***Manonmaniam Sundaranar University,***

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***Tirunelveli - 627 012 Tamilnadu, India***

***OPEN AND DISTANCE LEARNING (ODL) PROGRAMMES***

*(FOR THOSE WHO JOINED THE PROGRAMMES FROM THE ACADEMIC YEAR 2023–2024)*

# *B.Sc. Physics*

# *Course Material*

# *PHYSICS FOR EVERYDAY LIFE*

# *JSPH11*

***Prepared***

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# B.Sc. Physics I Year

## JSPH11 – PHYSICS FOR EVERYDAY LIFE

## Syllabus

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| V | **INDIAN PHYSICIST AND THEIR CONTRIBUTIONS:** C.V.Raman, Homi Jehangir Bhabha, Vikram Sarabhai, Subrahmanyan Chandrasekhar, Venkatraman Ramakrishnan, Dr. APJ Abdul Kalam and their contribution to science and technology. |
| **Recommended Text** | |
| 1 | The Physics in our Daily Lives, Umme Ammara, Gugucool Publishing, Hyderabad, 2019. |
| 2 | For the love of physics, Walter Lawin, Free Press, New York, 2011. |

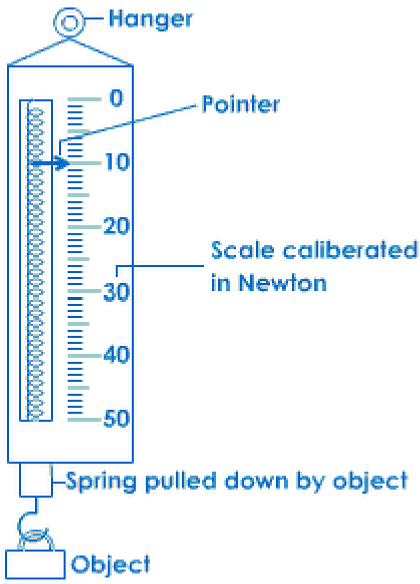
# UNIT I

# MECHANICAL OBJECTS

## SPRING SCALES

Spring scales, also known as mechanical spring balances, are devices used to measure the weight of an object. They work based on Hooke's Law, which states that the force needed to extend or compress a spring is directly proportional to the displacement of the spring from its equilibrium position.

**Construction:**




**Spring**: The most crucial component of a spring scale is the spring itself. It is typically made of a flexible material, like steel or other metals, which allows it to deform when subjected to an applied force. The spring is often coiled to increase its elasticity and sensitivity.

**Hook**: At the top end of the spring, there is a small hook or loop where you can attach the object whose weight you want to measure. This is where the force is applied to the spring.

**Housing**: The spring is usually enclosed within a protective housing made of metal or plastic. The housing ensures that the spring is not easily damaged or affected by external factors.

**Pointer/Indicator**: Inside the housing, there is a pointer or indicator that moves along a calibrated scale. When a force is applied to the spring, it stretches or compresses, causing the pointer to move and indicate the force applied.

**Working:**

The object whose weight needs to be measured is hung from the hook on the spring.

The weight of the object causes the spring to stretch or compress, depending on the design of the spring scale. The more weight added, the more the spring deforms.

As the spring stretches or compresses, the pointer attached to the spring moves along a calibrated scale, indicating the force applied or the weight of the object in the corresponding units (e.g., kilograms or pounds).

Once the weight stabilizes, you can read the weight measurement from the scale where the pointer points.

It's important to note that spring scales have limitations. They can be affected by variations in the elasticity of the spring due to temperature changes or prolonged use, leading to inaccuracies over time. Additionally, spring scales usually have a limited range of measurement, and using them near their maximum capacity may cause the spring to lose its elasticity permanently.

**Advantages:**

- Spring scales have a simple design with minimal moving parts, making them user-friendly for various applications.
- They are generally lightweight and compact, making them easy to carry and transport.
- They are often more affordable compared to electronic scales, making them a budget-friendly option for many users.
- They don't rely on electricity or batteries to function, which means they can be used anywhere, even in remote locations or during power outages.
- The measurement reading is directly indicated by the pointer on the scale, providing an instant and real-time weight measurement.

**Disadvantages:**

- Spring scales may not offer the same level of precision as electronic scales. The accuracy can be affected by factors like the quality and consistency of the spring's material and the wear and tear over time.
- They usually have a specific weight capacity, and using them beyond this range can cause permanent damage to the spring or lead to inaccurate readings.
- They can be affected by changes in temperature, which may impact the elasticity of the spring and result in measurement errors.

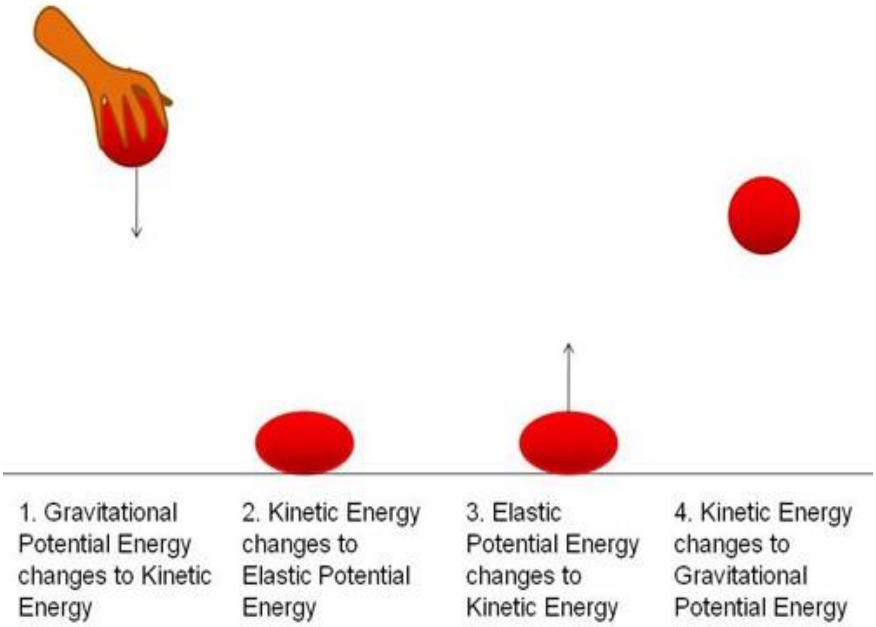
- Frequent use of spring scales can cause the spring to lose its elasticity gradually, affecting the scale's accuracy and reliability.
- The relationship between the force applied and the spring's deformation might not be perfectly linear, leading to less precise measurements, especially when dealing with small forces.

**Applications:**

- Spring scales are commonly used in laboratories, kitchens, and shops to measure the weight of small items such as food ingredients, chemicals, or packages.
- They are often used in schools and science classes to demonstrate the concept of force, elasticity, and Hooke's Law.
- Anglers frequently use spring scales to measure the weight of caught fish.
- Spring scales find applications in hobbies like model building, where they are used to weigh small components.
- Although electronic scales are more prevalent in industries, spring scales might still be used in certain applications where the accuracy requirements are not as high.

## BOUNCING BALLS

Bouncing balls, also known as rubber balls or superballs, are popular toys and objects that exhibit interesting and entertaining behavior when dropped or thrown on a hard surface. They are made from a special type of rubber or other elastic materials that allow them to rebound and bounce repeatedly.




Bouncing balls are typically made from a highly elastic material, such as natural rubber or synthetic rubber compounds like polybutadiene. These materials have a high coefficient of restitution, which means they can store and release kinetic energy efficiently during collisions.

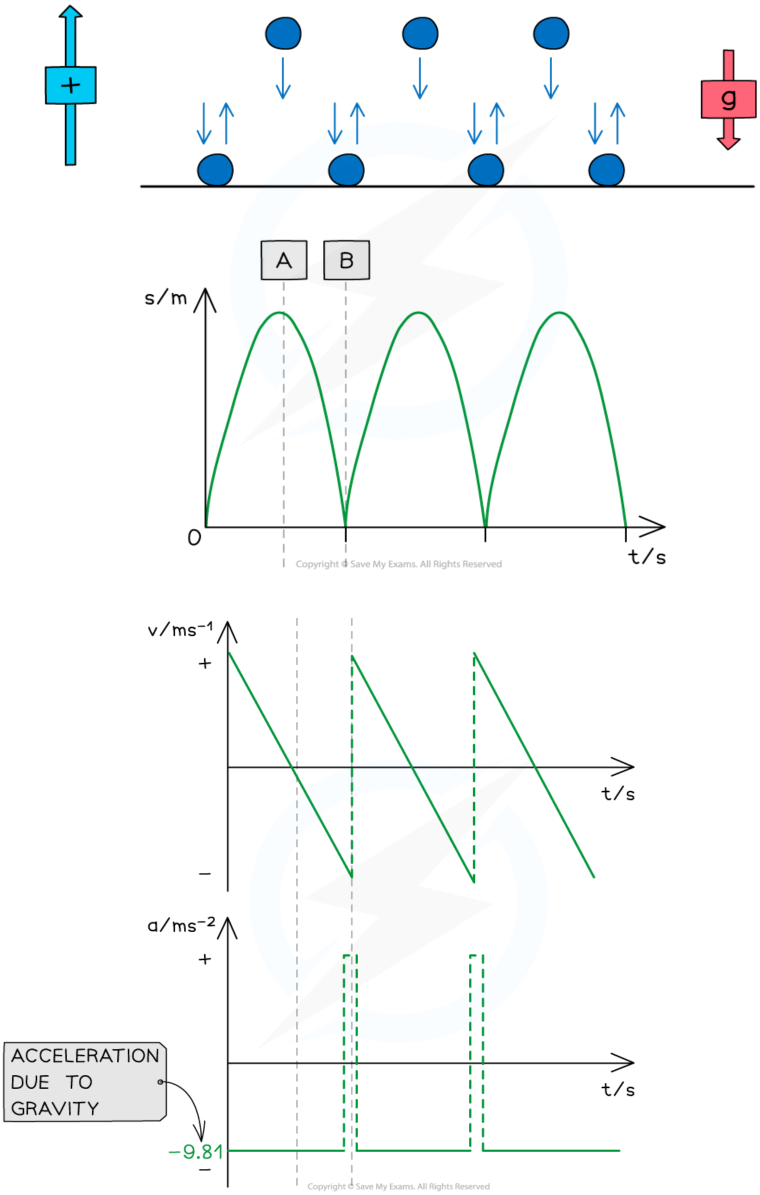
**Working:**

In the bouncing ball example, external forces such as air resistance are assumed to be zero. Hence, the only force acting on the ball is gravity. The motion of the ball can be split into different stages depending on the direction of the velocity vector; these stages are listed below. As a general rule, when the ball is travelling in the positive direction (upwards), the velocity can be assumed to be positive. When the ball travels in the negative direction (downwards), the velocity can be assumed to be negative. The positive and negative directions must be stated in each example.

- The first stage is where the ball bounces from the surface of the ground. It travels upwards towards its highest point.
- The second stage is the point at which the ball decelerates, changes direction once it has reached the peak point, and starts falling to the ground.
- The third stage is the point at which the ball is momentarily deformed, and bounces off the ground in an upward direction until it reaches its maximum height.
- The last stage is the point at which the ball has reached its maximum displacement, decelerates, and changes the direction of motion from upwards to downwards.

These stages are continuously repeated and shown in the sequence below. it seems the ball is experiencing an oscillatory motion. In reality, the ball experiences damping, where it loses potential energy and kinetic energy as it falls. This causes the amplitude of the height to reduce over time and eventually come to a stop due to friction forces like air resistance, which are assumed to be zero in an ideal scenario. The ball is not performing a simple harmonic motion, as the acceleration is not proportional to the displacement from an equilibrium position.

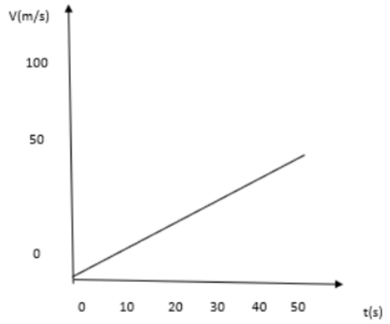
At the point of maximum height, the ball momentarily has zero velocity, and the direction of velocity is changing from positive to negative. The acceleration on the ball is the acceleration of gravity, which acts downwards on the ball. At the lowest point, the ball has its minimum potential energy, and the velocity changes from negative to positive. These stages can also be represented graphically using three plots including a displacement, velocity, and acceleration vs time graph.




The first graph is a displacement vs time graph. The ball moves upwards, reaching stage 1, i.e., maximum height, and its velocity is momentarily zero. The acceleration due to gravity causes the ball to change direction and start moving downwards at stage 2.

Once the ball hits the ground, its displacement is momentarily zero. It bounces off, changing the direction of motion and again reaching its maximum height. This is also reflected in the velocity graph; the velocity is at its maximum at the minimum displacement and goes through zero at its maximum heights. The change in direction when the ball reaches the ground causes a momentary acceleration as seen in the acceleration graph (as acceleration).

**Example:**




A) Using the graph above, find the displacement of the ball at 50 seconds.

B) Using the conservation of energy, find the velocity of the ball before it hits the ground from a height of three metres.

**Solution A:**

Using the graph above, we can find the displacement by using the area under the graph, which is equal to the displacement. The area of the triangle can be found using the formula below.

$$Area = \frac{1}{2} \cdot base \cdot length$$

$$Area = 0.5m \cdot 50m \cdot 50m = 1250m^3$$

**Solution B:**

We use the conservation of energy. So, we equate the potential energy and the kinetic energy.

$$E_{pot} = E_{kin} \cdot m \cdot g \cdot h = \frac{1}{2} \cdot m \cdot v^2$$

The mass is cancelled out in the above equation, and we re-arrange with respect to velocity.

$$v^2 = 2 \cdot g \cdot hv = \sqrt{2 \cdot 9.81 \frac{m}{s^2} \cdot 3m} = 7.67 \frac{m}{s}$$

## ROLLER COASTER

Roller coasters are thrilling amusement park rides that consist of a track with steep slopes, twists, and turns, designed to provide an exhilarating and exciting experience for riders.

The underlying principle of all roller coasters is the law of conservation of energy, which describes how energy can neither be lost nor created; energy is only transferred from one form to another. In roller coasters, the two forms of energy that are most important are gravitational potential energy and kinetic energy.

**The Track Design:** The roller coaster track is carefully designed with various elements, including:

**Hills:** The hills are designed to provide the roller coaster with potential energy as it climbs to the top. This energy is then converted into kinetic energy (motion) as the coaster descends.

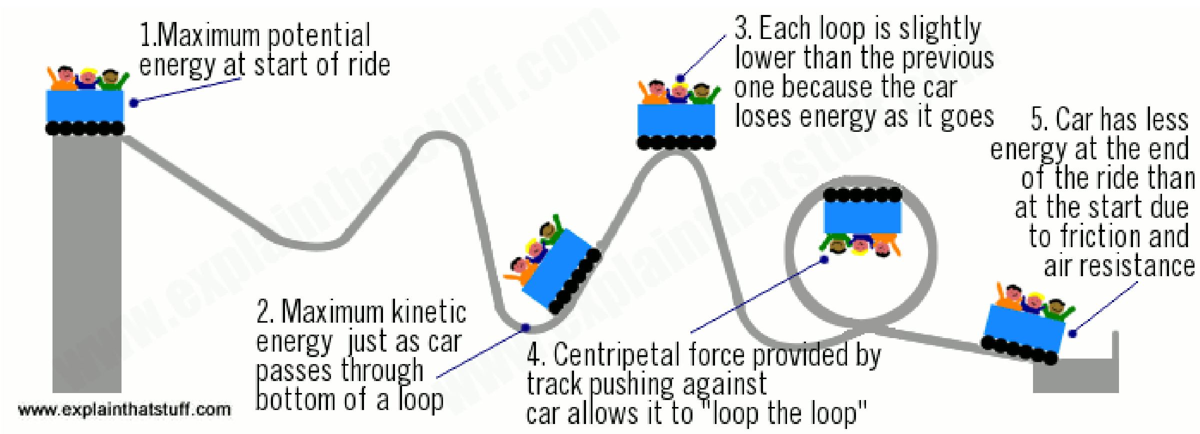
**Loops:** Loops are circular elements in which the roller coaster goes upside down. To complete the loop, the roller coaster must maintain sufficient speed and momentum.

**Twists and Turns:** These elements add excitement and variety to the ride. The roller coaster banks and turns at different angles to create different forces on the riders.

Cars can only make it through loops if they have enough speed at the top of the loop. This minimum speed is referred to as the critical velocity, and is equal the square root of the radius of the loop multiplied by the gravitational constant ($v_c = (rg)^{1/2}$).

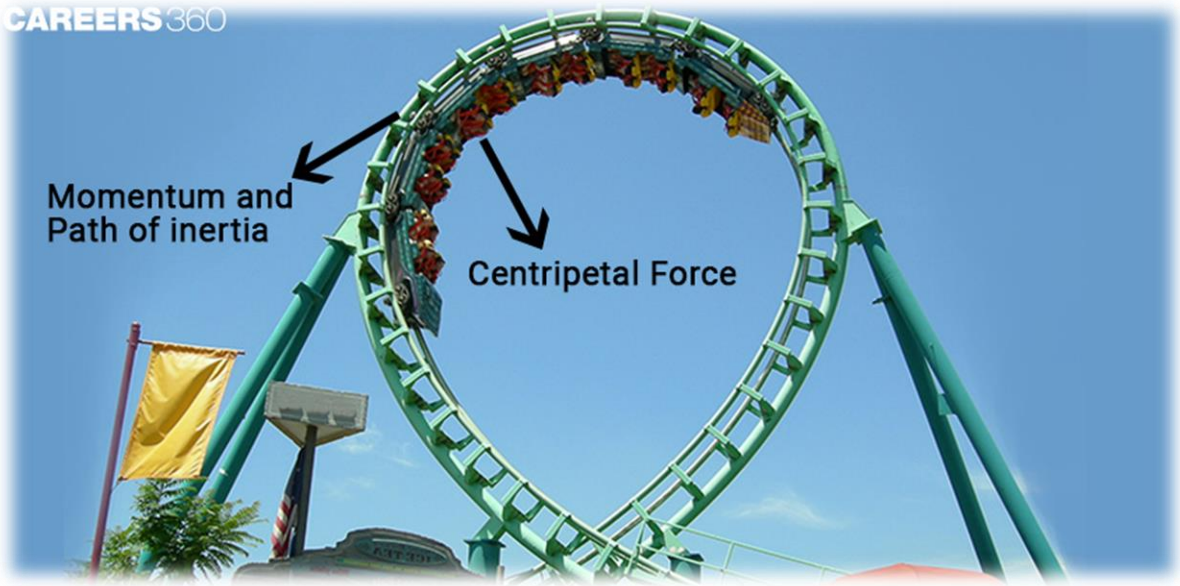
**The Roller Coaster Car:** The roller coaster car, also known as the coaster train, is a series of connected cars that carry passengers along the track.

Roller coasters rely on the principles of physics to create the thrilling experience.




**Gravity:** The force of gravity pulls the roller coaster train down the hills, providing the kinetic energy that propels it through the rest of the track.

Riders may experience weightlessness at the tops of hills (negative g-forces) and feel heavy at the bottoms of hills (positive g-forces). This feeling is caused by the change in direction of the roller coaster. At the top of a roller coaster, the car goes from moving upward to flat to moving downward. This change in direction is known as acceleration and the acceleration makes riders feel as if a force is acting on them, pulling them out of their seats. Similarly, at the bottom of hills, riders go from moving downward to flat to moving upward, and thus feel as if a force is pushing them down into their seats. These forces can be referred to in terms of gravity and are called gravitational forces




**Inertia:** The roller coaster's tendency to remain in motion due to its mass and velocity keeps it moving through the track, even in the absence of a motor.

**Centripetal Force:** During turns and loops, centripetal force acts towards the center of the curve, keeping the roller coaster on the track.

**Potential and Kinetic Energy:** At the top of a hill, the roller coaster has the most potential energy. As it descends, the potential energy is converted into kinetic energy (the energy of motion), which enables the roller coaster to travel through the track and overcome the forces of friction and air resistance.

Gravitational potential energy is the energy that an object has because of its height and is equal to the object's mass multiplied by its height multiplied by the gravitational constant (PE = mgh). Gravitational potential energy is greatest at the highest point of a roller coaster and least at the lowest point.

Kinetic energy is energy an object has because of its motion and is equal to one-half multiplied by the mass of an object multiplied by its velocity squared (KE = 1/2 $mv^2$). Kinetic energy is greatest at the lowest point of a roller coaster and least at the highest point. Potential and kinetic energy can be exchanged for one another, so at certain points the cars of a roller coaster may have just potential energy (at the top of the first hill), just kinetic energy (at the lowest point) or some combination of kinetic and potential energy (at all other points).

At the top of the first hill, a car's energy is almost entirely gravitational potential energy (because its velocity is zero or almost zero). This is the maximum energy that the car will ever have during the ride. That energy can become kinetic energy (which it does at the bottom of this hill when the car is moving fast) or a combination of potential and kinetic energy (like at the tops of smaller hills), but the total energy of the car cannot be more than it was at the top of the first hill. If a taller hill were placed in the middle of the roller coaster, it would represent more gravitational potential energy than the first hill, so a car would not be able to ascend to the top of the taller hill.

Cars in roller coasters always move the fastest at the bottoms of hills.

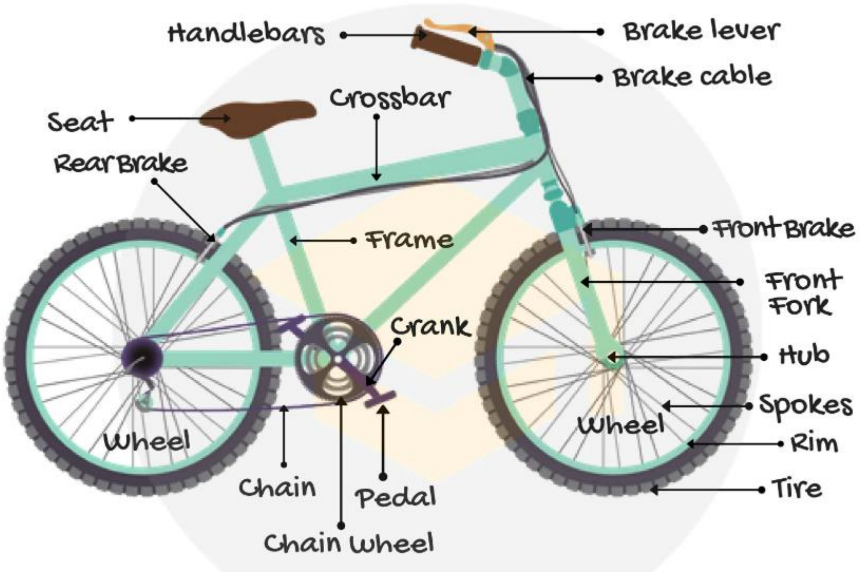
**Friction:** Friction exists in all roller coasters, and it takes away from the useful energy provided by roller coaster. Friction is caused in roller coasters by the rubbing of the car wheels on the track and by the rubbing of air (and sometimes water!) against the cars.

Most roller coaster loops are not perfectly circular in shape, but have a teardrop shape called a clothoid. In a clothoid, the radius of curvature of the loop is widest at the bottom, reducing the force on the riders when the cars move fastest, and smallest at the top when the cars are moving relatively slowly. This allowed for a smoother, safer ride and the teardrop shape is now in use in roller coasters around the world.

## BICYCLE

The bicycle is a simple and widely used mode of transportation, consisting of a frame with two wheels, pedals, and a handlebar for steering.

A bicycle is a machine that can magnify force or speed to move you up a hill more easily. It is also capable of changing the energy from the human body to energy for motion. Energy in all forms cannot be created or destroyed; energy can only change from one form to another. Cycling can feel like hard work at times because you must use a lot of muscle force to pedal. If you are going uphill you must work against the force of gravity. If you are trying to go fast you are working against a force called air resistance. If there are any bumps or turns then you must use energy to slow down and use the force of friction from the brakes. When riding a bicycle, you are always using energy to make the wheels go around and keep in motion.




**Frame**: The frame is the main structure of the bicycle, typically made of metal, such as steel, aluminum, or carbon fiber. It provides the foundation and support for all other components.

**Wheels**: Bicycles have two wheels, usually made of metal rims with rubber tires. The wheels are attached to the frame using axles and are kept in place by a set of bearings.

The wheel will increase the force or speed depending on how it is turned. The greater the diameter of the wheel the more your speed can increase. Wheels support your mass as you sit on the seat. The rubber tire sits inside a wheel that has a rim and several spokes, which make the wheel strong, lightweight and help reduce the force of air resistance. Like strands of a spider web, the spokes are pulled tight and are crisscrossed from the rim to the opposite rim. This design stops the wheel from crushing under the mass of the rider.

**Pedals and Crankset**: The pedals are attached to the crank arms, forming the crankset. When the rider pushes the pedals, the crankset rotates, transferring power to the chain.

**Chain**: The chain is a series of interconnected links that run between the front chainring (attached to the crankset) and the rear cassette.

**Gears**: Bicycles often have multiple gears, controlled by a gear shifter on the handlebar. The front chainring and rear cassette have different sizes, providing different gear ratios for various riding conditions.

**Brakes**: Brakes are essential for controlling the bicycle's speed and stopping. Common types of brakes are rim brakes, which apply pressure to the rim of the wheel, and disc brakes, which use a disc attached to the wheel hub.

**Handlebar**: The handlebar is the steering mechanism for the bicycle. It allows the rider to control the direction of the front wheel.

**Saddle (Seat):** The saddle is the seat of the bicycle, providing support and comfort for the rider.

**Chain rings and Cassettes**: The front chain ring(s) and rear cassette have teeth of different sizes, determining the gear ratios and the effort required for pedaling.

**Working:**

**Pedaling**: When the rider pushes down on the pedals, the crank set rotates, transferring rotational motion to the chain.

**Chain Movement**: As the chain moves, it engages with the teeth of the front chain ring and rear cassette, causing the rear wheel to rotate.

**Gear Shifting**: By using the gear shifter, the rider can change the effective gear ratio by moving the chain to different chainrings or cassette cogs. Lower gears offer easier pedaling but less speed, while higher gears provide more speed but require more effort.

**Steering**: The rider steers the bicycle by turning the handlebar, which controls the direction of the front wheel.

**Braking**: To slow down or stop, the rider applies pressure to the brake levers, activating the brakes, which slow down the rotation of the wheels and bring the bicycle to a halt.

**Balancing**: As the rider moves forward, the bicycle's design and the rider's body movements enable balancing on two wheels.

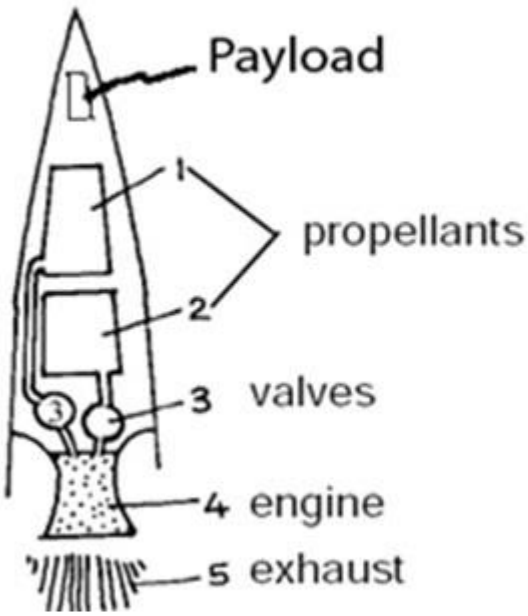
Instead of using gasoline or diesel fuel like motorized vehicles, bicycles turn our energy, created by our bodies, into kinetic energy. A bicycle can convert up to 90% of a person’s energy and movement into kinetic energy, making it the most efficient transportation mode to date. The kinetic energy created is then used to move the bicycle.

Momentum, along with a rider’s balance, helps keep the bike stable while traveling along a path.

The force used by pedaling allows the gears of a bike to spin the back wheel. As the back wheel rotates, the tire uses friction to grip the surface and move the bike in the desired direction.

## ROCKET

The principle behind the working of a rocket is based on Newton's third law of motion, which states that for every action, there is an equal and opposite reaction. Rockets work by expelling mass in one direction, creating a thrust in the opposite direction, propelling the rocket forward.




**Propellant**: Rockets use a combination of fuel and oxidizer, called propellant, stored in onboard tanks. The fuel can be a liquid (e.g., liquid hydrogen, kerosene) or a solid (e.g., solid propellant grains). The oxidizer supplies the oxygen required for combustion, as there is no air in space.

**Combustion**: To launch the rocket, the propellant is ignited. In liquid rockets, the fuel and oxidizer are mixed and ignited in a combustion chamber. In solid rockets, the combustion starts when the solid propellant is ignited.

**Thrust**: As the propellant burns, hot gases are produced. The combustion process releases a large amount of energy, creating a high-pressure gas that expands rapidly. The gas is expelled through a nozzle at the rear of the rocket, creating a jet of high-speed exhaust gases.

**Action and Reaction**: According to Newton's third law, the action is the expulsion of hot gases from the rocket's nozzle, and the reaction is the equal and opposite force that pushes the rocket in the opposite direction. This force is known as thrust.

**Conservation of Momentum**: As the rocket expels mass (hot gases) backward, the rocket gains momentum in the opposite direction. To maintain conservation of momentum, the rocket's total momentum (rocket mass multiplied by its velocity) must remain constant. As the mass decreases due to the expended propellant, the velocity of the rocket increases.

**Control and Stability**: To ensure that the rocket moves in the desired direction and remains stable, it is equipped with fins or other control surfaces. These surfaces can be adjusted to steer the rocket during flight.

**Staging**: Many rockets are designed with multiple stages, each containing its own set of engines and propellant. Once the propellant in a stage is nearly depleted, that stage is jettisoned, and the next stage ignites. Staging allows the rocket to shed weight and increase efficiency during its ascent.

**Escape Velocity**: To reach space and overcome Earth's gravitational pull, the rocket must reach a sufficient velocity known as escape velocity. Once the rocket surpasses this speed, it can break free from Earth's gravitational influence and enter space.

**Orbit and Trajectory**: Depending on the mission's objective, the rocket may need to achieve a specific orbit or trajectory.

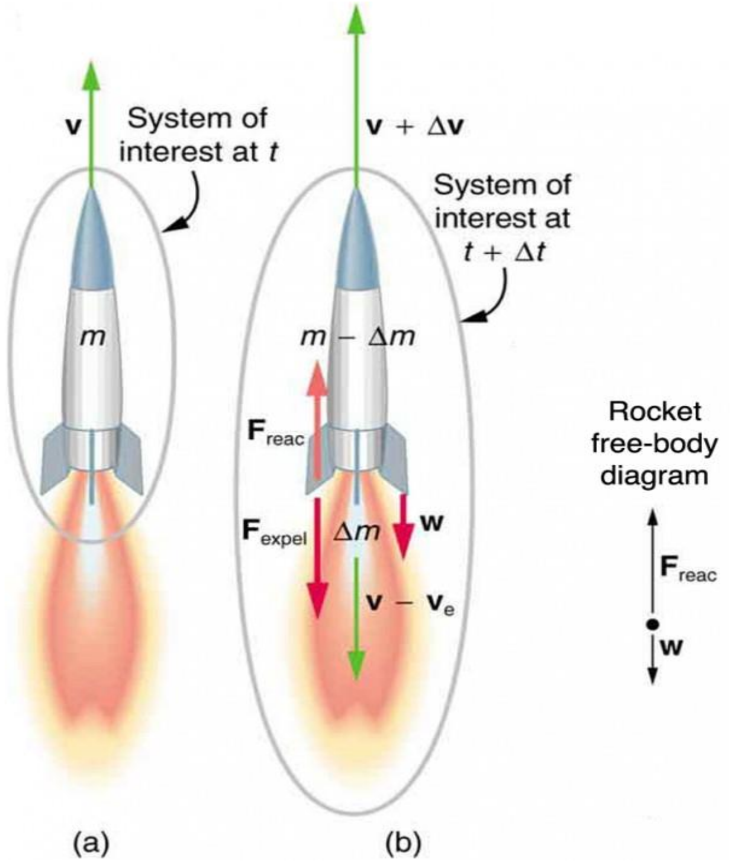



Figure shows a rocket accelerating straight up. In Figure 1a, the rocket has a mass *m* and a velocity *v* relative to Earth, and hence a momentum *mv*. In Figure 1b, a time Δ*t* has elapsed in which the rocket has ejected a mass Δ*m* of hot gas at a velocity $v_e$ relative to the rocket. The remainder of the mass (*m* - Δ*m*) now has a greater velocity (*v* + Δ*v*). The momentum of the entire system (rocket plus expelled gas) has actually decreased because the force of gravity has acted for a time Δ*t*, producing a negative impulse Δ*p* = -*mg*Δ*t*. (Remember that impulse is the net external force on a system multiplied by the time it acts, and it equals the change in momentum of the system.) So, the center of mass of the system is in free fall but, by rapidly expelling mass, part of the system can accelerate upward. It is a commonly held misconception that the rocket exhaust pushes on the ground. If we consider thrust; that is, the force exerted on the rocket by the exhaust gases, then a rocket's thrust is greater in outer space than in the atmosphere or on the launch pad. In fact, gases are easier to expel into a vacuum.

By calculating the change in momentum for the entire system over $\Delta t$, and equating this change to the impulse, the following expression can be shown to be a good approximation for the acceleration of the rocket.

$$a = \frac{v_e}{m}\frac{\Delta m}{\Delta t} - g$$

where $a$ is the acceleration of the rocket, $v_e$ is the escape velocity, $m$ is the mass of the rocket, $\Delta m$ is the mass of the ejected gas, and $\Delta t$ is the time in which the gas is ejected.

## Example on Rocket Propulsion

**Example:**

$2.80\times10^6$ kg is the mass at liftoff of Saturn. The fuel is burnt at the rate of $1.40\times10^4$ kg/s and the exhaust velocity is $2.40\times10^3$ m/s. What is the initial acceleration?

**Solution:**

Given:

Exhaust velocity, $v_e = 2.40\times10^3$ m/s

Mass of the rocket, m = $2.80\times10^6$ kg

Mass of fuel burnt, Δm = $1.40\times10^4$ kg/s

Acceleration due to gravity, g = 9.80 $m/s^2$

Substituting the above, in the formula, we get

$$a = \frac{v_e}{m}\frac{\Delta m}{\Delta t} - g$$

$$a = \frac{2.40\times10^3 m/s}{2.80\times10^6 kg}(1.40 \times 10^4 kg/s) - 9.80 m/s^2$$

$a = 2.20\ m/s^2$

This value is fairly small, even for an initial acceleration. The acceleration does increase steadily as the rocket burns fuel, because m decreases while $v_e$ and Δm/Δt remain constant. Knowing this acceleration and the mass of the rocket, we can show that the thrust of the engines is $3.36\times10^7$ N.

Rockets have enabled humanity to explore space, launch satellites into orbit, conduct scientific research, and send astronauts to the Moon and beyond. They are crucial for modern space exploration and continue to be at the forefront of our efforts to explore and understand the universe.

## SPACE TRAVEL

Space travel, also known as space exploration, refers to the use of spacecraft and related technologies to travel beyond Earth's atmosphere and explore outer space.

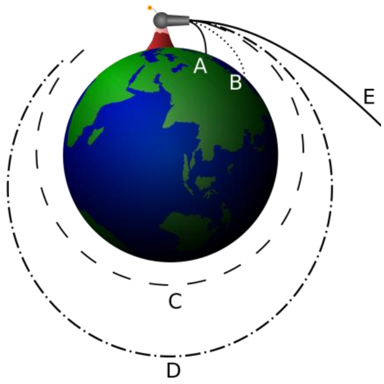
Objects in space follow the laws or rules of physics, just like objects on Earth do. Things in space have inertia. That is, they travel in a straight line unless there is a force that makes them stop or change. The movement of things in space is influenced by gravity. Gravity is an important force that can change the course of bodies in space or pull them off of one course, or even cause them to crash together.

While some objects in space travel in irregular paths, most (especially our near neighbours in space) tend to travel in orbits around the Sun or around planets. The orbits are usually close to circular, but are actually slightly flattened ellipses.

**Newton's Cannonball**

Orbits were famously described by Isaac Newton in 1687 (get used to seeing his name a lot). His work *Principia*, often considered one of the most important works in the history of science, proposed a clever thought experiment. In it, he asks us to imagine a cannon on top of a very tall mountain – so tall that its peak is in space.

If one fires a cannonball from this cannon, it will travel horizontally until the Earth's gravity pulls it back to the ground. But fire the cannonball fast enough, and it will travel so far that it will follow a complete circle and hit you in the back of the head (as shown in orbit C of this diagram):




In a circular orbit, centrifugal force balances the force of gravity. In other words, it's travelling fast enough that the ground curves away under the spacecraft as it 'falls' around the Earth, but not so fast that it flies off into space forever.

In low Earth orbit, a spacecraft would need to orbit at about 7-8 km/s to achieve this. The speed of a spacecraft in its orbit depends on the orbit's shape, the planet's mass, and its current distance from the planet's center. A spacecraft in a low circular orbit, for example, would need to travel faster than one in a high orbit, because a planet's gravity is stronger the closer you get to it.

Hence, it is a misnomer to say that astronauts floating on the International Space Station are 'weightless' or in 'zero gravity' because they are still under the influence of the Earth's gravity – at the ISS's altitude, the force of gravity is about 90% as strong as it is at sea level. A more accurate (and perhaps pedantic) term is 'freefall'. They *seem* weightless because the ISS is falling at exactly the same rate that their bodies are.

**1.Objectives of Space Travel:**

**Scientific Exploration:** Space missions are conducted to study celestial bodies, planetary systems, galaxies, and the cosmos, enhancing our knowledge of astrophysics, astronomy, and cosmology.

**Planetary Exploration:** Spacecraft are sent to explore planets, moons, asteroids, and comets, providing valuable insights into their geology, atmospheres, and potential for supporting life.

**Human Spaceflight:** Crewed missions involve sending astronauts to space to conduct experiments, live aboard space stations, and potentially colonize other celestial bodies like the Moon or Mars.

**Earth Observation:** Satellites are used to monitor Earth's weather, climate, natural disasters, and environmental changes, aiding in disaster management and resource management.

**Communication and Navigation:** Satellites in geostationary and other orbits enable global communication, GPS navigation, and satellite-based services.

**2.Space Agencies:**

**NASA:** The National Aeronautics and Space Administration (NASA) in the United States is one of the world's leading space agencies, responsible for a wide range of space missions, including human spaceflight and robotic exploration.

Roscosmos: Russia's space agency, Roscosmos, has a significant history in human spaceflight and continues to be a major player in space exploration.

**ESA:** The European Space Agency (ESA) is a collaboration of European countries, conducting space missions and research across various disciplines.

**CNSA:** The China National Space Administration (CNSA) is the space agency of China, known for its ambitious space missions and lunar exploration.

**ISRO:** The Indian Space Research Organisation (ISRO) is India's space agency, known for its cost-effective and successful space missions.

**3. Spacecraft and Launch Vehicles:**

Spacecraft can be categorized as crewed (carrying astronauts) or uncrewed (robotic probes). They are equipped with scientific instruments, communication systems, propulsion, and other necessary equipment.

Rockets, also known as launch vehicles, are used to propel spacecraft into space. They consist of multiple stages, each containing engines and propellant. Staging allows the rocket to discard empty stages and increase efficiency during launch.

**4. Challenges and Risks:**

Space travel involves exposure to microgravity, vacuum, extreme temperatures, and radiation, which pose challenges to human health and spacecraft design.

The vast distances in space and the time required to reach distant destinations make interstellar travel currently impractical for crewed missions.

Space missions require substantial financial investments, making space exploration a complex and costly endeavor.

# Unit II

# Optical Instruments and Laser

## VISION CORRECTIVE LENSES

Vision corrective lenses are eyeglasses or contact lenses designed to correct various vision problems, such as nearsightedness (myopia), farsightedness (hyperopia), astigmatism, and presbyopia. These lenses help individuals see more clearly by adjusting the way light enters the eye. Here's a brief overview of different types of vision corrective lenses:

**Single-Vision Lenses:** These lenses have a single prescription power throughout the entire lens and are used to correct one specific vision problem. They can be used for nearsightedness (myopia) or farsightedness (hyperopia).

**Bifocal Lenses:** Bifocals have two prescription powers in one lens. The upper part is for distance vision, while the lower part is for reading or close-up tasks. Bifocals are often used to address presbyopia, which occurs with age and results in difficulty focusing on close objects.

### Defects of Vision and their Correction

When the eye loses its ability to adjust its focal length, problems appear like a person cannot see the image correctly (blurring of vision), unable to view nearby objects or far away objects. When the defect in the refractive index occurs, the person cannot see the objects comfortably and distinctly. If not taken timely care of, the eyes might completely lose the power of accommodation.

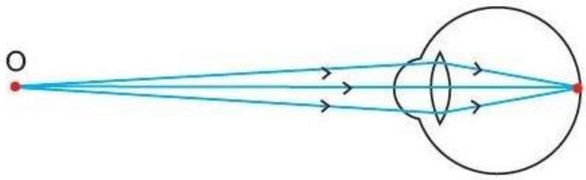
Myopia (near-sightedness) is the most common refractive vision disorder in children. It is characterized by blurring of objects viewed at a distance, and is commonly the result of abnormal elongation of the eyeball – which causes the refractive image formed by the cornea and the lens to fall in front of the photoreceptors of the retina.

Retina is that part of the eye which provides a surface for image formation. In myopia what happens is light rays entering the eyes converge too soon and are brought to focus before reaching the retina hence the image cannot be formed on the retina.

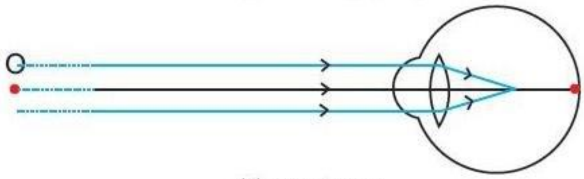
**Causes of Myopia**

This defect occurs when the focal point falls in front of the retina instead of on it. This can happen for two reasons:

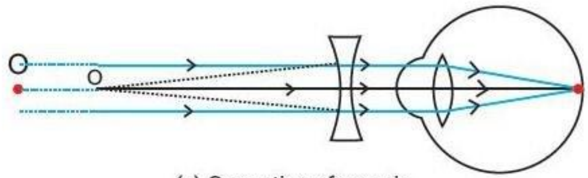
- The first is the high converging power of the eye's lens. In this case, the ciliary muscles are not relaxed enough, which causes the lens to thin out and for the converging power to decrease. This causes blurry images of distant objects.
- The other factor is an irregularly long shape of the eyeball, causing the focal point to be in front of the retina instead of on it. This results in a higher distance between the retina and the eye lens, which means that the eye is unable to see distant objects clearly. They appear blurry because the image is out of focus due to the long distance between the retina and the focal point.




(a) Far point of myopia eye




(b) myopia eye




(c) Correction of myopia

Correcting myopia involves adjusting the distance of the distant object so it appears closer to the far point of the eye, which would allow the eye to see the object clearly. This can be achieved by utilising a concave lens in front of the eye in the form of glasses.

This involves divergence of the light rays coming from the distant object, so they appear to come from the eye's far point, which helps to increase the focal length. This is the distance between the centre of the curved lens and the focal point.

The concave lens decreases the converging power of the eye lens, forming the image of the object on the retina. It illustrates that the image is created on the retina when the concave lenses are used compared to in front of the retina if the myopic eye is untreated.

If the focal length f is known, then the power p can also be estimated as they are inversely proportional, as shown below. The power is measured in dioptres (D), which is a measure of the degree of myopia. The higher the degree, the greater the elongation of the eye and the blurriness of images.

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$$

$$P[D] = \frac{1}{f}$$

Here, u is the distance of the distant object in metres, which is taken as infinity for the myopic eye, v is the far point in metres (the maximum clear vision distance), and f is the required focal length.

**Hypermetropia**

Hypermetropia is a defect that affects the ability to see nearby objects while still being able to see distant objects clearly. The distant objects that can be seen are usually positioned more than 25 cm away from the eye. Hypermetropia can have two reasons:

The first is low converging power. Here, the ciliary muscles are weakened and cannot thicken the eye lens when needed to increase its converging power. Hence, the image of close objects is formed behind the retina instead of on the retina.

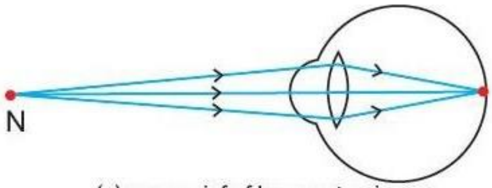
The other factor is the shape of the eyeball. When it is short, the retina is closer to the eye lens, causing the image of near objects to form behind the retina.

**Correction:**

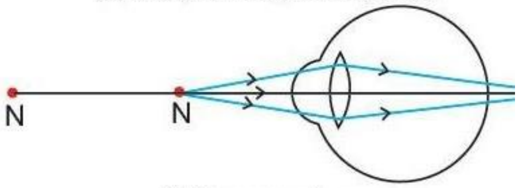
By using convex lenses in front of the eye, the light rays from near objects converge through the lens, forming an image of the object close to the near point N of the eye. Depending on the power of the lens used, the converging power will be increased accordingly.

When utilizing convex lenses, the image is created on the retina instead of behind the retina. N is the normal near point of the eye, which is 25 cm, while N' is the near point of a hypermetropic eye, which is more than 25 cm.

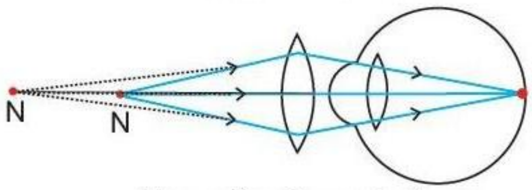
The power of the lens is set so that its focal length is equal to the near point of the eye.



(a) near poinf of hypemetropic eye



(b) Hypemetropia eye



(c) correction of hypemetropia eye

**Astigmatism**

Astigmatism is a common defect of vision caused by an uneven or asymmetric retina or focus of the eye or an irregular shape of the cornea of the eye. This causes some images to be sharper than others, as the rays that reflect from the object approach different points in the irregular or uneven eye.

**Astigmatism correction**

Astigmatism can be corrected partially with cylindrical spectacles that oppose the irregularity of the eye. This means that if the refractive error of the eye is +1.5, the correction of the refractive error is -1.5. However, as the spectacles are fixed and the eyes move, the distance is always varying so that the vision is not totally corrected at all times.

This problem is eliminated using contact lenses that are fixed on the eye. As they cover a large portion of the irregular cornea, they provide a total correction. Another option is laser correction, which uses laser technology to reshape an irregular cornea. This can also be used for other defects besides astigmatism.

**Presbyopia**

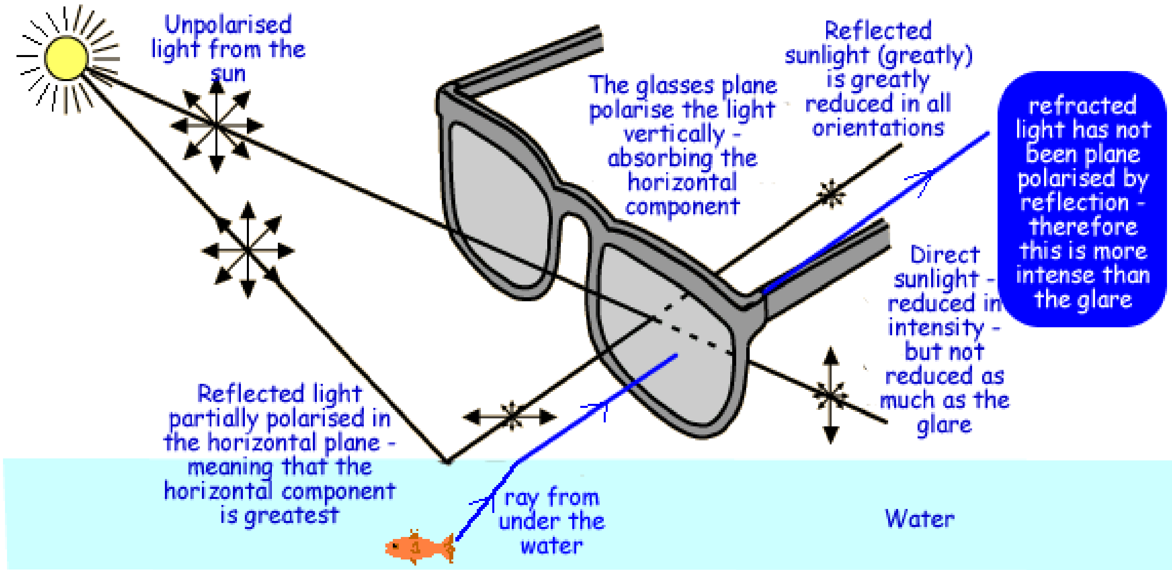
Presbyopia, which happens gradually as we age, is caused mainly in older people due to weakened ciliary muscles of the eye. The muscles lose their flexibility and thus are unable to focus properly on near objects. This defect can happen in conjunction with myopia, astigmatism, or hypermetropia. It affects the ability to see nearby objects.

**Presbyopia correction**

Presbyopia can sometimes appear in conjunction with myopia or hypermetropia, which would then require bifocal lenses that use concave or convex lenses at the top and the bottom of the spectacles, respectively. As presbyopia is associated with age, the formula for correction is given with respect to age or depending on the distance requirements.

## POLAROID GLASSES

Polaroid glasses, often referred to as polarized sunglasses or simply polarized glasses, are specialized eyewear designed to reduce glare and improve visual comfort in bright, sunny conditions. They have a unique feature called polarization, which helps to block certain types of light waves and reduce glare caused by reflections off surfaces like water, roads, and glass.




Polarized lenses contain a special filter that selectively blocks light waves that vibrate in specific orientations while allowing light waves that vibrate in a different direction to pass through. This filter is usually vertically oriented, which means it primarily blocks horizontally polarized light.

When light from the sun or other sources hits a flat, reflective surface (e.g., water, road, car hood), it becomes horizontally polarized due to the angle of reflection. This horizontally polarized light can create intense glare that can be both uncomfortable and potentially hazardous.

Polarized glasses effectively block this horizontally polarized light, reducing glare and enhancing visibility. They are particularly popular among outdoor enthusiasts, drivers, and anyone exposed to bright sunlight.

**Benefits of Polarized Glasses:**

**Reduced Glare:** The most significant advantage of polarized glasses is their ability to reduce glare from reflective surfaces. This makes them ideal for activities like driving, fishing, boating, skiing, and biking.

**Enhanced Visual Comfort:** By reducing glare and minimizing eye strain, polarized glasses offer increased visual comfort, especially in bright, sunny conditions.

**Improved Color and Contrast:** Polarized lenses often enhance color perception and improve contrast, making objects and details appear sharper and more vibrant.

**UV Protection:** Many polarized sunglasses also offer protection against harmful ultraviolet (UV) rays from the sun. This helps protect your eyes from potential damage caused by prolonged exposure to UV radiation.

**Better Visibility on Water:** Fishermen and boaters find polarized sunglasses especially helpful because they reduce glare on water surfaces, allowing them to see beneath the water's surface more clearly.

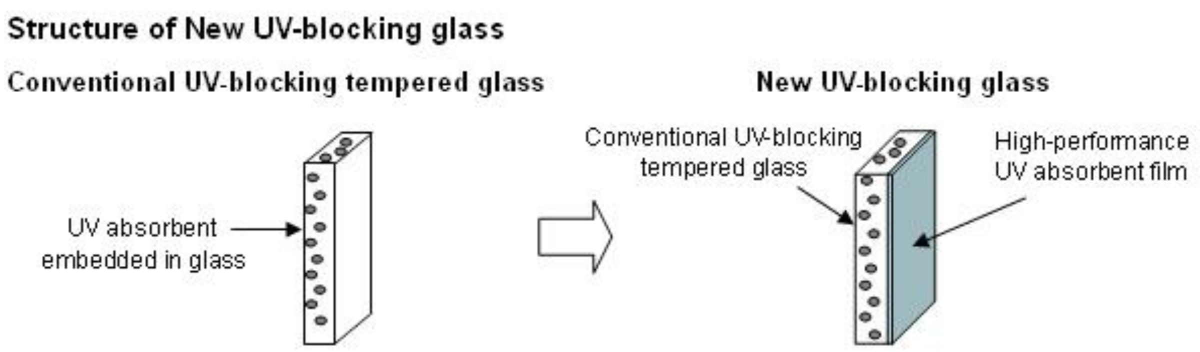
**Safer Driving:** Polarized glasses can improve road safety by reducing glare from other vehicles and road surfaces, enhancing your ability to see potential hazards.

While polarized glasses offer numerous benefits, they may not be suitable for all situations. For example, polarized lenses can affect the visibility of certain digital screens, like those in some car dashboards or GPS devices, so they may not be ideal for driving in such vehicles. Additionally, some individuals may experience difficulty reading LCD or LED displays while wearing polarized glasses.

## UV-PROTECTIVE GLASS

UV-protective glass, also known as ultraviolet (UV) blocking glass or UV-filtering glass, is a type of glass designed to reduce or block the transmission of harmful ultraviolet rays from the sun. This glass is commonly used in various applications to protect people, objects, and interiors from the damaging effects of UV radiation. Here are some key aspects of UV-protective glass:

**UV Radiation and its Effects:**




Ultraviolet (UV) radiation is a component of sunlight and artificial light sources. It is categorized into three types: UVA, UVB, and UVC. Prolonged exposure to UV radiation can have harmful effects on human health, such as skin aging, sunburn, and an increased risk of skin cancer. UV radiation can also cause fading and damage to materials, including fabrics, artwork, and furniture, as well as contribute to the degradation of plastics and other materials.

UV-protective glass is manufactured with coatings or additives that absorb or reflect UV rays, preventing them from passing through the glass. This glass typically allows visible light to pass through while blocking a significant portion of harmful UV radiation. Depending on the specific type and quality of UV-protective glass, it can block a substantial percentage of both UVA and UVB rays.

**Applications of UV-Protective Glass:**

**Windows and Doors:** UV-protective glass is commonly used in residential and commercial windows and doors to reduce the amount of UV radiation entering indoor spaces. This helps protect occupants and interior furnishings from UV damage.

**Art Galleries and Museums:** Artwork and artifacts are often sensitive to UV radiation. UV-protective glass is used in display cases and picture frames to safeguard valuable items from fading and deterioration.

**Automotive:** Some car windshields and windows are equipped with UV-protective coatings to reduce UV exposure for passengers and protect the vehicle's interior.

**Eyewear:** Many sunglasses and prescription eyeglasses incorporate UV-protective coatings to shield the eyes from harmful UV rays.

**Greenhouses:** UV-protective glazing materials are used in greenhouses to control the amount of UV radiation that reaches plants, preventing damage and providing optimal growing conditions.

**Benefits of UV-Protective Glass:**

Protects against UV-related health issues, such as sunburn and skin cancer.

Extends the lifespan of interior furnishings, fabrics, and artwork by reducing fading and degradation.

Maintains a more comfortable and cooler indoor environment by blocking excess heat associated with UV radiation.

Preserves the quality and color of items displayed in museums, galleries, and retail spaces.

Enhances the energy efficiency of buildings by reducing the need for air conditioning in sunny climates.

UV-protective glass is available in various grades and configurations to meet specific needs and budgets. When choosing UV-protective glass, it's essential to consider the intended application and the level of UV protection required. Additionally, regular maintenance and cleaning of UV-protective glass can help ensure its continued effectiveness in blocking UV radiation.

## Polaroid camera

A Polaroid camera is an instant camera that was popular in the 20th century for its ability to develop and print photographs immediately after taking a picture. The company Polaroid Corporation, founded by Edwin Land, was known for its innovative technology that allowed users to capture a moment and have a physical photograph in their hands within minutes.

Polaroid cameras used a type of instant film that contained all the necessary chemicals for developing a photo. When you took a picture, the film would come out of the camera, and you would need to wait a few moments for the image to develop. The iconic white-bordered photographs produced by Polaroid cameras became a staple of instant photography.

The construction and working of a typical Polaroid camera:

**Lens and Shutter:** The lens allows light to enter the camera and focuses it onto the film. The shutter controls the exposure by opening and closing to allow light to hit the film.

**Viewfinder:** The viewfinder helps you compose the shot by showing you the approximate framing of the image.

**Film Compartment:** This is where the instant film pack is inserted. The film pack contains multiple layers, including the film, a reagent pod, and the negative.

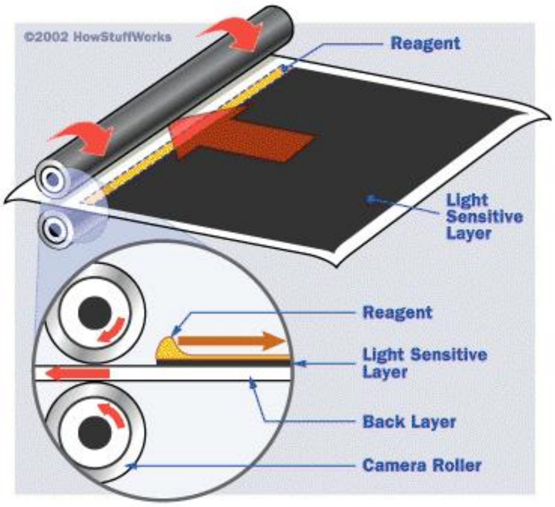
**Film Exposure and Processing:**

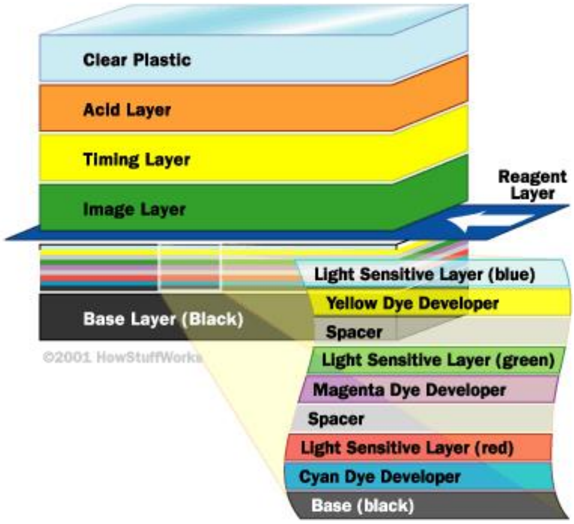
a. When you press the camera's shutter button, the shutter opens briefly, allowing light to pass through the lens and expose the film.

b. The exposed film passes through rollers inside the camera, spreading a chemical mixture contained in a pod evenly over the film.

c. The chemicals in the pod interact with the chemicals in the film to initiate the development process.

**Film Development:** Polaroid colour film has a larger number of active layers, including a blue-sensitive silver halide emulsion backed by a layer consisting of a yellow dye–developer compound, a green-sensitive layer backed by a layer of magenta dye–developer, and a red-sensitive layer backed by a cyan dye–developer. The dye–developer in each case consists of dye molecules (not colour couplers) chemically linked to developing agent molecules.




After exposure and activation by the alkaline jelly, the dye–developer molecules in each layer migrate into the adjacent silver halide layer. Development of exposed silver halide to a negative image anchors the dye–developer molecule in position. Dye–developer molecules in unexposed image areas are not used up by development but migrate into the receiving layer of the positive material. There they are immobilized, remaining as dye images corresponding to a positive of each silver halide layer in the negative film. The dyes thus re-create a full-colour positive image. The process depends on the controlled diffusion of the dye–developer molecules, achieved by spacing layers and balanced exposure and development time. Developing takes about one minute. Polacolor films include an 8 × 10-inch material for regular studio and view cameras (with separate processing machinery) and giant formats of 20 × 24 inches or even larger for special cameras.

**Image Emerges:** As the film continues to move through the camera, the image starts to appear on the film. This is a chemical reaction that creates the visible picture.

**Photo Ejection:** After a specified development time, the camera ejects the photograph from the front of the camera. The photograph is still wet and will need some time to fully dry.

**Image Protection:** To protect the developing photograph from exposure to light, many Polaroid cameras come equipped with a cover or shield that is removed after the photo is ejected.

The Polaroid camera's ability to produce an instant photograph without the need for external processing made it popular for quick and tangible image capture. Users could watch the image develop in front of their eyes and have a physical print in a matter of minutes.

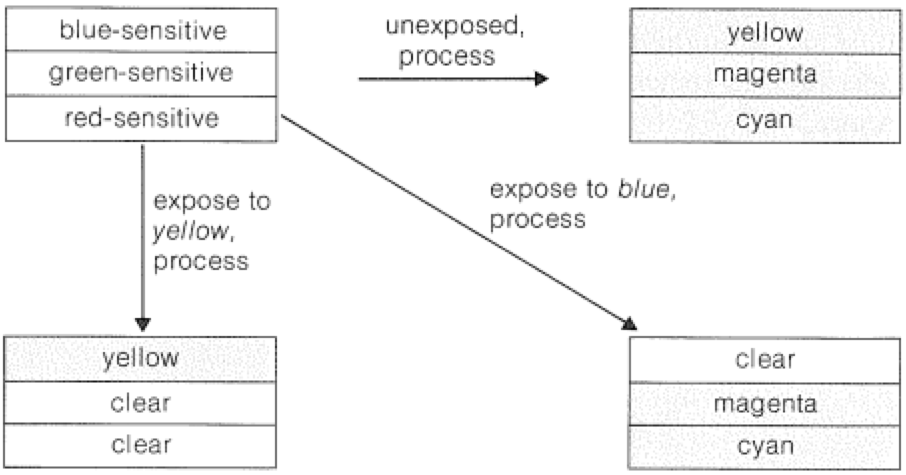
It's important to note that the specific construction and workings of Polaroid cameras may vary based on the model and technology used, but the fundamental principle of instant film development remains consistent.

## Colour photography

Colour photography is a method of capturing and reproducing images with the full spectrum of colors visible to the human eye. Unlike black and white photography, which records only shades of gray, color photography allows for the representation of a wide range of colors, making it the most common and popular form of photography.

The process of color photography involves capturing and recording the colors present in the scene. There are several methods for achieving this, with the most common being the use of color film or digital sensors.

The sensation of full colour in color transparencies produced by photographic means is achieved by *subtraction*. As a simple example, let us suppose that the subject to be photographed is blue. To obtain a blue image by shining white light through a transparency, the transparency is made to subtract (absorb) yellow light - that is, to absorb strongly in the 580nm region.




Schematic representation of the layer structure of color film and the color changes that occur on development

The emulsion of a typical color film has three silver-bromide layers separately sensitized by suitable dyes to blue, green, and red light. When processed, the color formed in each layer is *complementary* to the color to which the layer is sensitive. Thus, if *unexposed* film is processed, intense yellow, magenta, and cyan colors are respectively formed in the blue-, green-, and red-sensitive layers. Then, when white light strikes this processed film, the yellow layer subtracts the blue, the magenta subtracts the green, and the cyan subtracts the red, with the result that the film appears black, as corresponds to *no* exposure to light. However, if the film is exposed to strong blue light *before* processing, the blue-sensitive layer responds, and when the film is processed, no yellow dye is formed in the blue-sensitive layer. The transparency then contains only the subtraction colors, magenta and cyan. When white light enters a transparency of superimposed magenta and cyan dyes, only blue light is transmitted, as befits the color of the original sensitizing light. Similarly, exposure of the film to strong yellow light (containing no blue), followed by processing, results in formation of yellow dye and no magenta nor cyan. This is because the green- and red-sensitive emulsions both are sensitive to yellow light, while the blue-sensitive emulsion does not respond to yellow light.

In summary, the overall process from color film to the projection of a color image involves two separate conversions of each color into its complement, the net result being an image that has the same colors as the original subject.

**1. Color Sensitivity:** Color photography relies on the principle that different materials and technologies can be sensitive to different wavelengths of light. In color film and digital sensors, this sensitivity is typically achieved using a combination of three primary colors: red, green, and blue.

**2. Color Filters:** In color film, there are typically three layers of emulsion, each sensitive to one of the primary colors. In digital sensors, a pattern of color filters is used, usually in a Bayer filter pattern, where each pixel is filtered to capture either red, green, or blue light.

**3. Capture of Color Information:**

In color film photography, the three layers of emulsion are exposed to light, and each layer records the light that corresponds to one primary color.

In digital photography, the sensor records the intensity of red, green, and blue light for each pixel.

**4. Color Separation:** After the image is captured, color separation is performed to extract the information for each of the primary colors. This is done through chemical processes in color film or digital processing in the case of digital photography.

**5. Color Blending:** In color film, dyes that correspond to the primary colors (cyan, magenta, and yellow) are used to create the final color image through a subtractive color process. In digital photography, software blends the red, green, and blue color channels to produce a full-color image.

**6. Color Printing or Display:** Once the color image is created, it can be printed or displayed on a screen. In color printing, various methods are used, such as inkjet or photographic prints, to reproduce the colors accurately. In digital displays, each pixel is illuminated with the appropriate combination of red, green, and blue light to create the desired colors.

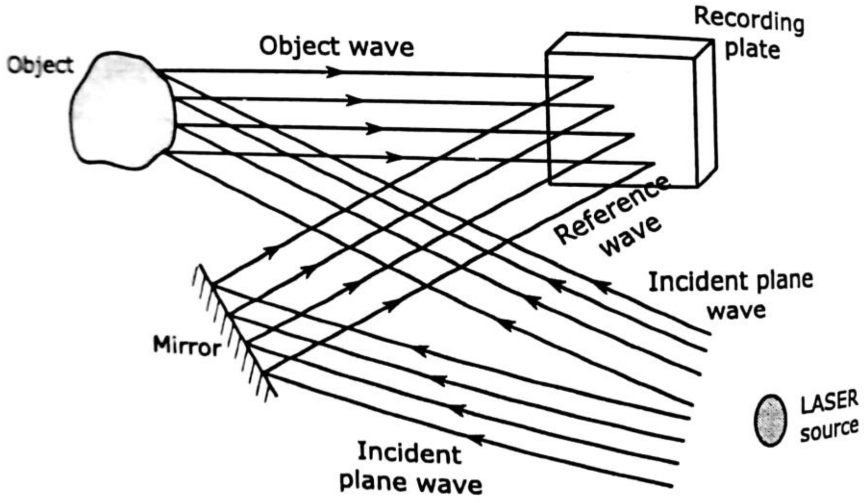
Color photography has been a significant advancement in the field of photography, allowing for more realistic and visually appealing representations of the world. It has evolved over time, from early color processes like Autochrome and Kodachrome to the digital photography technology used in modern cameras and smartphones. Color photography has become an integral part of our visual culture, used in art, journalism, advertising, and everyday life.

## Holography

Holography is a technique for creating three-dimensional (3D) images, known as holograms, that appear to be lifelike and have depth when viewed. In conventional photography , a negative is made first and using it a positive print is produced later. The positive print is only a 2D record of light intensity received from 3D object. Only intensity of light recorded and information of phase is lost. Denis Gabor introduced a new technique where intensity and phase both are recorded. This technique is called holography. Holography is done in two stages:

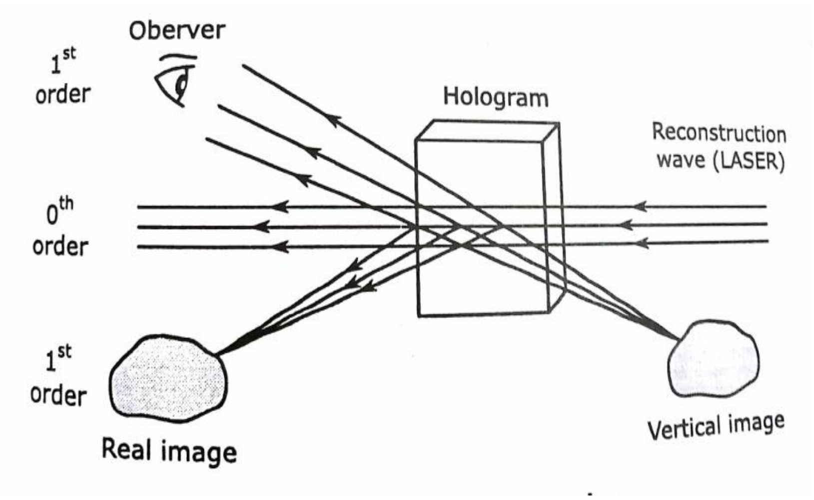
**1.Construction of image(freezing)**

A weak but broad beam of laser light is splitted into two beams by means of beam splitter. One beam directly goes to the photographic film is called as reference beam and second beam illuminates the object called as object beam. The light scattered by the object moves towards the photographic plate and interferes with the reference beam. The photographic plate carrying complex interference pattern of the object is called hologram. The object is stored in the hologram in the form of interference pattern. Whenever required the object can be viewed by illuminating the hologram as shown in the figure below-




**2.Reconstruction (unfreezing)**:

A laser beam identical to the reference beam is used for reconstruction of the object. This read out beam illuminates the hologram at the same angle as the reference beam. The hologram acts as a diffraction grating and secondary waves from hologram interferes constructively in certain directions and destructively in other directions. They form a real image in front of the hologram and a virtual image behind the hologram at the original site of the object. An observer sees light waves diverging from the virtual image. An image of the object appears where the object once stood and the image is identical to what our eyes would have perceived in all its details of the object.




**Application:**

- Hologram is reliable medium for data storage
- Hologram is used in concerts
- Hologram are used for authentication
- Holograms are used in exhibitions to avoid possible thefts.

## LASER

A laser, which stands for "Light Amplification by Stimulated Emission of Radiation," is a device that emits a highly focused and coherent beam of light. Unlike conventional light sources, lasers produce light through a process that involves the stimulation of atoms or molecules to emit photons in phase with one another. This coherent and intense light has numerous practical applications in various fields.

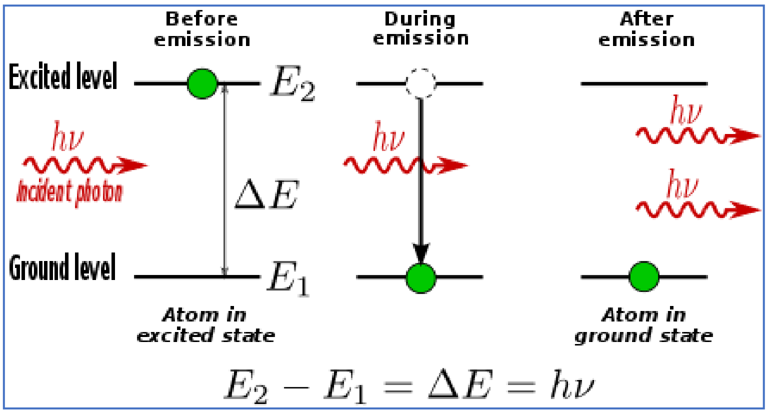
The output of a laser is a coherent electromagnetic field. A laser is created when electrons in the atoms in optical materials like glass, crystal, or gas absorb the energy from an electrical current or a light.

Light moves in waves. Ordinary visible light, say from a household light bulb or a flashlight, comprises multiple wavelengths, or colors, and are incoherent, meaning the crests and troughs of the light waves are moving at different wavelengths and in different directions.

In a laser beam, the light waves are "coherent," meaning the beam of photons is moving in the same direction at the same wavelength. This is accomplished by sending the energized electrons through an optical "gain medium" such as a solid material like glass, or a gas.

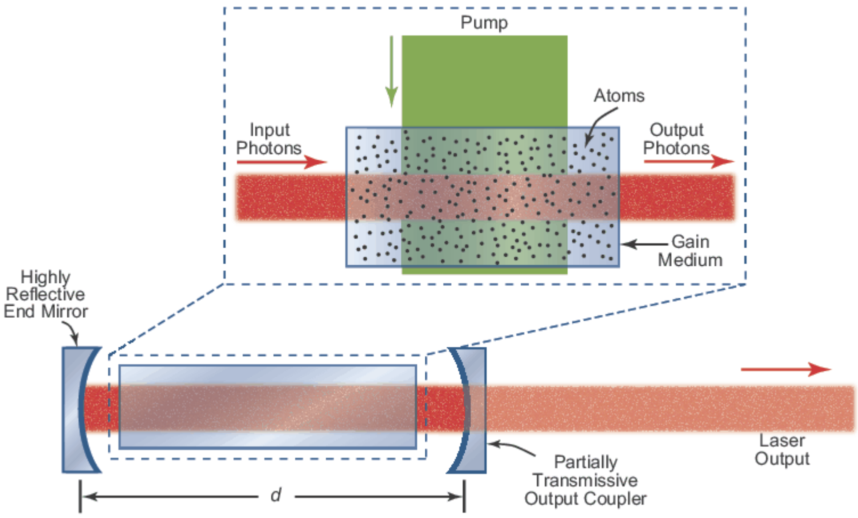
The particular wavelength of light is determined by the amount of energy released when the excited electron drops to a lower orbit. The levels of energy introduced can be tailored to the material in the gain medium to produce the desired beam color.

A mirror on one side of the laser's optical material bounces the photon back toward the electrons. The space between mirrors, or the "cavity," is designed so the photon desired for the particular type of optical gain medium are fed back into the medium to stimulate the emission of an almost exact clone of that photon. They both move in the same direction and speed, to bounce off another mirror on the other side to repeat the cloning process.



Two become four, four become eight and so on until the photons are amplified enough for them to all move past the mirrors and the optical material in perfect unison. Think of them as synchronized members of a marching band in the Rose Parade. And that unison gives the laser its power. Laser beams can stay sharply focused over vast distances, even to the moon and back.

Some lasers, such as ruby lasers, emit short pulses of light. Others, like helium–neon gas lasers or liquid dye lasers, emit light that is continuous. NIF, like the ruby laser, emits pulses of light lasting only billionths of a second. Laser light does not need to be visible. NIF beams start out as invisible infrared light and then pass through special optics that convert them to visible green light and then to invisible, high-energy ultraviolet light for optimum interaction with the target.




**Active Medium:** A laser has an active medium, which can be a gas, liquid, or solid material. This medium contains atoms or molecules capable of undergoing stimulated emission. Stimulated emission is a quantum process in which an atom, when excited by external energy, releases a photon of a specific wavelength while preserving the energy and phase of the incoming photon.

**Energy Input:** Energy is applied to the active medium, typically through a process called optical pumping. This can be achieved using electrical discharges, flash lamps, or other lasers, depending on the type of laser.

**Population Inversion:** Optical pumping excites the atoms or molecules in the active medium, causing them to reach a state of population inversion. This means that there are more atoms or molecules in an excited state than in the ground state.

**Stimulated Emission:** Photons passing through the active medium stimulate excited atoms or molecules to emit additional photons. These emitted photons are coherent with the stimulating photons, meaning they have the same frequency, phase, and direction. This results in the amplification of light.

**Resonator Cavity:** The laser cavity consists of mirrors at each end of the active medium. One mirror is fully reflective, while the other is partially reflective. This forms an optical resonator that allows light to bounce back and forth, amplifying the light through multiple passes.

**Laser Emission:** When the amplified light reaches a threshold intensity, it is emitted through the partially reflective mirror. This emitted light is a highly focused and coherent beam, commonly referred to as a laser beam.

Characteristics of laser light:

- Monochromatism
- Superior Collimation

- High Coherence
- High Output

Using these characteristics of lasers, they are applied in various fields such as optical communication and defence.

**Applications of Lasers:**

Lasers have a wide range of applications, including:

**Communication:** Lasers are used in fiber optics for high-speed data transmission and telecommunications. They also play a role in laser communication systems used in space.

**Medicine:** Lasers are employed in medical procedures such as laser surgery, eye surgery (LASIK), and dermatology for skin treatments. They can be used to cut, coagulate, and vaporize tissue with precision.

**Scientific Research:** Lasers are essential tools for a wide range of scientific experiments and research, including spectroscopy, laser cooling of atoms, and studying quantum phenomena.

**Military and Defense:** Lasers are used in range finders, target designators, and as weapons systems, including laser-guided munitions.

**Measurement and Metrology:** Lasers are used for precision measurements in applications like interferometry, laser rangefinders, and laser scanning for 3D mapping.

**Environmental Monitoring:** Lasers are used in lidar systems to measure atmospheric conditions and study environmental processes.

# Unit III

# PHYSICS OF HOME APPLIANCES

## FAN

A fan is a mechanical device that creates airflow to provide ventilation, cooling, or circulation of air in various applications, such as homes, offices, industrial settings, and electronics. Fans work by using the principle of fluid dynamics, where the movement of the fan blades creates a pressure difference that propels air from one area to another.

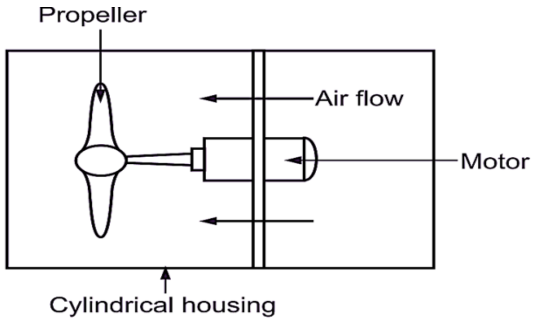
### Construction

The heart of an electric fan is its motor. It typically consists of a coil of wire (rotor) that spins inside a fixed magnetic field when an electric current passes through the coil. The motor is usually located at the center of the fan housing.

The blades or impeller are mounted on the shaft of the motor. These blades are designed to capture and move air. The shape and angle of the blades determine the efficiency and direction of airflow.

The blades are enclosed within a fan housing. This housing not only provides protection but also helps direct the airflow in a specific direction. The housing often includes vents or grilles to control the path of the air.

The fan is usually attached to a base and stand that allows it to be placed on a flat surface or mounted at a desired height. Some fans also come with oscillating mechanisms that allow the fan to rotate from side to side, increasing the area covered by the airflow.




When the fan is plugged into an electrical outlet or powered by batteries, electric current flows through the motor's coil.

The electric current creates a magnetic field around the coil. This magnetic field interacts with the fixed magnetic field inside the motor, causing the coil (rotor) to rotate.

As the motor's rotor spins, it turns the shaft to which the fan blades are attached. The blades are shaped in such a way that they create an area of low pressure on one side and high pressure on the other side as they move through the air.

The pressure difference created by the spinning blades causes air to move from the high-pressure side (behind the fan) to the low-pressure side (in front of the fan). This movement of air generates the airflow that we feel as a breeze.

The housing and design of the blades determine the direction and focus of the airflow. Some fans are designed to provide a straight stream of air, while others may oscillate to cover a larger area.

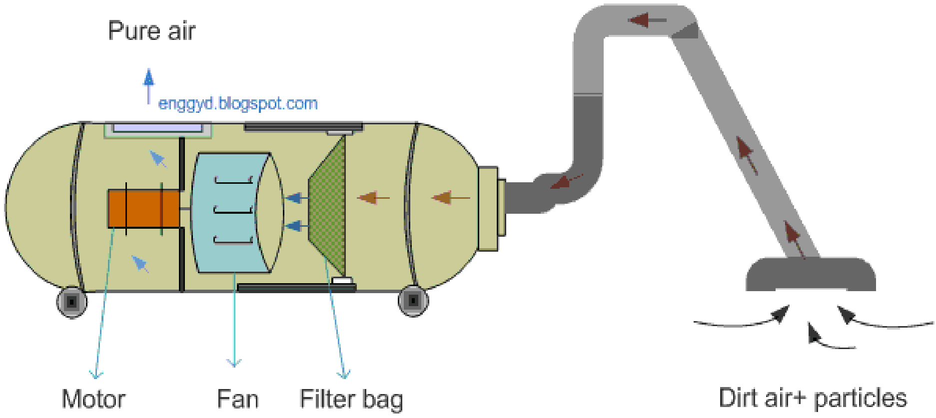
The generated airflow helps in cooling by promoting heat exchange and evaporative cooling. Fans also aid in ventilation by circulating fresh air and removing stagnant or hot air from a space.

**Applications:**

- Fans are used in vehicles to cool engines, radiators, and air conditioning systems, ensuring optimal performance and preventing engine overheating.
- Fans are integral components of heating, ventilation, and air conditioning (HVAC) systems. They help distribute conditioned air throughout buildings and contribute to efficient temperature control.
- Electric fans are often incorporated into electronic devices like computers, servers, and gaming consoles to prevent overheating and extend the lifespan of components.

## Vacuum Cleaner

Dust in the house contains the bacteria, fungal, allergic particles, mist, and environmental contaminants like perfluorooctanoic acid (PFOA), carbon dioxide, nitrous and sulfur oxides. Environmental contaminant concentration increases drastically in cities and metros due to the automobiles. A vacuum cleaner is one of the solutions to get a clean environment in the house. It helps in reducing the allergic environment in the house. Microfiltration bags used in the modern vacuum cleaner have the ability to capture 99% of the dust particles of size up to 0.3 microns.




The three key components need to be addressed when we are talking about vacuum cleaner explanation and these are the motor and fan, filters, and the suction hose and nozzle.

**Motor and Vacuum Cleaner Fan**

At the heart of every vacuum cleaner working model is an electric motor that drives a fan. The motor spins the vacuum cleaner fan, which creates a powerful suction force that pulls in air and any debris in its path. The air and debris are then pushed through a series of filters before being released back into the room.

Vacuum cleaner suction power is determined by the strength of the motor and the design of the fan. Motors are typically rated in watts, with higher-wattage motors producing more suction power. Similarly, a vacuum cleaner fan can be designed in different ways to maximize suction power while minimizing noise and energy consumption.

**Filters**

Filters play a critical role in a vacuum cleaner's ability to capture and contain dust and other airborne particles. They prevent these particles from being released back into the room, where they can be breathed in by occupants. There are several types of filters commonly used in vacuum cleaners, including:

**HEPA Filters**: These filters are designed to capture tiny particles as small as 0.3 microns in diameter, including pollen, pet dander, and other allergens. They are especially important for people with allergies or respiratory problems.

**Pre-Filters**: These filters capture larger particles before they reach the main filter, prolonging the life of the filter and improving overall performance.

**Post-Filters**: These filters capture any particles that escape the main filter, ensuring that the air released back into the room is as clean as possible.

**Suction Hose and Nozzle**

The suction hose and nozzle are the final components of a vacuum cleaner's cleaning system. The hose connects the cleaning head to the main body of the vacuum cleaner, while the nozzle is the part that comes into contact with the surface being cleaned. The nozzle is designed to create a seal with the surface, allowing the suction force to pull in dirt and debris.

**Working:**

- Materials flow from one location to another when a pressure difference is created between two locations.

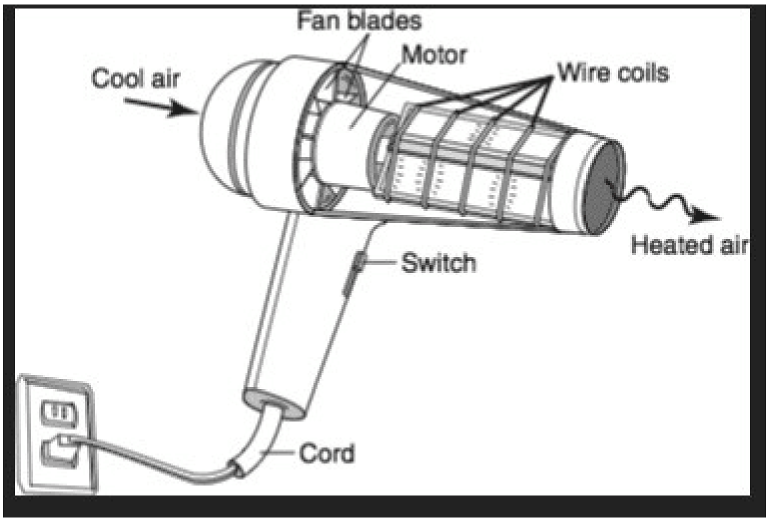
- This phenomenon is the basic working principle of an ideal vacuum cleaner. When a centrifugal fan rotates it makes the air to flow by adding it external kinetic energy.
- Air is sucked from behind and pushed forward with pressure and so negative pressure it creates behind the fan.
- An ideal vacuum cleaner has such centrifugal fan in it connected to a motor.
- This unit has suction and discharge connections, on the suction side filter bag is fitted before the hose connection.
- The discharge has another air purifier filter and opened to the atmosphere. When the electric power is given the motor rotates and so the centrifugal fan.
- Air from the suction side is sucked into the unit, along with the air all air born particles, cat allergen, mist, dirt, and small solid particles are carried to the suction filter.
- They are trapped in the filter and dirt free air is pushed out from the discharge opening.

## HAIR DRYER

A hair dryer or blow dryer is an electromagnetically device designed to blow normal or hot air over damp hair, in order to accelerate the evaporation of water particles and dry the hair. Hair dryers were invented around the end of the 19th century. The handheld, household hair dryer first appeared in 1920.

**Principle**

Normally, evaporation is controlled by relative humidity — the ratio of the amount of water the air holds to the amount it could hold. For example, if the relative humidity is 90%, that means that the air is holding 90% of its maximum volume of water. When air is heated, its relative humidity decreases. It still has the same amount of water, but it can hold more. The lower the relative humidity, the more easily water evaporates. Therefore, hot air will dry your hair faster, since the water in your hair will evaporate more quickly.




The two important components of a hair dryer are the electric fan and the heating element. The heating element is made out of nichrome wire, which is a resistor. A resistor resists the flow of electric energy, turning it into heat energy. In a hair drier, the air blows past the resistor, absorbing heat as it passes. Electric hair dryers work by blowing room temperature air in through the vents. The air then passes over nichrome wire coils that heat it, making it able to blow the hair dry with hot air. The process of air blowing on the hair speeds up water evaporation. Applying power to the hair dryer allows the motor to start spinning the fan inside, and that is what draws the air in through small air holes on the side of the dryer.

- A hair dryer operates on the principles of electric resistance heating and forced convection. When the device is turned on, electric current flows through a coiled wire or heating element within the dryer.
- This element is typically made of a high-resistance material, such as nichrome wire, which impedes the flow of electricity and generates heat in the process. The generated heat is then transferred to the surrounding air.
- Simultaneously, a motor in the hair dryer drives a fan or impeller, drawing in air from the surroundings. The heated air is then forced over the heating element and through the nozzle of the dryer.
- As the warm air comes into contact with wet hair, it accelerates the evaporation of water molecules on the hair’s surface, causing the hair to dry.
- The combination of electric heating and forced convection enables hair dryers to efficiently and quickly dry hair by manipulating the thermal energy transfer from the heating element to the surrounding air.

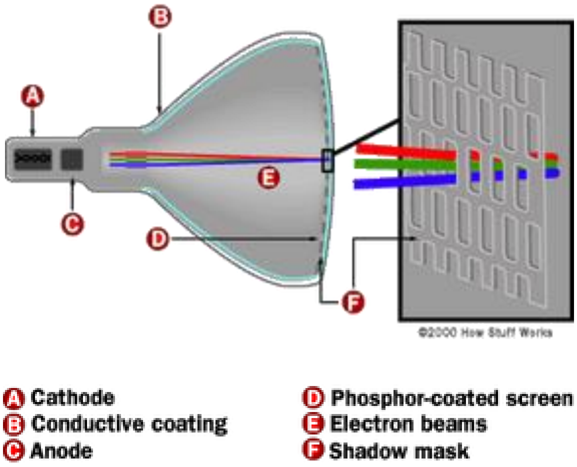
## TELEVISION

Television is a system for converting visual images (with sound) into electrical signals, transmitting them by radio or other means, and displaying them electronically on a screen. The most widely used information display device to date has been the cathode ray tube (CRT) TV.

A television basically consists of three parts: the TV camera that turns a picture and sound into a signal; the TV transmitter that sends the signal through the air; and the TV receiver (the TV set in the home) that captures the signal and turns it back into picture and sound. TV creates moving pictures by repeatedly capturing still pictures and presenting these frames to your eyes quickly that they seem to be moving. The images are flickering on the screen so fast that they fuse together in your brain to make a moving picture.

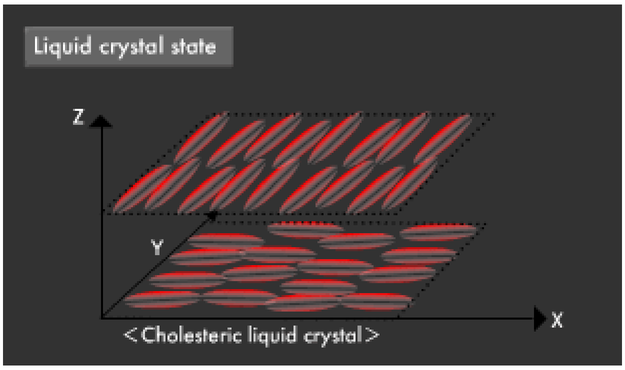
The CRT in a TV is a glass vacuum tube. The inner surface of the screen is coated with tiny phosphor dots that emit light in the three primary colors (red, green, and blue). These phosphor dots glow when struck by an electron beam, resulting in the images we see on screen. The electron beam is a focused stream of electrons pouring off an electrode to which negative voltage is being supplied.

The electrons emitted from the so-called electron gun strike the phosphor dots, causing them to glow. Deflection coils that create magnetic fields are used to enable the electron beam to strike any phosphor dot on the screen. The CRT TV has 525 scan lines on the screen. The electron gun "draws" odd lines, followed by even lines, 60 times a second. In short, we perceive the three glowing primary colors produced by the electron gun's drawing process as a continuous image. The drawbacks of CRT TVs are the high voltage required to emit electrons and the large, heavy devices they require, such as the electron gun. Furthermore, in order for the scanning lines to travel over large screen areas, a certain distance is required between the electron gun and the screen, effectively limiting how thin CRT TVs can be made.




**LCD displays**

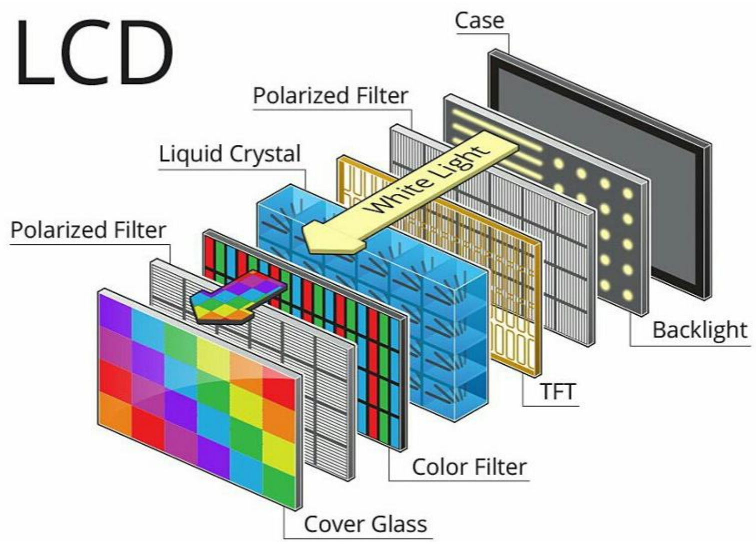
Liquid crystal was discovered in 1888 by Austrian botanist Friedrich Reinitzer (1857-1927).




While he was observing cholesteryl benzoate, Reinitzer noticed that it went through two stages. At 14 degrees Celsius, it went from a solid to a cloudy fluid (liquid crystal), and at 179 degrees Celsius it became a clear liquid. It was later learned that such state changes were due to the change in the arrangement of molecules within substances. A liquid consists of molecules that flow and are in a random state. When a liquid becomes a solid, the molecules lose their fluidity and fall into an orderly arrangement.

In liquid crystal state, molecules are arranged with moderate but not complete regularity. LCDs employ this liquid crystal property.

LCDs produce images by using liquid crystals to either transmit or block light. Liquid crystals used in displays must have their molecules arrange in an orderly fashion at room temperature and also react sensitively to voltage, changing their orientation. Liquid crystal molecules have a rod-like shape. Explained simply, when these rods are arranged horizontally, light from the bottom cannot pass through. When they are arranged vertically, however, light can pass through. The angle at which the rods are arranged defines the level of brightness in between. Using voltage to control the way these rods are arranged is the basic principle behind LCDs.

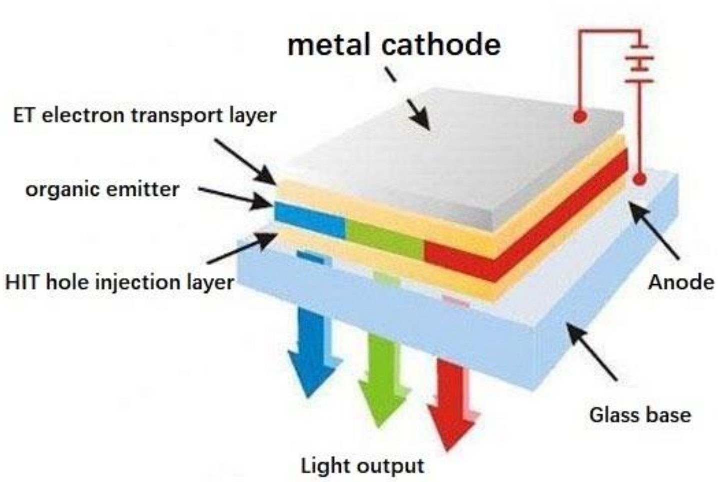



The structure of LCDs is a combination of liquid crystals sandwiched between two clear panels and polarizing filters that allows light to pass through in only one direction. The light source is a lamp positioned behind the display. Fluorescent lamps are commonly used in direct-view displays. The polarizing filter can pass only the light component from the light source that is parallel to the direction of its axis, and the molecular arrangement of liquid crystals determines whether that light passes through them or is blocked. This structure can represent white/black by turning power on/off. Adding red, green, and blue filters enables display in color.

**OLED Displays**

The principle used for emitting light in displays varies depending on the format. Liquid crystal displays require a white light source as a backlight in addition to the material used (liquid crystal). Cathode ray tubes emit light using accelerated electrons. Plasma displays use ultraviolet light emitted by electric discharges. If it were possible to emit RGB light by applying a current to a combination of materials with different properties like an LED, it may be possible to create a display in which each element emits its own light with very little electrical energy.

There is much anticipation that OLED (Organic Light Emitting Diode) displays will serve as such self-emitting displays. The material used is an organic compound.



Organic compound refers to compounds (other than CO, $CO_2$, etc.) containing carbon (C), and a typical example of a familiar organic compound is plastic. It is also possible to create inorganic light emitting diode displays using inorganic compounds, but as they would not operate stably for prolonged periods when using a direct current, the practical application of OLED displays that include materials that are able to operate with low-voltage direct currents has begun.

The structure of an OLED display is shown below. When voltage is applied between the electrodes on both sides (negative electrode and positive electrode), the electrons emitted by the negative electrode are injected into the emission layer by the electron injection transport layer. Meanwhile, on the positive electrode side, the "holes" created by the removal of electrons are injected into the emission layer by the hole injection transport layer. Electrons and holes enter an excited state when recombined in the emission layer, and light is emitted when they return to their ground state. The color emitted is determined by the wavelength of the light emitted by the substance used as the material.

# Unit IV

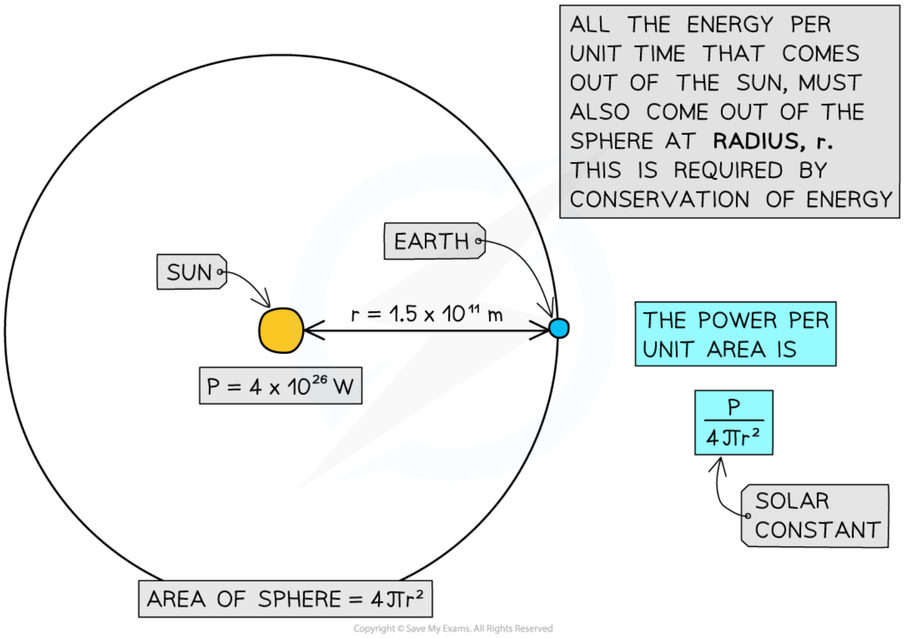
# Solar Energy

## Solar constant

The solar constant is a fundamental physical constant that represents the amount of solar electromagnetic radiation (solar irradiance) received at the outer atmosphere of Earth on a unit area that is perpendicular to the Sun's rays. It is a measure of the Sun's power output and serves as a standard value for the amount of solar energy reaching the Earth's upper atmosphere on a unit area.

The accepted value for the solar constant is approximately 1361 Watts per square meter ($W/m^2$). This means that for each square meter of the Earth's surface that is perpendicular to the Sun's rays and located at the outer atmosphere, it receives an average of 1361 Watts of solar energy.

It's important to note that the solar constant is not truly constant over time because the Sun's output can vary slightly due to solar activity cycles and other factors. However, for most practical purposes, 1361 $W/m^2$ is a reasonable average value to use when estimating solar energy availability for solar power applications on Earth.




The "constant" is fairly constant, increasing by only 0.2 percent at the peak of each 11-year solar cycle. Sunspots block out the light and reduce the emission by a few tenths of a percent, but bright spots, called plages, that are associated with solar activity are more extensive and longer lived, so their brightness compensates for the darkness of the sunspots. Moreover, as the Sun burns up its hydrogen, the solar constant increases by about 10 percent every billion years.

To measure the solar constant and not just the visible light, the entire spectrum of electromagnetic radiation is included in it. From the satellites, the solar constant is taken at the best direct measurements. To calculate a solar constant, the Stefan-Boltzman constant is used. In this case, the constant refers to the power per unit area emitted by a black body as a function of its thermodynamic temperature.

The Dimensional formula for solar constantThe solar constant is the incident ray of solar energy per unit area per second on the earth surface.Solar constant = Energy / (Unit area x Unit time) = $ML^2T^{-2}$ / ($L^2T$) = $MT^{-3}$

## General Applications of Solar Energy

Solar energy has a wide range of applications across various sectors, and its use continues to grow as technology advances and environmental concerns become more prominent. Here are some general applications of solar energy:

**Electricity Generation:**

Solar Photovoltaic (PV) Systems: Solar panels convert sunlight directly into electricity. These systems are commonly used for residential, commercial, and utility-scale electricity generation.

Concentrated Solar Power (CSP): CSP systems use mirrors or lenses to concentrate sunlight onto a receiver to generate high-temperature heat, which is then used to produce electricity through steam turbines.

**Heating and Cooling:**

**Solar Water Heaters:** Solar thermal collectors heat water for domestic use, swimming pools, and space heating.

**Solar Air Conditioning:** Solar energy can power absorption or desiccant-based cooling systems, reducing the energy needed for air conditioning.

**Solar Cooking and Drying:**

Solar Cookers: Solar ovens and cookers use concentrated sunlight for cooking food without the need for traditional fuel sources.

Solar Dryers: Solar dryers can be used to dry crops, fruits, and other products efficiently.

**Off-Grid Power:**

Remote Power Supply: Solar power is essential in off-grid areas, providing electricity for lighting, communications, and medical equipment.

Portable Solar Chargers: Portable solar panels and chargers are used for camping, hiking, and charging small electronic devices.

**Transportation:**

Solar Vehicles: Some electric vehicles (EVs) incorporate solar panels on their roofs to partially recharge the battery while parked or driving.

Solar-Powered Boats: Solar panels on boats and ships help power onboard electronics and reduce fuel consumption.

**Water Pumping:**

Solar Water Pumps: Solar-powered water pumps are used for irrigation, livestock watering, and supplying clean drinking water in remote areas.

**Space Applications:**

Spacecraft and Satellites: Solar panels are commonly used on spacecraft to provide power in outer space.

**Street Lighting:**

Solar Street Lights: Solar-powered streetlights store energy during the day and illuminate streets and public areas at night.

**Emergency and Disaster Relief:**

Solar Generators: Portable solar generators provide a source of electricity during power outages and emergencies.

**Environmental Monitoring:**

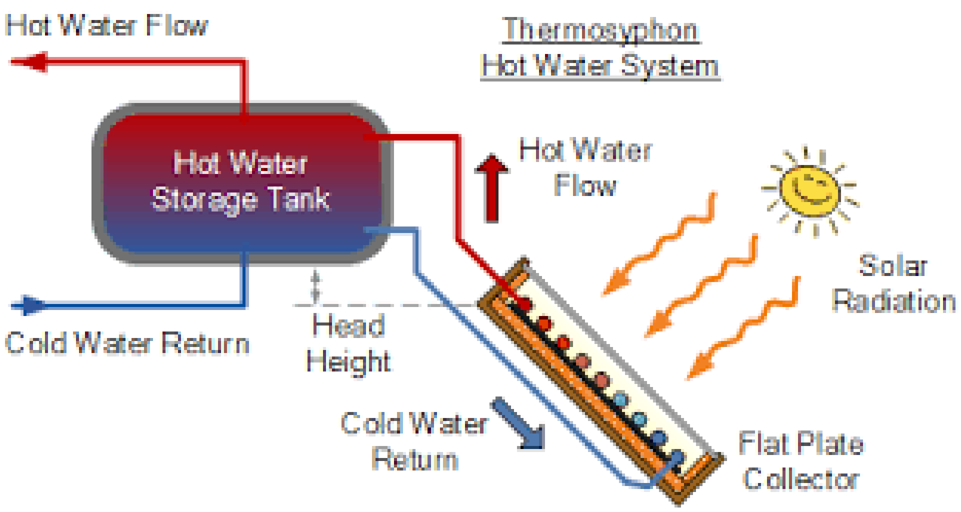
Remote Sensing: Solar-powered sensors and monitoring equipment are used in environmental research and data collection.

**Grid Integration:**

Net Metering: Excess electricity generated by solar PV systems can be fed back into the grid, reducing energy bills and supporting grid stability.

## SOLAR WATER HEATER

A solar water heater operates on the principle of harnessing solar energy to heat water for domestic or industrial use. The construction and working of a solar water heater involve several key components and processes.




**Components of a Solar Water Heater:**

**Solar Collector:** The solar collector is the heart of the solar water heater. It is responsible for capturing sunlight and converting it into heat. There are two main types of solar collectors: flat-plate collectors and evacuated tube collectors.

**Flat-Plate Collectors:** These collectors consist of a flat, insulated box with a glass or plastic cover. Inside the box, there is a dark-colored absorber plate with tubes or channels through which water or heat-transfer fluid flows.

**Evacuated Tube Collectors:** These collectors use a series of glass tubes containing an absorber plate. There is a vacuum layer between the tubes to improve insulation and heat retention.

**Heat Transfer Fluid:** In some systems, a heat-transfer fluid (usually a mixture of water and antifreeze) is used to transfer heat from the collector to the water in the storage tank. This fluid is circulated through the collector and then through a heat exchanger in the tank.

**Heat Exchanger:** The heat exchanger is a coil or series of pipes within the storage tank. It transfers the heat collected by the solar collector to the water in the tank. As the heat-transfer fluid flows through the coil, it releases its heat to the water.

**Storage Tank:** The heated water is stored in an insulated storage tank until it is needed for use. The tank is typically well-insulated to minimize heat loss.

**Circulation System :** In active solar water heating systems, a pump or circulation system is used to move the heat-transfer fluid from the collector to the heat exchanger in the storage tank. This circulation ensures efficient heat transfer.

**Working of a Solar Water Heater:**

**Solar Energy Absorption:** When sunlight strikes the absorber plate in the solar collector, it heats up. This heat is then transferred to the heat-transfer fluid (if used) or directly to the water in the collector.

**Heat Transfer to Fluid:** If a heat-transfer fluid is used, it circulates through the collector, absorbing heat and becoming hot in the process.

**Heat Exchange:** The hot heat-transfer fluid (or hot water from the collector, if no heat-transfer fluid is used) is pumped or flows through the heat exchanger in the storage tank. Heat is transferred from the fluid to the water in the tank, raising its temperature.

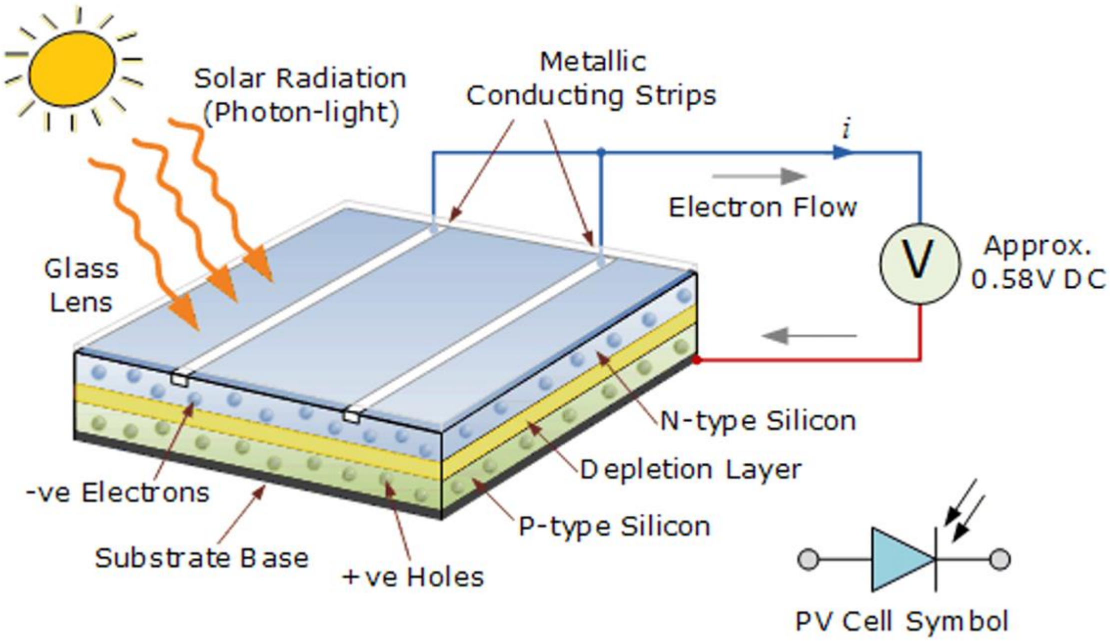
**Storage:** The hot water is stored in the insulated storage tank, ready for use when needed.

**Distribution:** Hot water from the storage tank can be distributed to domestic plumbing fixtures and appliances for various purposes, such as bathing, showering, dishwashing, and laundry.

Solar water heaters operate most efficiently when they receive direct sunlight. They are particularly effective in sunny regions, providing a sustainable and energy-efficient way to meet hot water needs while reducing energy bills and carbon emissions. Proper system design, regular maintenance, and appropriate sizing based on local conditions are essential for maximizing the performance of a solar water heater.

## SOLAR PHOTOVOLTAIC CELLS

Solar photovoltaic cells, often referred to simply as solar cells, are devices that convert sunlight directly into electricity through a process known as the photovoltaic effect. These cells are a crucial component of solar panels and play a central role in harnessing solar energy for various applications, including electricity generation, water heating, and more.




**Absorption of Sunlight**: Solar cells are typically made from semiconductor materials like silicon. When sunlight (composed of photons) strikes the surface of the solar cell, some of these photons are absorbed by the semiconductor material.

**Generation of Electron-Hole Pairs**: When a photon is absorbed, it excites an electron within the semiconductor material, causing it to move from its lower energy level (valence band) to a higher energy level (conduction band). This creates an electron-hole pair, where the electron is in the conduction band, and the hole is in the valence band.

**Electron Flow**: The presence of these electron-hole pairs creates an electric field within the semiconductor. This electric field drives the separated electrons towards the front surface of the cell and the holes towards the back surface.

**Electricity Generation**: The movement of electrons creates an electric current, which can be harnessed as electricity. This is typically achieved by placing metal contacts on the front and back surfaces of the cell to capture the electrons and provide a path for the current to flow through an external circuit.

**Inverter and Grid Connection**: The electricity generated by a single solar cell is quite small, so multiple cells are interconnected within a solar panel to produce a usable amount of electricity. The direct current (DC) electricity generated by the panels is then passed through an inverter, which converts it into alternating current (AC) suitable for use in homes or to feed into the electrical grid.

Solar photovoltaic cells come in various types, including monocrystalline, polycrystalline, and thin-film solar cells. Each type has its own characteristics in terms of efficiency, cost, and appearance.

Solar energy has gained significant popularity as a clean and renewable source of electricity because it produces no greenhouse gas emissions and relies on an abundant and free energy source: sunlight. It has applications ranging from small-scale residential installations to large utility-scale solar farms.

## GENERAL APPLICATIONS OF SOLAR CELLS

Solar cells, also known as photovoltaic cells, are devices that convert sunlight into electricity. They have a wide range of applications across various sectors due to their clean, renewable, and sustainable energy generation capabilities. Here are some general applications of solar cells:

**Residential Solar Power**: Solar panels installed on rooftops or in residential areas generate electricity for homes. This reduces reliance on grid electricity, lowers energy bills, and decreases carbon emissions.

**Commercial Solar Power**: Businesses and commercial facilities use solar panels to generate electricity and reduce operating costs. It's an environmentally friendly way to power offices, factories, and other commercial spaces.

**Utility-Scale Solar Farms**: Large-scale solar power plants or solar farms consist of thousands of solar panels. They feed electricity into the grid to supply power to a wide area, serving as a significant source of clean energy.

**Remote Power Generation**: Solar cells are used in off-grid and in remote areas, cells they are connecting to a centralized power grid is impractical or costly. These applications include powering remote cabins, telecommunications equipment, and weather stations.

**Portable Solar Chargers**: Portable solar chargers and power banks are popular for charging electronic devices like smartphones, laptops, and camping equipment. They are useful for outdoor activities, emergency backup, and charging devices in areas without access to power outlets.

**Solar-Powered Water Pumps**: Solar cells can be used to power water pumps for irrigation in agriculture and to provide clean drinking water in rural or remote areas.

**Solar Street Lighting**: Solar-powered streetlights use photovoltaic panels to collect energy during the day and illuminate streets, parks, and pathways at night. They are energy-efficient and reduce the need for grid-connected street lighting.

**Solar-Powered Vehicles**: Solar cells integrated into electric vehicles (EVs) or solar-powered cars can extend the vehicle's range by harnessing sunlight to charge the battery.

**Space Exploration**: Solar panels are commonly used on spacecraft and satellites to generate electricity from the sun's energy in outer space. They provide power for scientific instruments, communication, and navigation systems.

**Solar Desalination**: Solar-powered desalination plants use solar energy to produce freshwater from seawater or brackish water, addressing water scarcity issues in coastal regions.

**Solar-Powered Ventilation**: Solar attic fans and ventilation systems use solar energy to reduce heat buildup in attics and improve energy efficiency in homes and commercial buildings.

**Solar-Powered Boats**: Solar panels on boats and marine vessels can provide power for navigation equipment, lighting, and auxiliary systems, reducing the need for fossil fuels.

**Solar-Powered Airplanes**: Some experimental aircraft use solar cells on their wings to generate electricity for propulsion or onboard systems, allowing for long-duration flights.

The applications of solar cells continue to expand as technology advances and the world seeks cleaner and more sustainable energy solutions to reduce reliance on fossil fuels.

# UNIT V

# INDIAN PHYSICIST AND THEIR CONTRIBUTION

## C.V. Raman

Sir Chandrasekhara Venkata Raman, commonly known as C.V. Raman, was an Indian physicist who made significant contributions to the field of science and technology. He is best known for his discovery of the Raman effect, which earned him the Nobel Prize in Physics in 1930.

Raman displayed an early interest in science and was a brilliant student. He attended Presidency College in Madras (now Chennai), where he obtained his bachelor's degree in physics and continued on to complete his master's degree. He then pursued further studies at the University of Cambridge and received a PhD in 1921 for his research on diffraction of light.

In recognition of his discovery of the Raman effect, C.V. Raman was awarded the Nobel Prize in Physics in 1930. He was the first Asian and the first non-white person to receive a Nobel Prize in a scientific category.

**Raman Effect:** In 1928, Raman discovered that when light passes through a transparent substance, a small fraction of the light is scattered in all directions. Most of this scattered light has the same frequency as the incident light, but a small portion of it has different frequencies due to interactions with the molecules of the material. This phenomenon became known as the "Raman effect." It provided a groundbreaking insight into the interaction of light with matter and opened up a new way of studying molecular structures and vibrations. Raman spectroscopy is widely used in various fields, including chemistry, biology, materials science, and medicine.

**Molecular Spectroscopy**: Raman's discovery of the Raman effect led to the development of a new branch of spectroscopy known as Raman spectroscopy. This technique allows scientists to analyze the vibrational and rotational modes of molecules, providing valuable information about their chemical composition and structural characteristics. Raman spectroscopy has become an essential tool in many scientific and industrial applications.

**Acoustics and Music:** Before his work in optics, Raman made contributions to acoustics and music. He conducted research on the physics of stringed instruments and the propagation of sound in various media, leading to insights into the tonal qualities of musical instruments.

**Other Contributions:** Raman made significant contributions to the understanding of the behavior of light in different mediums, including liquids and crystals. He also conducted studies on the diffraction of light and the optics of colloids. His work encompassed a wide range of topics in physics and provided a foundation for future research in various subfields.

**Scientific Leadership and Legacy:** Raman's research not only advanced the field of physics but also inspired generations of scientists in India and around the world. He established the Raman Research Institute in Bangalore, India, which continues to be a center of scientific research and education. His legacy also includes numerous awards, honors, and institutions named after him, as well as his role in promoting scientific research and education in India.

## Homi Jehangir Bhabha

Homi Jehangir Bhabha , often referred to as the "Father of the Indian Nuclear Program," was an Indian physicist who made significant contributions to science and technology, particularly in the field of nuclear physics. He played a crucial role in establishing India's nuclear research capabilities and promoting scientific education in the country.

**Early Life and Education:** Bhabha was born on October 30, 1909, in Bombay (now Mumbai), India, to a wealthy Parsi family. He showed an early aptitude for science and went on to study at Cambridge University, where he completed his doctoral studies under Nobel laureate Ralph H. Fowler.

**Founding the Tata Institute of Fundamental Research (TIFR):** Bhabha established the Tata Institute of Fundamental Research (TIFR) in Mumbai in 1945. TIFR became a pioneering institution for research in various fields of science, including nuclear physics, mathematics, and astronomy. Bhabha's vision was to create a world-class research center that would foster cutting-edge research and education in India.

**Nuclear Physics and Cosmic Rays:** Bhabha made significant contributions to the study of cosmic rays and nuclear physics. He proposed the "Bhabha Scattering," a theoretical description of the scattering of high-energy electrons by photons. This work helped to understand the interactions between particles and contributed to the development of quantum field theory.

**Nuclear Energy and the Atomic Energy Establishment:** Bhabha recognized the potential of nuclear energy for India's development and advocated for the peaceful use of nuclear technology. He played a pivotal role in establishing the Atomic Energy Establishment, Trombay (now known as Bhabha Atomic Research Centre or BARC) in 1954. BARC became the epicenter of India's nuclear research and development efforts.

**Research in Nuclear Reactors:** Bhabha's leadership at BARC led to the development of India's first nuclear research reactor, Apsara, in 1956. He also initiated the construction of the CIRUS (Canada-India Research U.S.) reactor in collaboration with Canada. These reactors paved the way for research in various fields, including nuclear physics, material science, and radiochemistry.

**Nuclear Weapon Program:** While Bhabha primarily focused on peaceful applications of nuclear technology, he also recognized the strategic importance of nuclear deterrence. He was involved in laying the groundwork for India's nuclear weapons program.

**International Collaboration:** Bhabha believed in international collaboration and cooperation in scientific research. He played a key role in establishing partnerships with international research institutions and scientists, which helped India access global expertise and resources.

**Legacy and Recognition:** Bhabha's contributions to science and technology earned him recognition both in India and internationally. He received numerous awards, including the Adams Prize from the University of Cambridge and the Padma Bhushan from the Government of India.

**Unfortunate Passing:** Tragically, Bhabha's life was cut short in 1966 when he died in a plane crash near Mont Blanc in the Alps. Despite his untimely death, his legacy and contributions continue to influence India's scientific landscape.

## Vikram Sarabhai

Vikram Ambalal Sarabhai (1919–1971) was an Indian scientist, visionary, and innovator who is often referred to as the "Father of the Indian Space Program." He played a pivotal role in shaping India's space research and development efforts and made significant contributions to science, technology, and education.

**Early Life and Education:** Vikram Sarabhai was born on August 12, 1919, in Ahmedabad, India. He hailed from a prominent industrialist family. He pursued his education in India and abroad, obtaining degrees in natural sciences and engineering.

**Establishment of ISRO:** Sarabhai was instrumental in establishing the Indian Space Research Organisation (ISRO) in 1969. He recognized the potential of space technology for India's development and worked tirelessly to make India self-reliant in space-related activities.

**Space Research and Satellite Programs:** Under Sarabhai's leadership, ISRO initiated a series of successful satellite programs that brought communication, meteorology, and remote sensing capabilities to India. The launch of India's first satellite, Aryabhata, in 1975, marked a significant milestone in the country's space journey.

**Thumba Equatorial Rocket Launching Station:** Sarabhai founded the Thumba Equatorial Rocket Launching Station (TERLS) in Thumba, Kerala, in 1962. It became a center for launching sounding rockets to study the Earth's upper atmosphere.

**Nehru Planetarium and Science Education:** Sarabhai was passionate about science education and popularization. He established the first Nehru Planetarium in Mumbai in 1977 to promote astronomy and space science among the general public and students.

**Atomic Energy Commission**: Apart from his contributions to space science, Sarabhai also played a role in India's atomic energy program. He was a member of the Atomic Energy Commission of India and contributed to the peaceful applications of atomic energy.

**Multidisciplinary Research:** Sarabhai's interests extended beyond space and atomic energy. He encouraged research in various scientific disciplines and aimed to integrate science and technology for societal progress.

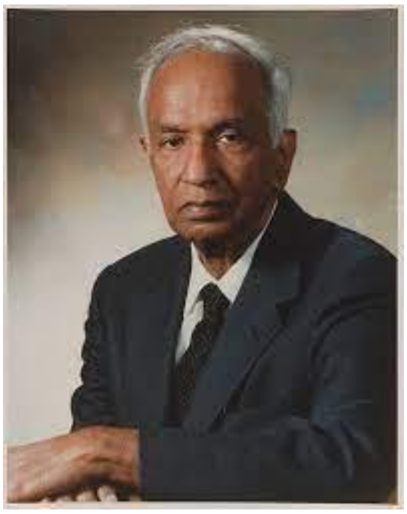
**International Collaborations:** Sarabhai believed in collaboration and cooperation with international space agencies and organizations. He emphasized the importance of peaceful uses of space technology for the betterment of humanity.

**Recognition and Legacy:** Vikram Sarabhai received numerous awards and honors, including the Padma Bhushan. His vision, dedication, and leadership laid the foundation for India's achievements in space exploration. His legacy continues through ISRO's ongoing missions and advancements.

**Passing:** Tragically, Vikram Sarabhai passed away on December 30, 1971, at the young age of 52. Despite his short life, his impact on India's space program and scientific community is immeasurable.

## Subrahmanyan Chandrasekhar

Subrahmanyan Chandrasekhar (1910–1995) was an Indian-American astrophysicist who made significant contributions to our understanding of stars, particularly their structure, evolution, and behavior under gravitational forces. He is best known for his work on the structure and evolution of white dwarf stars and for formulating the Chandrasekhar limit, which describes the maximum mass a white dwarf star can have before it undergoes gravitational collapse.



**Early Life and Education:** Chandrasekhar was born on October 19, 1910, in Lahore (now in Pakistan). He came from a family of scientists and academics. He displayed an early aptitude for mathematics and physics. He studied at the University of Cambridge, where he earned his Ph.D. and conducted groundbreaking research on the behavior of stars.

**Chandrasekhar Limit:** One of Chandrasekhar's most significant contributions is the formulation of the Chandrasekhar limit in 1930. He showed that when a star exhausts its nuclear fuel and collapses under its own gravity, there is a critical mass limit (now known as the

Chandrasekhar limit) beyond which the star will continue to collapse and eventually form a white dwarf. This concept laid the foundation for understanding the later stages of stellar evolution.

**White Dwarf Structure:** Chandrasekhar's work on the theoretical structure of white dwarf stars provided insights into their properties, such as density, temperature, and pressure. He introduced the concept of electron degeneracy pressure, which supports white dwarf stars against further gravitational collapse.

**Stellar Dynamics and Black Holes:** Chandrasekhar's research extended to various aspects of stellar dynamics, including the behaviour of stars in binary systems. He also explored the concept of black holes, particularly the final stages of massive stars' evolution leading to the formation of black holes.

**Nobel Prize:** In 1983, Chandrasekhar was awarded the Nobel Prize in Physics for his groundbreaking work on the physical processes involved in the structure and evolution of stars. His research fundamentally advanced our understanding of astrophysics.

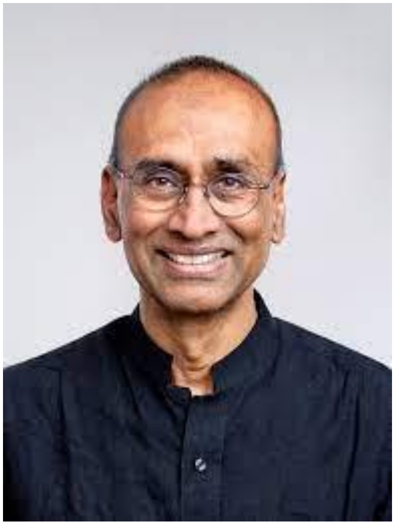
**Teaching and Influence:** Chandrasekhar held teaching positions at several prestigious institutions, including the University of Chicago, where he spent a significant part of his career. He mentored numerous students and researchers who went on to become leaders in astrophysics and related fields.

**Legacy:** Chandrasekhar's contributions continue to influence astrophysics and cosmology. His work has implications for the study of supernovae, neutron stars, black holes, and other phenomena related to stellar evolution.

**Passing:** Subrahmanyan Chandrasekhar passed away on August 21, 1995, in Chicago. His legacy lives on through his research, writings, and the impact he had on the field of astrophysics.

## Venkatraman Ramakrishnan

Venkatraman "Venki" Ramakrishnan (born April 29, 1952) is an Indian-American structural biologist who is renowned for his work on the structure and function of ribosomes, complex cellular structures responsible for protein synthesis. He was awarded the Nobel Prize in Chemistry in 2009 for his contributions to the understanding of ribosomal structure, a fundamental breakthrough in molecular biology.



**Early Life and Education:** Venki Ramakrishnan was born in Chidambaram, Tamil Nadu, India. He pursued his undergraduate studies at Baroda University and later earned his Ph.D. in physics from Ohio University in the United States.

**Structural Biology and Ribosomes:** Ramakrishnan's most significant achievement is his groundbreaking work on elucidating the structure of ribosomes at the atomic level. Ribosomes are essential cellular components responsible for translating the genetic code into proteins. Ramakrishnan's research helped unveil the detailed molecular architecture of ribosomes, providing insights into their intricate mechanisms of protein synthesis.

**Nobel Prize in Chemistry:** In 2009, Venki Ramakrishnan, along with Thomas A. Steitz and Ada E. Yonath, was awarded the Nobel Prize in Chemistry for their pioneering work on ribosomal structure. Their combined efforts greatly enhanced our understanding of how ribosomes function and opened up new avenues for drug development.

**Institute of Molecular Biology:** Ramakrishnan has held several prestigious academic positions throughout his career. He served as the Head of the Structural Studies Division at the Medical Research Council (MRC) Laboratory of Molecular Biology in Cambridge, United Kingdom.

**Promotion of Science Education and Outreach:** In addition to his research, Ramakrishnan has been a vocal advocate for science education and communication. He has emphasized the importance of fostering a scientific culture and promoting scientific literacy.

**President of the Royal Society:** In 2015, Ramakrishnan was elected as the President of the Royal Society, a highly esteemed scientific organization in the United Kingdom. As President, he focused on promoting interdisciplinary research and strengthening the role of science in society.

**Books and Publications:** Ramakrishnan is also an author and has written books that offer insights into the process of scientific discovery and the importance of research. His writings aim to inspire young scientists and educate the public about the wonders of science.

**Awards and Recognition:** In addition to the Nobel Prize, Ramakrishnan has received numerous awards and honors for his exceptional contributions to science, including knighthood by the British government.

## A.P.J.Abdul Kalam

Dr. Avul Pakir Jainulabdeen Abdul Kalam, commonly known as A.P.J. Abdul Kalam, was an Indian scientist, visionary, and statesman who served as the 11th President of India from 2002 to 2007. He was a prominent figure in Indian science and technology, known for his contributions to aerospace engineering and his commitment to education, youth empowerment, and national development.

**Early Life and Education:** Born on October 15, 1931, in Rameswaram, Tamil Nadu, India, Kalam hailed from a modest background. Despite his humble beginnings, he showed an early interest in science and technology. He pursued his education in physics and engineering, earning degrees from renowned institutions.

**ISRO and DRDO:** Dr. Kalam played a pivotal role in India's space and defense programs. He joined the Indian Space Research Organisation (ISRO) in the 1960s and was involved in the development of India's first satellite launch vehicle. Later, he contributed significantly to the Defense Research and Development Organisation (DRDO), particularly in missile development.

**Integrated Guided Missile Program:** Dr. Kalam's leadership of the Integrated Guided Missile Development Program (IGMDP) led to the successful development of indigenous missile systems like Prithvi, Agni, and Akash. His contributions bolstered India's defense capabilities and technological self-reliance.

**Nuclear Tests and National Pride:** He played a role in India's nuclear tests in 1998, which drew both international attention and domestic pride. He emphasized the peaceful uses of nuclear technology for energy and medical purposes.

**Vision 2020 and Technology for Development:** Dr. Kalam was known for his forward-looking vision of India as a developed nation by the year 2020. He believed that technology and innovation were key drivers of socio-economic progress and worked towards their integration into India's development agenda.

**Wings of Fire:** He authored the book "Wings of Fire," an autobiography that detailed his life journey, from his childhood to his achievements in the field of science and technology. The book remains an inspiration to many, especially young students.

**Presidency:** In 2002, he was elected as the President of India, serving a five-year term. He was widely regarded as the "People's President" due to his accessibility, humility, and dedication to uplifting marginalized communities.

**Education and Youth Empowerment:** He had a deep passion for education and believed that young people were the future of the nation. He frequently interacted with students, encouraging them to pursue careers in science, technology, and innovation.

**Post-Presidential Activities:** After his presidency, Dr. Kalam continued to inspire through lectures, writings, and engagements with students and the public. He remained an advocate for science, education, and societal progress.

**Passing:** Dr. A.P.J. Abdul Kalam passed away on July 27, 2015, while delivering a lecture at the Indian Institute of Management Shillong. His passing was mourned by people across India and around the world.