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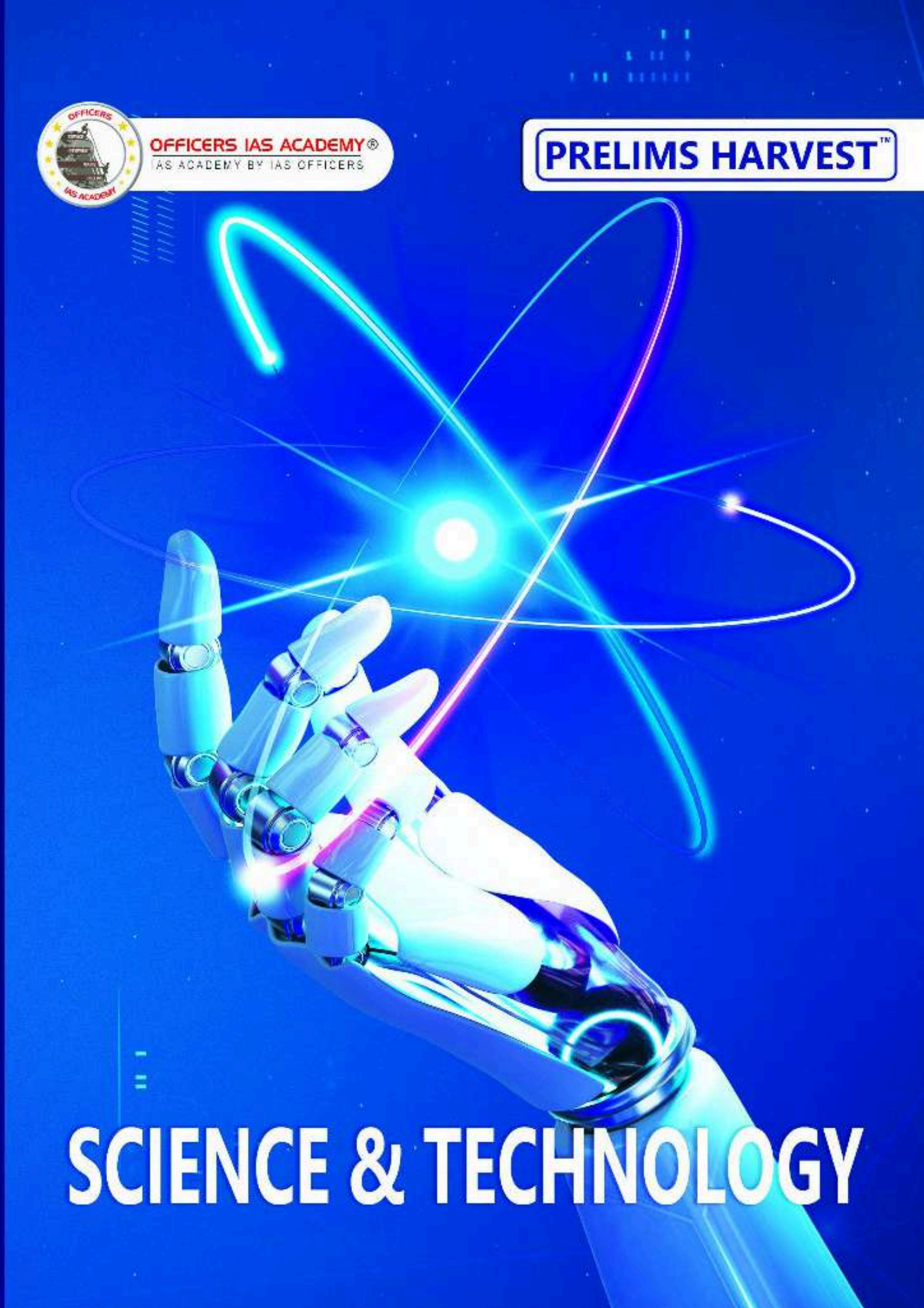

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MESSAGE FROM THE DIRECTOR

Dear Aspirant,

This book is dedicated to YOU, the untiring civil service aspirant who has the drive and commitment to persevere towards clearing this exam which is considered as one of the toughest exams in the world.

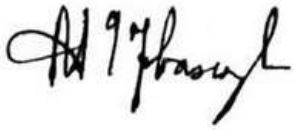
We congratulate you on choosing this book for **"Science & Technology"**. Our attempt here is to simplify important concepts without losing the key points. Hence, we hope you will find this book useful in your civil services journey.

About this book

This book is a distillation of the expertise of the faculty at Officers IAS academy, explained in simple and easy to understand language. What you get to study in this book has been painstakingly collated by our faculty through their years of teaching and mentoring thousands of aspirants.

A strong zeal from you to clear this exam combined with our coaching and textbook will, I am sure help you scale great heights.

I wish you the very best in the most important endeavour of your life.



R. A. Israel Jebasingh

(IAS, 2004 Batch All India Rank 59)

Director of Officers IAS Academy

HOW TO USE THIS BOOK?

Hello Aspirant!

There is a subtle difference between putting in effort and putting in the right & focussed effort. That difference could mean whether you get into the civil services or not!

Aspirants know that the first step to become a Civil Servant is to crack the Preliminary Exam (Prelims) conducted by the UPSC. At first glance, any UPSC Prelims question paper might give the impression that many of the questions asked were 'random', 'remote', 'unexpected', 'out of syllabus', 'from obscure areas' etc.,

But, upon careful consideration one can see that there are some hidden patterns present in the way how some of them were framed. We in the R&D of Officers IAS Academy, understand this.

Our R&D team consists of about 25 members, all of whom have appeared in multiple UPSC Mains & Interviews. This team of veterans spent a year, meticulously combing through the question papers of the past 26 years of UPSC preliminary exams to identify patterns, repetitions & outliers.

The team carefully isolated all such patterns, high-value topics from every subject and has prepared a 'hitlist'. Based on these insights we have prepared books, which we rightfully call as 'Prelims Harvest' books.

Please note: We do not advocate the use of these books as 'Standard' sources. However, instead of reading endless number of books for the UPSC preparation, aspirants can focus on the standard books (NCERTs, etc.,) for the foundational knowledge and then devout the rest of their time in studying the Officers IAS Academy's Prelims Harvest books.

So, please use the Prelims Harvest Books in conjunction with the primary sources (NCERTs, etc.,) and get the best value for your time invested in your UPSC preparation.

Thank you!

R&D Team,
Officers IAS Academy, Chennai.

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PHYSICS *(*MECHANICS*)*

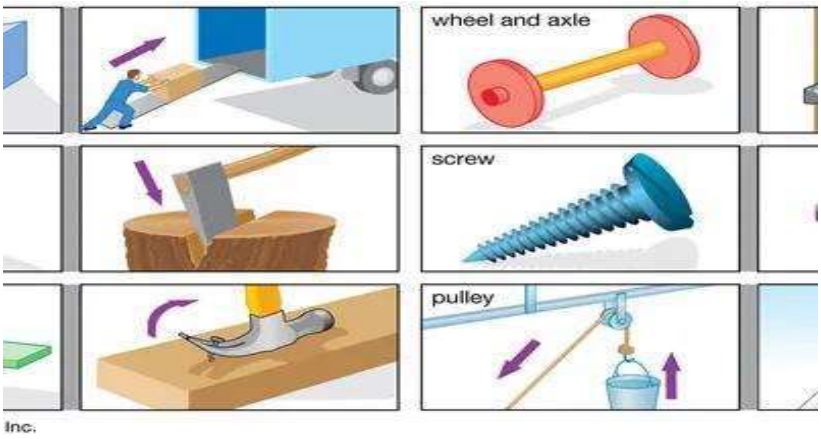
Brahma Gupta- anticipated Newton by declaring that all things gravitate to the earth.

- Brahma Gupta (598 – 668 CE) was an Indian mathematician and astronomer.
- He was the first to give rules to compute with zero.
- In 628 CE, he is the first person to describe gravity as an attractive force and used the term '*Gurutvakarṣaṇam'* in Sanskrit to describe it.
- He anticipated Newton by declaring that all things gravitate to the earth.
- He authored two early works on mathematics and astronomy,
    1. Brahmasphuṭa-siddhanta,
    2. Khaṇḍakhadyaka.
- **Brahmasphuṭa-siddhanta**, written in 628, in Sanskrit.
    - It contains ideas including a good understanding of the mathematical role of zero,
    - Rules for manipulating both negative and positive numbers.
    - Method for computing square roots, solving linear and quadratic equations,
    - Rules for summing series,
    - Brahmagupta's identity and the Brahmagupta's theorem.
- **Khaṇḍa-khadyaka**, written in 665 CE, a more practical text. It contains eight chapters covering topics such as,
    - The longitudes of the planets, diurnal rotation, lunar and solar eclipses, risings and settings, the moon's crescent and conjunctions of the planets.

Simple machine

- Simple machine refers to any of several devices with few or no moving parts that are used to modify motion and the magnitude of a force in order to perform work.
- They are the simplest mechanisms known that can use leverage or mechanical advantage to increase force.

- Thus, a simple machine helps us in doing the same amount of work with lesser force.
    - Few examples of simple machines are inclined plane, pulley, lever, wedge, wheel, screw.



Surface tension

- Surface tension is the tendency of liquid surfaces at rest to shrink into the minimum surface area possible.
- Surface tension, property of a liquid surface is displayed by its acting as if it were a stretched elastic membrane.
- Surface tension is what allows objects with a higher density than water such as razor blades and insects (e.g. water striders) to float on a water surface without becoming even partly submerged.
- At liquid–air interfaces, surface tension results from the greater attraction of liquid molecules to each other.

- There are two primary mechanisms in play,
    1. An inward force on the surface molecules causing the liquid to contract.
    2. A tangential force parallel to the surface of the liquid. This tangential force is generally referred to as the surface tension.
- The net effect is the liquid behaves as if its surface were covered with a stretched elastic membrane.
- Because of the relatively high attraction of water molecules to each other through a web of hydrogen bonds, **water has a higher surface tension** (72.8 millinewtons (mN) per meter at 20 °C) than most other liquids.
- Surface tension is an important factor in the phenomenon of **capillarity**.

Momentum- vector quantity

- Momentum can be defined as 'Mass in motion'.
- All objects have mass, so if an object is moving, then it has momentum, it has its mass in motion.
- The amount of momentum that an object has is dependent upon two variables:
    1. How much stuff is moving and
    2. How fast the stuff is moving.
- Thus Momentum depends upon the variables mass and velocity.

    Momentum = mass • velocity
- Momentum is a **vector quantity.**
- A vector quantity is a quantity that is fully described by **both magnitude and direction.**

Centrifugation

- The term centrifuge can refer to a machine that houses a rapidly rotating container to separate its contents by density or to the act of using the machine.
- Centrifuges are most often used to separate different liquids and solid particulates from liquids, but they may be used for gases.
- They are also used for purposes other than mechanical separation.

Everyday Applications

- Centrifugation is a widely used technique in research, industry, and clinical laboratories.
- It has many applications including,

- the purification of biological samples,
- the separation of cells and organelles,
- the analysis of proteins and nucleic acids, and
- the preparation of diagnostic specimens.

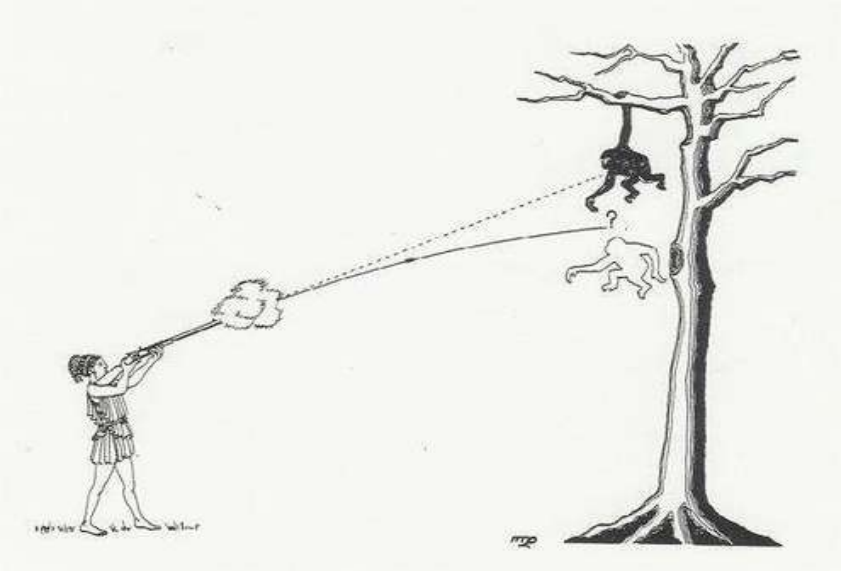
- These are common in our daily life, mainly to quickly separate liquids from solids.
  - **Washing machines** use centrifugation during the spin cycle to separate water from laundry.
  - A similar device spins the water out of **swimsuits**.
  - **Salad spinners**, used to wash and then spin dry lettuce and other greens

Monkey and the Hunter

- The monkey and the hunter is a physics demonstration often used to illustrate the effect of gravity on projectile motion.
- In essence, the problem is as follows:
  - A hunter with a blowgun goes out in the woods to hunt for monkeys and sees one hanging in a tree. The monkey releases its grip the instant the hunter fires his blowgun. Where should the hunter aim in order to hit the monkey?
- To answer this question,
  - According to Galileo's law, **all objects fall with the same constant acceleration of gravity** (about 9.8 metres per second near the Earth's surface), regardless of the object's weight.
- Furthermore, horizontal motions and vertical motions are independent.
- Gravity acts only upon an object's vertical velocity, not upon an object's horizontal velocity.
- **The hunter's dart, therefore, falls with the same acceleration as the monkey.**
- Assume for the moment that gravity was not at work.
  - In that case, the dart would proceed in a straight-line trajectory at a constant speed (**Newton's first law**).
- Gravity causes the dart to fall away from this straight-line path, making a trajectory that is in fact a parabola.
- Now, consider what happens if the hunter aims directly at the monkey, and the monkey releases its grip the instant the hunter fires,

- Because the force of gravity accelerates the dart and the monkey equally, they fall the same distance at the same time.

- The monkey falls from the tree branch, and the dart falls the same distance from the straight-line path it would have taken in the absence of gravity.
- Therefore, **the dart will always hit the monkey**,
  - No matter how much the initial speed of the dart or the acceleration of gravity be.



Capillary action

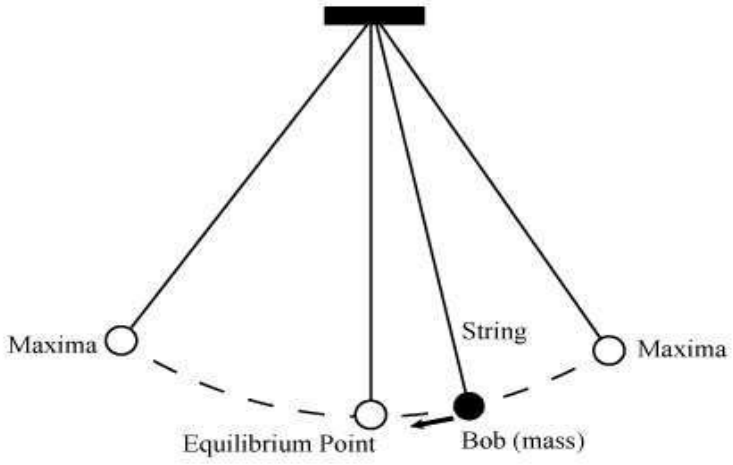
- Capillary action is the process of a liquid flowing in a narrow space without the assistance of, or even in opposition to, any external forces like gravity.
- The effect can be seen in the drawing up of liquids between the hairs of a paint-brush, in a thin tube, in porous materials such as paper and plaster, in some non-porous materials such as sand and liquefied carbon fiber, or in a biological cell.
- It occurs because of intermolecular forces between the liquid and surrounding solid surfaces.
- Capillary action is a reason for
  - blotting of ink
  - spread a water drop on a cotton cloth
  - rising of water from the roots of a plant to its foliage

New models of Motorcars are fuel efficient

- A "streamlined" design is one in which objects that move through a gas or liquid are shaped to match these lines that reduce the energy required to produce that motion.
- Multi point fuel injection system injects fuel into individual cylinders, based on commands from the 'on board engine management system computer—popularly known as the Engine Control Unit/ECU.
- These techniques result not only in better 'power balance' amongst the cylinders but also in higher output from each one of them, along with faster throttle response.
    - Therefore, a streamlined body and multi point fuel injection helps in fuel efficiency in motor cars.
- The radial tyres and catalytic converter with exhaust do not contribute to making the car more fuel efficient.

A simple pendulum

- A simple pendulum consists of a large mass (bob) suspended by a light string from a rigid support.
- The length of the string is large compared to the dimensions of the bob.
- A stationary pendulum has its string in a vertical position with the bob hanging straight down. This is known as the pendulum's equilibrium position. (since if left undisturbed, the pendulum will remain in this position).
- Oscillations (to and fro motion) are set up in a pendulum by displacing the bob from its equilibrium positions and releasing it.



Viscosity

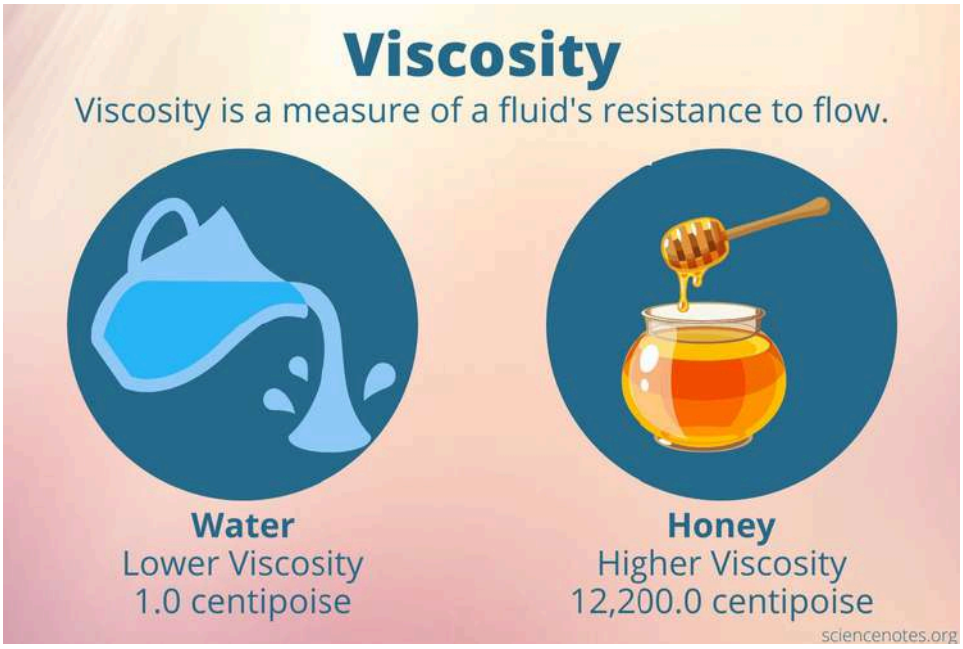
- Viscosity is defined as the resistance of a fluid (liquid or gas) to a change in shape or movement of neighbouring portions relative to one another.
- It denotes the opposition to flow.
- Viscous liquids like syrup and shampoo flow slowly.
- Less viscous liquids like water and gasoline flow quickly.
- The viscosity of a liquid usually depends on its temperature.
- Viscosity generally decreases as the temperature increases.
- Viscosity generally increases as the temperature decreases.

The Microscopic View

- The viscosity of a liquid is related to the ease with which the molecules can move with respect to one another. Thus the viscosity of a liquid depends on the:
    - **Strength of attractive forces** between molecules, which depend on their composition, size, and shape.
    - The **kinetic energy of the molecules**, which depend on the temperature.

Explain why an increase in temperature generally results in a decrease in viscosity?

- As the temperature increases the average kinetic energy of the molecules in a liquid increases.
- The greater average kinetic energy of the molecules more easily overcomes the attractive forces that tend to hold the molecules together.



Specific gravity

- Specific gravity, formally known as relative density, is a measure of the density of a substance **in comparison to the density of water** (standard substance).
- The usual standard of comparison for solids and liquids is water at 4 °C (39.2 °F),
    - It has a density of 1.0 kg per litre (62.4 pounds per cubic foot).
- Gases are commonly compared with dry air,
    - It has a density of 1.29 grams per litre (1.29 ounces per cubic foot) under so-called standard conditions (0 °C and a pressure of 1 standard atmosphere).
- For example,
    - **Liquid mercury** has a density of 13.6 kg per litre; therefore, its **specific gravity is 13.6.**
    - **Carbon dioxide (the Gas)**, which has a density of 1.976 grams per litre under standard conditions, has a specific **gravity of 1.53.**

Buoyancy

- Buoyancy (the ability of an object to float in water or air) is intimately related to specific gravity.
    - If a substance has specific gravity less than that of a fluid, it will float on that fluid.
- For example,
    - **Helium-filled balloons will rise in air,**

- **Oil will form a slick on water, and**
- **Lead will float on mercury.**

Where is it used?

- Specific Gravity is the basis of methods used throughout history to concentrate ores.
- The methods that depend on differences in specific gravity to obtain concentrated ore

  are as follows,
  - Panning,
  - Jigging,
  - Shaking,
  - Spiral separation and
  - Heavy-medium separation.

Specific gravity	
Highest- in rocks rich in iron, magnesium oxide and heavy metals.	*Lowest*- in those rich in alkalies, silica and water.

Weight

- Weight is a measurement of the gravitational force acting on an object.
- Weight is given by the formula (W = mg). where,
  - **m**->mass of the body,
  - **g**-> acceleration due to gravity
- Weight is expressed in Newton (N).
- Mass is an intrinsic property of the body and remains the same wherever the body might be.
- The weight of the body differs by place.
  - For example, objects weigh less on the moon where gravity is lower compared to the Earth.
- Mass is a universal constant. It **remains the same at earth surface or at any point** above the surface of earth.
- **Acceleration due to gravity decreases with altitude.** Since, greater altitude means greater distance from the Earth's centre.

- The following formula approximates the Earth's gravity formula variation with altitude:

$$g_r = g_o \left(\frac{re}{r_e + h} \right)^2$$

  - Where, gr =is the gravity measure at height above sea level.
  - re =is the Earth's mean radius.
  - go =is the standard gravity.

Earth is not a perfect sphere

- Earth is not a perfect sphere because its two poles cause it to bulge out in the middle.
- It spins on its axis and the **centrifugal force** makes the part at the equator bulge out slightly.

A four wheeler moving in a sharp circular path at high speed

- In the case of an object moving along a circular path two types of forces which may act upon namely,
  1. Centripetal,
  2. Centrifugal.
- As they have opposite impact, the object remains in balance.
- When centrifugal force gets disturbed, then the object will leave the balance and skid towards an outward direction.

Acceleration due to Gravity

- Gravity is the universal force of attraction that exists between all things or matter in the universe.
- It may be thought of as the driving force that holds everything together.
- Gravity is measured by the acceleration or movement it imparts on free falling objects.
- The acceleration of gravity at the Earth's surface is approximately 9.8 m/s2.
  - As a result, for every second an item is in free fall, its speed rises by approximately 9.8 m/s2.

Formula of Acceleration due to Gravity

- The force on any object is given by,
- F = mg Where,
    - F is the force acting,
    - g is the acceleration due to gravity,
    - m is the mass of the body.
- According to the universal law of gravitation,

$$F = GMm/(r+h)2$$

    - F, the force between two bodies,
    - G, the universal gravitational constant,
    - M, the mass of the object,
    - m, the mass of the earth,
    - r, the radius of the earth,
    - h, the height above the surface of the earth.
- Since the height is negligibly small compared to the radius of the earth, rearrange the above expression as, **F = GMm / r2**.
- Now equating both the expressions,

  mg = GMm / r2

  g = GM / r2

Density

- Density (volumetric mass density or specific mass) is the substance's mass per unit of volume.
- Mathematically, density is defined as mass divided by volume.

$$\rho = \frac{m}{V}$$

  Where, ρ is the density, m is the mass, and V is the volume.

Approximate mean velocity with which the earth moves round the sun in its Orbit?

- The answer is **30km/s.**

FOR FULL BOOK,

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