II YEAR

SPORTS SCIENCE

UG DEPARTMENT OF PHYSICS

KARTHIK G

Unit: 1

Measurement: Physical quantities. Standards and Units. International system of Units. Standards of time, length and mass. Precision and significant figures.

Newton's laws of motion: Newton's first law. Force, mass. Newton's second law. Newton's third law. Mass and weight. Applications of Newton's laws.

Projectile motion: Shooting a falling target. Physics behind Shooting, Javelin throw and Discus throw.

Unit: 2

Conservation laws: Conservation of linear momentum, collisions – elastic and inelastic. Angular momentum. (Physics behind Carom, Billiards, Racing)

Centre of mass: Physics behind Cycling, rock climbing, Skating,

Gravitation: Origin, Newton's law of gravitation. Archimedes's principle, Buoyancy (Physics behind swimming)

Unit: 3

Food and Nutrition: Proteins, Vitamins, Fat, Blood pressure. Problems due to the deficiency of vitamins.

Energy: Different forms of Energy, Conservation of mass-energy.

Physical exercises: Walking, Jogging and Running, Weight management.

Unit: 1

INTRODUCTION:

Physics is quantitative science based on measurement of physical quantities. Understanding of different physical phenomena requires the need to measure relevant physical quantities. Physical quantities are those which can be defined and measured. Without measurement there can be no advancement in physics. Experimental measurements are essential to verify theoretical laws. We use number of physical quantities (in daily life) like length, time, area, volume etc., to describe an event or a phenomenon. For measuring a physical quantity, a standard reference is necessary. This reference is known as ‘unit’.

SYSTEM OF UNITS (CGS & SI)

The International System of units based on seven base units is at present internationally accepted unit system and is widely used throughout the world. In computing any physical quantity the units for derived quantities involved in the relationships are treated as though they were algebraic quantities till the desired units are obtained

1. **CGS System** In this system, the unit of length is **Centimeter**, the unit of mass is **Gram** and the unit of time is **Second**.
2. **FPS System** In this system, the unit of length is **Foot**, the unit of mass is **Pound** and the unit of time is **Second**.
3. **MKS System** In this system, the unit of length is **Meter**, the unit of mass is **Kilogram** and the unit of time is **Second**.
4. **SI System** This system contain seven fundamental units and two supplementary fundamental units. The SI units are used in all physical measurements, for both the base quantities and the derived quantities obtained from them. Certain derived units are expressed by means of SI units of special names such as joule, Newton, watt etc.

PHYSICAL QUANTITIES

"All quantities in terms of which laws of physics can be expressed and which can be measured directly or indirectly are called physical quantities"

Physical quantities can be classified into two types

a. Fundamental Physical Quantities
b. Derived Physical Quantities

a). Fundamental Physical Quantities:

The physical quantities which are independent of any other qunatities are called fundamental physical quantities.

Sl .No	Physical Quantities	SI Unit
1.	Mass	Killogram
2.	Length	Meter
3.	Time	Second
4.	Electric current	Ampere
5.	Thermodynamic Temperature	Kelvin
6.	Amount of substance	Mole
7.	Luminous intensity	Candela

Note: **Suplimentary Physical Quantities**

i).	Plane angle	Radian
ii).	Solid angle	Steradian

b). **Derived Physical uantities**

1.	Area	Square meter
2.	Volume	Cubic meter
3.	Speed	Meter/Second
4.	Velocity etc.	Meter/Second

STANDARDS OF TIME

To measure any time interval we need a clock. We now use an atomic standard of time, which is based on the periodic vibrations produced in a cesium atom. This is the basis of the cesium clock, sometimes called atomic clock. The cesium atomic clocks are very accurate. In principle they provide portable standard. The national standard of time interval ‘second’ as well as the frequency is maintained through four cesium atomic clocks. A cesium atomic clock is used at the National Physical laboratory (NPL), New Delhi to maintain the Indian standard of time.

STANDARDS OF LENGTH

We are familiar with some direct methods for the measurement of length. For example, a metre scale is used for lengths from 10^{-3} m to $10^{2m.}$. A vernier callipers is used for lengths to an accurecy of 10^{-4} m. A screw gauge and a spherometer can be used to measure lengths as less as 10^{-5} m.

STANDARDS OF MASS

Mass is a basic property of matter. It does not depend on the temperature, pressure or location of the object in space. The SI unit of mass is kilogram (kg).

The kilogram is an inconvenient unit in dealing with atoms molecules. In this case, there is a standard unit of mass, called the unified atomic mass unit (u), which has been established for expressing the mass of atoms as

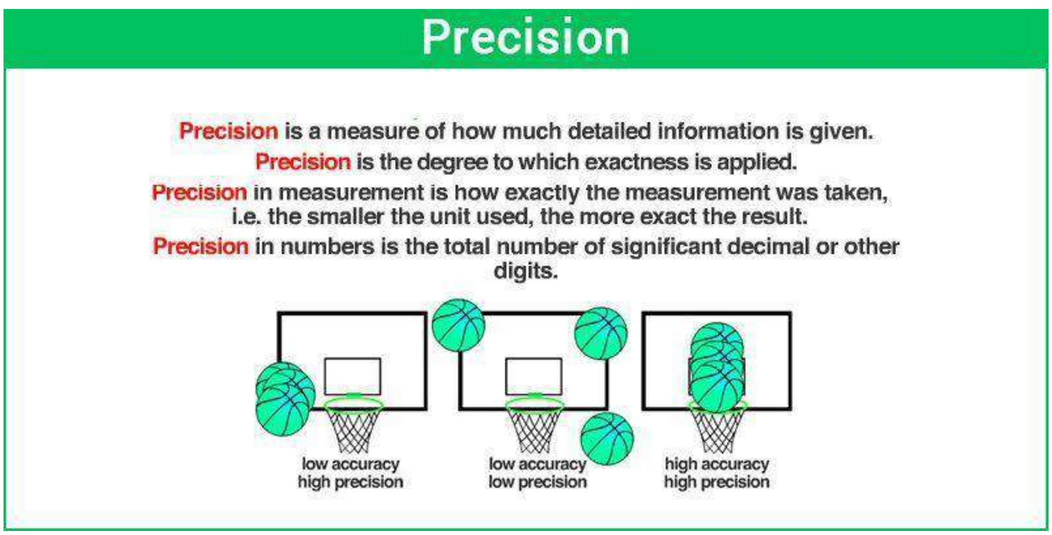
1 united atomic mass unit is (1/12) of the mass of an atom of carbon – 12 isotope $^{12}_{6}C$ including the mass of electrons 1u = 1.6X10^{-27} kg

Mass of commonly available objects can be determined by common balance. Large masses are determined by gravitational methods, while small masses are measured by mass spectroscopes, which work on the principle of motion of charged particles in electric and magnetic fields.

PRECISION AND SIGNIFICANT FIGURES

Precision

If you weigh an object five times and you get 3.2 kg every time, then your measurement is very precise. Precision refers to a value in decimal numbers after the whole number, and it does not relate to accuracy. The concepts of accuracy and precision are almost related, and it is easy to get confused.



Precision is a number that shows an amount of the information digits and it expresses the value of the number.

For Example- The appropriate value of pi is 3.14 and its accurate approximation. But the precision digit is 3.199 which is less than the exact digit. It has numerous forms in statistics, arithmetic, precision etc.

Difference between Precision and Accuracy

Basis	Accuracy	Precision
Definition	It could be defined as the level of correctness of a measurement to its true value.	It could be defined as the sharp exactness of a measurement.
Measurement Method	Has one factor used for measuring.	Has multiple factors for measurement.
Mutual Relationship	Accurate items have to be precise in most cases.	Precise items may or may not be accurate.

For instance:

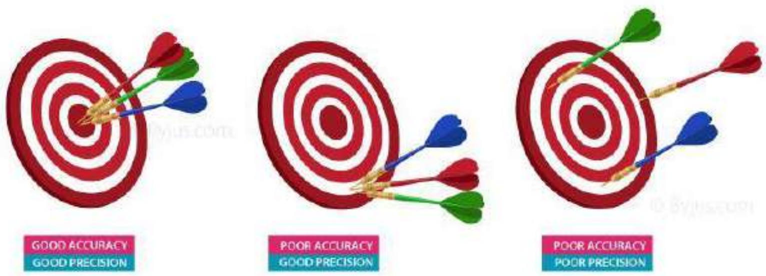
- A number that is not precise but accurate.
- A number that is not accurate but precise.
- A number that is precise and accurate.

Precision is the amount of information that is conveyed by a value. Where as **Accuracy** is the measure of correctness of the value in correlation with the information.

Let's consider the value of "pi", i.e, 3.142857143.

According to the questions:

- A number that is not precise but accurate is 3.14. It is accurate based on closeness and no other number with three digits can get closer to the target.
- A number that is not accurate but precise is 1.1423345678901234567890. It is very precise as it conveys more information. But cannot be considered accurate because it's not near the target.
- A number that is precise and accurate is 3.142857143. It is the only number which has maximum accuracy and precision if the target value is 3.142857143.



The above figure shows a dart game having three images,

(i) The first one shows Good accuracy and good precision, as all the three darts are close to the maximum score region (accurate) and also all the darts are close to each other (precise).

(ii) The second figure shows Poor accuracy but good precision, as all the three darts are close enough but far away from the maximum score region.

(iii) The third figure shows Poor accuracy and poor precision, as all the darts are neither nearby nor to the maximum score region.

Significant figures

Significant figures are used to establish the number which is presented in the form of digits. These digits carry a meaningful representation of numbers. The term significant digits are also used often instead of figures. We can identify the number of significant digits by counting all the values starting from the 1st non-zero digit located on the left. **For example,** 12.45 has four significant digits.

Definition

The significant figures of a given number are those significant or important digits, which convey the meaning according to its accuracy. For example, 6.658 has four significant digits. These substantial figures provide precision to the numbers. They are also termed as significant digits.

Rules for Significant Figures

- All non-zero digits are significant. 198745 contains six significant digits.
- All zeros that occur between any two non zero digits are significant. For example, 108.0097 contains seven significant digits.
- All zeros that are on the right of a decimal point and also to the left of a non-zero digit is never significant. For example, 0.00798 contained three significant digits.
- All zeros that are on the right of a decimal point are significant, only if, a non-zero digit does not follow them. For example, 20.00 contains four significant digits.
- All the zeros that are on the right of the last non-zero digit, after the decimal point, are significant. For example, 0.0079800 contains five significant digits.
- All the zeros that are on the right of the last non-zero digit are significant if they come from a measurement. For example, 1090 m contains four significant digits.

Rounding Significant Figures

A number is rounded off to the required number of significant digits by leaving one or more digits from the right. When the first digit in left is less than 5, the last digit held should remain constant. When the first digit is greater than 5, the last digit is rounded up. When the digit left is exactly 5, the number held is rounded up or down to receive an even number. When more than one digit is left, rounding off should be done as a whole instead of one digit at a time.

There are two rules to round off the significant numbers:

1. First, we have to check, up to which digit the rounding off should be performed. If the number after the rounding off digit is less than 5, then we have to exclude all the numbers present on the right side.
2. But if the digit next to the rounding off digit is greater than 5, then we have to add 1 to the rounding off digit and exclude the other numbers on the right side.

Significant Figures Examples

Q.1: Identify the number of significant digits/figures in the following given numbers.
45, 0.046, 7.4220, 5002, 3800

Solution:

Number	Number of Significant digits/figures
45	Two
0.046	Two
7.4220	Five
5002	Four
3800	Two

Q.2: Write 12.378162 correct to 4 significant digits.

Solution:

The number 12.378162, rounded to 4 significant digits is 12.38 Hence, 12.38 is the answer.

NEWTON'S LAWS OF MOTION

Sir Isaac Newton worked in many areas of mathematics and physics. He developed the theories of gravitation in 1666 when he was only 23 years old. In 1686, he presented his three laws of motion in the "Principia Mathematica Philosophiae Naturalis."

By developing his three laws of motion, Newton revolutionized science. Newton's laws together with Kepler's Laws explained why planets move in elliptical orbits rather than in circles.

NEWTON'S FIRST LAW OF MOTION

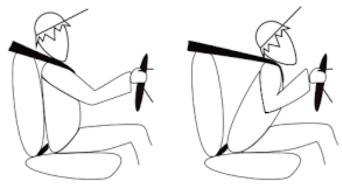
A body will remain at rest or continue to move with uniform velocity unless an external force is applied to it.

First law of motion is also referred to as the 'Law of inertia'. It defines inertia, force and inertial frame of reference.

Applications in our Daily life

1. Brakes applied by a Bus Driver Abruptly

While travelling on a bus, when the bus driver abruptly applies the breaks, we tend to feel a momentary pull in the forward direction. The reason behind this jerk felt by the passengers sitting inside the bus is the law of inertia. Due to the inertia of motion, our body continues to maintain a state of motion even after the bus stops, thereby pushing us in the forward direction.



2. An Object Placed on a Plane Surface

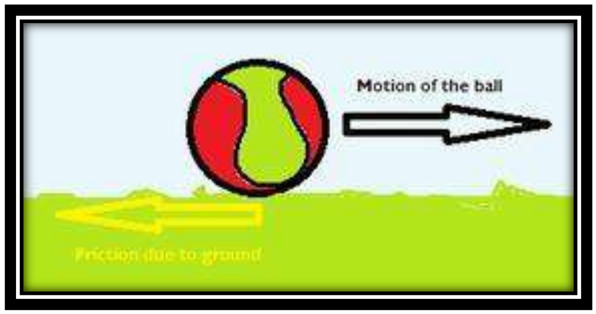
One of the finest examples of Newton's first law of motion is an object that is simply placed on the surface of the earth. The natural tendency of the object is to maintain its state of rest until a force acts on it. For instance, a book kept on a bookshelf does not change its shape, size, or position until acted upon by an external force.

3. Marathoner Running beyond Finish Line

A marathon runner is not able to stop himself right after crossing the finish line. He/She tends to take time and cover a few meters of distance running beyond the finish line. This is because the inertia of motion or Newton's first law of motion resists a sudden termination of motion and compels the body to maintain its state of motion.

4. A Ball Rolling on the Ground

As per Newton’s first law of motion, a ball rolling on the ground tends to maintain its state of motion till infinity, if no external force acts on it; however, the force of friction acting on the ball from the outside helps to break the motion of the ball and brings it to rest.

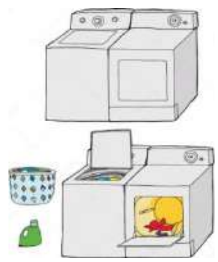


5. An Object Thrown in Outer Space

If an object is thrown in outer space, it tends to move in a direction to infinity. This is because outer space lacks environment, air, and the force of gravity. Hence, the object does not receive any resistance to the motion; therefore, it continues to exhibit motion until it hits a celestial body, strikes a meteorite, or enters the gravitational field of a planet, thereby demonstrating the first law of motion in real life.

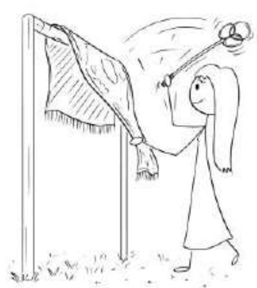
6. Washing Machine Dryer

A washing machine dryer entirely works upon the principle of the law of inertia. To dry the clothes, the drum of the washing machine dryer is subjected to motion, which further causes the clothes to move; however, the water molecules contained in the cloth do not follow the motion and stay at their position of rest. Due to the gravitational pull of the earth, the water gets collected at the base of the drum. The holes of the drum let the water out, leaving the clothes dry.



7. Dusting a Carpet

To remove the dust particles from a carpet, it is hanged on a wire and a piece of the stick is used to hit the carpet repeatedly. This induces motion in the carpet, whereas the dust particles continue to maintain their state of rest. When the carpet moves back, the dust particles get carried away with air or fall to the ground due to gravity, thereby demonstrating the law of inertia.



8. Shaking a Tree

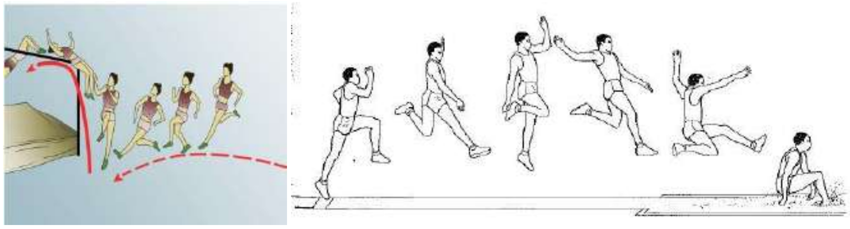
When the branch of a tree is vigorously shaken with the help of an external force, it comes to motion; however, the leaves attached to the branch do not comprehend the motion and tend to maintain their state of rest. The motion of the branch of the tree and the inertia of rest exhibited by the leaves cause the shedding of leaves.

9. The Jerk when a Vehicle Starts

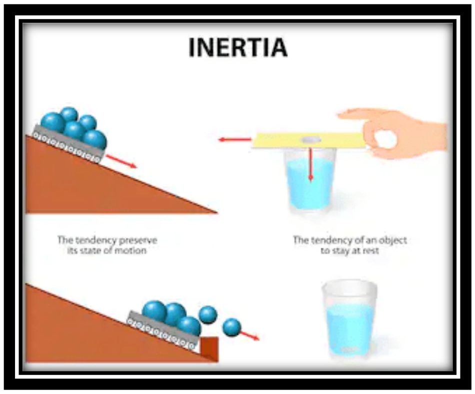
When a vehicle starts suddenly, a jerk is felt by the passengers and the drivers sitting inside the vehicle that pulls them backwards. This is because the car comes in motion, but the body continues to sustain its state of rest, thereby leading to a sudden and momentary change in the state known as a jerk.

10. Athlete taking a Short Run before Long/High Jump

An athlete takes a short distance run before a long jump or a high jump. This is because by running a short distance, the player prepares his body and sustains motion in it. This helps him to exhibit a smooth jump. A similar demonstration of the inertia of motion can be observed when a bowler takes a small run before throwing a ball.



LAW OF INERTIA (Explanation):



A block of stone that is hardly be pushed along the ground while a small wooden block can easily be pushed along the ground. The mass of the stone or wooden block is the mass of inertia.

Fore example:

A person riding a bicycle along a leveled road if stops pedaling does not come to rest immediately. The bicycle continues to move forward due to inertia. A small coin is put on a card and placed over the mouth of a glass. When the card is flicked away with the finger horizontally, the coin drops neatly into the glass due to inertia.

NEWTON'S SECOND LAW OF MOTION

When an external force is applied to a body of constant mass the force produces acceleration, which is directly proportional to the force and inversely proportional to the mass of the body.

$$F = ma$$

Where,

F = net force acting on an object

m = mass of the body

a = acceleration due to gravity

Applications in our Daily life

1. **Try to move an object**

   Like stopping a moving ball rolling on the ground.

2. **Pushing a car and a truck**

Newton's second law of motion can be observed by comparing the acceleration produced in a car and a truck after applying an equal magnitude of force to both. It is easy to notice that after pushing a car and a truck with the same intensity, the car accelerates more than the truck. This is because the mass of the car is less than the mass of the truck.

3. **Racing Cars**

Reducing the weight of racing cars to increase their speed, engineers try to keep vehicle mass as low as possible, as lower mass means more acceleration, and the higher the acceleration the greater the chances of winning the race.

4. **Rocket launch**

For a rocket to leave the earth's orbit and enter outer space, a force called thrust is required. As per the second law of motion given by Sir Issac Newton, the force is proportional to the acceleration; therefore, to launch a rocket, the magnitude of thrust is increased, which in turn increases the acceleration. The speed achieved by the rocket finally helps it to escape the earth's gravitational field and enter space.

5. Kick the ball

When we kick the ball we exert force in a specific direction, which is the direction the ball will move. In addition, the more forcefully the ball is kicked, the more force we apply to it and the further away the ball is.

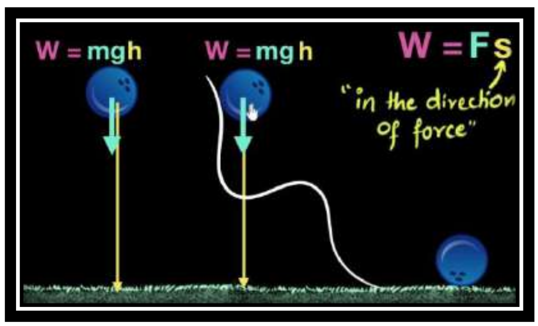
6. Car crash

During a car crash, there exists a force between the obstacle and the car, which is known as the impact force. The magnitude of the impact force depends on the mass of the objects involved in the collision and the speed with which the objects move. This means that the greater the mass of the objects involved in the collision, the more will be the intensity of the impact force. Similarly, the more the acceleration with which the car moves, the greater will be the magnitude of the impact force.

7. Two people walking

When the two walking people, if one is heavier than the other, the one who weighs the heaviest walks slower because the acceleration of the one who weighs the lighter is more.

8. Object thrown from a height



When an object is thrown from a certain height, the gravitational pull of the earth helps it to develop acceleration. The acceleration increases as the object advanced towards the earth. According to Newton's second law of motion, the acceleration developed by a body is directly proportional to the force. When the object hits the ground, the impact force comes into action. This is the reason why a brittle object thrown from a tall building suffers more deformity than the situation where the same object is thrown from a comparatively shorter building.

9. Karate player breaking slab of bricks

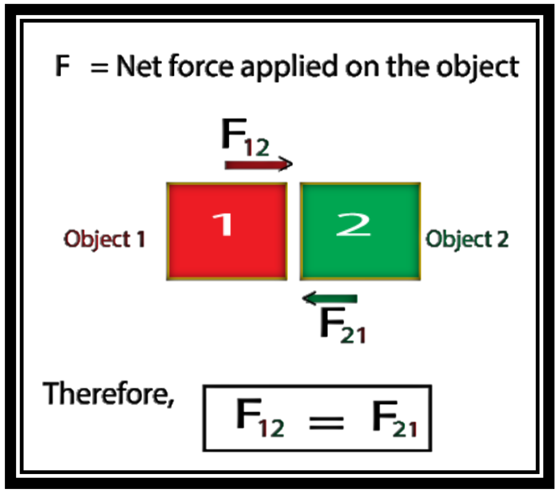
A karate player makes use of the second law of motion to perform the task of breaking a slab of bricks. Since, according to law, the force is proportional to the acceleration, the player tends to move his/her hands over the slab of bricks swiftly. This helps him/her to gain acceleration and produce a proportionate amount of force. The force is sufficient enough to break the bricks.

10. Driving a car

In simple terms, Newton's second law of motion states that if force is applied to any object that has mass, it will result in the production of an equivalent amount of acceleration in the object. For instance, when we turn on the ignition system of the car, the engine of the car produces sufficient force that enables the car to move with proportionate acceleration.

NEWTON’S THIRD LAW OF MOTION

For every reaction there is an equal and opposite reaction



Body 1 affects by a force F1 on body2 which effects by a force F2 on body 1

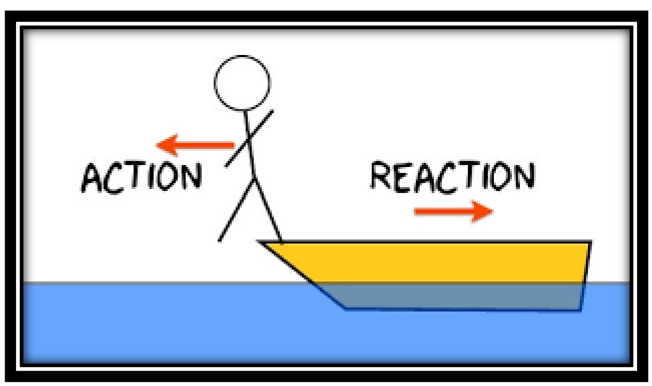
$$\mathbf{T = W = m\,g}$$

Where,

T=W= Weight of an object

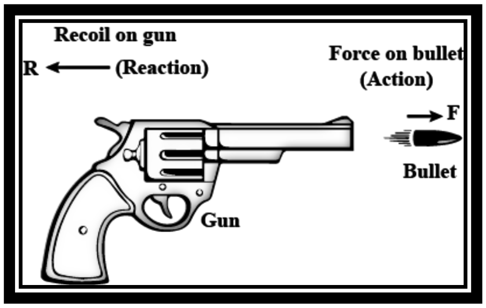
m = mass of the body

a = acceleration due to gravity



Applications in our Daily life

1. **Recoil of a Gun**



The recoil of a gun is one of the best demonstrations of action-reaction forces. When a bullet is fired from a gun, the gun moves backward. The action force exerted due to firing is in a forwarding direction that causes the bullet to move ahead. The jerk felt on the gun that pulls it in the backward direction exists due to the reaction force. This is the reason why a person operating a gun takes the support of his shoulder to avoid injury.

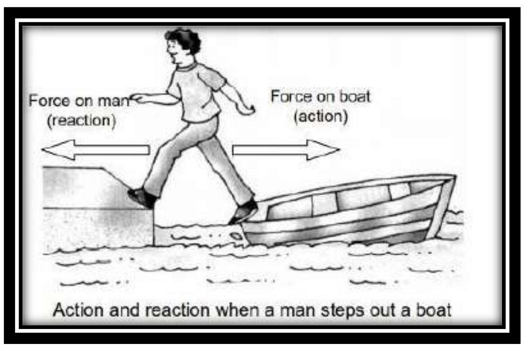
2. **Swimming**

A person swimming in a forward direction pushes the water in the backward direction with his/her hands. This force applied by the person acts as the action force, which leads to the generation of a reaction force. This pair of forces, acting together simultaneously on the person's body and the water, causes the person to swim in the forward direction.

3. **Pushing the Wall**

When a person sitting on a chair pushes the wall with his feet, the chair moves backward. The motion of the chair cannot exist without the existence of a force. Therefore, the force responsible to move the chair is the reaction force. The reaction force is always exerted in the direction opposite to the direction of the action force. Hence, the chair moves in a backward direction.

4. **Diving off a Raft**



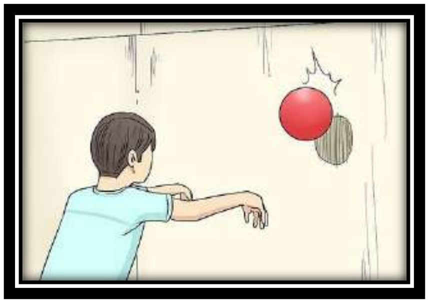
Action and reaction when a man steps out a boat

When a person jumps out of a boat and steps on the bank, the boat moves back in the direction opposite to the direction of the jump. The force applied by the person on the rigid surface of the ground is the action force. In contrast to the action force, a reaction force gets generated that pushes the boat and causes it to move.

5. **Space Shuttle**

When a rocket is ignited, a series of chemical reactions take place that generate a huge amount of gases. These gases when hit the ground cause a force that helps the rocket to move upward. A similar process occurs in the jet engine. The only difference is that the rocket is required to carry an oxidizing agent because it has to enter an environment that does not contain oxygen.

6. **Throwing a Ball**



When a ball is thrown on the floor or a wall, it bounces back. The force exerted by the ball on the ground or wall is the action force. The force that the ground or wall exerts on the ball in response to the action force causes the ball to jump or bounce back. This force is nothing but the reaction force.

7. **Walking**

When we walk, a significant amount of force and pressure is exerted on the ground by our feet. The ground in response exerts an equal amount of force in the opposite direction. In absence of the reaction force produced by the ground, our foot sinks. Similarly, if the action force supplied by the foot of the person is significantly higher, the reaction force can help us to jump. Hence, walking is possible because a pair of action-reaction forces act on the feet and the ground.

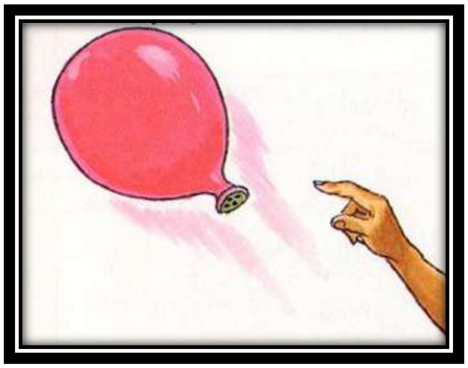
8. **Hammering a Nail**

While hammering a nail in the wall, a force is felt on the person's hand who is holding the hammer. It gets developed as a result of the force applied by the person on the nail. Both the forces are directly proportional to each other, which means with an increase in the action force, the reaction force increases.

9. Jumping

A person jumping on a hard floor gets hurt more severely than a soft surface. This is because the weight of the person causes an action on the surface. The surface, in turn, generates a reaction force that acts in the opposite direction. The hard surface does not absorb any force and generates the same amount of force in response. On the other hand, the soft surface that is elastic in nature absorbs a significant portion of the action force and therefore, generates less reaction force.

10. Evacuating a Balloon



A balloon filled with air when released with its end untied lets out air with force. With the help of the action force that is caused due to the air rushing out of the balloon, a reaction force gets developed that causes the balloon to move upward.

PROJECTILE MOTION

Projectile motion is **the motion of an object thrown or projected into the air, subject to only the acceleration of gravity**. The object is called a projectile, and its path is called its trajectory

The three types of Projectile Motion are:

- Oblique projectile motion.
- Horizontal projectile motion.
- Projectile motion on an inclined plane

Oblique projectile motion

Oblique projectile is a projectile thrown with the velocity v at an angle with horizontal. Velocity v is resolved into its two rectangular components. The force of gravity in horizontal direction is zero. If you throw a ball parallel to the ground then it is said to be an oblique projectile.

Horizontal projectile motion

When any object is thrown from horizontal at an angle θ except 90°, then the path followed by it is called trajectory, the object is called projectile and its motion is called projectile motion.

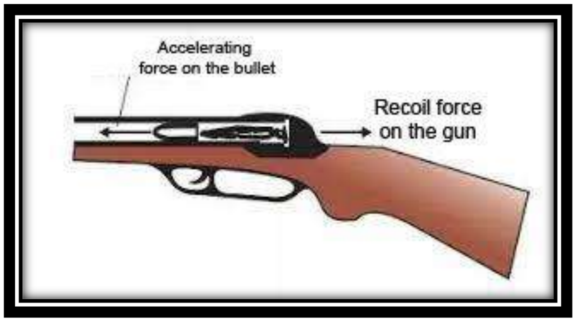
Projectile motion on an inclined plane

An inclined projectile motion is when the fired projectile lands on an inclined plane where its inclination angle is between 0 and 90 degrees. Therefore this angle of inclination makes the equations of the projectile motion.

Examples in Real Life

- Throwing a Basketball in the Basket.
- Javelin Throw.
- Archery.
- Water Escaping a Hose.
- Car and Bike Stunts.
- Golf Ball.

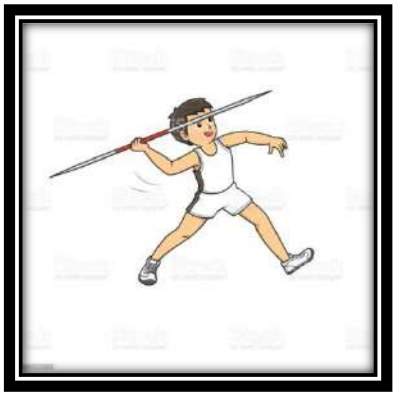
PHYSICS BEHIND SHOOTING



Recoil of a Gun: When the bullet is fired from the gun, it gives a large velocity to the bullet in the forward direction. Since no external force acts on the system, so the momentum of the system (gun + bullet) must be zero after firing. Thus, gun moves backwards with a momentum equal to the momentum of the bullet. Since the mass of the gun is much greater than the mass of the bullet therefore, the velocity of recede of the gun is much less than the velocity of the bullet. That is why gun recoils or moves backwards.

PHYSICS BEHIND JAVELIN THROW

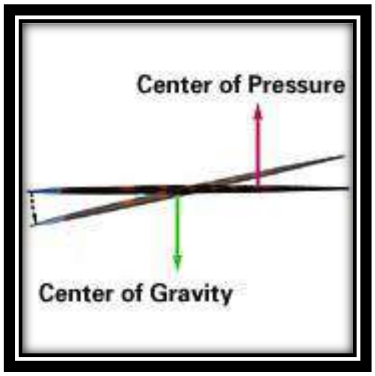
Throwing a javelin involves strength, speed and technique. If a thrower is deficient in one of these aspects, she can still be competitive. However, to be an elite javelin thrower, an athlete must be strong and quick, and have tremendous technique and knowledge on how a javelin flies.



History of Javelin

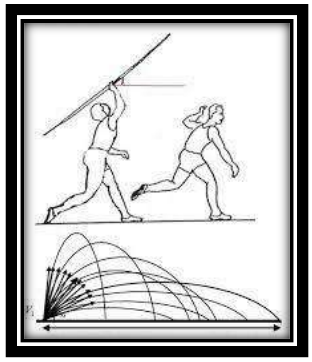
Javelin throwing has been around since the Ancient Games. It was not until 1780 that it was strictly thrown for distance in the Olympics. In 1986, the javelin that was used in Olympic competition was modified, forcing Olympic throwers to change the angle of their release.

Center of Gravity and Pressure



The two most important factors involving the physics of throwing a javelin are the center of gravity and center of pressure. The center of gravity is near the grip and does not change during throw. "Throwing through the tip," a popular term of how to throw a javelin, means throwing through the grip or center of gravity. The center of pressure is the aerodynamic force of drag and lift on the javelin. The change in 1986 made javelins much easier to throw and much easier to measure because the center of pressure was moved back behind the center of gravity of the javelin.

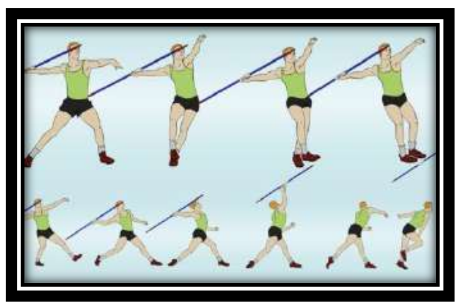
Attack Angle



The maximum throw at the angle 45^0

Throwing at the optimal attack angle is throwing the javelin at the angle at which the air flows most efficiently around the javelin. To produce maximum distance, the javelin must be thrown at the attack angle to minimize drag and maximize lift and speed. The attack angle for throwing in a head wind is slightly more down causing less lift than when a javelin is thrown into a tail wind.

Throwing Angle



No absolute angle will guarantee the farthest distance on each throw. Wind speed and direction change the optimal angle of release significantly. Also, the strength and speed at which the thrower can produce changes the direction at which the javelin should be thrown. Before the 1986 change in javelins, some of the best throwers in the world would throw the javelin with as little as a 30-degree angle but at greater speed because they were able to hold onto the javelin longer, producing more force. Elite throwers now still use this method; however, the most common method is releasing the javelin at about a 40-degree angle, causing more lift and flight to the javelin.

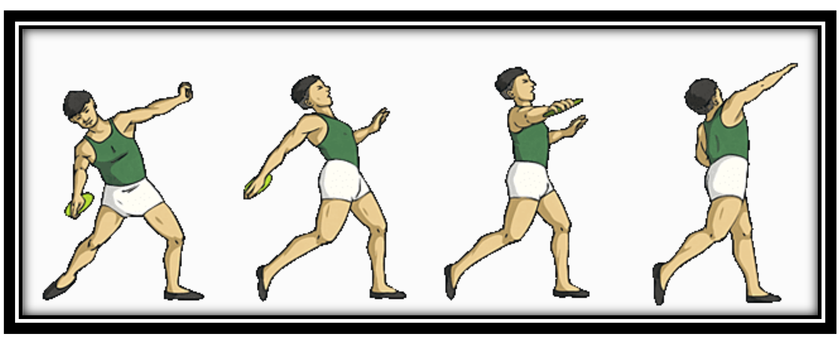
PHYSICS BEHIND DISCUS THROW

The shape of a discus resembles the airfoil of an airplane wing, which gains greater lift as wind speed increases, according to aerodynamic engineers. As a result, you can throw a discus farther against the wind than with it, according to a 2000 report by the University of California Davis. Computer simulations and test flights also show that the gyroscopic spin of a discus, atmospheric conditions and altitude affect discus flight in various ways.

Atmospheric Factors

Aircraft gain greater lift in cold air because its slower-moving molecules are closer together than warm air, making it denser. Cold air gives any aerodynamically shaped object, such as a discus, more support to stay aloft. Research at the University of Texas Institute for Geophysics reported in the "American Journal of Physics" that a discus travels about 5 inches farther on a cold winter day at 32 degrees than on a hot summer day at 104 degrees. Air is also denser at sea level than high altitudes. A discus travels 7.5 inches farther in Rome, Italy, 120 feet above sea level, than in Mexico City, 7,300 feet above sea level.

Gyroscopic Action

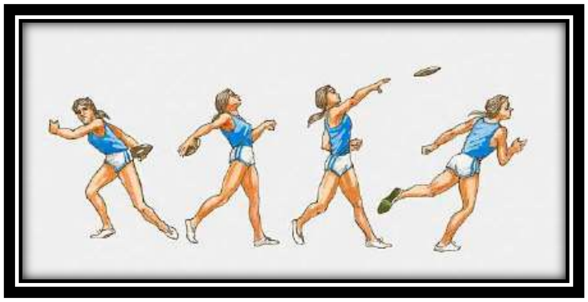


A discus spins as it leaves an athlete's hand. This gyroscopic, spinning motion stabilizes the discus in flight. The faster it spins, the greater its angular momentum and the more its gyroscopic action resist tilting or changing its spin axis. The cross-section of a discus is wing-like, so spin holds its aerodynamic shape pointed into the wind. This maintains lift and prolongs flight time.

Headwinds

Baseball pitchers and football quarterbacks know their throws will lose speed when they throw into oncoming winds. However, a discus thrower combines the physics of aerodynamic lift and gyroscopic stability with a headwind to gain an advantage. The Texas researchers documented that a discus thrown into a 20-mph headwind can fly up to 25 feet farther than a discus thrown with that wind.

Body Spin



The characteristic spinning windup and delivery of a discus thrower creates great speed at release. While a baseball pitcher has, at most, only a 180-degree arc through which to accelerate the ball before release, the discus thrower has two full spins. In addition, as also practiced by figure skaters, drawing the arms inward while spinning preserves angular momentum by increasing spin velocity. Careful timing increases acceleration just before re-extending for release. The best discus throw combines physical strength with complex physics.