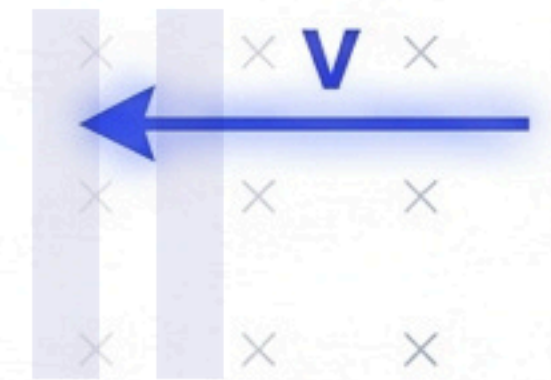


CHAPTER 6 | ELECTROMAGNETIC INDUCTION

6.6 Motional Electromotive Force

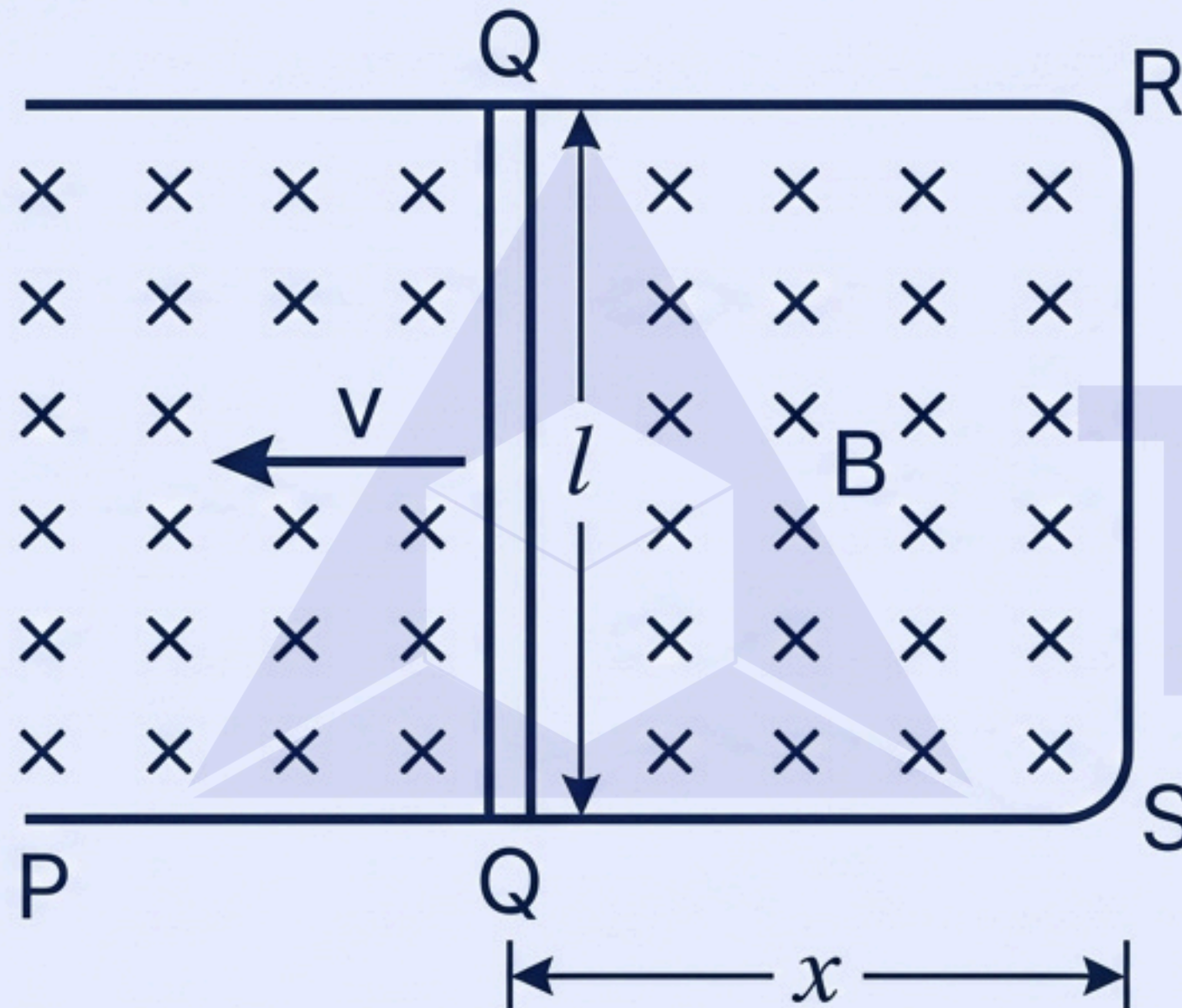
Generating Voltage through Motion
in a Magnetic Field



Master the core NEET/JEE concepts behind **Eq. 6.5** and **Eq. 6.6**.

SYSTEM ANATOMY

A Rod Moving on Conducting Rails



- Imagine a rectangular conducting loop PQRS placed in a uniform, time-independent magnetic field B (perpendicular to the plane).
- The arm PQ (length l) is free to slide.
- We move PQ to the left with a constant velocity v .
- Assumption: Zero friction and no energy loss.

FARADAY'S LAW IN ACTION

How Motion Alters Magnetic Flux

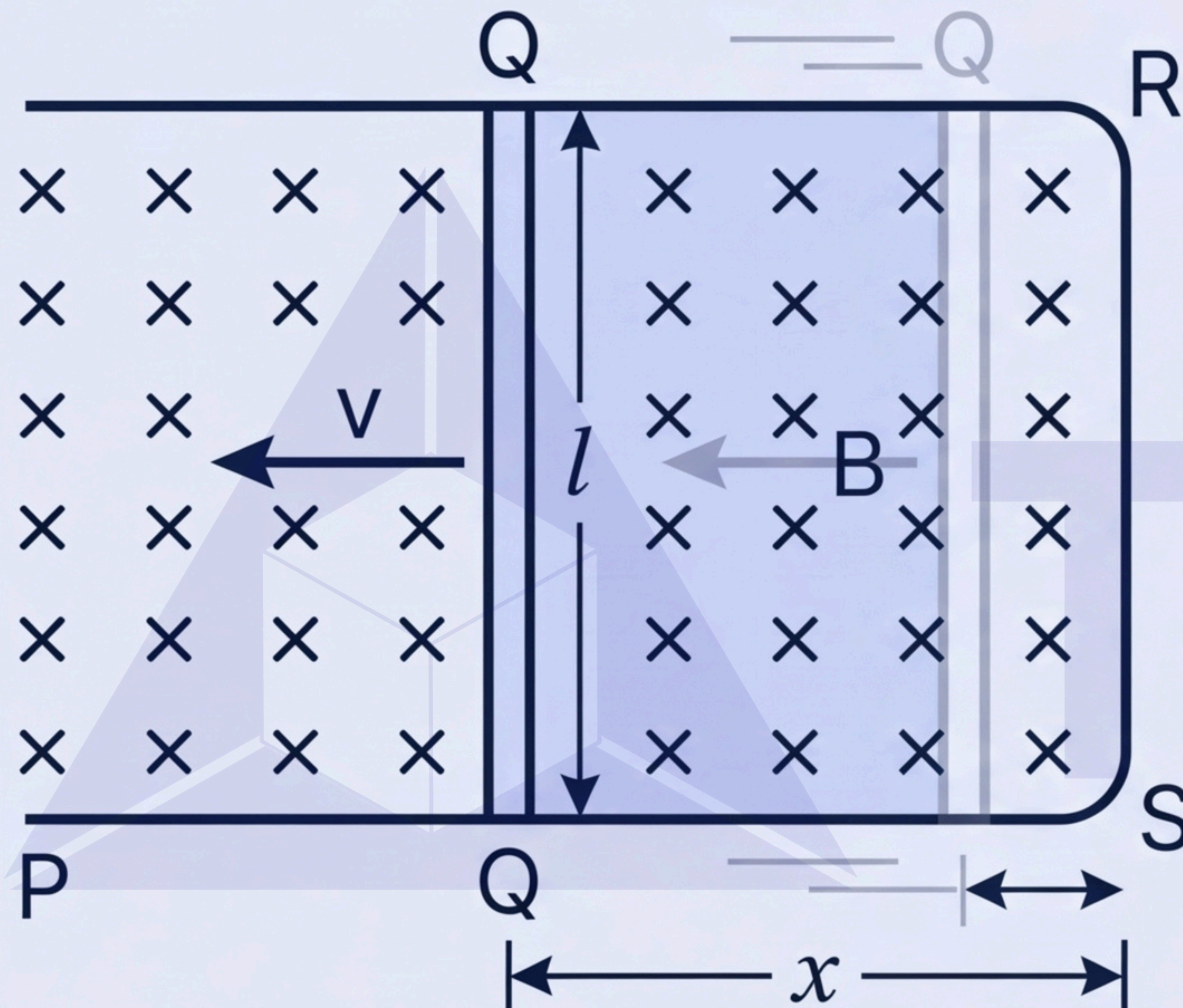
As rod PQ moves, the enclosed area of loop PQRS decreases.

The magnetic flux enclosed is:

$$\Phi_B = B \cdot l \cdot x$$

Because distance x is decreasing over time, the flux Φ_B is constantly changing.

According to Faraday's Law, this rate of change of **flux** induces an **EMF** in the loop!





You've Learned the Theory. Let's Test Them Now.

$$E=mc^2$$



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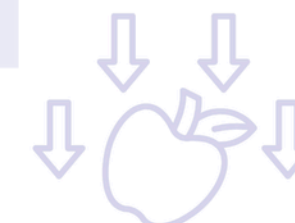
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ESSENTIAL FORMULA | EQ. 6.5

Deriving $\varepsilon = Blv$

Step 1: $\varepsilon = -\frac{d\Phi_B}{dt} = -\frac{d(Blx)}{dt}$

Step 2: $\varepsilon = -Bl \frac{dx}{dt}$

Step 3: Since velocity $v = -\frac{dx}{dt}$ (as x is decreasing):

$$\varepsilon = Blv$$

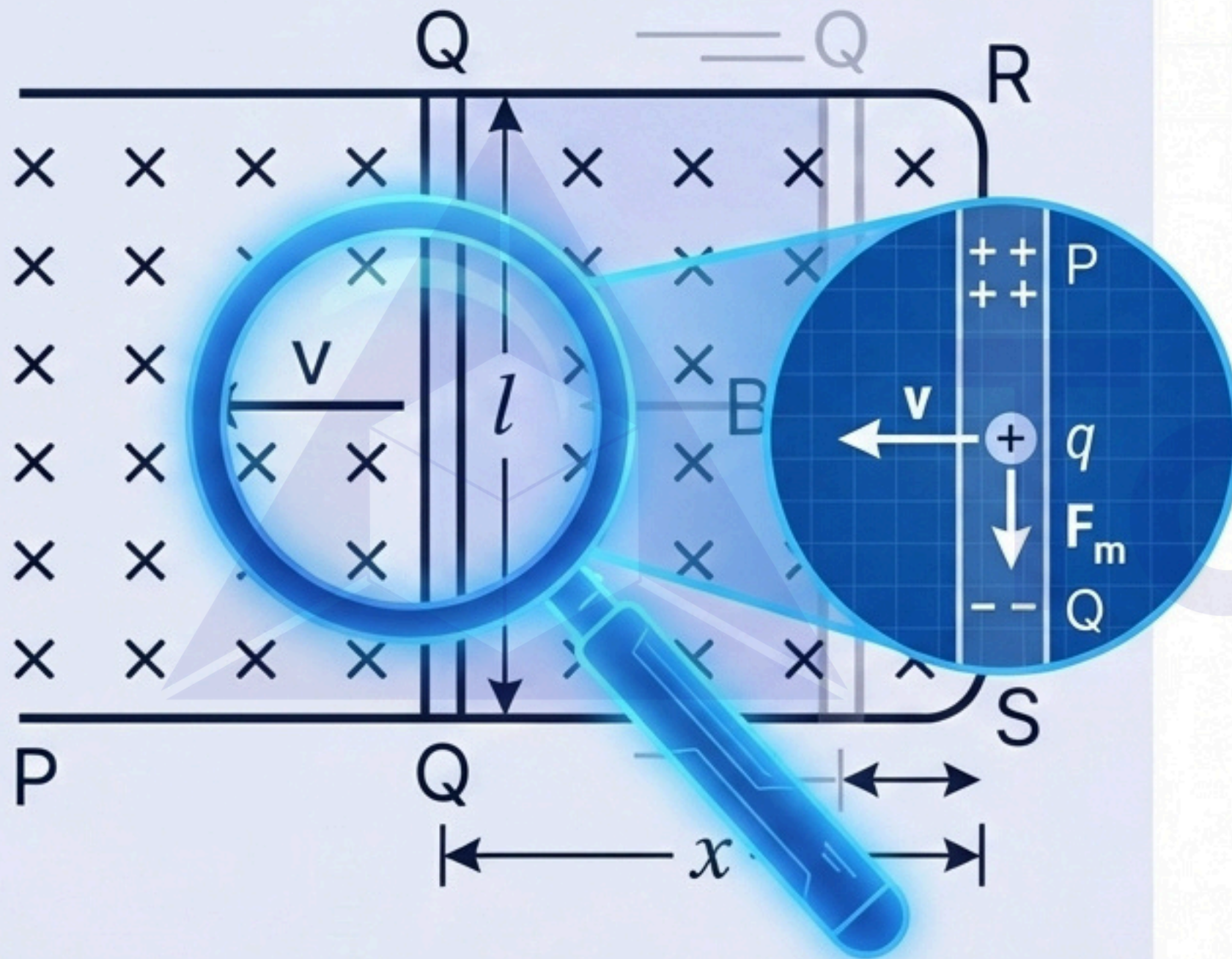
The induced EMF is the product of Magnetic Field (B), Length (l), and Velocity (v).

ALTERNATIVE PROOF

Why Charges Move

- Every free charge q in the moving rod is travelling with speed v through field B .
- It experiences a Lorentz force: $F = qvB$ directed towards Q.
- The work done moving this charge from P to Q is $W = \text{Force} \times \text{distance} = (qvB)l$.
- Since EMF is work done per unit charge ($\epsilon = W/q$):

$$\epsilon = Blv \text{ (Identical result!)}$$



The Symmetry of Nature

Moving Conductor (Motional EMF)

- Rod moves in a static magnetic field.
- Force on charges arises from the Magnetic component ($\mathbf{v} \times \mathbf{B}$).

Stationary Conductor (Farardday's original discovery)

- Rod is stationary in a changing magnetic field.
- Force on charges must arise from an induced Electric field ($\mathbf{E}$).
(Eq. 6.6: $\mathbf{F} = q\mathbf{E}$)

Fundamental Significance: Electricity and magnetism are deeply interconnected.

KEY TAKEAWAYS

Mastery Unlocked

- **Motional EMF** is the voltage induced by moving a conductor through a magnetic field, changing the loop's area.
- The magnitude of this induced EMF is mathematically given by $\epsilon = Blv$.
- This phenomenon can be perfectly explained by both **Faraday's Law** (macro flux change) and the **Lorentz force** (micro charge mechanics).

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