\oint \vec{E} \cdot d\vec{A} = \frac{q_{enc}}{\epsilon_0}$$

Choose a **Gaussian surface** the integral.

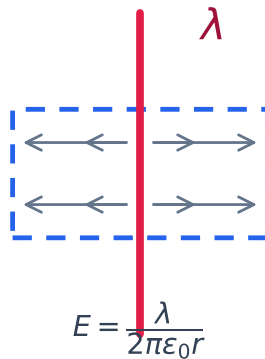
matching the **symmetry** so  $E$  comes out of

# Gauss's law, in detail

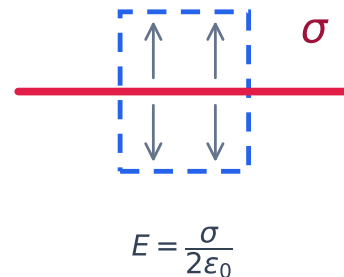
Spherical  
(point / sphere)



Cylindrical  
(line / cylinder)



Planar  
(sheet / pillbox)



$$\text{Gauss: } \oint \mathbf{E} \cdot d\mathbf{A} = Q_{\text{enc}}/\epsilon_0$$

*Sphere, cylinder, or pillbox – matched to the symmetry.*

A Gaussian surface is chosen to match the symmetry of the charge

# A full-credit Gauss's-law answer has four parts

## 1. name the surface

say which **Gaussian surface**  
sits

you chose and where it

## 2. state the symmetry

why  $E$  is **constant** on it and **perpendicular** to it – the **area vector**  
 $d\vec{A}$  points along the outward normal

## 3. compute the flux

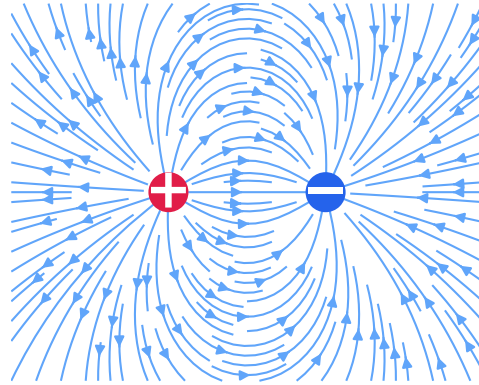
$\Phi_E = \oint \vec{E} \cdot d\vec{A} = EA$ , with  $A$  the surface's own area

## 4. equate and solve

$EA = \frac{Q_{\text{enc}}}{\epsilon_0}$ , then say clearly *which* charge is enclosed

Three symmetries qualify and no others: **spherical**, **cylindrical** and **planar**.  
Anything else needs integration.

# Electric Fields

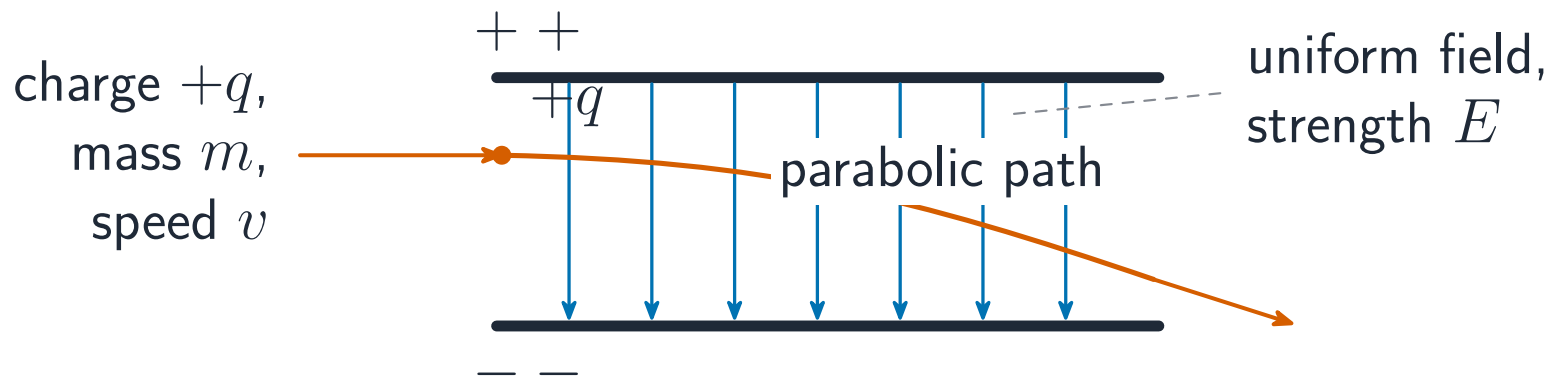


$$\vec{p} = q\vec{d} \cdot \text{lines leave } + \text{ enter } - \cdot$$

denser  $\Leftrightarrow$  stronger  $|\vec{E}|$

Electric field lines of a dipole point from the positive to the negative charge

## Electric Fields, continued



A charge crossing a uniform field follows a parabolic path

## Exercises 2.1-2.3

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**2.1** State Gauss's law.

[1]

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**2.2** State the electric field inside a conductor in electrostatic equilibrium.

[1]

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**2.3** A charge of  $5.0 \times 10^{-9}$  C is enclosed by a closed surface ( $\epsilon_0 = 8.85 \times 10^{-12}$ ). Find the flux through it.

[2]

## Exercises 2.1-2.3

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**2.1** State Gauss's law. [1]

**2.1**

- the net electric flux through a closed surface equals the enclosed charge divided by  $\epsilon_0$
- 

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

**2.2**

- zero
- 

**2.3** A charge of  $5.0 \times 10^{-9}$  C is enclosed by a closed surface ( $\epsilon_0 = 8.85 \times 10^{-12}$ ). Find the flux through it. [2]

**2.3**

- $\Phi_E = \frac{Q_{\text{enc}}}{\epsilon_0} = \frac{5.0 \times 10^{-9}}{8.85 \times 10^{-12}} = 565 \text{ N m}^2 \text{ C}^{-1}$

## Exercises 3.1-3.2

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**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

☐

**A**  $kq/r^2$

**B** zero

**C** at its maximum

**D** infinite

---

**3.2** Inside a charged conducting sphere in equilibrium, the electric field is

[1]

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**3.1 B**

- charge enclosed.

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**B** zero

**C** at its maximum

**D** infinite

**3.2 B**

- zero.

## Exercise 3.3 (a)

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**3.3** A point charge  $+8.0 \times 10^{-9}$  C sits at the centre of a spherical surface of radius 0.20 m ( $\epsilon_0 = 8.85 \times 10^{-12}$ ,  $k = 8.99 \times 10^9$ ).

(a) Find the flux through the sphere.

[2]

## Exercise 3.3 (a)

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**3.3** A point charge  $+8.0 \times 10^{-9} \text{ C}$  sits at the centre of a spherical surface of radius  $0.20 \text{ m}$  ( $\epsilon_0 = 8.85 \times 10^{-12}$ ,  $k = 8.99 \times 10^9$ ).

(a) Find the flux through the sphere.

[2]

(a)

- $$\Phi_E = \frac{Q}{\epsilon_0} = \frac{8.0 \times 10^{-9}}{8.85 \times 10^{-12}} = 904 \text{ N m}^2 \text{ C}^{-1}$$

## Exercise 3.3 (b)

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**3.3** A point charge  $+8.0 \times 10^{-9}$  C sits at the centre of a spherical surface of radius 0.20 m ( $\epsilon_0 = 8.85 \times 10^{-12}$ ,  $k = 8.99 \times 10^9$ ).

(b) Find the field at the surface.

[2]

## Exercise 3.3 (b)

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**3.3** A point charge  $+8.0 \times 10^{-9}$  C sits at the centre of a spherical surface of radius 0.20 m ( $\epsilon_0 = 8.85 \times 10^{-12}$ ,  $k = 8.99 \times 10^9$ ).

(b) Find the field at the surface.

[2]

(b)

- $$E = \frac{kq}{r^2} = \frac{8.99 \times 10^9 \times 8.0 \times 10^{-9}}{(0.20)^2} = 1.8 \times 10^3 \text{ N C}^{-1}$$