

احجز مكانك واستعد للامتحان بثقة كاملة

$$F = \frac{Gm_1m_2}{r^2}$$

ملزمة العلوم الفصل الثاني

Inspire 8 عام لعام 2026

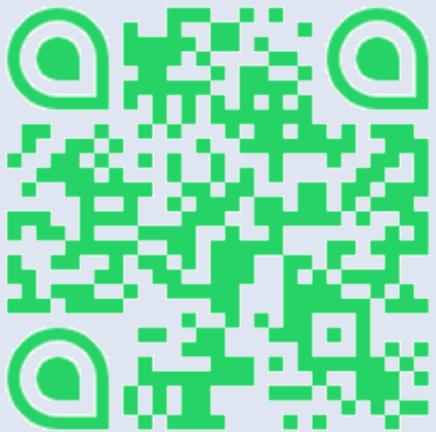
$$EF = ma$$

EF

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تنويه:
تم إنشاء هذه الملزمة لمساعدتك، ولكن المرجع الرئيسي هو الكتاب،
وسيكون هناك ملف إضافي للأمثلة.

NOLOGIA™



للتواصل والحجز



انضم للقناة

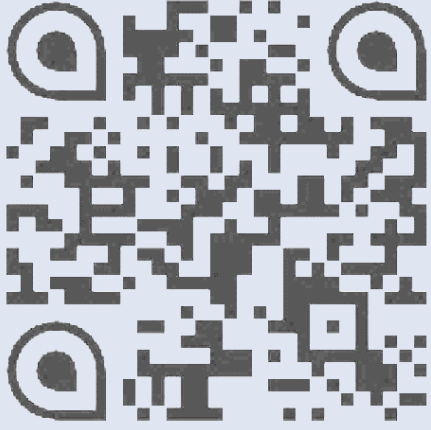
احصل على شرح
الملزمة كاملة
بـ 99
درهم فقط

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Module (1): Forces and Motion

	Lesson Title	Page
1-1	Position and Motion	4
1-2	Force and Acceleration	20
1-3+4	Force Pairs + Gravitational Force	36

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Module (1): Forces and Motion

01

First Lesson: Position and Motion

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Position and Motion

A Comprehensive Guide to Understanding How Things Move

From the high-speed train to a crawling sea turtle, understanding physics starts with two questions: Where are you? and How fast are you going?

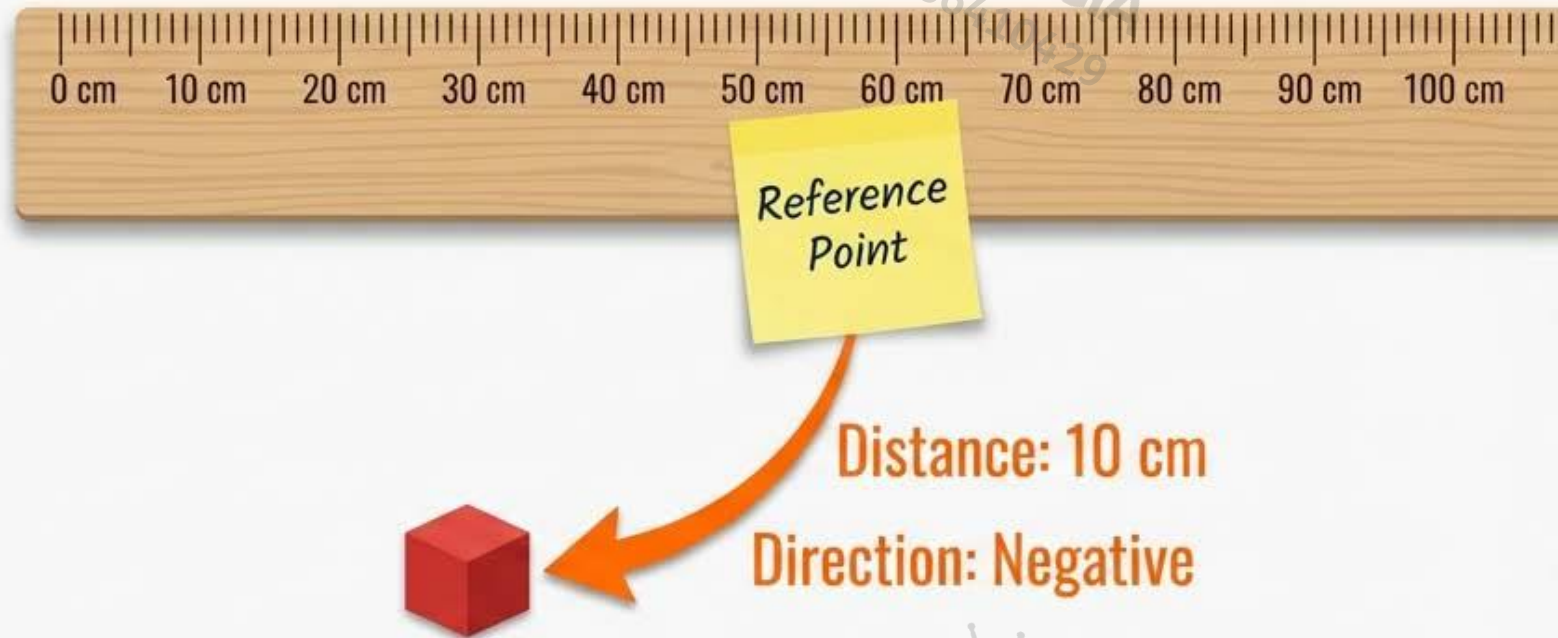
You Cannot Be “Here” Without a “There”

Position

An object's distance and direction from a reference point.

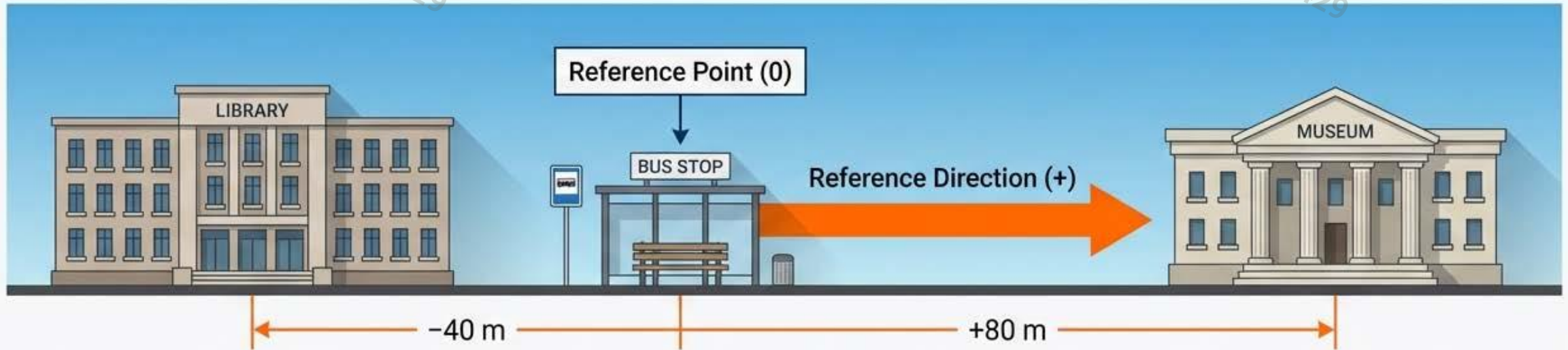
Reference Point

The starting point you choose to describe the location, or position, of an object.



A complete description of your position includes a **distance**, a **direction**, and a **reference point**.

The Reference Direction



Roboto

The reference direction is the positive (+) direction. The opposite is negative (-).

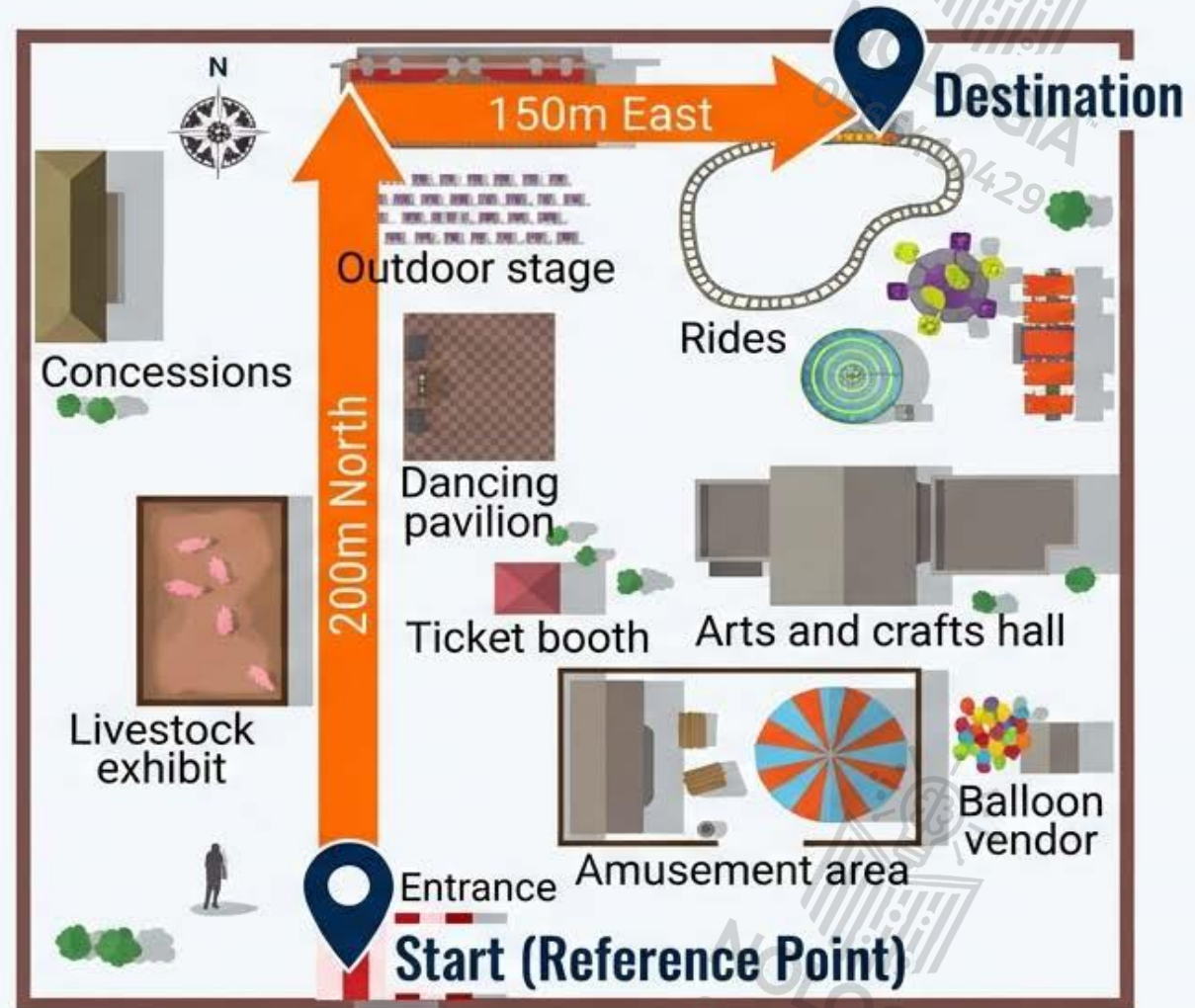
Roboto

The reference direction is arbitrary. You decide which way is positive. Once chosen, everything in the opposite direction becomes negative.

Navigating in Two Dimensions

3-Step Process

1. Choose a reference point.
2. Specify reference directions (North & East).
3. Determine distance along each direction.

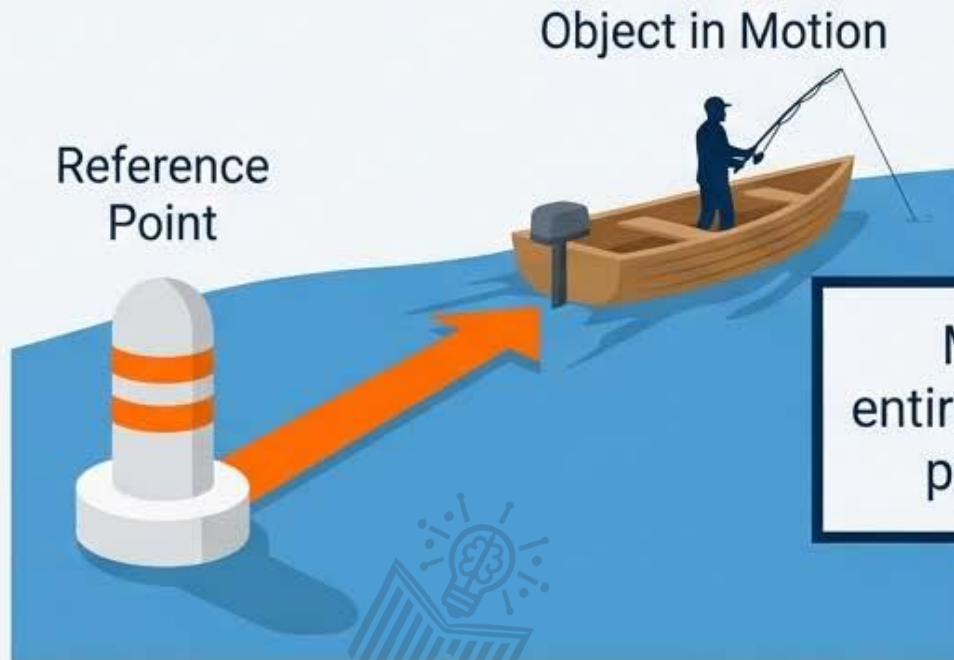


To find the destination: Walk 200m North, then 150m East.

Motion is Relative

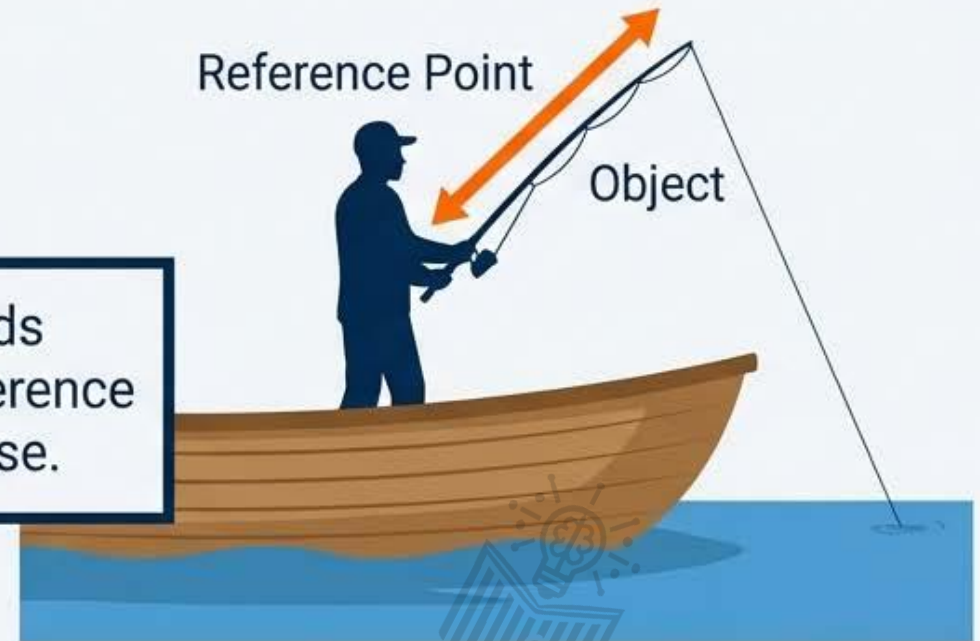
Motion is the process of changing position relative to a reference point.

Panel A



Distance changes relative to the buoy.
Motion occurs.

Panel B



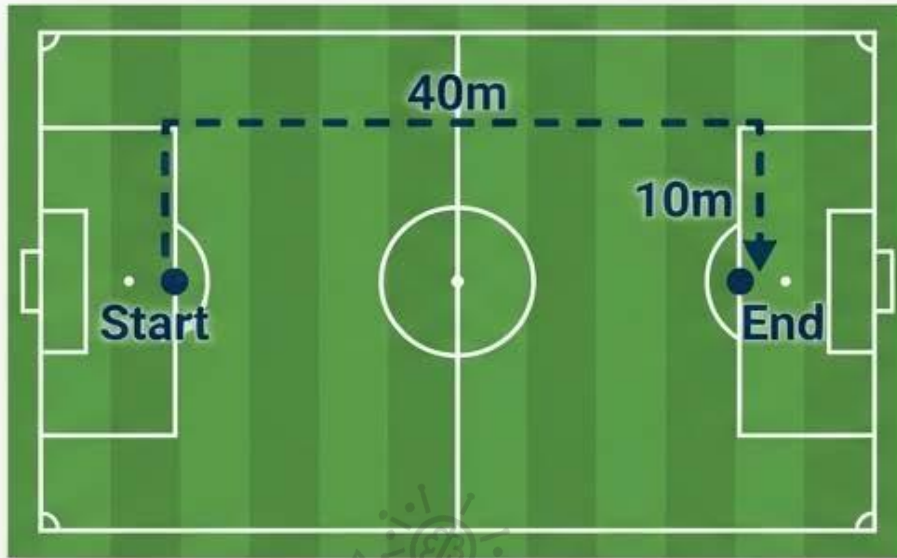
Distance to the pole does not change.
No relative motion.

Motion depends
entirely on the reference
point you choose.

Distance vs. Displacement

Distance

The total length of the path traveled.



Total Distance = 50m

Displacement

The difference between the initial and final position.



Displacement = 30m

Critical Insight:

If you run a full lap and finish where you started, your Distance is 400m, but your Displacement is 0.

Defining Speed

Speed: A measure of the distance an object travels per unit of time.

Units: Meters per second (m/s) or Kilometers per hour (km/h).

1. Constant Speed



Equal distance each second.

2. Changing Speed



Distance increases each second.

Calculating Average Speed

$$\text{Average Speed (v)} = \frac{\text{Total Distance (d)}}{\text{Total Time (t)}}$$

Truck



d = 2,380 km
t = 28 h

Calculation:

$$2380 \div 28 = 85 \text{ km/h}$$

Soccer Ball



d = 34 m
t = 2.0 s

Calculation:

$$34 \div 2.0 = 17 \text{ m/s}$$

Sprinter



d = 100 m
t = 10 s

Calculation:

$$100 \div 10 = 10 \text{ m/s}$$

Velocity: Speed with a Direction

Speed tells you how fast. Velocity tells you how fast AND where.



- **Speed:** Identical (600 km/h).
- **Velocity:** DIFFERENT (Opposite directions).



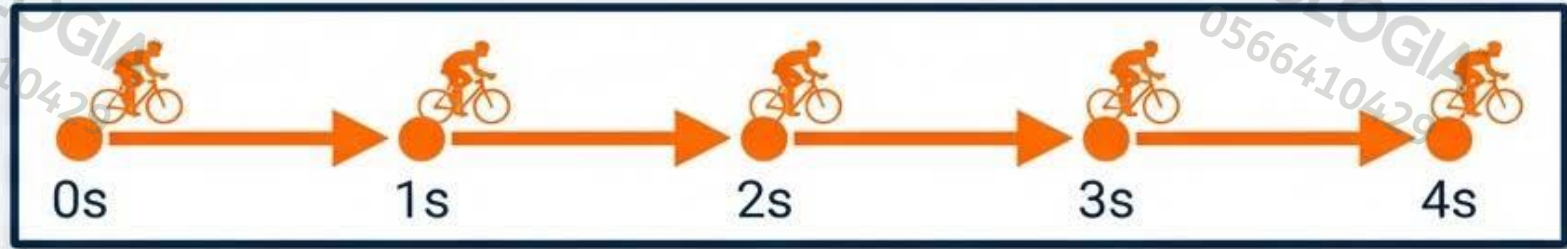
Vectors

The length of the arrow represents the speed (magnitude).

The tip of the arrow indicates the direction.

Visualizing Velocity Changes

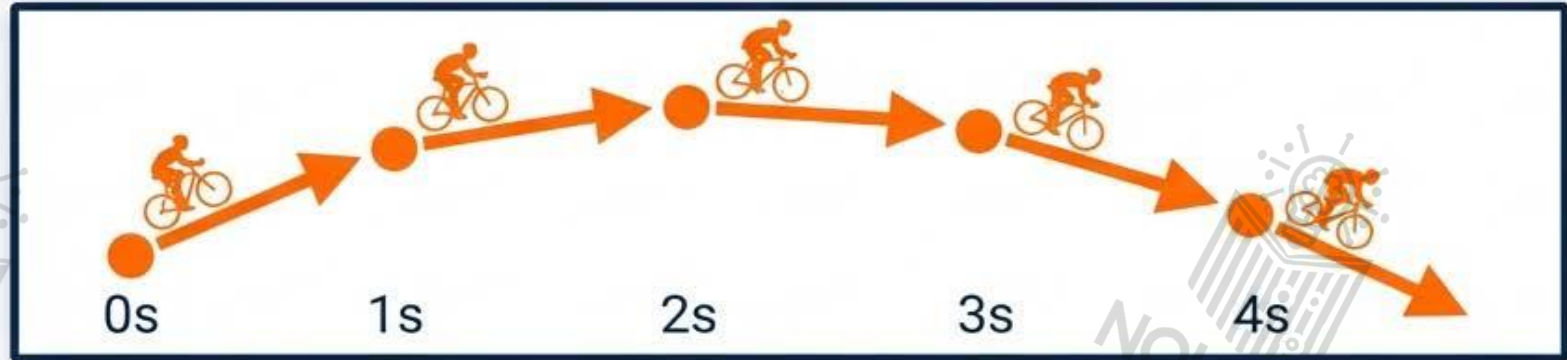
Constant Velocity



Changing Speed



Changing Direction



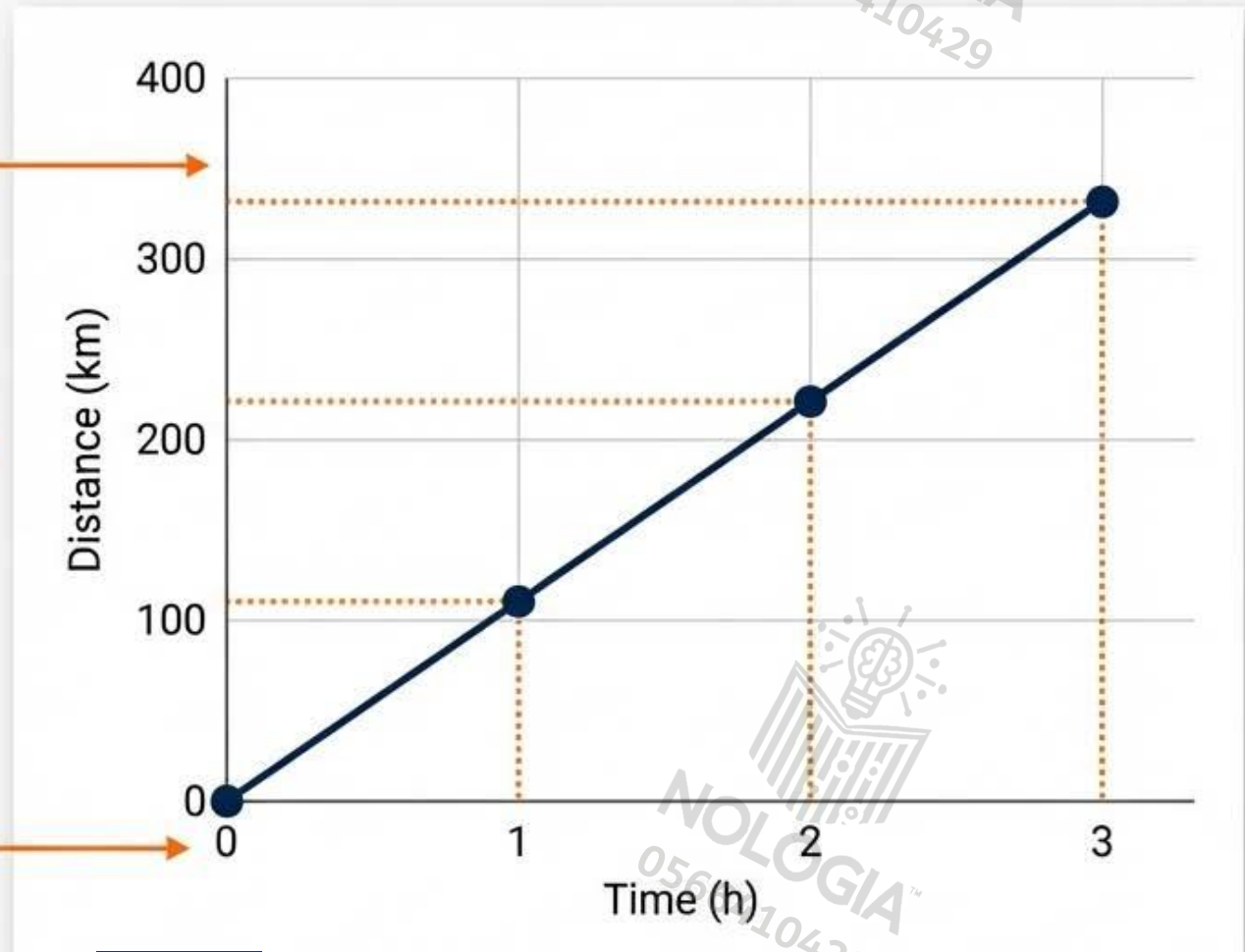
Velocity changes when: 1. Speed changes, 2. Direction changes, or 3. Both change.

Plotting Motion on a Graph

Train Motion Data	
Time (h)	Distance (km)
0	0
1	110
2	220
3	330

Dependent Variable (Y)

Independent Variable (X)



Interpreting Distance-Time Graphs

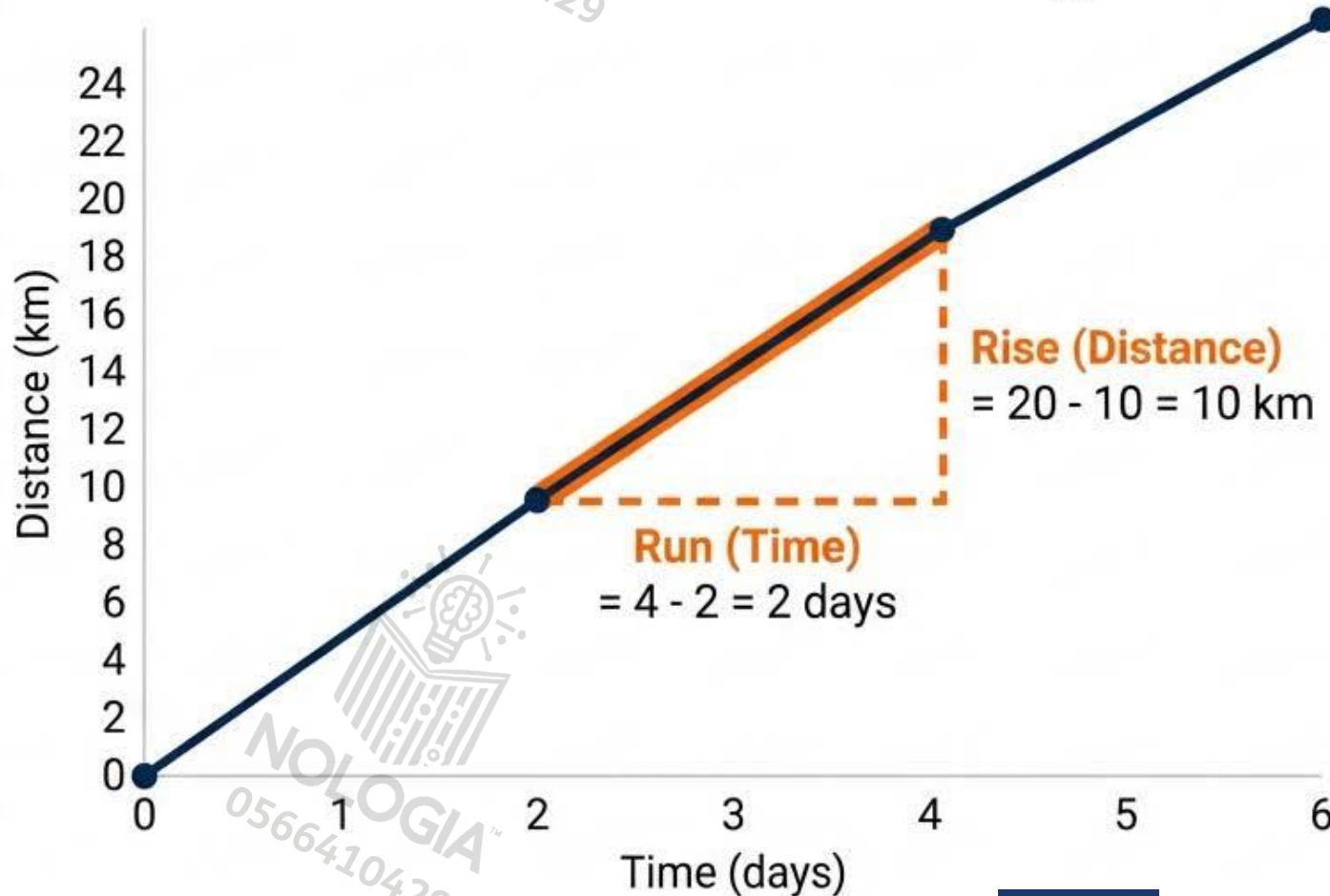
The slope of the line represents the speed.



Steeper = Faster
Flatter = Slower
Horizontal = Stopped

Calculating Speed from a Graph

Hawksbill Sea Turtle Tracking



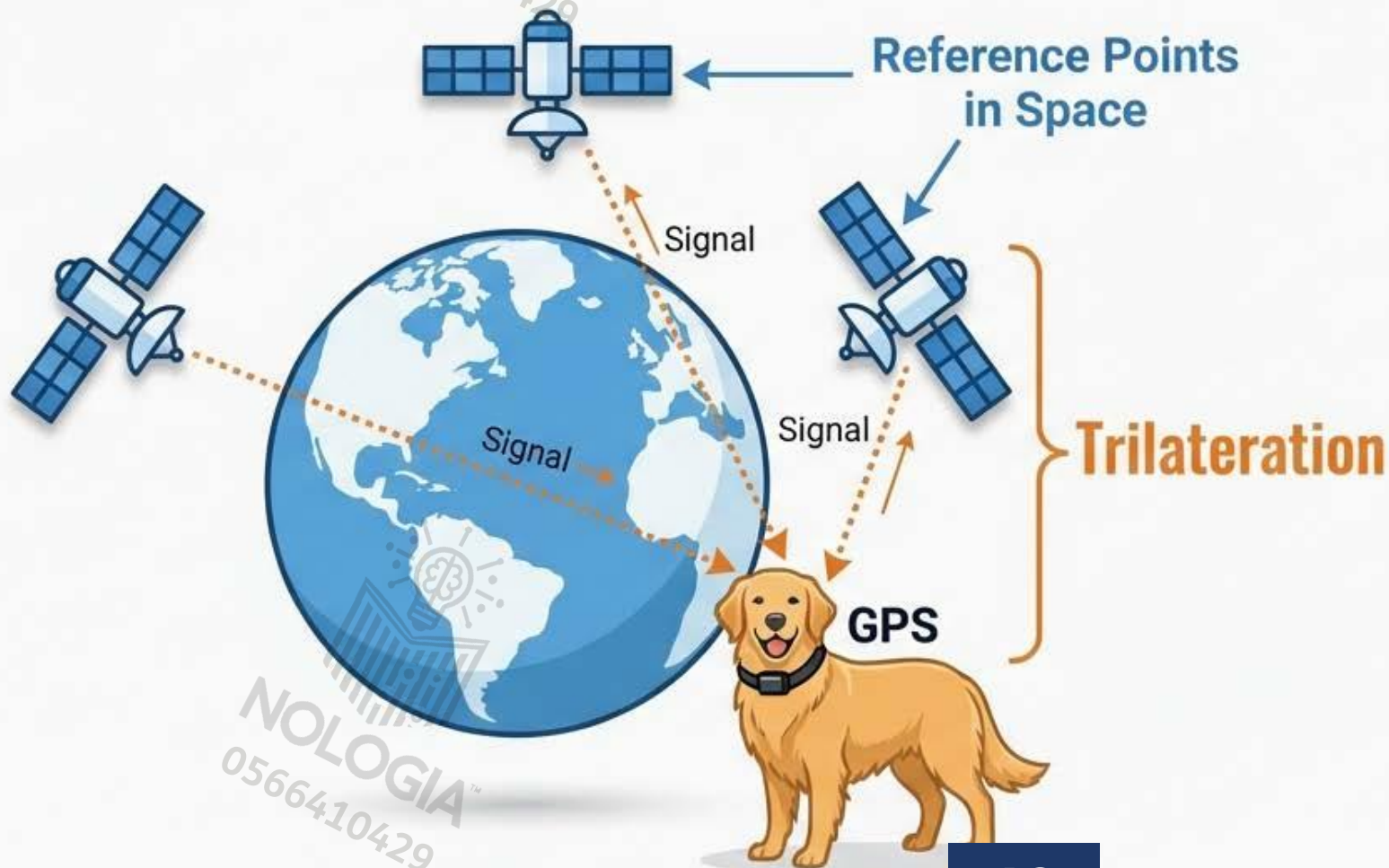
$$\text{Speed} = \frac{\text{Rise}}{\text{Run}}$$

$$\text{Speed} = \frac{10 \text{ km}}{2 \text{ days}}$$

$$\text{Speed} = 5 \text{ km/day}$$

Technology Focus: GPS

Global Positioning System

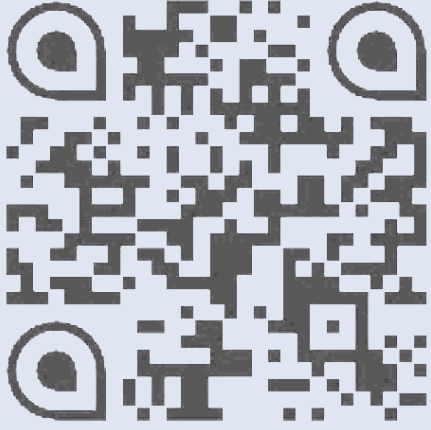


1. **Network:** 24+ satellites orbit Earth.
2. **Reference:** Satellites act as moving reference points.
3. **Calculation:** The receiver measures distance to multiple satellites to pinpoint exact location.

Summary & Key Concepts

Concept	Definition / Key Point
Position	Location relative to a reference point.
Displacement	Difference between start & end (Vector).
Speed	Distance / Time (Scalar).
Velocity	Speed + Direction (Vector).
Graph Slope	Steeper = Faster. Horizontal = Stopped.

Everything is relative. Motion is always defined by the Reference Point you choose.



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Module (1): Forces and Motion

02

Second Lesson: Force and Acceleration



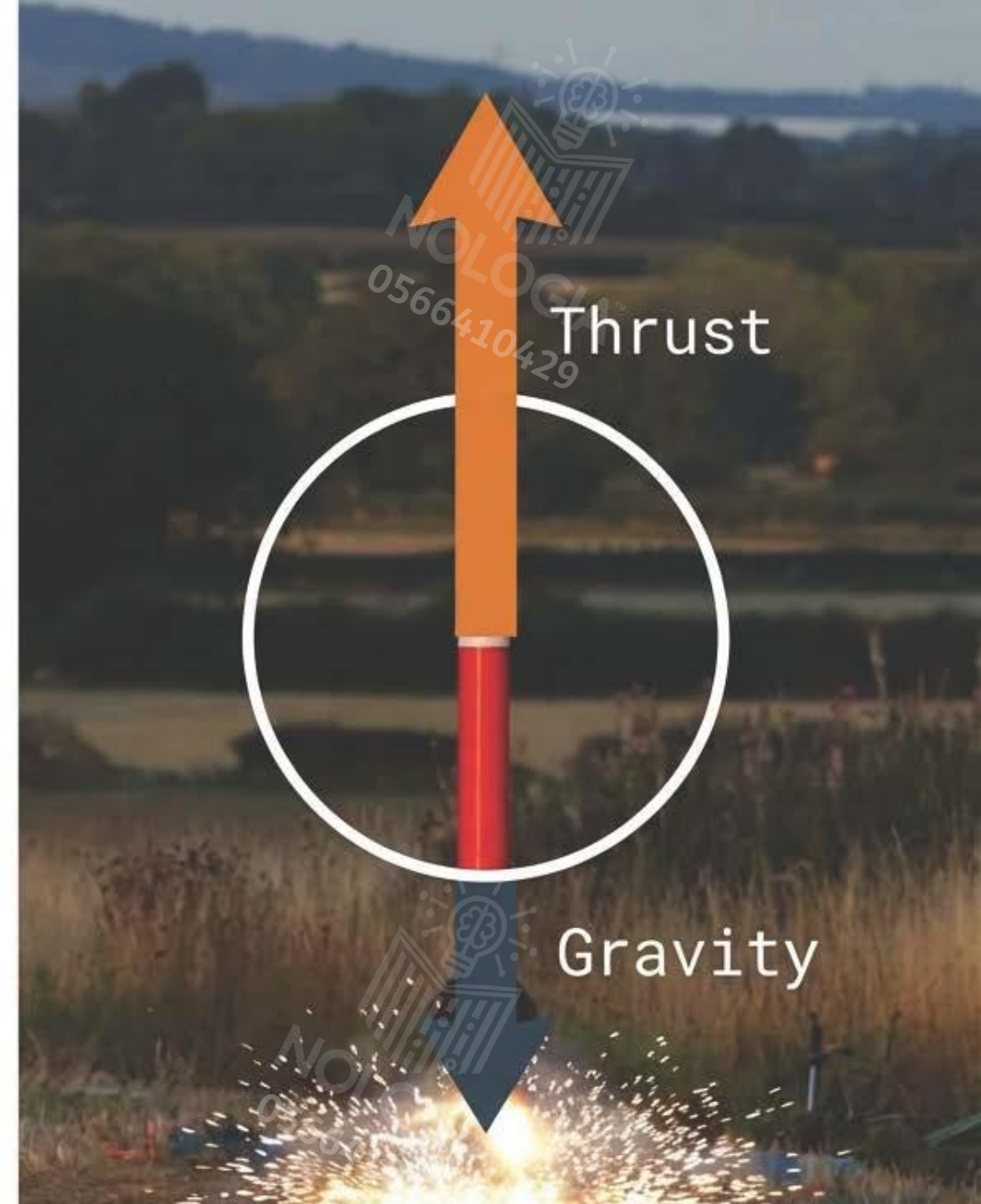
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Forces and Acceleration

A Comprehensive Guide to Motion, Laws, and Analysis

From the kick of a soccer ball to the launch of a rocket, understanding physics starts with understanding how motion changes. This guide explores the relationship between Force, Mass, and Acceleration.



Defining Acceleration: The Change in Motion

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Acceleration is the measure of the change in velocity during a period of time. It is a vector, meaning it has both magnitude and direction.

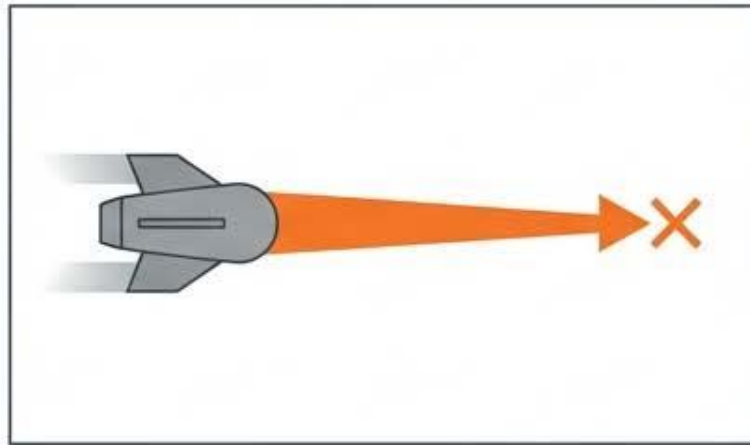
Unit: m/s^2

Increasing Speed



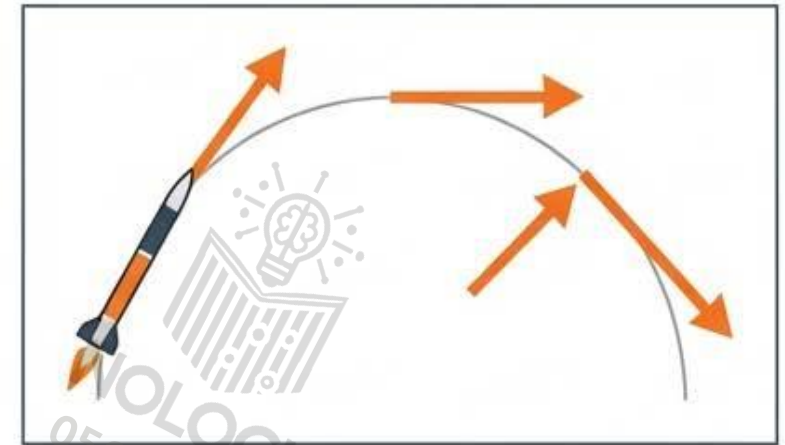
Velocity magnitude increases over time.

Decreasing Speed



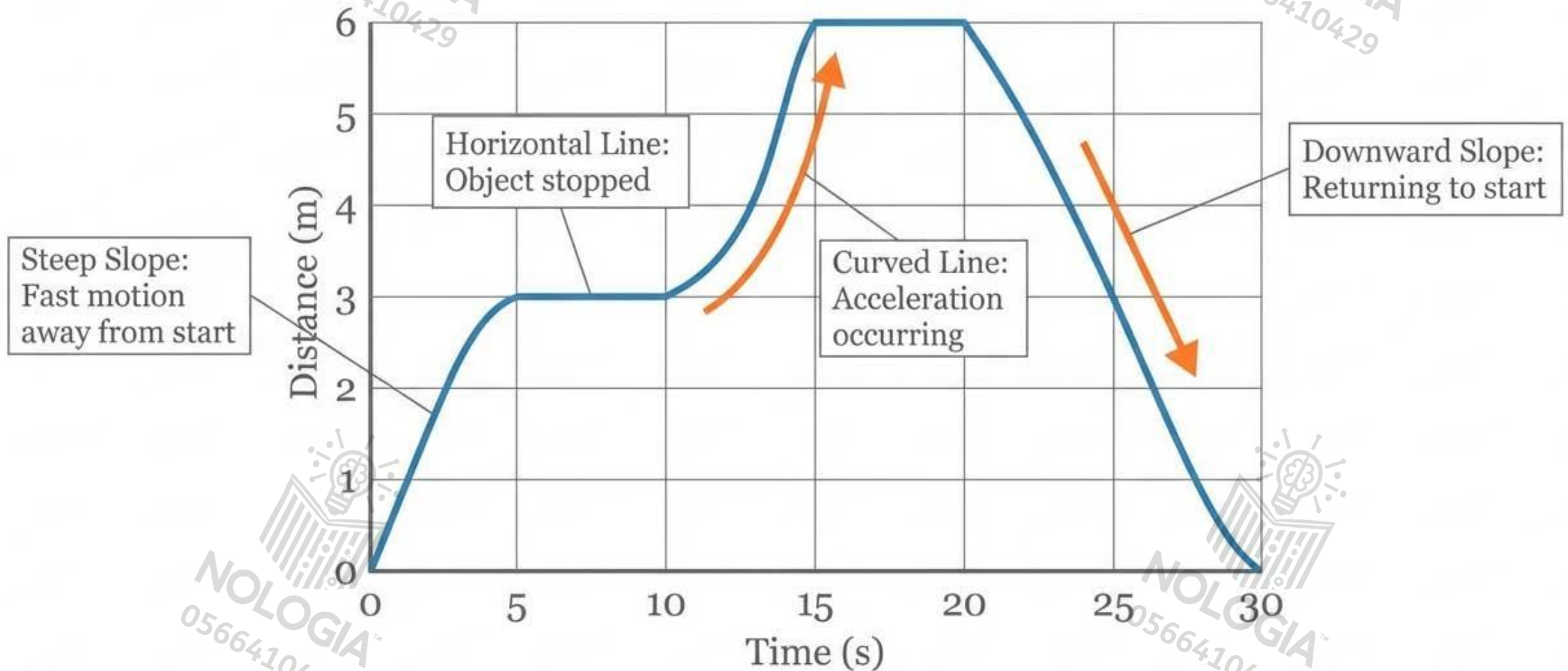
Velocity magnitude decreases to zero.

Changing Direction



Direction of velocity vector changes, even if magnitude is constant.

Visualizing Motion: Graph Analysis



Force: The Agent of Change

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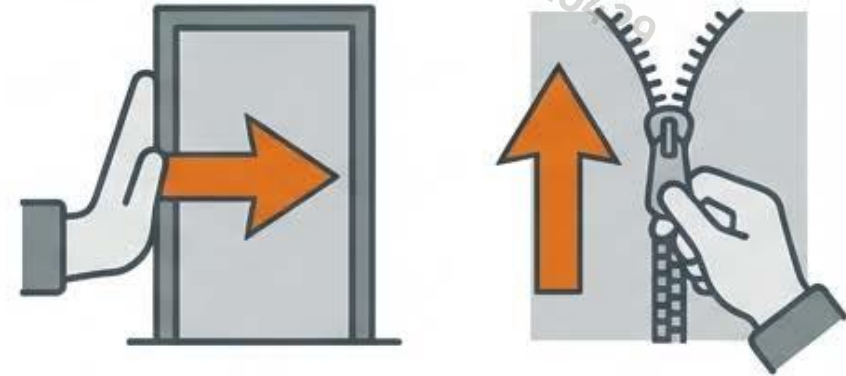
Definition

A push or a pull on an object. Forces have both strength (magnitude) and direction.

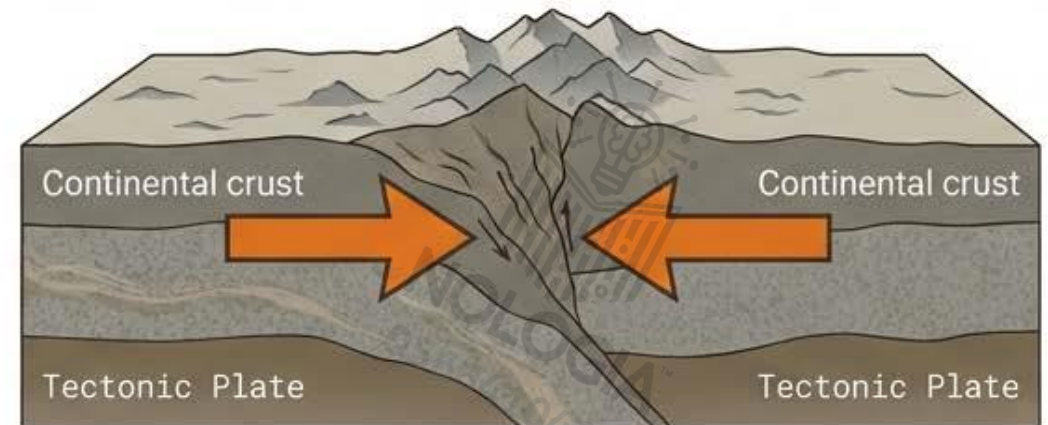
Contact Force

A push or pull on one object by another object that is touching it.

Everyday Forces



Earth Science Connection: Tectonic Plates



Newton's Second Law of Motion

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$$a = \frac{F}{m}$$

Acceleration
(m/s²)

Net Force
(N)

Mass
(kg)

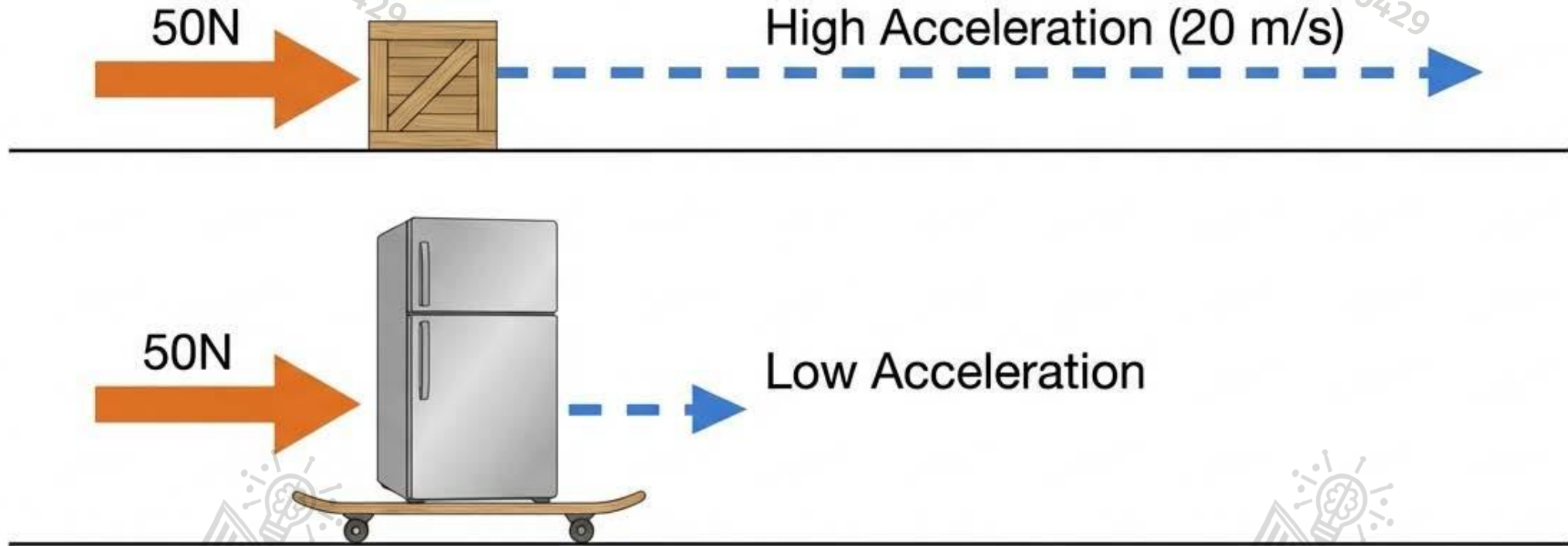
Proportional to Force ↑
More Force = More Acceleration ↑

Inversely Proportional to Mass ↓
More Mass = Less Acceleration ↓

Mathematical
Model

Lab Evidence: Mass vs. Acceleration

Investigation: When Push Comes to Shove (PhET)



Conclusion: A larger mass (refrigerator) requires significantly more force to achieve the same acceleration as a smaller mass.

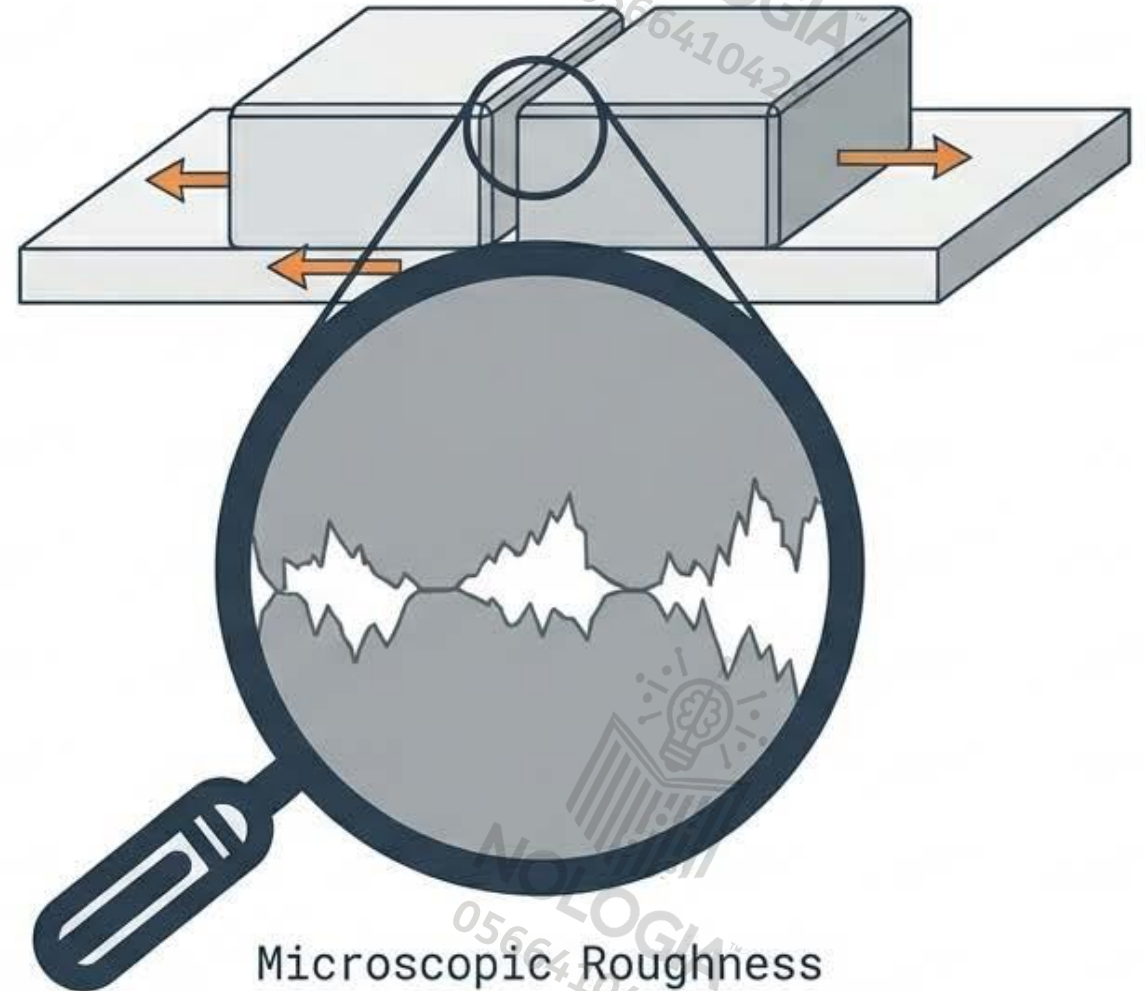
Friction: The Opposing Force

Definition:

A force that resists the sliding motion of two surfaces that are touching.

The Microscopic Truth:

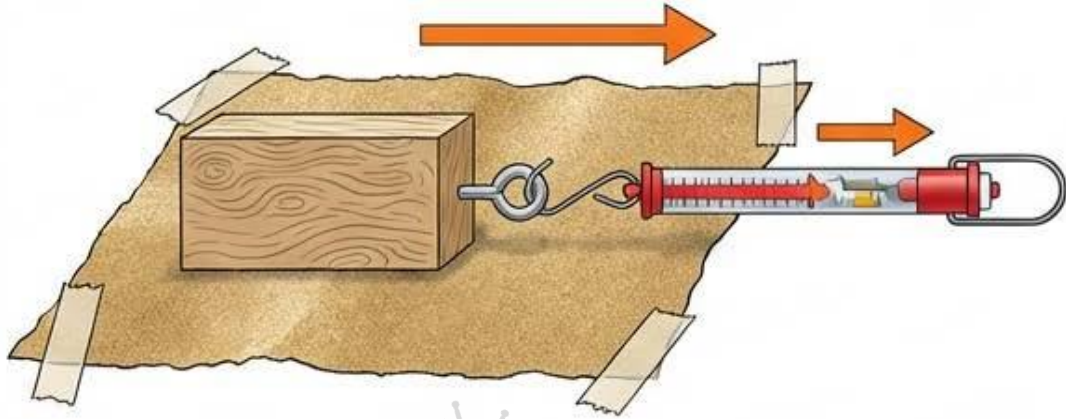
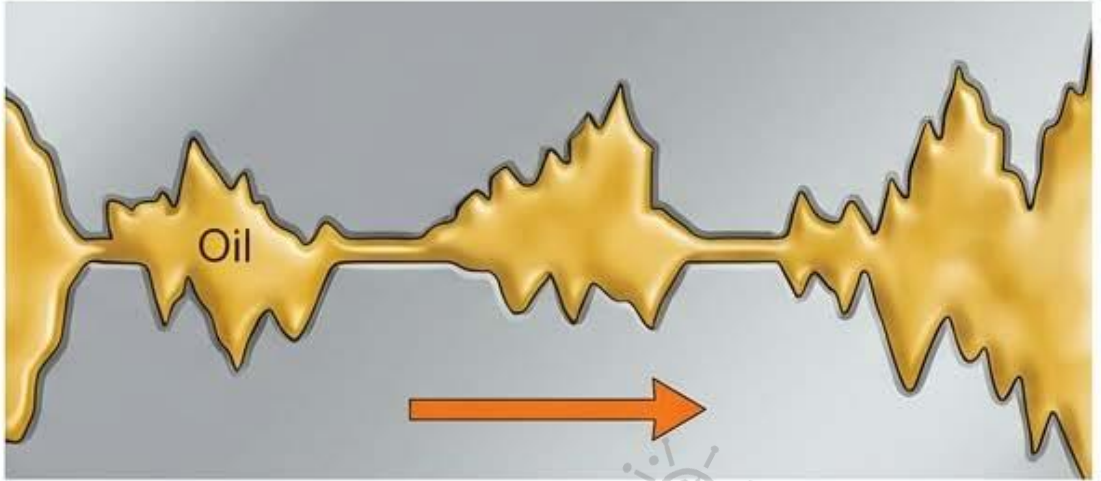
Even surfaces that look smooth to the eye have microscopic dips and bumps. When surfaces slide past each other, these “peaks and valleys” catch on one another.



Factors Affecting Friction

Investigation: Lab – Sticky Situation

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Surface Texture	Lubrication
 Rough surfaces (Sandpaper) exaggerate dips and bumps. Result: High Friction (More force needed).	 Lubricants (Oil/Soap) fill the gaps between microscopic bumps. Result: Low Friction (Surfaces slide easier).

Modeling Physics: Free-Body Diagrams

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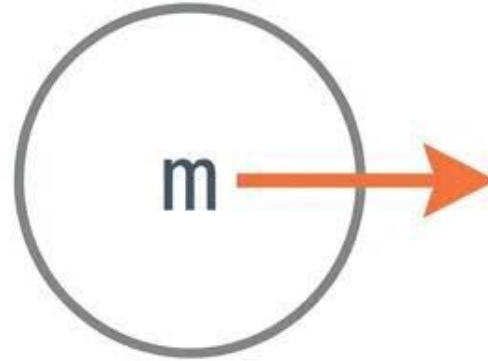
The Body

The Force

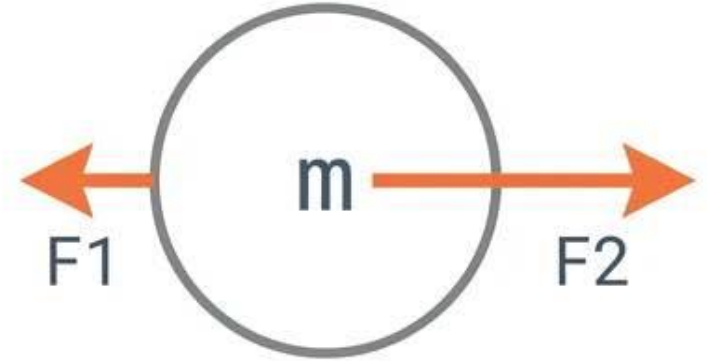
Magnitude & Direction



Draw a circle or box to represent the mass.



Draw an arrow extending from the center in the direction of the force.

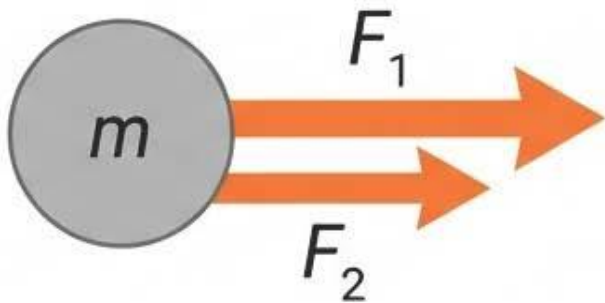


The length of the arrow indicates strength. This object is being pulled harder to the right.

Calculating Net Force

Net Force = The sum of all forces

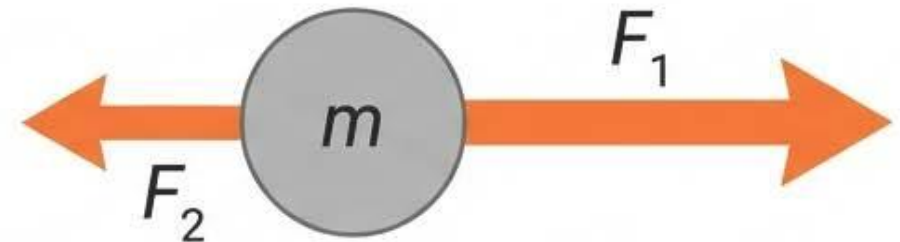
Forces in Same Direction



$$\text{Net Force} = F_1 + F_2$$



Forces in Opposite Directions



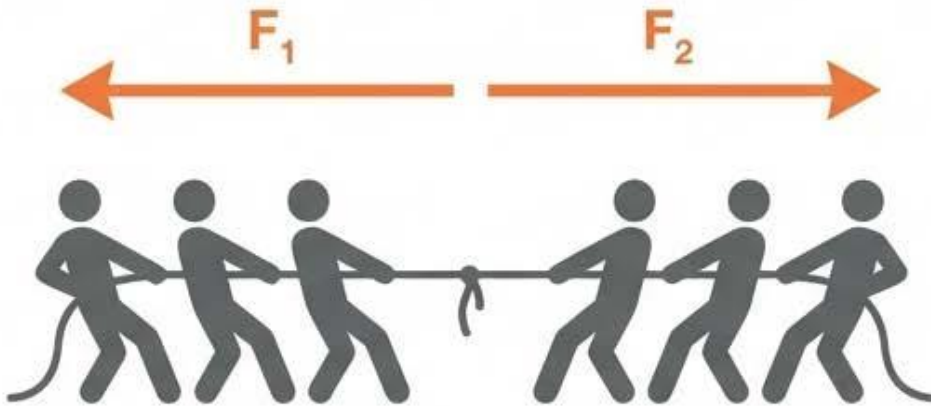
$$\text{Net Force} = F_1 - F_2$$



Comparison: Balanced vs. Unbalanced Forces

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Balanced Forces



Net Force = 0 N

NO Change in Motion
Forces cancel each other out.

Unbalanced Forces



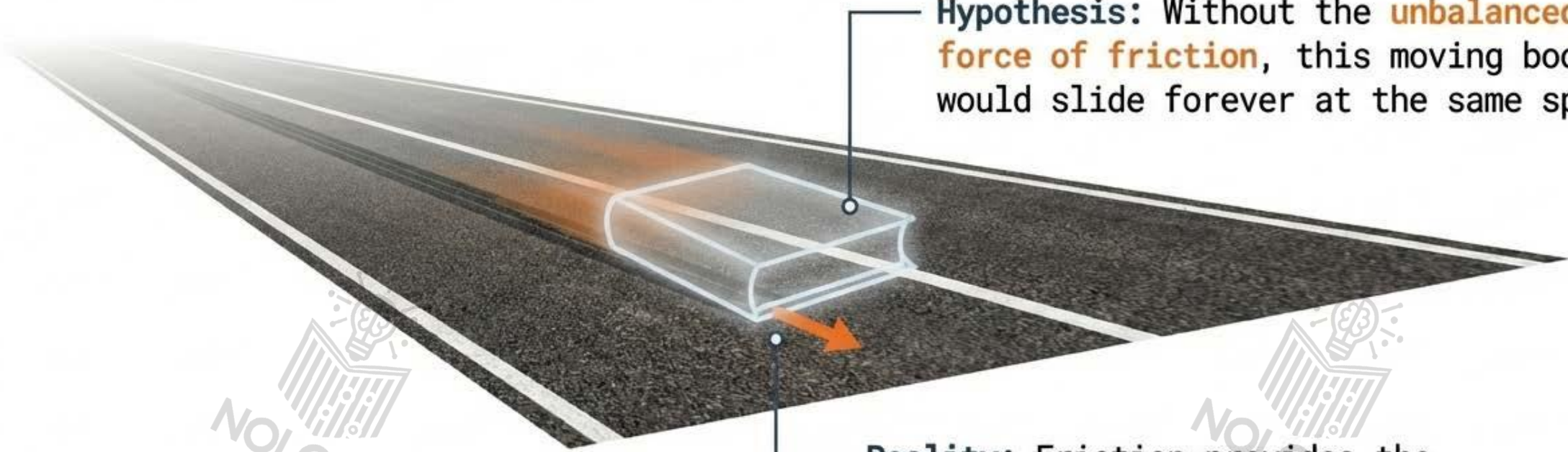
Net Force $\neq 0\text{ N}$

Object **ACCELERATES**
Motion changes in direction of the net force.

Newton's First Law of Motion

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Law of Inertia: An object at rest will stay at rest, and an object in motion will stay in motion, unless acted on by a force.



Hypothesis: Without the **unbalanced force of friction**, this moving book would slide forever at the same speed.

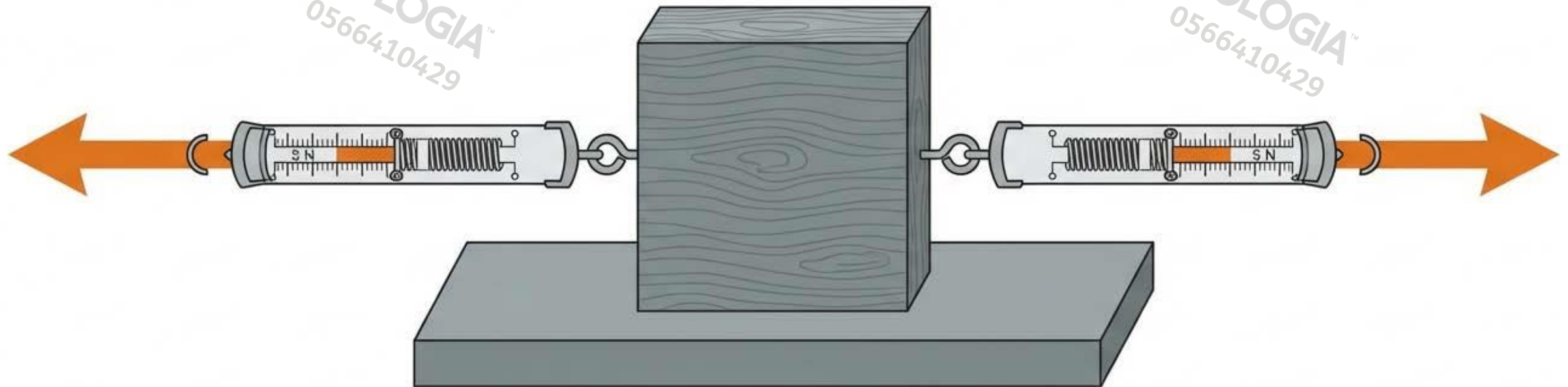
The diagram shows a 3D perspective of a dark grey ramp with white lines. A book is shown in two positions: a solid orange one at the top and a transparent one further down. An orange arrow points from the transparent book towards the bottom of the ramp, indicating its direction of motion. A line connects the text 'Hypothesis' to the transparent book.

Reality: Friction provides the unbalanced force that stops the motion.

A line connects the text 'Reality' to the orange arrow on the ramp.

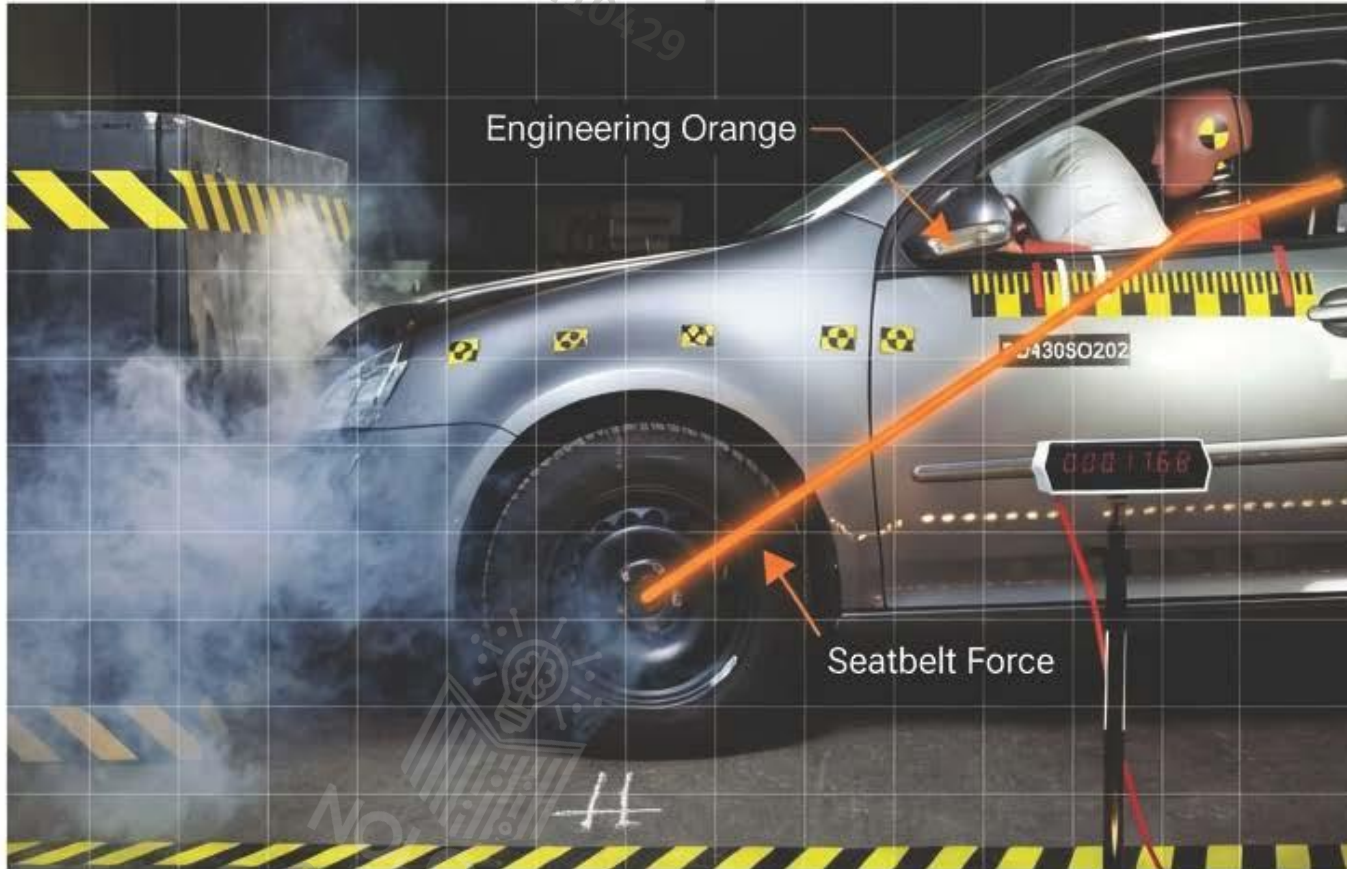
Lab Evidence: A Balancing Act

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Observation:	Force Left (5N) = Force Right (5N)
Net Force:	0 N
Result:	Static Equilibrium (The block does not move).

Physics in Action: Vehicle Crash Test Engineer



Analysis

The Problem: Inertia

- ⚙ In a crash, the car stops, but the passenger continues moving forward at the original speed (Newton's 1st Law).

The Solution: Unbalanced Force

- 🛑 Seatbelts and airbags provide the necessary unbalanced force to stop the passenger safely, matching the car's motion.

The NOLOGIA Physics Cheat Sheet

Formulas

- $F = m \times a$ →

- $a = F / m$ ←

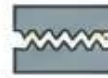
- Net Force: Sum of vectors 

Definitions

- Inertia: Resistance to change in motion.



- Friction: Resistance from surface roughness.



- Equilibrium: Net Force = 0.



$$\Sigma F = 0$$

Key Rules

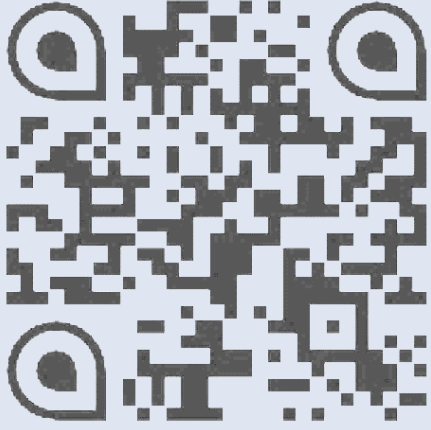
- Unbalanced Force → Acceleration.



- Balanced Force → No Change.



Concept Mastery Complete.



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Module (1): Forces and Motion

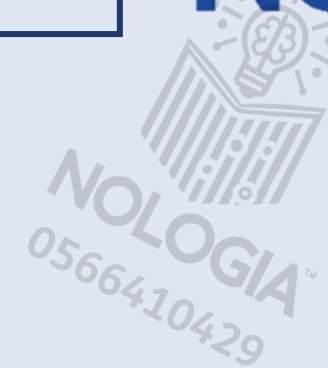
03

04

Third & Fourth Lessons:
Force Pairs &
Gravitational Force

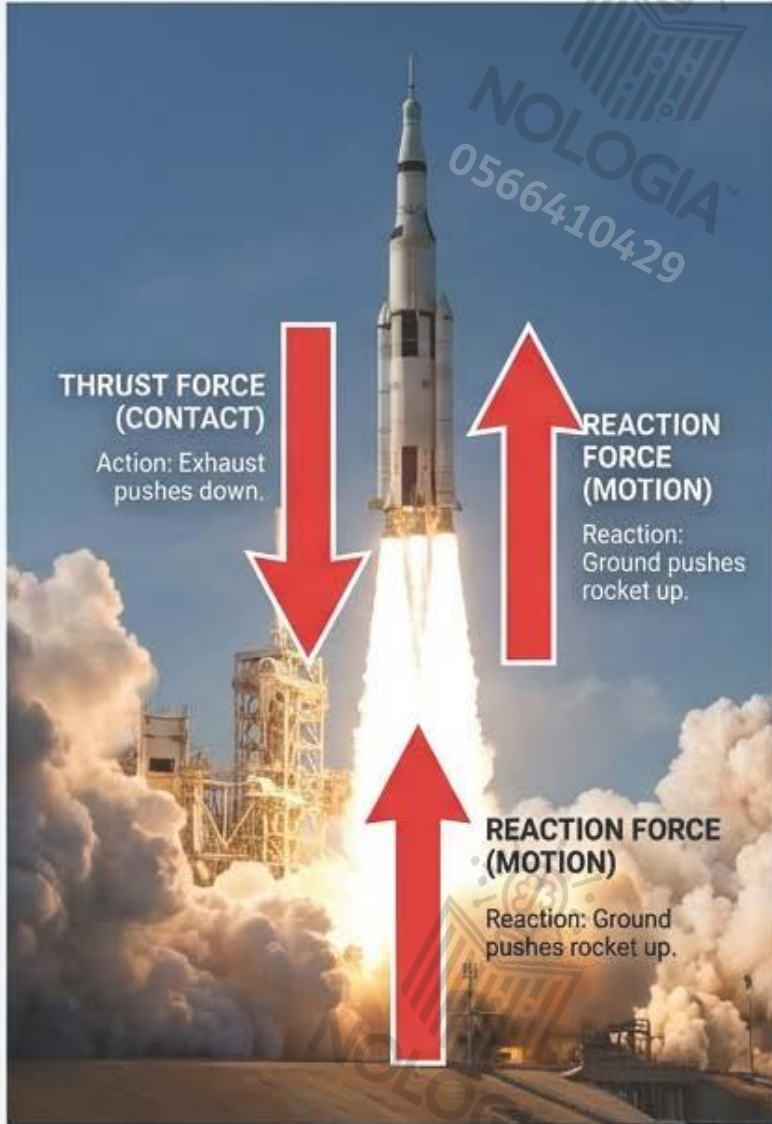


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CONTACT FORCES



NOLOGIA | Module 01

Forces and Motion

From Contact to Fields: A Comprehensive Guide to Newton's Third Law & Gravitational Force

FIELD FORCES



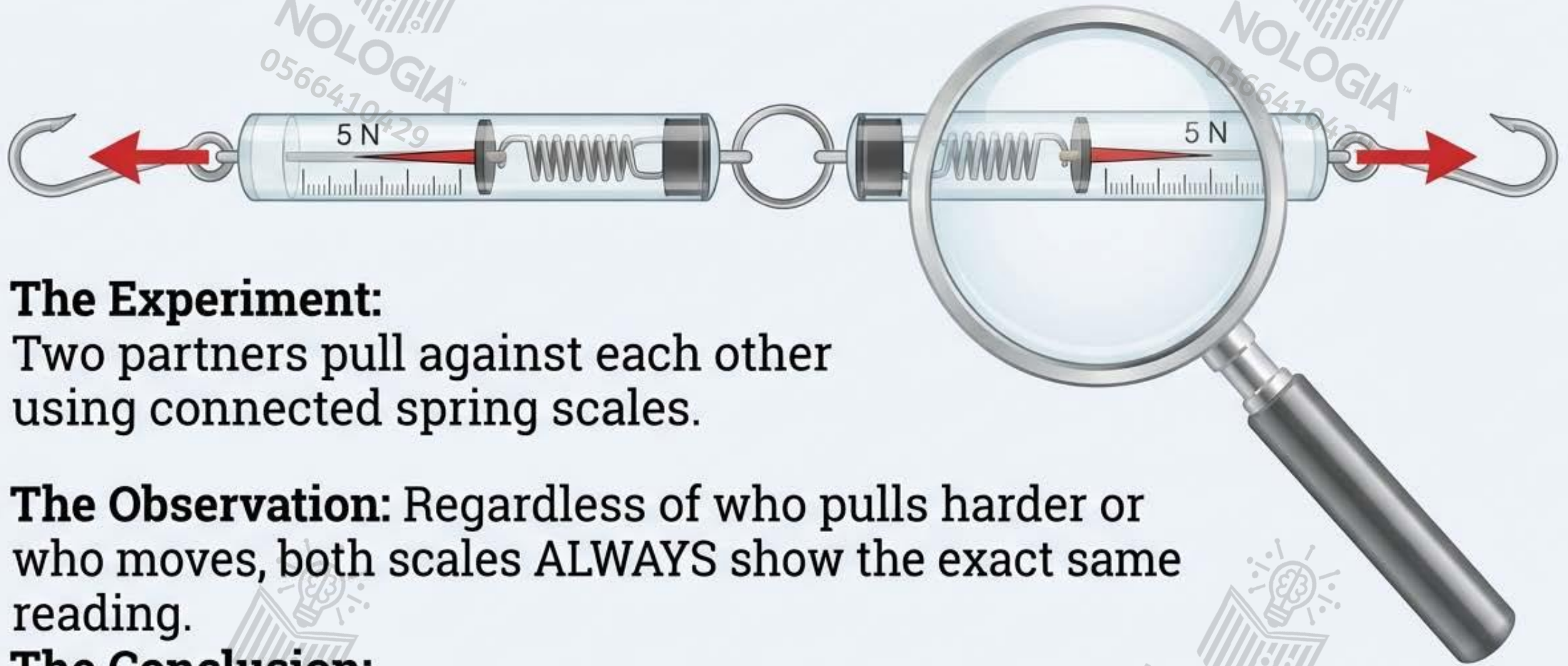
Newton's Third Law of Motion

For every action, there is an equal and opposite reaction.

When an object applies a force on another object, the second object applies a force of the same strength on the first object, but the force is in the opposite direction.



Lab Investigation: Pulling Your Weight



- **The Experiment:**
Two partners pull against each other using connected spring scales.
- **The Observation:** Regardless of who pulls harder or who moves, both scales ALWAYS show the exact same reading.
- **The Conclusion:**
The **Conclusion:** Forces always exist in pairs. You cannot touch something without being touched back with equal force.

Critical Distinction: Force Pairs vs. Balanced Forces

Force Pairs (Action/Reaction)



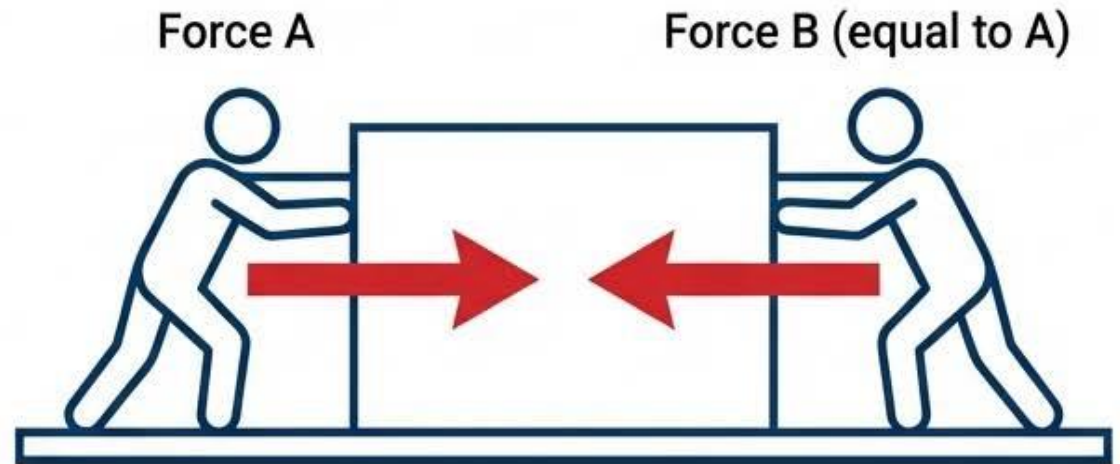
Scenario: Racket hits Ball.

Rule: Forces act on TWO different objects.

Result: They DO NOT cancel out. Net Force $\neq 0$.

Outcome: Motion changes (Ball accelerates).

Balanced Forces



Scenario: Two people push one box equally.

Rule: Forces act on the SAME object.

Result: They DO cancel out. Net Force = 0.

Outcome: No change in motion.

Collision Dynamics

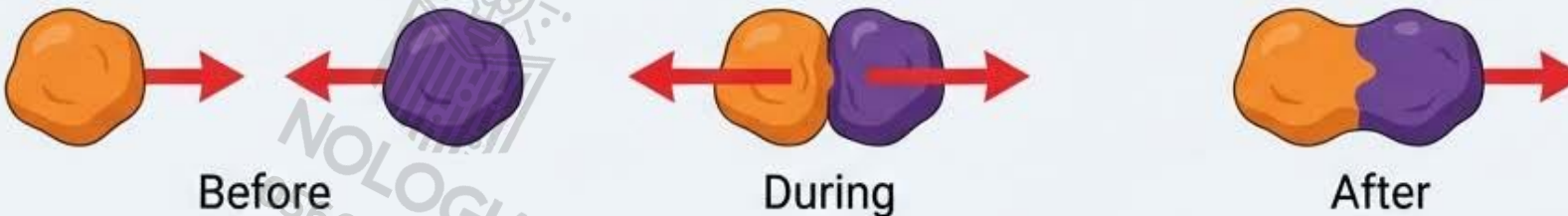
Elastic vs. Inelastic Collisions & The Role of Mass

Elastic Collision (Bouncing)



Objects bounce off each other. Kinetic energy is conserved.

Inelastic Collision (Sticking)



Objects stick together. (e.g., A football tackle).

Newton's 3rd Law Application

In a collision between a large Truck and a small Car:

- Force is EQUAL on both.
- Acceleration is DIFFERENT ($a = F/m$).

The smaller mass experiences a larger acceleration.

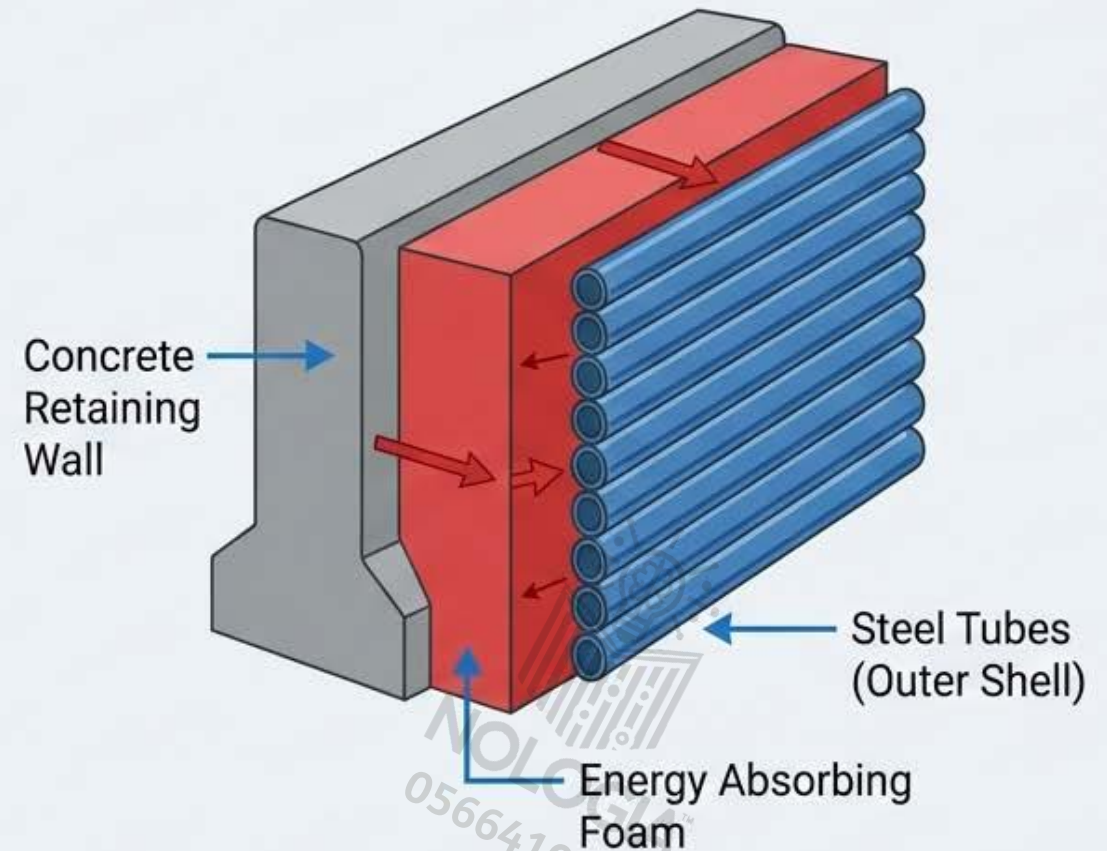
Engineering Safety: SAFER Barriers

Steel And Foam Energy Reduction

Context: High-speed racing crashes.

Mechanism: The barrier extends the TIME of impact.

Physics Result: By lengthening the time of contact, the force is distributed, and energy is transferred to the wall structure rather than the driver.



Introduction to Gravitational Force

A Field Force Acting Over a Distance

Gravity: An attractive force that exists between all objects that have mass.

Field Force: Acts over a distance without physical contact. A region of space containing a physical quantity at every point.



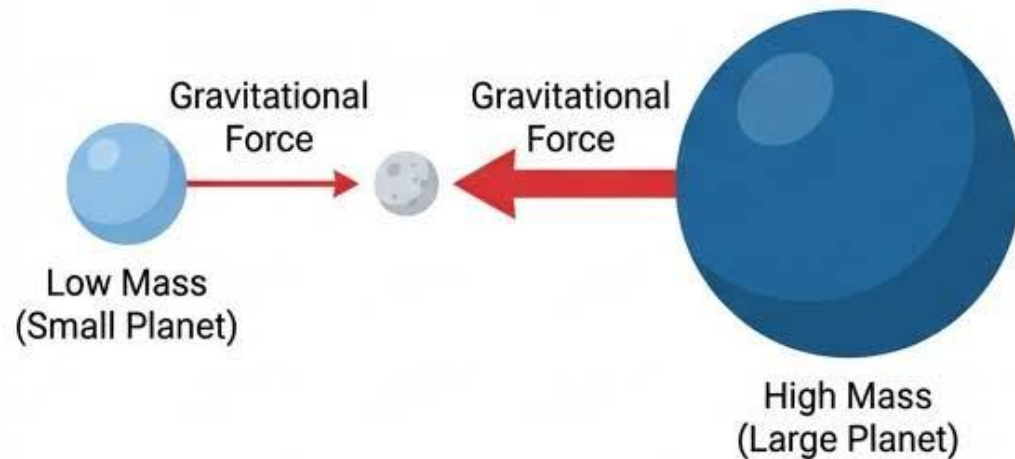
Global Evidence: 'Down' always means toward the **center** of the mass.

Gravity in Action



Factors Affecting Gravity: Mass & Distance

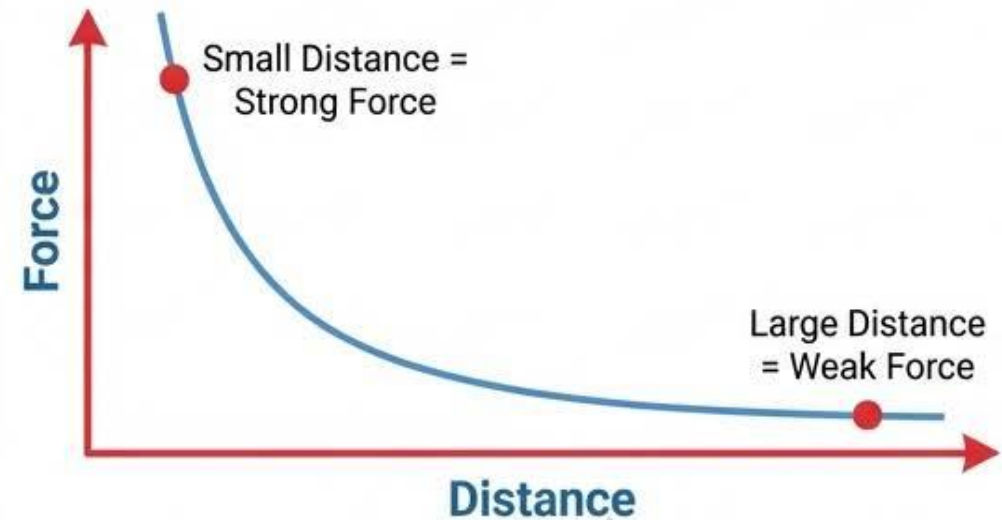
Mass (Direct Relationship)



As Mass increases, Gravitational Force increases.

- Example: Earth has stronger gravity than the Moon.

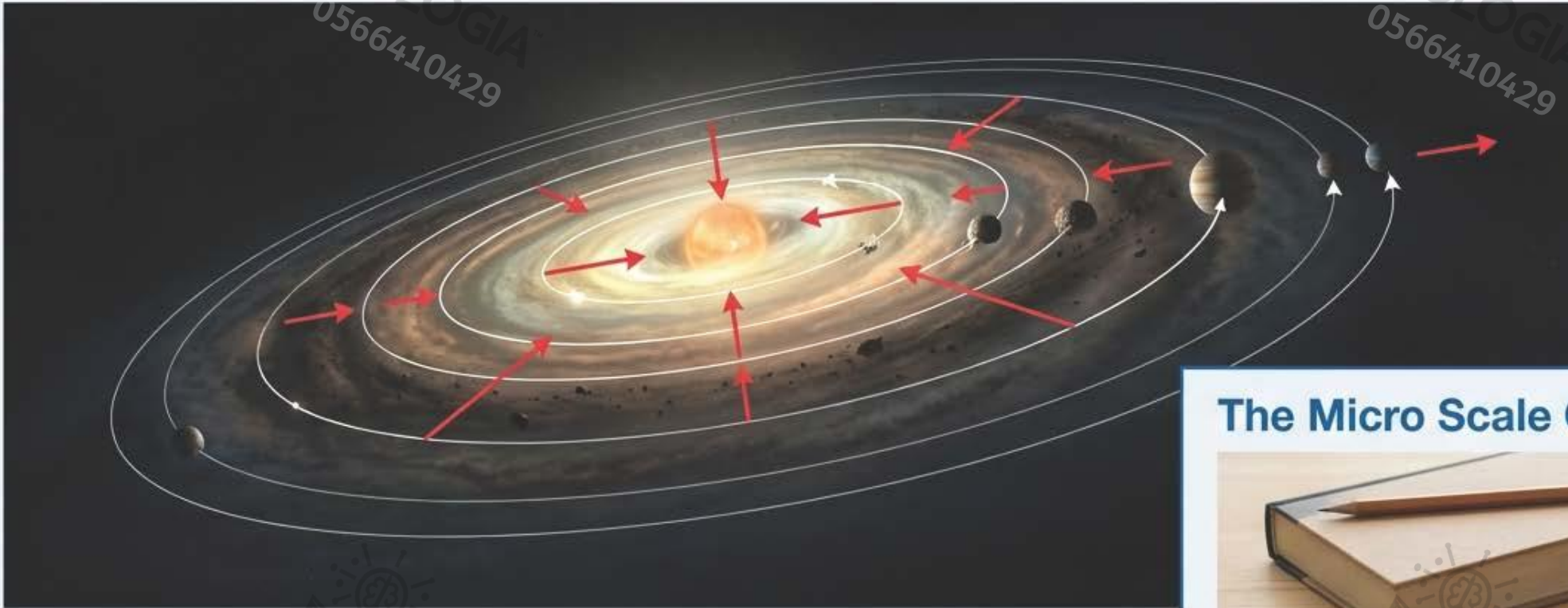
Distance (Inverse Relationship)



As Distance increases, Gravitational Force decreases.

- Data: A 45kg person weighs 440N on Earth, but only 0.12N at the distance of the Moon.

Gravity at Different Scales



Macro Scale: Gravity pulled gas and dust into a disk to form the Sun and planets. It keeps Earth in orbit.

The Micro Scale Question



Why don't the book and pencil stick together?

Answer: They DO have gravitational fields, but their masses are so tiny compared to Earth that the force is negligible and cannot overcome friction.

Core Vocabulary: Mass vs. Weight

MASS



Definition: Amount of matter in an object.

Unit: Kilograms (kg).

Constancy: Constant everywhere (Earth, Moon, Space).

WEIGHT



Definition: Gravitational force exerted on an object.

Unit: Newtons (N).

Constancy: Changes based on location (gravity).



Lab Note: Lab "Weighing Washers" demonstrated a constant ratio between mass and weight on Earth.

The Mathematics of Gravity

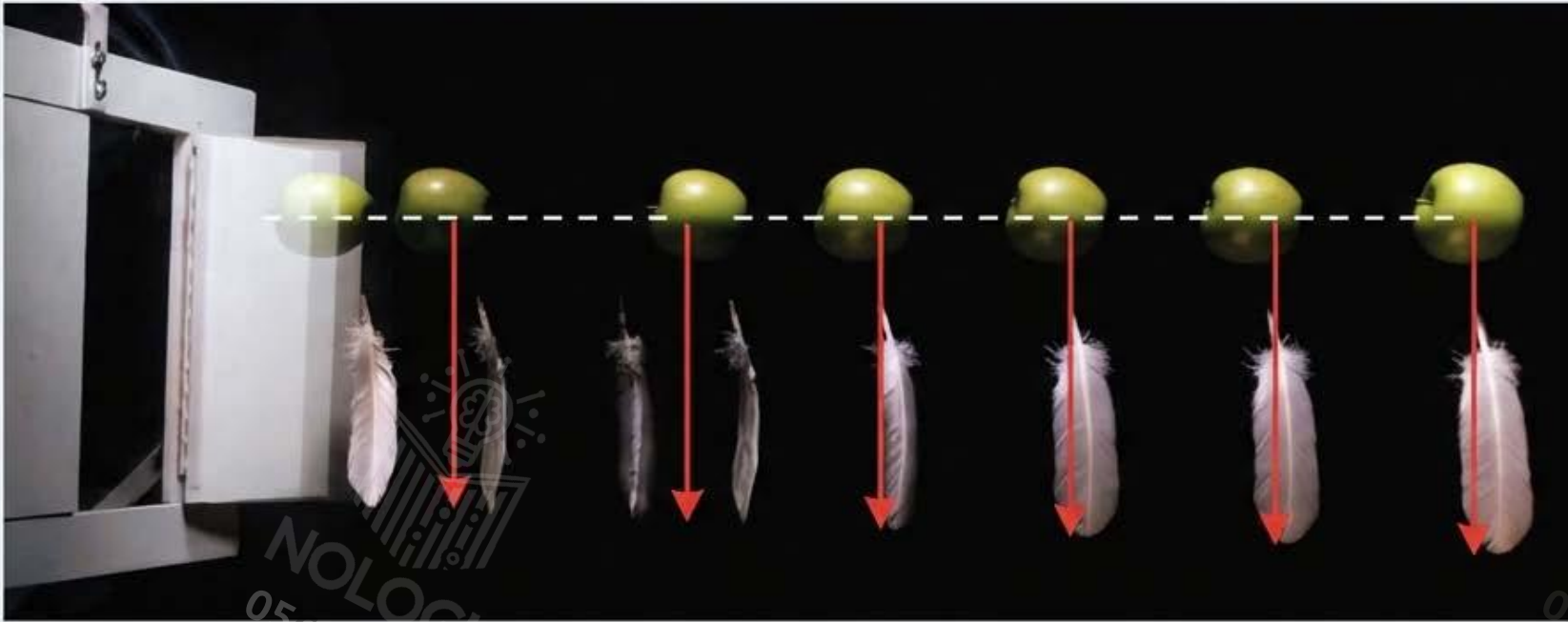
$$W = mg$$

Weight (N) = Mass (kg) $\times$ Gravitational Acceleration (m/s^2)

Gravitational Acceleration (g)

On Earth: $g \approx 9.8 \text{ m/s}^2$

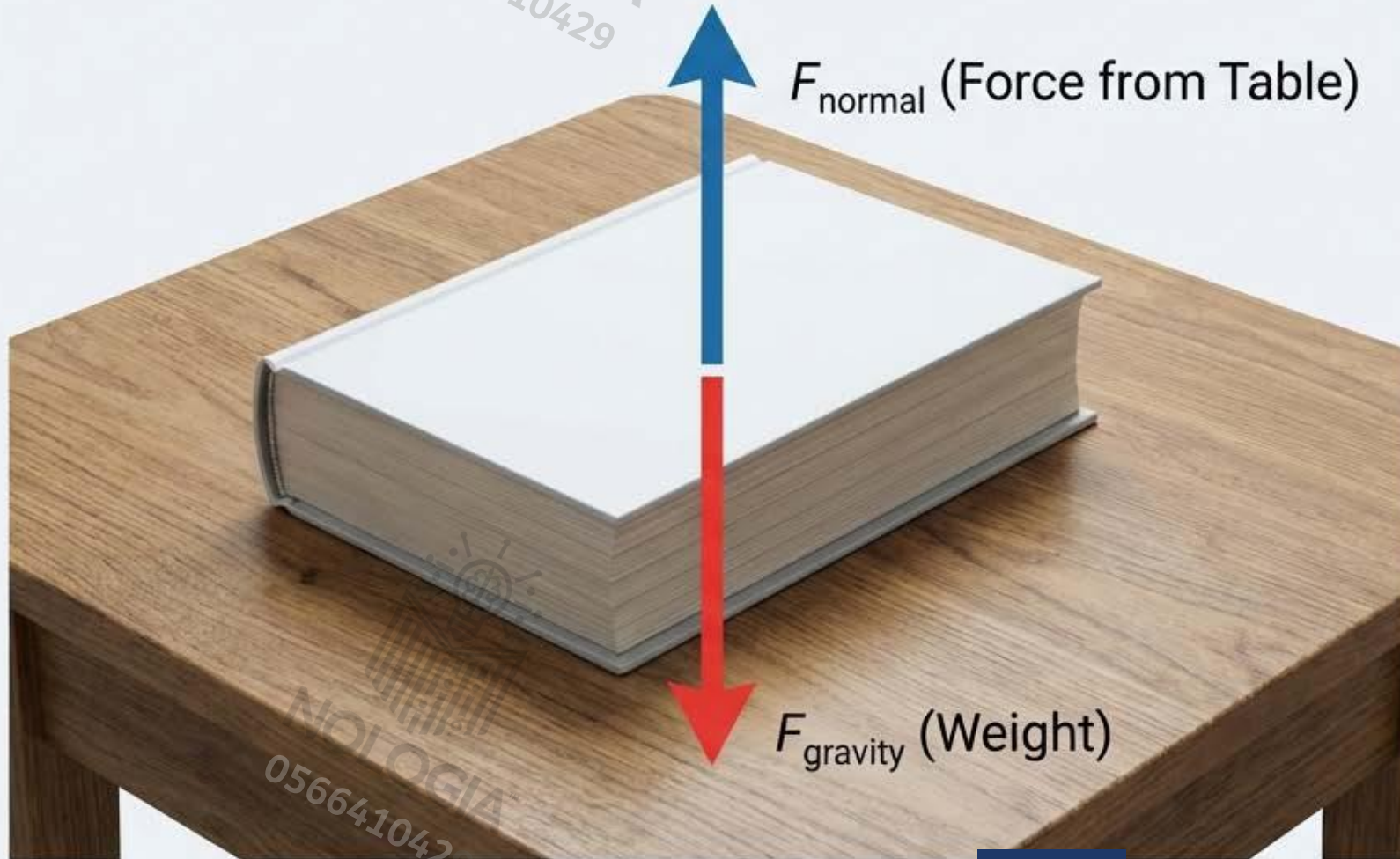
This means falling objects increase speed by 9.8 m/s every second.



In a vacuum (no air resistance), gravity accelerates all objects equally, regardless of mass.

Force Interaction: The Normal Force

Analyzing a Stationary Object



Why doesn't the book fall?

- Gravity pulls down.
- The table exerts a Normal Force pushing up.
- Conclusion: These are Balanced Forces. Net Force = 0.

Comprehensive Vocabulary Review

Newton's 3rd Law: For every action, there is an equal and opposite reaction.

Force Pair: The two forces acting on two different objects.

Normal Force: The support force exerted by a stable object (like a table).

Elastic Collision: Objects bounce off.

Inelastic Collision: Objects stick together.

Gravity: An attractive force between all objects with mass.

Field: A region of space containing a physical quantity at every point.

Mass: The amount of matter in an object (kg).

Weight: The force of gravity on an object ($W = mg$).

Review: Analyze and Conclude

Q: If you pull on a spring scale with 10N against a partner, what does their scale read?

A: 10N. Forces in a pair are always equal.

Q: If the distance between two objects is doubled, what happens to gravity?

A: It decreases significantly (Inverse relationship).

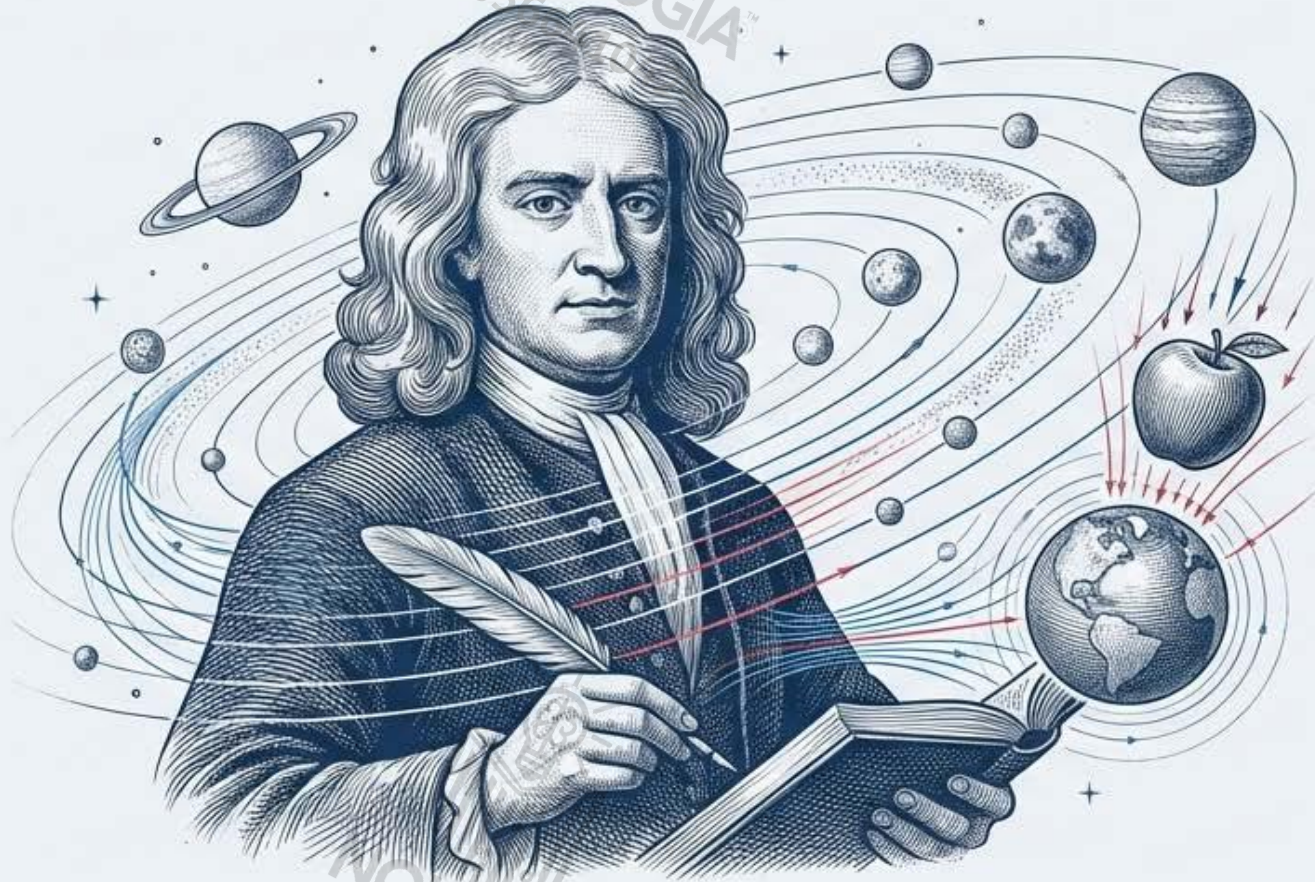
Q: Why do a feather and hammer fall at the same speed on the Moon?

A: Lack of air resistance; gravity accelerates all masses equally.

Q: Calculate the weight of a 2kg book on Earth ($g = 9.8$).

A: $W = 2 \times 9.8 = 19.6 \text{ N}$.

“The Universal Law” in Helvetica Now Display



Historical Context:

In the late 1600s, Sir Isaac Newton published *The Principia*. He revealed that the laws of motion and gravity are universal—governing everything from an apple falling to the orbits of galaxies.

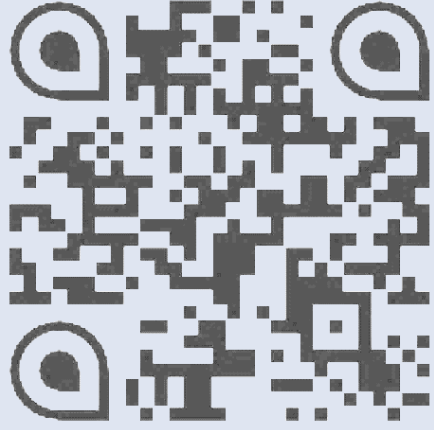
Mastery of Forces Complete.

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Module (2): Mechanical Energy

Lesson Title	Page
2-1+2 Kinetic Energy + Potential Energy	53
2-3 Conservation of Energy	69

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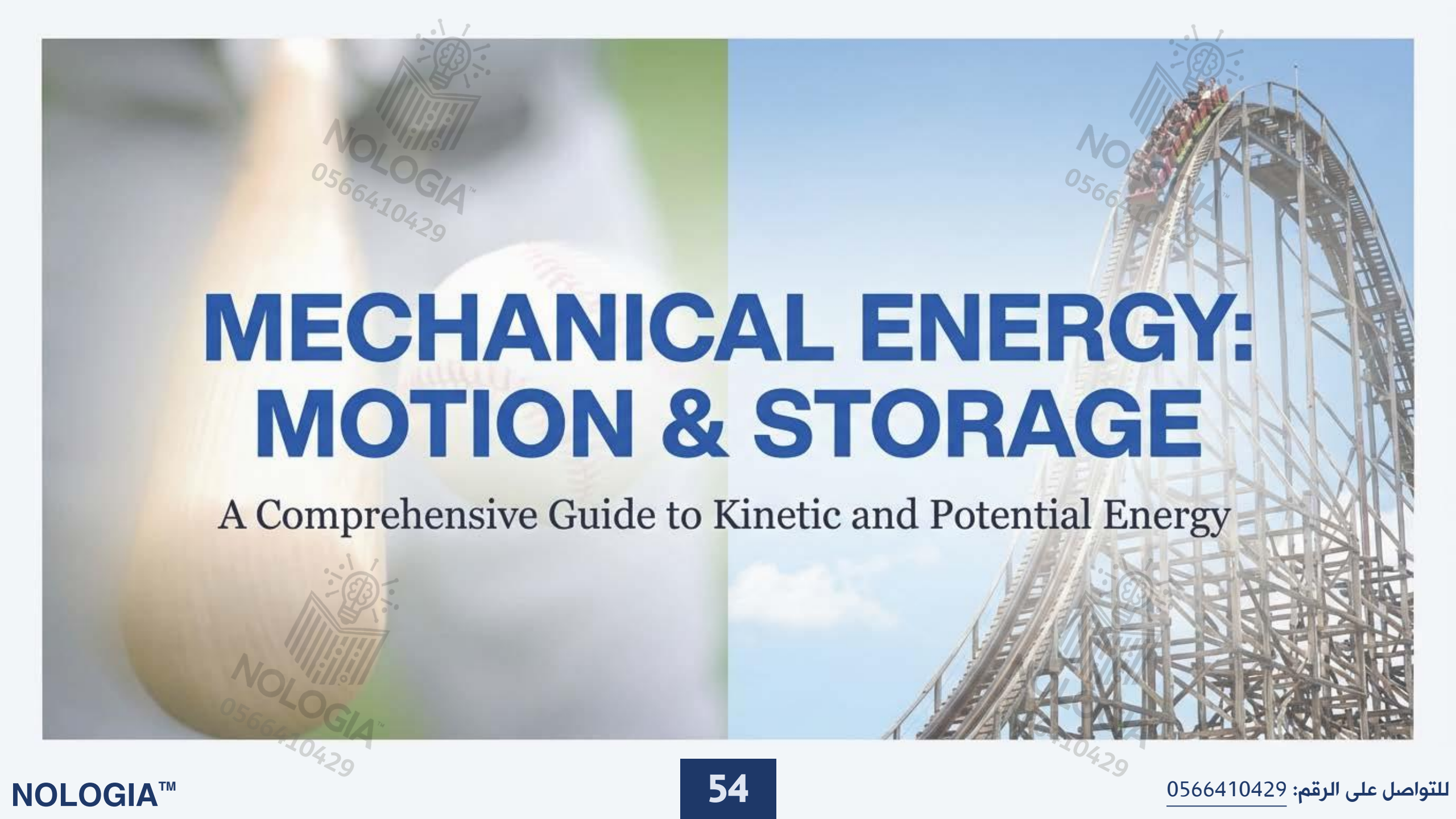
Module (2): Mechanical Energy

01

02

First & Second Lessons:
Kinetic Energy &
Potential Energy

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MECHANICAL ENERGY: MOTION & STORAGE

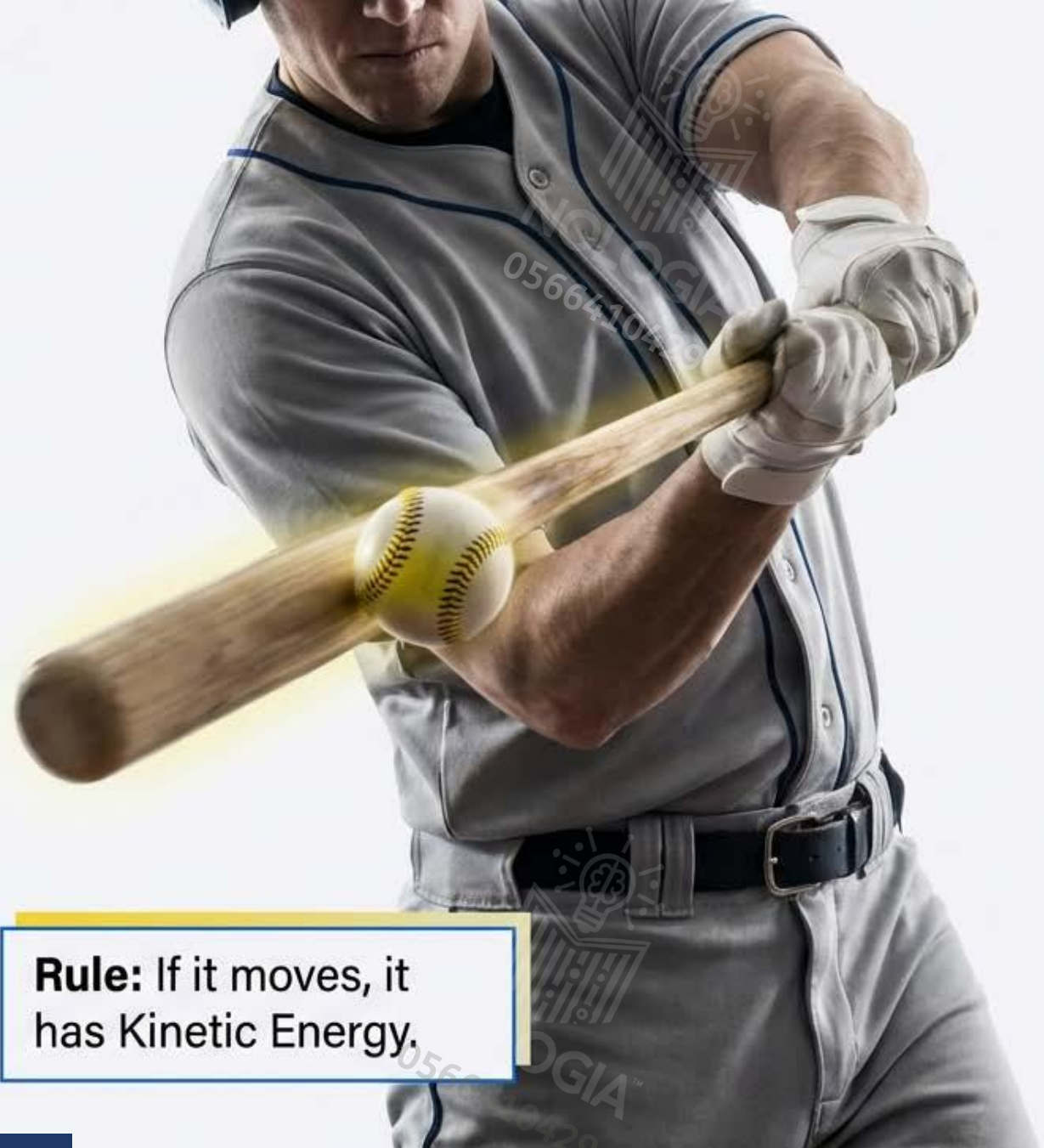
A Comprehensive Guide to Kinetic and Potential Energy

Kinetic Energy is the Energy of Motion

Kinetic energy (KE) is the energy due to motion. All moving objects have kinetic energy. Think of a baseball flying across a field—its ability to cause change (like breaking a window or hitting a glove) comes from its motion.

The amount of KE depends on two factors:

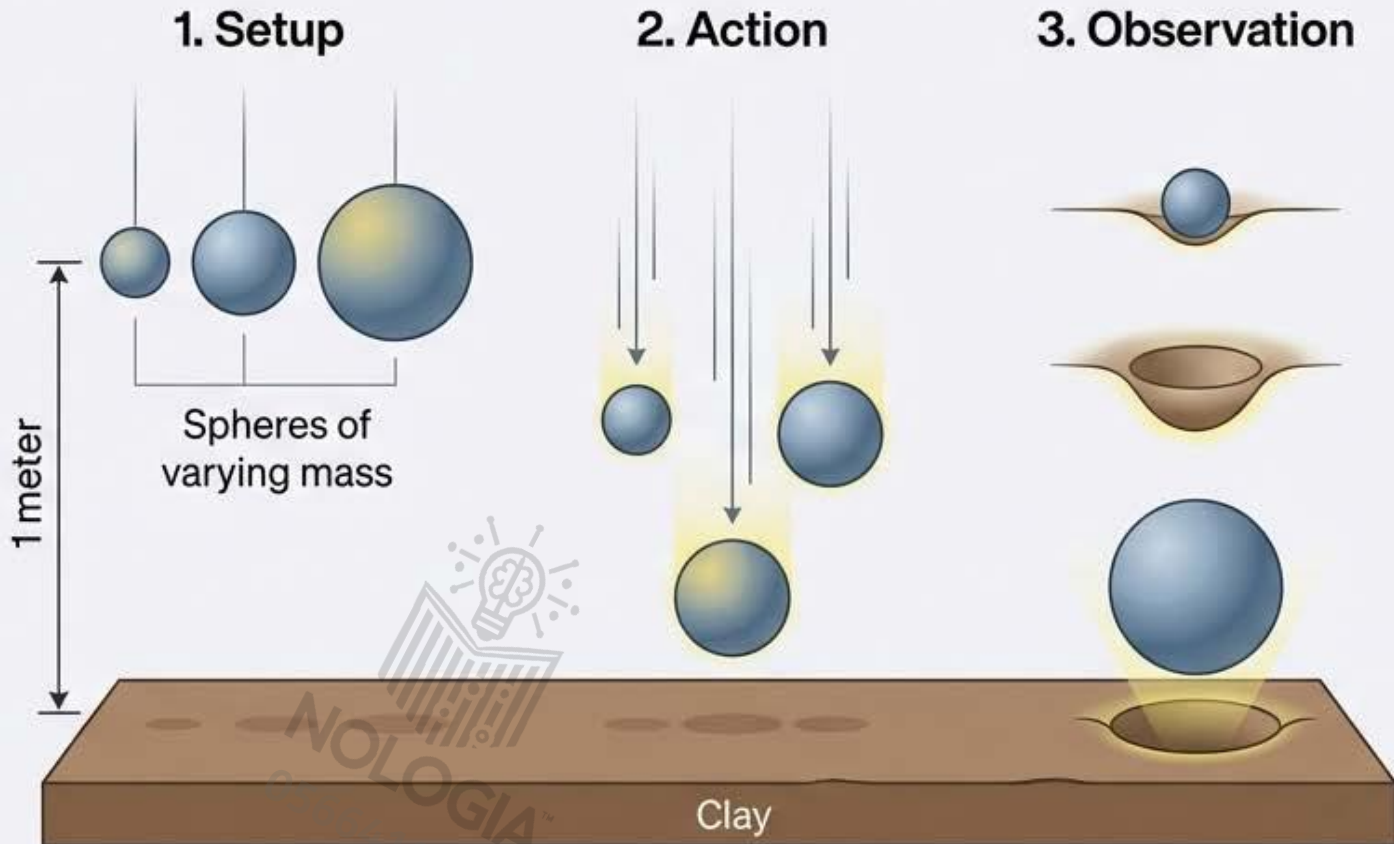
- 1. Speed
- 2. Mass



Rule: If it moves, it has Kinetic Energy.

Investigation: Does Mass Matter?

Lab Experiment Overview

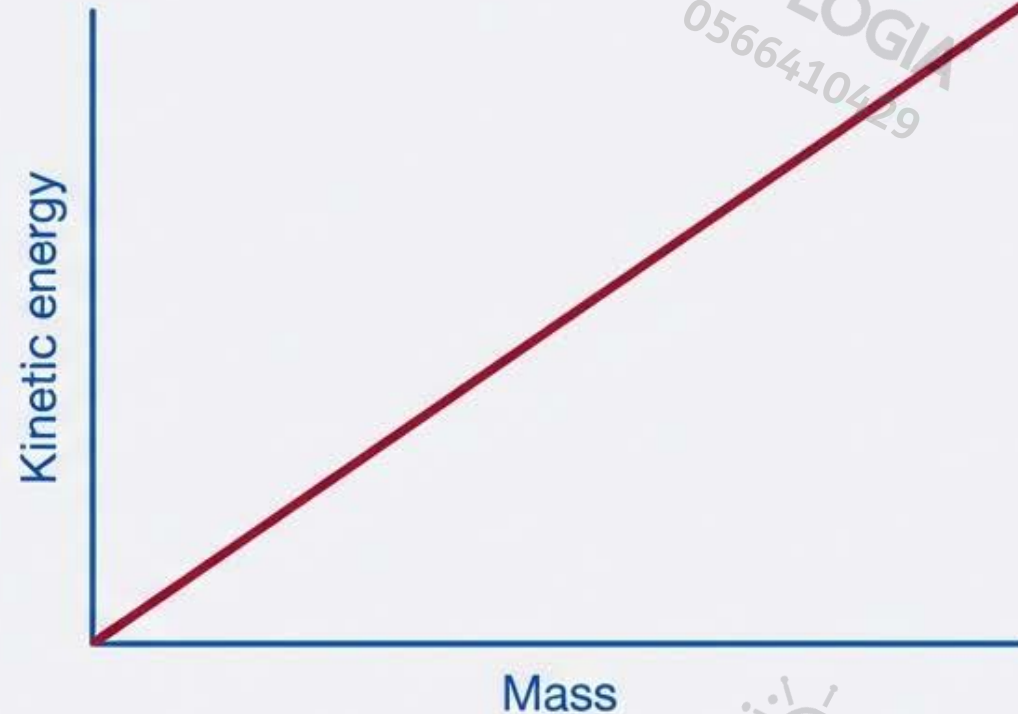


Procedure:

Spheres of different masses are dropped from a constant height. The volume of the resulting crater is measured using water drops.

Result: The sphere with the largest mass created the largest crater. Mass increases impact energy.

The Physics of Mass & Kinetic Energy

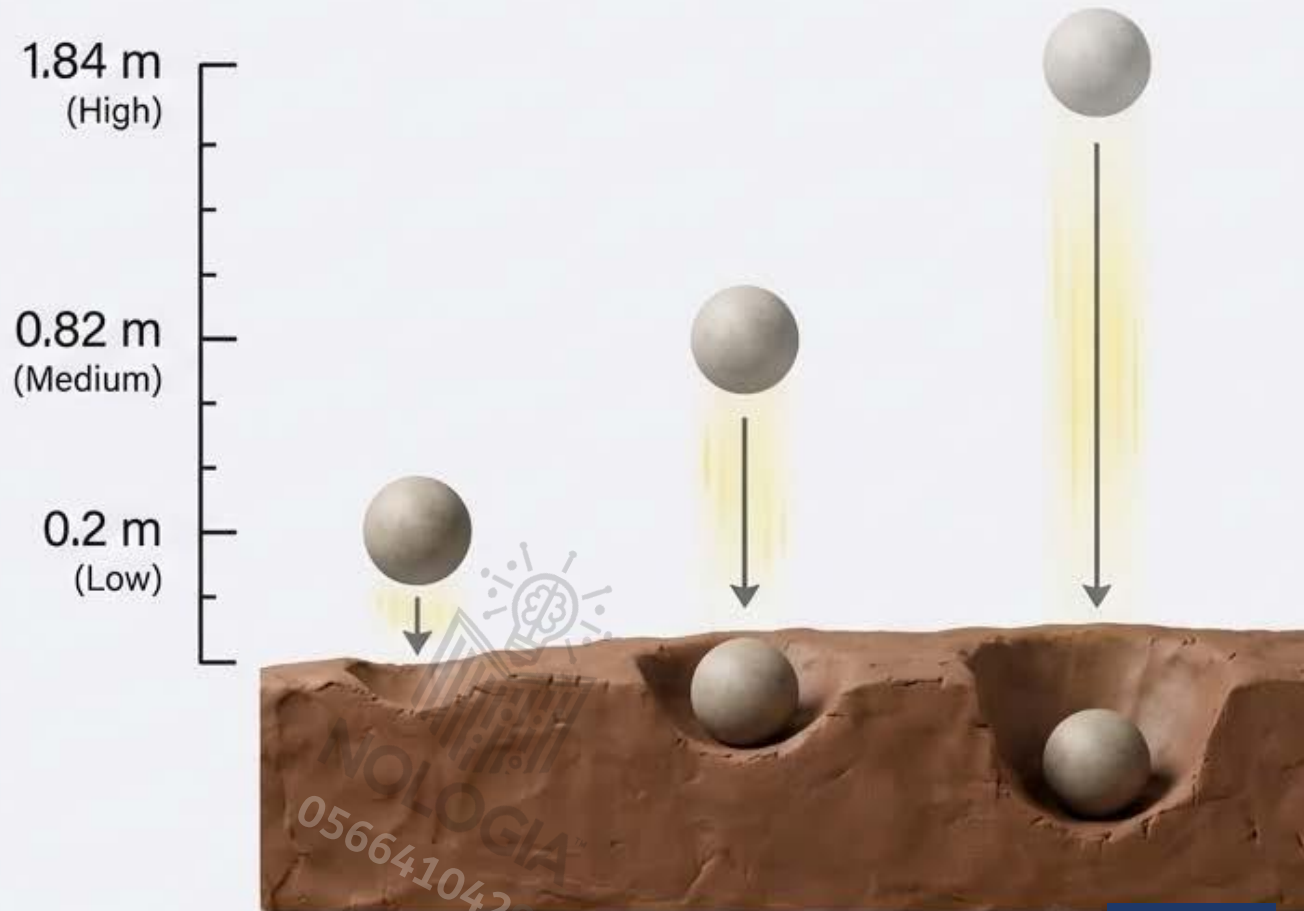


Kinetic energy depends linearly on mass ($KE \propto m$). If you double the mass, the Kinetic Energy doubles.

Example: A baseball has more KE than a tennis ball traveling at the same speed because it has more mass.

Investigation: Picking Up Speed

Isolating Velocity as a Variable



Procedure:

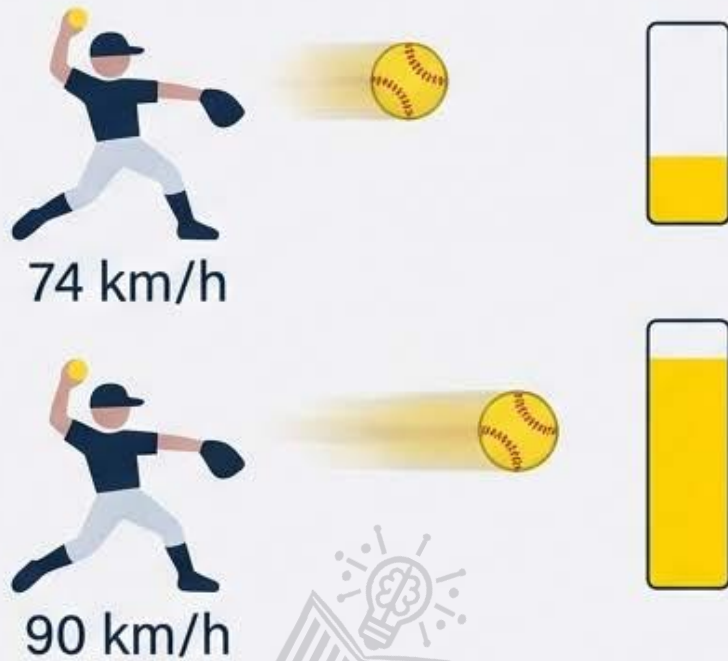
The same sphere (constant mass) is dropped from increasing heights. Higher drops generate higher impact speeds.

Result:

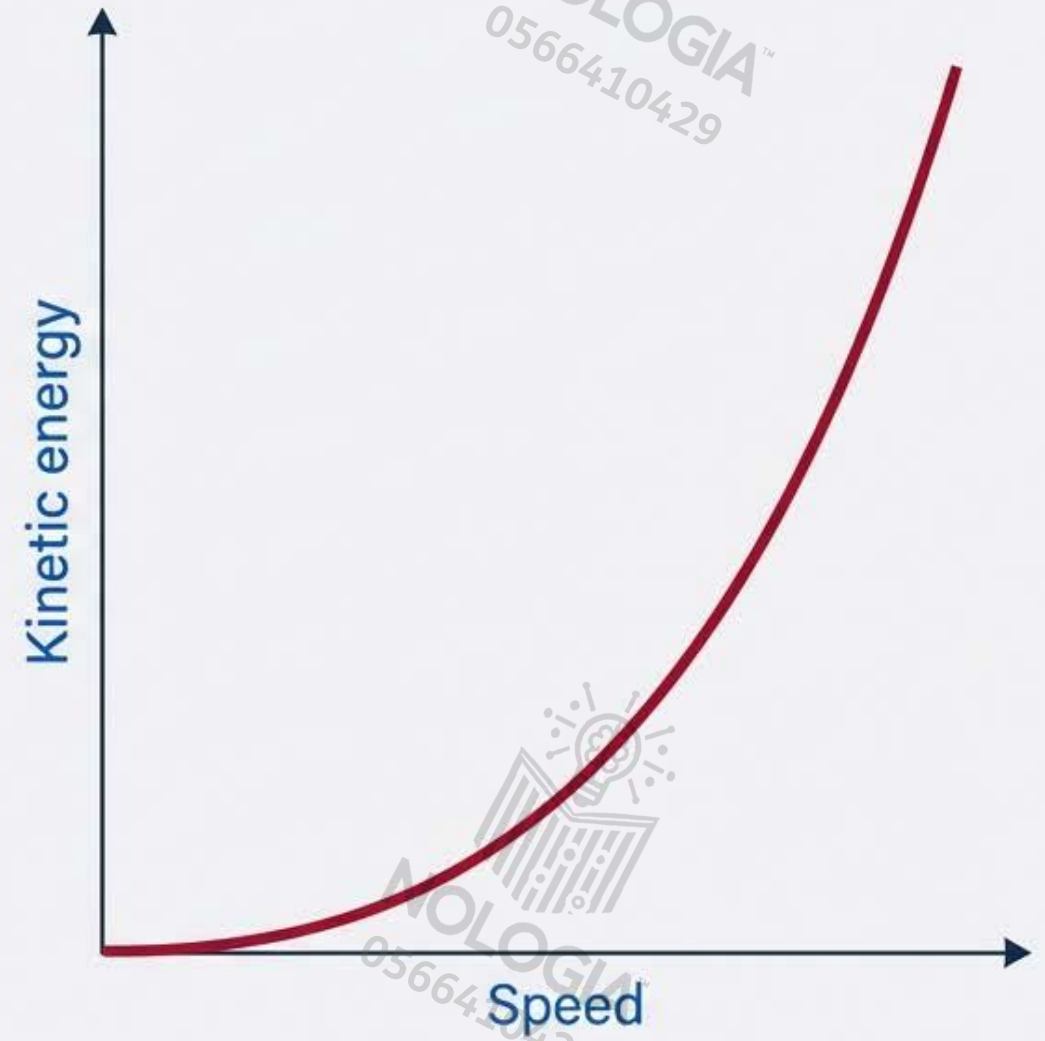
The higher the drop, the faster the speed upon impact, and the larger the crater created.

The Physics of Speed & Kinetic Energy

Kinetic energy has a nonlinear relationship with speed ($KE \propto v^2$).



Rule: Increasing speed has a much greater effect than increasing mass. If speed doubles, kinetic energy quadruples.



Two Forms of Motion

Translational Kinetic Energy

Motion due to a change of position (moving from point A to point B). Example: A thrown ball.

Rotational Kinetic Energy

Energy associated with motion around an axis. Example: A spinning Ferris wheel.



Potential Energy: Energy Waiting to Happen

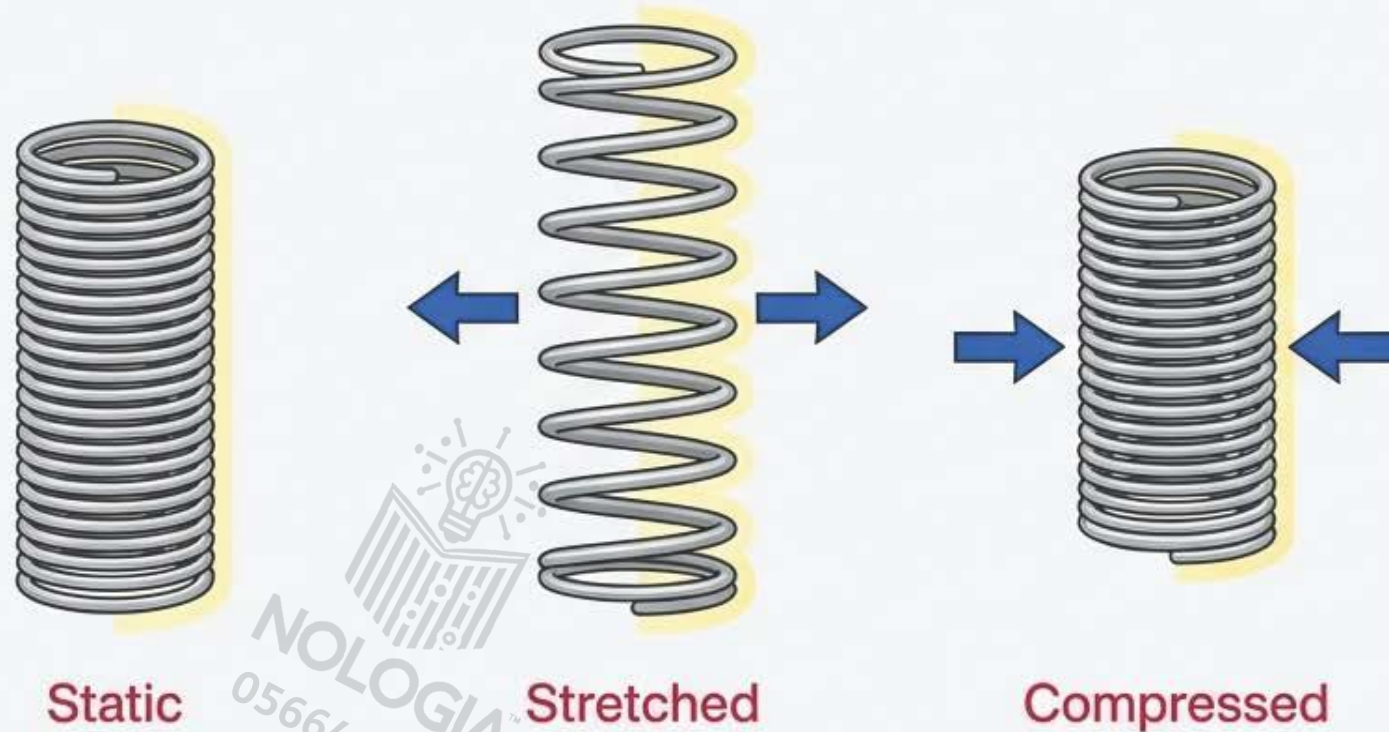


Potential Energy (PE) is stored energy due to the interactions between objects or particles.



- It is not 'doing' work yet; it is stored.
- It depends on the positions of objects (height, compression).
- Examples: A rock on a hill, a stretched rubber band, a coffee cup on a table.

Elastic Potential Energy & Systems

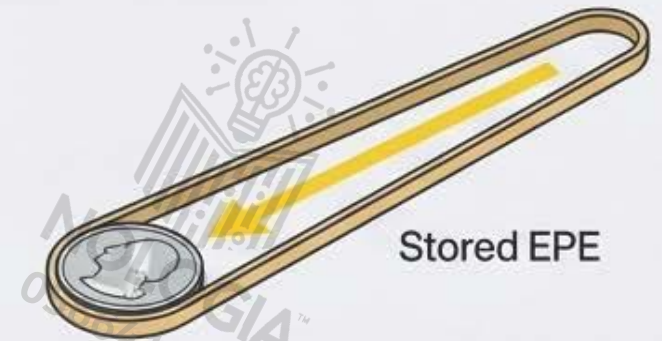


Investigation: Slingshot Physics

Lab Procedure: A rubber band is stretched to push a nickel.

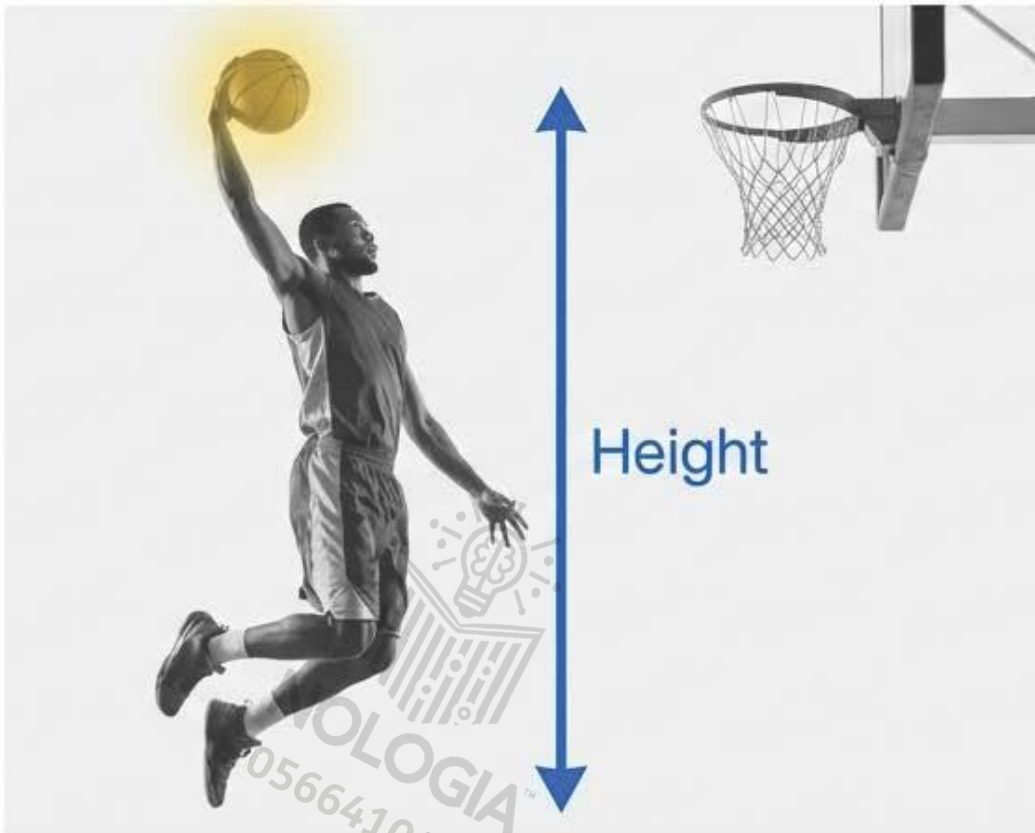
Result: The farther the band is stretched, the farther the nickel travels.

Concept: The rubber band and nickel form a System. Work done to change the shape (stretch) is stored as Elastic Potential Energy.



Gravitational Potential Energy (GPE)

Energy stored due to the gravitational attraction between an object and Earth.



Two factors determine GPE:

- **Mass:** Heavier objects store more GPE.
- **Height:** Objects higher from the ground store more GPE.

Concept: To increase GPE, a force must be applied to lift the object against gravity.

Data Analysis: Dropping the Ball

Comparing Mass and Height Effects on GPE

Marble 1 (Mass = 7 g)

Height 0.5 m	Impact: 2 drops volume
Height 2.0 m	Impact: 8 drops volume

Marble 2 (Mass = 2.5 g)

Height 0.5 m	Impact: 1 drop volume
Height 2.0 m	Impact: 3 drops volume

Analysis

Pattern 1: As height increases, energy (crater size) increases.

Pattern 2: The heavier marble (7g) always has more energy than the lighter one (2.5g) at the same height.

The Physics of Lifting: GPE Relationships

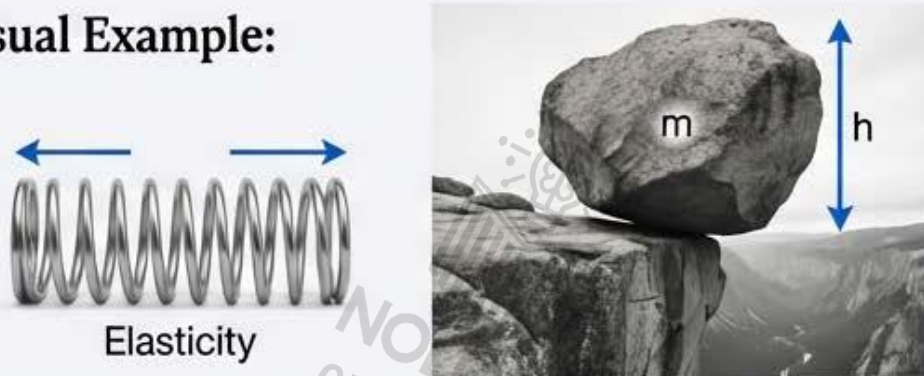
Real-world application of GPE.



GPE and Mass are linearly related. GPE and Height are linearly related.

Scenario: Lifting a full backpack requires more **force** against gravity than an empty one. Therefore, the full backpack stores more **Gravitational Potential Energy** at the same height.

Master Comparison: Kinetic vs. Potential

Kinetic Energy (KE)	Potential Energy (PE)
Definition: Energy of Motion.	Definition: Stored Energy (Position/Condition).
Key Variables: Mass (m) and Speed (v).	Key Variables: Mass (m), Height (h), Elasticity.
Math Relationship: Linear to Mass. Squared to Speed (v^2).	Math Relationship: Linear to Mass and Height. ↗ & ↗
Visual Example:  A speeding baseball.	Visual Example:  Elasticity A stretched spring or rock on a hill.

STEM Career: Roller Coaster Designer

Applying physics to create safe and thrilling experiences.

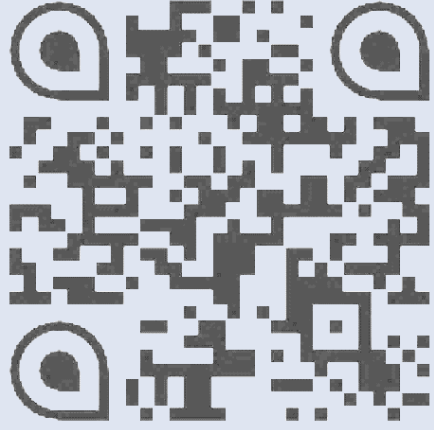


Engineers use physics to design rides that are thrilling but safe. The first hill drags the coaster up to maximize Gravitational Potential Energy. This PE then converts into Kinetic Energy, providing the speed needed to safely traverse loops and turns.

Summary & Key Takeaways

- **Energy** is the ability to cause change.
 - **Kinetic Energy** depends on **Mass** (linear) and **Speed** (squared). Speed has a larger effect on energy than mass.
 - **Potential Energy** is stored due to position (**Height**) or condition (**Stretched/Compressed**).
 - **Systems**: We analyze energy by looking at the interaction between objects (e.g., Earth + Ball).
- **Conservation**: Energy is never lost, just transformed (e.g., PE converts to KE on a coaster).

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Module (2): Mechanical Energy

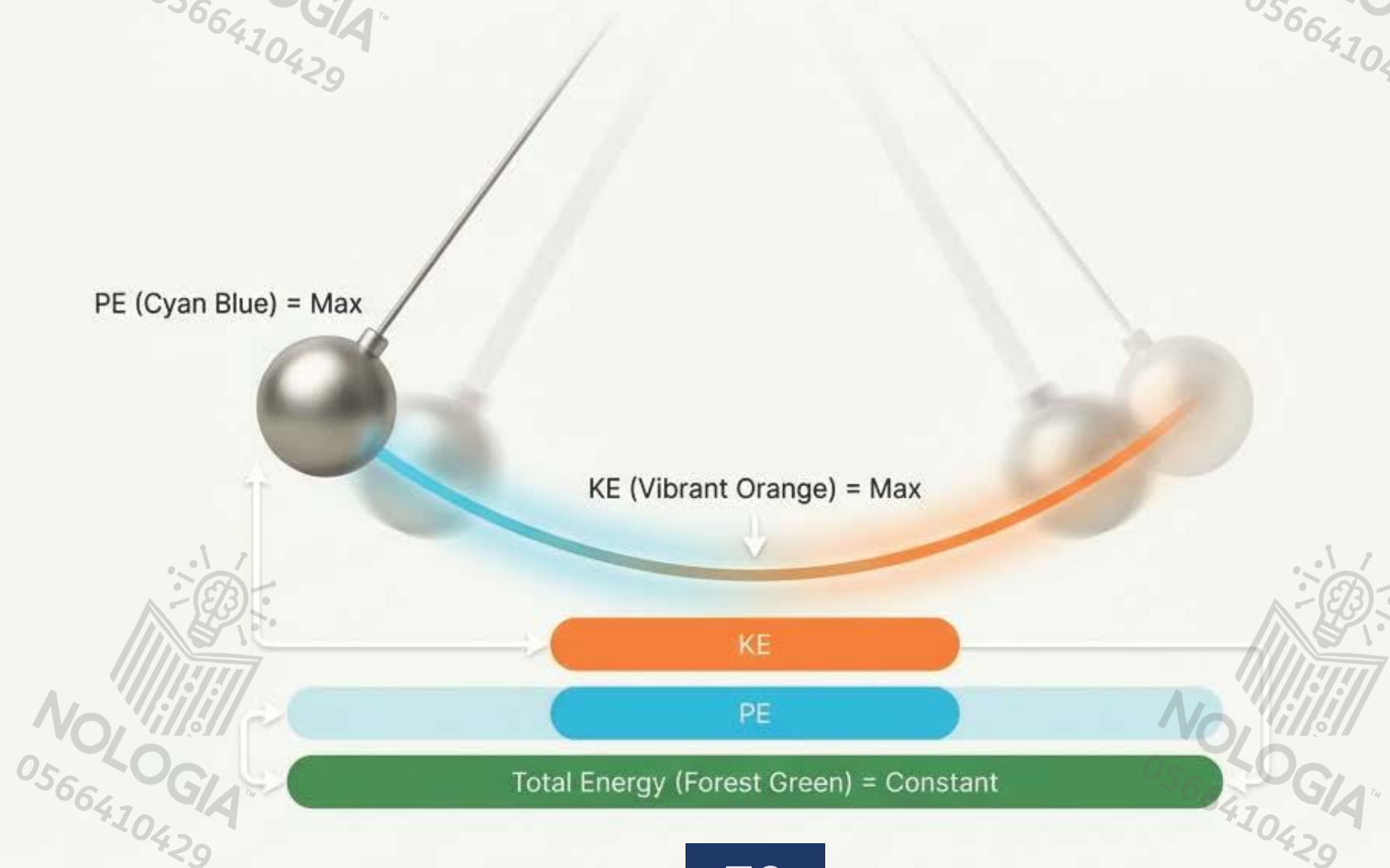
03

Third Lesson: Conservation of Energy

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Conservation of Energy

From Pendulums to Power Plants: Tracking the Flow of the Universe





Moving and Off the Ground

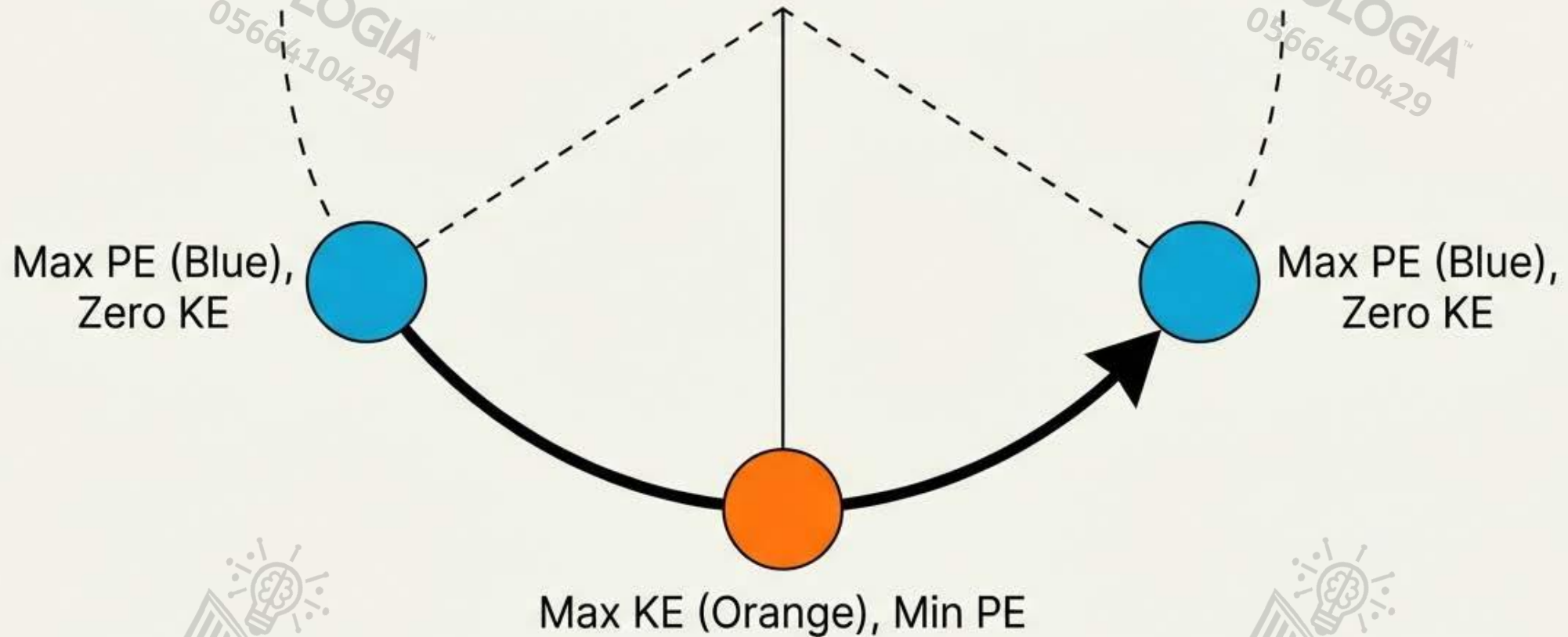
Consider a rider on a water slide. They possess two traits simultaneously:

1. **Height**: Above the ground (Gravitational **Potential Energy**).
2. **Speed**: In motion (**Kinetic Energy**).

$$\text{Mechanical Energy} = \text{Potential Energy} + \text{Kinetic Energy}$$

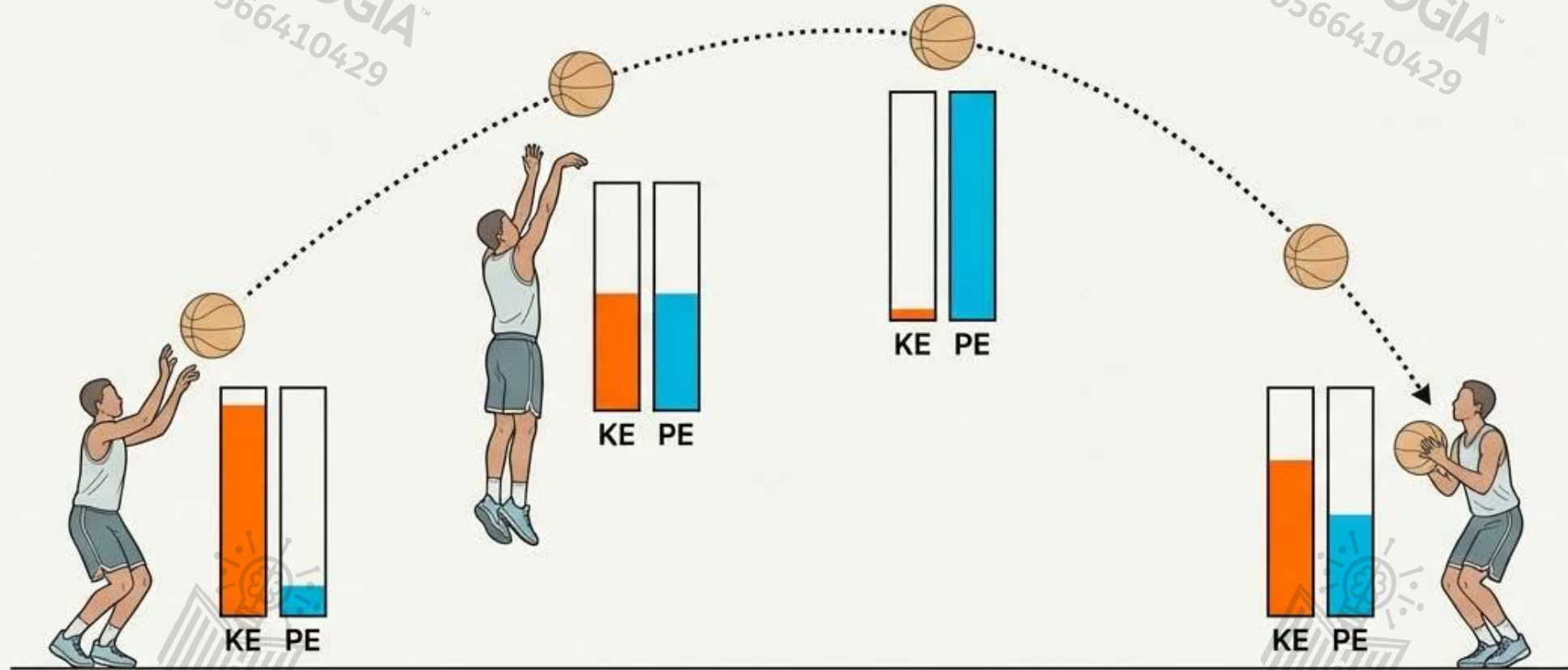
Unit of Measurement: Joules (J)

The Pendulum: A Perfect Trade



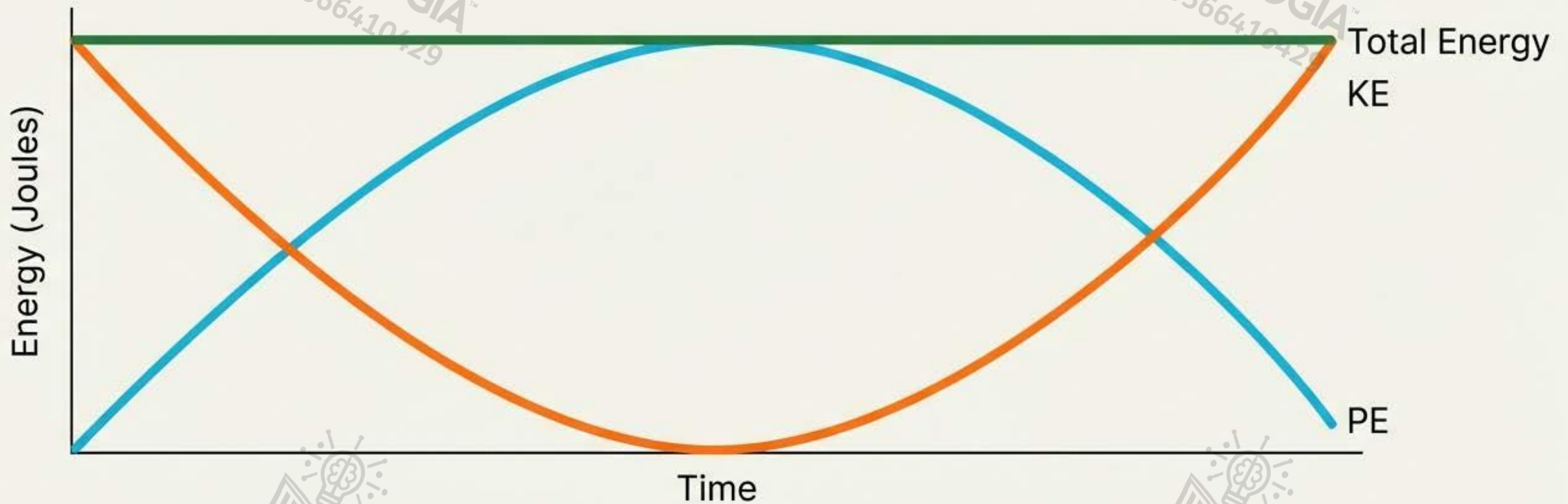
Energy is constantly transferred. Gravity pulls it down (gaining speed/KE), and inertia carries it up (gaining height/PE).

The Trajectory of a Toss



As Kinetic Energy decreases, Potential Energy increases by the same amount.
The speed at the bottom determines the height at the top.

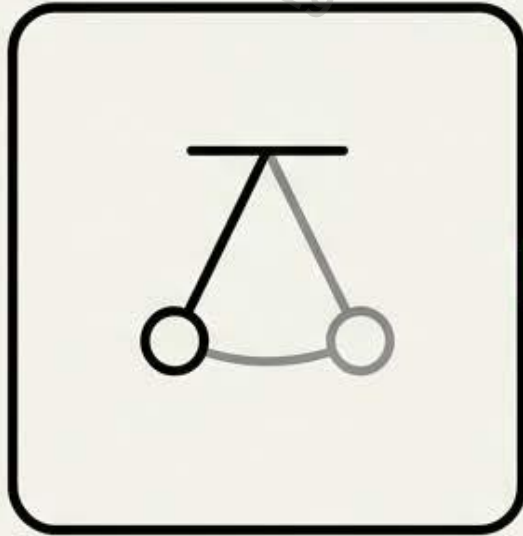
The Law of Conservation of Energy



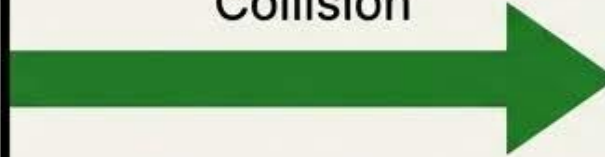
The Law: Energy is neither created nor destroyed.
It is only transferred from one form to another.

Systems and Transfer

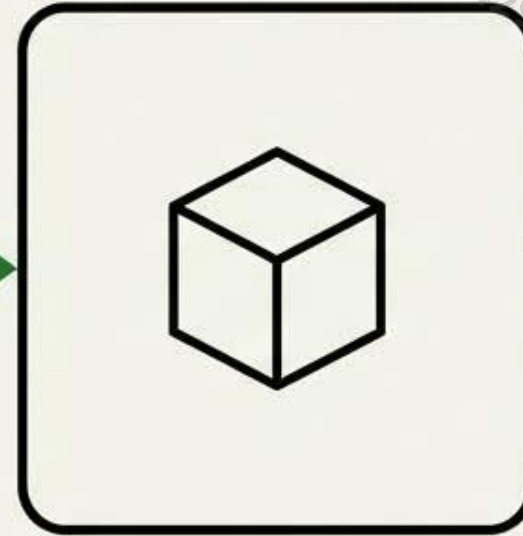
Source Object: Pendulum



Collision



Receiver Object: Box



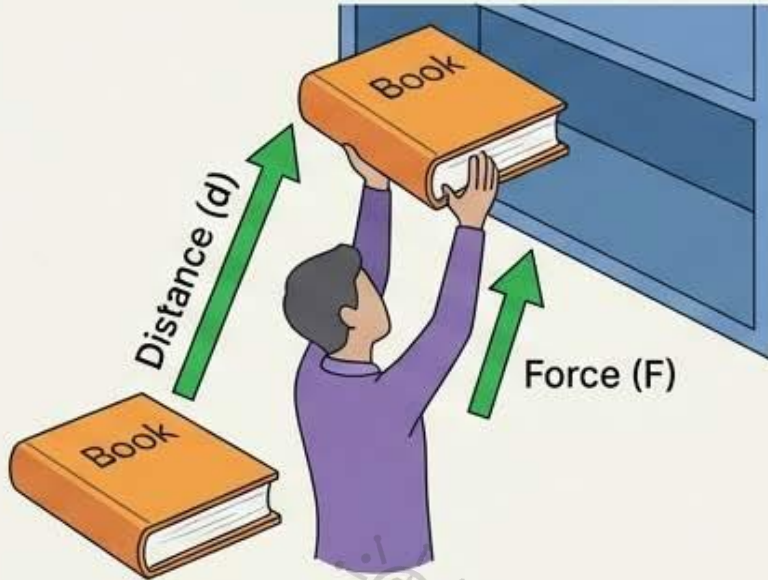
Evidence of Transfer

1. Motion: The box moves after impact.
2. Sound: Vibration heard upon impact.
3. Speed Change: Pendulum slows down, Box speeds up.

What is Work?

$$\text{Work (W)} = \text{Force (F)} \times \text{Distance (d)}$$

WORK DONE



WORK DONE

Force applied + Object moves = **WORK DONE.**

NO WORK DONE



NO WORK DONE

Force applied + No movement = **NO WORK DONE.**

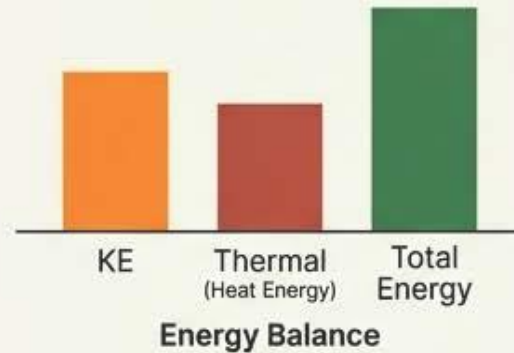
Work is the transfer of energy. If the object does not move in the direction of the force, no work is done.

Friction: Where Does the Energy Go?

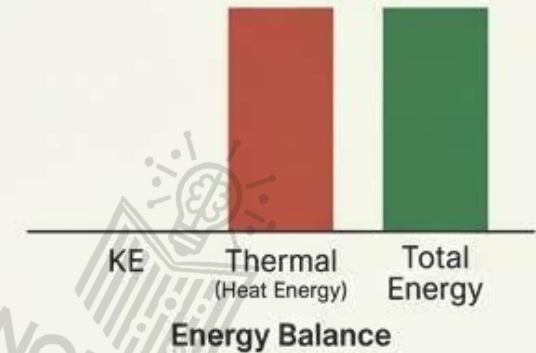
Coasting



Braking



Stopped

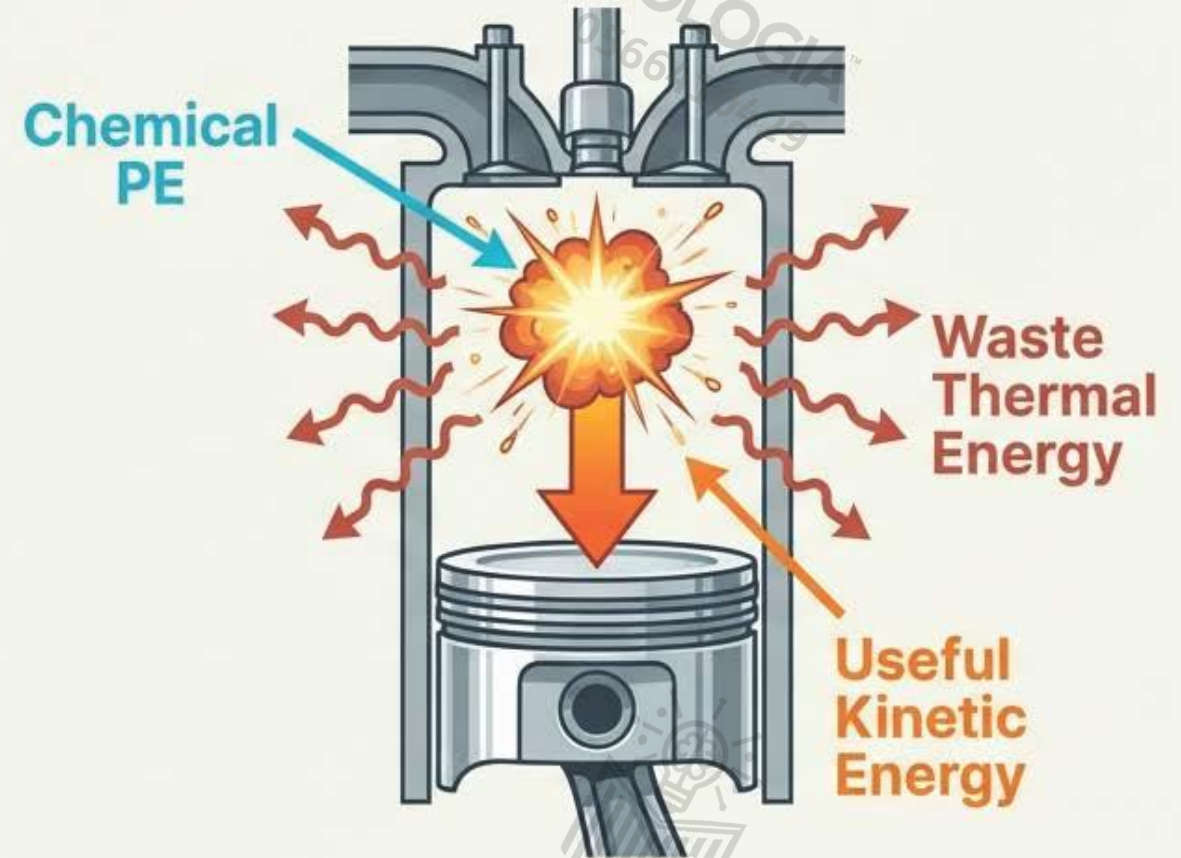


Energy isn't lost; it is transformed into heat (Thermal Energy) by Friction.

Thermodynamics: Quantity vs. Quality

First Law: The quantity of energy in the universe is constant.

The Reality: “Running out of energy” means running out of USEFUL energy.



In most machines, a significant portion of energy becomes heat that cannot do work.

Entropy and the Spread of Energy

The Second Law of Thermodynamics

Ordered

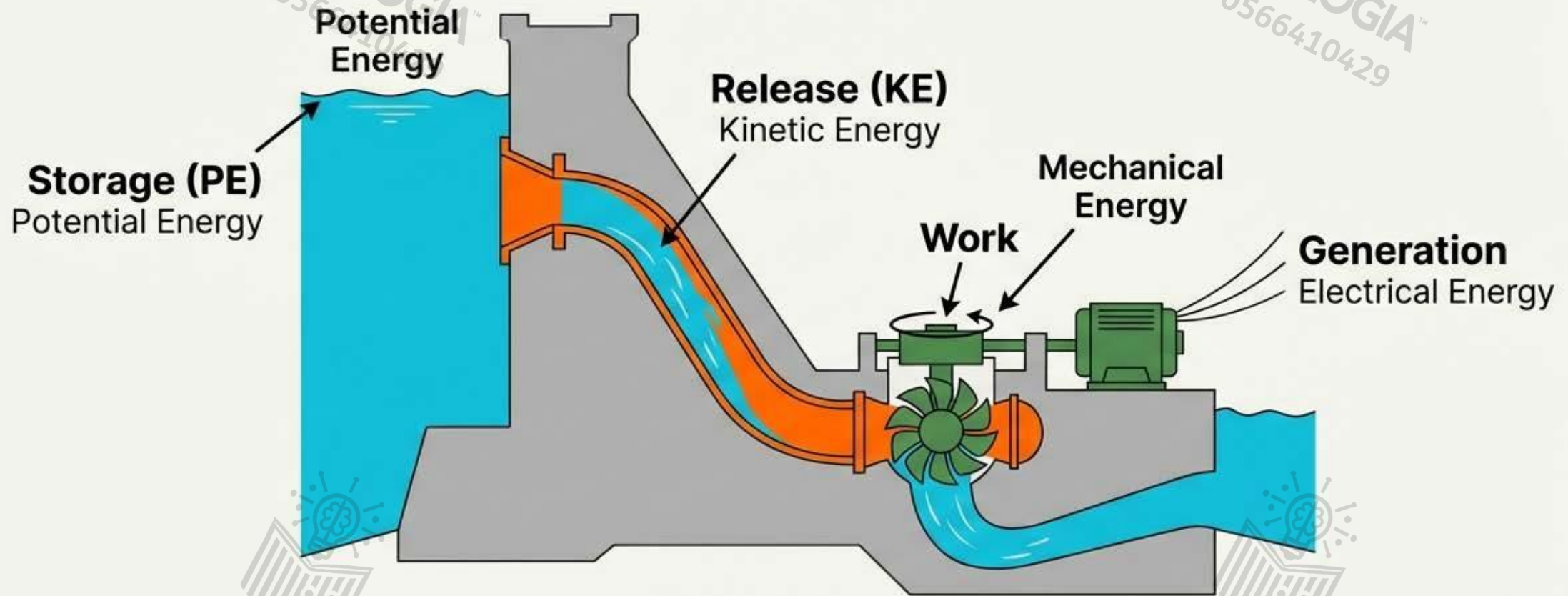


Disordered



Energy spontaneously tends to become more disordered.
It flows from hot to cold and is difficult to gather back.

Application: Hydroelectric Power



From the height of the reservoir to the light in your room, energy is never created, only changed.

Nothing is Lost, Only Changed



∞ **The Rule:** Energy cannot be created or destroyed.



The Math: Mechanical Energy = PE + KE.



The Reality: Friction transforms Mechanical Energy into Thermal Energy.



The Trend: Energy flows from concentrated to spread out (Entropy).

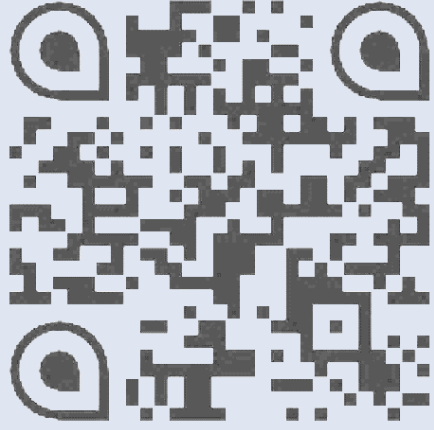
Key Definitions & Formulas

Term	Definition
Mechanical Energy	The sum of potential and kinetic energy in a system.
Kinetic Energy (KE)	Energy of motion. Depends on mass and speed.
Potential Energy (PE)	Stored energy. Gravitational PE depends on mass and height.
Work (W)	Force x Distance. Transfer of energy through motion.
Law of Conservation	Energy total remains constant in a closed system.
Friction	Force that resists motion, converting mechanical energy to thermal energy.
Thermodynamics	The study of energy and how it changes forms.

Module (3): Electromagnetic Forces

	Lesson Title	Page
3-1	Magnetic Forces	84
3-2+3	Electric Forces + Simple Circuits	100
3-4	Electromagnetism	116

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Module (3): Electromagnetic Forces

01

First Lesson: Magnetic Forces



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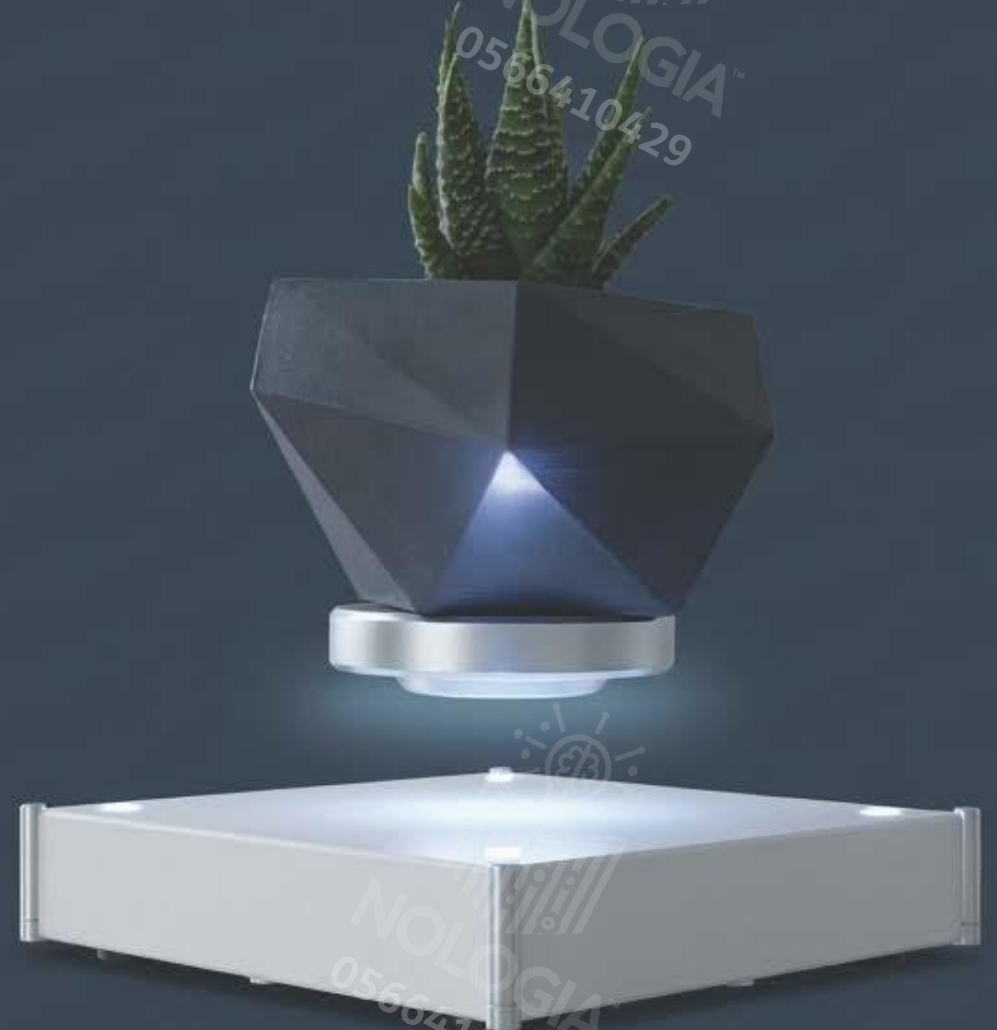
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MAGNETIC FORCES: THE INVISIBLE ARCHITECTURE

A NOLOGIA Comprehensive Guide to Attraction, Repulsion, and Fields.

What keeps this plant floating? It isn't magic; it is the precise application of magnetic force. In this guide, we will investigate the invisible rules that govern magnets, from the atomic structure inside a nail to the molten core of our planet.



ACTION AT A DISTANCE: DEFINING MAGNETIC FORCE

Definition: A **Magnetic Force** is a noncontact force, meaning it applies force without direct physical contact.

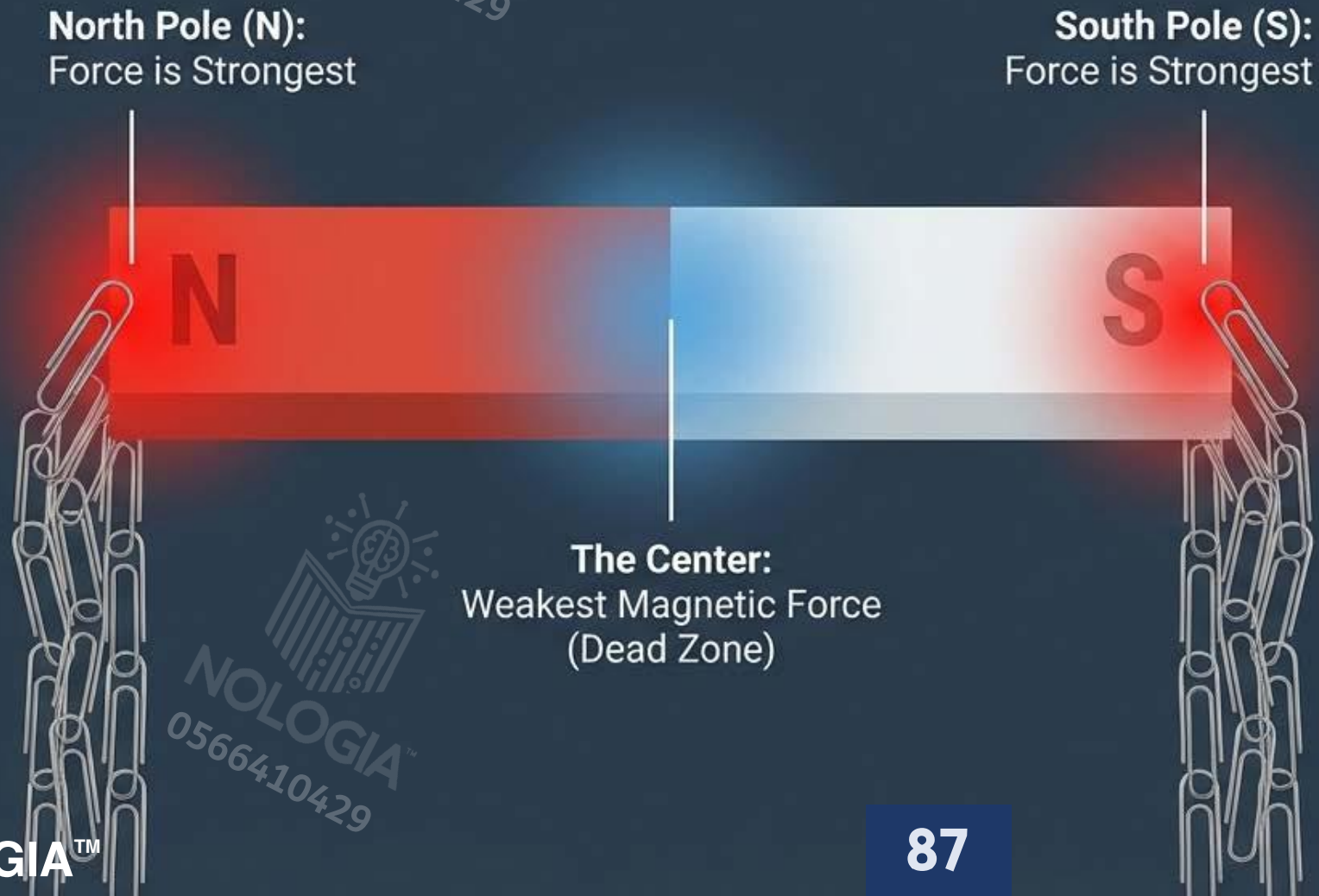
The Evidence (Lab Results):

1. **Attraction:** Magnets attract materials containing **Iron, Nickel, or Cobalt**.
2. **Terminology:** These are called **Ferromagnetic elements** (from Latin 'ferrum' for iron).
3. **Non-Magnetic:** Wood, plastic, glass, and copper (pennies) are not attracted.

Key Concept: A magnet is defined as any object that attracts iron and materials with magnetic qualities similar to iron.



THE GEOGRAPHY OF FORCE: MAGNETIC POLES

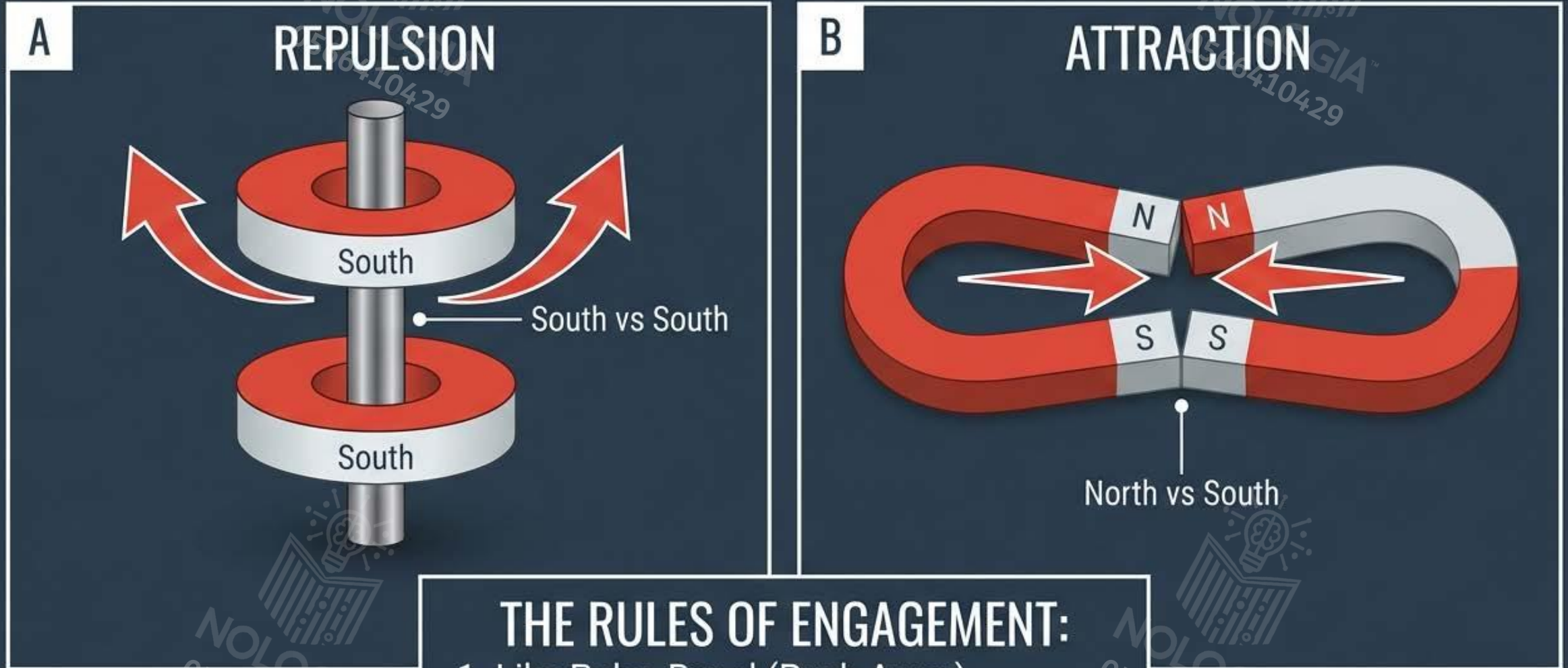


Investigative Note

If you break a magnet in half, you do not get a separate North and South.

You get two smaller, complete magnets, each with its own N and S poles.

THE LAWS OF INTERACTION: PUSH AND PULL

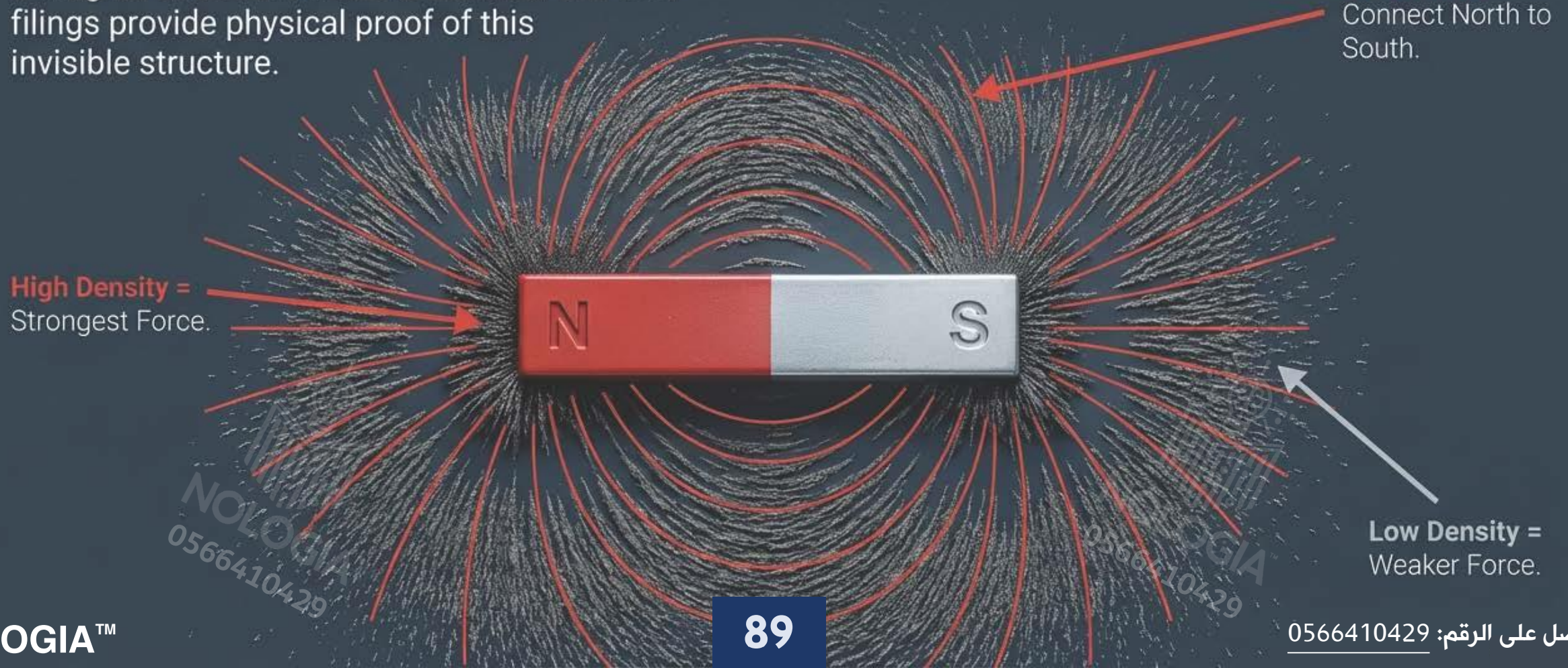


THE RULES OF ENGAGEMENT:

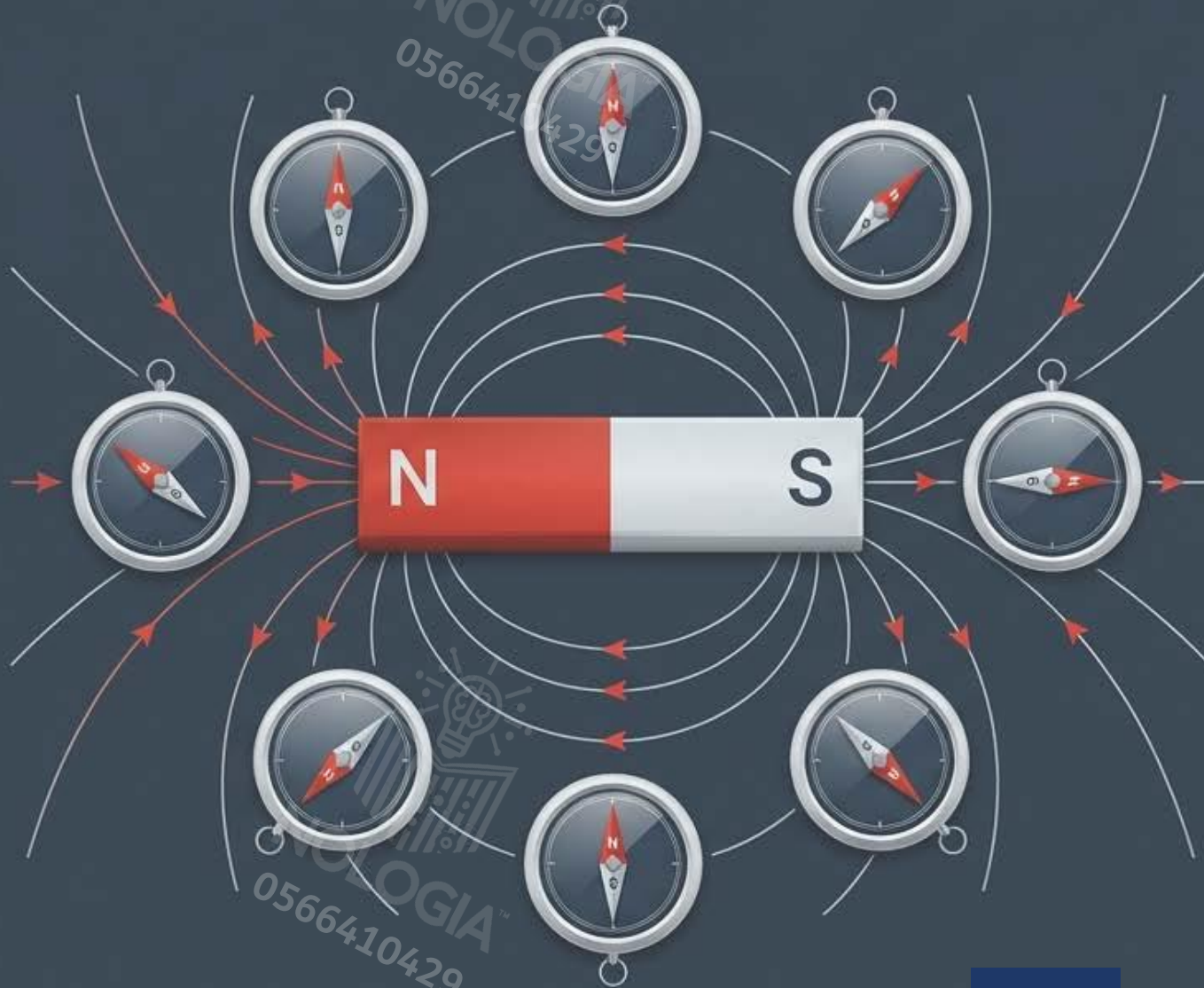
1. Like Poles Repel (Push Away).
2. Opposite Poles Attract (Pull Together).

VISUALIZING THE INVISIBLE: THE MAGNETIC FIELD

A **Magnetic Field** is the invisible area surrounding a magnet where the force is exerted. The iron filings provide physical proof of this invisible structure.



THE NAVIGATOR: HOW A COMPASS WORKS

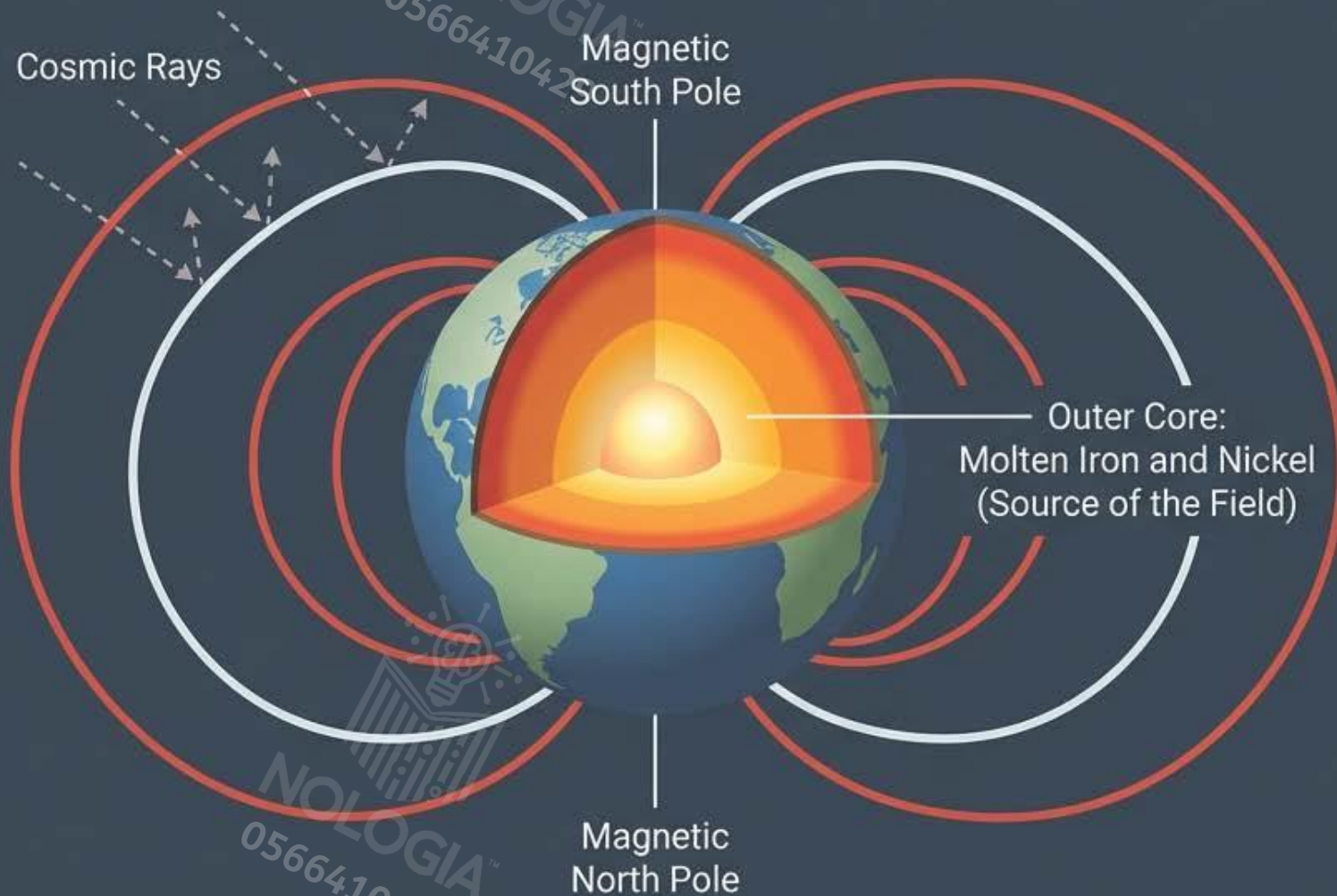


A compass needle is simply a small magnet that is free to spin.

It acts as a detector, aligning itself with the magnetic field lines.

Note: The North pole of the compass needle points toward the South pole of the magnet (because opposites attract).

PLANETARY PHYSICS: EARTH AS A GIANT MAGNET



The Polarity Paradox: Earth's Geographic North attracts the 'North' of compasses. Since opposites attract, Earth's physical magnetic pole in the North is actually a South pole.

The magnetic pole is dynamic, currently moving from Canada toward Siberia at ~40 km/year.

BIOLOGICAL CONNECTIONS: MAGNETIC MIGRATION



INTERNAL COMPASS:

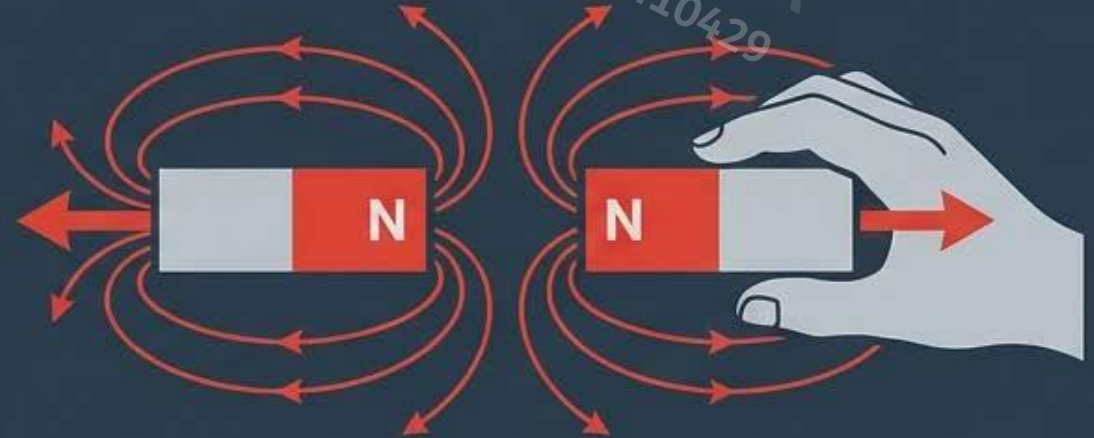
Animals such as birds, salmon, and monarch butterflies possess an innate ability to detect Earth's magnetic field.

EVIDENCE: Studies show migratory birds realign their flight paths to match magnetic headings, allowing navigation across featureless oceans without visual landmarks.

STORING FORCE: MAGNETIC POTENTIAL ENERGY



Stored Energy (Spring)



Stored Energy (Magnetic)

Magnetic Potential Energy is energy stored in an object due to its position within a magnetic field.

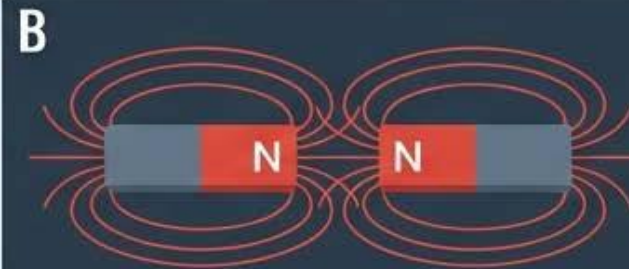
The Rule: Whenever you force a magnet against its natural tendency (pushing repelling poles together OR pulling attracting poles apart), you increase the stored Potential Energy.

THE PHYSICS OF POSITION: CHANGING POTENTIAL ENERGY

LIKE POLES (Repelling)



Pushing
Together.



Potential Energy
INCREASES.

OPPOSITE POLES (Attracting)



Pulling
Apart.



Potential Energy
INCREASES.

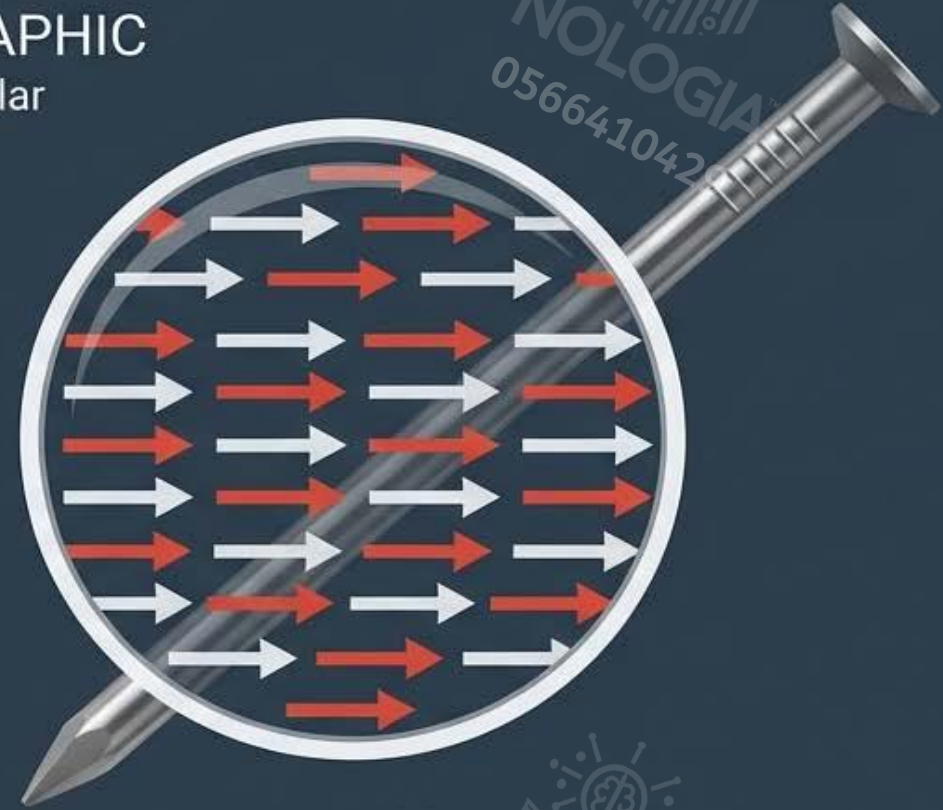
Energy Conversion: When you 'let go' of the magnets, this stored Potential Energy converts into Kinetic Energy (movement) as the magnets snap together or fly apart.

THE MICROSCOPIC VIEW: MAGNETIC DOMAINS

ZOOM-IN GRAPHIC
Roboto Regular



Non-Magnetic
(Random Domains cancel each other out).



Magnetic
(Aligned Domains combine forces).

A **Magnetic Domain** is a region where the magnetic fields of atoms all point in the same direction.

ENGINEERING MAGNETISM: ALIGNING THE DOMAINS

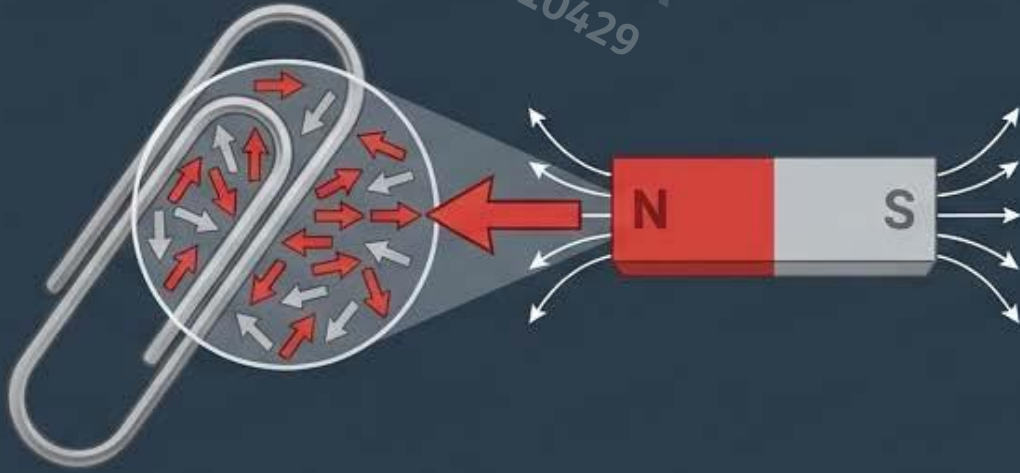


Key Insight

The strong magnetic field of the permanent magnet pulls the domains of the nail into alignment.

TEMPORARY VS. PERMANENT MAGNETS

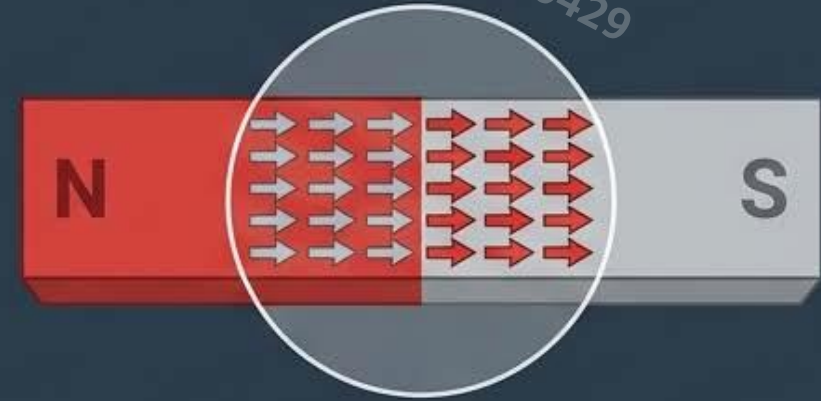
TEMPORARY MAGNETS



Material: Soft Iron.

Behavior: Domains align easily but scramble immediately when the field is removed.

PERMANENT MAGNETS



Material: Mixtures like Alnico (Aluminum, Nickel, Cobalt).

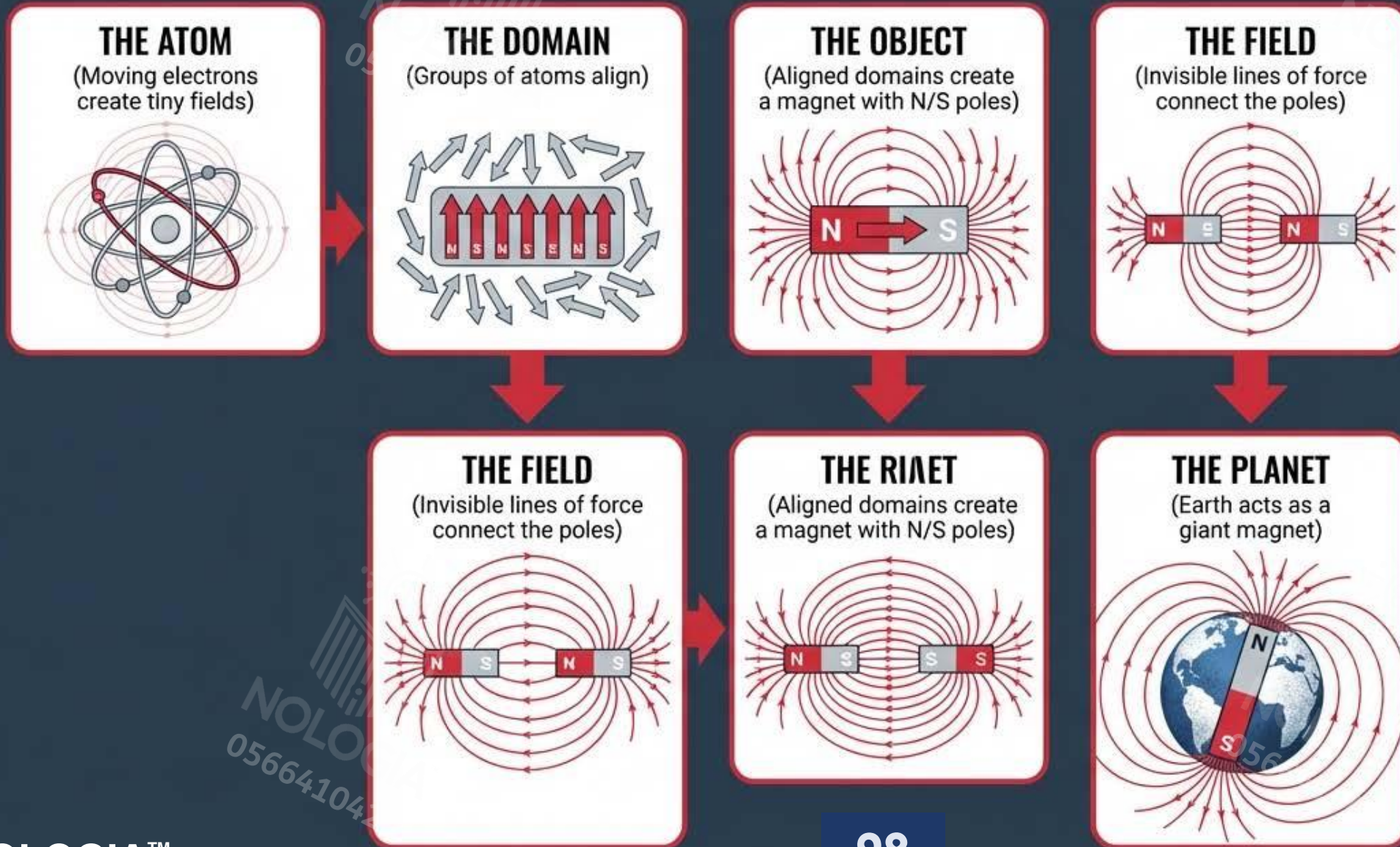
Behavior: Domains remain locked in alignment without an external field.

Demagnetization: Heating or striking a permanent magnet can shake the domains back into a random pattern, destroying the magnetism.

SYNTHESIS: THE CONNECTED SYSTEMS

Vocabulary Recap

- Ferromagnetic
- Noncontact Force
- Potential Energy
- Geomagnetism



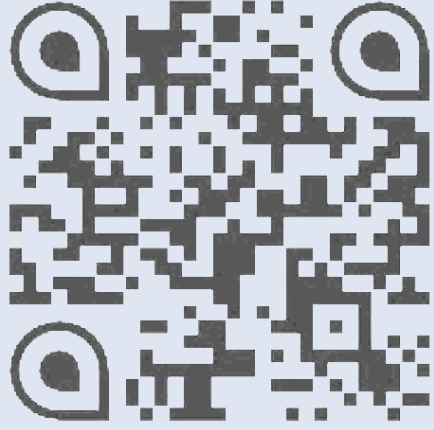
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"Science is the observation of the invisible. From the navigation of migratory birds to the simple act of holding a note on a refrigerator, magnetic forces shape our world."

COMPREHENSIVE REVIEW

- ☒ - Can you define a noncontact force?
- ☒ - Can you predict how potential energy changes when magnets move?
- ☒ - Can you explain why a compass points North?

End of Module 03 Guide.



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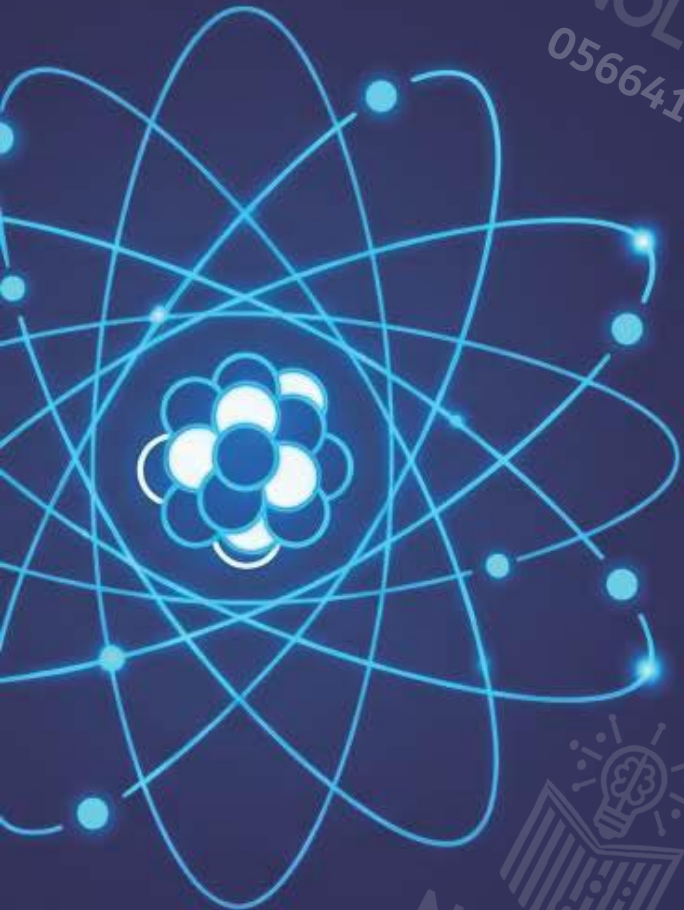
Module (3): Electromagnetic Forces

02

03

Second & Third Lessons:
Electric Forces &
Simple Circuits

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Electric Forces & Simple Circuits

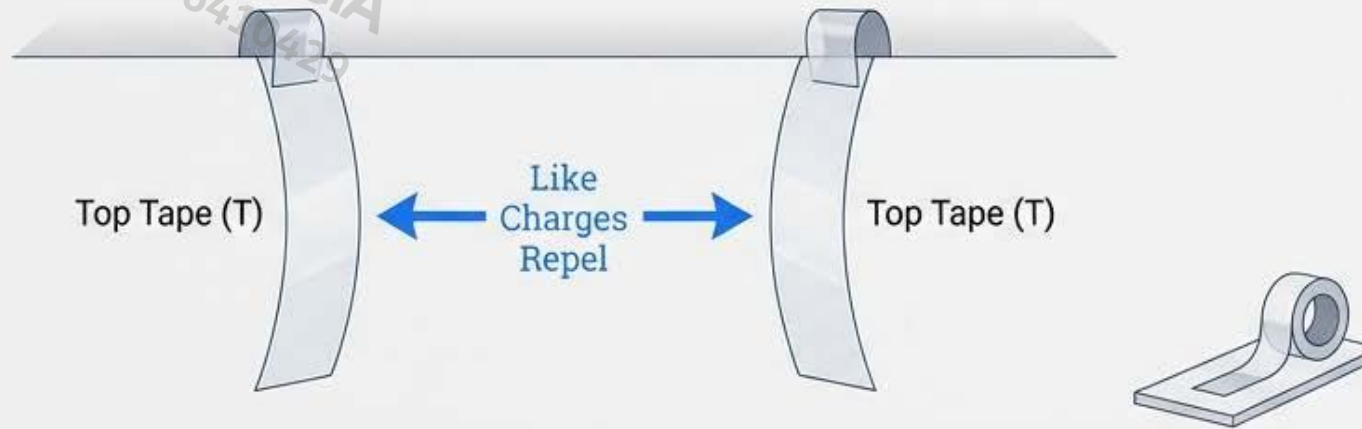
A Comprehensive Study

A Comprehensive Study Guide by NOLOGIA

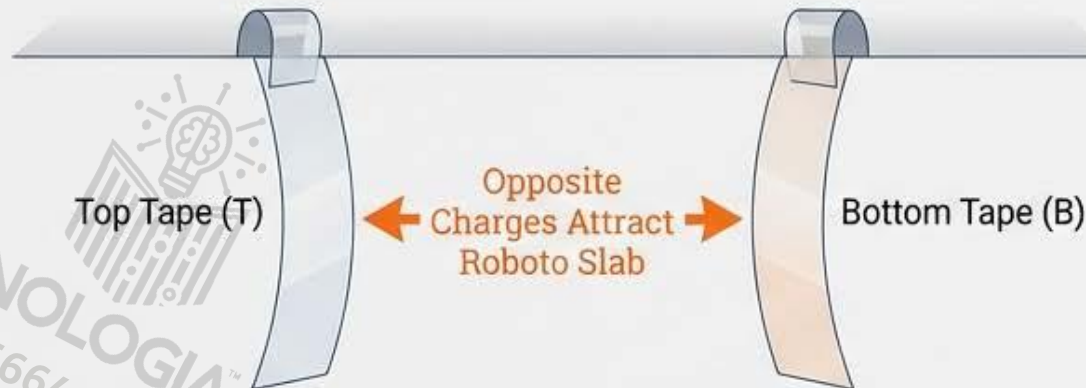


The Foundation: How Electric Charges Interact

Repulsion: Like Charges Repel



Attraction: Opposite Charges Attract



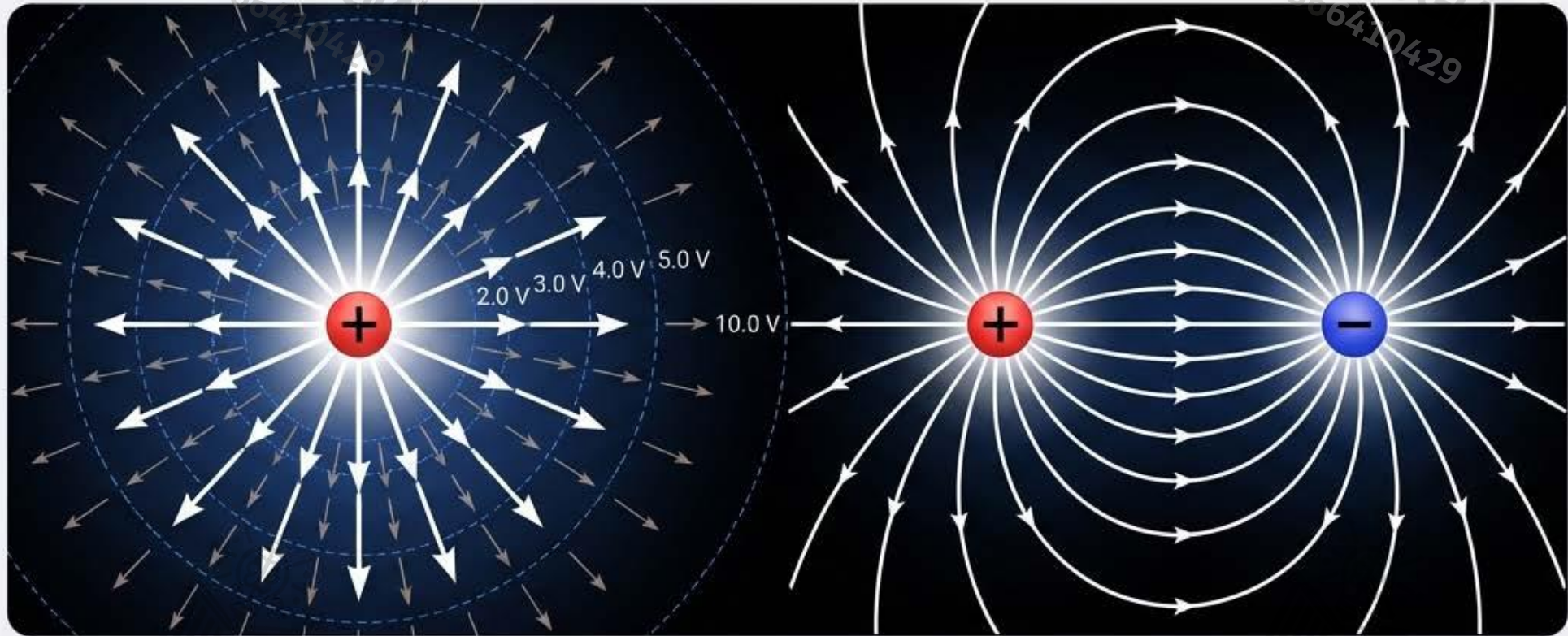
Evidence (The Tape Lab):

1. **Procedure:** Strips of tape were pulled apart to create static charge.
2. **Observation:** Two 'Top' tapes pushed away (Repulsion). A 'Top' and 'Bottom' tape pulled together (Attraction).

Key Inference: A charged object does not have to touch another charged object to apply a force.

The Invisible Influence: Electric Fields

An electric field surrounds charged particles, allowing force to act across a distance.



Factor 1: Total Charge.

More charge = Stronger field.

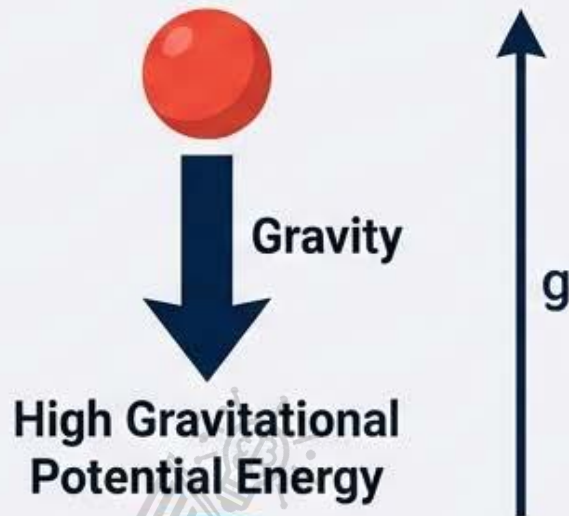
Factor 2: Distance.

Greater distance = Weaker force.

Understanding Potential Energy

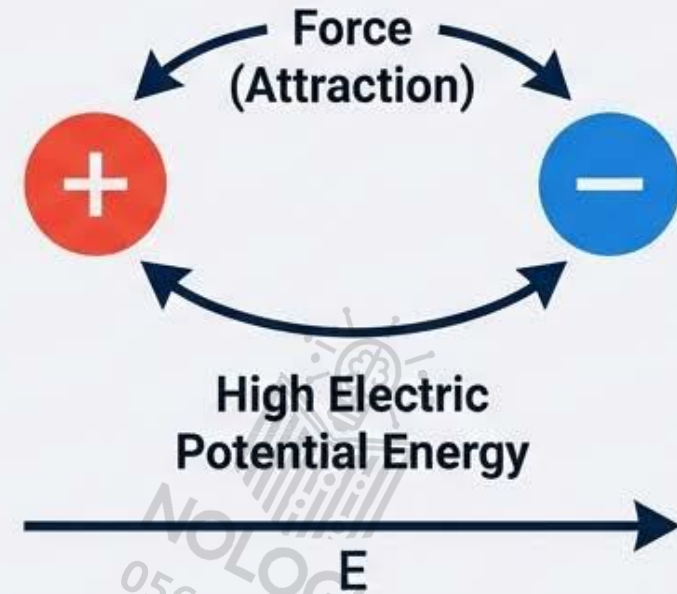
Definition: Stored energy due to the interactions of charges in an electric field.

Gravity (Analog)



Energy is added to the system when you apply force to keep unlike charges apart.

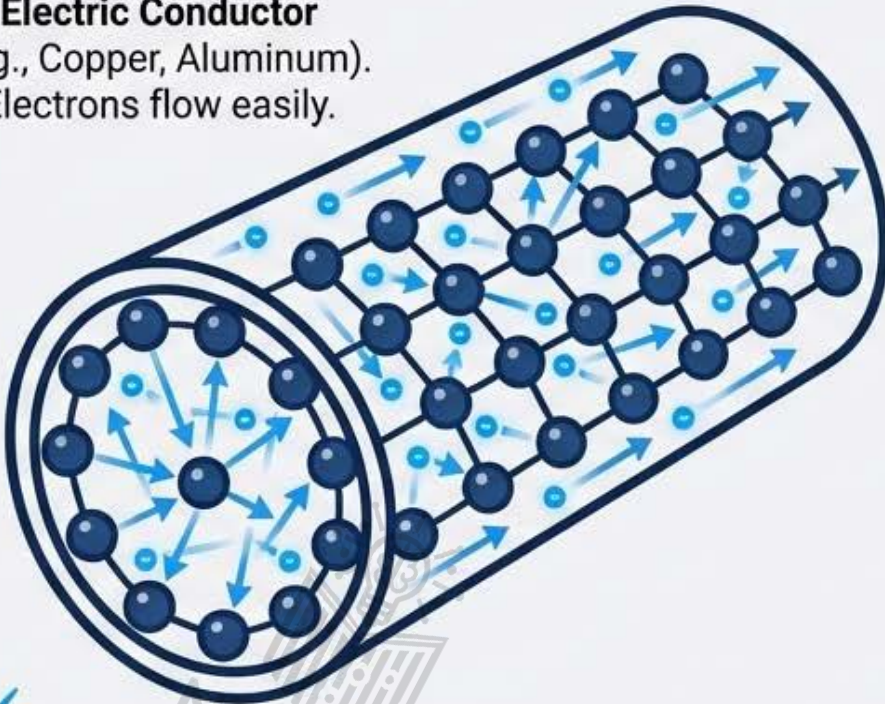
Electricity



Material Interaction: Conductors vs. Insulators

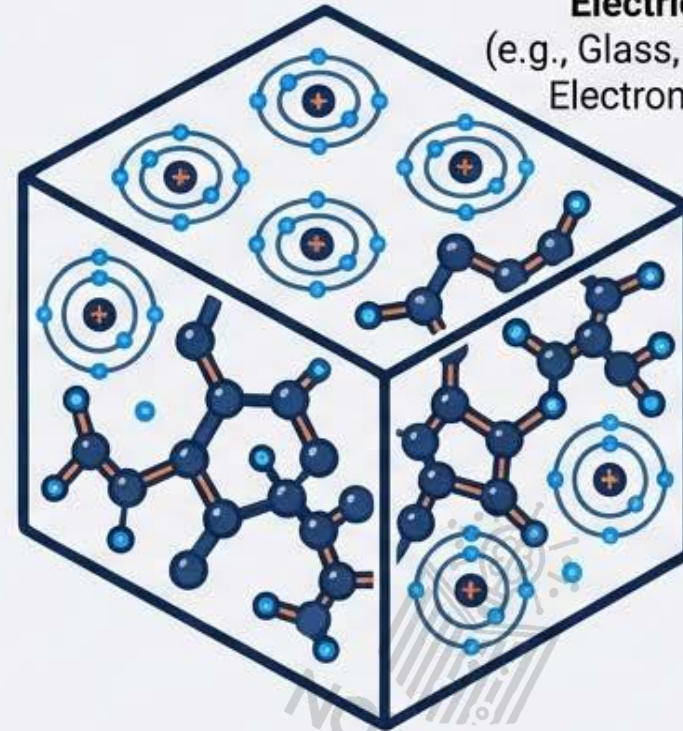
Electric Conductor

Electric Conductor
(e.g., Copper, Aluminum).
Electrons flow easily.



Electric Insulator

Electric Insulator
(e.g., Glass, Rubber, Wood).
Electrons are stuck.



Application: Lightning rods use metal to conduct dangerous charges safely to the ground.

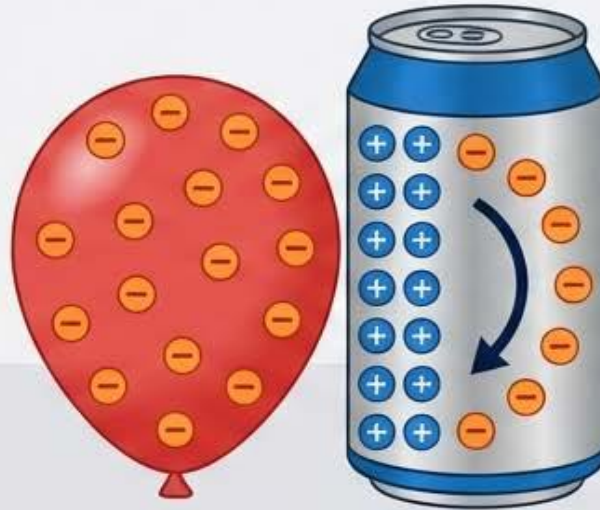
Charging Without Touching: Induction

1. Neutral State



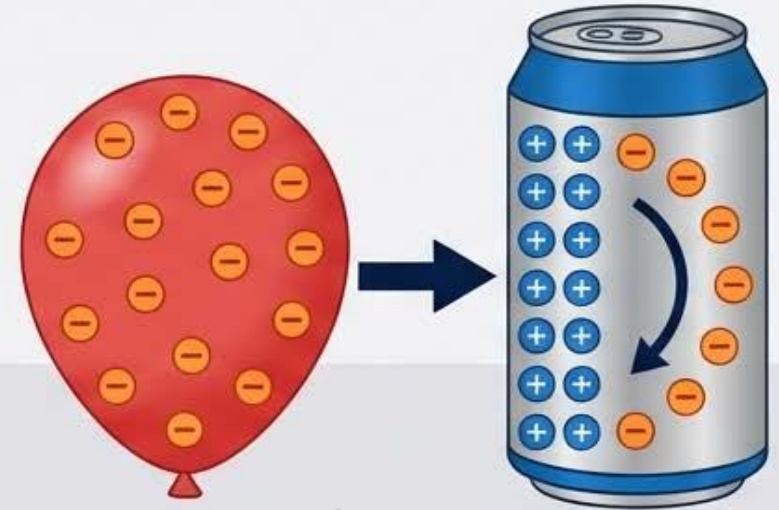
Soda Can

2. Approach



Polarization

3. Result



Attraction Force

Induction charges an object by rearranging internal charges without contact.

Charging by Contact: Conduction

1. Initial State



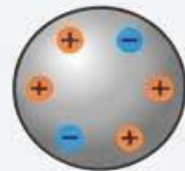
Tank A



Tank B

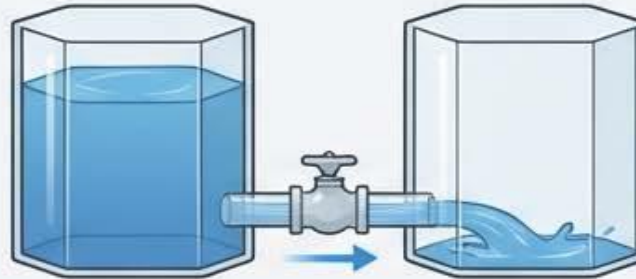


Sphere A



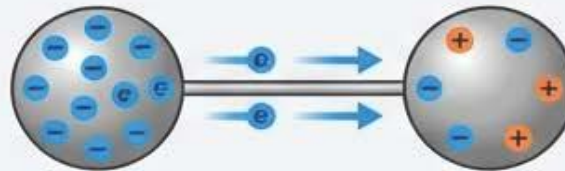
Sphere B

2. Connection & Flow



Tank A

Tank B



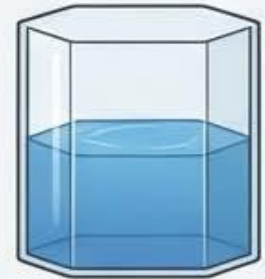
Sphere A

Sphere B

3. Equilibrium



Tank A



Tank B



Sphere A

Sphere B

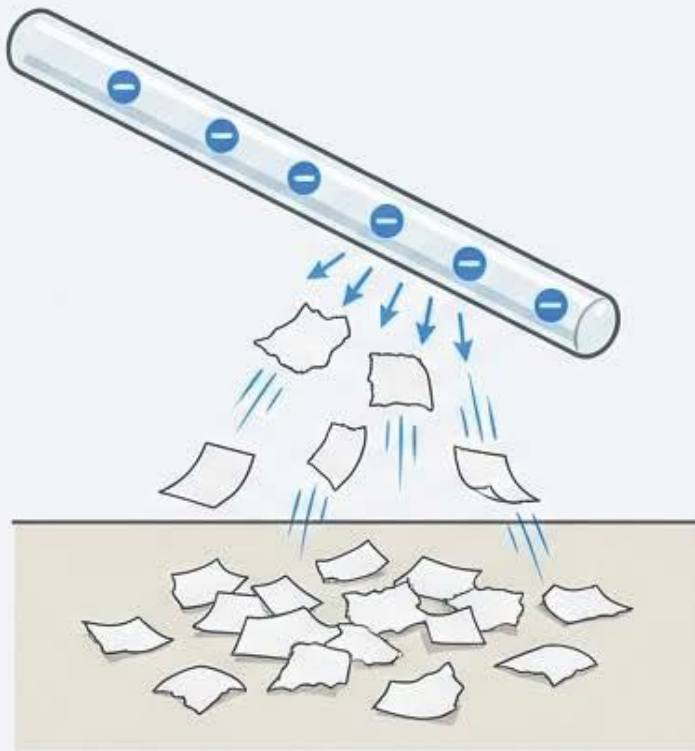
Conduction: Transferring charge between conductors by touching
Electrons flow until concentration is equal.

Conservation of Charge: The total charge in a closed system does not change; it just moves.

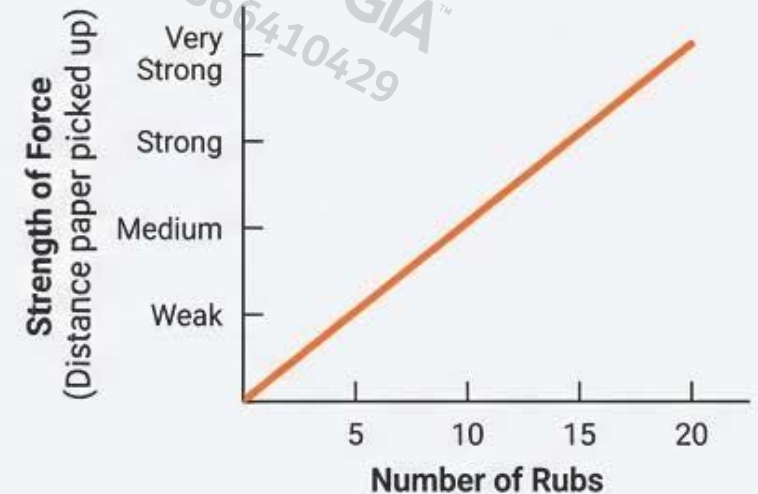
Lab Evidence: The Paper Pick Up



Friction creates Charge.



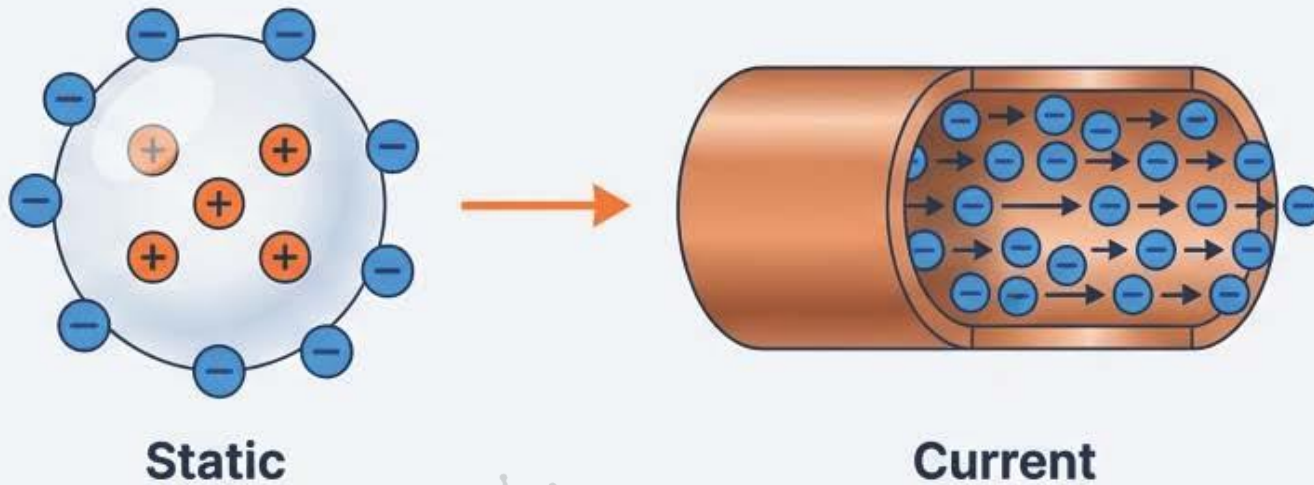
Charged rod attracts neutral paper bits.



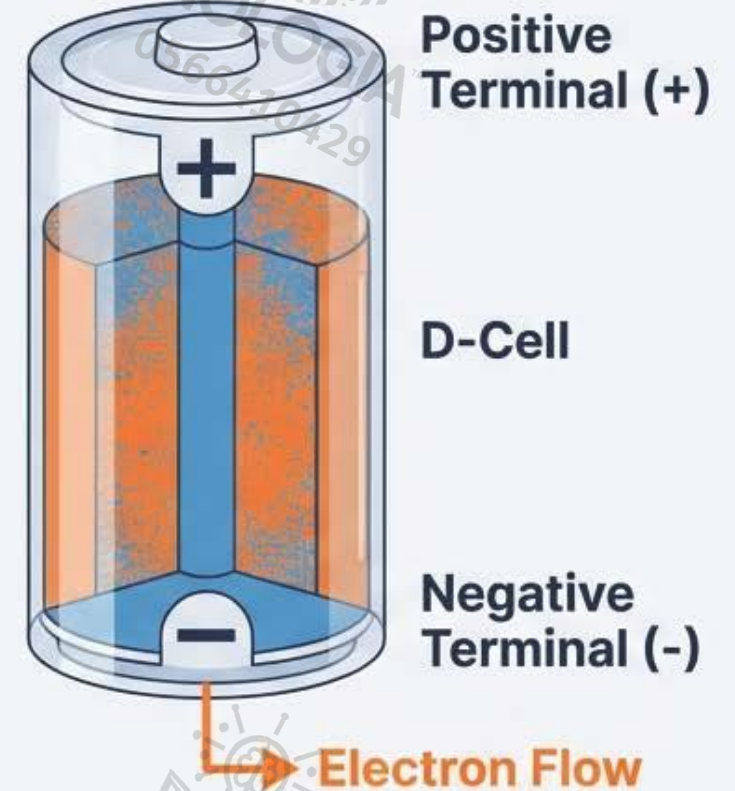
Findings:

- Rubbing transfers electrons.
- More rubbing = More charge transferred.
- Result: Stronger force picks up paper from a greater distance.

From Static to Dynamic: Electric Current

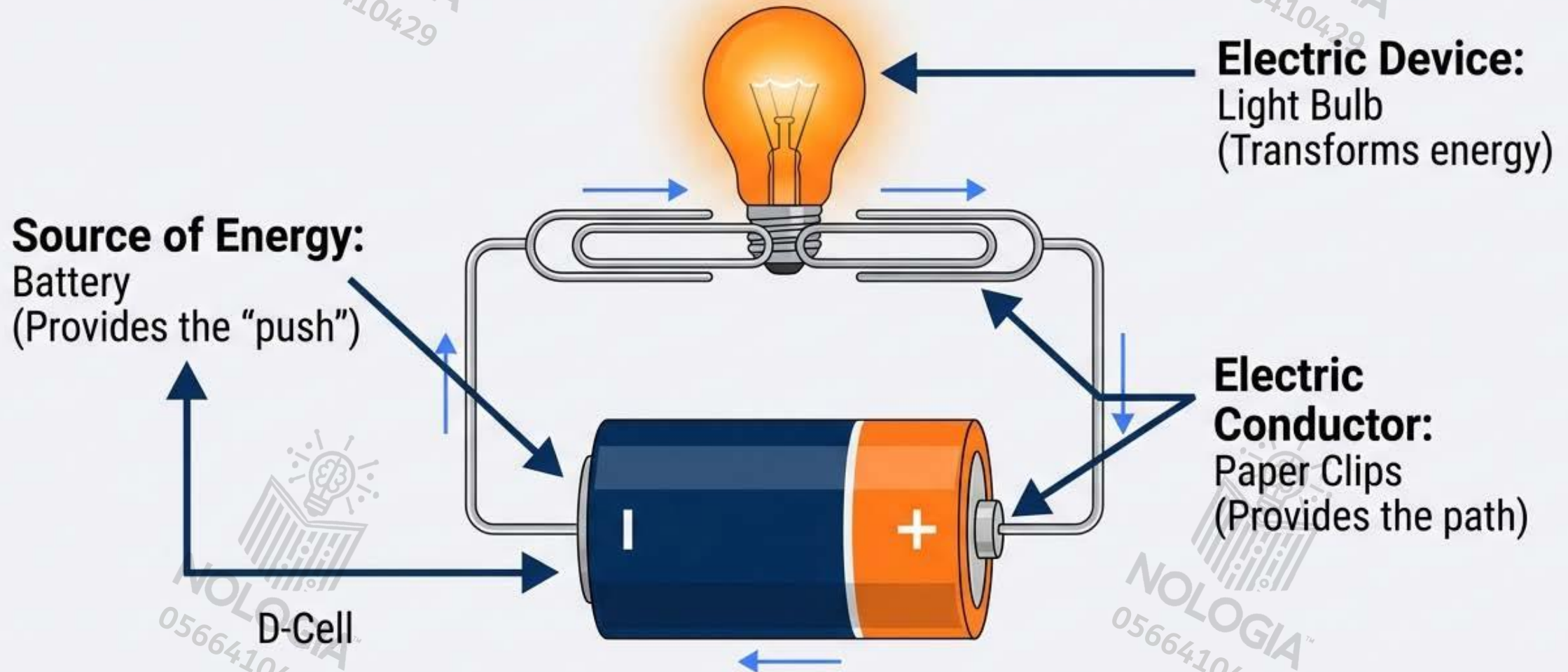


Electric Current is the movement of electrically charged particles.



The **Battery** uses chemical reactions to separate charges, creating the force that drives current.

Anatomy of a Simple Circuit



Controlling the Flow: Open vs. Closed Circuits

OPEN CIRCUIT (Incomplete Path - No Flow)



A switch is a device designed to break or complete the loop safely.

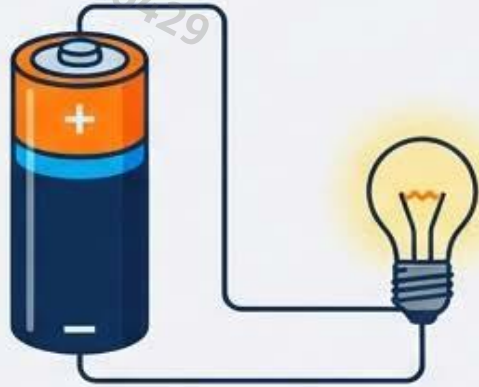
CLOSED CIRCUIT (Complete Path - Current Flows)



A switch is a device designed to break or complete the loop safely.

The Push: Understanding Voltage

Voltage (V) is the electric potential energy difference between two places on a circuit.

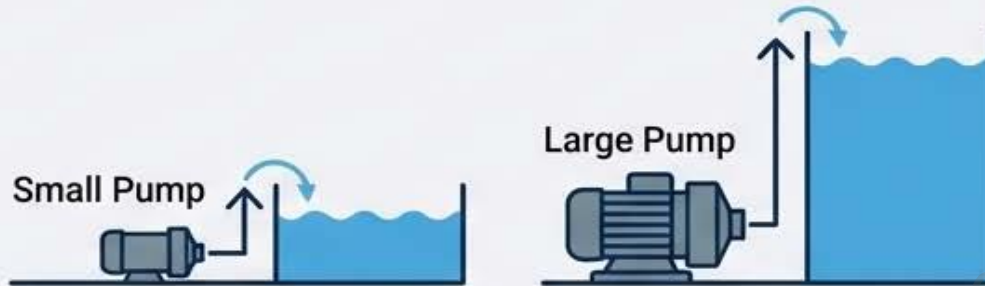


1.5V (Low Potential Difference)



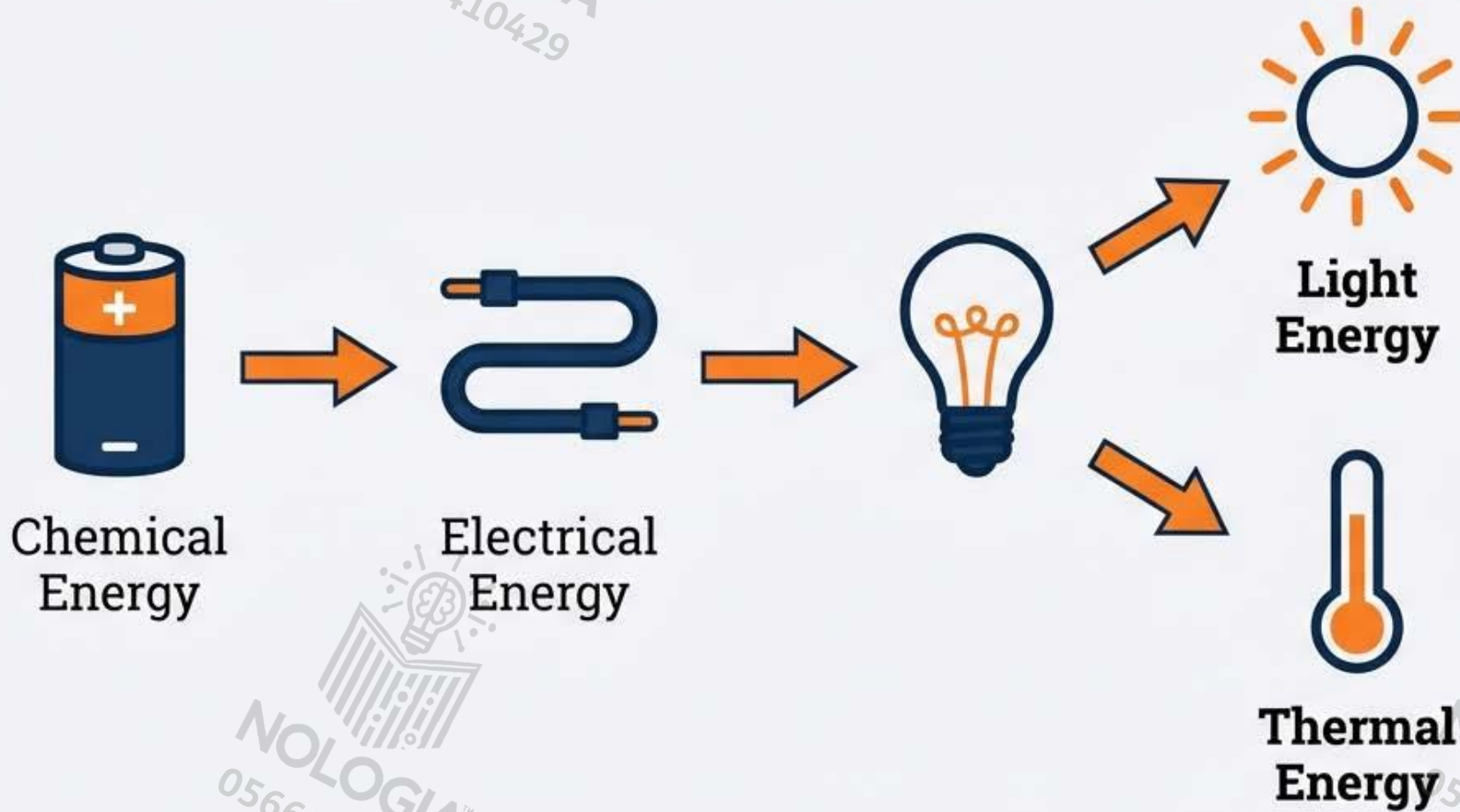
9V (High Potential Difference)

Higher voltage transforms more electric energy into light and heat.



Voltage is like the height the pump pushes the water.

Energy Transformation



Electricity is a carrier. It is transformed into other forms by the device.

Science & Society: The Smart Grid

The Problem: Aging infrastructure and overload lead to blackouts.

The Solution (Smart Grid):

- **Computer Routing:** Automatically sends power where needed (green lines).
- **Smart Meters:** Allow homes to track usage and save energy.
- **Scale:** Transmission lines carry over 110,000 Volts.



Module Review: Key Concepts

Forces

Like charges repel;
Opposites attract. Force
depends on charge
amount & distance.



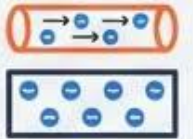
Charging Methods

Induction (No touch) vs.
Conduction (Touch).



Materials

Conductors (Free electrons,
e.g., Copper) vs. Insulators
(Stuck electrons, e.g.,
Rubber).



Current

The flow of charged
particles through a
conductor.



Voltage

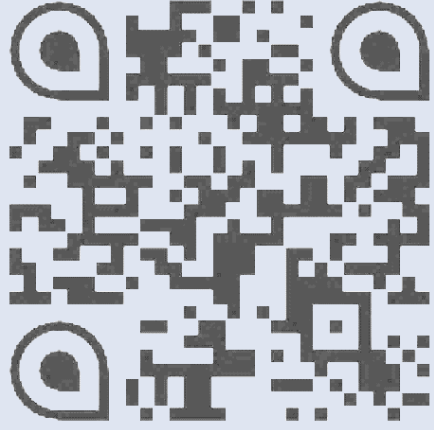
The electric potential
energy difference (The
"Push").



Circuit Rules

Requires Energy Source,
Device, and Conductor in
a Closed Loop.





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قم بمسح رمز الـ QR



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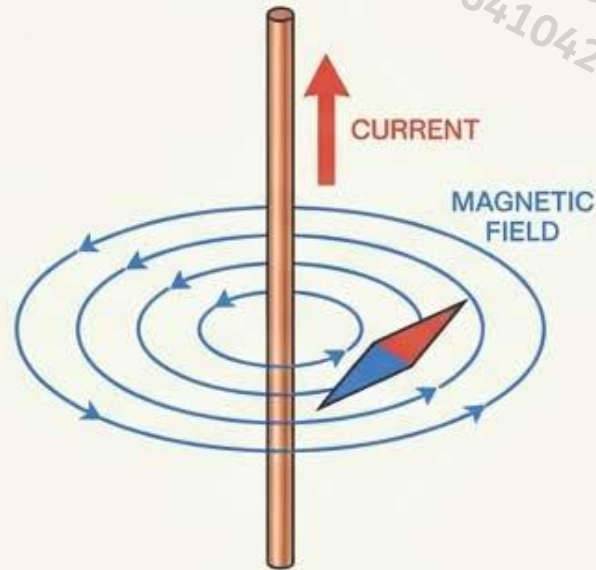
Module (3): Electromagnetic Forces

04

Fourth Lesson: Electromagnetism

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اضغط هنا: 0566410429

Electricity Creates Magnetism

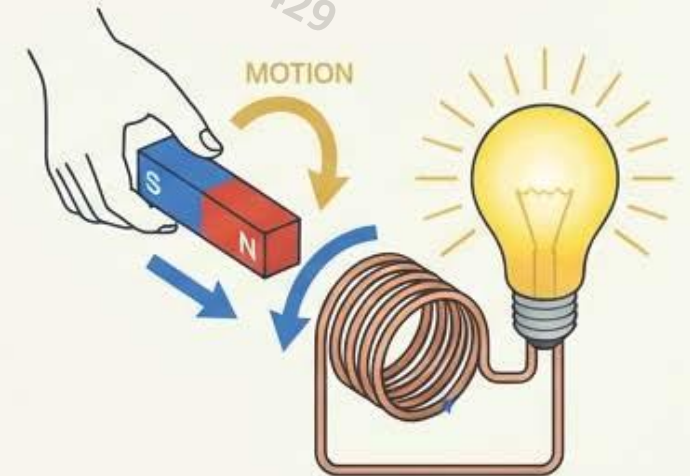


An electric current flowing through a wire produces a magnetic field around it. The direction of this field is determined by the direction of the current, demonstrating the fundamental link between electricity and magnetism.

Electromagnetism: The Physics of Connection

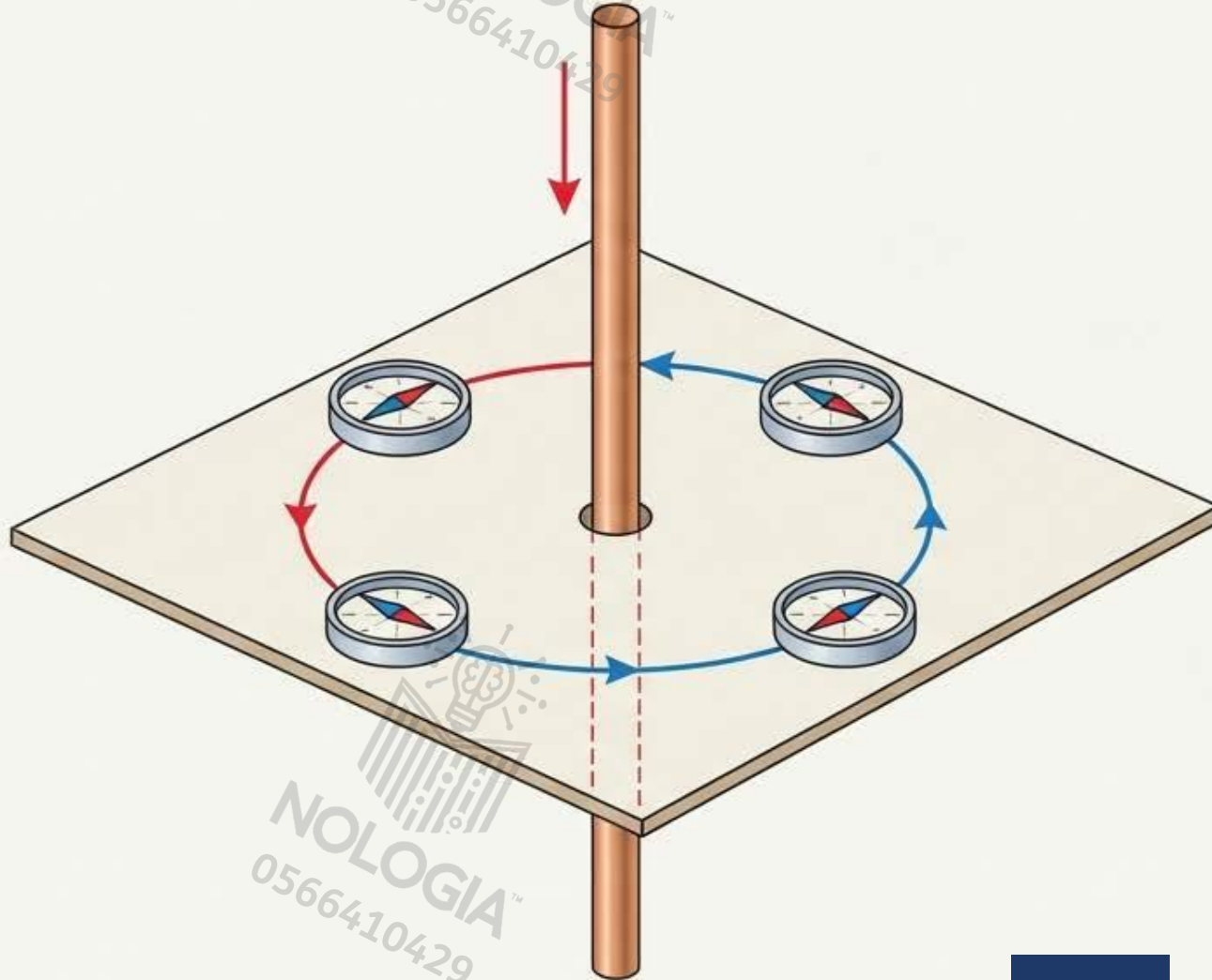
A Comprehensive NOLOGIA Guide
to Fields, Motors, and Generators

Magnetism Creates Electricity



Moving a magnetic field across a conductor, or vice versa, induces an electric current within the conductor. This principle of electromagnetic induction is the basis for power generation.

The Fundamental Discovery: Current Creates Magnetism



Core Concept: Electromagnetism is the interaction between electric charges and magnets.

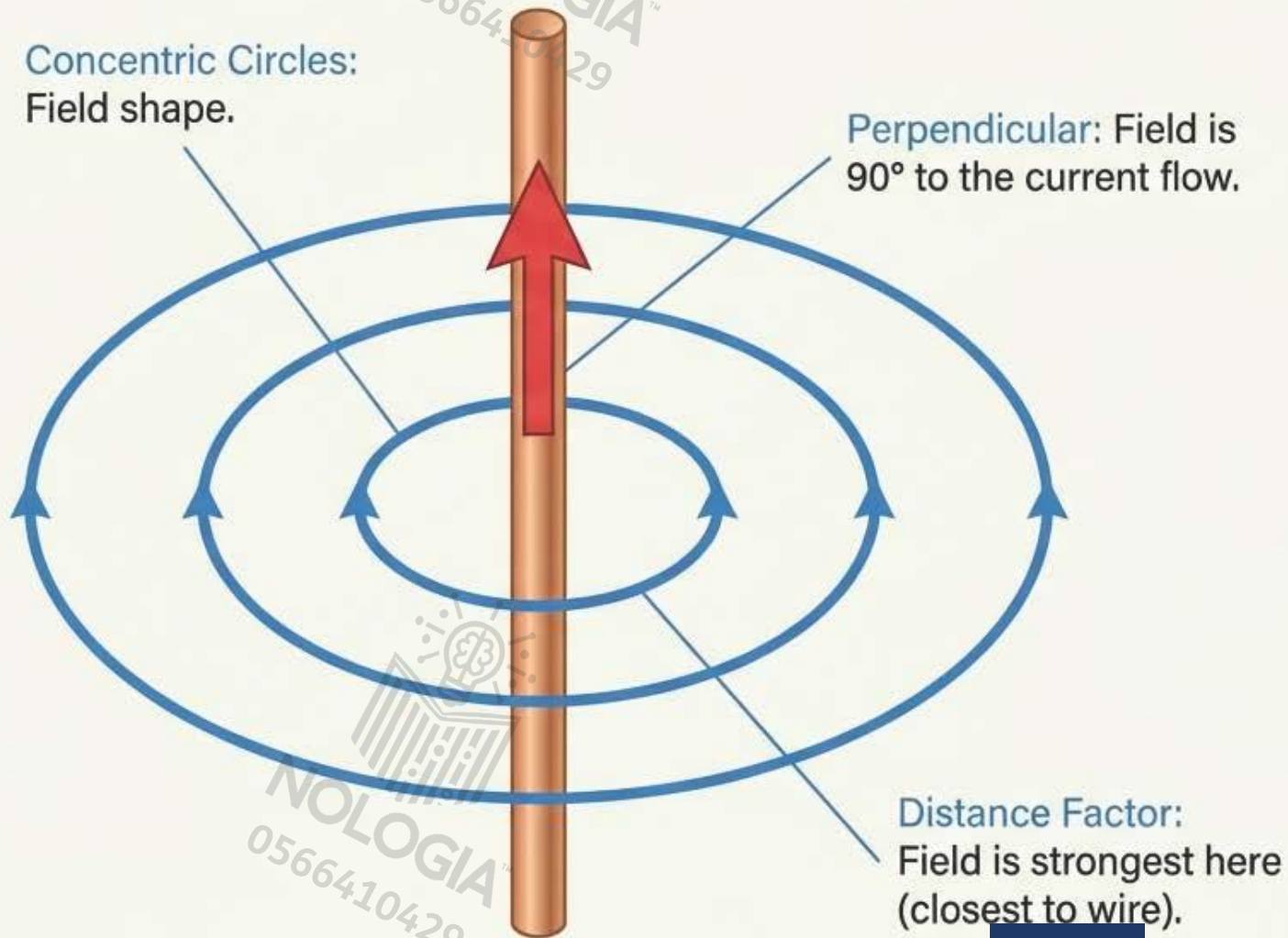
Lab Evidence:

1. Observation: When electric current flows through a wire, it deflects a nearby compass needle.
2. Conclusion: An electric current produces a magnetic field. This field surrounds the wire.

Key Detail:

The field exists only when charges are moving. If the current stops, the field disappears.

Visualizing the Magnetic Field

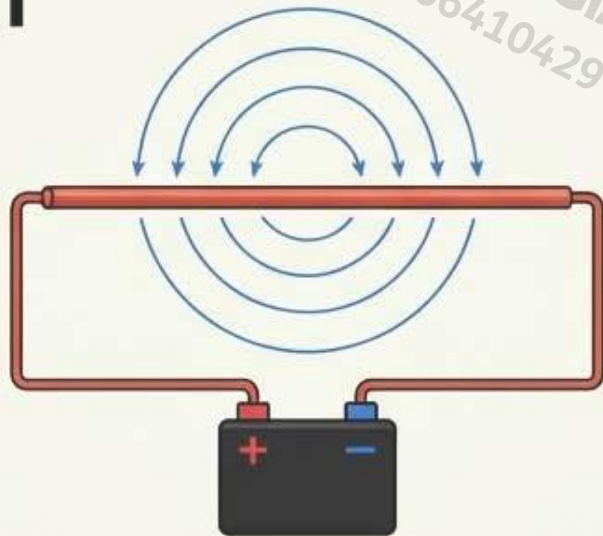


Strength Factors:

1. **Distance:** The magnetic field is strongest closer to the wire.
2. **Current:** Increasing voltage (current) increases field strength.

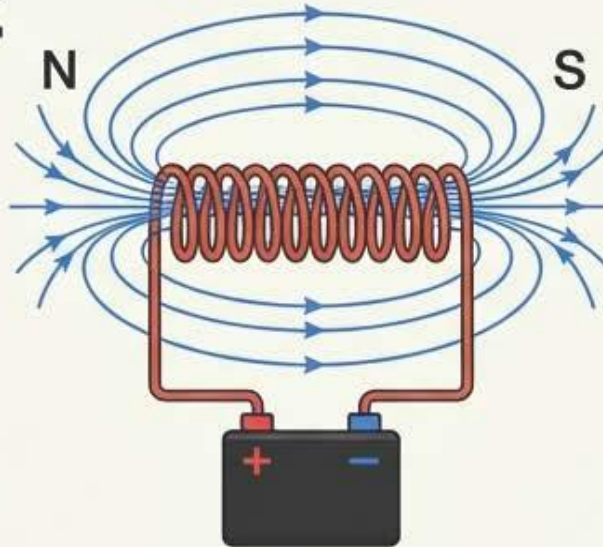
Building an Electromagnet

1



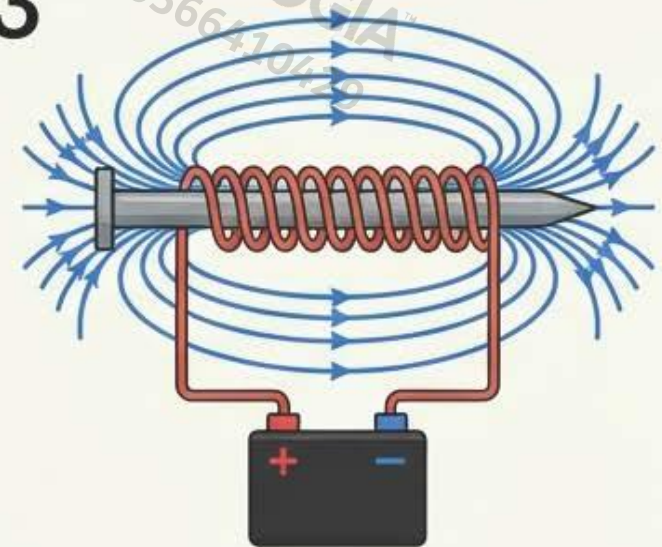
Weak Field

2



Stronger Field
(Fields Combine)

3



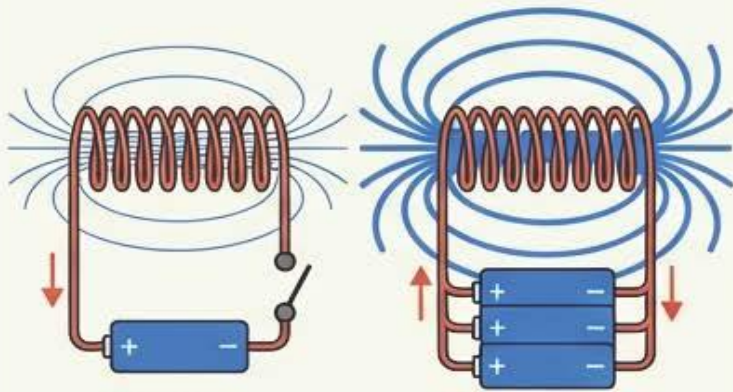
Electromagnet
(Strongest Field)

Definition: An Electromagnet is a temporary magnet made by wrapping a current-carrying wire coil around a magnetic core (like iron). The core intensifies the field significantly.

Three Ways to Increase Electromagnet Strength

Data from the "Electromagnet Challenge"

Increase Current

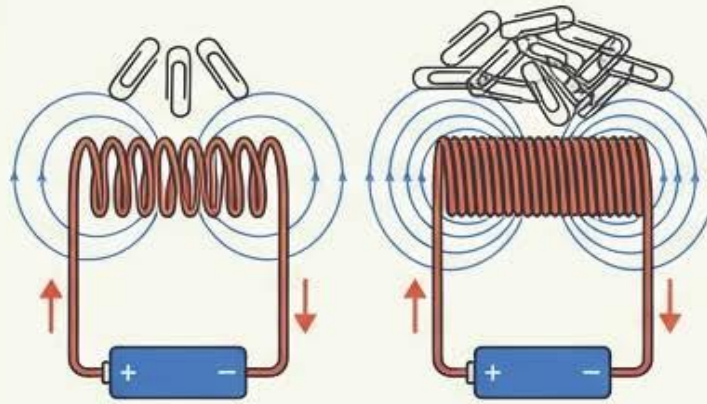


1 Battery

3 Batteries

More current (higher voltage) produces a stronger magnetic field.

Increase Loops

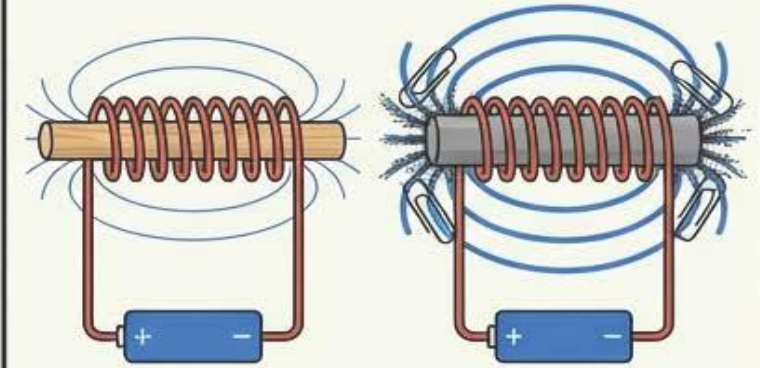


10 Turns

50 Turns

More turns in the coil concentrate the magnetic field, increasing strength.

Improve Core



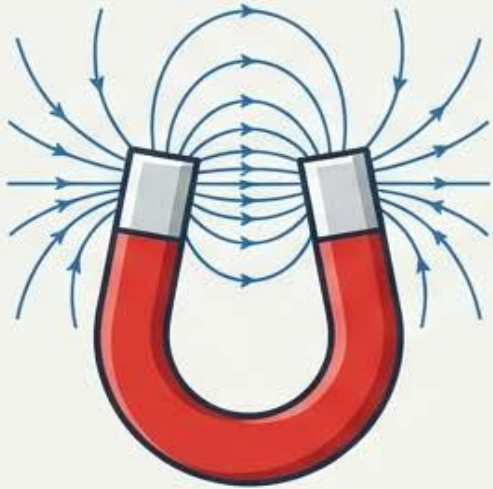
Wooden Core

Iron Core

A magnetic core, like iron, intensely concentrates the magnetic field, drastically increasing strength.

Findings: Strength depends on Voltage, Number of Turns, and Core Material.

Comparison: Electromagnets vs. Permanent Magnets



Permanent Magnet

	Permanent	Electro
Control	Cannot be turned off	Can be turned On/Off
Field Strength	Fixed/Constant	Adjustable (via current)
Polarity	Fixed Poles	Reversible (reverse current)



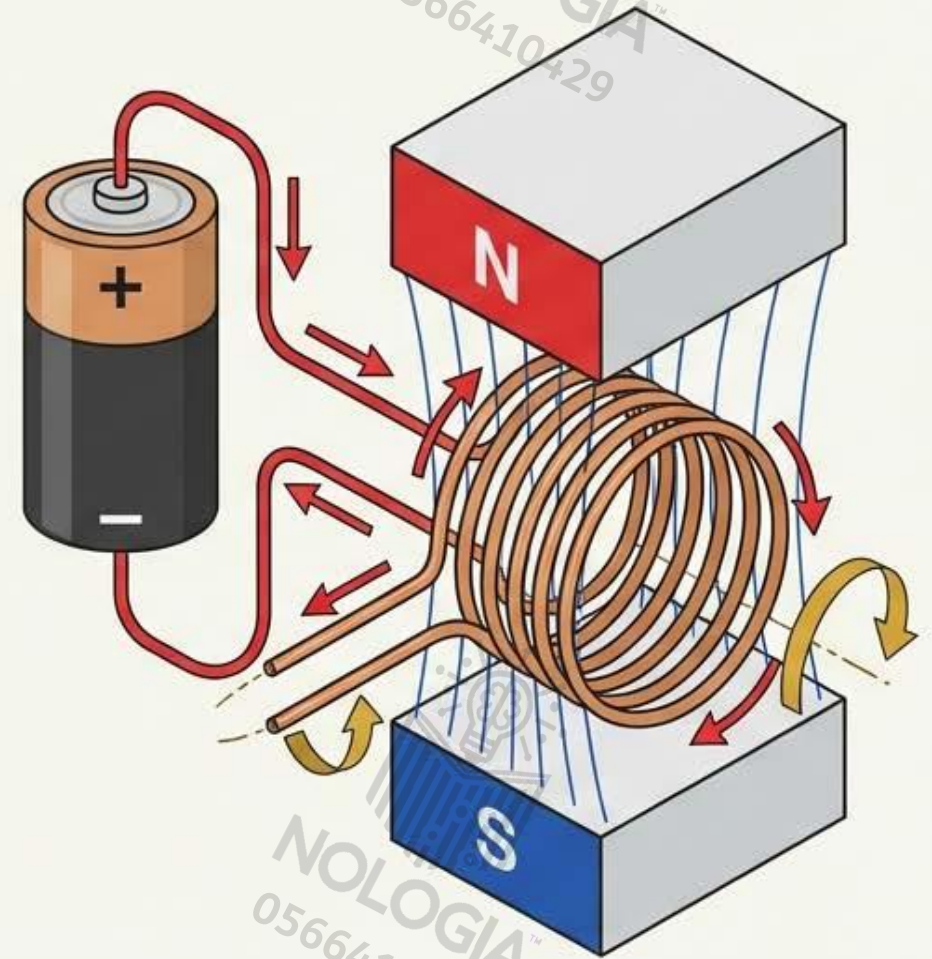
Electromagnet

Electromagnets are essential for heavy industry because they can release their load.

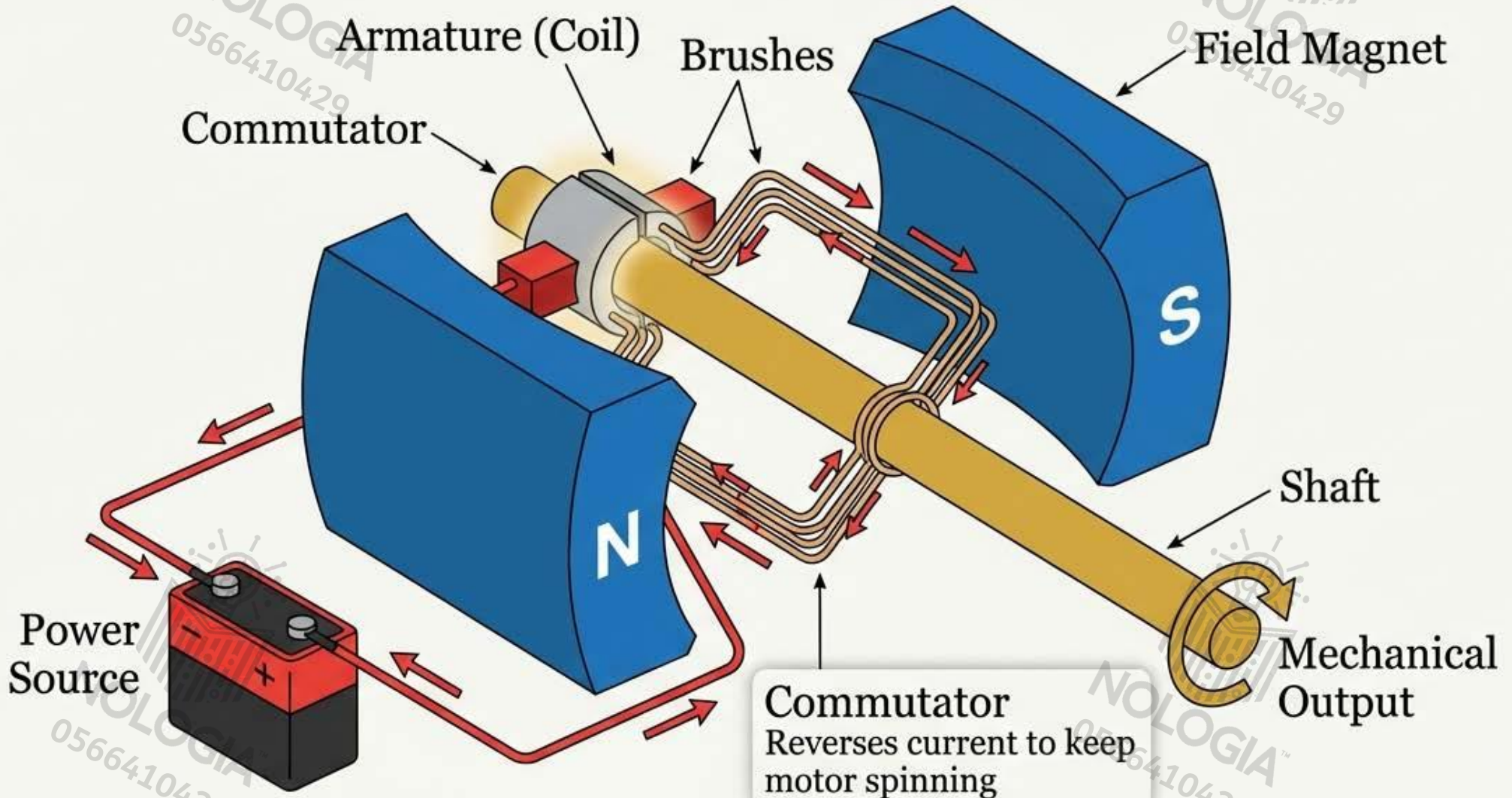
The Electric Motor: Creating Motion

A device that transforms **Electrical Energy** (Input) into **Mechanical Energy** (Output).

1. **Current flows through** the coil. •
2. **Coil becomes** an electromagnet. •
3. **Coil interacts with permanent magnets** (Repulsion). •
4. **Coil rotates.** •



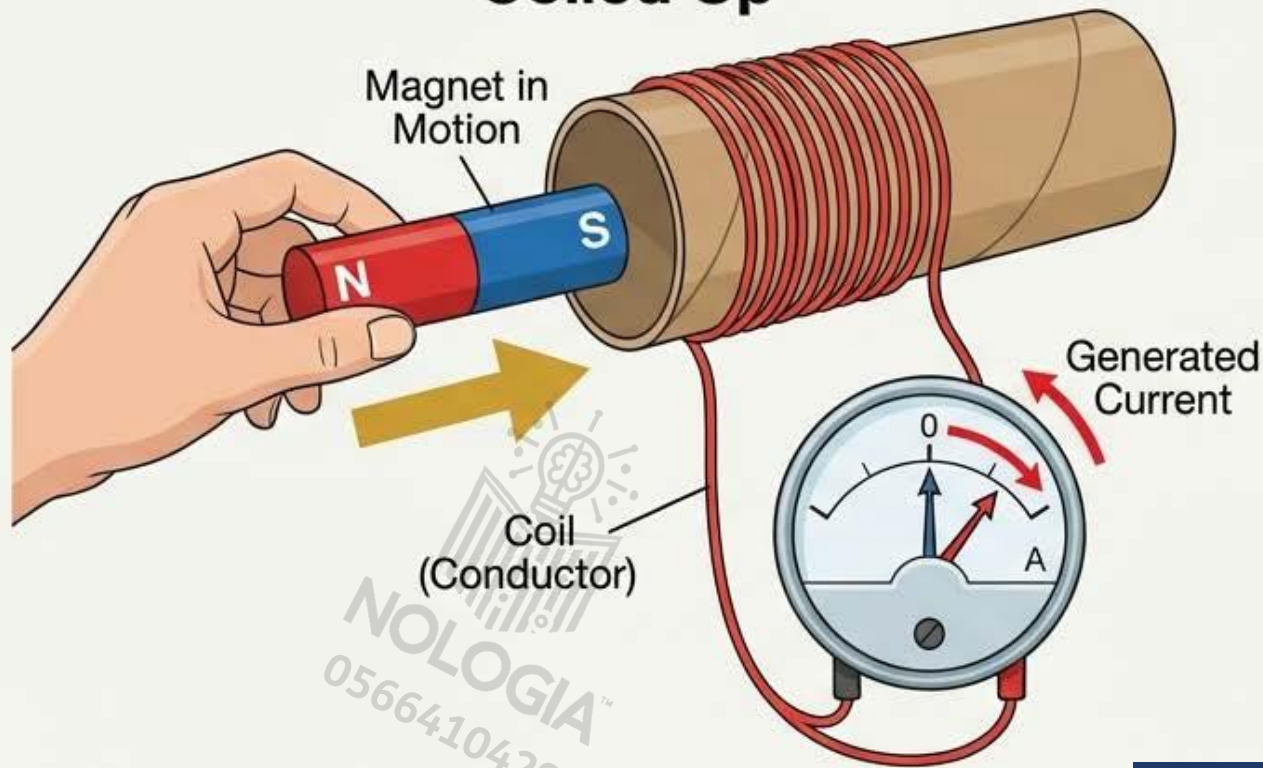
Anatomy of a DC Motor



The Reverse Phenomenon: Electromagnetic Induction

Can magnets produce electricity? Yes.

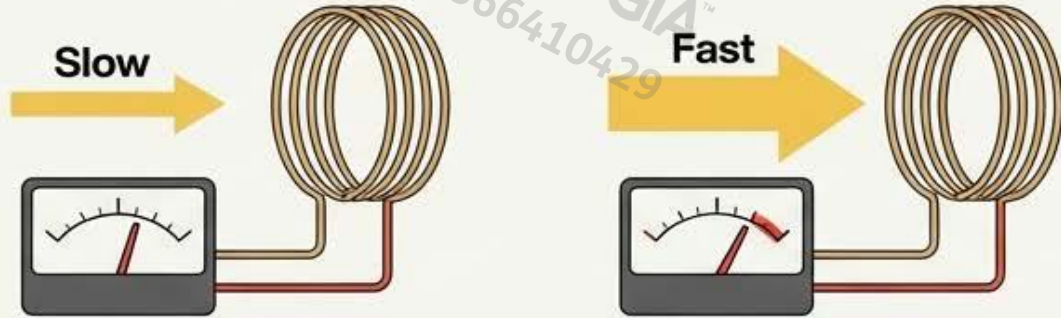
Coiled Up



- **Electromagnetic Induction:** Generating an electric current by moving a conductor through a magnetic field.
- **Evidence:** Moving the magnet creates a reading. Stopping the magnet stops the reading. No magnet stops the reading. No battery is involved!

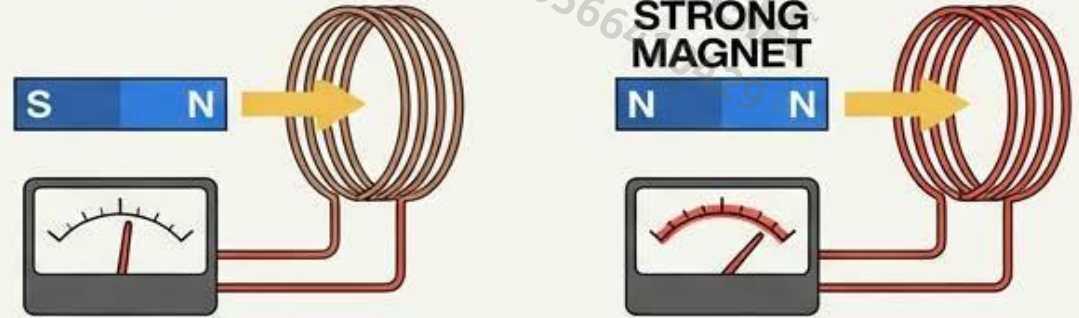
Factors Affecting Induced Current

1. Speed of Motion



Faster motion induces larger current.

2. Magnet Strength



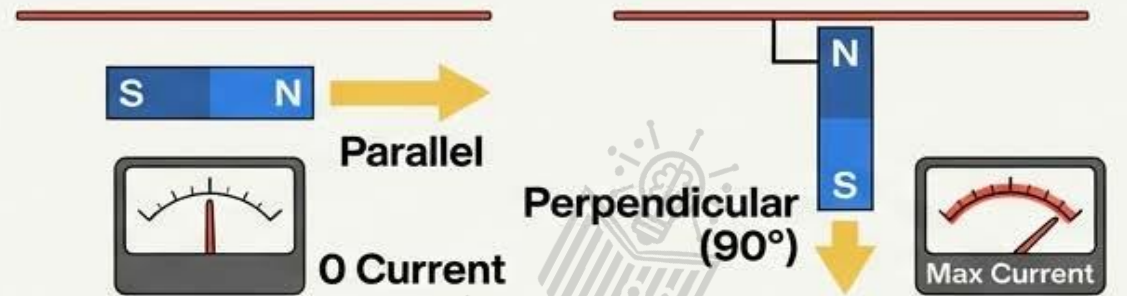
Stronger magnet induces larger current.

3. Number of Coils



More coils induce larger current.

4. Angle of Cut

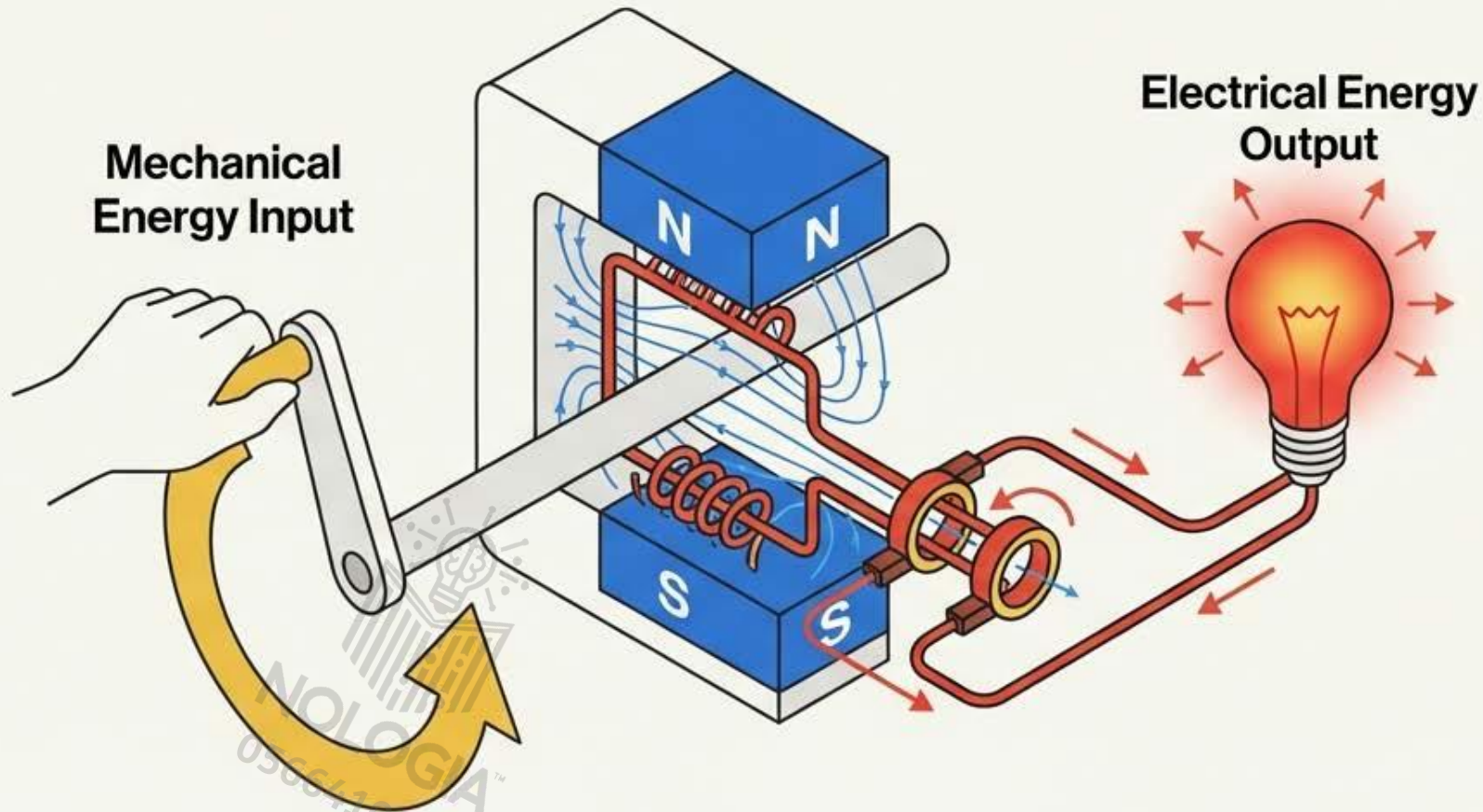


Cutting field lines at 90° induces maximum current.

To maximize current: Move faster, use stronger magnets, add more coils, and cut the field lines at 90° .

The Electric Generator: Creating Electricity

A device that transforms **Mechanical Energy** (Input) into **Electrical Energy** (Output).

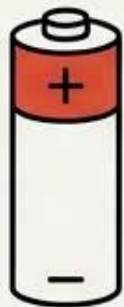
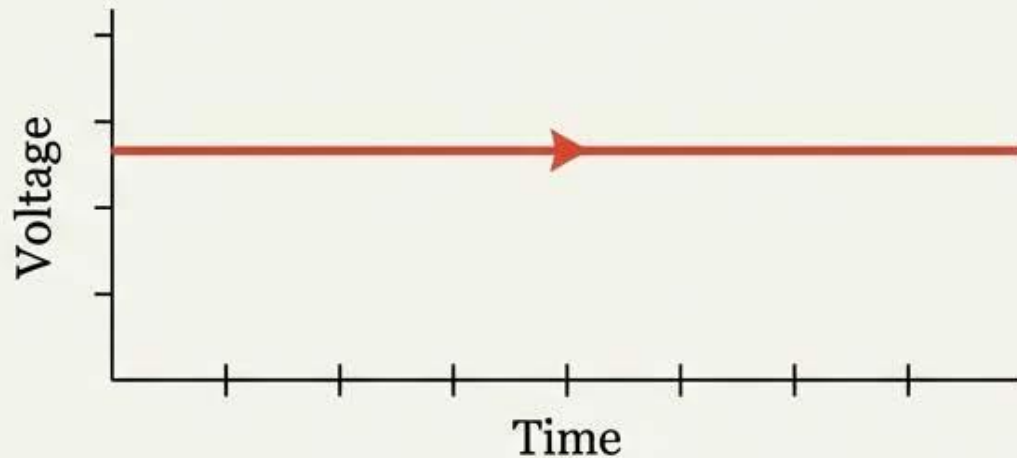


1. **Mechanical force** spins the coil.
2. Coil cuts through **magnetic field lines**.
3. **Current is induced** in the wire.

**Mechanica Now
Display Bold**

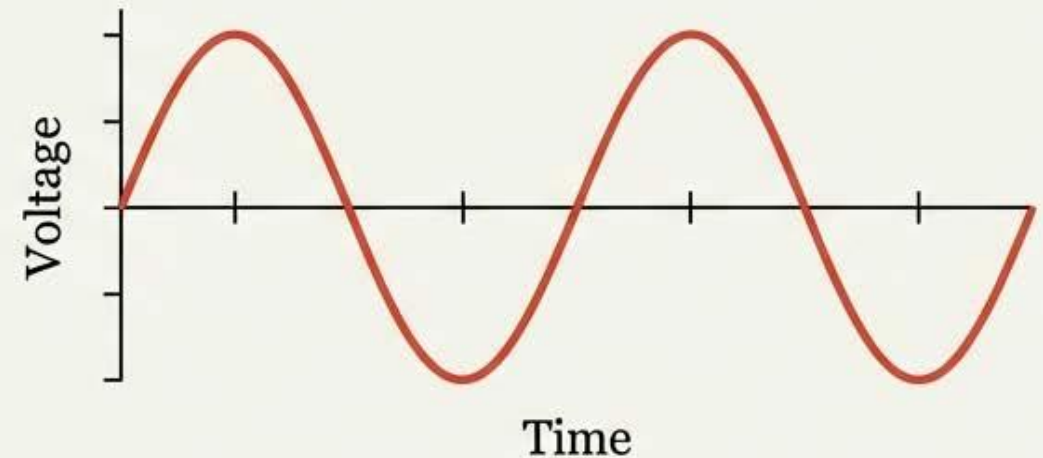
Direct Current (DC) vs. Alternating Current (AC)

Direct Current (DC)



Flows in one direction only.

Alternating Current (AC)



Changes direction regularly.



Generators produce AC because the rotating coil flips its orientation to the magnet every half-turn.

Master Comparison: Motor vs. Generator

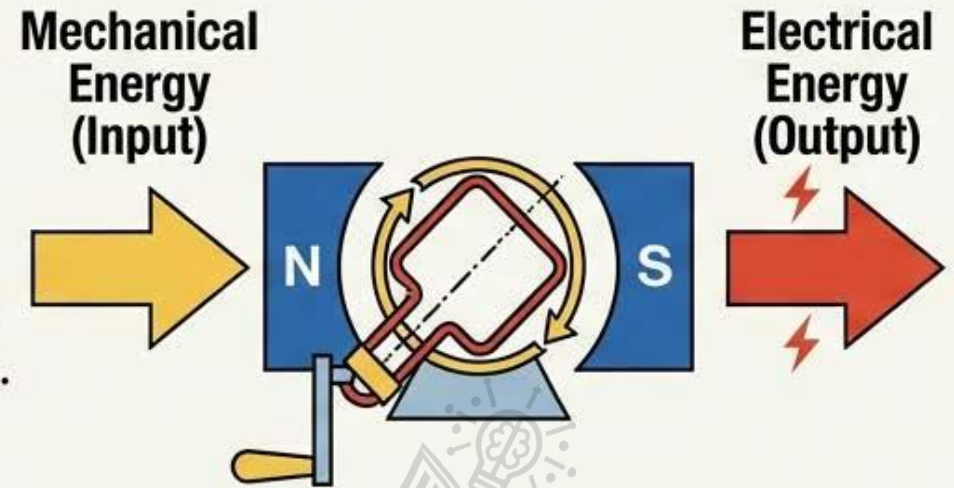
Electric Motor

Mirror

Electric Generator



Key Similarity:
Both rely on the
interaction of coils
and magnetic fields.



Examples:
Fan, Drill, Car

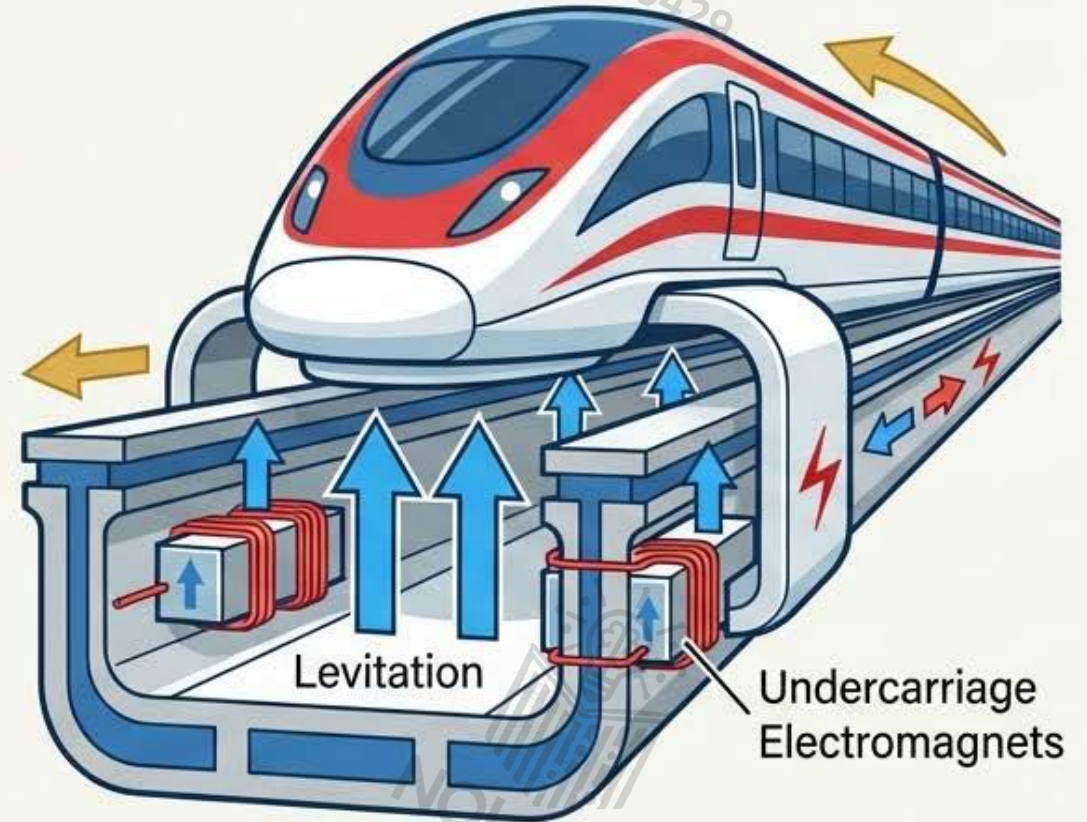
Examples:
Wind Turbine, Power Plant

Advanced Application: Maglev Trains

- **Mechanism:**

1. Levitation: Powerful electromagnets repel to lift the train (Zero Friction).
2. Propulsion: Polarity of track magnets switches rapidly (AC) to pull the train forward.

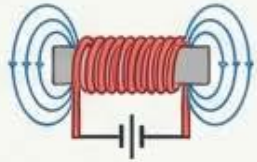
****Result:** Speeds up to 375 mph.



Summary Checklist: The Physics of Electromagnetism



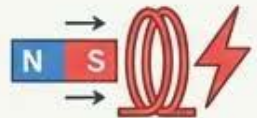
1. **Oersted's Law:** Moving charges create a magnetic field



2. **Electromagnet:** Coil + Core + Current = Strong controllable magnet



3. **Motor:** Electrical Energy $\rightarrow$ Mechanical Energy



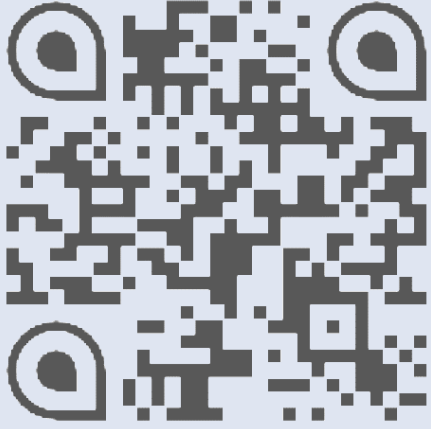
4. **Induction:** Moving magnets near coils creates current



5. **Generator:** Mechanical Energy $\rightarrow$ Electrical Energy (AC)



6. **Output Factors:** Speed, Strength, Coils, and Angle (90°) affect intensity



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ختاماً، نسأل الله أن يوفقكم، وأن
تكون هذه الملزمة قد حققت
الفائدة المرجوة ♥



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