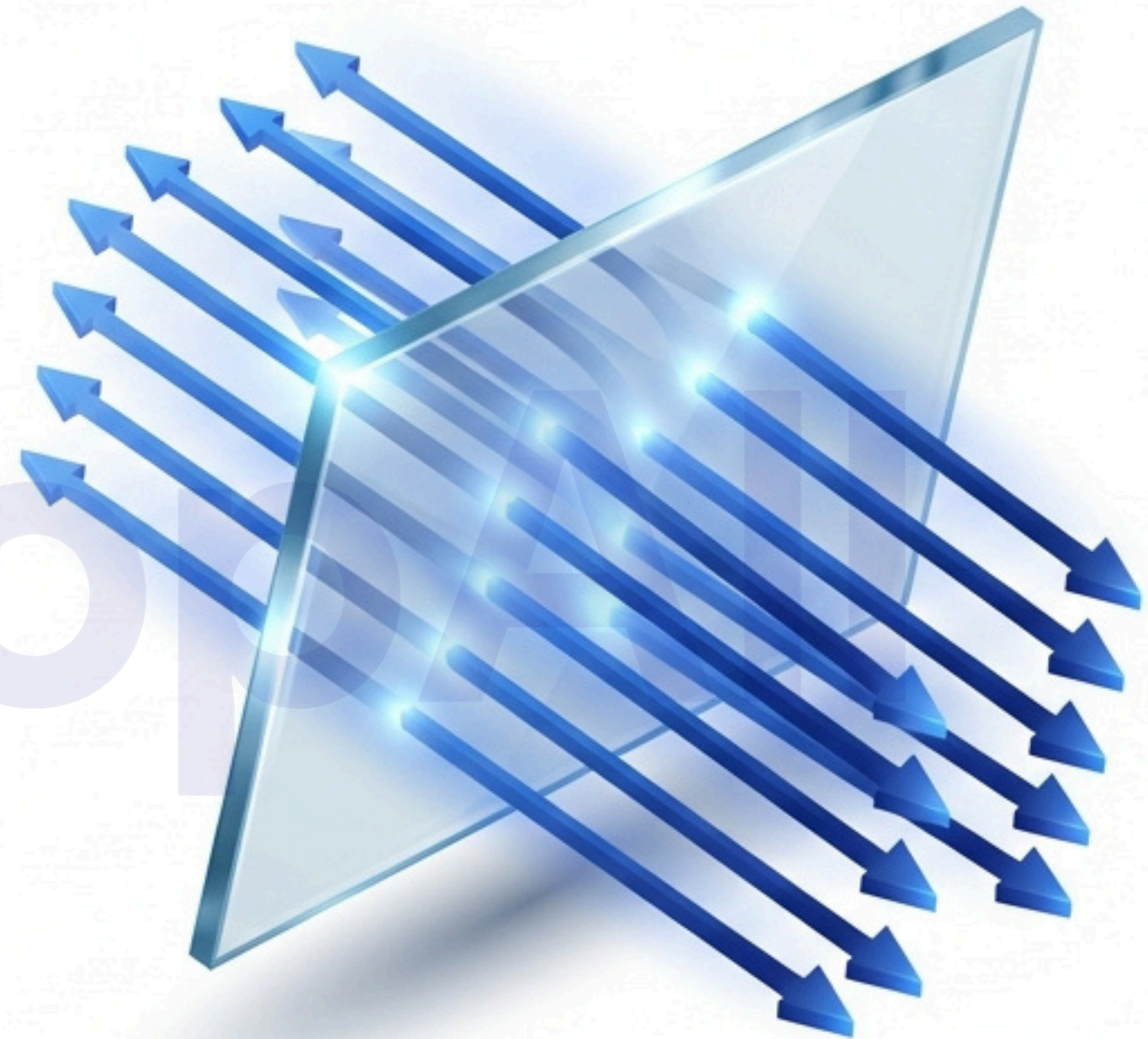


Electric Flux (Φ_E)

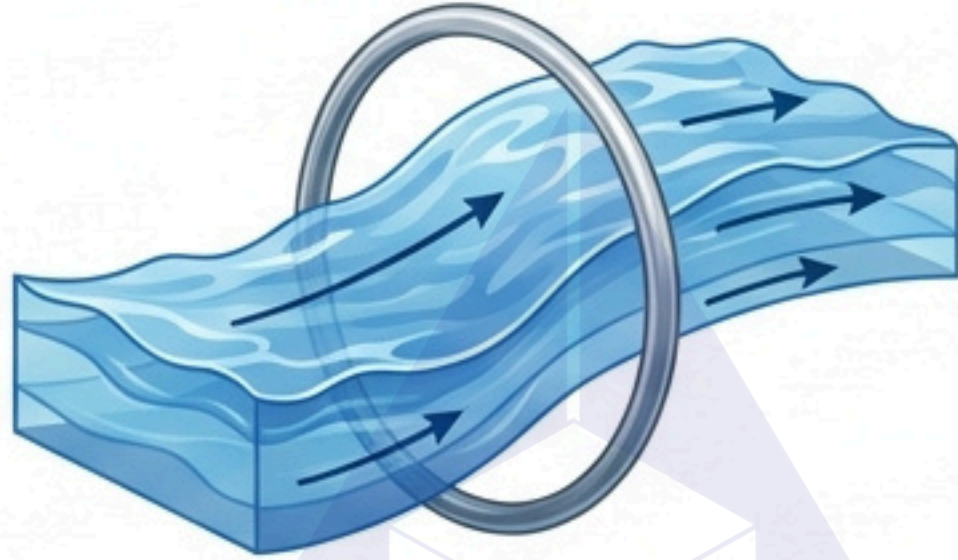
Measuring how much **electric field** passes through a given surface.

Flux is the mathematical bridge between invisible electric fields and the geometry of the physical world.

↓ ↓
Swipe/Scroll to begin



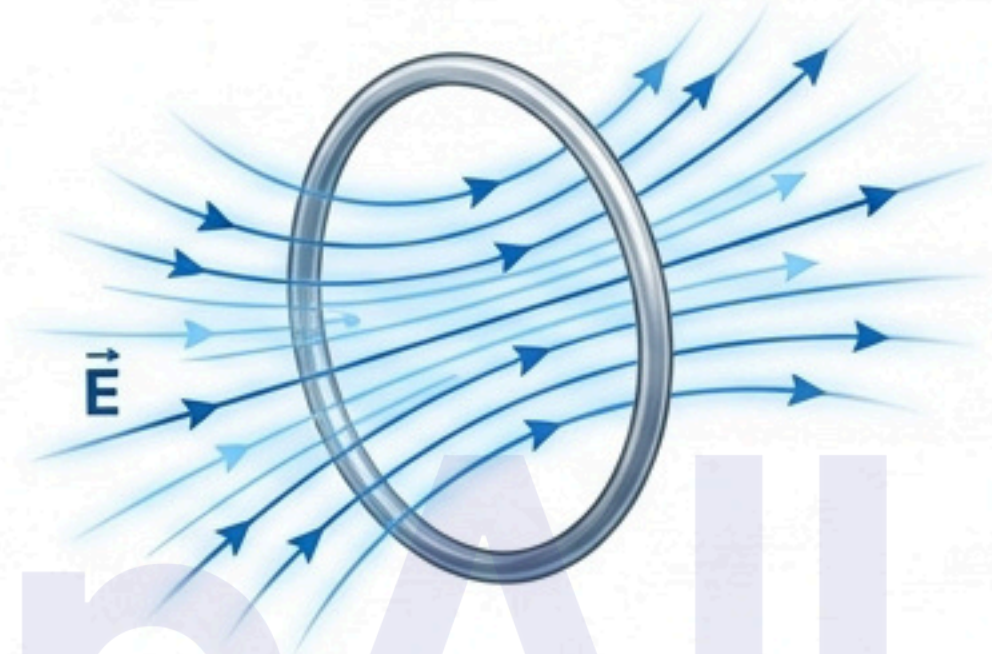
The Fluid Flow Analogy



Water Flow

The volume of water crossing a ring depends on the water's velocity (v) and the ring's area (S).

Physical Matter Flowing



Electric Flux

There is no physical matter flowing. Instead, we measure the relative "number of field lines" crossing an area (S) in an electric field.

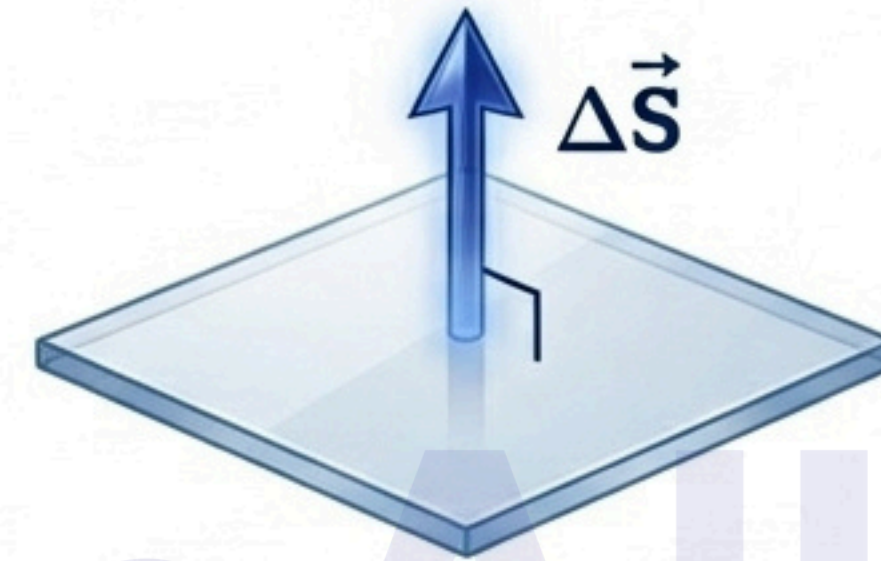
Mathematical Abstraction

Electric Flux $\propto$ Number of field lines crossing the area.

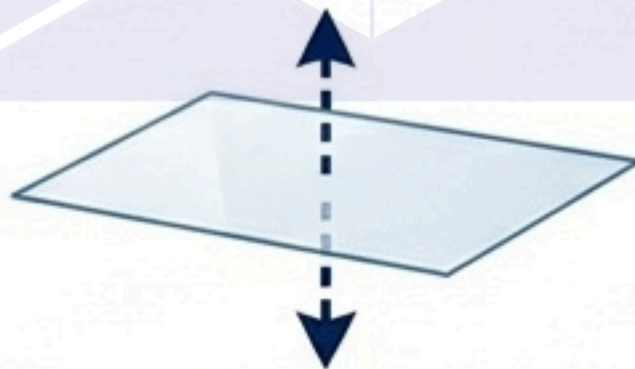
Redefining Area: The Area Vector ($\Delta\vec{S}$)

To calculate flux, area must have a direction.
The direction of a planar area vector is strictly along its normal (perpendicular).

$$\Delta\vec{S} = \Delta S \hat{n} \text{ (Magnitude} \times \text{Direction)}$$

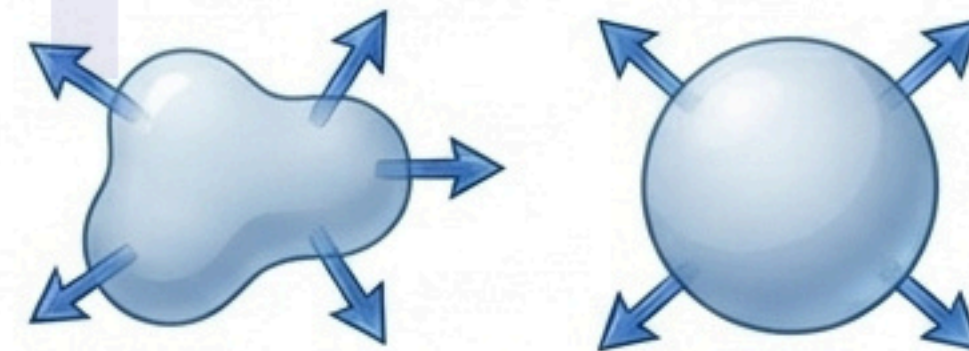


Open Surface



Normal can be either side

Closed Surface



Normal always points outward



Convention Alert! For any closed surface (like a sphere or cube), the area vector $\Delta\hat{S}$ always points in the direction of the outward normal.



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$$E=mc^2$$



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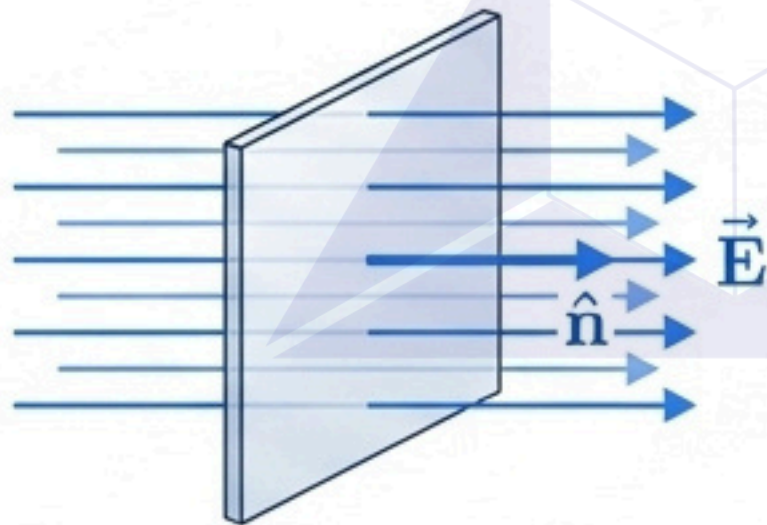


The Role of Orientation (θ)

$$\Delta\Phi = \mathbf{E} \cdot \Delta\mathbf{S} = E \Delta S \cos\theta$$

(where θ is the angle between $\hat{\mathbf{E}}$ and normal $\hat{\mathbf{n}}$)

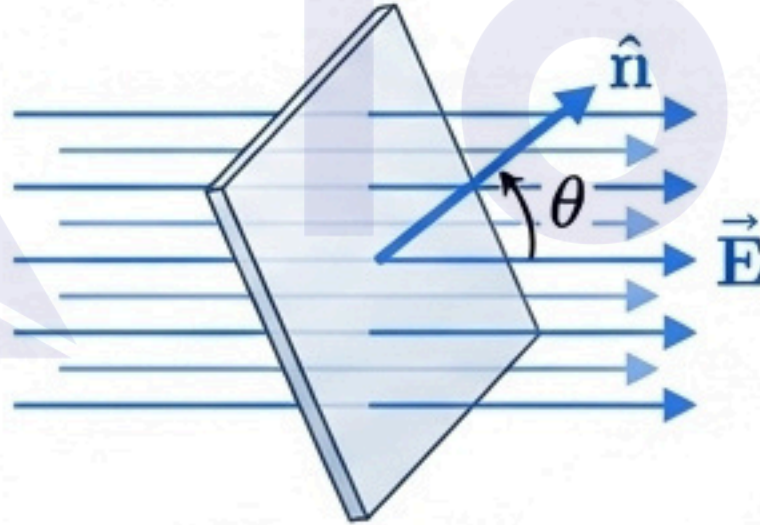
Maximum Flux



$$\theta = 0^\circ \rightarrow \cos(0) = 1$$

$$\Delta\Phi = E \Delta S$$

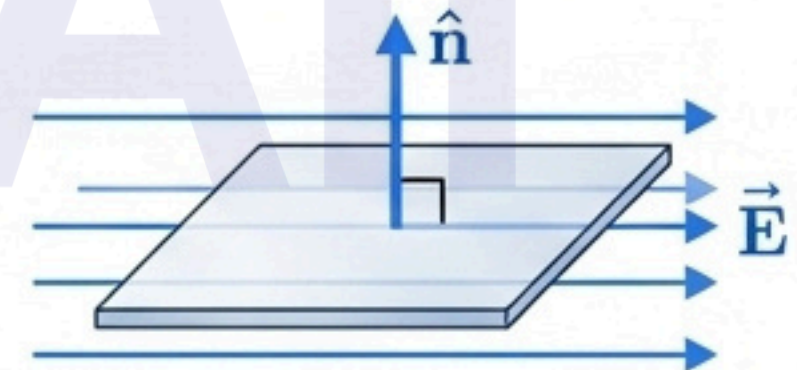
Partial Flux



θ is acute ($0^\circ < \theta < 90^\circ$).

$$\Delta\Phi = E \Delta S \cos\theta$$

Zero Flux

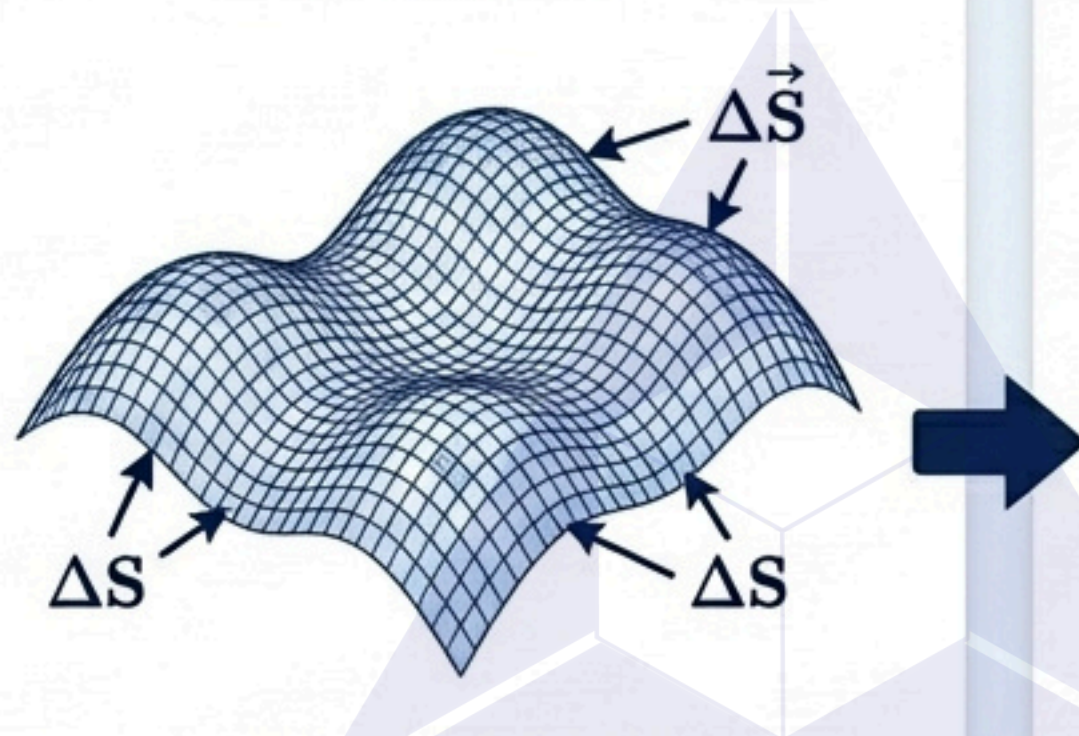


$$\theta = 90^\circ \rightarrow \cos(90) = 0$$

$$\Delta\Phi = 0$$

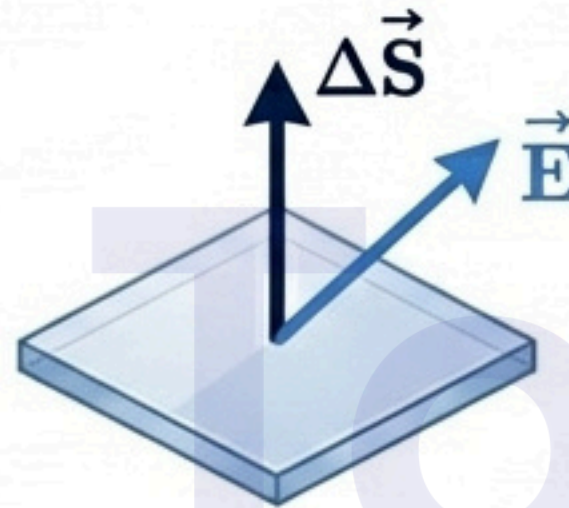
Calculating Flux for Any Surface

1. Divide



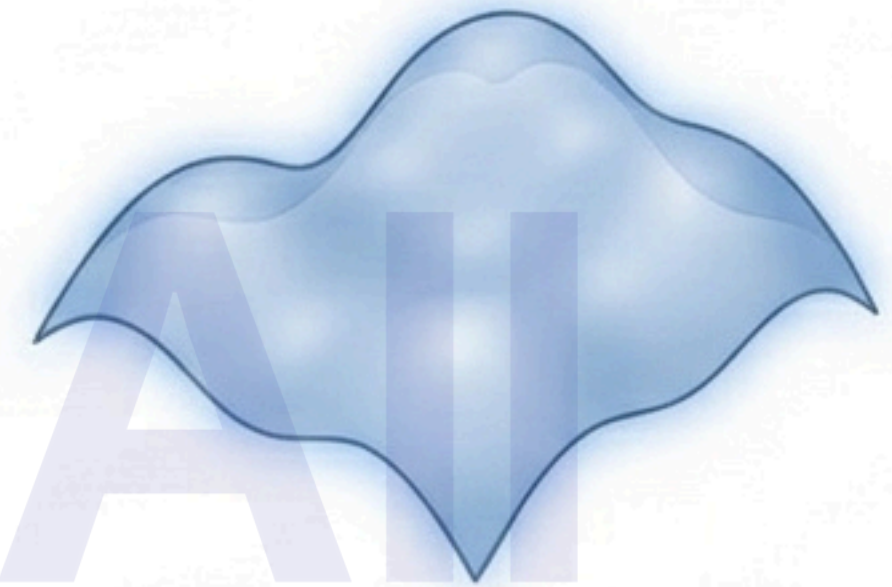
Break the entire surface into macroscopically small, flat planar elements (ΔS).

2. Calculate



Find the flux for just one small element:
 $\Delta \Phi = \vec{E} \cdot \Delta \vec{S}$.

3. Integrate



Sum them all up over the entire surface taking the limit $\Delta S \rightarrow 0$.

$$\Phi \simeq \sum \vec{E} \cdot \Delta \vec{S} \xrightarrow{\text{(limit)}} \Phi = \int \vec{E} \cdot d\vec{S}$$

SI Unit: $\text{N} \cdot \text{m}^2/\text{C}$

Core Summary

- ✓ **Flux** is the dot product of Electric Field and Area Vector: $\Phi = \mathbf{E} \cdot \mathbf{A}$.
- ✓ The Area Vector (ΔS) always points normal (perpendicular) to the surface.
- ✓ For closed 3D surfaces, the normal must point **outward**.

Exam Practice

Q: A circular ring is placed parallel to a uniform electric field. What is the flux?

Ans: Zero. (If the ring is parallel to the field, its normal is at 90° to the field. $\cos(90^\circ) = 0$).

Q: If $\mathbf{E}$ is along the $+x$ axis, what is the flux through a square plane lying perfectly flat in the y - z plane?

Ans: Maximum ($\mathbf{E} \cdot \mathbf{A}$). (The normal of the y - z plane points along the x -axis, so $\theta = 0^\circ$).

Next Chapter: 1.10 Electric Dipole →



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