احجز مكانك واستعد للامتحان بثقة كاملة

ملزمة العلوم الفصل الأول
Inspire 8 متقدم لعام 2027

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Energy and Motion

Module (1): Forces and Motion

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Module (1): Forces and Motion

01

First Lesson:

Position and Motion

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Notes

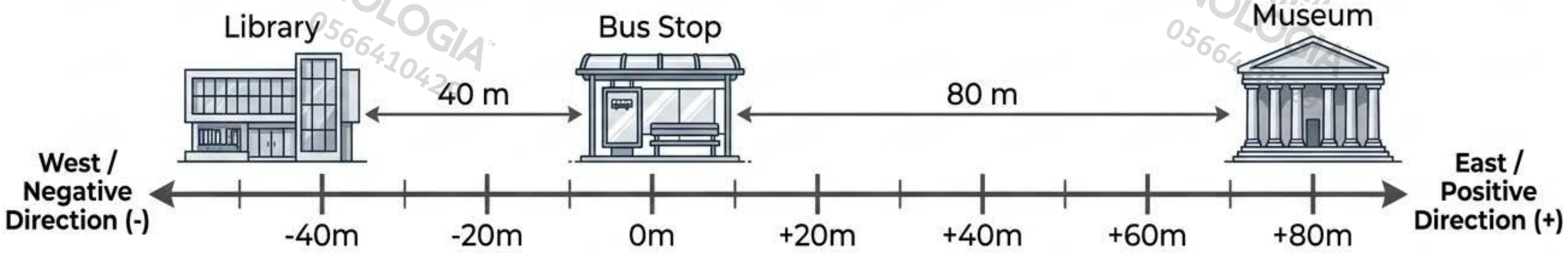


The Physics of Motion

A complete visual guide to position, distance, speed, and velocity.

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DEFINING POSITION IN SPACE



Reference Point:
The arbitrary starting point chosen to describe a location (e.g., the bus stop).

Distance:
How far away the object is from the reference point (measured in meters, the SI base unit).

Reference Direction:
The orientation from the reference point (e.g., **positive**/negative, East/West).

POSITION = REFERENCE POINT + DISTANCE + DIRECTION

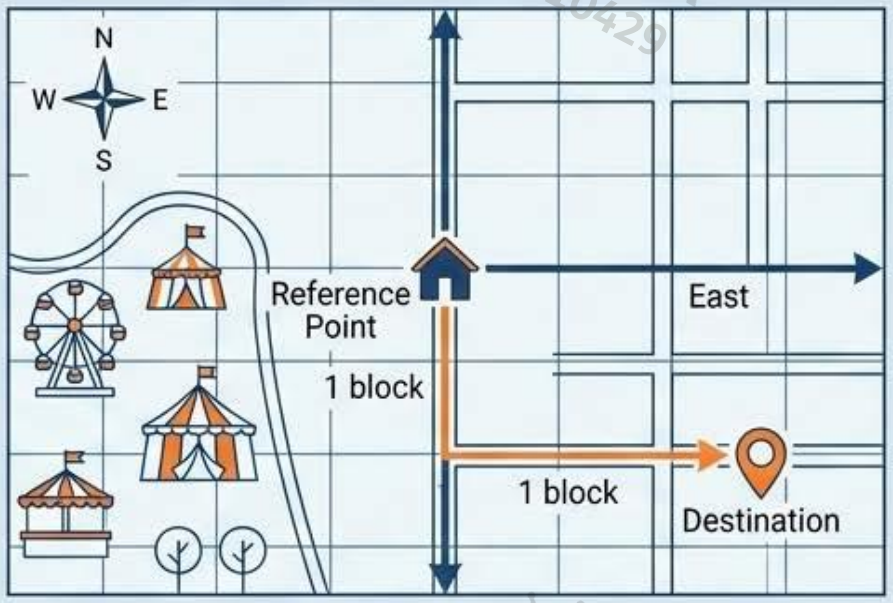
From One Dimension to Two

1D Navigation:



1D Navigation: Movement along a single straight line. Requires only one distance and one direction (e.g., positive or negative).

2D Navigation:



2D Navigation: Finding position on a plane. Requires a reference point, two reference directions (e.g., South and East), and distances along both directions.

Note: Scientists use SI (International System of Units) meters to eliminate confusion in all measurements.

The Perspective of Motion

Key Principle: All motion is relative to a certain point in space.

Scenario A (Observer = Boat)



If the fishing pole is the reference point, the man's position does not change. He is not moving.

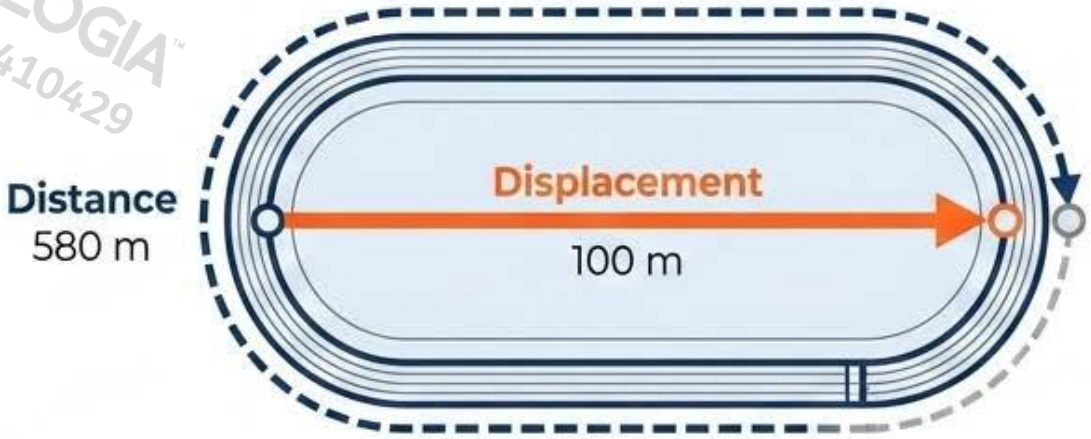
Scenario B (Observer = Buoy)



If the buoy is the reference point, the man's distance is changing. He is in motion.

Conclusion: The actual location hasn't changed; only the description changes because the reference point changed.

Distance vs. Displacement



Distance	Displacement
The total length of the actual path traveled	The shortest straight-line difference between initial and final position.
Highly dependent on the exact route taken	Completely independent of the route; only cares about Start and Finish.
Cannot be zero if the object moves	Is exactly zero if the object finishes exactly where it started (e.g., completing one full lap on a race track).

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The Mathematics of Speed

Speed measures how fast something moves—the distance an object travels in a given amount of time.

Average Speed (in m/s). Most moving objects don't travel at a constant rate, so we calculate the average over the whole trip.

$$\bar{v} = \frac{d}{t}$$

Total Distance (in m).

Total Time (in s).

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Constant vs. Changing Speed

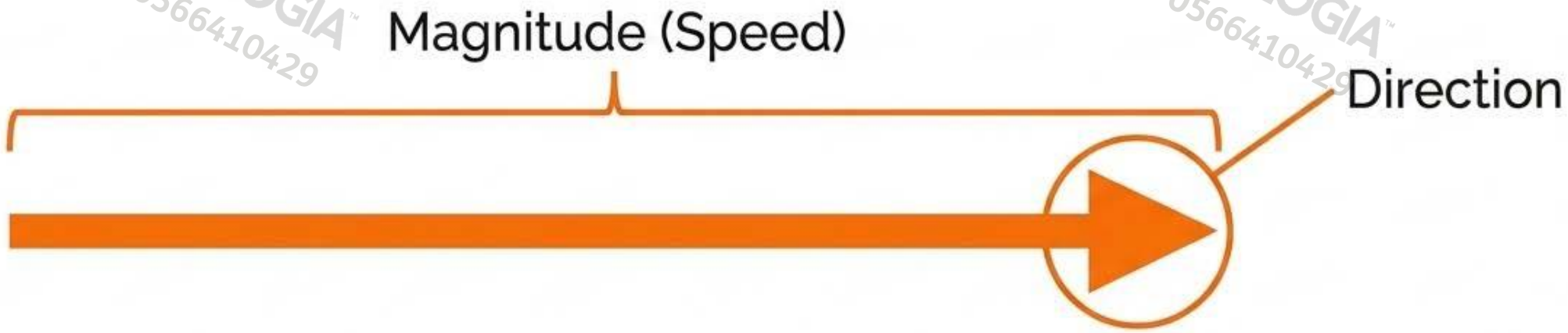
Constant Speed:
The object covers the exact same distance during each equal time interval.



Changing Speed:
The distance traveled each second gets larger (or smaller). Speed is actively changing.



Vectors and Velocity



Vector: A measurement quantity that requires BOTH magnitude (size/amount) and direction.

Velocity: The speed AND the direction of a moving object.

Key Takeaway: You can share the magnitude and direction by drawing a simple arrow. A short arrow means slow; a long arrow means fast.

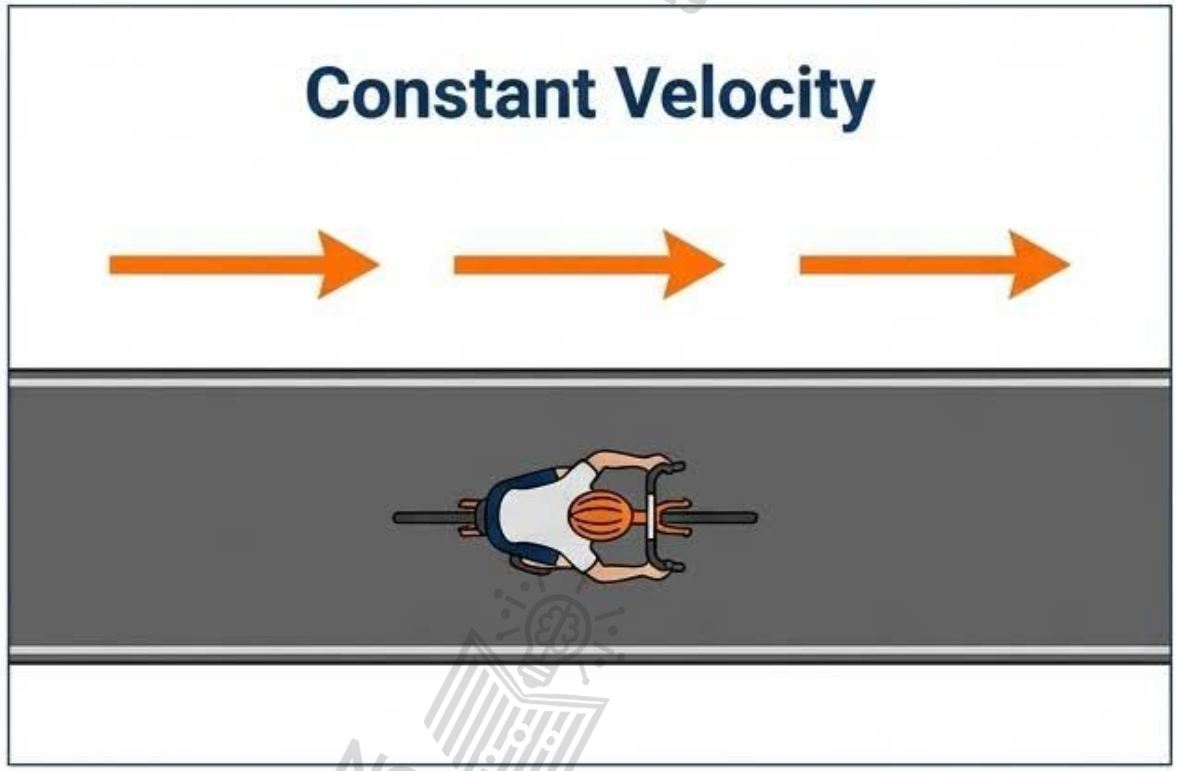
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When Does Velocity Change?

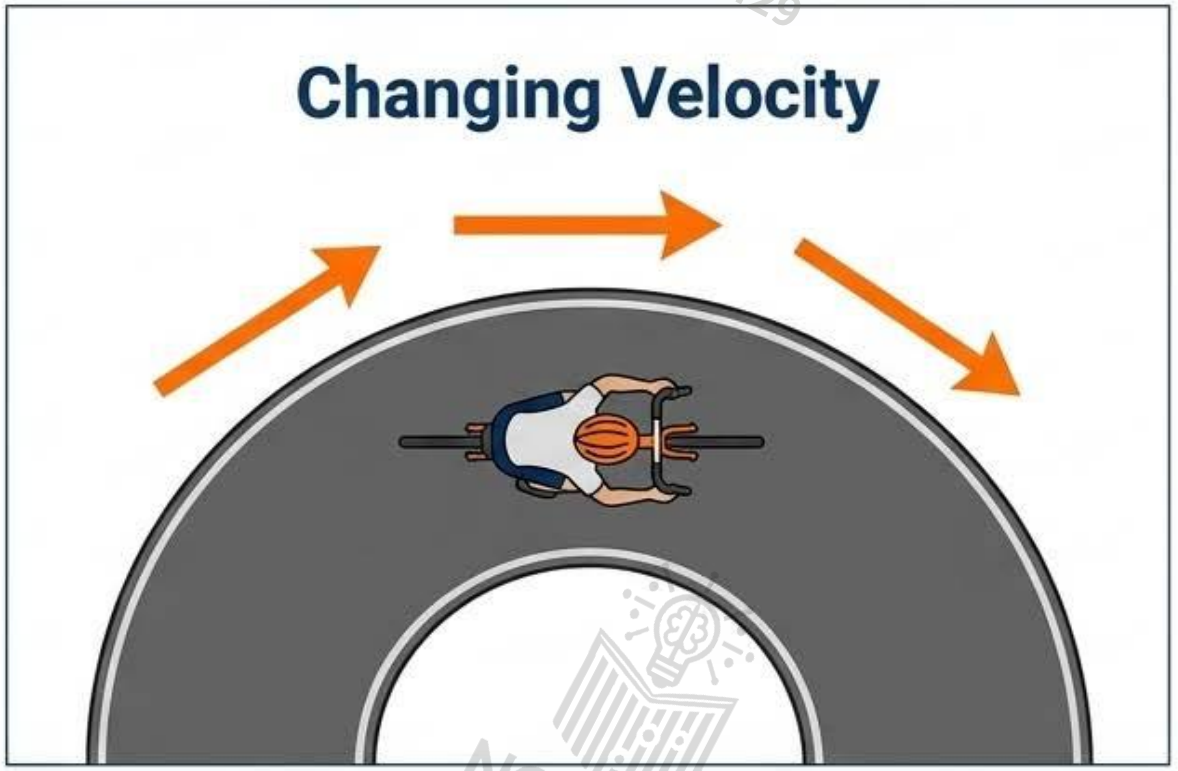
Rule: Because velocity is a vector, it changes if the speed changes OR if the direction changes.

Constant Velocity



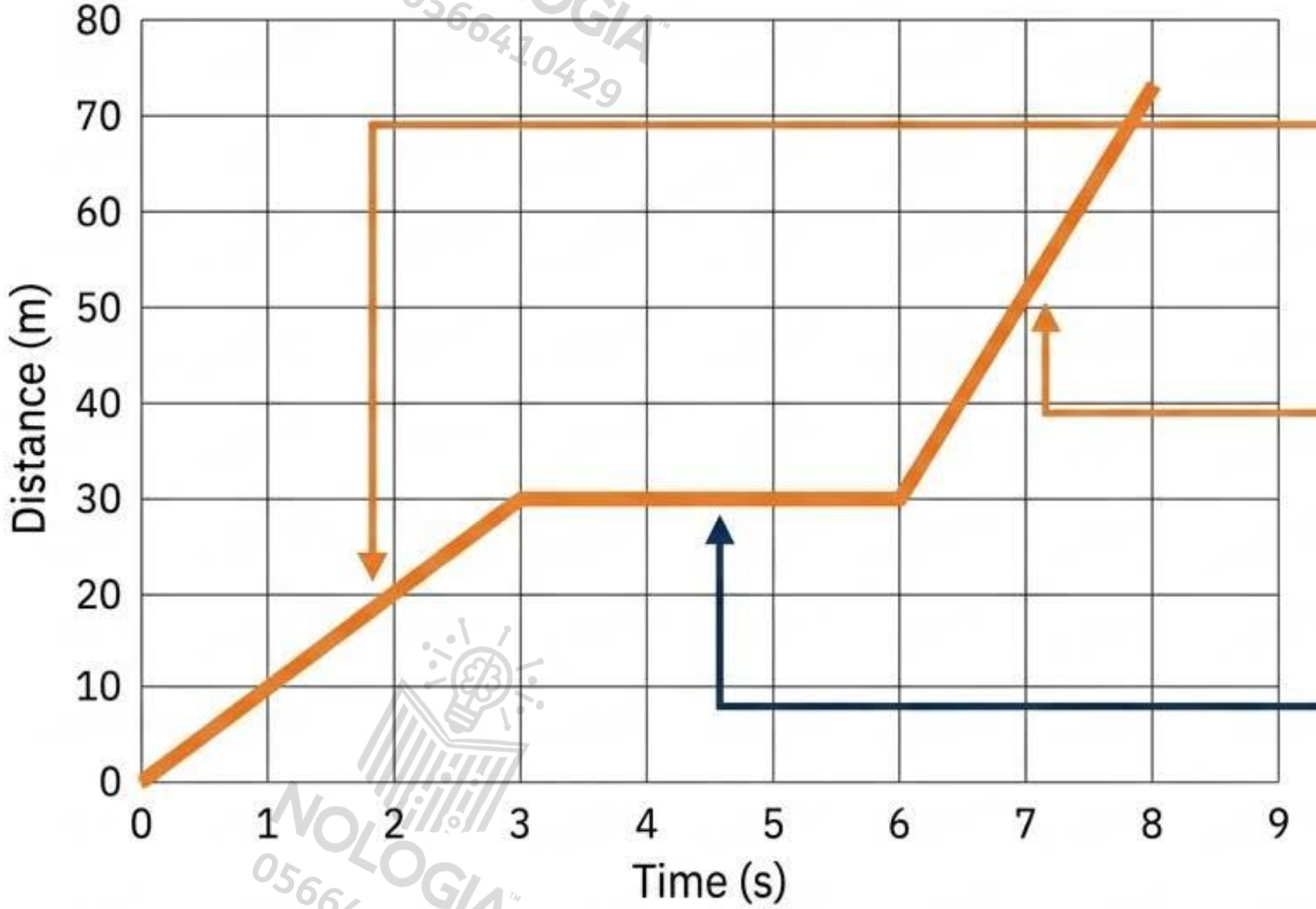
Constant Velocity: Object moves at a steady speed in a perfectly straight line. Arrows are identical in length and direction.

Changing Velocity



Changing Velocity: Even if the cyclist pedals at the exact same speed, going around a curve means the direction changes. Therefore, the velocity is constantly changing.

Decoding Distance-Time Graphs



Straight Line = Constant Speed.
The object is moving at a steady rate.

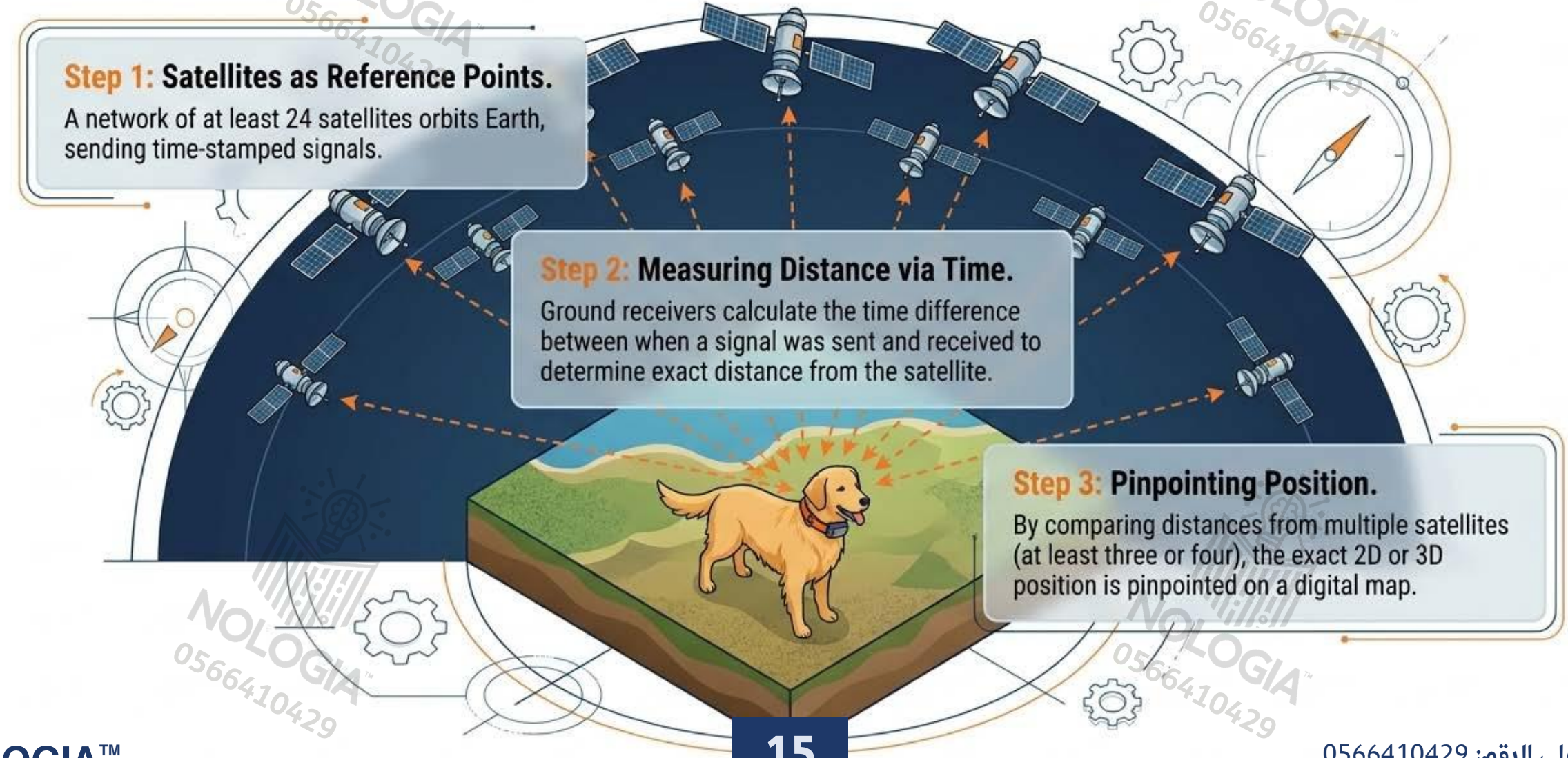
Steeper Line = Greater Speed.
The object is covering more distance in less time.

Flat Line = Zero Speed.
Position is not changing as time passes; the object is stopped.

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Real-World Physics: How GPS Works

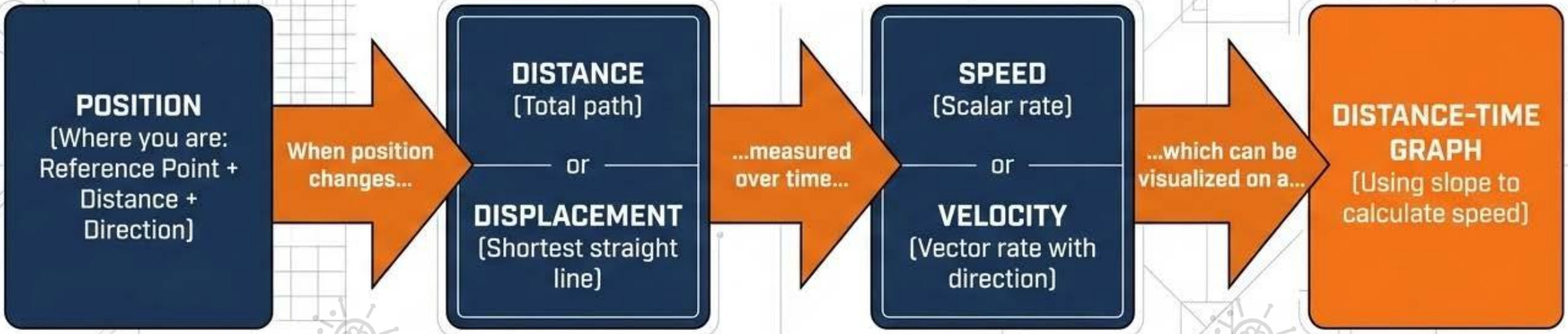
A **Global Positioning System** uses the physics of reference points, distance, and time to locate objects on Earth.



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The Unified Framework of Motion

The NOLOGIA Map of Motion



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Exam Preparation

Choose the correct answer:

The data in the table shows how far a sea turtle travels over several days. What would the line on a plot of this data look like?

A. The line would curve upward and to the right.

B. The line would go up and down.

C. The line would point straight upward to the right.

D. The line would point upward then downward.

Green Sea Turtle's Distance and Time Data

Time (days)	Distance (km)
0	0
1	16
2	32
3	48
4	64
5	80
6	96

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Module (1): Forces and Motion

02 Second Lesson:

Force and Acceleration

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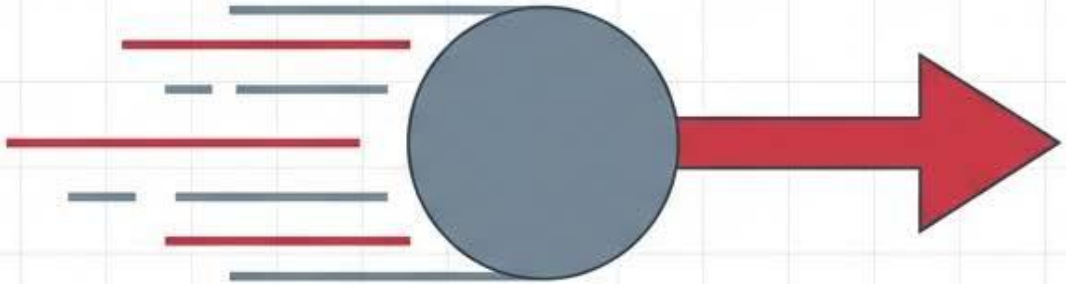
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Unit 2: Module 1

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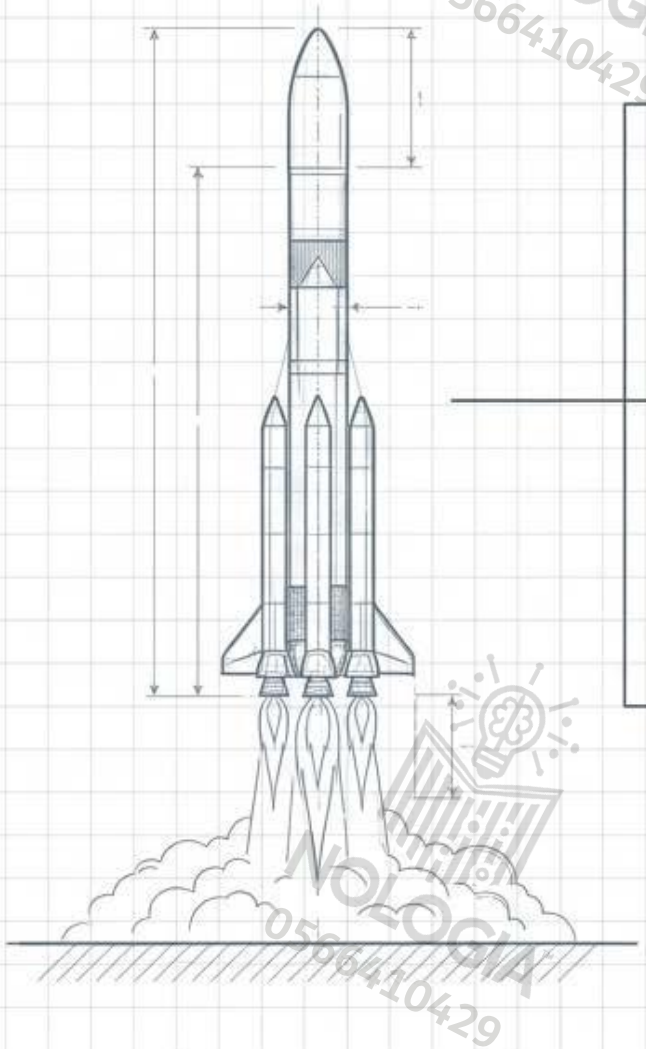


Blueprint for Motion: Understanding Forces and Acceleration

A Comprehensive Visual Study Guide

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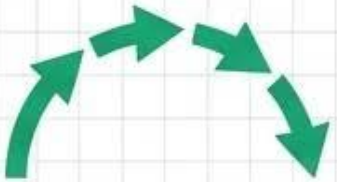
Acceleration is Any Change in Velocity



Speed Increases

Speed Decreases

Direction Changes



Key Fact Box

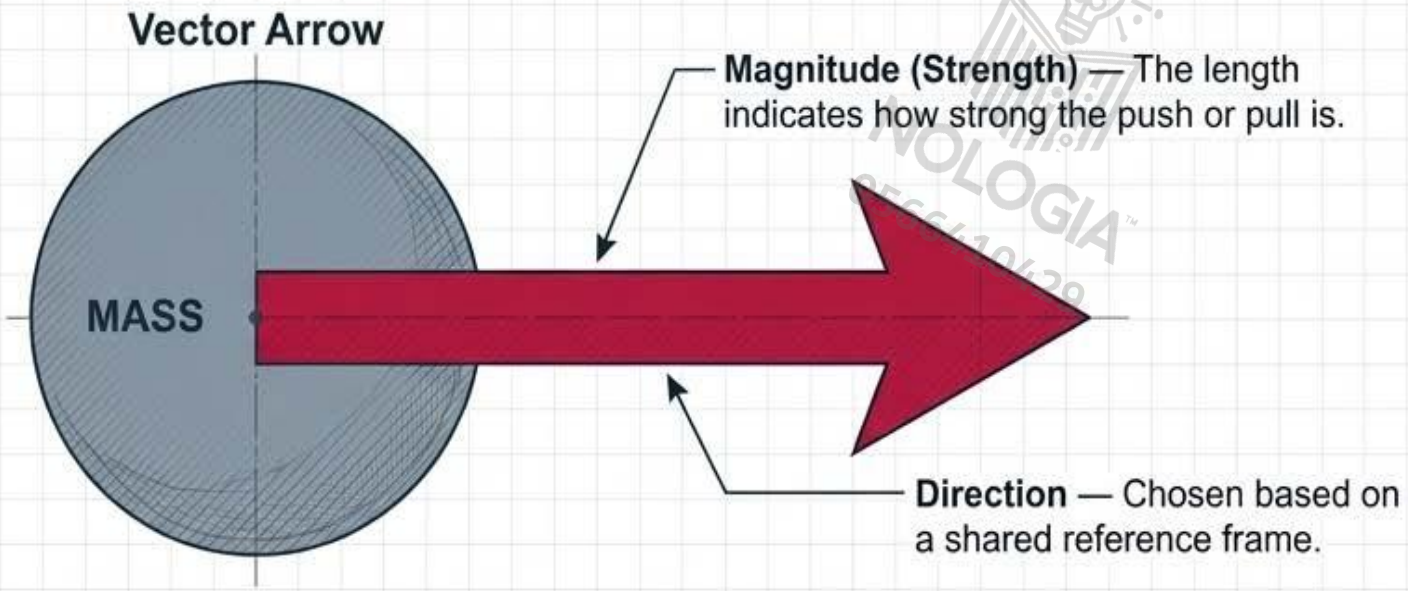
Acceleration is a rate: how much velocity changes during a period of time.

SI Unit: meters per second squared (m/s^2).

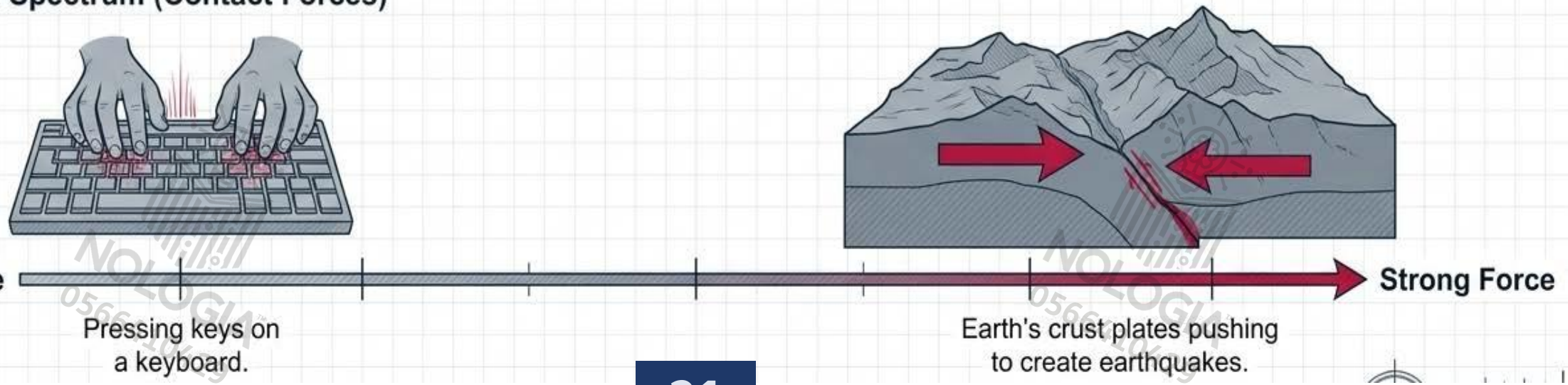
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The Cause of Acceleration: Force

Force: A push or a pull on an object. Because acceleration is a vector, force is also a vector.



Real-World Spectrum (Contact Forces)



Newton's Second Law: The Mathematical Model

$$a = F / m$$

Directly Proportional

More Force = More Acceleration



Inversely Proportional

More Mass = Less Acceleration



Quick Calculation Callout:
If **F** = 100 N and **a** = 2 m/s², then **m** = 50 kg.

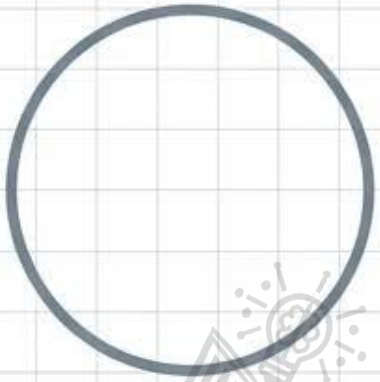
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Abstracting Reality: Drawing a Free-Body Diagram

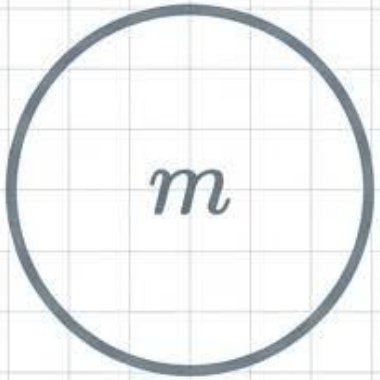
Step 1: The Object

Draw a circle.



Step 2: The Mass

Place an ‘m’ inside to represent the object’s mass.



Step 3: The Force

Draw an arrow starting from the center, pointing in the direction of the push/pull. Size = Strength.

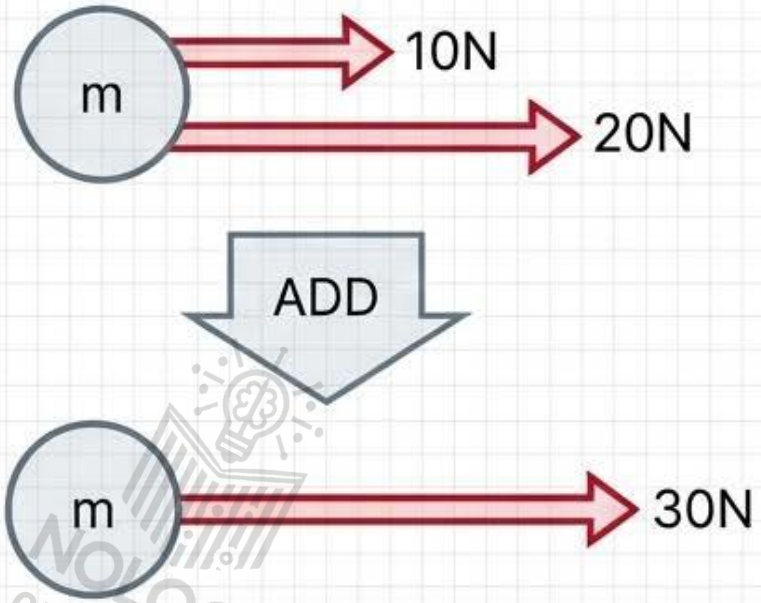
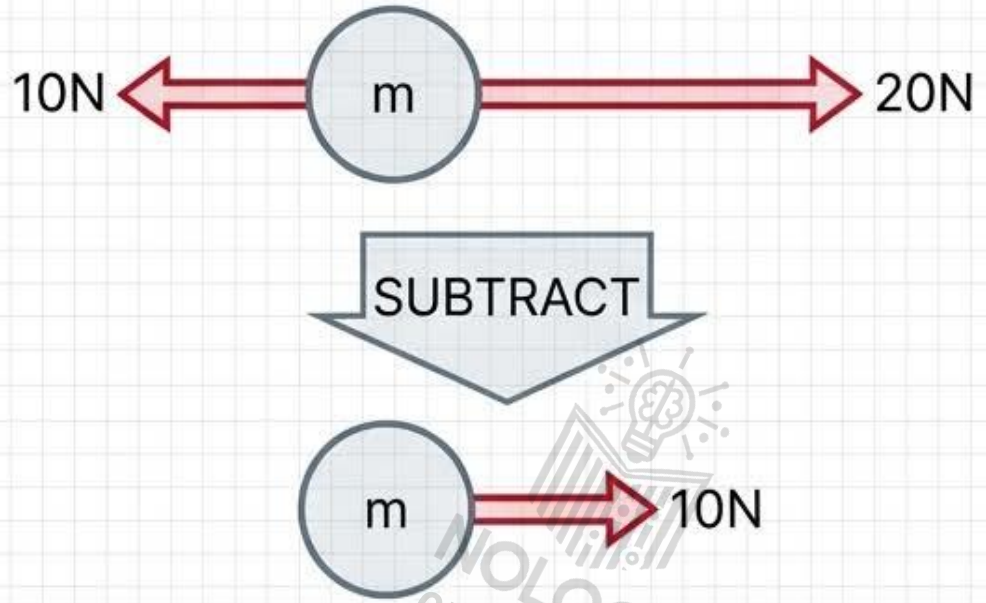


Key Takeaway: A free-body diagram is a simple model used by scientists to understand systems with multiple applied forces.

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Calculating Net Force: Combining Multiple Vectors

Net Force: The sum of all forces acting on an object. If the net force is NOT zero, motion WILL change.

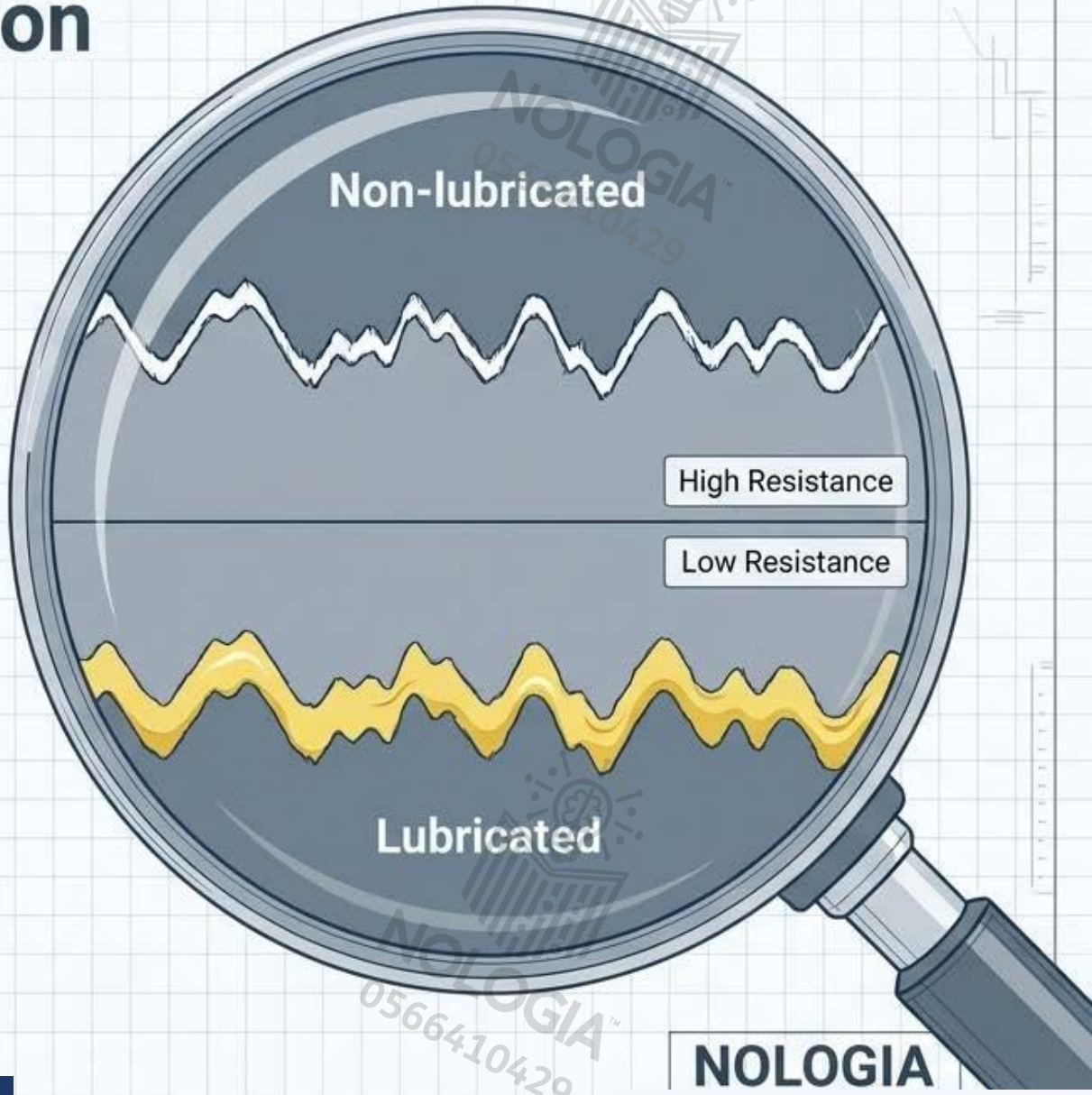
Path 1: Same Direction	Path 2: Opposite Directions
	

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The Invisible Opponent: Friction

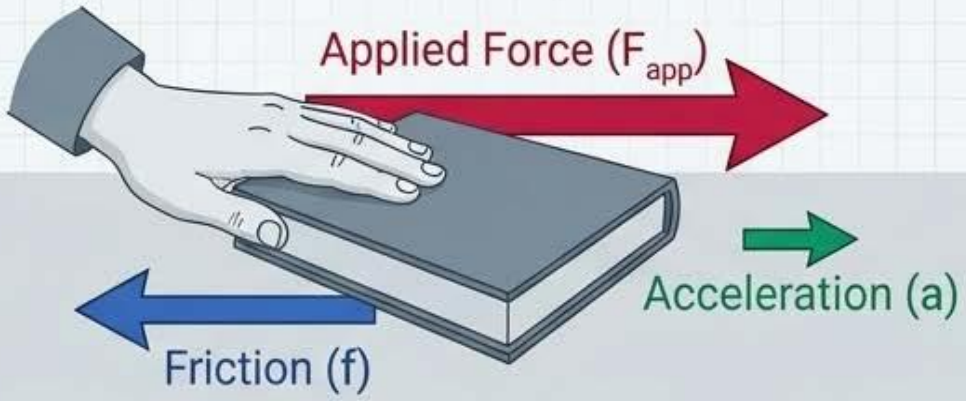
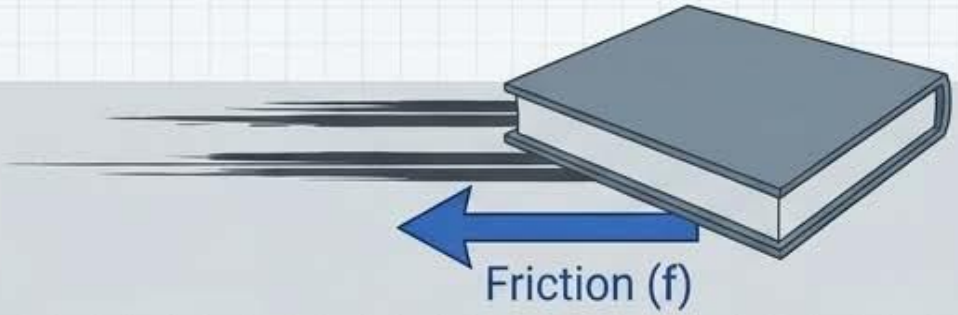
Key Concept: Friction is a force that resists the sliding motion of two touching surfaces. It is caused by microscopic roughness.





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Why Objects Stop on Earth

Panel 1: The Push	Panel 2: The Release
	
Applied force > Friction **Result:** Book accelerates.	Applied force is gone. **Result:** Book slows down and stops.

Thought Experiment Box

What if there were zero friction? According to Newton's second law, the book would continue moving at the exact same speed and direction forever, because no net force would exist to change its motion.

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Newton's First Law of Motion

If **Net Force = 0** (and acceleration = 0)...

For an object at rest

...it will STAY at rest.



For an object in motion

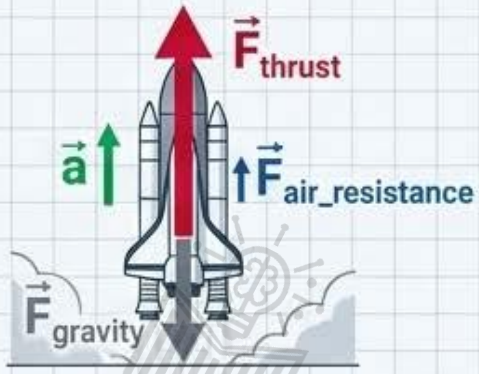
...it will STAY in motion at a constant speed and direction.



...UNLESS acted upon by an outside force.

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Diagnostic Matrix: Balanced vs. Unbalanced Forces

	Balanced Forces	Unbalanced Forces
Net Force	Exactly Zero (0 N)	Greater than Zero (>0 N)
Effect on Motion	No change. Object remains at rest OR continues at constant velocity.	Motion changes. Object accelerates (speeds up, slows down, or turns).
Real-World Example	 A tied tug-of-war, or skiers being pulled up a mountain at a constant, steady speed.	 A rocket launching from the ground.

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Study Guide | Always check the Net Force first.

NOLOGIA Master Blueprint: Forces & Motion

The Golden Equation

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

F = Newtons

a = m/s^2

m = kg

Free-Body Rules



Add same direction, subtract opposite direction.

Friction Facts

- Opposes motion. $\vec{F}_{fr}$
- Caused by microscopic surface bumps.
- Reduced by lubrication.

Newton's Laws Summary

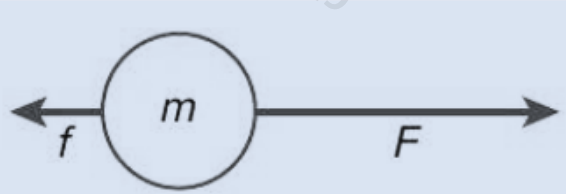
- **1st:** No net force = No change in motion.
- **2nd:** Force causes acceleration based on mass.

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Complete your study. Master the motion.

Exam Preparation

An object has a force acting on it to the right and has a frictional force to the left as shown below. Use the model below to answer questions 1 and 2.



1) **What change in motion will result from the forces modeled?**

   A. There will be no change in motion because the forces are in opposite directions.

   B. The object will slow down because of the friction force.

   C. The object will accelerate to the right.

   D. The object will accelerate to the left.

2) **What would a model of the net force look like?**

   A. The arrow would be to the right at the same length as before, because friction is a different force.

   B. The arrow would be to the right but shorter than before to account for the friction force.

   C. There would be no net force because the two forces are in opposite directions.

   D. The arrow would be to the left because friction is slowing the object down.

3) **A train moves at a constant speed down a straight track. Which of the following scientific explanations is true?**

   A. No forces act on the train as it moves.

   B. The train moves because no forces are acting against it.

   C. The forces of the train's engine balance the force of friction opposing it.

   D. An unbalanced force keeps the train moving.

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Module (1): Forces and Motion

03 Third Lesson: Force Pairs

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Force Pairs & Newton's Third Law

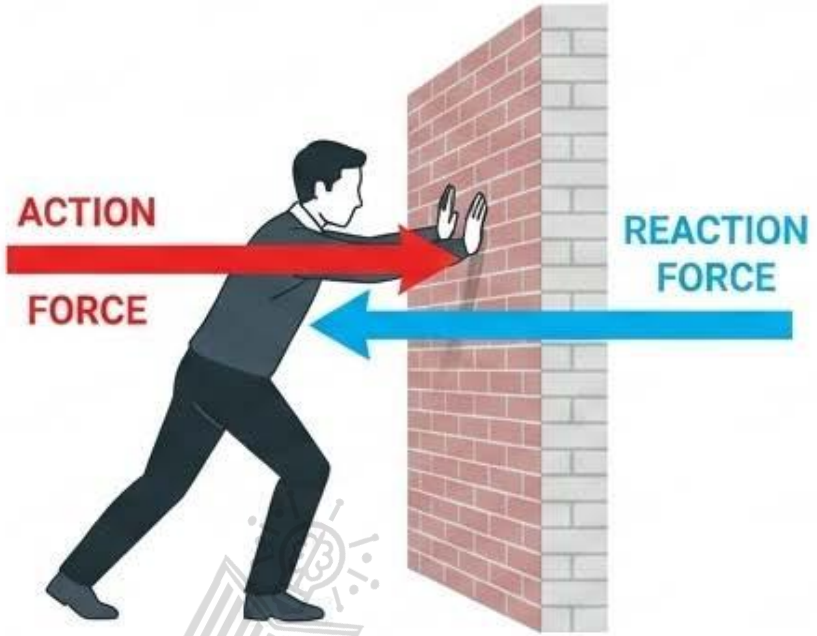
A Comprehensive Visual Guide to Opposing Forces, Collisions, and Motion Mechanics



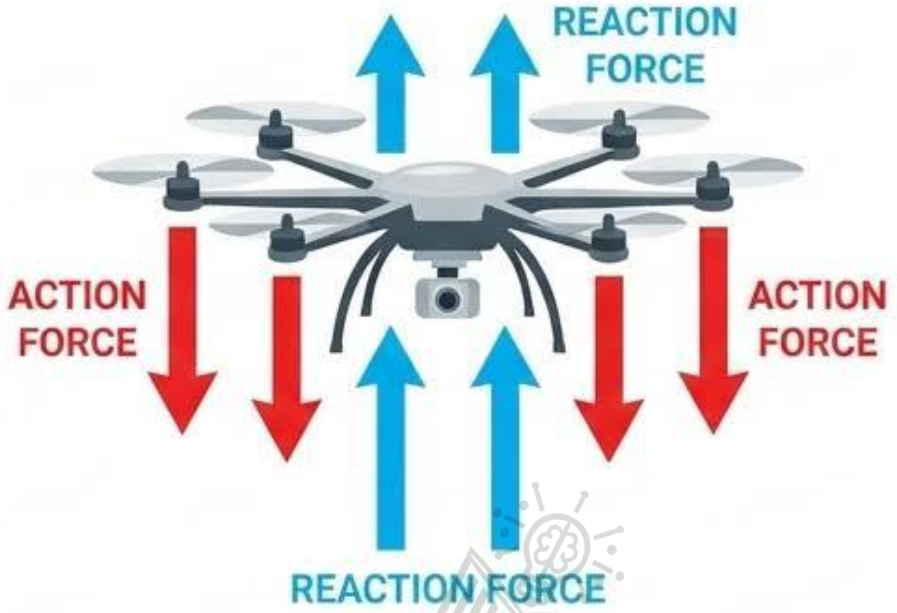
Comprehensive Student File // 100% Visual Synthesis

The Core Rule: Newton's Third Law of Motion

When one 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.**



If you push a little, the wall pushes a little.
Push a lot, the wall pushes a lot.



Even with small air particles, pushing a large amount of air downward leads to a large push back upward.

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Visualizing Physics: Free-Body Diagrams

How scientists simplify complex forces to calculate motion.

All forces come in pairs, which can make understanding motion complicated. Free-body diagrams strip away the environment (water, air, background) and focus only on the net forces acting on the specific object being measured.

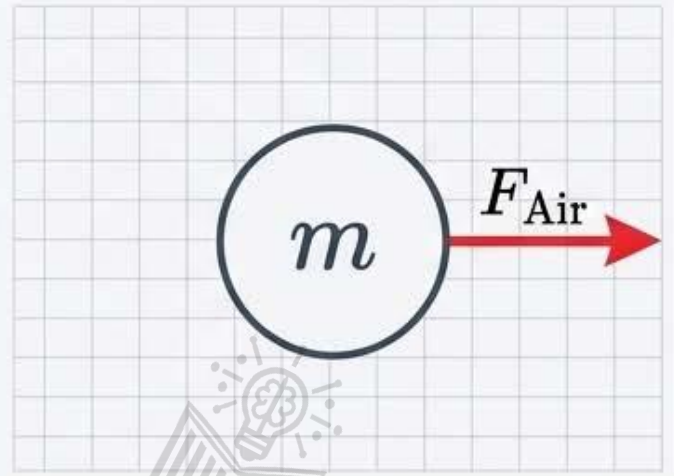
Step 1: Reality



Step 2: Abstraction



Step 3: The Free-Body Diagram



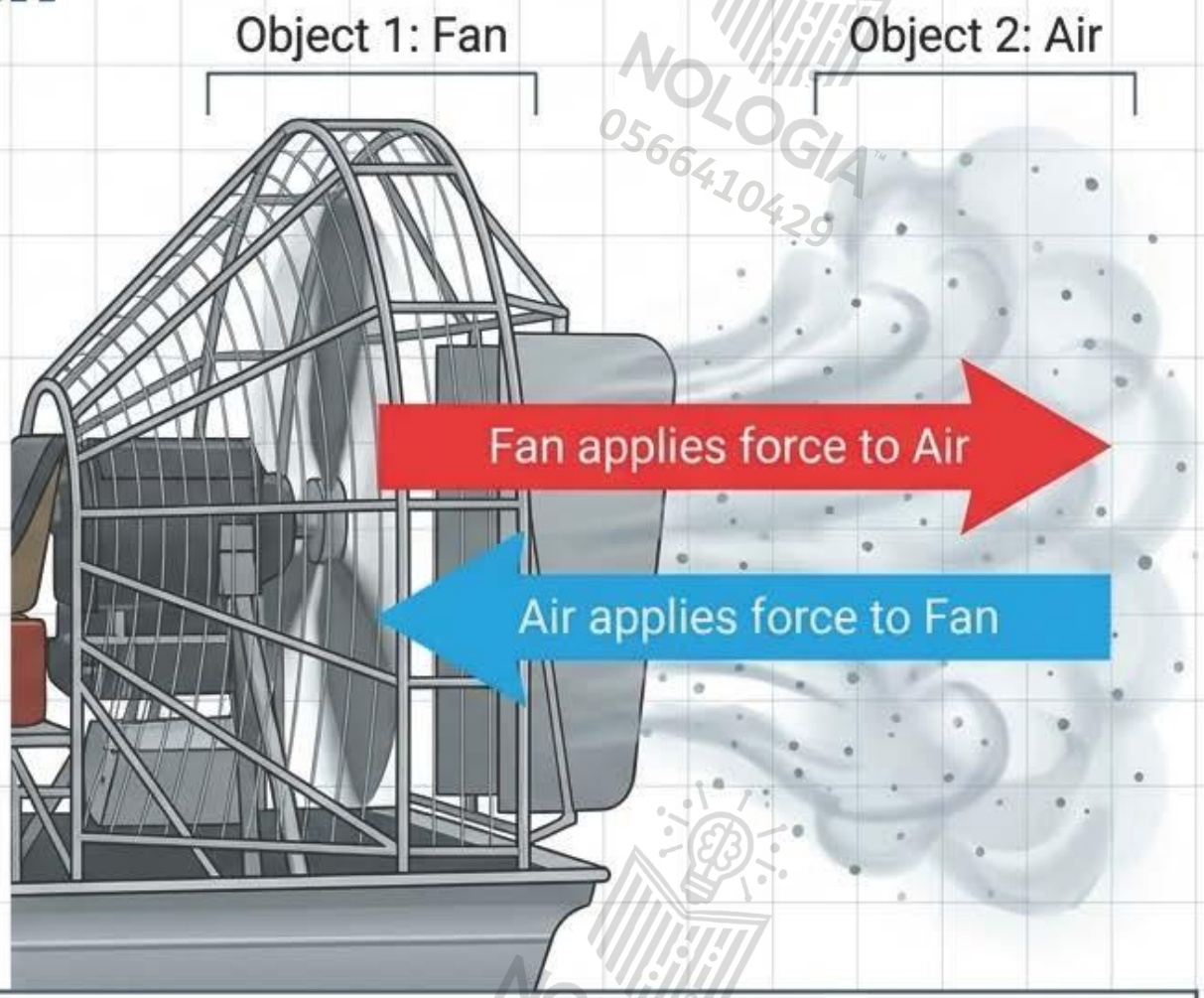
Why only one arrow? Because the object is the boat, not the air. We only map the force of the air acting on the boat.

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Anatomy of a Force Pair

Forces never exist alone. A force pair is the specific combination of forces two interacting objects apply directly to each other.

The 3 Rules of Pairs
☑ 1. They depend entirely on each other.
☑ 2. They are always the exact same strength.
☑ 3. They always act in opposite directions.

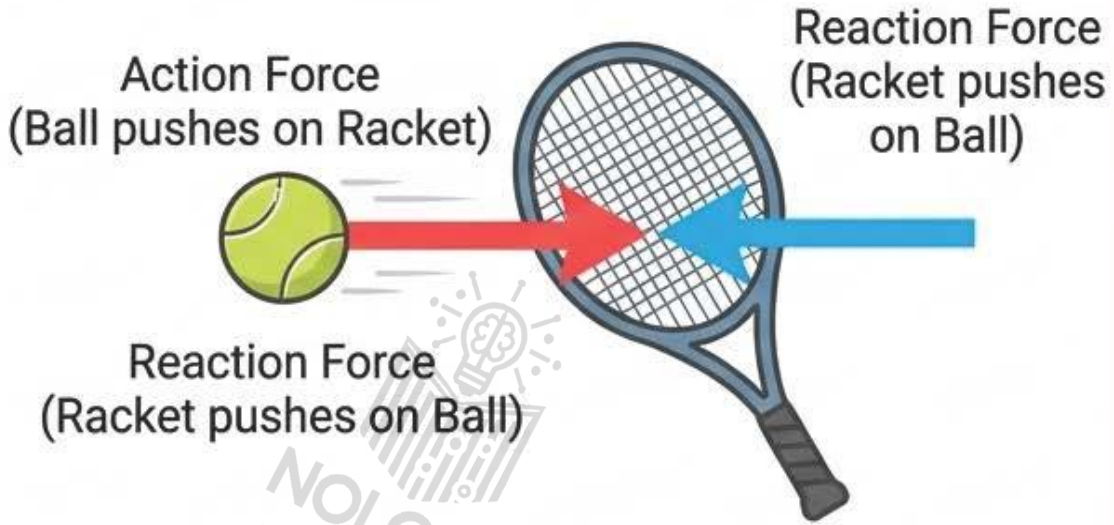


NOLOGIA **NOLOGIA Study Tip:** Force pairs are the fundamental building blocks of all movement, from walking on the ground to rockets in space.

The Ultimate Distinction: Why Objects Move
Force Pairs vs. Balanced Forces

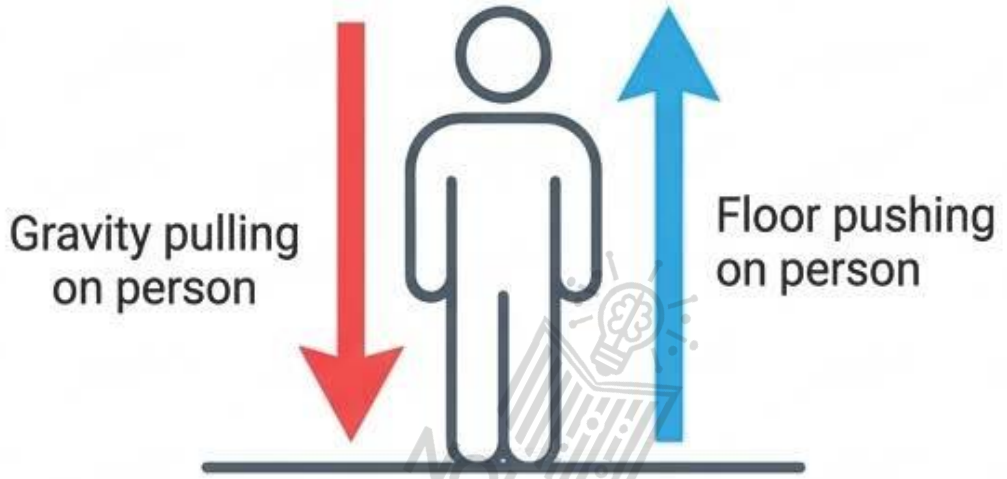
Force Pairs (Newton's 3rd Law)

- **Target Rule:** Forces act on DIFFERENT objects.
- **Net Force:** Does NOT equal zero. (Objects can accelerate).



Balanced Forces (Newton's 1st Law)

- **Target Rule:** Forces act on the SAME object.
- **Net Force:** Results in exactly ZERO. (No change in motion).

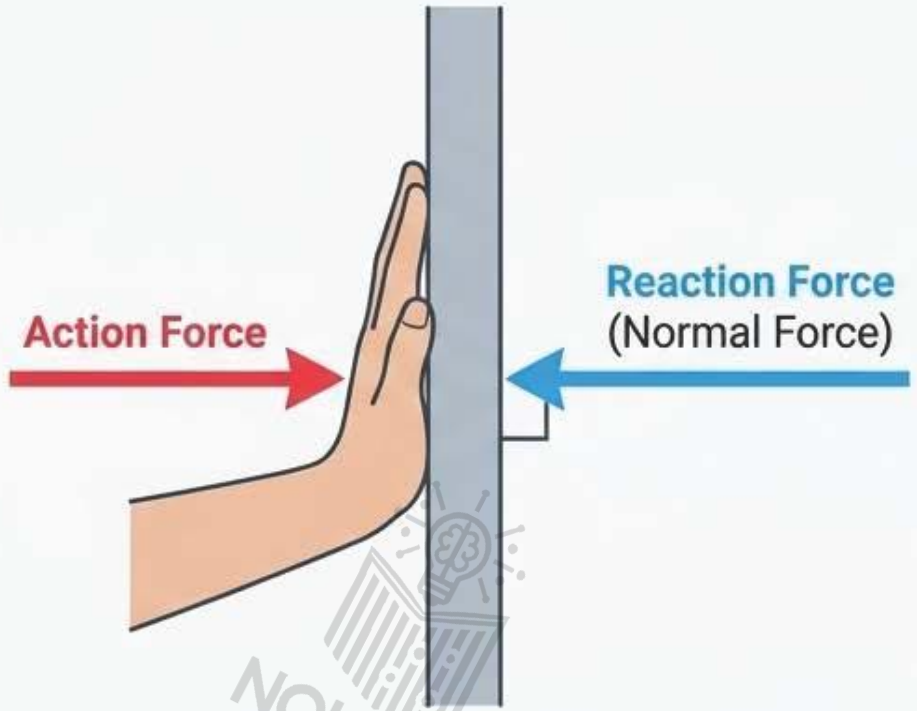


Adding forces only results in a net force of zero if the forces act on the exact same object.

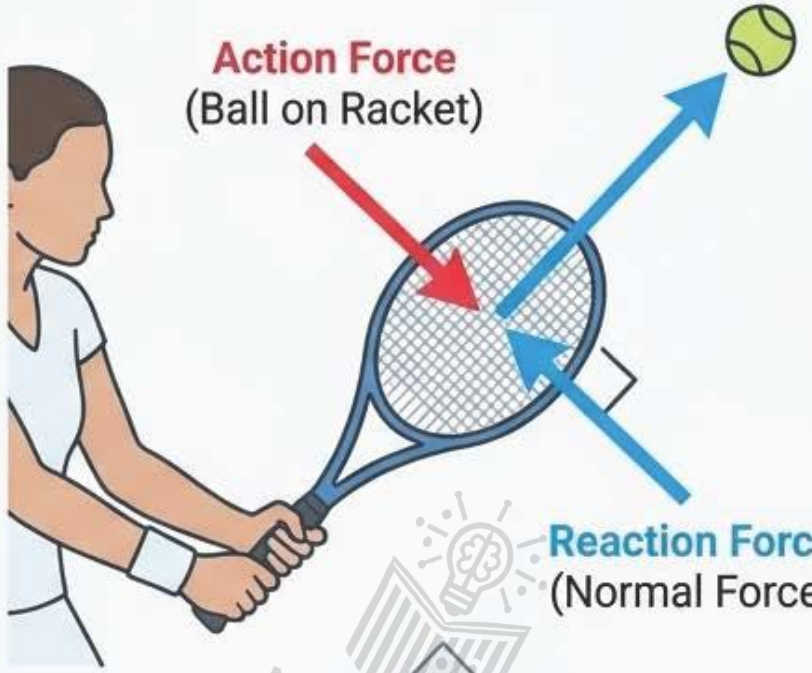
The Normal Force: When Surfaces Push Back

The **normal force** is the specific reaction force that pushes back perpendicular (at a 90-degree angle) to an object's surface.

Flat Surface



Angled Surface



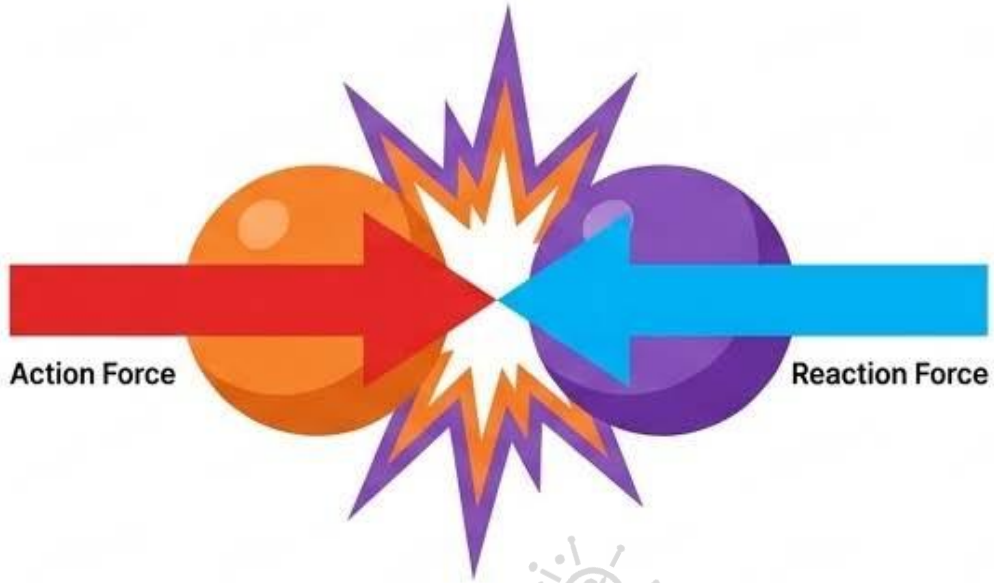
This is why a tennis player turns her racket! The racket applies a normal force in the exact perpendicular direction she wants the ball to travel.

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Forces in Motion: Collision Mechanics

When moving objects collide, Newton's third law dictates an immediate, mutual exchange of force.

Force Exchange Breakdown
1. Object A applies a force to Object B. (Object B accelerates in the direction of the hit).
2. Simultaneously, Object B applies an equal force back on Object A. (Object A slows down, stops, or reverses direction).



If the mass of the objects is exactly the same, they will absorb the equal forces equally. If masses differ, the resulting acceleration changes.

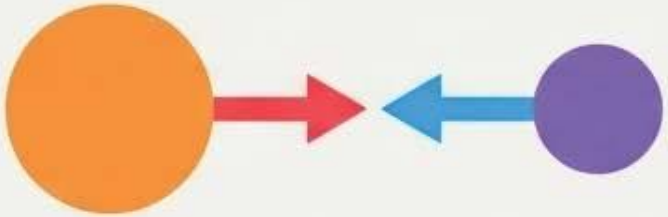
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Collision Matrix: Elastic vs. Inelastic

Elastic Collisions

Objects bounce off each other upon impact.

Before



After



Inelastic Collisions

Objects collide and stick together as a single mass. Example: Football players tackling each other.

Before



After



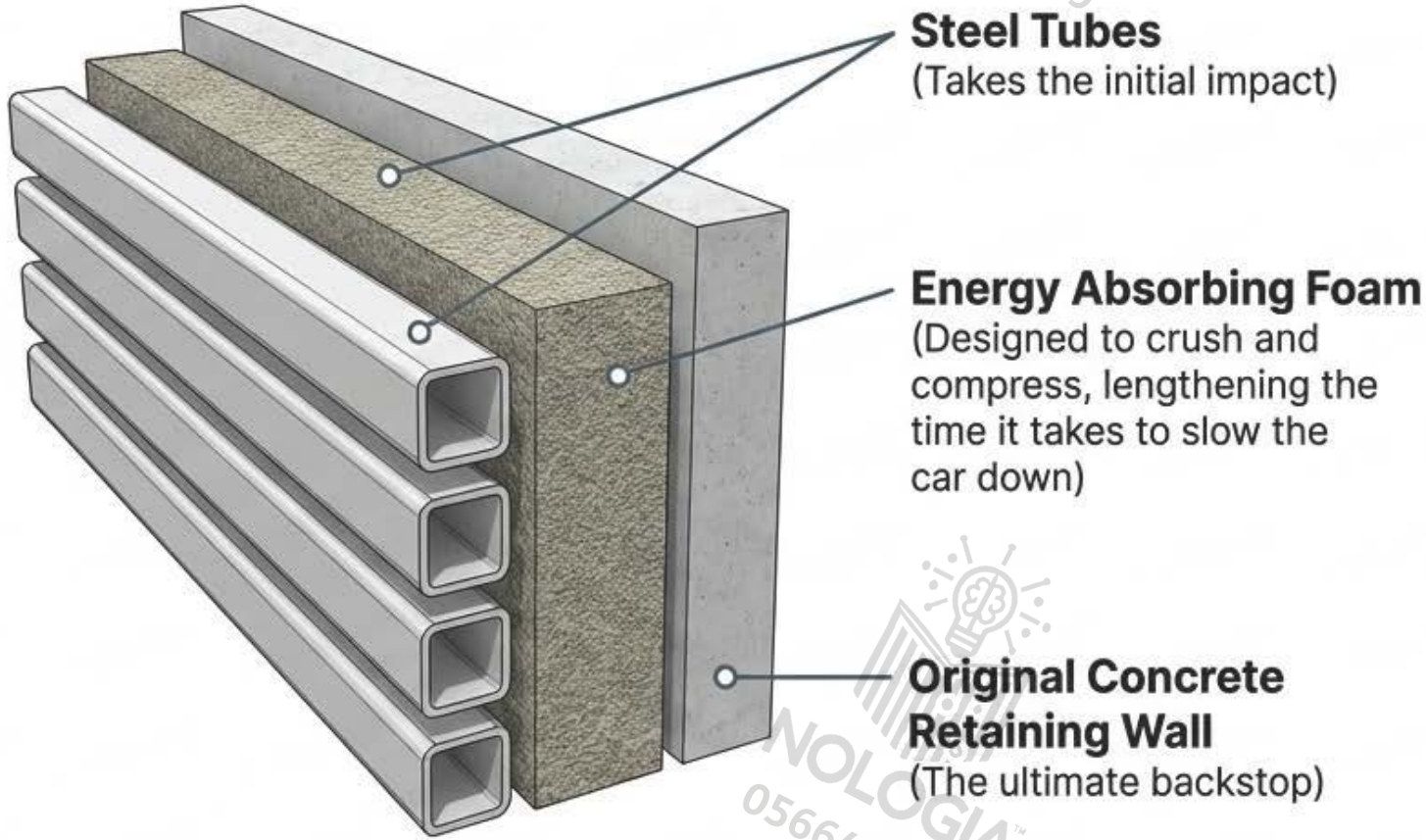
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Real-World Application: SAFER Barriers in Racing

Surviving a 290 km/h racecar crash requires managing Newton's third law.
The goal is to transfer energy into the track, not the driver.

By doubling the amount of time the car spends in contact with the wall, the barrier reduces the immediate push back (reaction force) on the driver.
The energy crushes the foam instead of injuring the human.



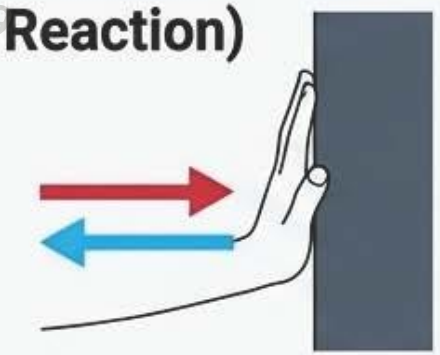
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The NOLOGIA Master Summary

Newton's Third Law & Force Mechanics at a Glance

The Core Rule (Action = Reaction)

Forces occur in pairs. Equal strength, opposite direction.



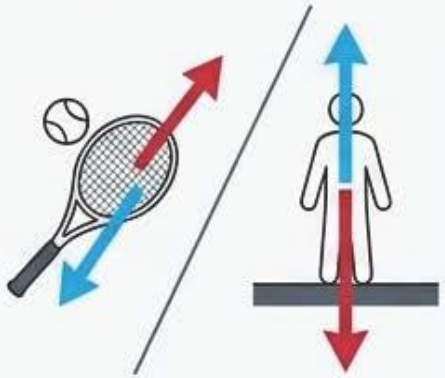
Visualizing Net Force

Free-body diagrams strip away the environment to show only forces acting on one object.



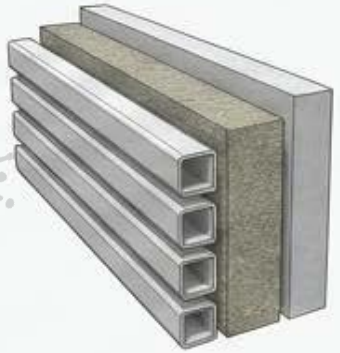
The Critical Distinction

Force Pairs act on different objects (motion occurs). Balanced Forces act on the same object (net force = zero, no motion).



Collisions & Safety

Elastic (bounce) vs. Inelastic (stick). Safety engineering lengthens collision time to disperse reaction forces.



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Exam Preparation

A person is applying a force to the right on an object as shown.



1) What forces are acting on the person?

A. a slightly smaller force to the left because the object is accelerating.

B. a force equal to the force applied going to the left.

C. a force to the right to apply the force to the object.

D. a force to the right because the object is accelerating.

2) The person is standing on ice with little to no friction. What will be the motion of the person applying the force to the object?

A. begin to move to the right because that is the direction of the push.

B. no change in motion because the person is pushing the object.

C. begin to move to the left because the object pushes on the person.

D. begin to move to the right with the object.

3) Which of the following systems does NOT represent a force pair?

A. When you push on a bike's brakes, the friction between the tires and the road increases.

B. When a diver jumps off a diving board, the board pushes the diver up.

C. When an ice skater pushes off a wall, the wall pushes the skater off of the wall.

D. When a boy pulls a wagon, the wagon pulls back on the boy.

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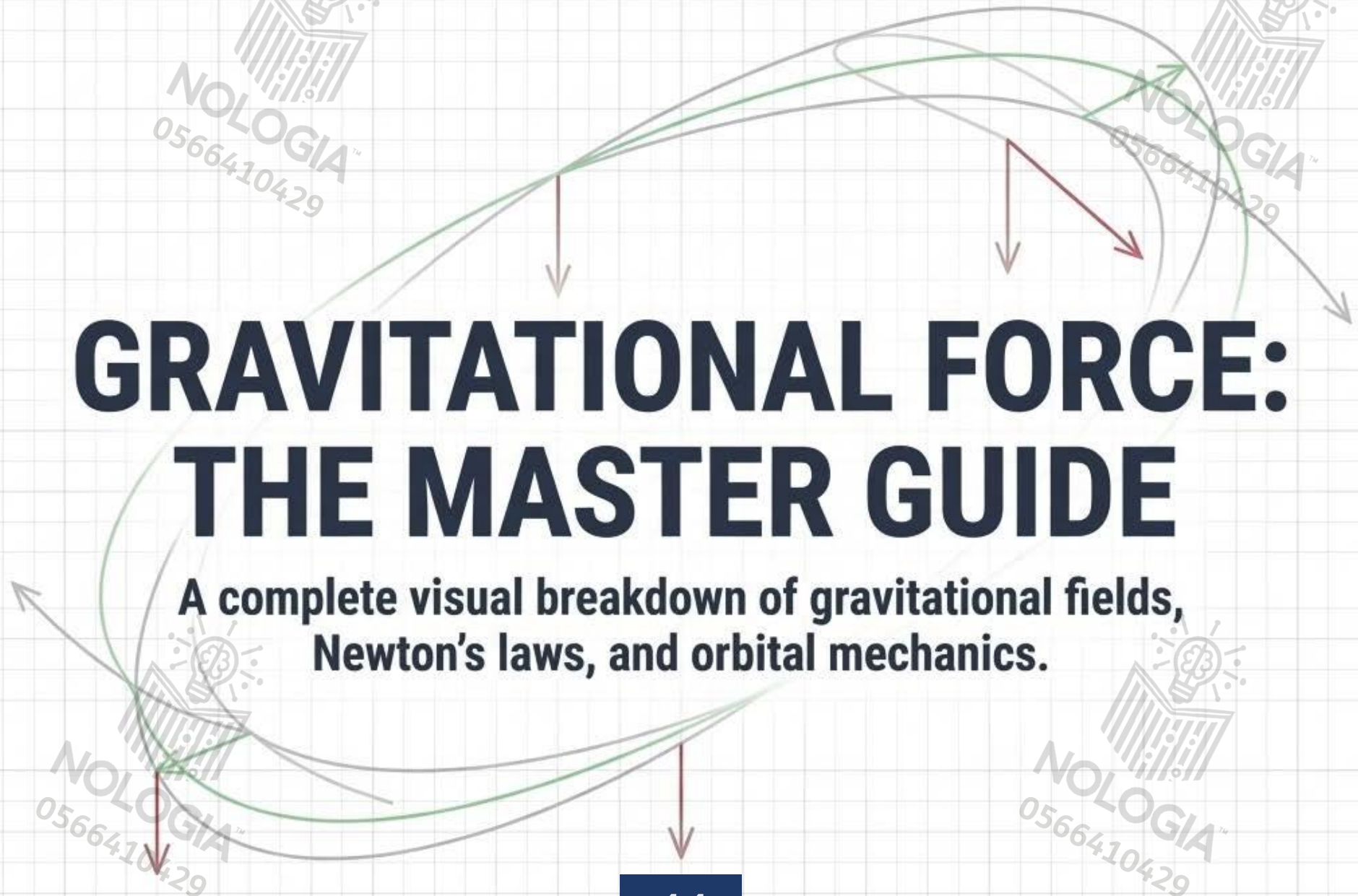
Module (1): Forces and Motion

04 Fourth Lesson: Gravitational Force

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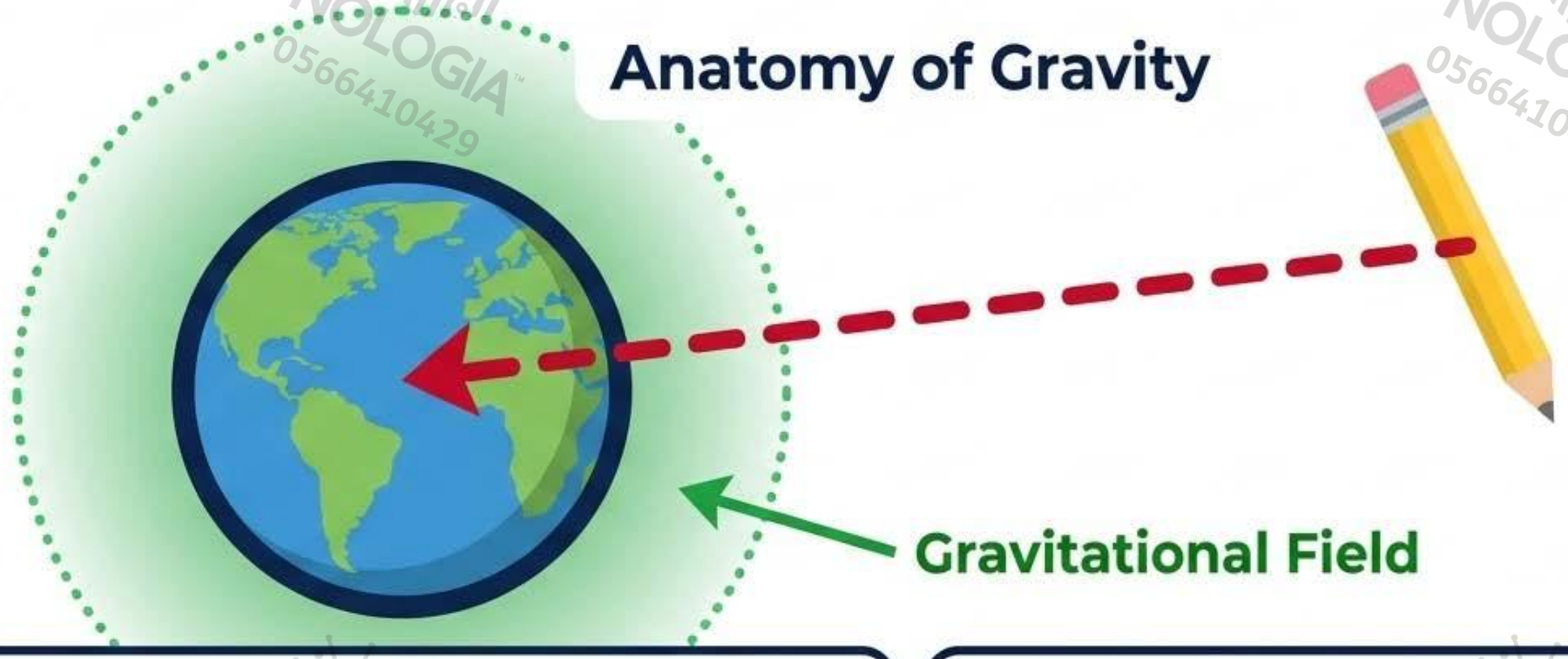
GRAVITATIONAL FORCE: THE MASTER GUIDE

A complete visual breakdown of gravitational fields, Newton's laws, and orbital mechanics.

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The Core Concept: What is Gravity?

Anatomy of Gravity



Gravity (Gravitational Force)
An attractive force that exists between all objects that have mass.

Gravitational Field
A region of space that has a physical quantity (such as a force) at every point.

KEY INSIGHT: Because of the gravitational field, an object does not have to touch Earth for gravity to act on it. **y acts through space.**

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The Two Pillars of Gravity



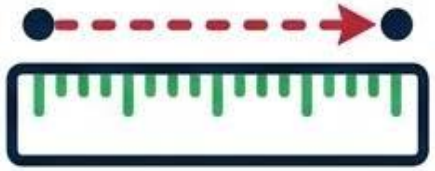
Historical Context: In the late 1600s, Sir Isaac Newton summarized the universal rules governing these forces in his foundational text, *Principia: The Mathematical Principles of Natural Philosophy.*

1. Mass



The amount of matter in an object.

2. Distance



The physical space between two objects.

NOLOGIA MASTER RULE: EVERY OBJECT WITH MASS EXERTS A GRAVITATIONAL PULL, BUT ITS STRENGTH DEPENDS ENTIRELY ON THESE TWO FACTORS.

Factor 1: The Role of Mass

Direct Proportional Relationship.

When the mass of one or both objects increases, the gravitational force between them also increases.

Newton's Third Law: Each object exerts the exactly same attraction on the other object, regardless of their individual mass differences.

Scenario A



Low Mass = Weak Force

Scenario B

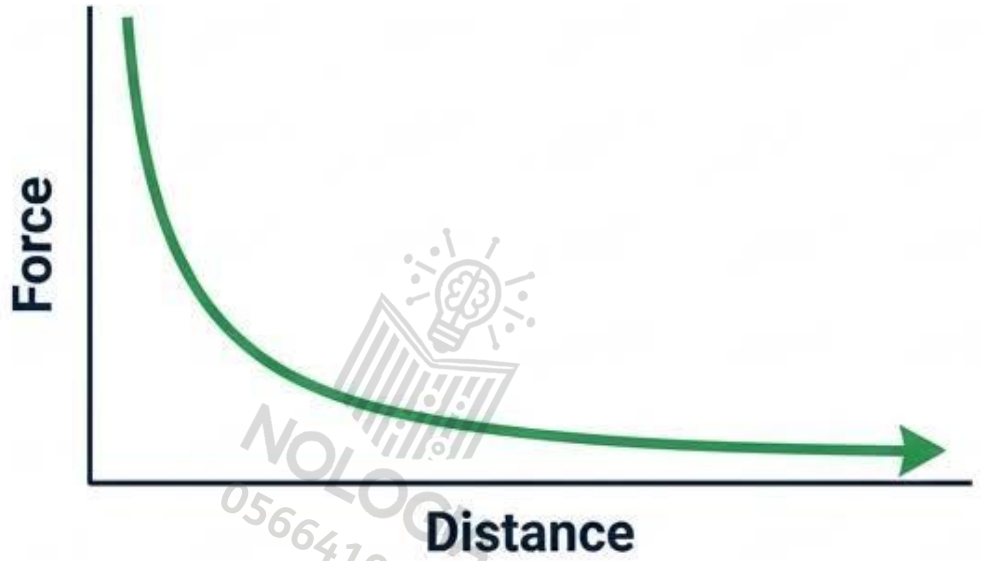


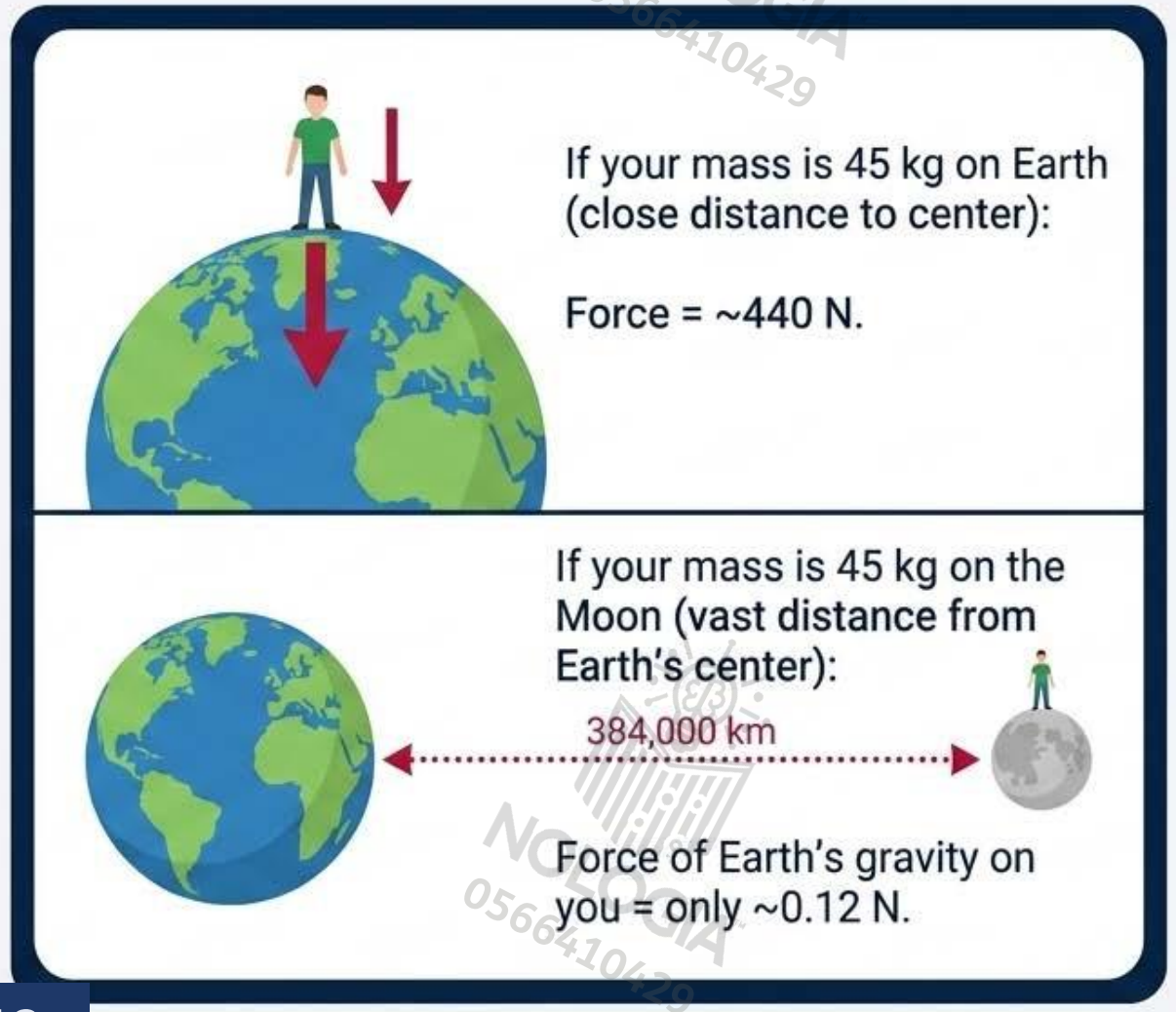
High Mass = Strong Force

Factor 2: The Role of Distance

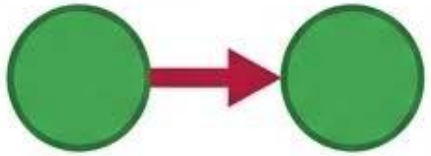
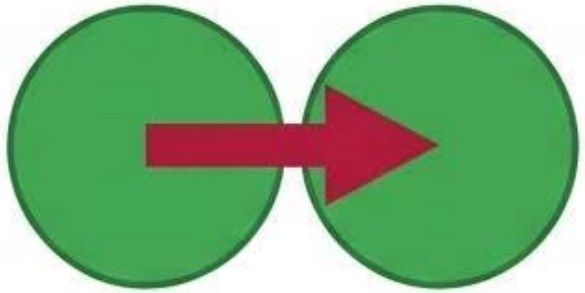
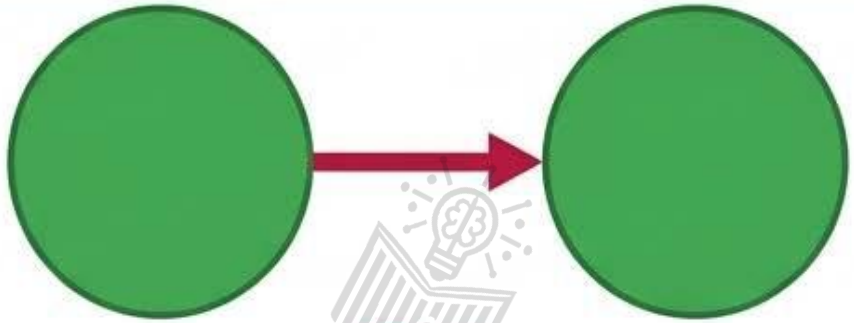
Inverse Proportional Relationship.

As the distance between objects increases, the attraction between them decreases.





Synthesis Matrix: Mass vs. Distance

Change in Mass	Change in Distance: Decreased Distance	Change in Distance: Increased Distance
Baseline Mass	 Force	 Force Decreases
Increased Mass	 Force Increases	 Force

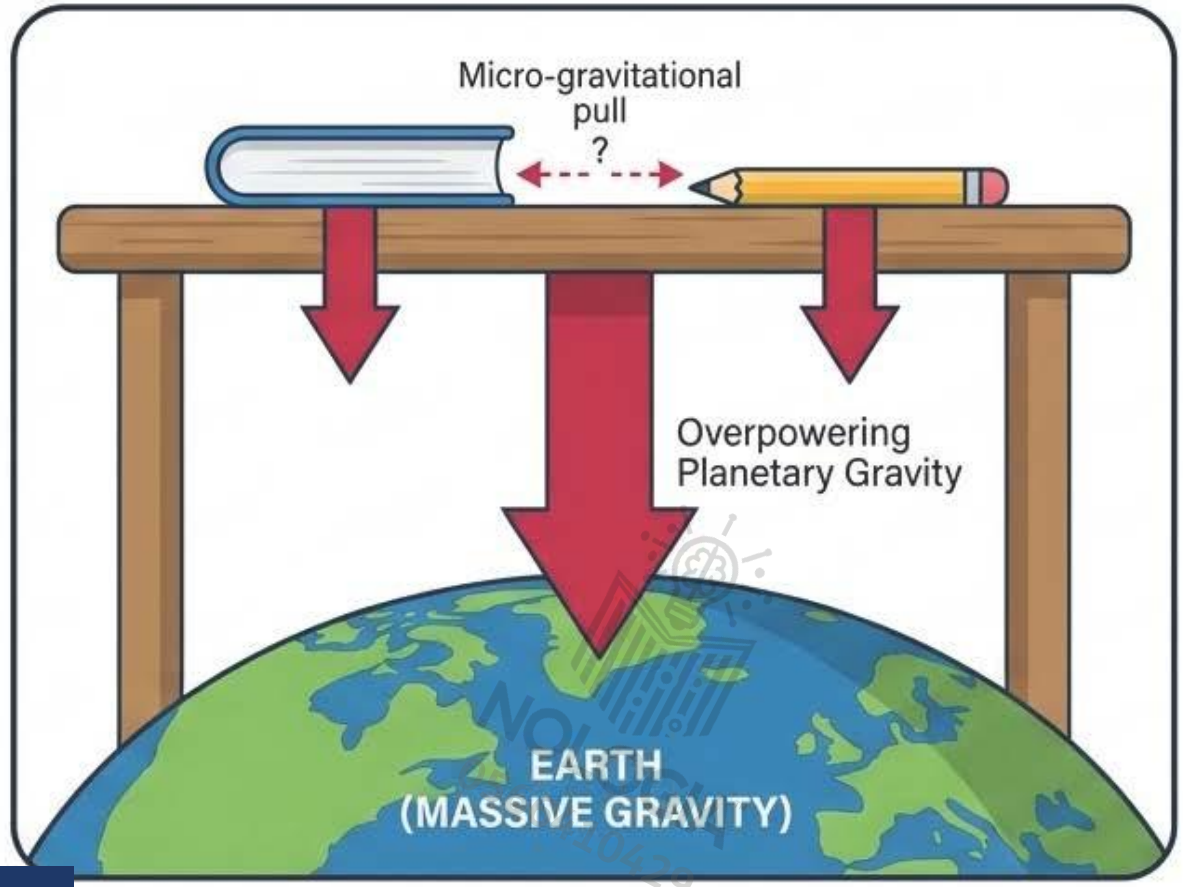
Synthesis Insight: Maximum gravity requires maximum mass and minimum distance.

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Addressing the Misconception: The Gravity of Small Objects

Why don't a pencil and a book attract each other on a desk?

- All objects have mass, meaning all objects possess a gravitational field.
- The masses of the pencil and book are microscopic compared to Earth.
- They do pull on each other slightly, but the force is incredibly weak—not enough to overcome friction and cause a change in motion.



Gravitational Acceleration (g)

The Law

When gravity is the only force acting on falling objects, they all fall at the exact same acceleration regardless of their mass.

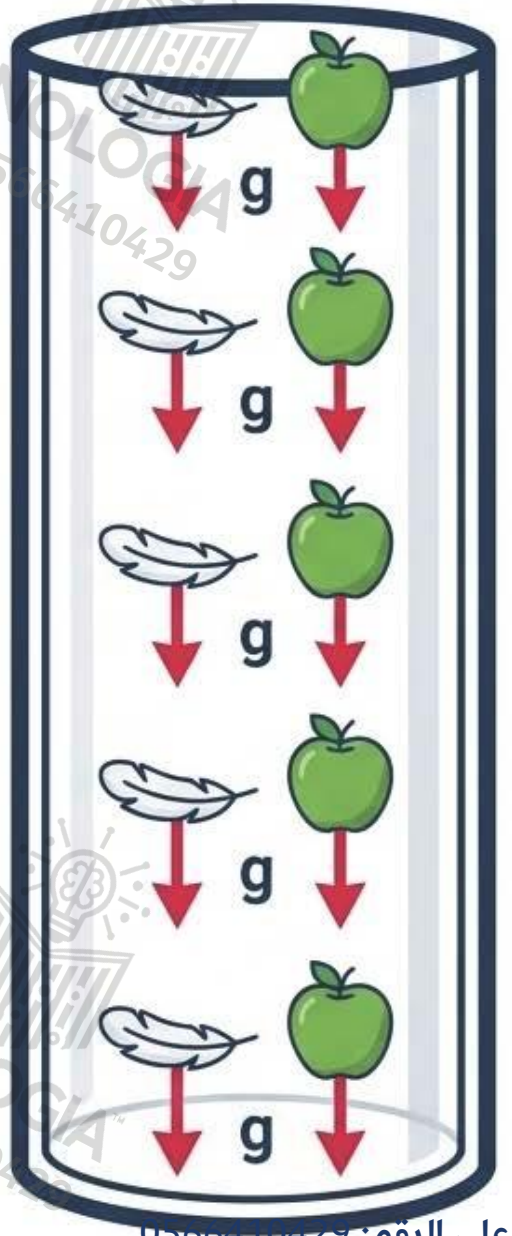
The Constant

$$g = 9.8\ m/s^2$$

Close to Earth's surface.

The Air Resistance Caveat

The feather and apple only fall at the same time in a vacuum. In the real world, air resistance opposes gravity and slows lighter objects down.



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MASS VS. WEIGHT: THE ULTIMATE COMPARISON

	MASS	WEIGHT
Definition	The amount of matter in an object.	The gravitational force exerted on an object.
Unit of Measurement	Kilograms (kg)	Newtons (N)
Location Dependency	Never changes. A 45 kg student is 45 kg on Earth, the Moon, and in deep space.	Changes constantly based on the strength of the local gravitational field.

The Weight Equation Breakdown

$$W = m \times g$$

Weight
(Measured in Newtons, N)

Mass
(Measured in Kilograms, kg)

Gravitational Acceleration
(9.8 m/s² on Earth)

Mini-Calculation Example

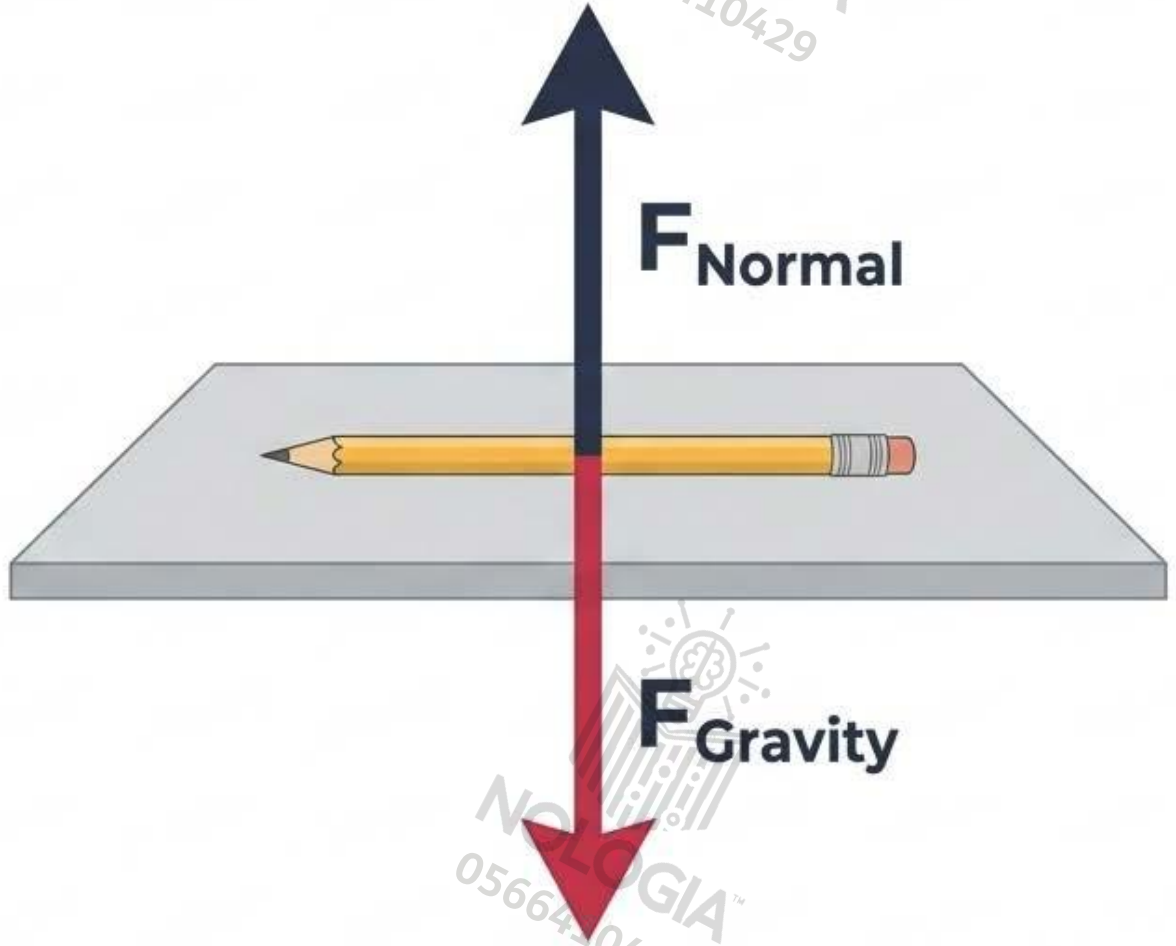
Example: If a book has a mass of 2 kg on Earth...

$W = 2 \times 9.8 = 19.6$ N

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NORMAL FORCE: NEWTON'S THIRD LAW IN ACTION

- **Normal Force:** Newton's third law of motion states that for every force, there is an equal but opposite force.
- The gravity of Earth pulls the pencil downward (its weight).
- The table pushes back up on the pencil with an equal, opposite force called the normal force, creating equilibrium.



MACRO-GRAVITY: CREATING THE SOLAR SYSTEM

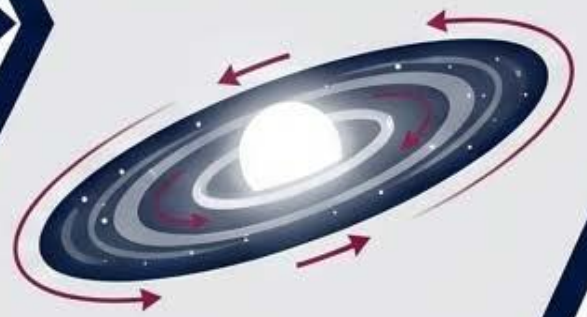
STEP 1: THE CLOUD

Gravity pulls together a massive cloud of gas, ice, and dust in space.



STEP 2: THE DISK

The cloud shrinks, flattens, and becomes a rapidly rotating disk. The dense center forms the Sun.



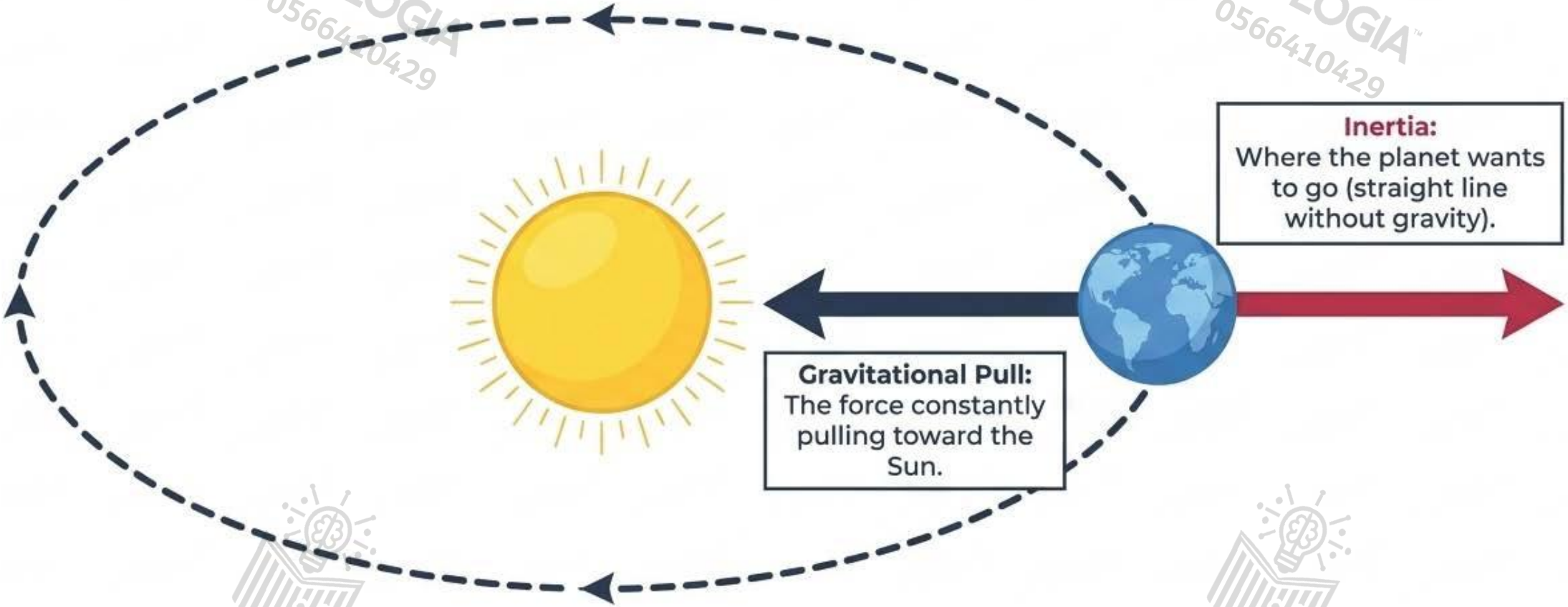
STEP 3: THE PLANETS

Remaining bits of material collide and stick together via gravitational pull, forming larger masses until planets like Earth are born.



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MACRO-GRAVITY: ORBITAL MECHANICS



Result: The continuous elliptical orbit. Everything in the solar system is held together by the Sun's gravitational force.

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NOLOGIA Master Summary

Core Definitions

- → **Gravity:** An attractive force between masses.
- → **Field:** A region of space possessing a physical quantity.

The Rules of Gravity

- → ↑ **Mass** = ↑ **Gravity** (Direct Proportion)
- → ↑ **Distance** = ↓ **Gravity** (Inverse Proportion)

The Constants

- **Acceleration on Earth:** $g = 9.8\ m/s^2$
- **Mass (kg):** Constant anywhere.
- **Weight (N):** Changes based on local gravity.

The Equation

$$W = m \times g$$

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Exam Preparation

The model below represents a star orbited by two planets—Planet A and Planet B. The star is also orbited by a mysterious object, Object X, which entered into the star's gravitational field. The star is the most massive object, followed by Planet B, Planet A, and Object X.

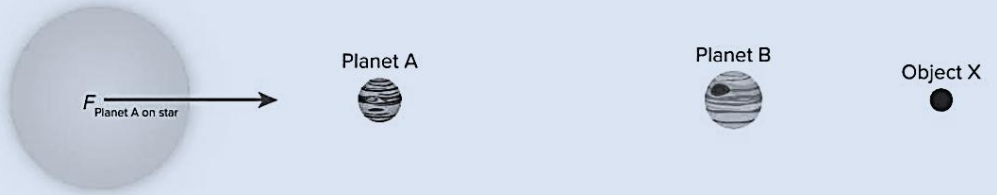
1) **In the model, how is the mass of the objects represented?**

   A. The mass is represented by the size of the objects.

   B. The mass is represented by the distance between the objects.

   C. The mass is represented by the color of the objects.

   D. The mass is not represented.



2) **The gravitational force from Planet A on the star is shown in the model. How should the arrow that represents the gravitational force from the star on Planet A be represented?**

   A. It should point from Planet A toward the star and will be longer because the star has more mass.

   B. It should point from Planet A toward the star and will be the same size because it is an equal and opposite force.

   C. It should point from Planet A toward the star and will be shorter because Planet A has less mass.

   D. There is no arrow to represent because gravitational force is only in one direction.

Energy and Motion

Module (2): Mechanical Energy

	Lesson Title	Page
2-1	Kinetic Energy	60
2-2	Potential Energy	77
2-3	Conservation of Energy	90

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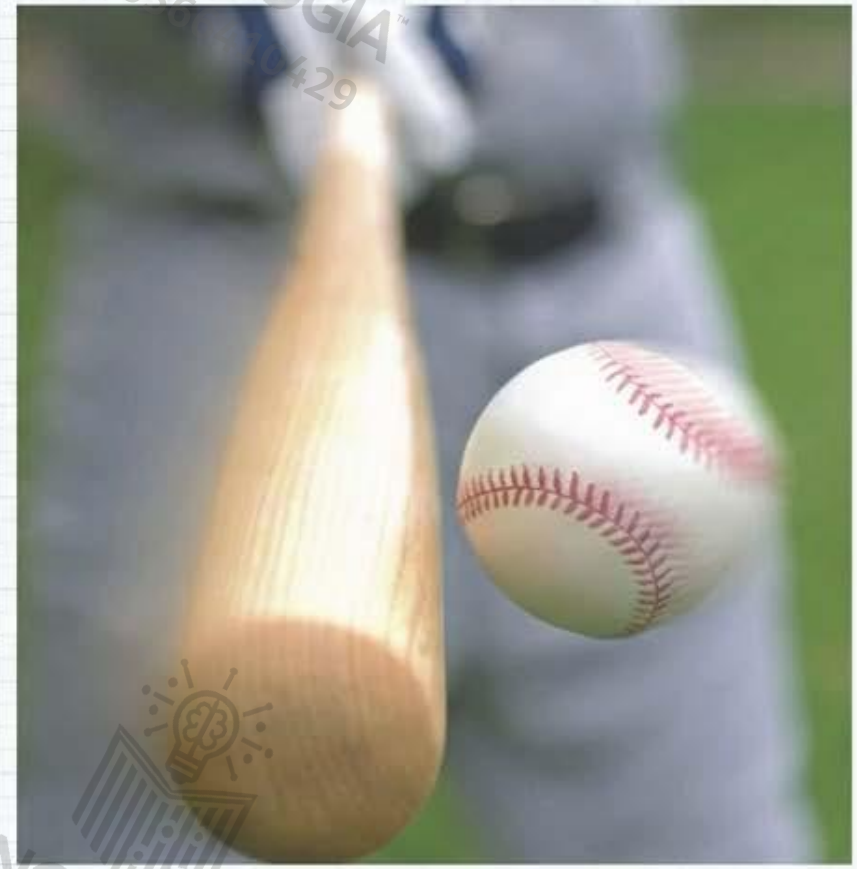
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Module (2): Mechanical Energy

01 First Lesson: Kinetic Energy

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Kinetic Energy: The Complete Guide

Master the physics of motion, mass, and speed.

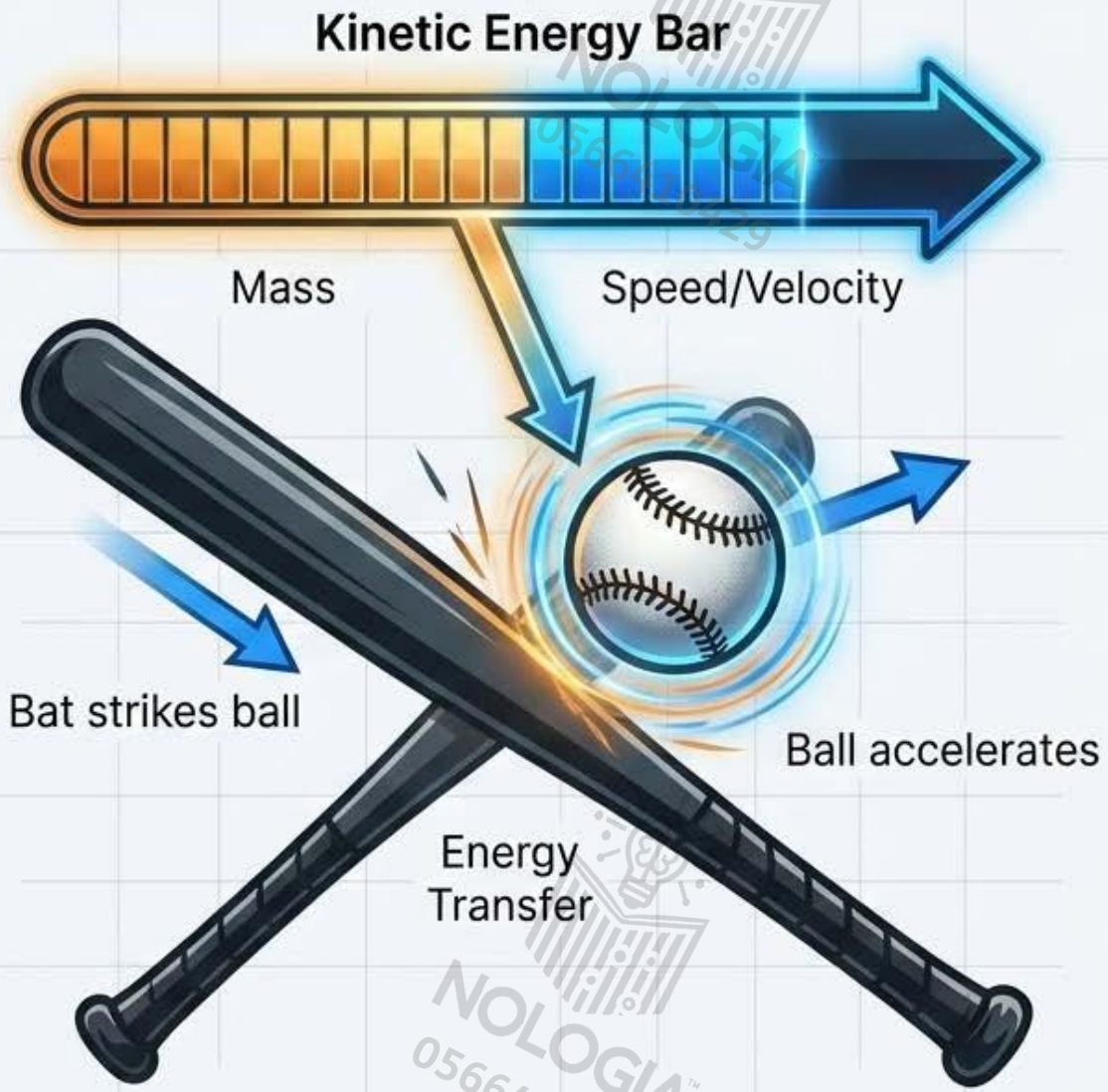
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Energy in Motion

Kinetic Energy (KE) is the energy an object has due to its **motion**.

The Golden Rule: All moving objects possess kinetic energy.

The Mechanism: A change in motion (like a bat launching a ball) happens because the moving object transfers its kinetic energy.



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The Two Pillars of Kinetic Energy

What determines exactly how much kinetic energy a moving object has?



1. Mass
(The amount of matter)



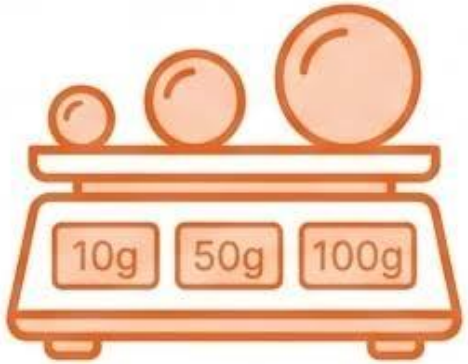
2. Speed
(How fast it moves)

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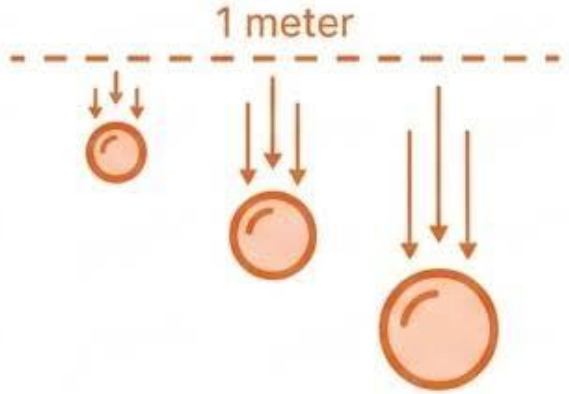
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Investigating Mass

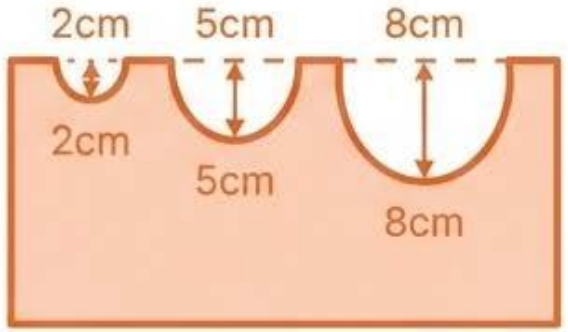
Step 1:



Step 2:



Step 3:



Observation:

Dropping spheres of different masses from the exact same height creates different-sized craters in clay.

Conclusion:

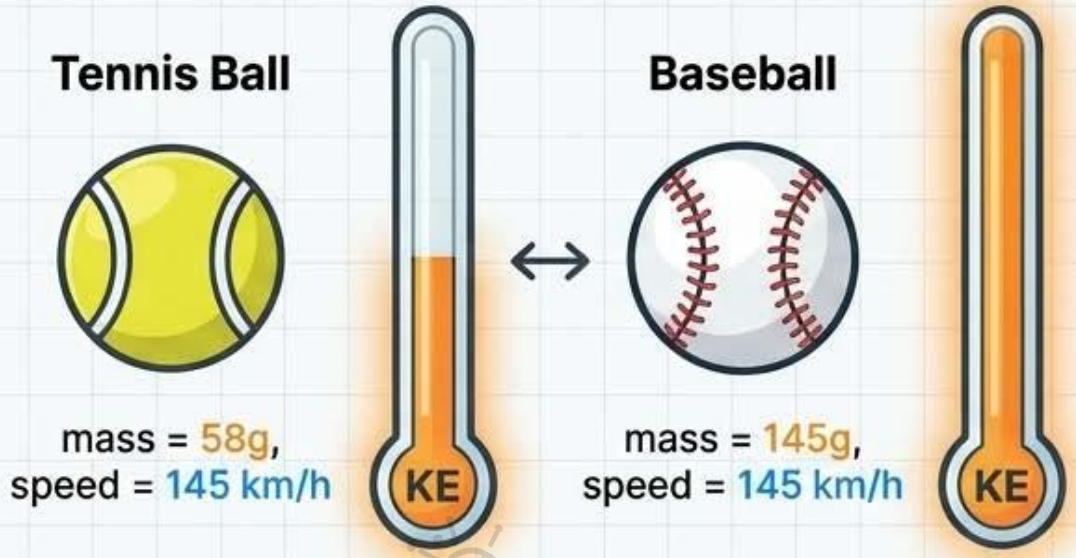
The sphere with the largest mass creates the largest crater. Why? Because it possessed the most kinetic energy upon impact.

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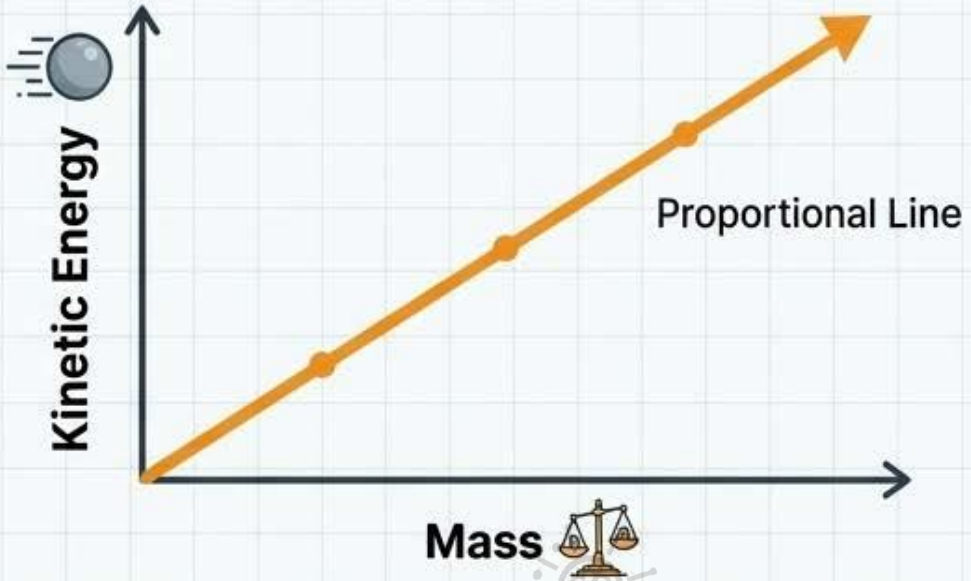
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The Mass-Energy Relationship

Energy Comparison (Same Speed)



Visualizing the Relationship



The Rule:

If objects travel at the **same speed**, the one with more mass has more KE.

The Formula:

$$KE \propto m$$

Graph Takeaway:

This is a proportional, linear relationship.

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Mathematical Thinking: Mass

Because the relationship is linear, Kinetic Energy changes by the exact same factor as the mass.

IF
Mass increases by a factor of 4 $\times 4$

THEN
Kinetic Energy increases by a factor of 4 $\times 4$

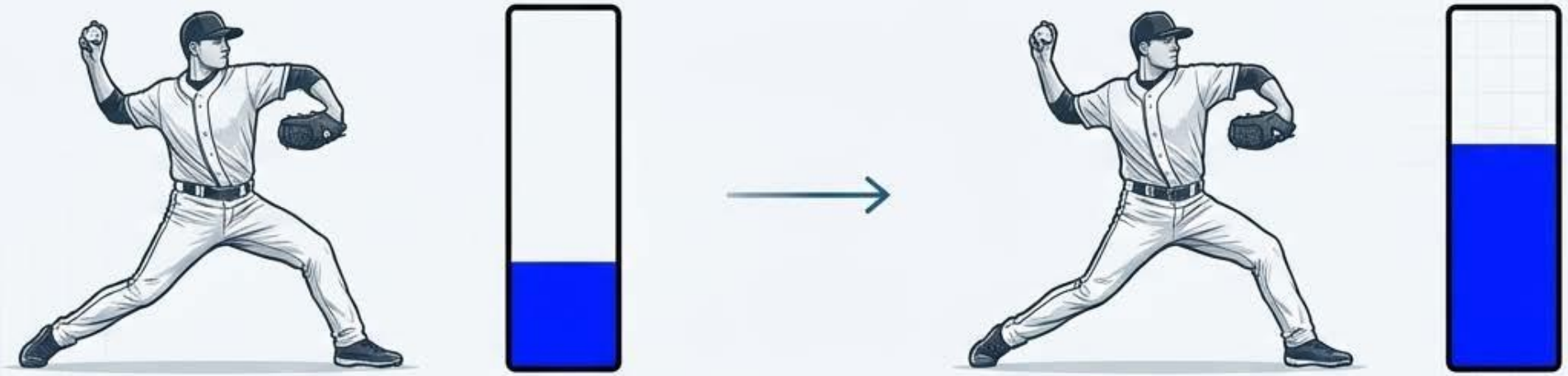
IF
Mass decreases by a factor of 1/2 $\times \frac{1}{2}$

THEN
Kinetic Energy decreases by a factor of 1/2 $\times \frac{1}{2}$

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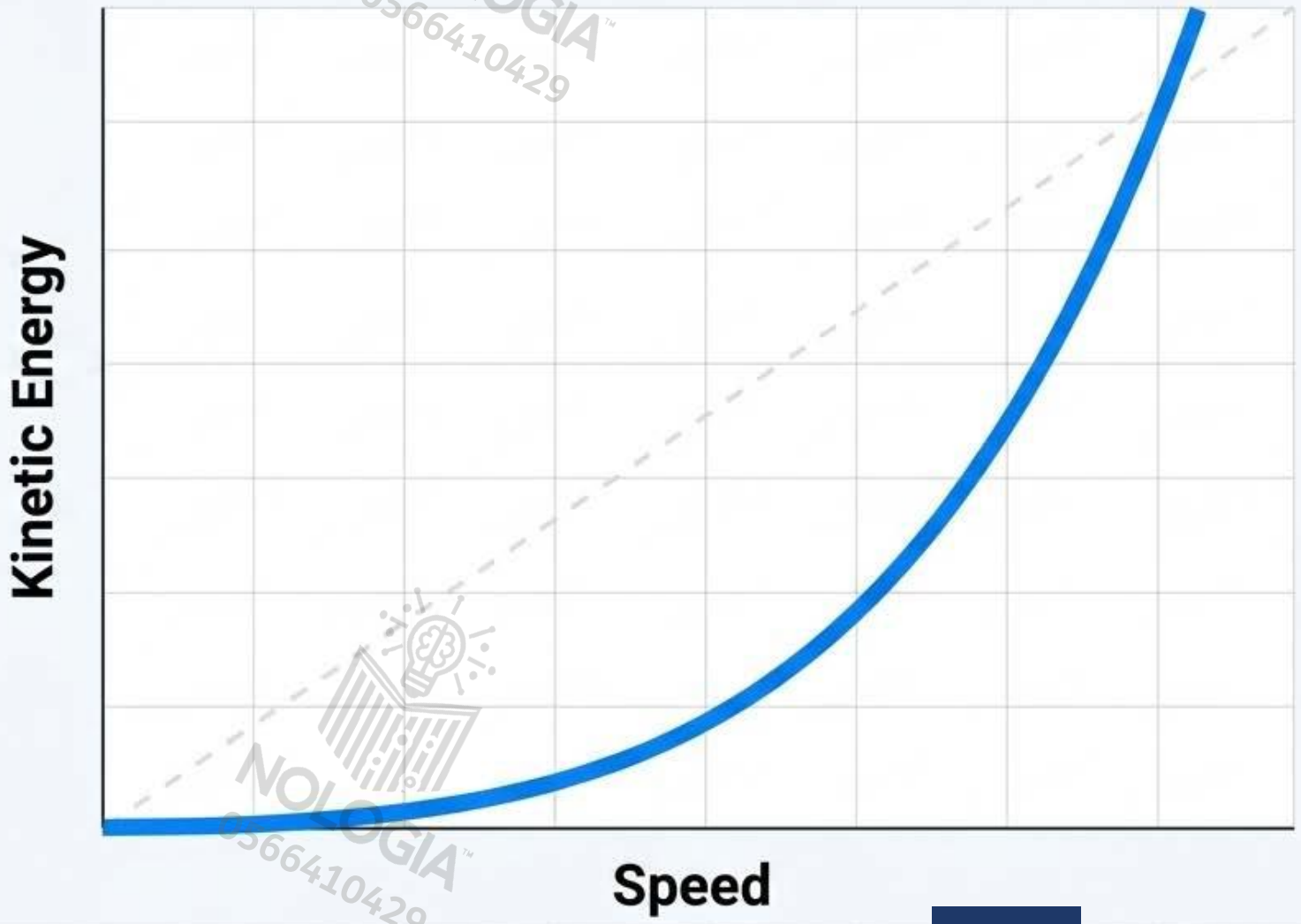
Investigating Speed

An object's kinetic energy heavily depends on how fast it is moving.



The Rule: If mass is identical (the same baseball), the faster moving object has more kinetic energy.

The Speed-Energy Relationship



The Formula: $KE \propto v^2$ (Kinetic Energy is proportional to speed squared).

Graph Takeaway: This is a proportional, nonlinear (square) relationship. Speed increases Kinetic Energy much faster than mass does.

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Mathematical Thinking: Speed

Because it is squared, KE changes by the square of the speed factor.

THE PITCHER

IF
speed doubles **x2** → **THEN**
Kinetic Energy quadruples **x4**

THE HORSE

A horse gallops at 40 km/h, then slows to 20 km/h.
speed is cut in half **x1/2** → **THEN**
Kinetic Energy is reduced to a quarter **x1/4**

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Summary: Mass vs. Speed

Mass (m)	Speed (v)
Proportional, Linear	Proportional, Nonlinear (Square)
$KE \propto m$	$KE \propto v^2$
Straight Line 	Upward Curve 
KE changes by the same factor	KE changes by the square of the factor.

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Two Types of Motion

Motion isn't just going from Point A to Point B.



Translational Motion



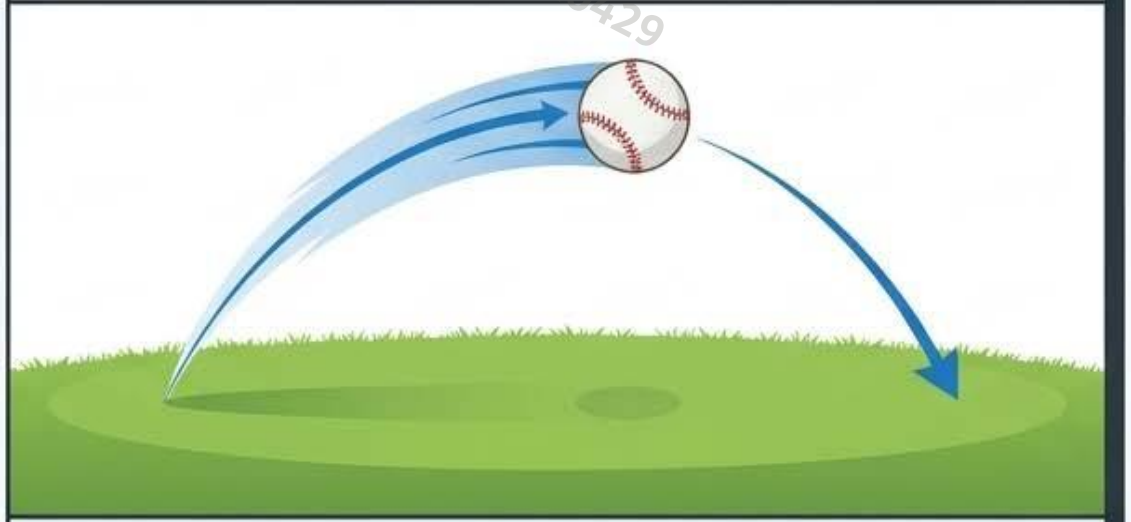
Rotational Motion

There are two primary categories of kinetic energy based on how an object moves through space.

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Two Types of Kinetic Energy

Translational Kinetic Energy



- **What it is:** Motion energy due to a change of position.
- **The Action:** Moving from one point to another.
- **Example:** A baseball thrown across a field.

Rotational Kinetic Energy



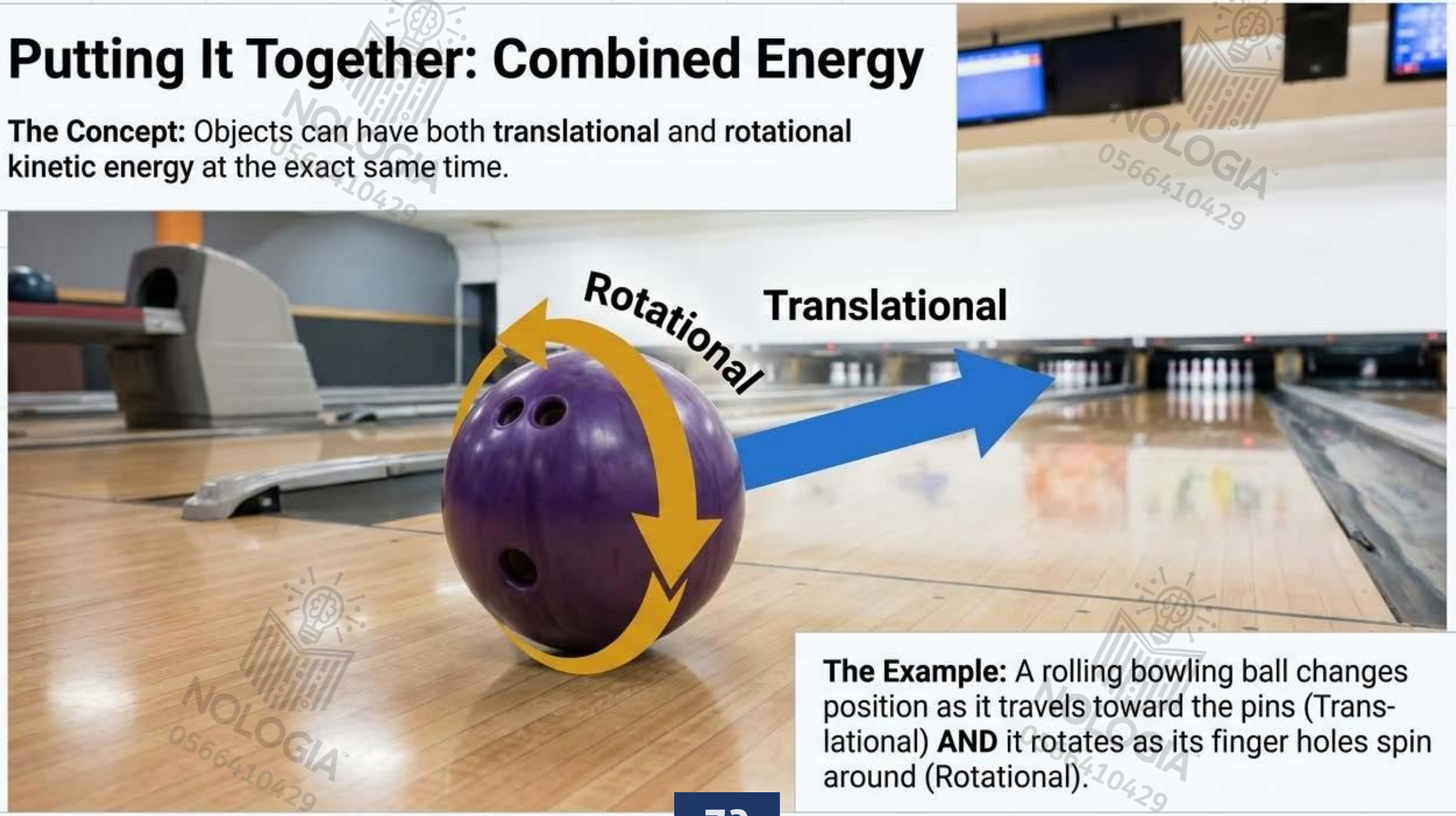
- **What it is:** Motion energy that does not involve changing overall position.
- **The Action:** Spinning or rotating in place.
- **Example:** A Ferris wheel spinning in a park.

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Putting It Together: Combined Energy

The Concept: Objects can have both **translational** and **rotational kinetic energy** at the exact same time.



The Example: A rolling bowling ball changes position as it travels toward the pins (Translational) **AND** it rotates as its finger holes spin around (Rotational).

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NOLOGIA Master Checklist

Chapter Review

- ✓ Definition: Kinetic Energy (KE) is the energy of motion.
- ✓ Mass: KE increases linearly with Mass ($KE \propto m$).
- ✓ Speed: KE increases exponentially with Speed squared ($KE \propto v^2$).
- ✓ Translational KE: Energy of changing position.
- ✓ Rotational KE: Energy of spinning in place.

Combined: Objects can exhibit both types simultaneously.

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End of Lesson 1: Kinetic Energy.

Print this guide for your final exam review.

Exam Preparation

1) Aiden collected canned goods for a neighborhood service project. He pulled a plastic wagon behind him to put the items in. From the time Aiden began until he finished collecting, the mass of the wagon tripled. The walk back to Aiden's house was downhill and the speed of the wagon tripled. What happened to the kinetic energy when the mass tripled? What happened to the kinetic energy when the speed tripled?

A. When the mass tripled, the kinetic energy increased by a factor of 3. When the speed tripled, the kinetic energy increased by a factor of 3.

B. When the mass tripled, the kinetic energy increased by a factor of 3. When the speed tripled, the kinetic energy increased by a factor of 9.

C. When the mass tripled, the kinetic energy increased by a factor of 9. When the speed tripled, the kinetic energy increased by a factor of 3.

D. When the mass tripled, the kinetic energy increased by a factor of 9. When the speed tripled, the kinetic energy increased by a factor of 9.

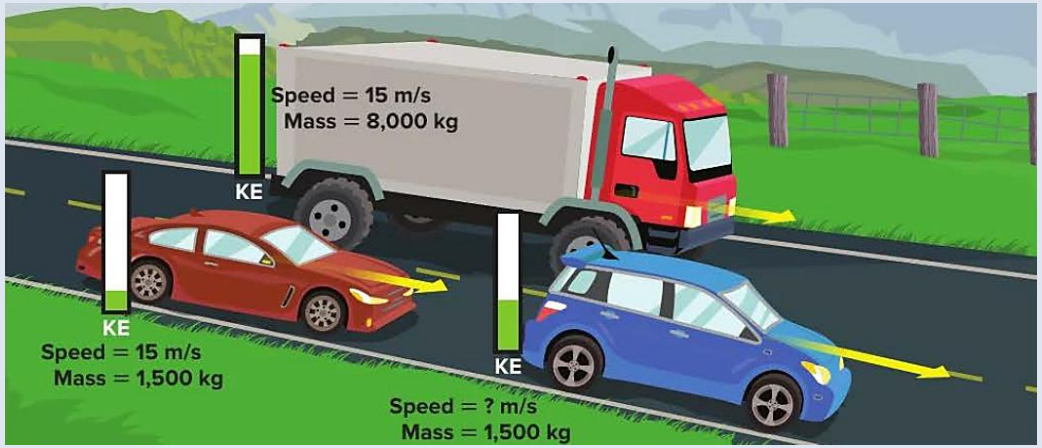
2) What can you determine about the speed of the blue car?

A. The blue car's speed is the same as the red car's speed.

B. The blue car's speed is less than the truck's speed.

C. The blue car's speed is equal to the truck's speed.

D. The blue car's speed is greater than the red car's speed.



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Module (2): Mechanical Energy

02 Second Lesson:

Potential Energy

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Potential Energy

The Physics of Stored Energy, Shape, and Invisible Fields.

1. Zero motion at the peak?



2. Where is the energy hiding?

3. What pulls it back down?

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What is Potential Energy?

Interactions + Distance Change = **Potential Energy**

Potential energy is the energy due to interactions between objects or particles when distance changes.

Key Concept

The amount of potential energy an object has depends strictly on the positions of objects or particles. It is stored energy.

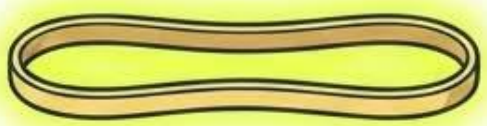
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Elastic Potential Energy (EPE)

Energy stored in objects that are compressed or stretched, such as springs and rubber bands.



Increase Stretch Distance



Increase Elastic Potential Energy



Increase Initial Kinetic Speed

The farther back the rubber band is stretched, the larger the change in position between objects, and the greater the stored potential energy.

The State of a Spring Matrix

Static	Compressed	Stretched
		
Shape Status: Original / Resting	**Shape Status:** Changed (Pushed together)	**Shape Status:** Changed (Pulled apart)
Energy Status: Zero Elastic Potential Energy. The spring wants to return to this state.	**Energy Status:** High Elastic Potential Energy.	**Energy Status:** High Elastic Potential Energy.

Rule: The more you change its shape from static, the greater the elastic potential energy it contains.

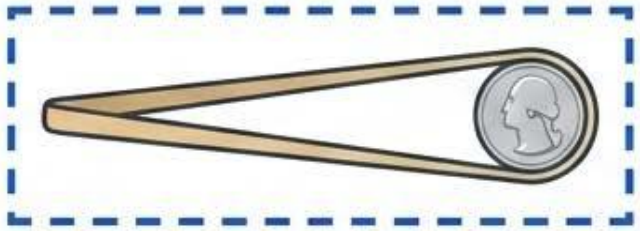
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Mapping Energy Systems

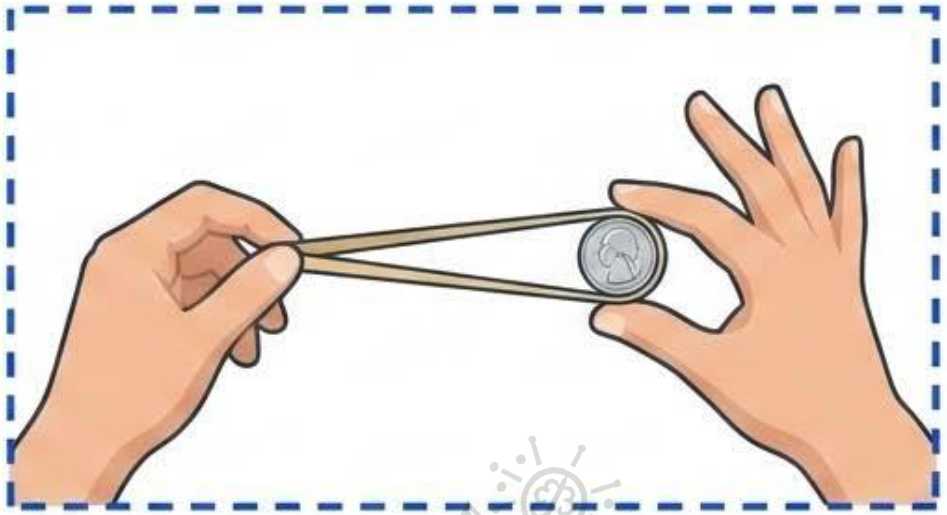
When looking at energy, you must identify the components and how they change.

Closed System



Closed System: Focus is entirely on the interactions between the rubber band and the nickel.

Open System



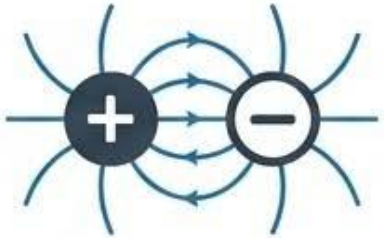
Open System: The surrounding environment is involved in the energy transfer.

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Energy from Invisible Fields

Not all potential energy requires physical contact. Some forms involve different forces acting across invisible fields that extend into surrounding space.

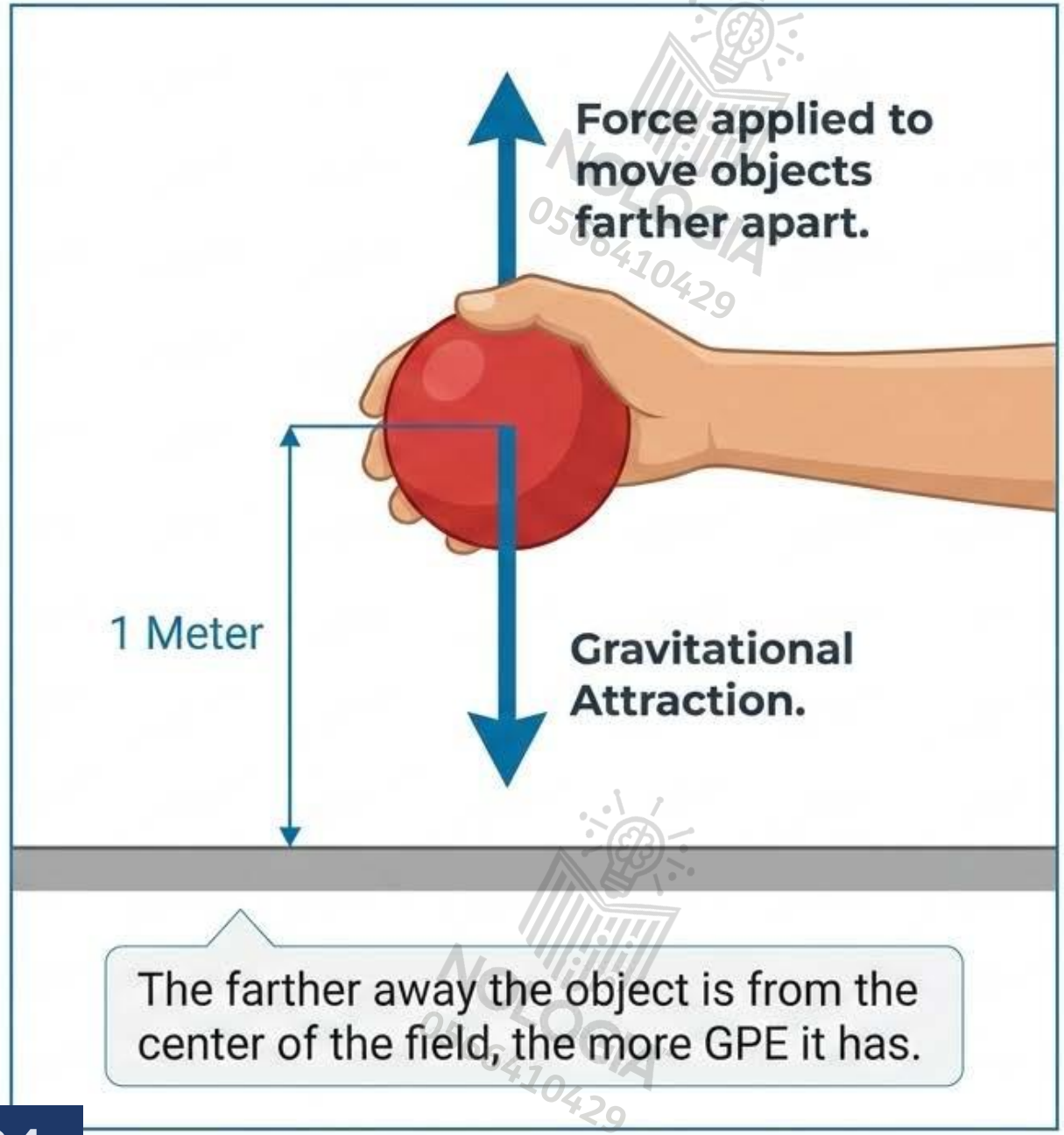
Gravitational Potential Energy	Electric Potential Energy	Magnetic Potential Energy
		
Due to forces in a gravitational field (requires at least one very large object).	Due to forces in an electric field.	Due to forces in a magnetic field.

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Gravitational Potential Energy (GPE)

Definition: Stored energy due to the interactions of objects in a gravitational field.

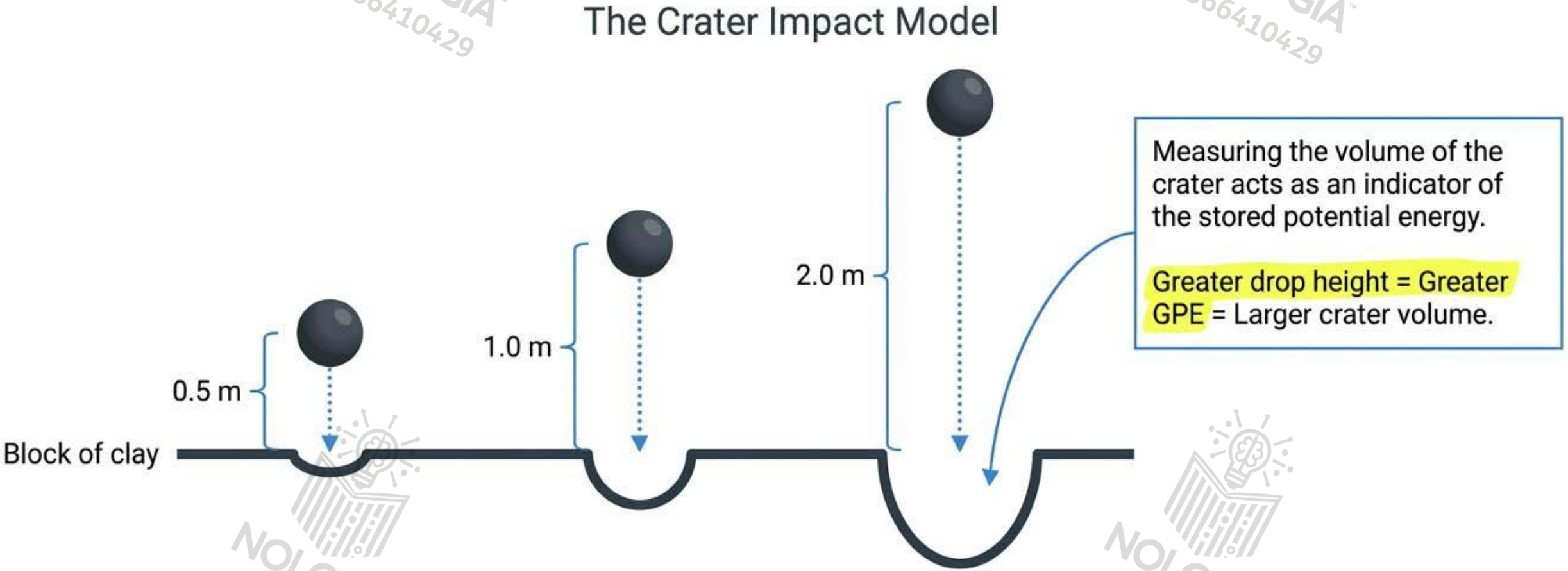
Key rule: GPE only becomes significant when at least one very large object is involved, such as Earth.



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The Position Variable (Height vs. Energy)



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The Mass Variable (Mass vs. Energy)

Gravitational potential energy and mass have a proportional relationship.



More force needed to lift a heavy mass = More GPE



Less force needed to lift to the same height = Less GPE

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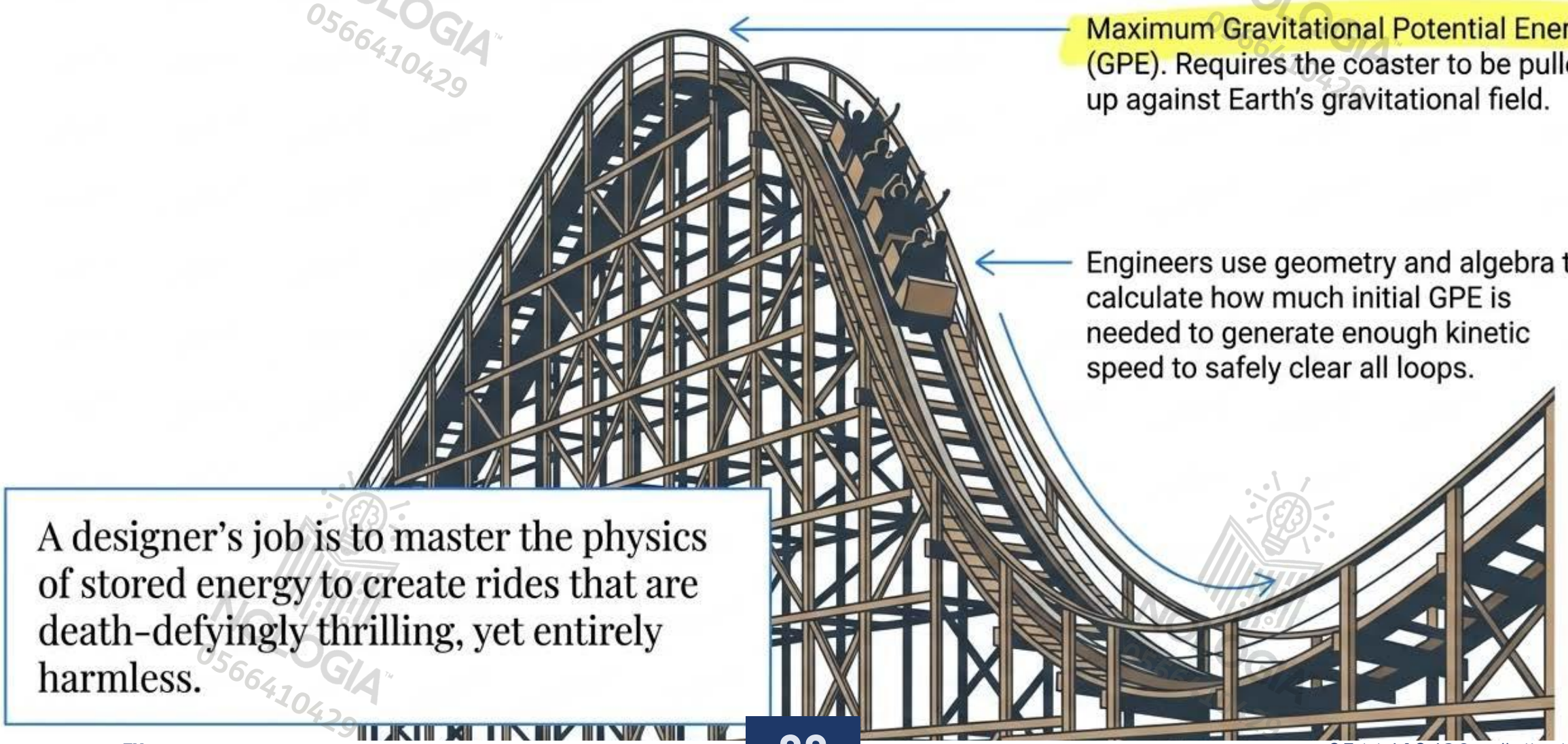
The Ultimate Synthesis: EPE vs. GPE

Elastic Potential Energy (EPE)	Gravitational Potential Energy (GPE)
The Trigger: Changing an object's SHAPE.	The Trigger: Changing an object's POSITION in a field.
Key Variable: Distance of stretch/compression.	Key Variables: Distance from surface (Height) and Mass.
Classic Example: Rubber bands, springs, slingshots.	Classic Example: Dropping a ball, lifting a backpack.

Regardless of the type, ALL potential energy represents a change in the relative positions of c[illegible]nents within a system.

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STEM Application: Roller Coaster Design



A designer's job is to master the physics of stored energy to create rides that are death-defyingly thrilling, yet entirely harmless.

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Exam Preparation



1) **In the rack there are two basketballs. Which basketball has more energy?**

   A. The top basketball has more energy because it is farther away from surface of Earth.

   B. The bottom basketball has more energy because it is closer to surface of Earth.

   C. Both basketballs have the same amount of energy because they have the same mass.

   D. Both basketballs have the same amount of energy because they are not moving.

2) **In the rack there is a bike helmet and a pair of roller skates. The mass of the bike helmet is 550 g and the mass of a roller skate is 2,000 g. Which item has more energy?**

   A. The bike helmet has more energy because it has less mass.

   B. The roller skate has more energy because it is has more mass.

   C. Both items have the same amount of energy because they are the same distance from the surface of Earth.

   D. Both items have the same amount of energy because they are not moving..

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Module (2): Mechanical Energy

03 Third Lesson:

Conservation of Energy

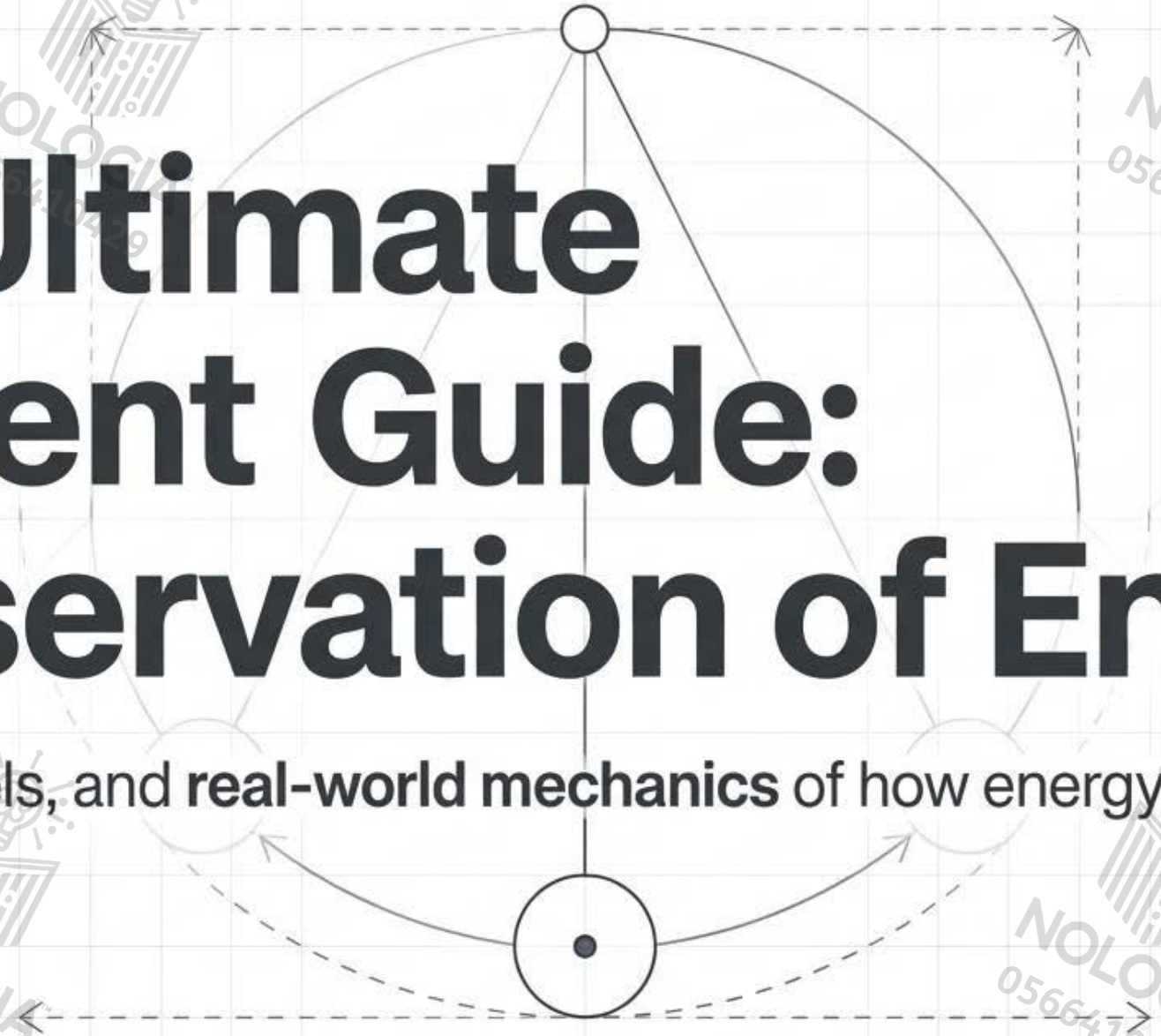
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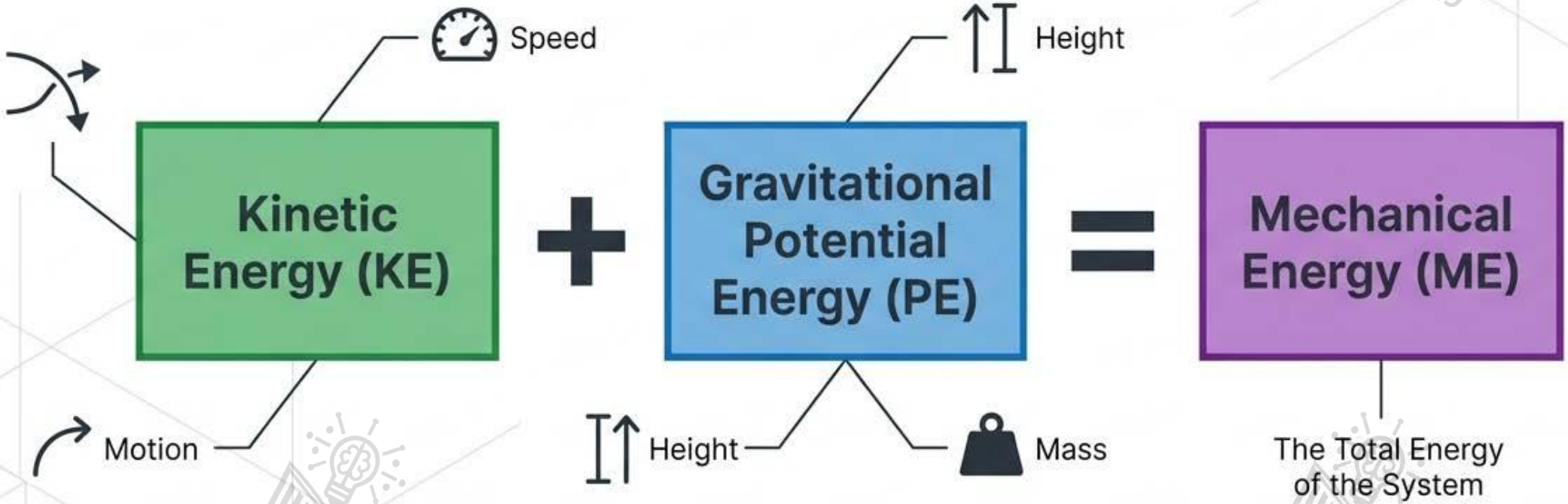
The Ultimate Student Guide: Conservation of Energy

The rules, models, and **real-world mechanics** of how energy moves.



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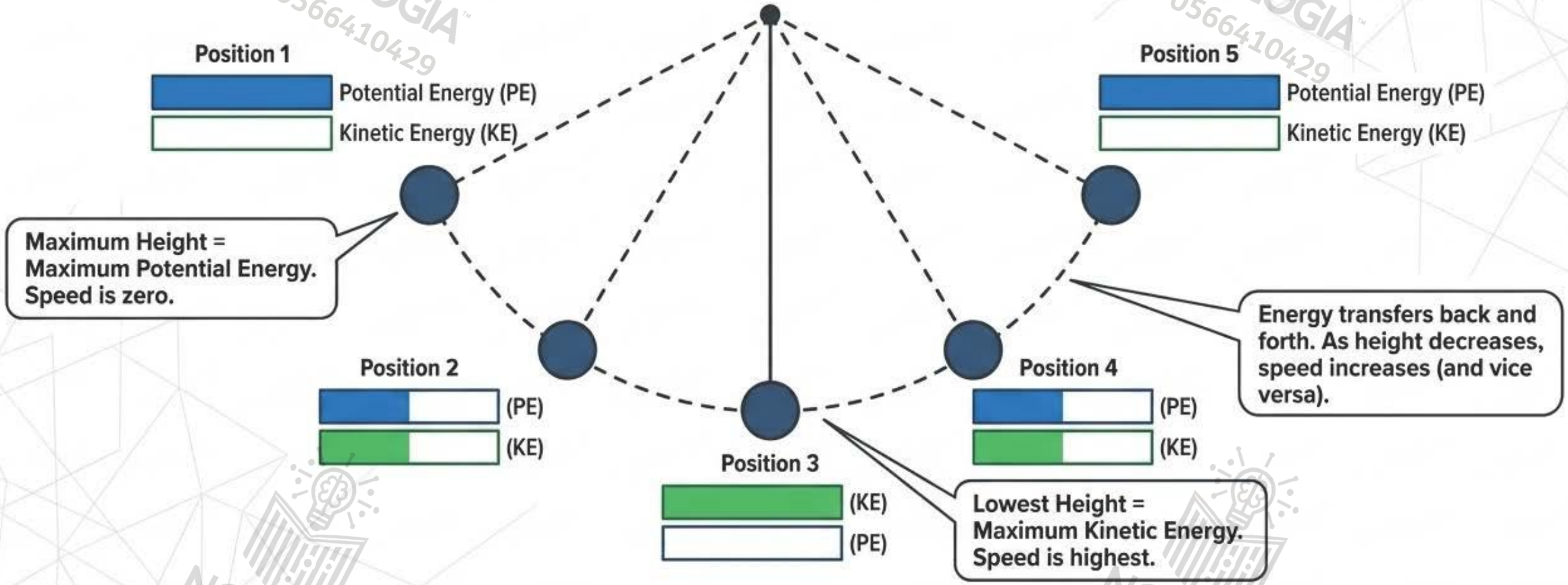
The Core Equation: Mechanical Energy



All forms of energy are measured in Joules (J).

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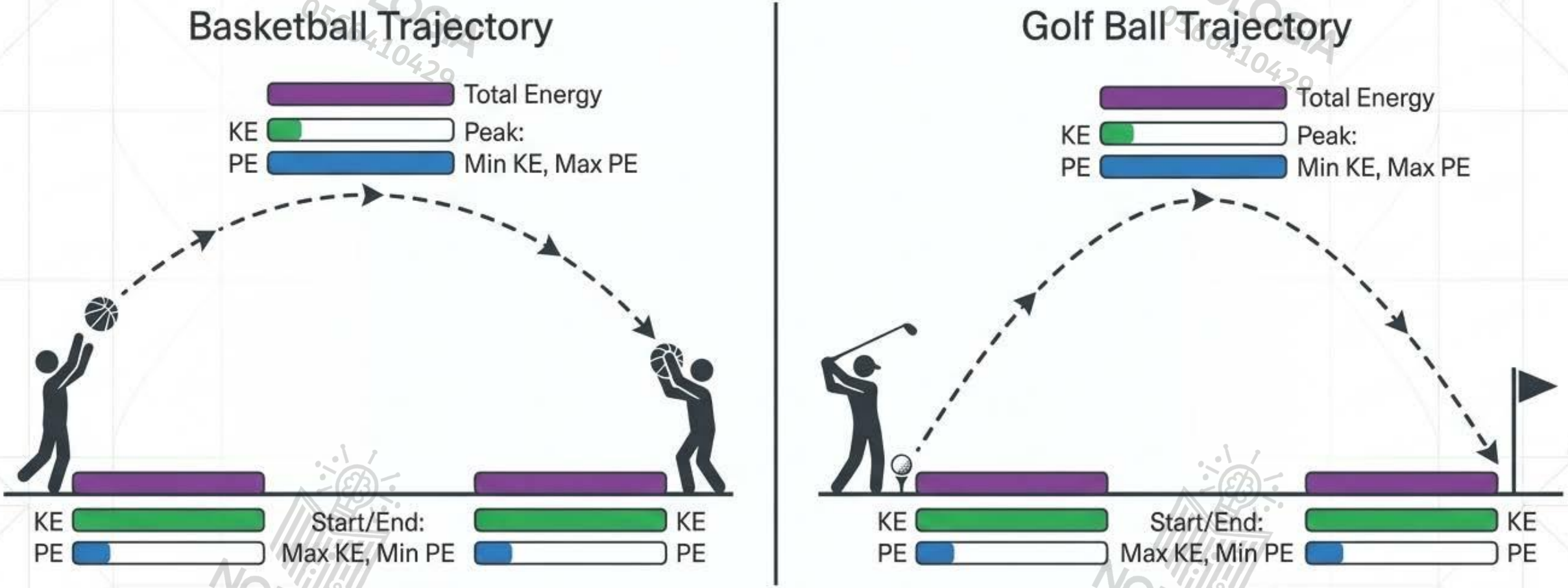
The Perfect Transfer: The Pendulum Model



The amount of potential energy at the release determines the maximum kinetic ener the bottom of the arc.

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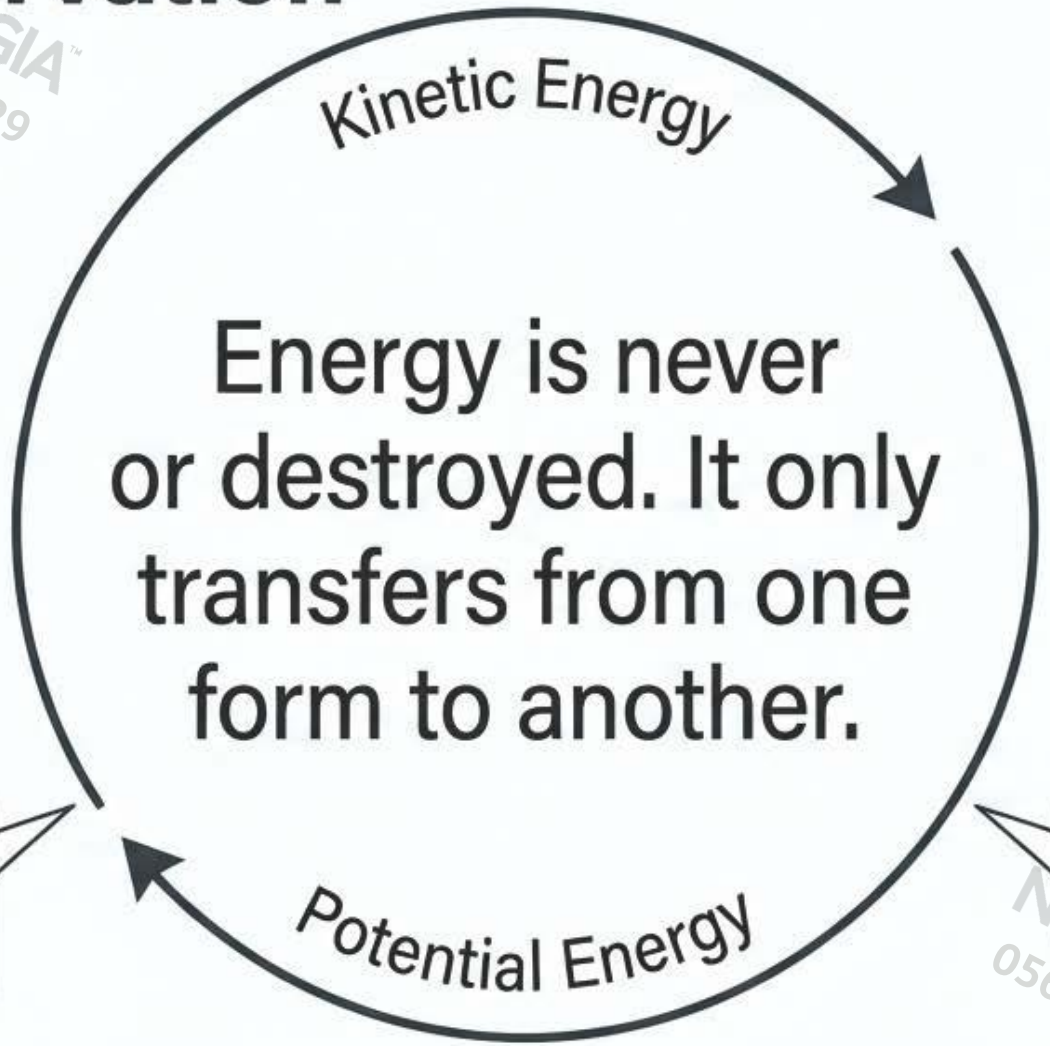
The Universal Pattern: Projectiles in Motion



The total energy (Purple) remains constant throughout both projectile motions, while kinetic energy (Green) and potential energy (B ntinuously transform into one another.

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The Golden Rule: Law of Conservation of Energy



The decrease in gravitational potential energy is perfectly matched by the increase in kinetic energy.

The overall amount of energy in a closed system remains entirely unchanged.

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The Physics of "Work"

Work is the transfer of energy to an object by a force that makes the object move in the direction of the force.

Branch 1



Push bicycle (Force Applied) + Bicycle moves → **WORK IS DONE** (Energy transferred)

Branch 2



Push locked bicycle (Force Applied) + Bicycle does not move → **NO WORK** (No transfer)

Branch 3



Stop pushing (No Force) + Bicycle coasts forward → **NO WORK** (No new transfer happening)

Mapping Energy Transfer Systems



How do we know energy transferred?

Motion Change. The box gains mechanical energy and moves. The pendulum loses mechanical energy and slows down.

Sound. Some mechanical energy is used to create a vibration, heard as a sound. A change in sound is proof of energy transfer.

The Friction Factor: Where does the energy go?

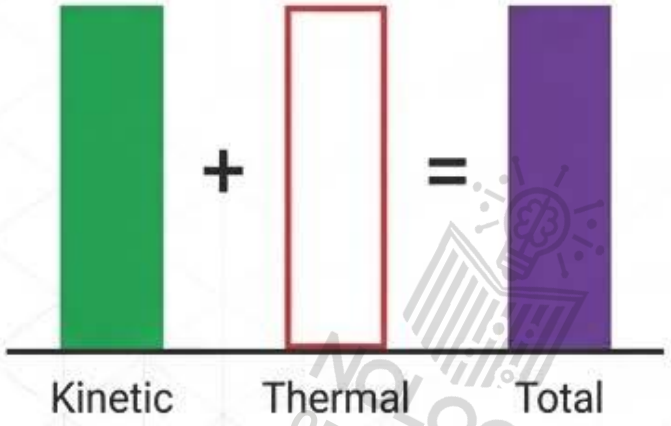
Coasting → Applying Brakes → Stopped

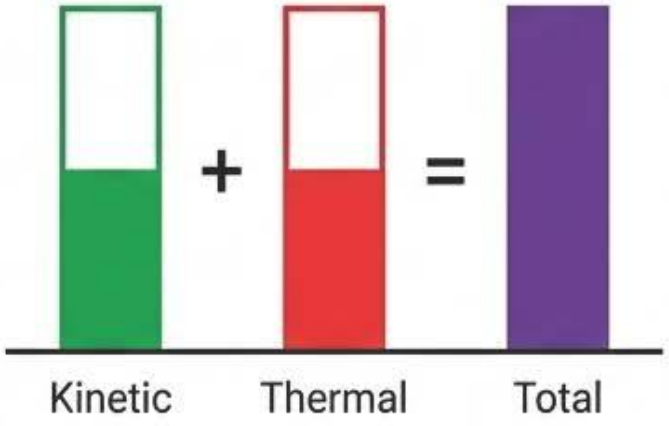


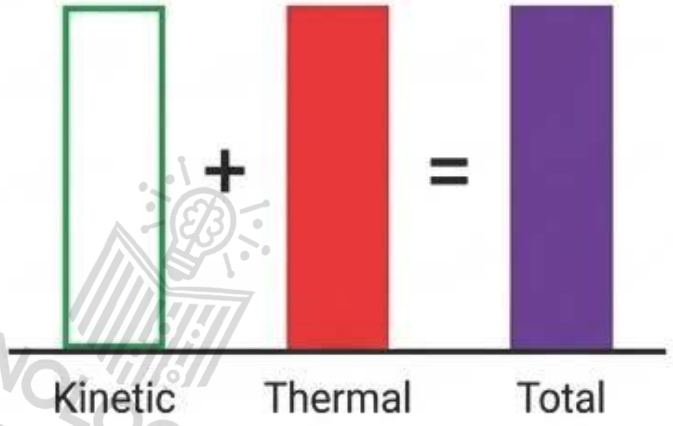


Friction transfers mechanical energy into the air and tires.









Things stop because friction transforms us[illegible]netic energy into dispersed

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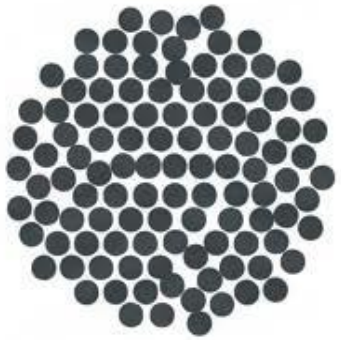
The Thermodynamics Diagnostic Matrix

The 1st Law (Conservation)	The 2nd Law (Entropy)
Core Principle: Energy quantity remains the same; it only changes form.	**Core Principle:** Energy tends to become more disordered and random.
Also Known As: Law of Conservation of Energy.	**Also Known As:** Law of Entropy.
Real-World Example: Burning gasoline. Energy in gas changes to moving car parts and thermal energy.	**Real-World Example:** As energy changes to thermal energy via friction, it can no longer be used to do useful work.
Status: Focuses on the Quantity of energy.	**Status:** Focuses on the Quality of useful energy decreasing.

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Understanding Entropy

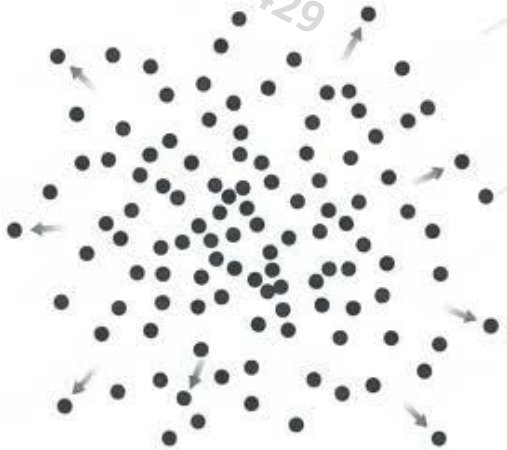
Low Entropy



Concentrated & Useful
Energy is highly organized.
Can be used to do work.

Time / Increase in Entropy

High Entropy

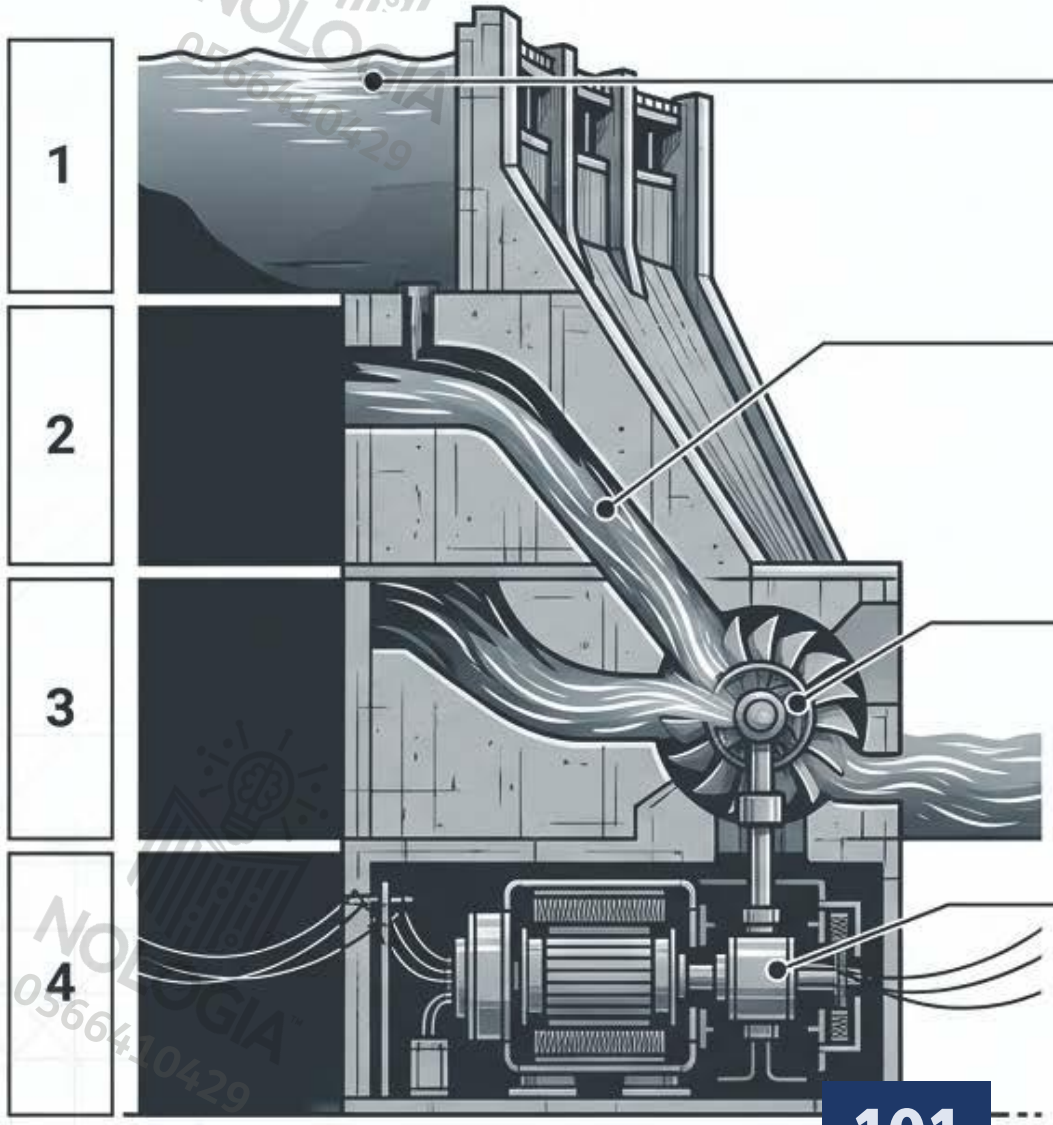


Random & Disordered
Thermal energy spreads into the air.
Molecules move faster and spread out.
Cannot be harnessed for useful work.

The universe will eventually run out of useful energy when all energy is spread out with maxi randomness (Entropy).

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Real-World Application: Generating Electricity



Water held high behind the dam.
↓
Potential Energy.
(Built across a flowing water source).

Water falls through steep tunnels inside the dam.
↓
Potential becomes **Kinetic Energy.**

Moving water does work on turbine blades, causing them to spin.
↓
Kinetic becomes **Mechanical Energy.**

Spinning turbine powers the generator.
↓
Mechanical becomes **Electrical Energy**, carried by wires to homes.

The NOLOGIA Master Summary

The 1 Core Equation

ME = KE + PE (Measured in Joules).

Kinetic (motion) and Potential (height/mass) inversely relate.

The 2 Grand Laws

- **1st Law: Conservation** (Energy is immortal, just changes costumes).
- **2nd Law: Entropy** (Energy quality degrades over time into disordered heat).

The 3 Transfer Mechanisms

Work

Force causing motion.

Friction

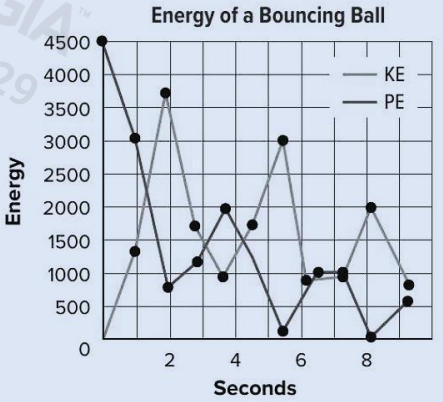
Turns kinetic energy into thermal energy.

Generators

Converts mechanical spinning into electrical power.

Exam Preparation

The graph shows the kinetic energy (KE) and potential energy (PE) of a bouncing ball over a period of 9 seconds.



1) **When does the ball have the most kinetic energy?**

   A. At the start, because it is the highest off the ground.

   B. At the end, because it is moving fastest as it approaches the ground for the final bounce.

   C. At second 2, because it is moving fastest as it approaches the ground for the first bounce.

   D. At second 4, because it has reached its second highest bounce.

2) **What statement best describes what happens to the total mechanical energy of the ball as it bounces?**

   A. The total amount of energy remains the same because the law of conservation of energy says energy is conserved.

   B. The total amount of energy goes down because some energy becomes thermal energy due to the force of friction acting on the ball.

   C. The total amount of energy goes up because energy is gained from the force of gravity every time the ball bounces.

   D. The total amount of energy remains the same because work is being done on the ball by the force of gravity every time the ball bounces.

Energy and Motion

Module (3): Electromagnetic Forces

	Lesson Title	Page
3-1	Magnetic Forces	105
3-2	Electric Forces	118
3-3	Simple Circuits	135
3-4	Electromagnetism	148

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Module (3): Electromagnetic Forces

01 First Lesson:
Magnetic Forces

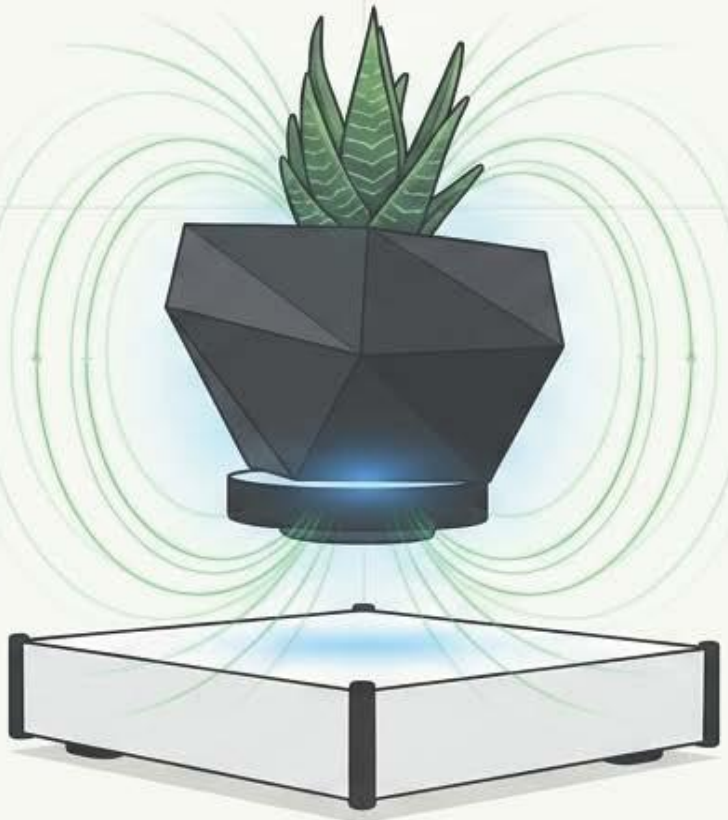
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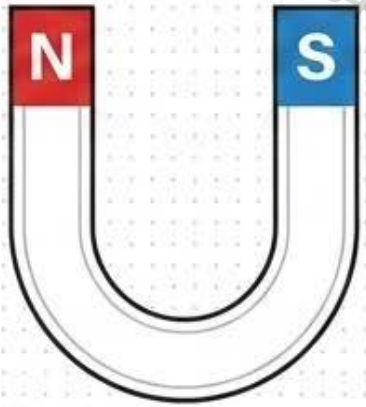
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Magnetic Forces: The Ultimate Study Guide

From atomic domains to Earth's shifting magnetic field.

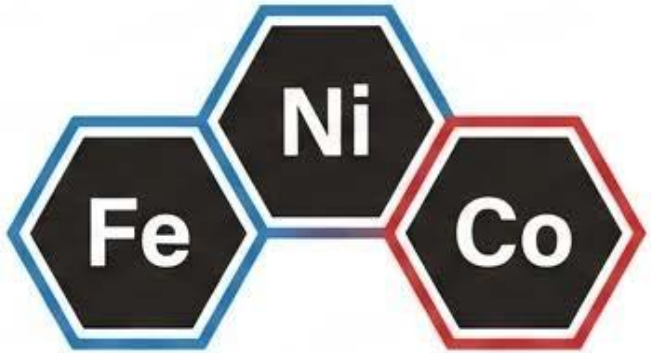


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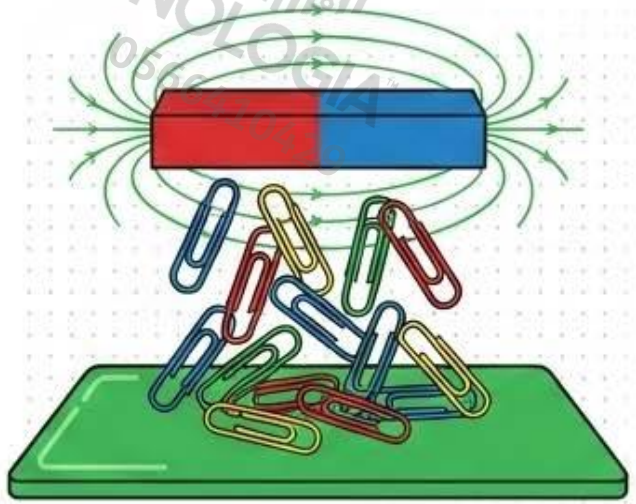
The Magnet

An object that attracts **iron** and other materials with similar magnetic qualities.



Ferromagnetic Elements

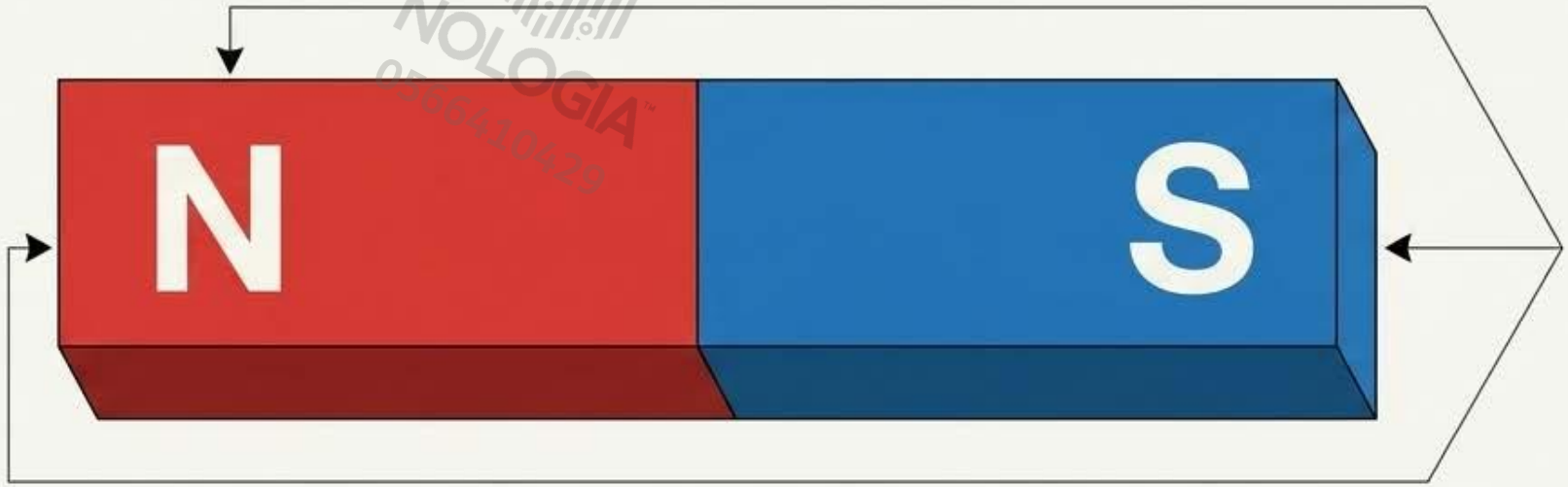
Materials that have an especially strong attraction to magnets.



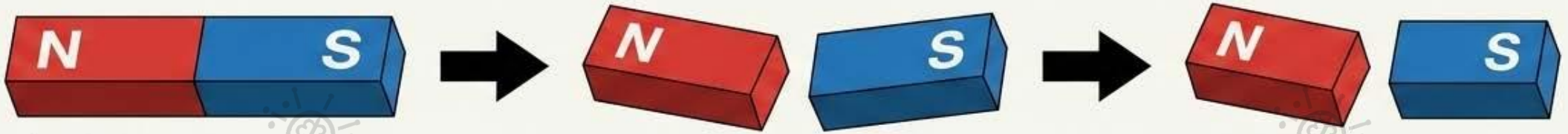
The Force

Magnetic Force is a noncontact force, meaning it applies attraction or repulsion without direct physical contact.

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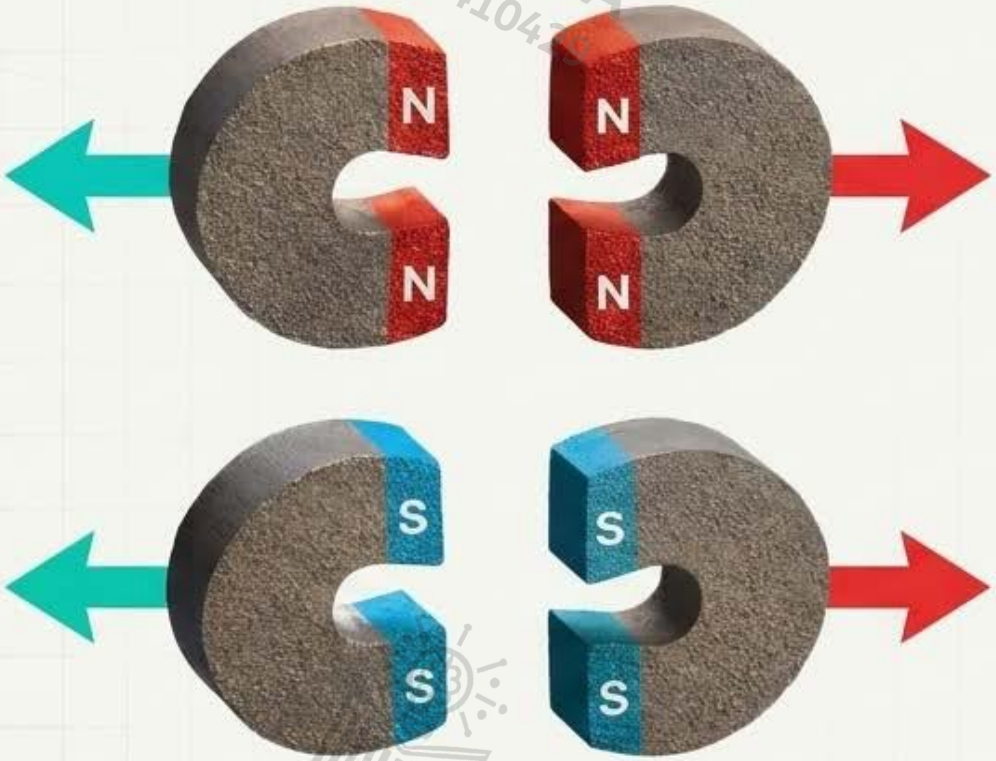


Magnetic Poles: The specific locations where the magnetic force is strongest.



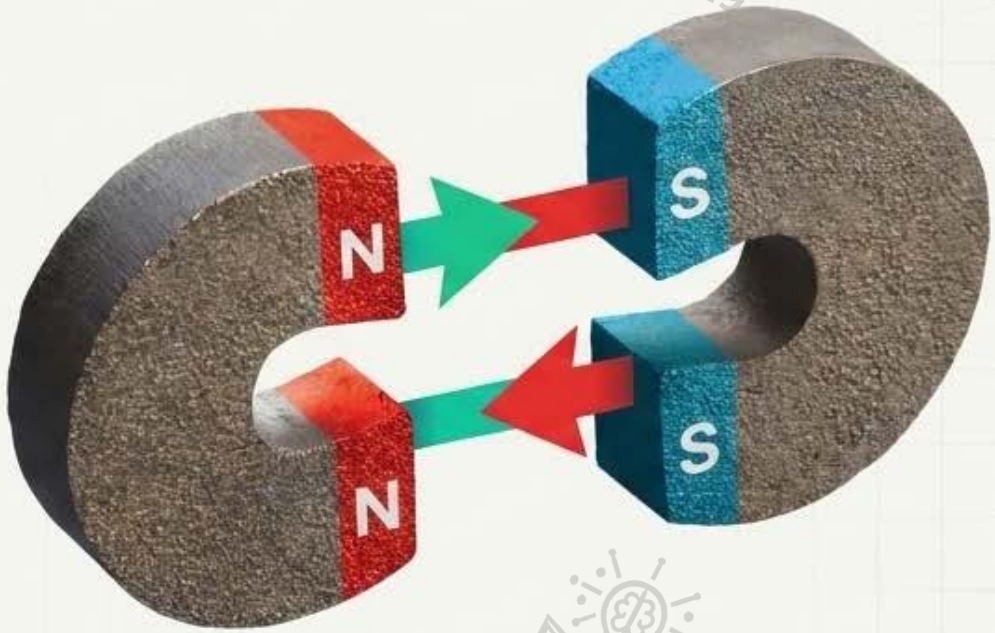
You cannot isolate a magnetic pole. If you break a magnet into pieces, every single piece will instantly possess both a North (N) and a South (S) pole.

Repulsion (Pushing Away)



Similar Poles Repel.

Attraction (Pulling Together)

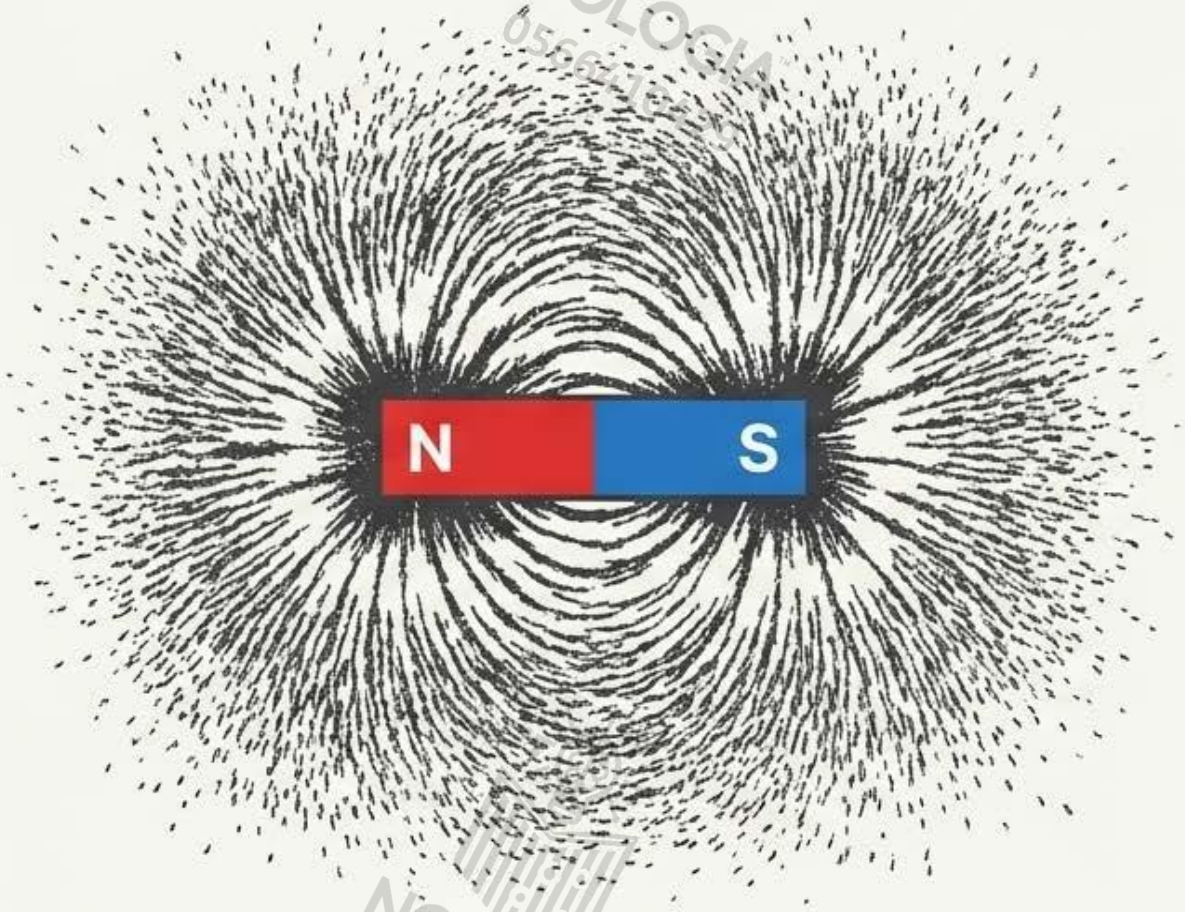


Opposite Poles Attract.

The force exists between the poles of a[illegible] magnets, acting entirely at a distance.

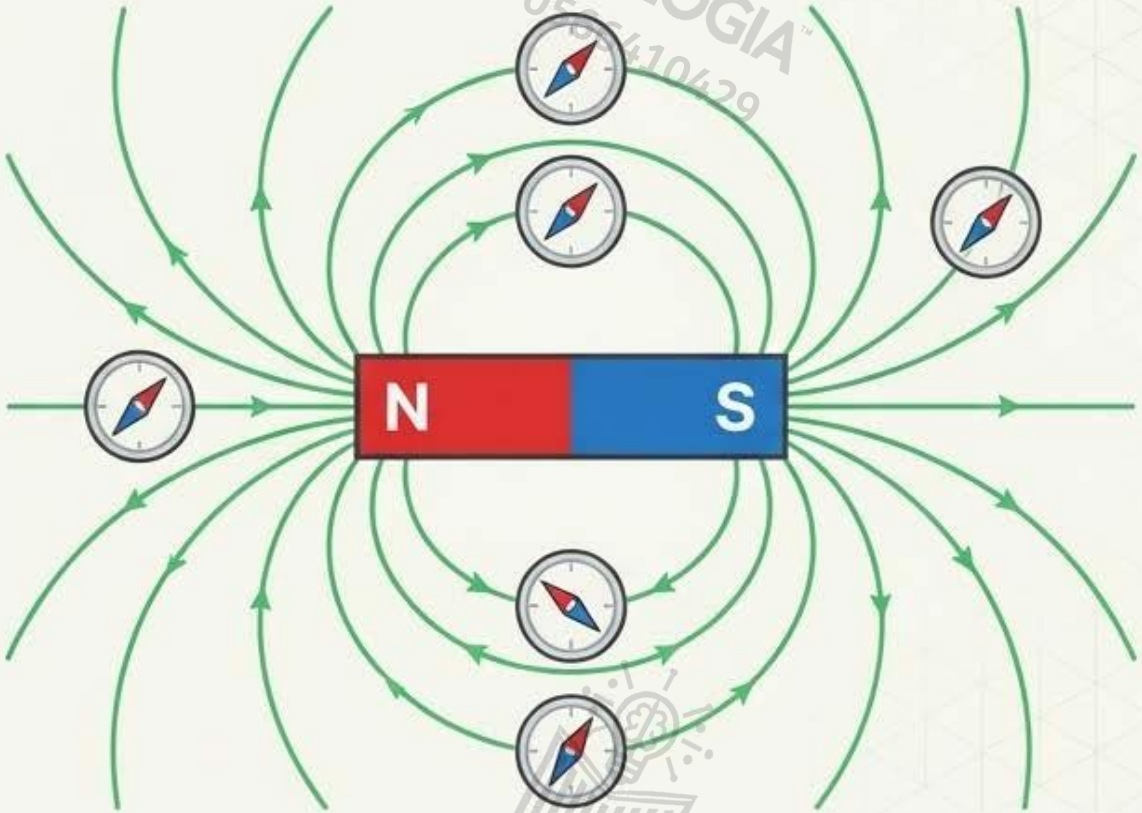
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THE PATTERN



Magnetic Field Lines: An invisible force field surrounding the magnet. Lines are packed closest at the poles, where the force is strongest.

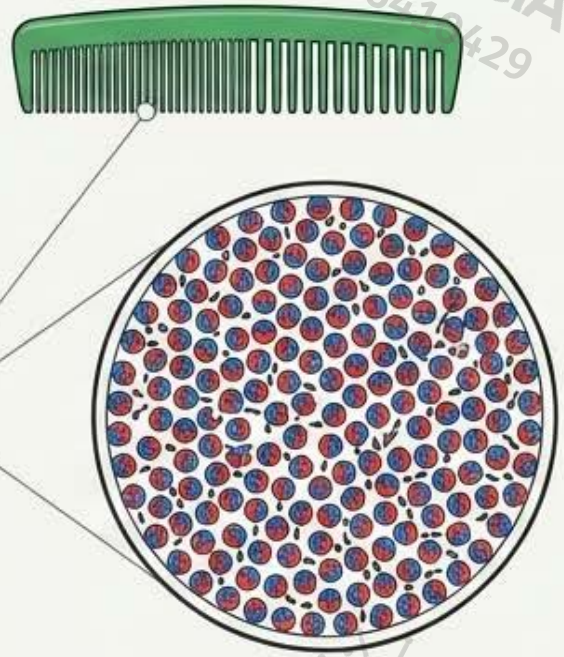
THE DETECTOR



A compass needle is a tiny magnet. It does not point directly at the poles; instead, it perfectly aligns with the curved magnetic field lines.

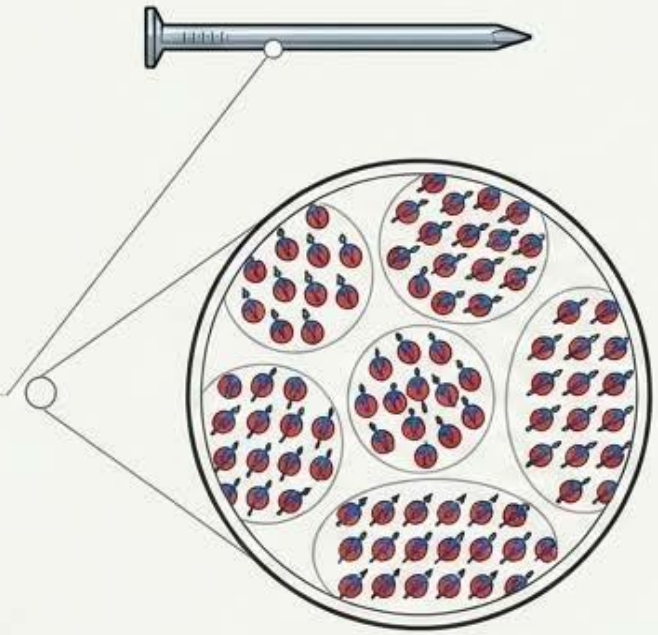
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Nonmagnetic



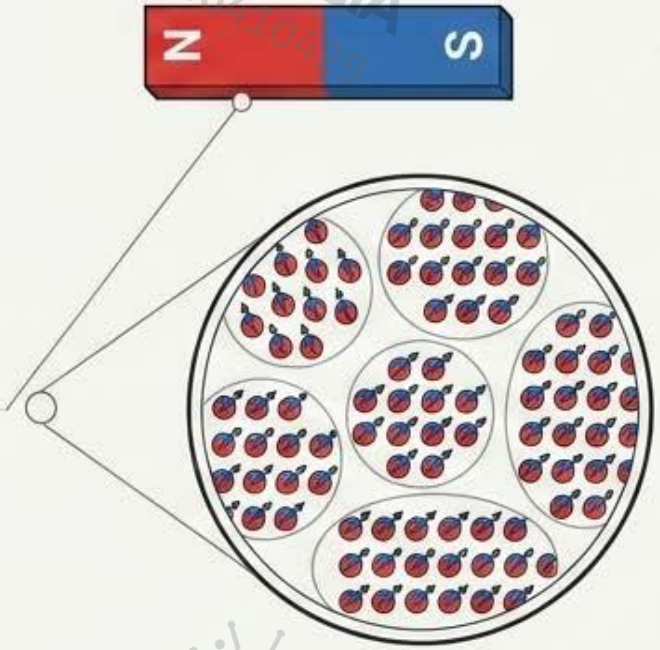
Random Atoms
Magnetic fields cancel out.
Cannot be magnetized.

Magnetic Material



Random Domains
Fields cancel each other out.
Not yet a magnet, but has potential.

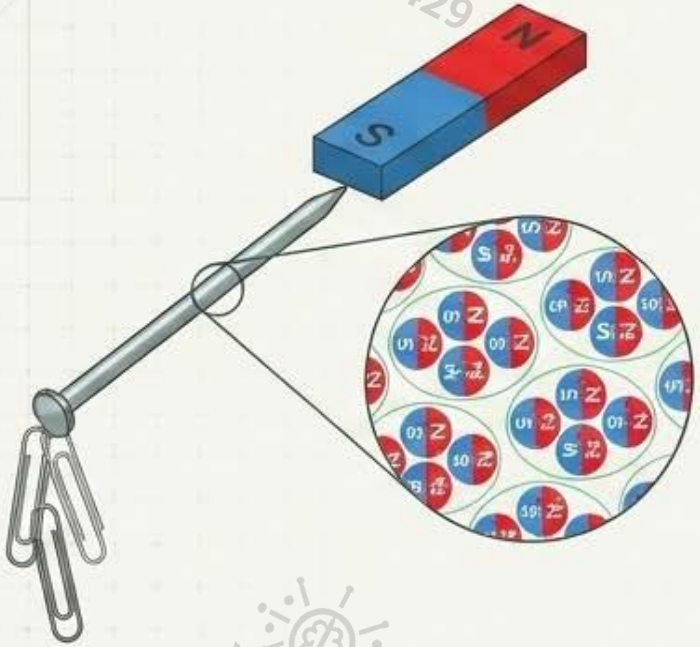
True Magnet



Aligned Domains
The individual fields combine to form a single, powerful magnetic field.

NOLOGIA MODULE 06 // MATERIAL TYPES

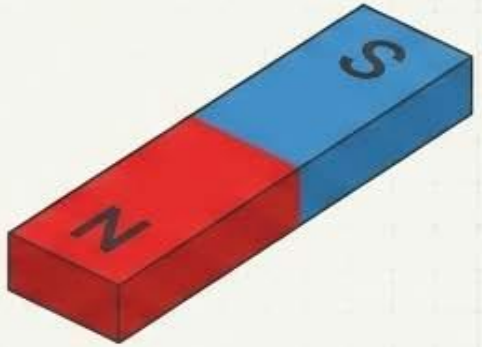
Temporary Magnets



Creation: Domains line up only when placed inside a strong external magnetic field.

Loss: The moment the external field is removed (moving the nail away), domains instantly return to a random arrangement. Magnetism is lost.

Permanent Magnets



Creation: Made by rubbing a material repeatedly with a magnet, or heating/cooling materials inside a strong magnetic field.

Retention: Domains remain firmly aligned even when the external magnetic field is entirely removed.

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NOLOGIA MODULE 07 // MAGNETIC POTENTIAL ENERGY

Magnetic Potential Energy is stored energy based on the distance and orientation of magnetic poles.

Pushing Similar Poles Together. (Requires applied force; Potential Energy increases).





Pushing Similar Poles Together. (Requires applied force; Potential Energy increases).

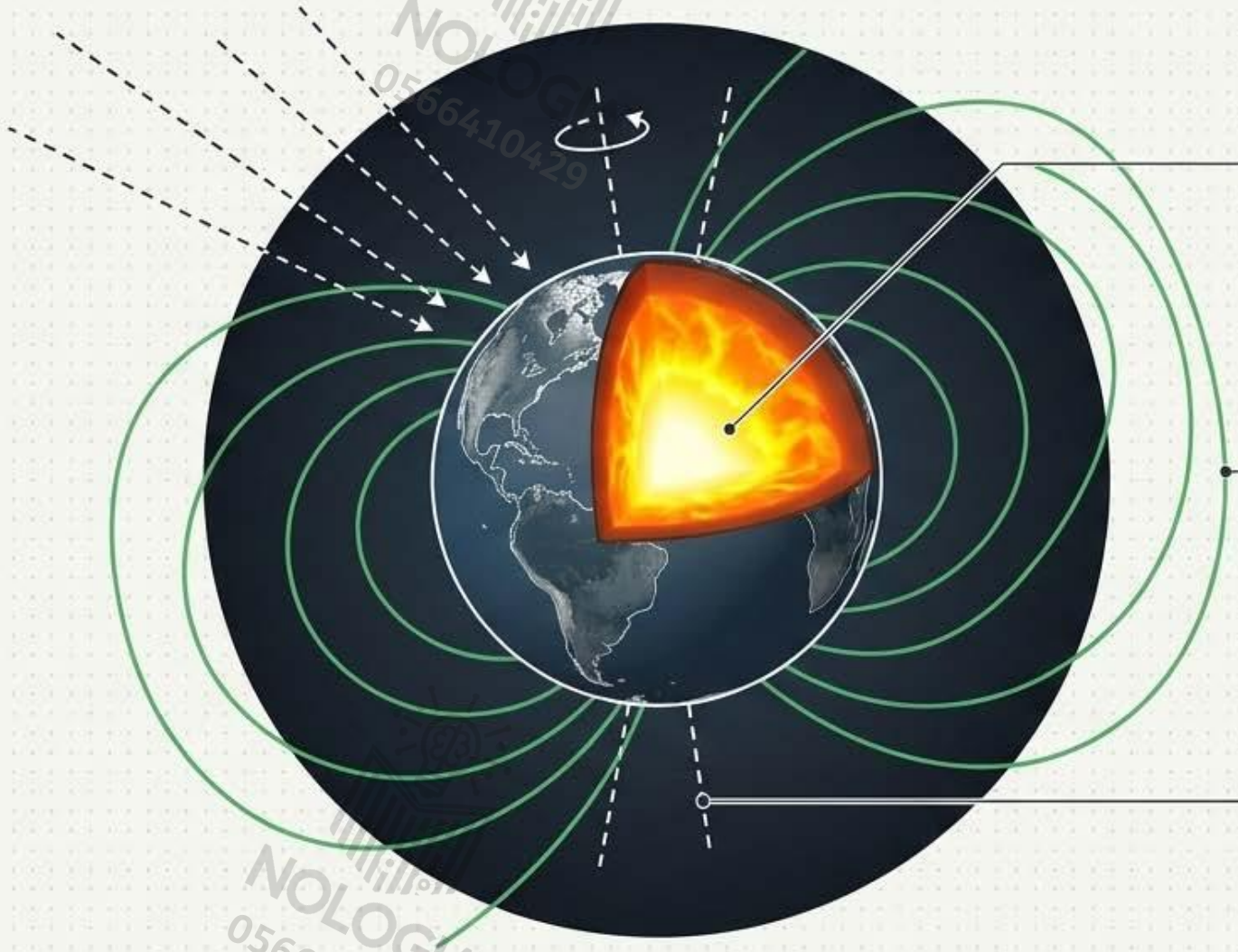
Pulling Opposite Poles Apart. (Requires applied force; Potential Energy increases).





Pulling Opposite Poles Apart. (Requires applied force; Potential Energy increases).

Core Rule: Applying force against a magnet's natural inclination stores energy in the magnetic field.



The Source

Spinning molten iron and nickel in Earth's outer core generates the magnetic field.

The Shield

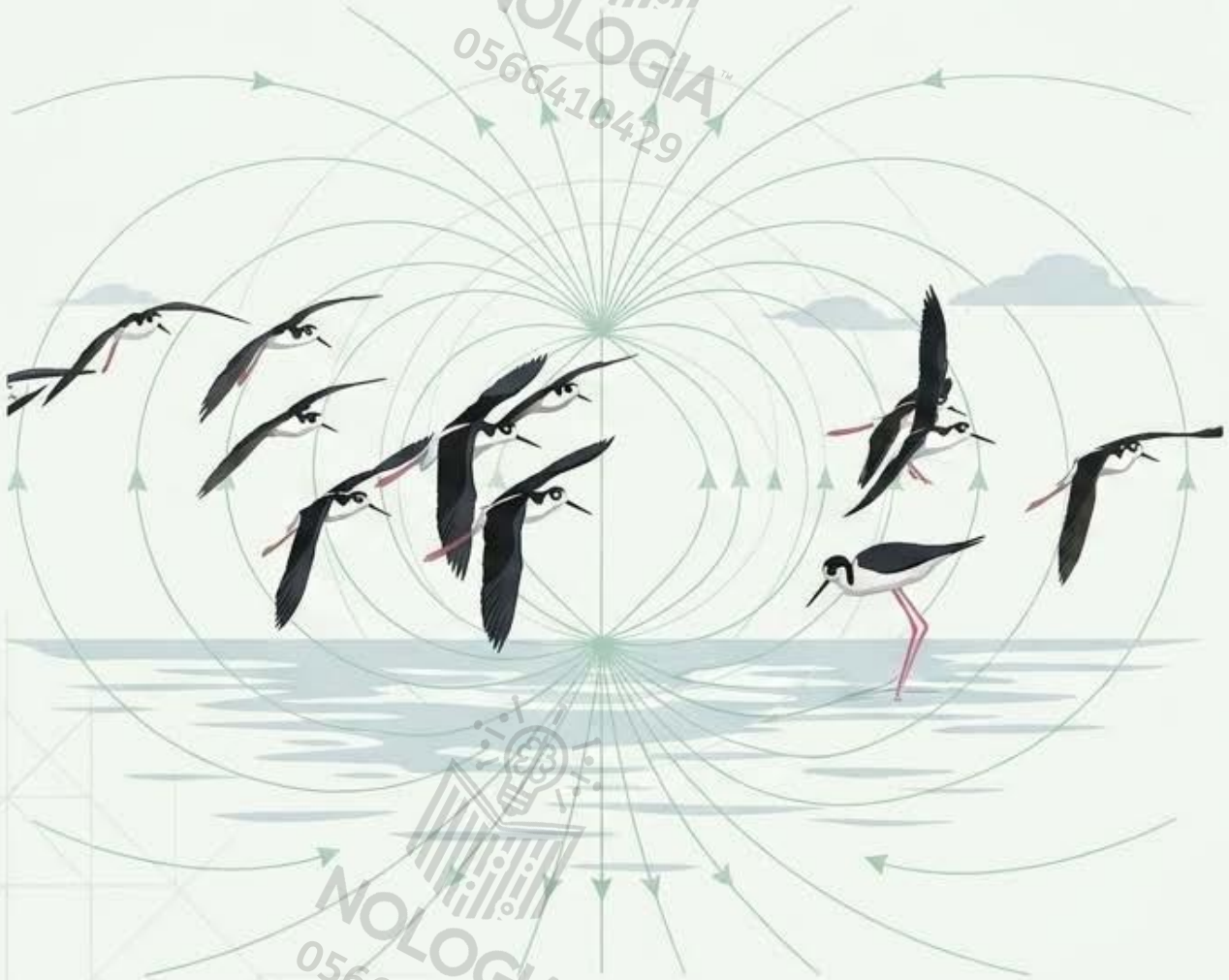
The field protects Earth by pushing away charged particles and cosmic rays from the Sun.

The Shift

Earth's magnetic pole is inconstant. It is currently moving roughly 40 km per year, and global field strength has weakened 10% since the 19th century.

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NOLOGIA MODULE 09 // NATURE'S NAVIGATORS



The Phenomenon

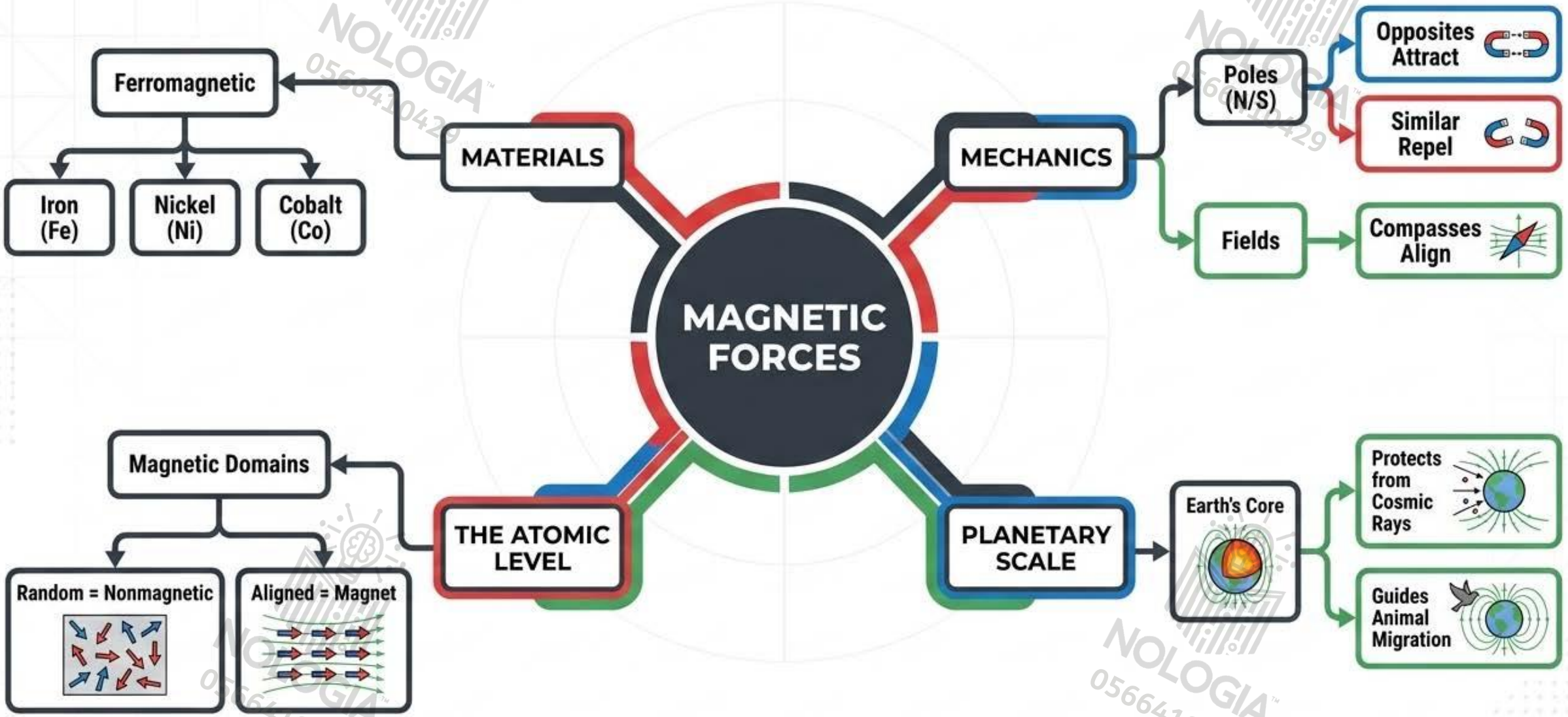
Each year, thousands of animals—including birds, salmon, and monarch butterflies—migrate across continents using an internal compass.

The Mechanism

Scientists are studying special proteins found in the eyes of migratory birds. These proteins allow the animals to actively "detect" Earth's invisible magnetic field lines, ensuring they never lose their heading.

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NOLOGIA MODULE 10 // MAGNETIC FORCES SUMMARY



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Exam Preparation

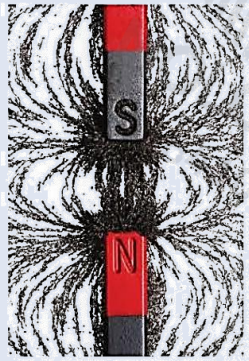
1) **Which system best illustrates attractive forces?**

   A. X, because the magnetic field lines connect to each other.

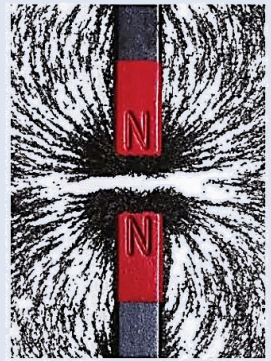
   B. Y, because the magnetic field lines repel each other.

   C. X, because the magnetic field lines repel each other.

   D. Y, because the magnetic field lines connect to each other.



X



Y

2) **Which system would need an external force to move the magnets closer together?**

   A. X, because the magnets are attracting.

   B. Y, because the magnets are repelling.

   C. X, because the magnets are repelling.

   D. Y, because the magnets are attracting.

3) **In which system could you increase the magnetic potential energy by pushing the two magnets closer together?**

   A. X, because the magnets are attracting.

   B. Y, because the magnets are repelling.

   C. X, because the magnets are repelling.

   D. Y, because the magnets are attracting.

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Module (3): Electromagnetic Forces

02 Second Lesson:
Electric Forces

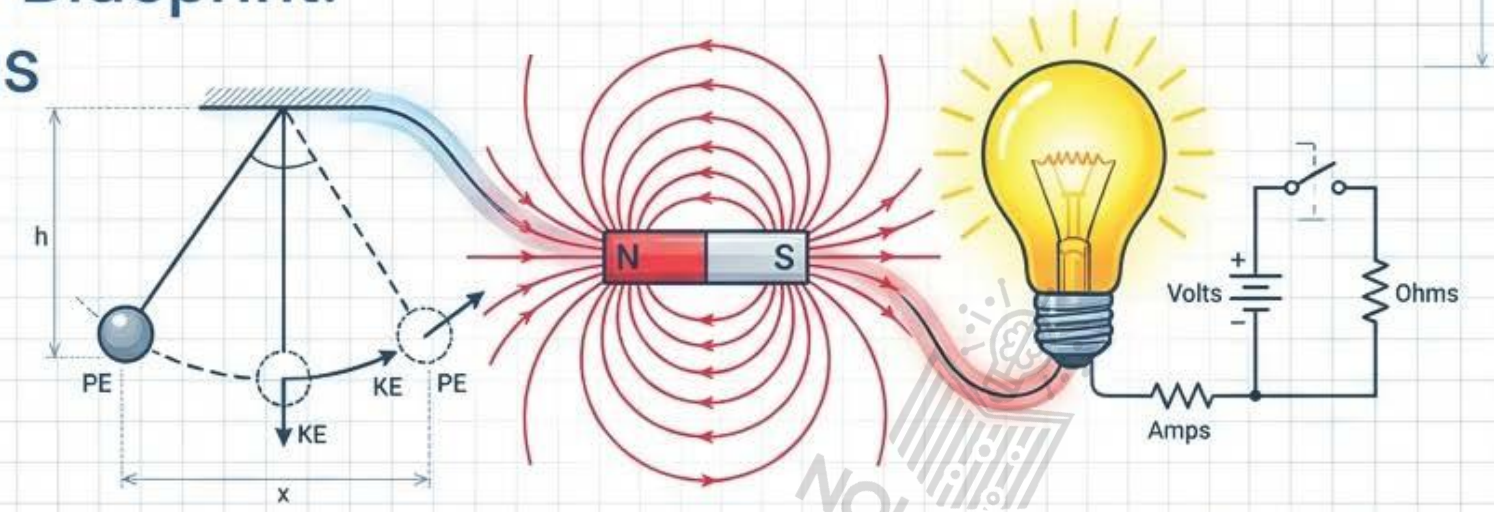
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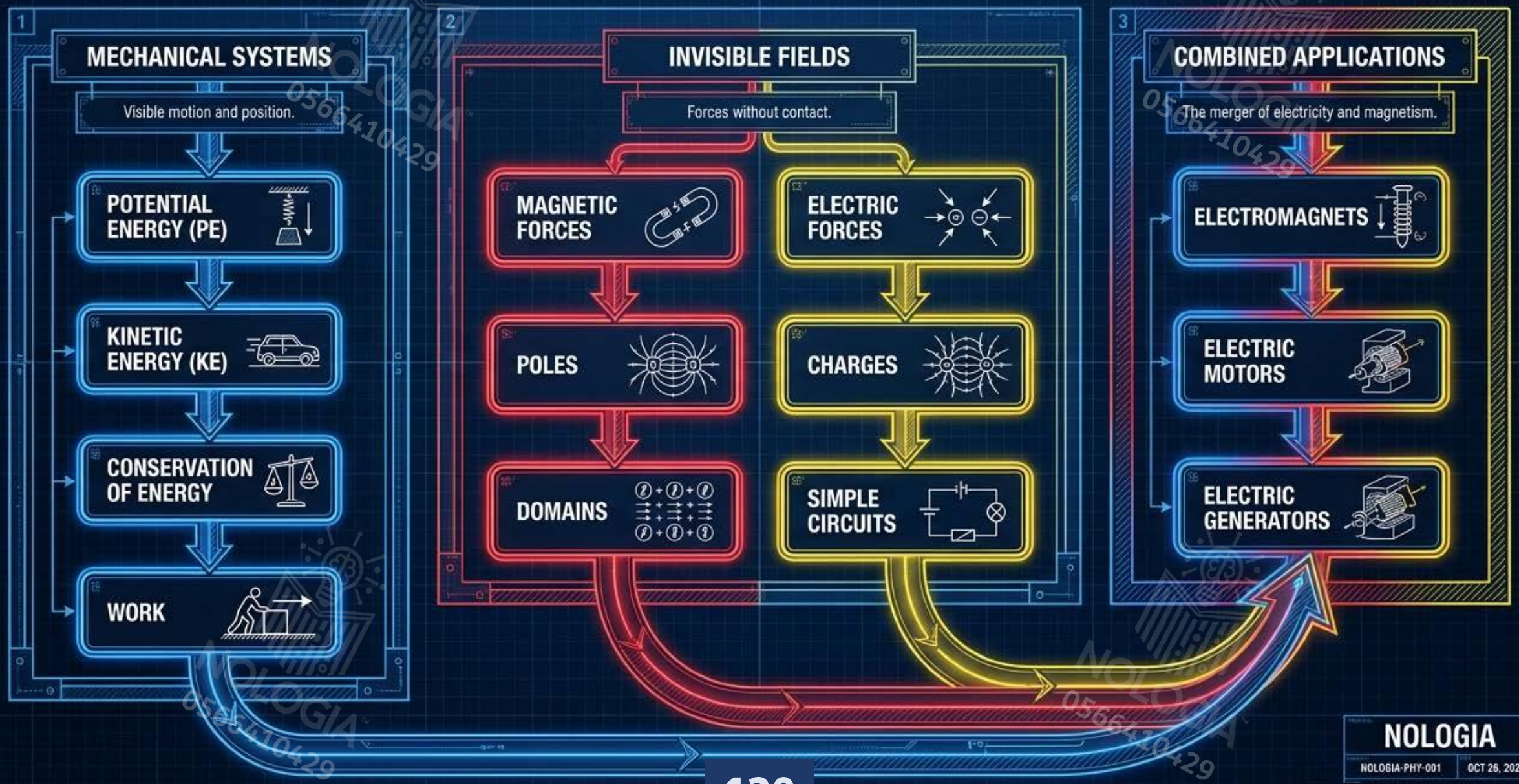
The Physics of Invisible Forces

A Comprehensive Master Blueprint: From Mechanical Systems to Electromagnetism



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NOLOGIA MASTER MAP: THE CONNECTED SYSTEMS OF PHYSICS



Potential Energy: Stored Energy of Position

Concept: Potential energy is the energy due to interactions between objects or particles when distance changes.

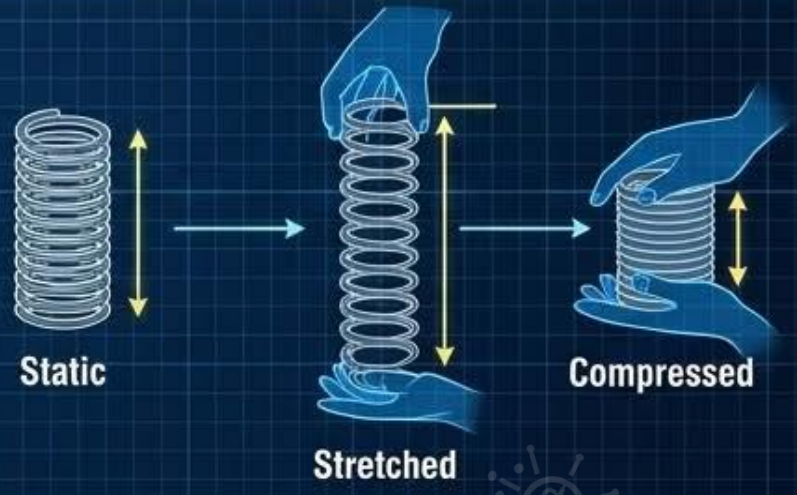
Gravitational Potential Energy (GPE)



- **What interacts?**
  - An object and Earth's gravitational field.

- **How to increase it?**
  1. Increase the mass of the object.
  2. Increase the height (distance) from Earth.

Elastic Potential Energy (EPE)



- **What interacts?**
  - Objects that are compressed or stretched.

- **How to increase it?**
  - Increase the distance the object is stretched or compressed (e.g., pulling a rubber band further back).

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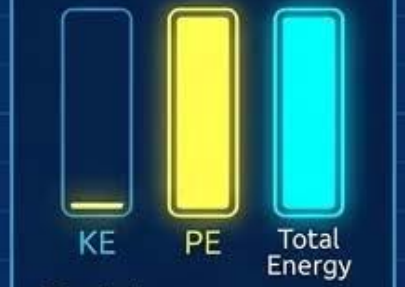
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THE LAW OF CONSERVATION OF ENERGY

Energy is always transferring from one form to another; it is not created or destroyed.
Total Energy = Kinetic Energy (KE) + Potential Energy (PE).



Leaving hands:
Maximum Speed,
Minimum Height.



Peak Arc:
Minimum Speed,
Maximum Height.



Falling: KE increases,
PE decreases.

NOLOGIA STUDY TIP

Think of KE and PE as a seesaw. When one goes up, the other must go down to keep the Total Energy bar completely flat.

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Energy Transfer: Work, Friction, and Power

Work & Friction (The Energy Tax)

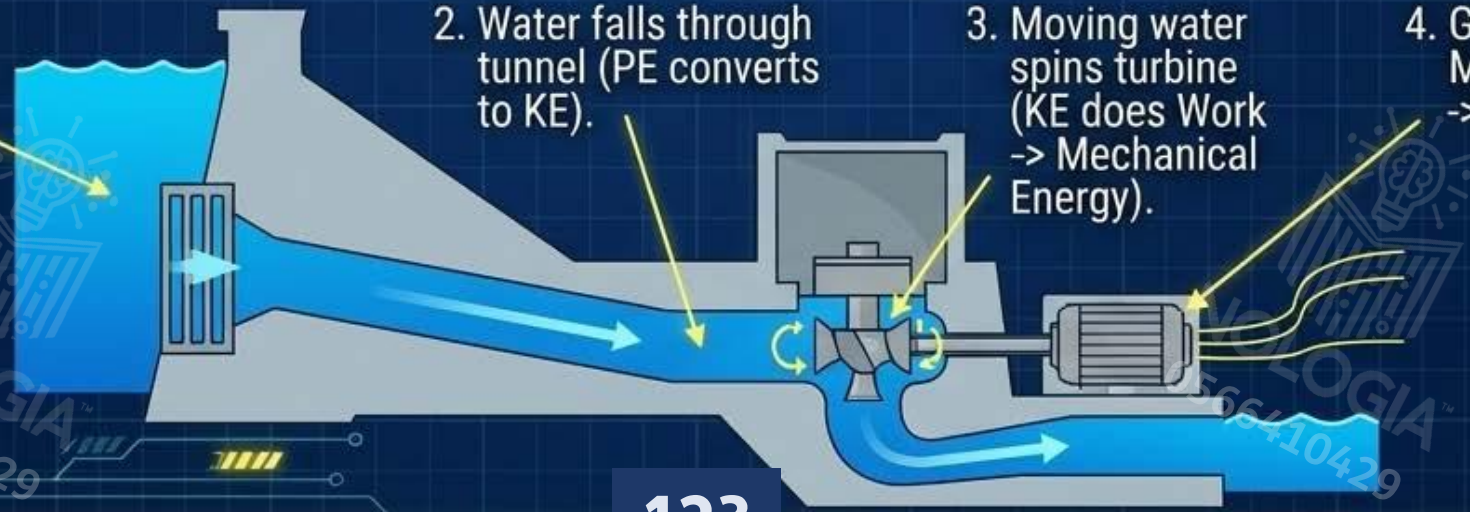


Work: Transfer of energy by a force that makes an object move. (Static = No Work. Moving = Work).

Thermal Energy Loss: Friction (brake pads or air resistance) causes mechanical energy to transfer to thermal energy (heat). Total energy is still conserved!

The Hydroelectric Sequence (Real-World Application)

1. Water behind dam (High Gravitational PE).
2. Water falls through tunnel (PE converts to KE).
3. Moving water spins turbine (KE does Work -> Mechanical Energy).
4. Generator converts Mechanical Energy -> Electrical Energy.



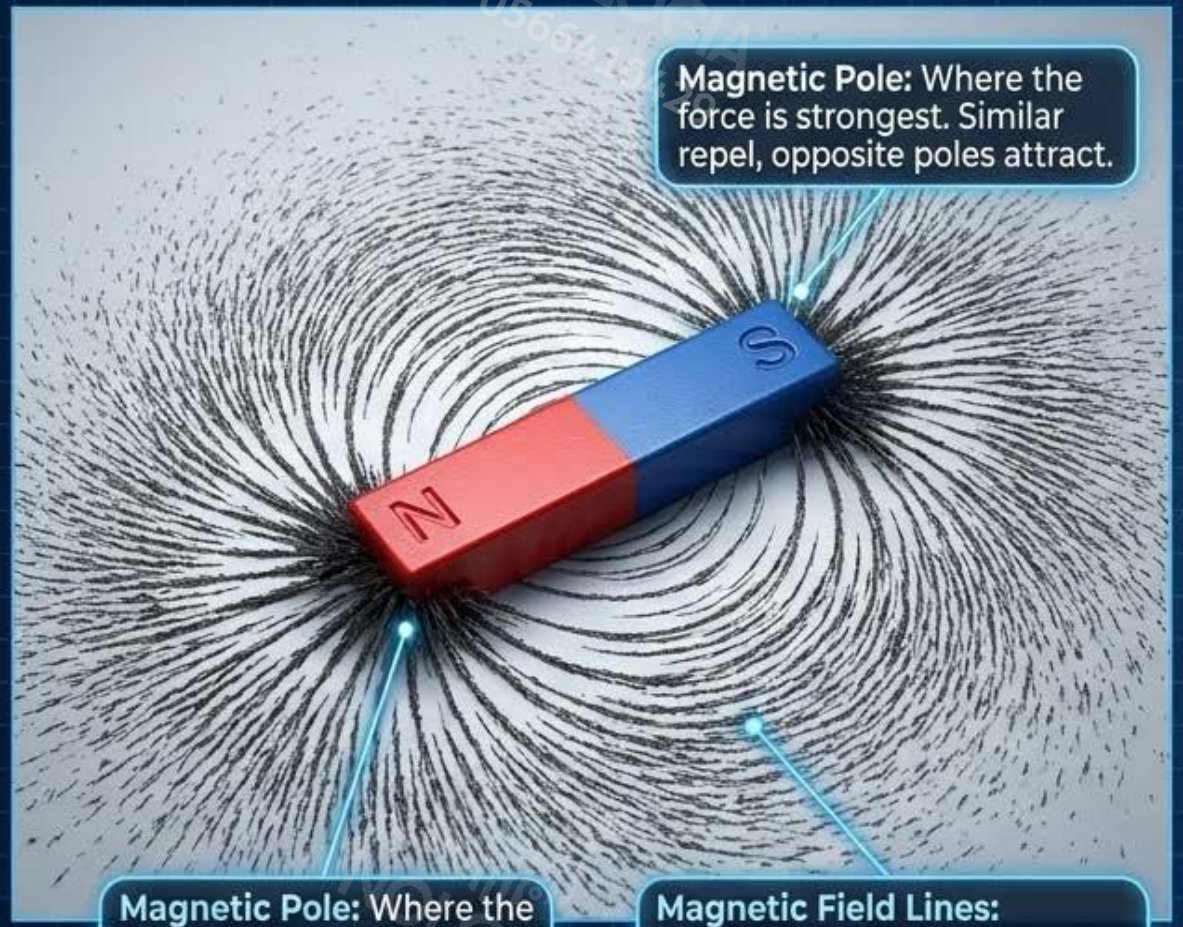
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Magnetic Forces and Invisible Fields

The Magnetic Anatomy

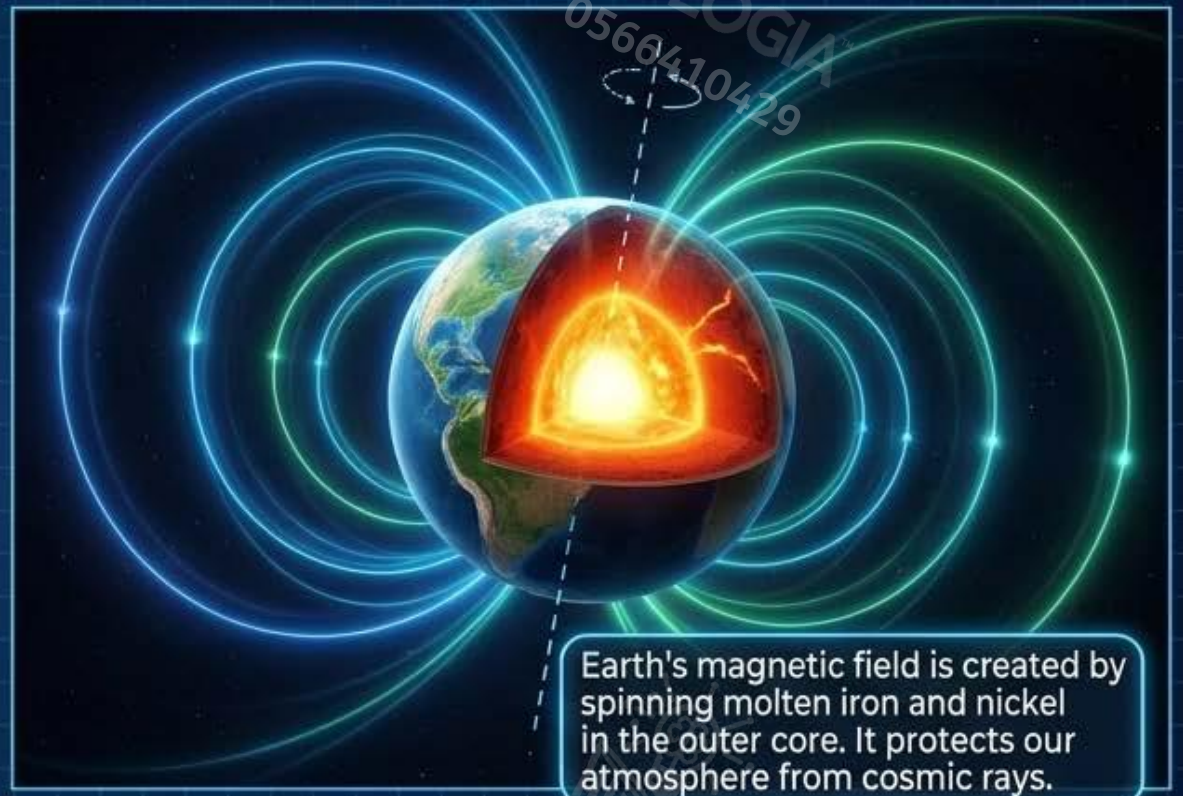


Magnetic Pole: Where the force is strongest. Similar repel, opposite poles attract.

Magnetic Pole: Where the force is strongest. Similar poles repel, opposite poles attract.

Magnetic Field Lines: Closest at the poles (strongest force). Farther apart = weaker force.

Earth as a Magnet



Earth's magnetic field is created by spinning molten iron and nickel in the outer core. It protects our atmosphere from cosmic rays.

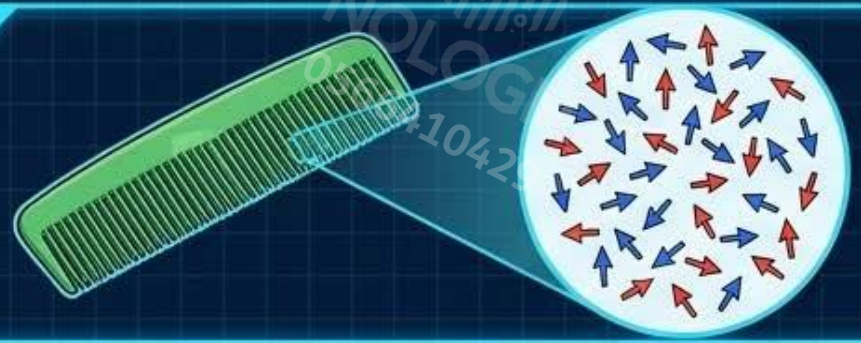


Compass Connection: A compass needle is just a tiny magnet that aligns with these invisible field lines. Geographic North is actually a magnetic south pole!

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The Architecture of a Magnet: Magnetic Domains

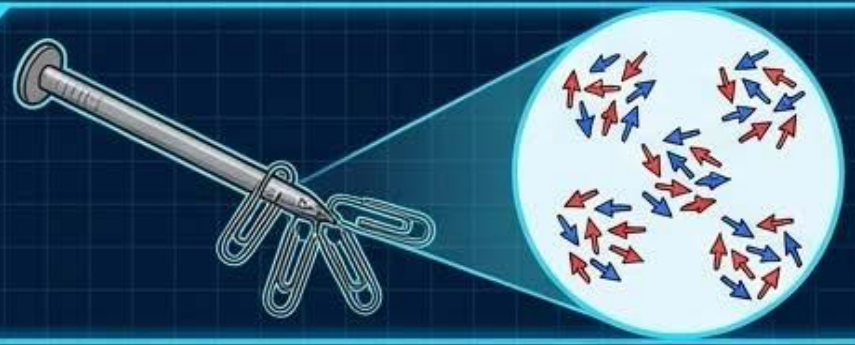
A



Nonmagnetic Material (Plastic Comb)

Domains point in random directions.
Magnetic fields cancel each other out.
Cannot be magnetized.

B



Magnetic Material / Temporary Magnet (Steel Nail)

Made of ferromagnetic elements (iron, nickel, cobalt).
When placed in a strong magnetic field, domains temporarily align.
Loses alignment when the external field is removed.

C



Permanent Magnet (Bar Magnet)

Created by heating magnetic materials and cooling them inside a strong magnetic field. Fields combine to form one unified force.
Domains are permanently locked.

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Electric Forces and Charges

The strength of an electric force depends on two variables:
1. Total amount of charge.
2. Distance between objects.

The Potential Energy Parallel

Gravity (Mass)



Pulling a mass AWAY from Earth increases Gravitational Potential Energy.

Electricity (Charge)



Pulling unlike charges (Positive & Negative) AWAY from each other increases Electric Potential Energy.

The Golden Rule of Charges



(+) and (+) = Repel



(-) and (-) = Repel



(+) and (-) = Attract

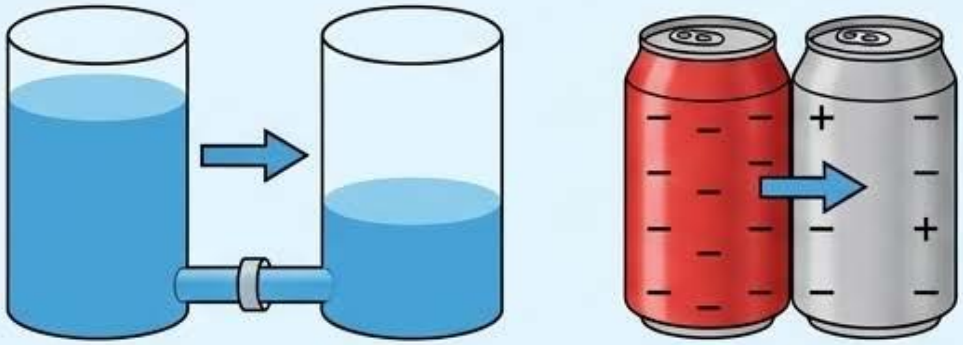
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Transferring Charge: Movement & Materials

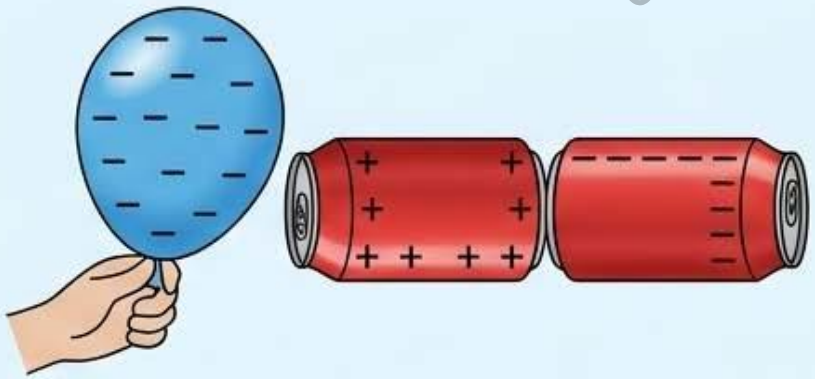
Transfer Matrix

Conduction (Touching)



Process: Direct contact required. Charges flow from higher concentration to lower until exactly equal.

Induction (Without Touching)



Process: A charged object is brought near (not touching). It repels similar charges and attracts opposite ones, polarizing the object.

The Material Divide

Conductors
Electrons move easily.
Examples: Copper, Aluminum, Lightning rods.

Insulators
Electrons cannot easily move.
Examples: Glass, Rubber, Wood, Air.

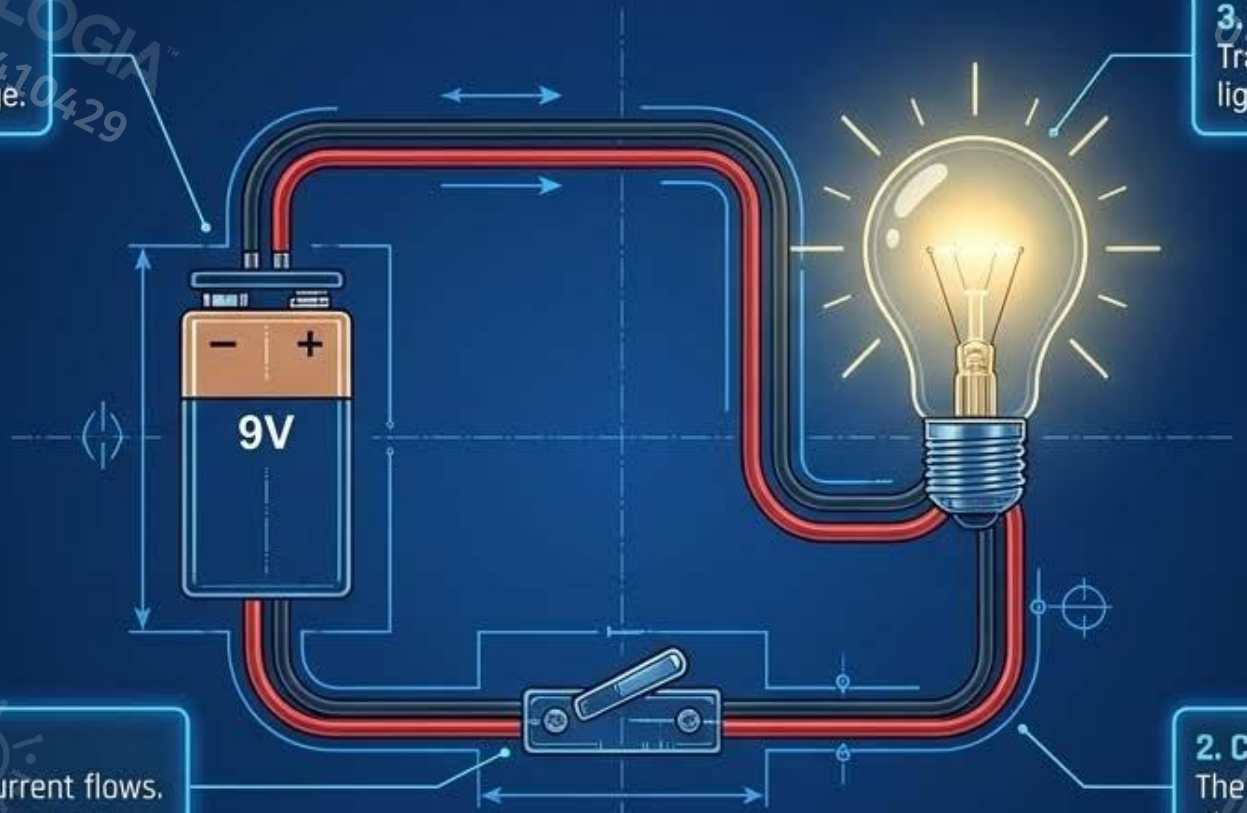
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Anatomy of a Simple Circuit

1. Energy Source (Battery):
Contains chemicals that react to separate charges, providing voltage.

3. Electric Device (Bulb):
Transforms electrical energy into light and thermal energy.



4. Switch (The Gatekeeper):
Closed circuit = continuous loop, current flows.
Open circuit = loop broken, current stops.

2. Conductor (Wire):
The copper pathway that allows electrically charged particles to travel.

Electric Current: The movement of electrically charged particles.

Voltage: The electrical potential energy difference between two places on a circuit (acts like pressure pushing the charges).

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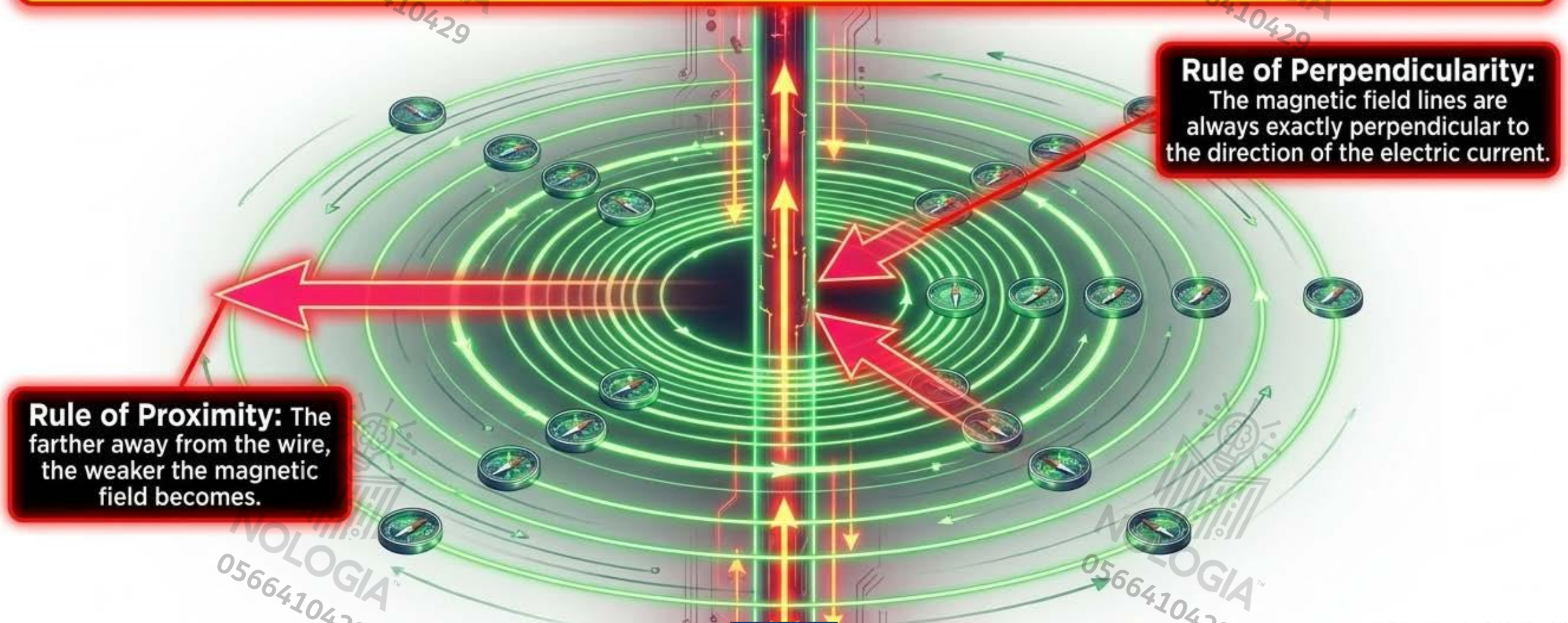
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The Unification: Electromagnetism

The Revelation: A magnetic field actually surrounds all moving charged particles. Moving electricity creates a magnet!



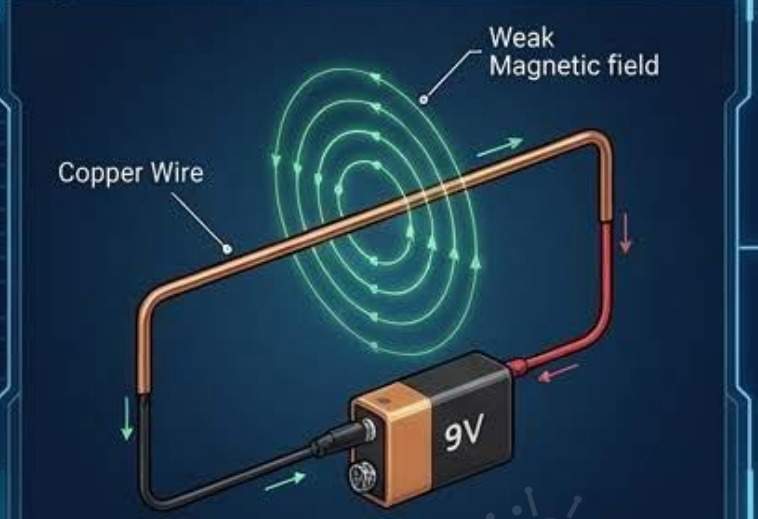
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Engineering Electromagnets

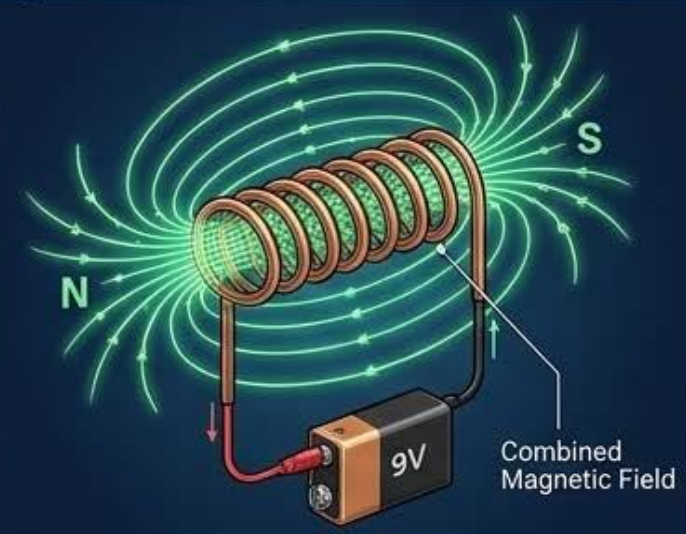
An electromagnet is a temporary magnet made with a current-carrying wire coil wrapped around a magnetic core.

The NOLOGIA Upgrade Blueprint

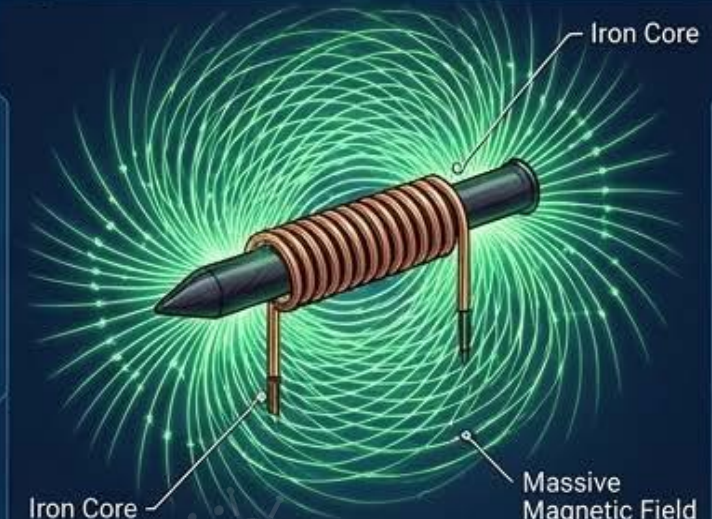
1 Level 1: Straight Wire



2 Level 2: The Coil



3 Level 3: The Iron Core



Control Panel

Advantage over Permanent Magnets

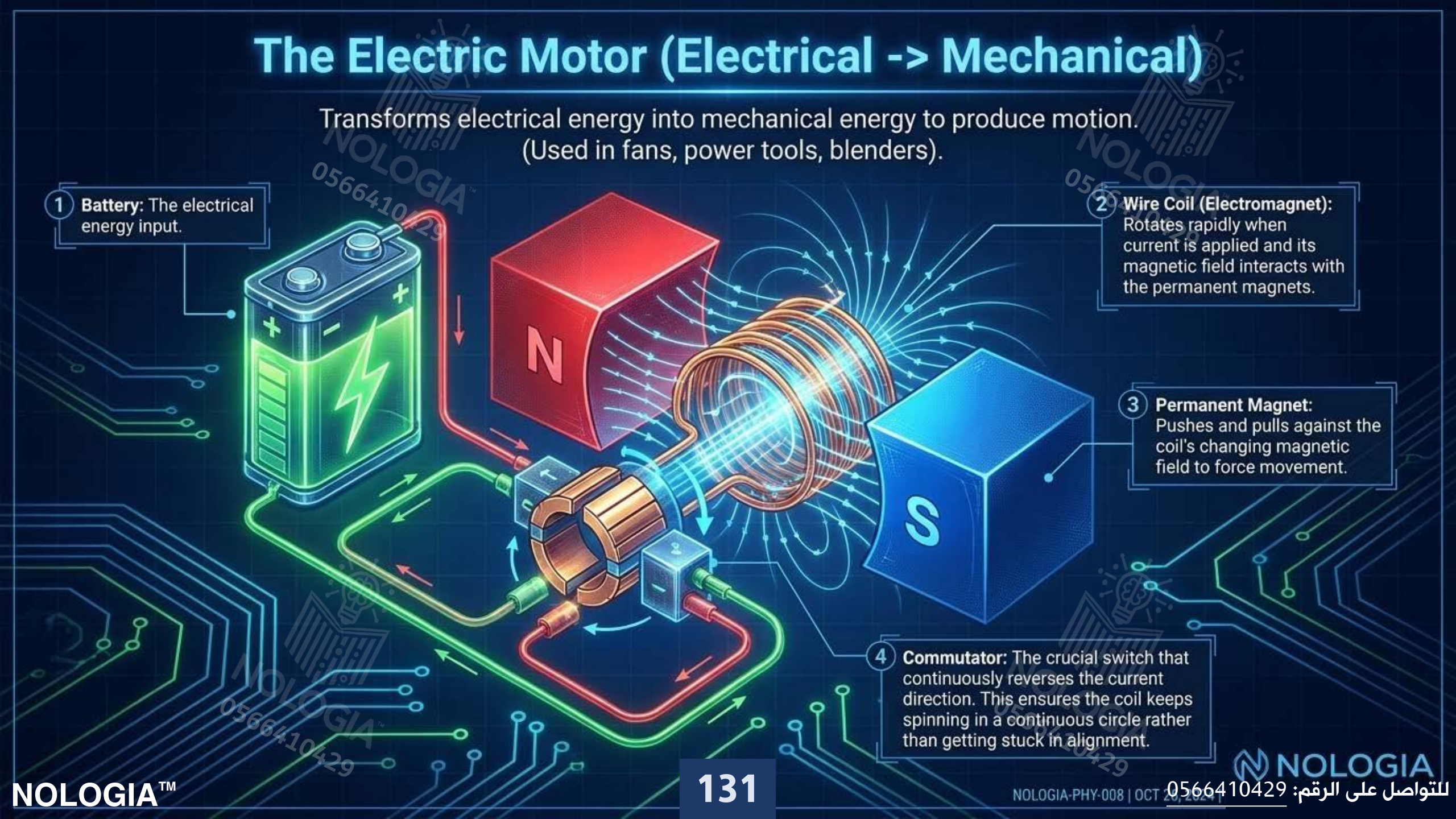
1. They can be turned on and off instantly.
2. Their strength can be precisely controlled by altering the voltage or the number of coils.
3. Their poles reverse if the current direction reverses.

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The Electric Motor (Electrical -> Mechanical)

Transforms electrical energy into mechanical energy to produce motion.
(Used in fans, power tools, blenders).



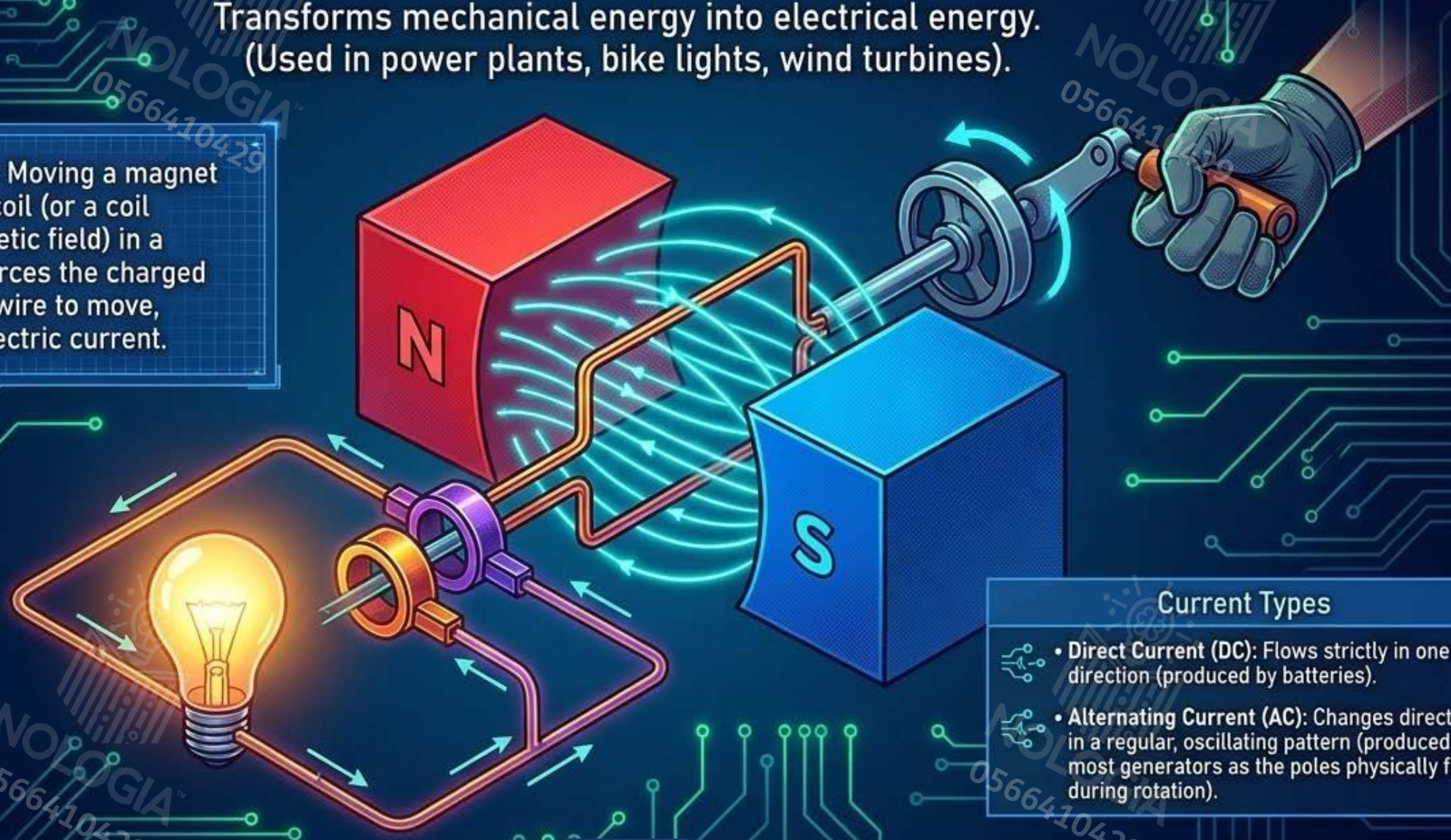
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The Electric Generator (Mechanical -> Electrical)

Transforms mechanical energy into electrical energy.
(Used in power plants, bike lights, wind turbines).

The Mechanism: Moving a magnet through a wire coil (or a coil through a magnetic field) in a closed circuit forces the charged particles in the wire to move, producing an electric current.



Current Types

- **Direct Current (DC):** Flows strictly in one direction (produced by batteries).
- **Alternating Current (AC):** Changes direction in a regular, oscillating pattern (produced by most generators as the poles physically flip during rotation).

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NOLOGIA Master Matrix: Motors vs. Generators

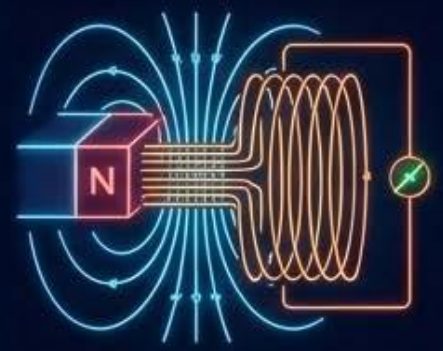
Feature	Motor	Generator
Input Energy	Electrical	Mechanical
Output Energy	Mechanical	Electrical
Key Components	Battery, Coil, Magnet, Commutator	Crank (Motion), Coil, Magnet
Real-World Example	Electric Fan	Wind Turbine

Maximizing Current in a Generator

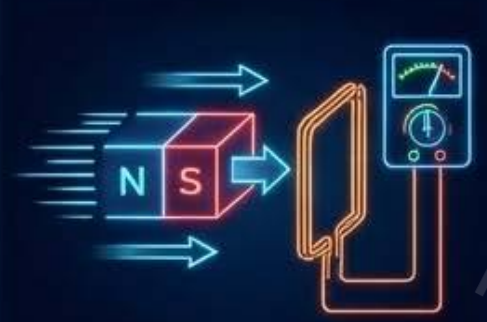
1. Stronger Magnet



2. More Coils/Loops



3. Faster Motion



4. Perpendicular Angle



NOLOGIA Master Bluep 133 omplete. You are ready.

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Exam Preparation

1) **Which statement explains why socks would cling to a blanket?**

   A. The socks and blanket dried together which caused them to cling to each other.

   B. The socks and blanket are conductors that picked up some positive charges that keep the clothes together.

   C. The socks and blanket are insulators that picked up some negative charges that keep the clothes together.

   D. The clothes picked up opposite charges. The opposite charges are attracted to each other.

2) **Which solution would reduce this problem in a dryer?**

   A. A crinkled-up ball of aluminum foil will conduct the charges and remove the charges from the clothes.

   B. Place less clothes in the dryer to prevent rubbing.

   C. Lower the electricity the dryer uses to lower the number of charges in the dryer.

   D. Dry clothes without them touching so that the clothes do not dry together.

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Module (3): Electromagnetic Forces

03 Third Lesson:
Simple Circuits

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Mastering Electrical Circuits & The Grid

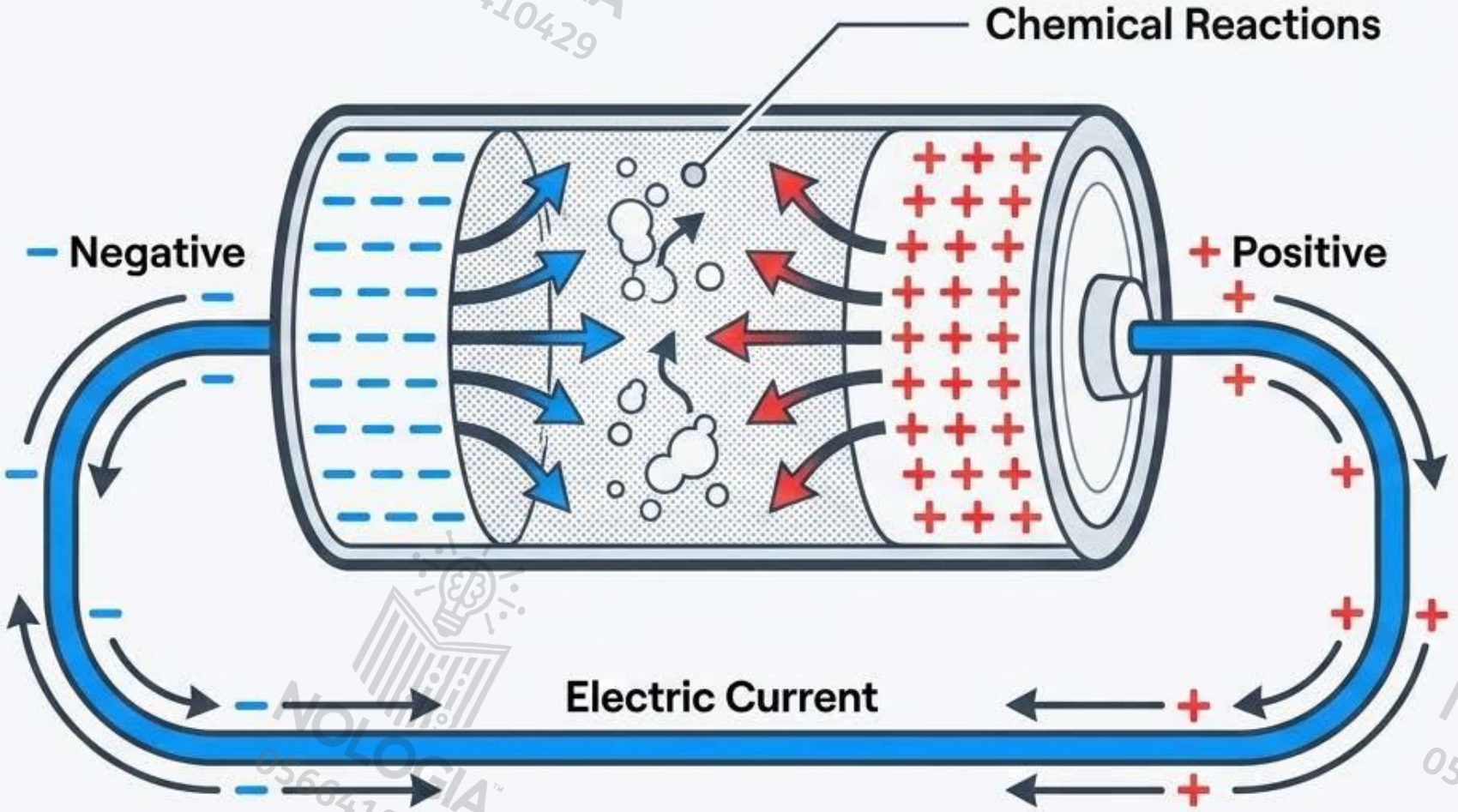
The NoLOGIA Comprehensive Study Guide



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The Particle Push

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NOLOGIA Study Notes

Electric Current: The continuous movement of electrically charged particles.

The Rule of Charges: Like charges repel; opposite charges attract. Electrico charges onay. This interaction forces particles to travel along the wire.

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Anatomy of a Simple Circuit

Source of Electric Energy: A battery provides the push.





Electric Device: A light bulb where electrical energy is transferred and transformed.

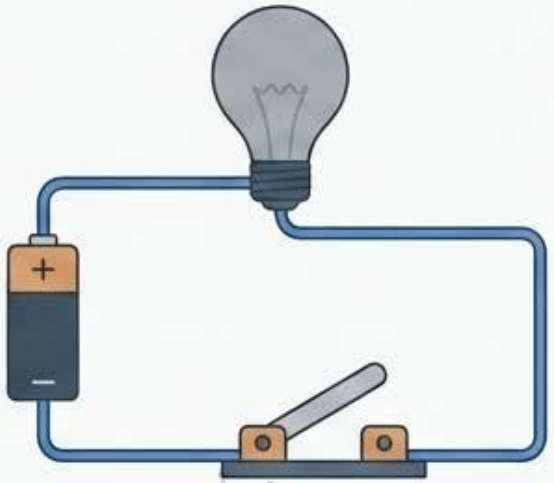


Electric Conductor: Copper. Electric wires are usually made of copper because it is one of the best conductors, allowing charged particles to move easily.

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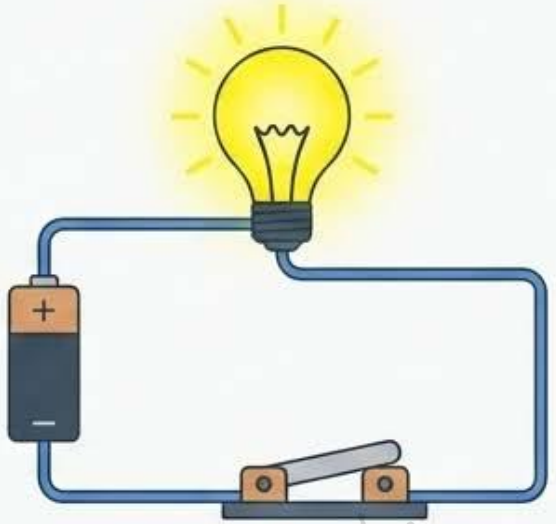
The Switch State Matrix

Open Circuit



Open Circuit: The path is broken. The circuit is not complete, and NO electric energy flows.

Closed Circuit



Closed Circuit: The path is complete. Electric energy flows freely through the system.

Takeaway: A switch functions simply by changing a circuit between an open and closed state.

What is Voltage?

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

Explanation: Energy stored in the battery moves the charged particles. The amount of energy transformed depends on the battery's voltage.



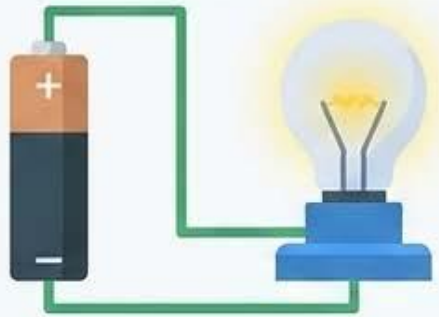
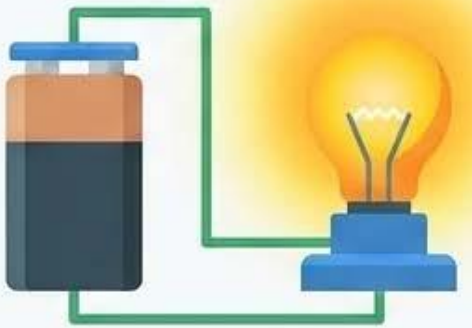
Low Voltage (1.5V): Lower potential energy difference



High Voltage (9V): Higher potential energy difference

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The Voltage Impact Table

Low Voltage Source (1.5V Battery)		Lower potential energy difference. Transfers standard amount of energy.
High Voltage Source (9V Battery)		Higher potential energy difference. Produces about six times more light and thermal energy than the 1.5V battery.

Higher voltage = Higher energy transfer.

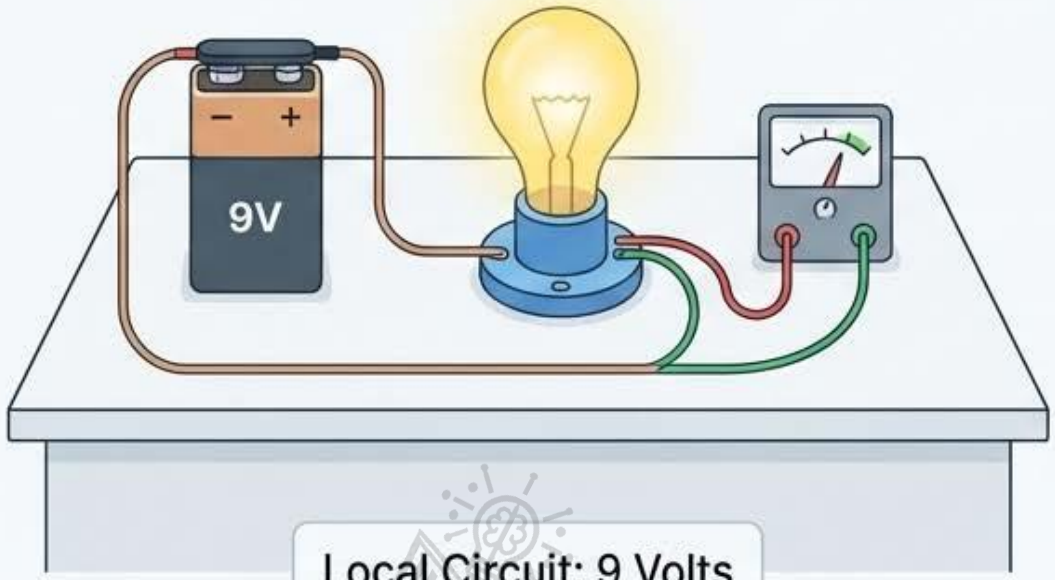
NOLOGIA Study Notes

Energy Transfer and Transformation

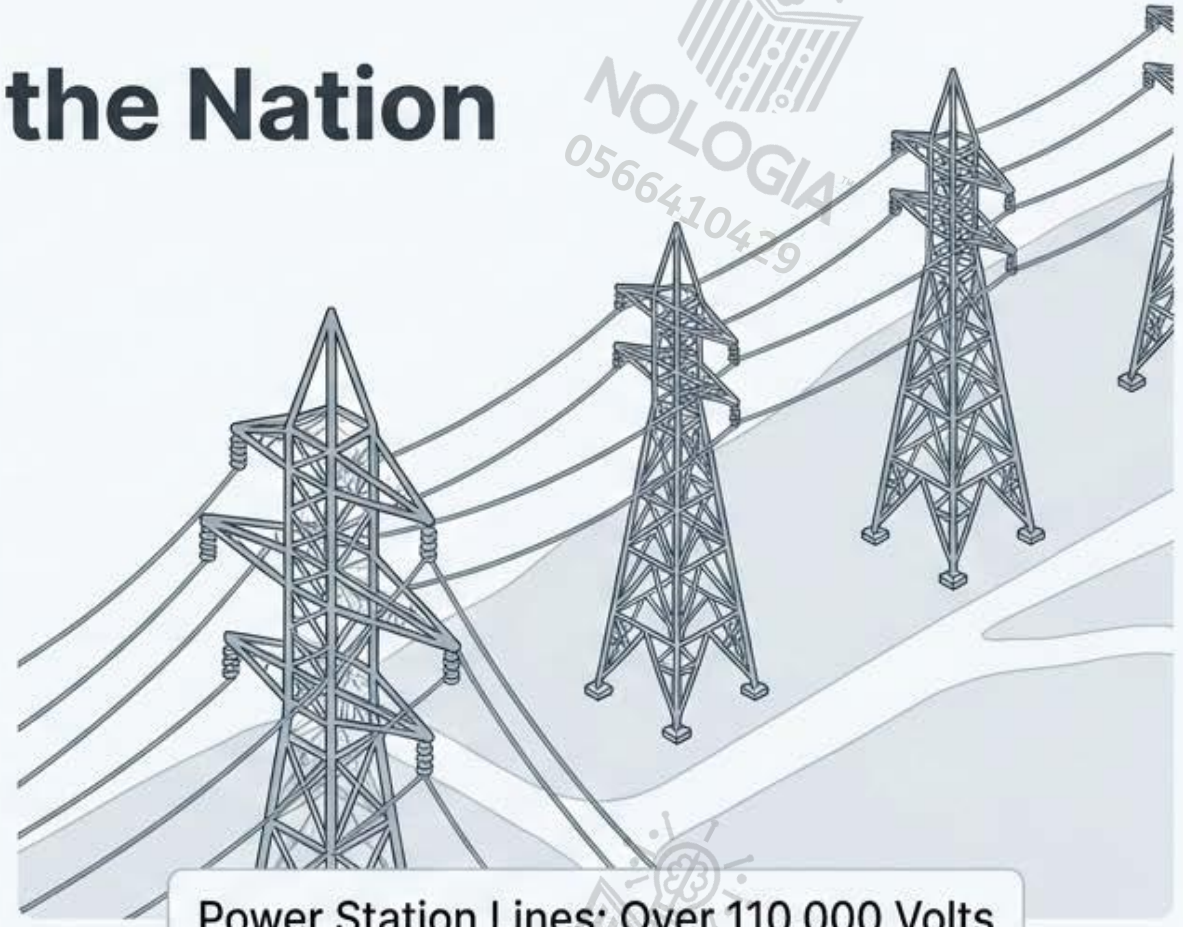


NOLOGIA Core Principle: In a circuit, electrical energy doesn't disappear; it is transferred to devices and transformed into new forms like light and heat.

Scale Up: From the Lab to the Nation



Local Circuit: 9 Volts



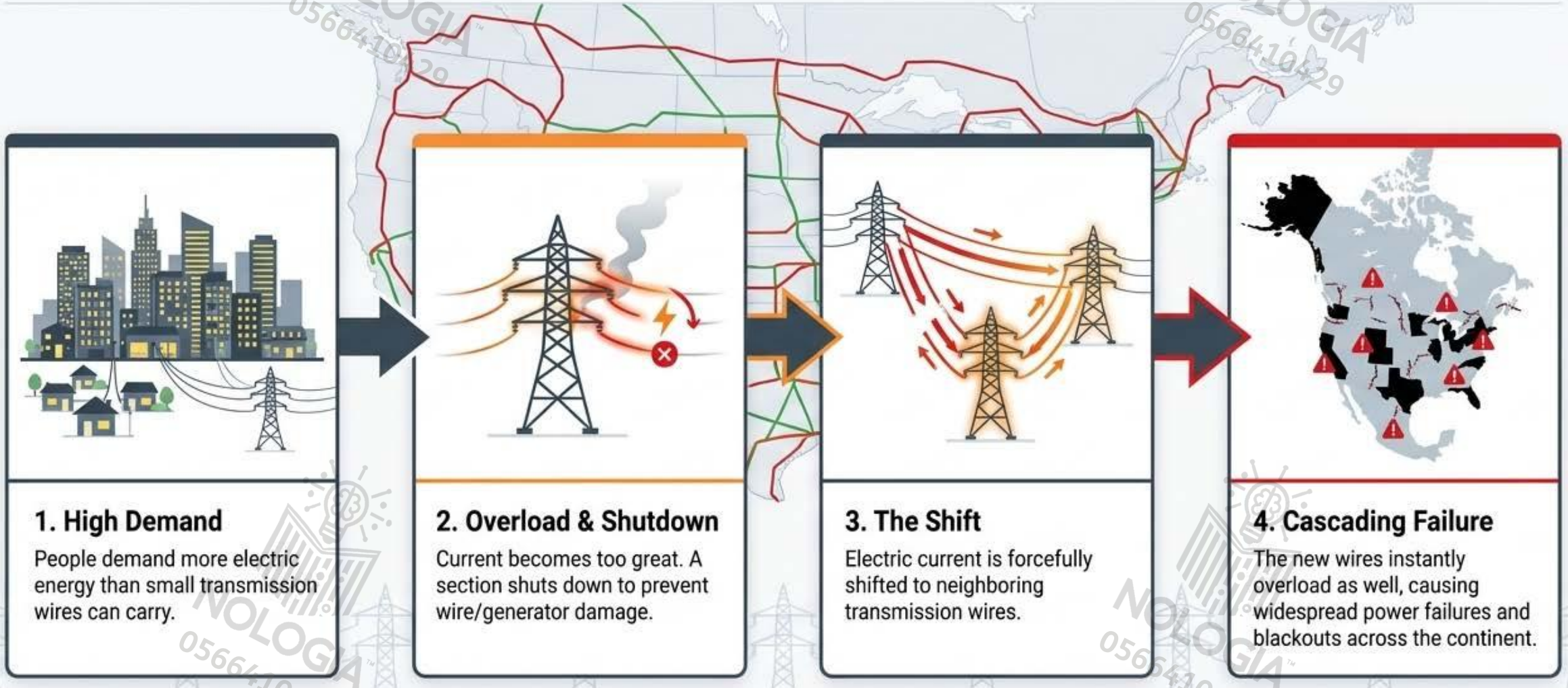
Power Station Lines: Over 110,000 Volts

The fundamental physics are identical. Whether powering a tiny light bulb or an entire city, circuits require a **source**, a **conductor**, and a device. Power companies just **scale up** the voltage dramatically to meet massive energy needs.

The North American Power Grid: A System Under Stress

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The grid is an electric super highway of interconnected transmission wires, but it is aging quickly.



1. High Demand

People demand more electric energy than small transmission wires can carry.

2. Overload & Shutdown

Current becomes too great. A section shuts down to prevent wire/generator damage.

3. The Shift

Electric current is forcefully shifted to neighboring transmission wires.

4. Cascading Failure

The new wires instantly overload as well, causing widespread power failures and blackouts across the continent.

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Smart Grid Routing Map

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The Solution

A Smart Grid uses computers at distribution centers to constantly analyze electric energy needs.

Dynamic Routing

Instead of failing, the system automatically routes electric power from where it is produced directly to where it is needed, bypassing overloaded lines.

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The Consumer Connection



- **Smart meters** connect to personal **computers**, allowing families to see exactly how much energy each device uses.
- **Consumers** can identify where they unwisely use electricity.
- Adjusting habits decreases personal costs AND reduces stress on the national grid.

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Exam Preparation

A 1.5 V battery is connected to a light bulb with some wires. One of the wires is cut, breaking the circuit.

1) What is the electrical potential energy difference across the light bulb after the wire is cut?

   A. 0.0 V.

   B. 1.5 V.

   C. -1.5 V.

   D. Need more information.

2) After the wire is cut, what is the electrical potential energy difference across the two ends of the cut wire?

   A. 0.0 V.

   B. 1.5 V.

   C. -1.5 V.

   D. Need more information.



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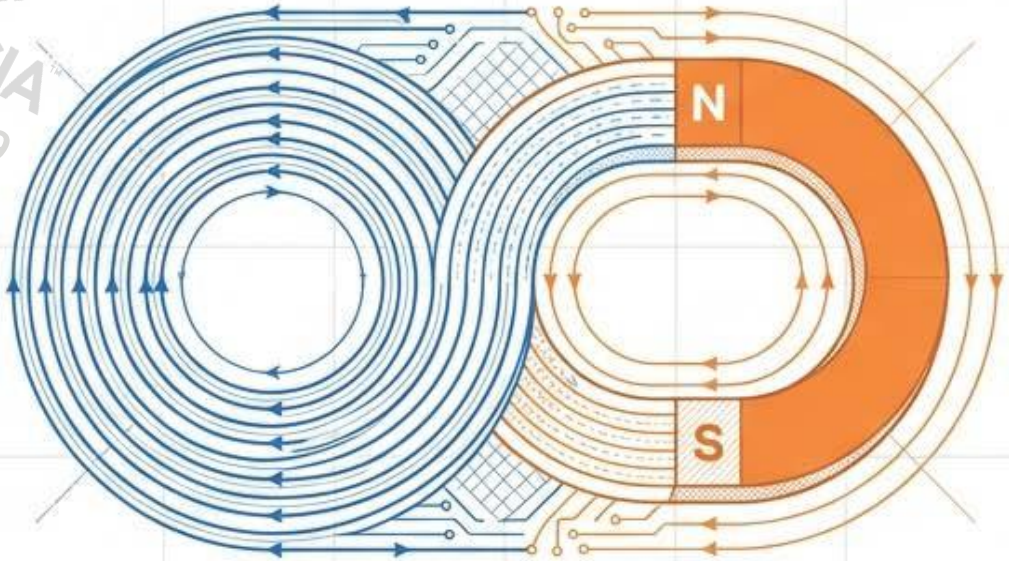
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Module (3): Electromagnetic Forces

04 Fourth Lesson:
Electromagnetism

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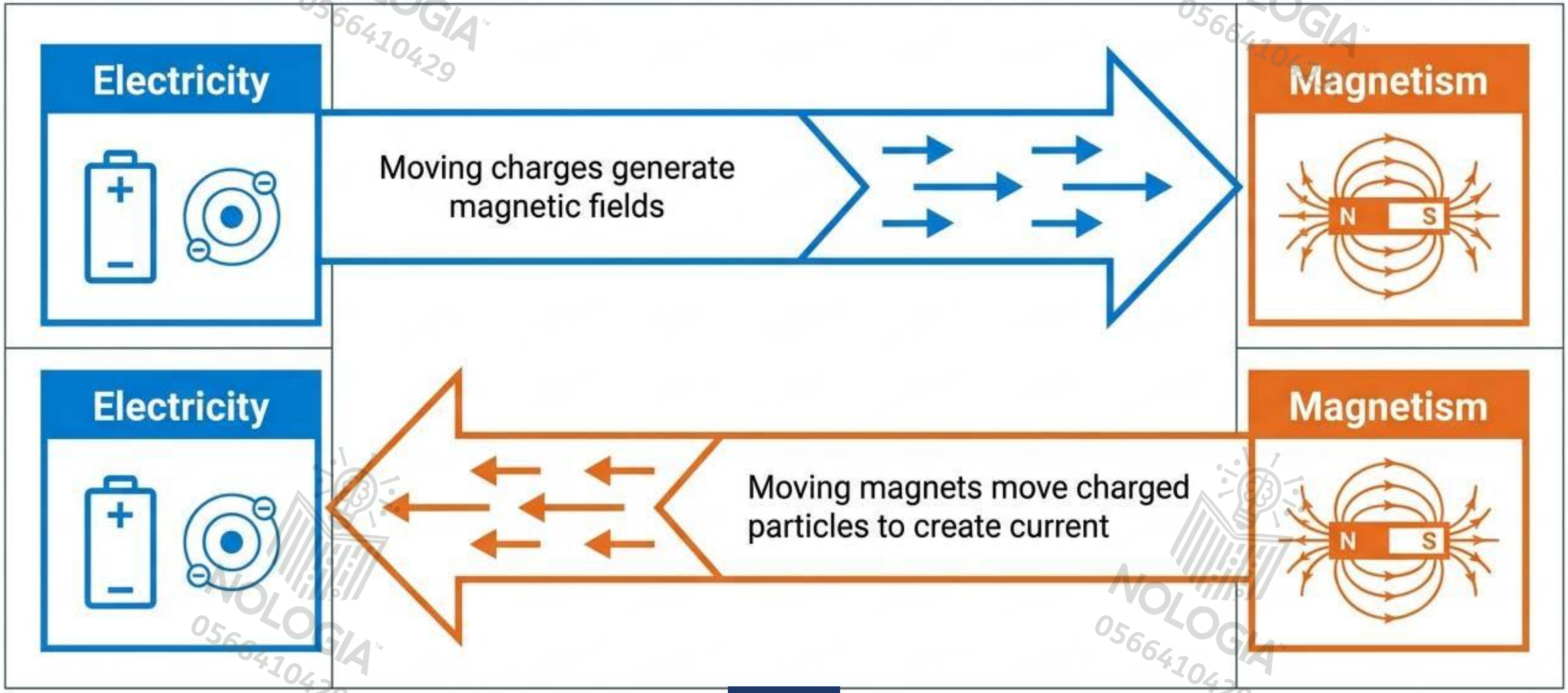
Electromagnetism: The Complete Reference Guide

A visual breakdown of magnetic fields, motors, and generators.

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The Two-Way Street of Physics

All phenomena in this guide rely on this single, perfectly symmetrical relationship.



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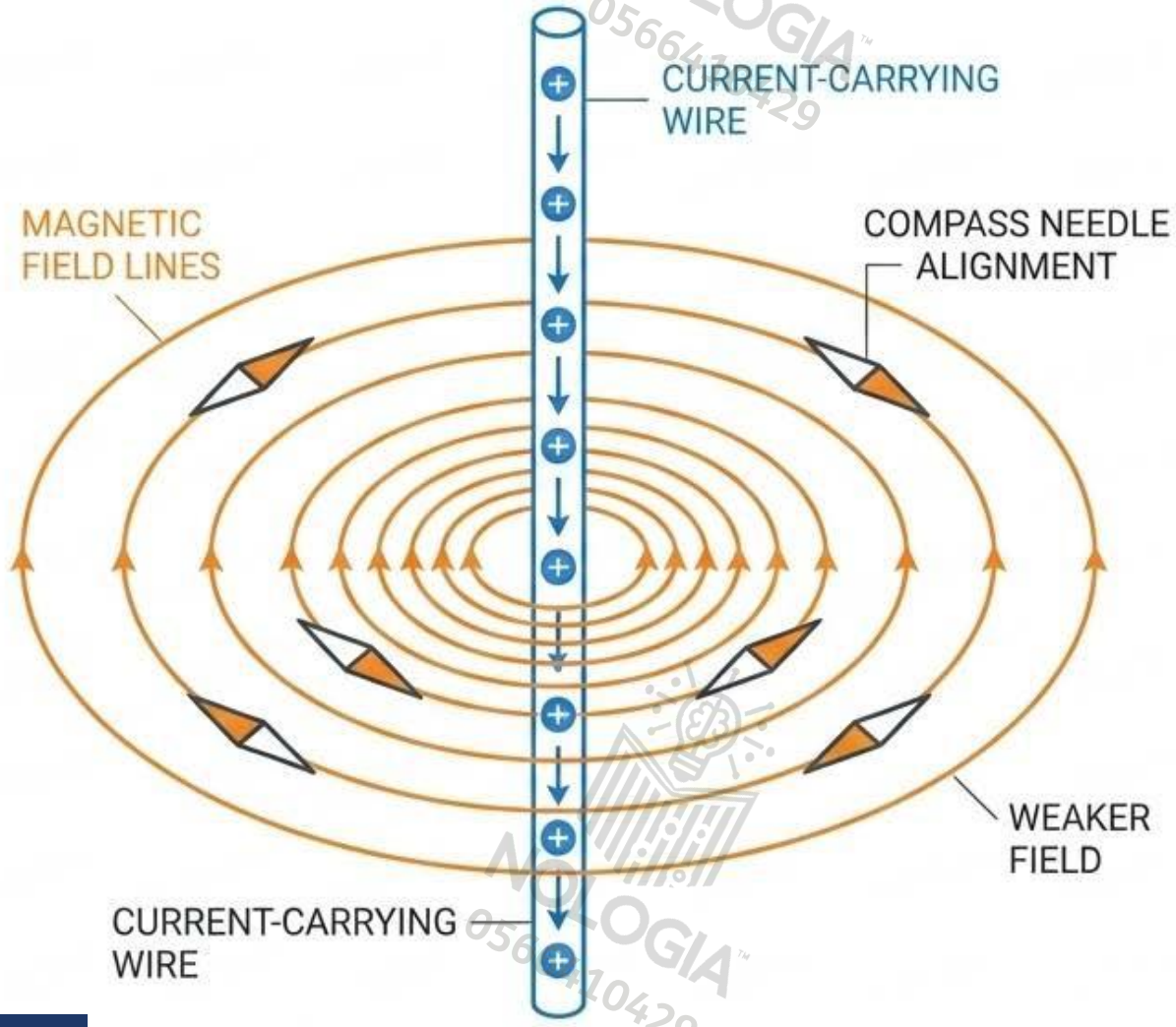
Principle 1: Moving Charges Create Magnetic Fields

KEY FACT BOX

A magnetic field surrounds all moving charged particles. If the current stops, the magnetic field disappears.

OBSERVATION PANEL

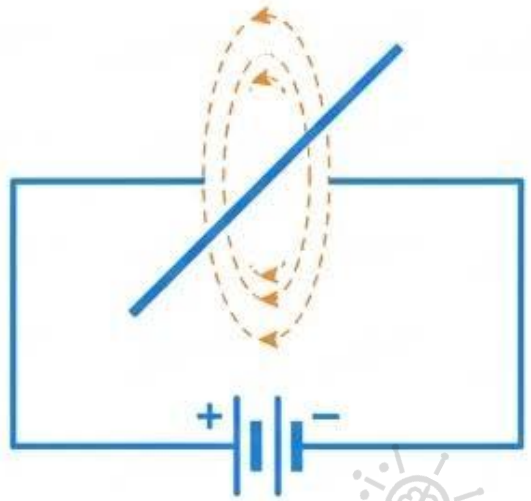
The magnetic field is perpendicular to the current (forming concentric circles). The field is strongest closest to the wire and weaker further away.



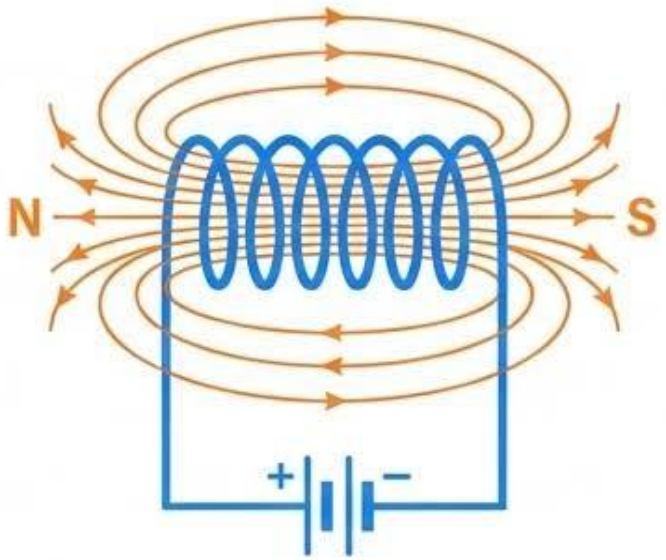
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Leveling Up: Strengthening the Magnetic Field

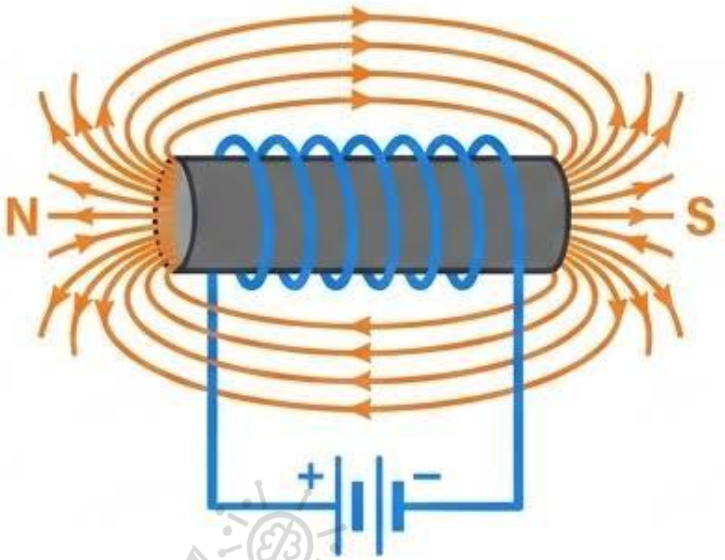
Step 1: Straight wire (weakest field).



Step 2: Wire wound into a coil (fields around individual loops combine, increasing strength).



Step 3: Coil wrapped around an iron core (greatly intensifies the field).



Diagnostic Box (Device Test):

Out of 20 coils with no core, 20 coils with a wooden core, and 20 coils with an iron nail core, the iron nail core produces the strongest magnetic force.

The Electromagnet & Its Three Superpowers

Definition: A temporary magnet made with a current-carrying wire coil wrapped around a magnetic core.
Application: Used in metal detectors and scrap yards.

Advantage 1:
On/Off Control.
Turning off the current instantly drops magnetic materials.



Advantage 2:
Variable Strength.
Controlled by adding more loops or increasing current.

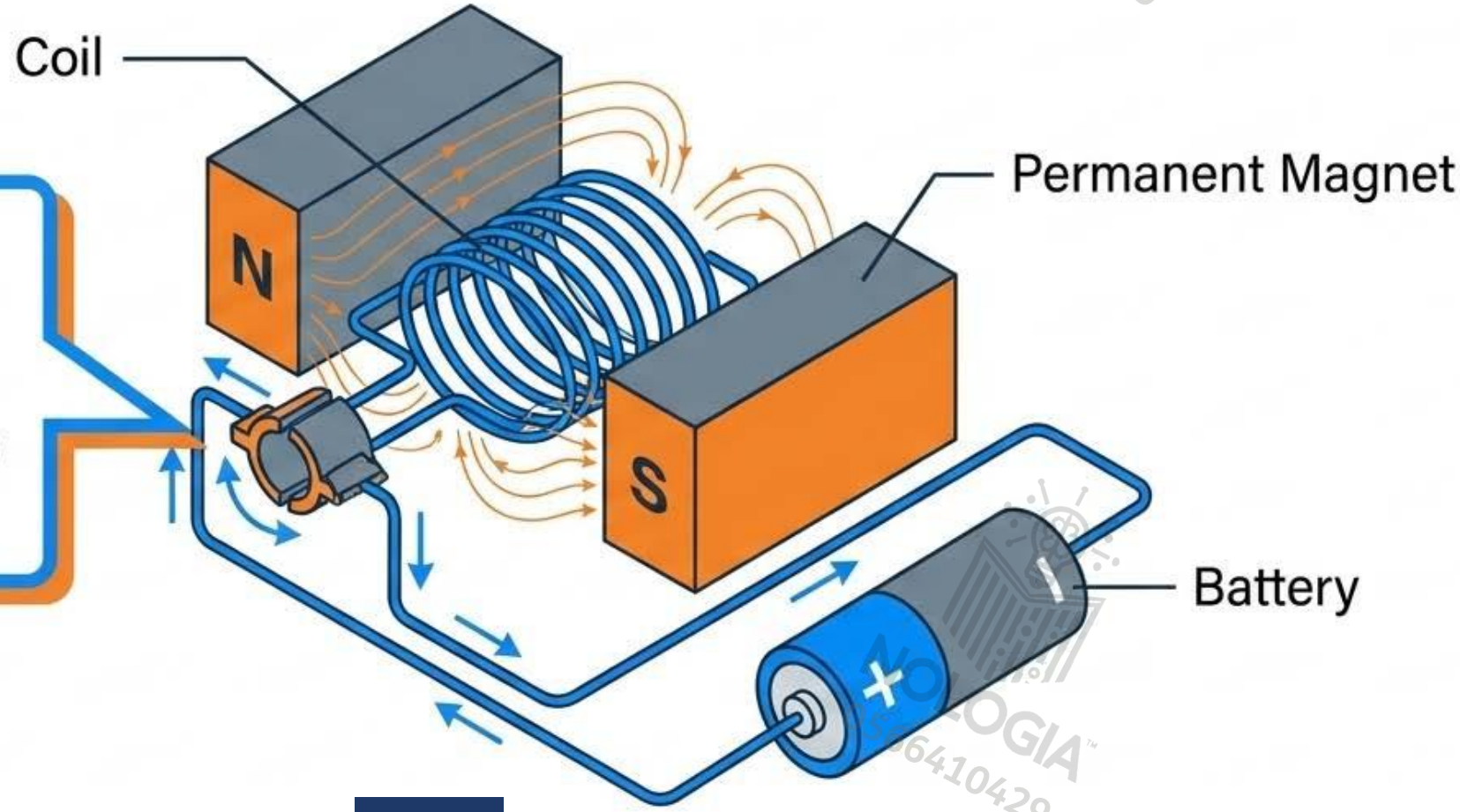
Advantage 3:
Reversible Poles.
The North and South poles flip if the current direction reverses.

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Application 1: Anatomy of the Electric Motor

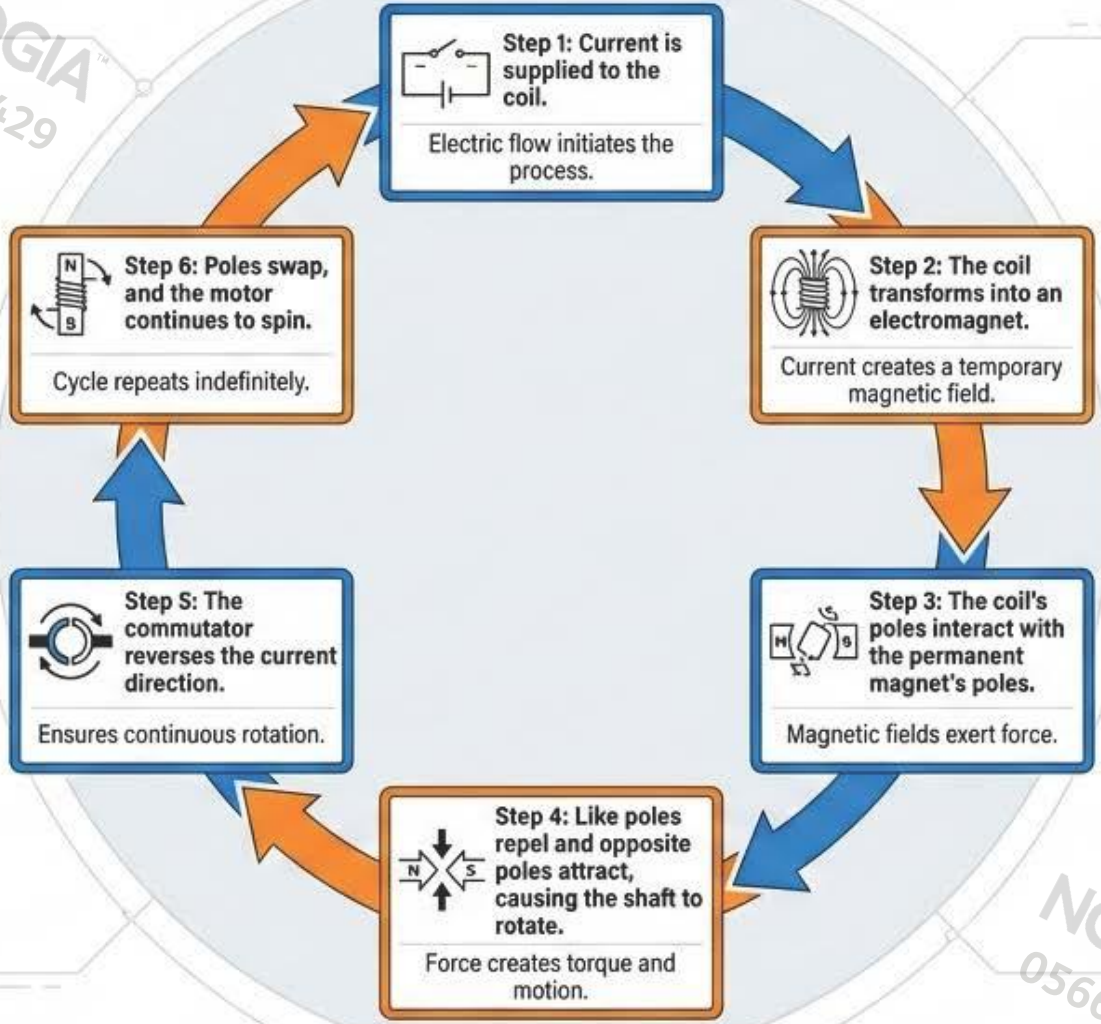
Core Function Box: Transforms electrical energy into mechanical energy (motion).

The Commutator: An electrical switch that continuously reverses the current in the coil to keep it spinning.



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Motor Mechanics: The Cause-and-Effect Loop



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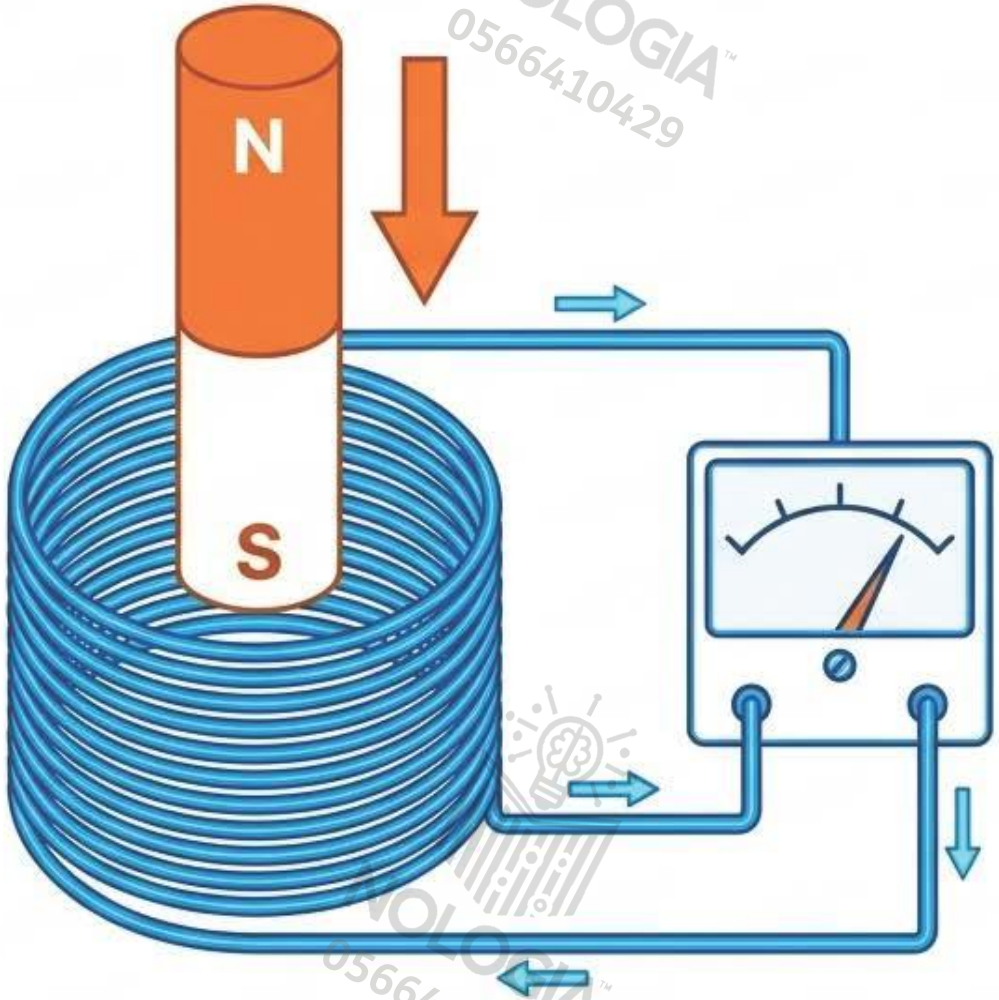
Principle 2: Generating Electric Current

Key Fact Box

Moving a magnet through a wire coil in a closed circuit forces the charged particles to move, producing an electric current.

Observation Panel

When the magnet stops moving, the current drops to zero. The direction of the current depends on the direction the magnet moves.

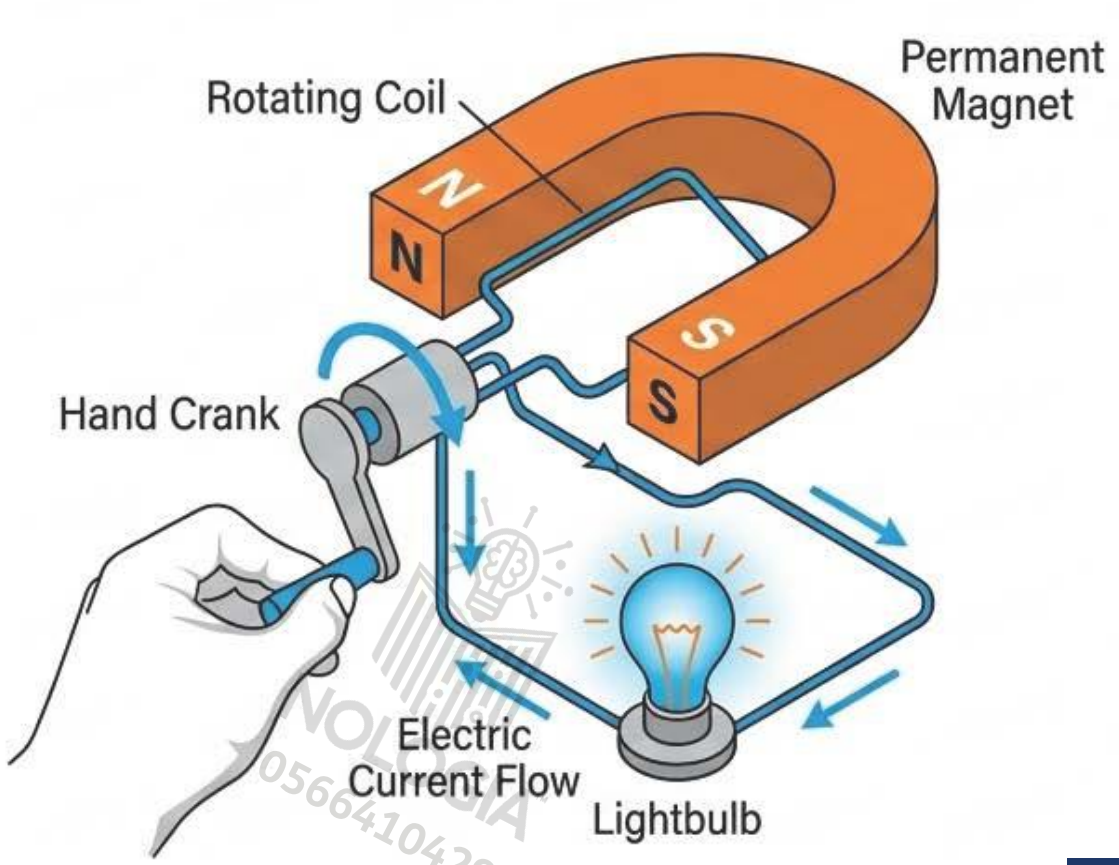


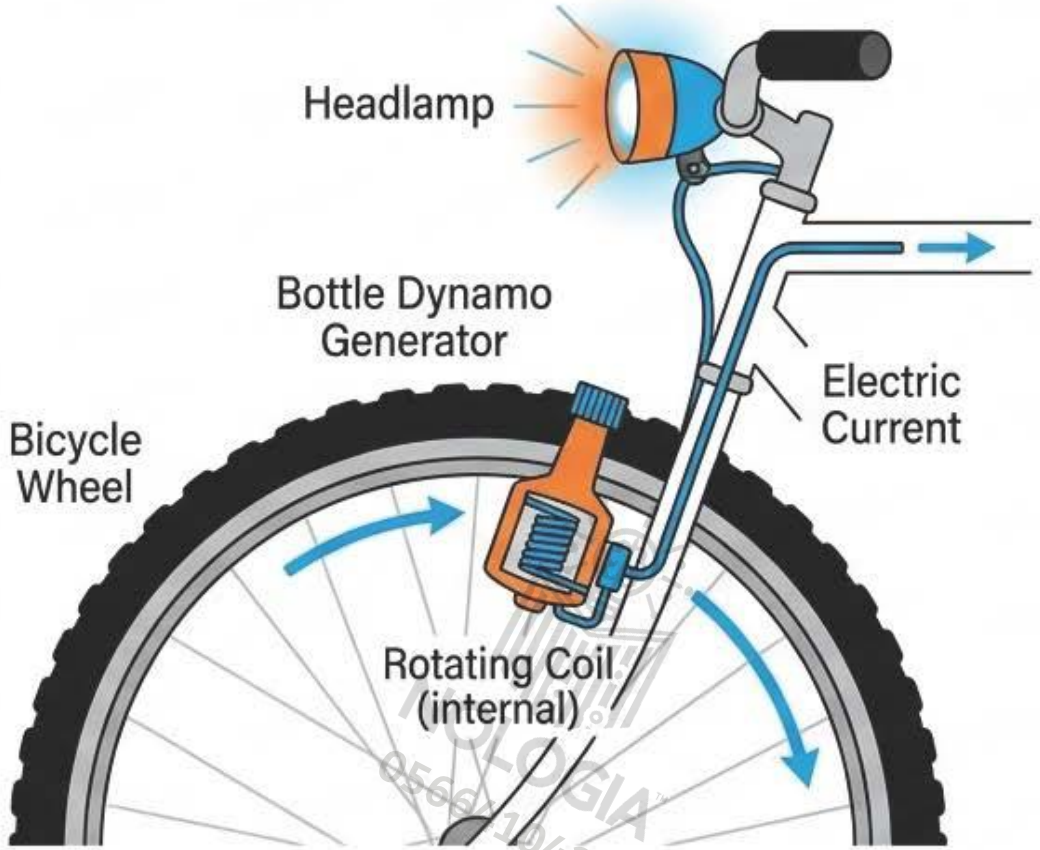
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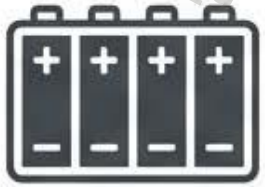
Application 2: The Electric Generator

Core Function Box	Mechanism
A device that uses a magnetic field to transfer mechanical energy into electrical energy.	As the crank turns, mechanical energy forces the wire coils to rotate through the permanent magnetic field, continually producing electric current.



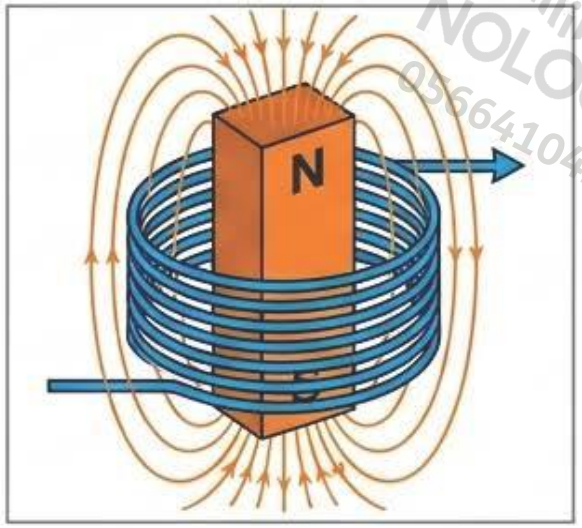


The Current Matrix: DC vs. AC

Direct Current (DC)	Alternating Current (AC)
  Flows in one continuous direction.	  Changes direction in a regular pattern.
• Produced by **batteries**.	• Produced by generators.
• Flows in **one continuous direction**.	• Changes direction **in a regular pattern** as the rotating coil **lines up with the poles of the magnet.**

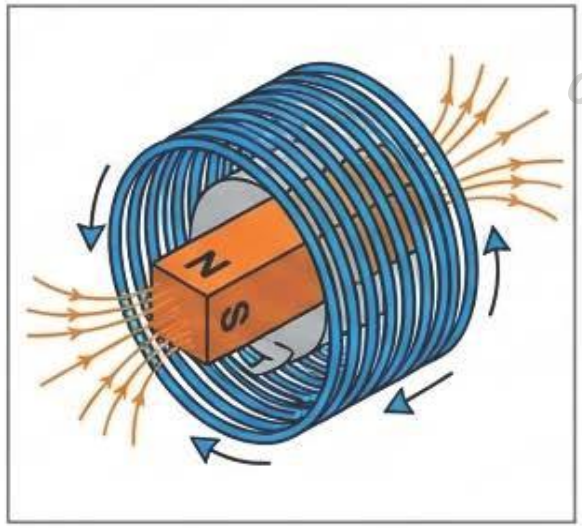
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Maximizing Power: 4 Ways to Increase Generator Current



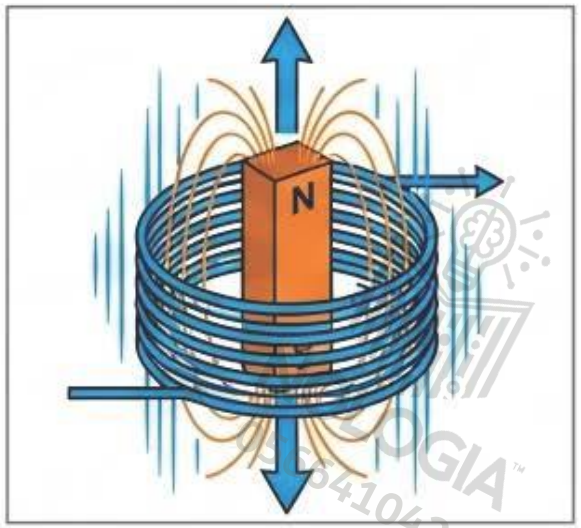
Stronger Magnet

(Proportional to the strength of the magnet).



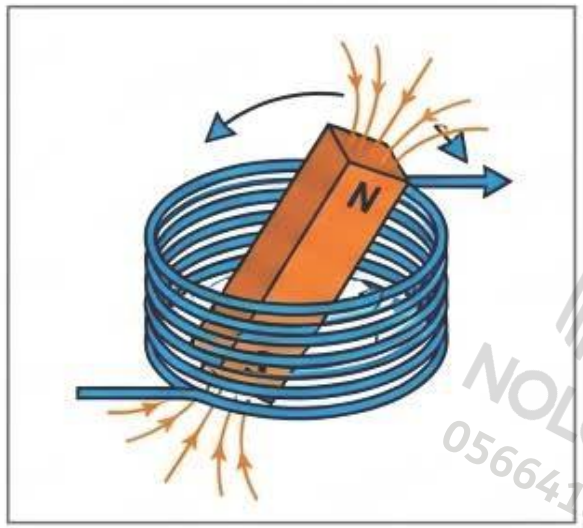
More Coils

(Increases with the number of loops or by adding a magnetic core).



Faster Motion

(Increasing the speed of the magnet or crank).



More Perpendicular

(Less perpendicular alignment results in a weaker current).

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The Ultimate Synthesis: Motor vs. Generator

	Electric Motor	Electric Generator
Input Energy	Electrical	Mechanical
Output Energy	Mechanical	Electrical
Core Mechanism	**Current** creates a **magnetic field** to push against a **permanent magnet**	**Physical rotation** through a **magnetic field** pushes **electrons** to create **current**
Key Component	Requires a **Commutator**	Produces **Alternating Current**

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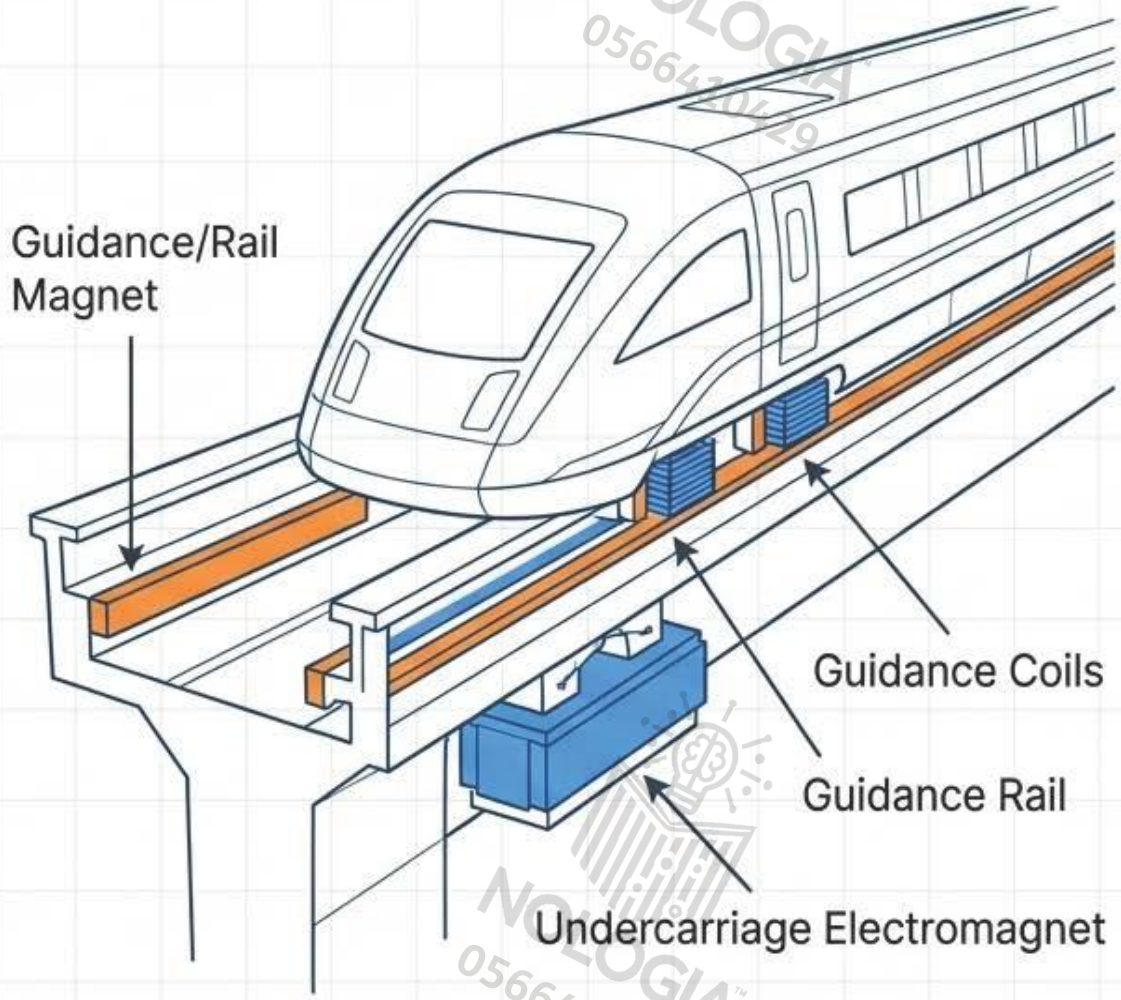
Extreme Engineering: Maglev Suspension

Context

Maglev (Magnetic Levitation) trains utilize electromagnetic suspension to float above the tracks, eliminating friction. They can reach speeds of 375 mph.

Mechanism

Strong electromagnets attached to the train are repelled by permanent magnets in the track. Guidance coils constantly update to ensure smooth running.



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NOLOGIA Quick-Reference Cheat Sheet

To Strengthen an Electromagnet:

1. Increase Electric Blue Voltage/Current.
2. Increase Number of Coils.
3. Add an Magnetic Orange Iron Core.

To Increase Generator Output:

1. Stronger Magnetic Orange Magnet.
2. More Coils.
3. Faster Motion.
4. More Perpendicular Alignment.

Definitions:

Commutator (Reverses Electric Blue motor current).

AC (Electric Blue Alternating Current - Magnetic Orange Generator).
DC (Electric Blue Direct Current - Battery).

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Exam Preparation

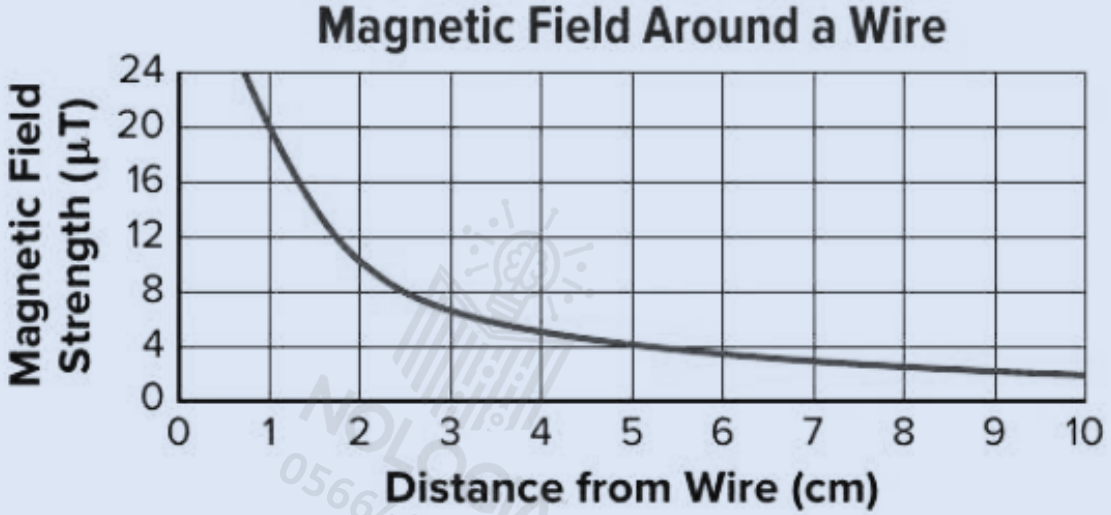
How much larger is the magnetic field strength 1 cm from the wire compared to 5 cm from the wire?

A. It is the same.

B. It is twice as large.

C. It is three times as large.

D. It is five times as large.



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تكون هذه الملزمة قد حققت
الفائدة المرجوة ♥

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