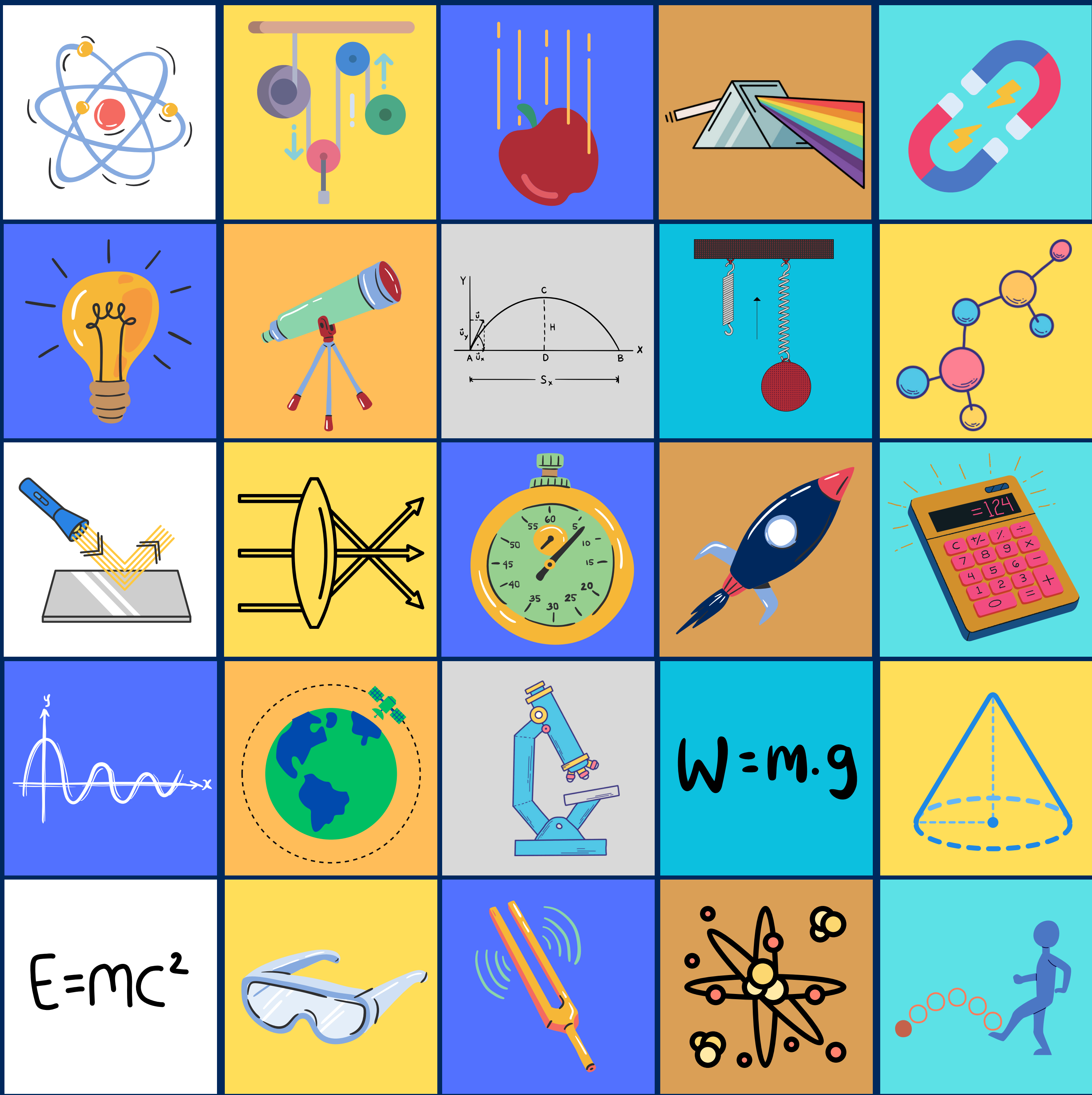


CLASS 9th NOTES

PHYSICS

GRAVITATION

PRASHANT KIRAD

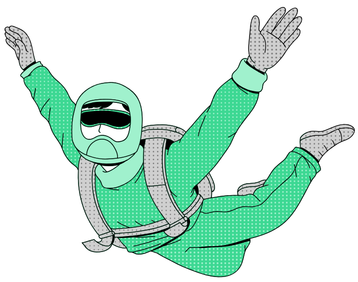
Gravitation

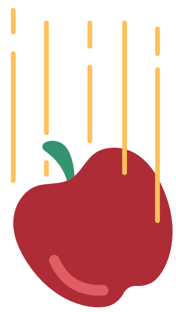
Gravitation

It is the force of attraction between any two bodies. All the objects in the universe attract each other with a certain amount of force, but in most cases, the force is too weak to be observed due to the very large distance of separation. Besides, gravity's range is infinite but the effect becomes weaker as objects move away.

Examples:

- The force that causes the ball to come down is known as gravity
- Gravity keeps the planets in orbit around the sun.
- Gravity is the force that causes a rock to roll downhill.





Newton's Universal Law of Gravitation

Newton's Law of gravitation states that every object in the universe attracts every other object by a force that is directly proportional to the product of their masses and inversely proportional to the square of the distance between them.

Let there are two objects of mass m_1 and m_2 and the distance between the objects is r, then according to law of universal attraction, the attraction between the objects

$F \propto m_1.m_2$

And $F \propto \frac{1}{r^2}$

Therefore, $F \propto \frac{m_1.m_2}{r^2}$

Or $F = G\frac{m_1.m_2}{r^2}$, Where G is constant whose value is 6.67×10^{-11}.

Relation between Newton's third law of motion and Newton's law of gravitation:

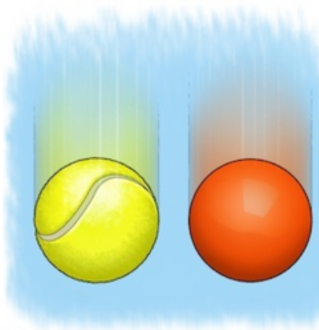
According to Newton's third law of motion, "***Every object exerts equal and opposite force on other object but in opposite direction."***

" According to Newton's law of gravitation, "Every mass in the universe attracts the every other mass."

In case of freely falling stone and earth, stone is attracted towards earth means earth attracts the stone but according to Newton's third law of motion, the stone should also attract the earth and really it is true that stone also attracts the earth with the same force F = m × a but due to very less mass of the stone, the acceleration (a) in its velocity is 9.8 m/s2 and acceleration (a) of earth towards stone is 1.65 × 10-24 m/s2 which is negligible and we cannot feel it.

Importance of universal law of Gravitation:

- The force that binds us to the earth.
- The motion of moon around the earth.
- The motion of earth around the sun.
- The tides due to moon in the sea.



Free Fall:

- When an object is thrown upward, it reaches certain height, then it starts falling down towards earth. It is because the earth's gravitational force exerts on it.
- This fall under the influence of earth is called ***'free fall of an object'.***
- ***During this free fall direction do not change but velocity continuously changes which is called acceleration due to gravity.***
- ***Its unit is same as acceleration m/s.***
- When an object is under free fall, acceleration due to gravity is constant at g = 9.8ms-2.
- Value of g does not depend on mass i.e. any object big or small experiences the same acceleration due to gravity under free fall. All three equations of motion are valid for freely falling objects as it is under uniform motion.
- The sign of convention → towards earth g is positive/ away from earth g is negative.

Gravitational Acceleration:

The acceleration produced in the motion of a body falling under the force of gravity is called acceleration due to gravity. It is denoted by 'g'.

The force (F) of gravitational attraction on a body of mass m due to earth of mass M and radius R is given by

$$F = G\frac{mM}{R^2} \qquad ...(1)$$

We know from Newton's second law of motion that the force is the product of mass and acceleration.

$$\therefore \quad F = ma$$

But the acceleration due to gravity is represented by the symbol g. Therefore, we can write

$$F = mg \qquad ...(2)$$

From the equation (1) and (2), we get

$$mg = G\frac{mM}{R^2} \quad \text{or} \quad g = \frac{GM}{R^2} \qquad ...(3)$$

When body is at a distance 'r' from centre of the earth then $g = \frac{GM}{r^2}$.

$G = 6.673 \times 10^{-11} Nm^2/kg^2$, $M = 6 \times 10^{24}$ kg, $R^2 = (6.37 \times 10^6)^2\ m^2$

Then,

$$g = \frac{6.67\times10^{-11}\times6\times10^{24}}{(6.4\times10^6)^2}$$

$$= \frac{40.02\times10^{13}}{40.96\times10^{12}}$$

$$= \frac{40.02}{40.96}\times10 = 0.977\times10$$

$$\therefore\ \mathbf{g = 9.77\ m/s^2}$$

Relationship and difference between 'G' and 'g' :

G = Gravitational constant

g = Acceleration due to gravity

$$g = \frac{GM}{r^2}$$

Difference between G and g :

	Acceleration due to gravity (g)		Universal Gravitational Constant (G)
1.	The Acceleration produced on a freely falling body due to gravitational force is known as Acceleration due to gravity.	1.	The force of attraction between any two objects of unit masses separated by unit distance in the universe is known as Universal Gravitational Constant.
2	It is denoted by g	2.	It is denoted by G
3.	It changes from place to place	3.	Its value is constant everywhere in the universe.
4.	Its units are m/sec^2	4.	Its units are Nm^2/kg^2

Equation of motion when an object is falling freely towards earth or thrown vertically upwards :

- There are three equations of motion.
- For free-falling bodies when falling with uniform accelerated motion, these equations of motion under uniform acceleration can be applied to the motion of freely falling bodies.
- For a falling object, the acceleration due to gravity is 'g', so 'a' is replaced with 'g' while the distance 's' of the freely falling bodies is replaced by the height 'h' of the freely falling bodies.

(a) The first equation of motion, $v = u + at$

becomes $\boxed{v = u + gt}$

v = final velocity
u = initial velocity
g = acceleration due to gravity
t = time taken by the body

(b) The second equation of motion, $s = ut + \frac{1}{2}at^2$

becomes $\boxed{h = ut + \frac{1}{2}gt^2}$

h = distance travelled by the body
t = time taken
u = initial velocity
g = acceleration due to gravity

(c)the third equation of motion, $v^2 = u^2 + 2as$

becomes $\boxed{v^2 = u^2 + 2gh}$

v = final velocity
u = initial velocity
g = acceleration due to gravity
h = distance travelled by the body

Mass:

- It can be defined as the measure of the amount of matter in a body.
- The SI unit of mass is Kilogram (kg).
- The mass of a body does not change at any time.

Weight:

- It is the measure of the force of gravity acting on a body.
- The formula for weight is given by:

$$W = mg \qquad g = 9.8 \text{ N/kg}$$

- As weight is a force its SI unit is also the same as that of force, SI unit of weight is Newton (N).
- It depends on mass and the acceleration due to gravity, the mass may not change but the acceleration due to gravity does change from place to place.
- The weight of an object on the Moon is 1/6 times the weight on Earth.

Difference between Mass and Weight:

Sl. No.	Mass	Weight
1.	The mass is a scalar quantity.	The weight is a vector quantity.
2.	Mass of a rigid body is regular everywhere in the universe.	The weight of a rigid body alters from place to place and inclines zero at the center of the earth.
3.	Mass can be resulted by a traditional balance.	Weight can be defined as spring balance
4.	The unit of mass is kg or g.	The unit of weight is Newton.
5.	Mass can never be zero.	Weight can be zero based on the gravity acting upon it.
6.	Mass does not change based on location.	Weight changes based on location, depending on the gravity it experiences.
7.	Mass is measured using an ordinary weighing scale.	Weight is measured using spring balance.

Factors affecting value of *g*

Earth is not a perfect sphere. The radius of earth increases when we go from pole to equator. Therefore, in most of the calculation, we can take g as constant at the surface of earth or closer to it. But, as we move away from earth, we can use equation $g = \frac{GM}{d^2}$ for solving problems.

Thrust and Pressure

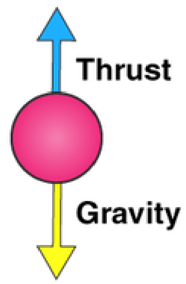
Thrust: Force acting on an object perpendicular to the surface is called thrust. The effect of thrust depends on the area of contact.

Pressure: Pressure is defined as the force per unit area. If a force F is applied on a surface of area A, then the pressure P is defined as:

$$Pressure = \frac{Force}{Area} \text{ or } P = \frac{F}{A}$$

Unit of Pressure : ***N/m² or Pascal (Pa).***

Buoyancy: The buoyant force is the upward force exerted on an object wholly or partly immersed in a fluid. This upward force is also called Upthrust. Due to the buoyant force, a body submerged partially or fully in a fluid appears to lose its weight, i.e. appears to be lighter



The following factors affect buoyant force:

- the density of the fluid
- the volume of the fluid displaced
- the local acceleration due to gravity

Density: The mass per unit volume is called density of an object. If M is the mass and V is the volume, then density (d) is:

$$\text{Density } (d) = \frac{\text{Mass (M)}}{\text{Volume (V)}}$$

SI unit $= kg/m^3$

Archimedes' Principle: ***"The upward buoyant force that is exerted on a body immersed in a fluid, whether partially or fully submerged, is equal to the weight of the fluid that the body displaces and acts in the upward direction at the center of mass of the displaced fluid".***

Applications of Archimedes' principle:

- ***Submarine***
- ***Hot-air balloon***
- ***Hydrometer***

Relative density:

The ratio of the density of a substance to that of the density of water is called relative density.

$$\text{Relative density} = \frac{\text{Density of a substance}}{\text{Density of water}}$$

It has no unit.

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