

Exercise walk-through

8.5

Electric Flux

AP Physics C: Electricity and Magnetism

Electric flux

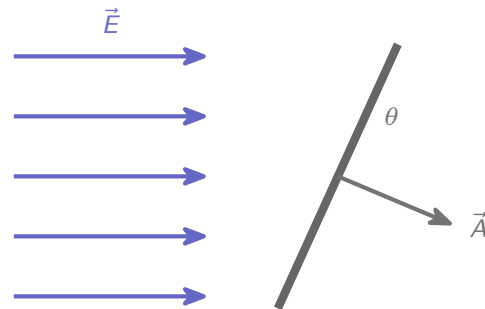
Electric flux counts the field lines through a surface:

Uniform, then general

$$\Phi_E = \vec{E} \cdot \vec{A} = EA \cos \theta$$

$$\Phi_E = \oint \vec{E} \cdot d\vec{A}$$

Largest when $\vec{E} \perp$ the surface ($\theta = 0$); zero when parallel.



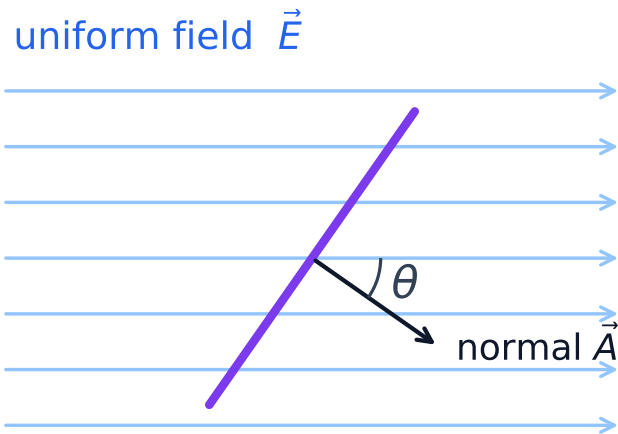
Worked example – the field on a ring's axis

**A ring of radius R carries total charge Q .
Find E at a point a distance z along its axis.**

- every element is the same distance $\sqrt{R^2 + z^2}$ away
- the perpendicular components **cancel** by symmetry; only the axial part survives
- $\cos \theta = \frac{z}{\sqrt{R^2 + z^2}}$, so $E = \frac{kQz}{(R^2 + z^2)^{3/2}}$

Check the limits: at $z = 0$, $E = 0$ (the centre); for $z \gg R$ it becomes kQ/z^2 , the point charge again.
State the cancellation – that sentence is the mark.

Electric flux through a surface depends on



$$\Phi_E = \vec{E} \cdot \vec{A} = EA \cos \theta \quad \cdot \quad \text{max when } \vec{E} \parallel \vec{A}$$

Electric flux through a surface depends on the angle between the field and the surface normal

Exercises 2.1-2.3

2.1 Find the flux through a 0.20 m^2 flat surface placed face-on to a uniform 500 N C^{-1} field. [2]

2.2 State when the flux through a flat surface is zero, relative to the field. [1]

2.3 State what the net flux through a closed surface depends on. [1]

Exercises 2.1-2.3

2.1 Find the flux through a 0.20 m^2 flat surface placed face-on to a uniform 500 N C^{-1} field. [2]

2.1

- $\Phi_E = EA = 500 \times 0.20 = 100 \text{ N m}^2 \text{ C}^{-1}$

2.2 State when the flux through a flat surface is zero, relative to the field. [1]

2.2

- when the field is parallel to the surface (perpendicular to its normal)

2.3 State what the net flux through a closed surface depends on. [1]

2.3

- the net charge enclosed by the surface

Exercises 3.1-3.2

3.1 The electric flux through a flat surface in a uniform field is

[1]

☐

A EA

B $EA \cos \theta$

C E/A

D EA^2

3.2 The flux through a surface is zero when the field is

[1]

☐

A perpendicular to the surface

B parallel to the surface (grazing it)

C very strong

D uniform

Exercises 3.1-3.2

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[1]

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3.1 B

- $EA \cos \theta$.

3.2 The flux through a surface is zero when the field is

[1]

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A perpendicular to the surface

B parallel to the surface (grazing it)

C very strong

D uniform

3.2 B

- parallel to the surface (grazing it).

Exercise 3.3 (a)

3.3 A uniform field of 300 N C^{-1} passes through a 0.40 m^2 square.

(a) Find the flux when the square faces the field.

[2]

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(a) Find the flux when the square faces the field.

[2]

(a)

- $\Phi_E = EA = 300 \times 0.40 = 120 \text{ N m}^2 \text{ C}^{-1}$

Exercise 3.3 (b)

3.3 A uniform field of 300 N C^{-1} passes through a 0.40 m^2 square.

(b) Find the flux when the square is tilted so its normal is 60° from the field. [2]

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(b) Find the flux when the square is tilted so its normal is 60° from the field. [2]

(b)

- $\Phi_E = EA \cos 60^\circ = 120 \times 0.5 = 60 \text{ N m}^2 \text{ C}^{-1}$