

# PHY101

## AN INTRODUCTION TO PHYSICS

### Important subjective

#### Lec 1 - Introduction to physics and this course

##### What is physics?

**Answer:** Physics is the study of the fundamental laws that govern the behavior of the natural world.

##### What are some of the different areas of physics?

**Answer:** Some of the different areas of physics include mechanics, electromagnetism, thermodynamics, quantum mechanics, and relativity.

##### Why is studying physics important?

**Answer:** Studying physics is important because it provides a deeper understanding of the natural world, provides a foundation for many other sciences, and can be a rewarding and intellectually stimulating experience.

##### What is the difference between mechanics and electromagnetism?

**Answer:** Mechanics deals with the motion of objects and the forces that cause that motion, while electromagnetism is concerned with the interactions between electrically charged particles and magnetic fields.

##### What is thermodynamics?

**Answer:** Thermodynamics is the study of the behavior of heat and temperature in systems.

##### What is quantum mechanics?

**Answer:** Quantum mechanics deals with the behavior of subatomic particles and the principles of uncertainty and probability.

##### What is relativity?

**Answer:** Relativity describes the behavior of objects moving at high speeds or in strong gravitational fields.

**What is typically covered in an introductory physics course?**

**Answer:** An introductory physics course typically covers the basic principles of physics, including the laws of motion, energy, and thermodynamics.

**What is a laboratory experiment in a physics course?**

**Answer:** A laboratory experiment in a physics course provides hands-on experience with physics concepts and allows students to see these concepts in action.

**What are some resources available to students who are interested in studying physics?**

**Answer:** Resources available to students who are interested in studying physics include textbooks, online resources, academic journals, and physics courses.

## Lec 2 - Kinematics – I

### What is kinematics?

**Answer:** Kinematics is the branch of physics that deals with the study of the motion of objects without considering the forces that cause that motion.

### What is displacement?

**Answer:** Displacement is the change in position of an object. It is a vector quantity, which means it has both magnitude and direction.

### What is velocity?

**Answer:** Velocity is the rate at which an object changes its position. It is also a vector quantity, and its magnitude is equal to the speed of the object.

### What is acceleration?

**Answer:** Acceleration is the rate at which an object changes its velocity. It is also a vector quantity, and its magnitude is equal to the rate of change of velocity.

### What is the equation for average velocity?

**Answer:** The equation for average velocity is  $v = \Delta x / \Delta t$ , where  $v$  is the average velocity,  $\Delta x$  is the change in displacement, and  $\Delta t$  is the change in time.

### What is the equation for average acceleration?

**Answer:** The equation for average acceleration is  $a = \Delta v / \Delta t$ , where  $a$  is the average acceleration,  $\Delta v$  is the change in velocity, and  $\Delta t$  is the change in time.

### What is free fall?

**Answer:** Free fall is the motion of an object that is falling under the influence of gravity, with no other forces acting on it.

### What is the acceleration due to gravity?

**Answer:** The acceleration due to gravity is a constant rate of 9.8 meters per second squared ( $m/s^2$ ) near the Earth's surface.

**What is the equation for velocity in free fall?**

**Answer:** The equation for velocity in free fall is  $v = gt$ , where  $v$  is the velocity,  $g$  is the acceleration due to gravity, and  $t$  is the time elapsed since the object was dropped.

**What is the equation for distance traveled by an object in free fall?**

**Answer:** The equation for the distance traveled by an object in free fall is  $d = (1/2)gt^2$ , where  $d$  is the distance traveled by the object in free fall,  $g$  is the acceleration due to gravity, and  $t$  is the time elapsed since the object was dropped.

## Lec 3 - Kinematics – II

### What is projectile motion?

**Answer:** Projectile motion is the motion of an object that is thrown, launched, or dropped near the Earth's surface and moves along a curved path under the influence of gravity.

### What are the two components of motion in projectile motion?

**Answer:** The two components of motion in projectile motion are the horizontal and vertical components.

### What is the equation of motion for projectile motion in the x direction?

**Answer:** The equation of motion for projectile motion in the x direction is  $x = x_0 + v_{0x}t$ , where  $x$  is the final position,  $x_0$  is the initial position,  $v_{0x}$  is the initial velocity in the x direction, and  $t$  is the time elapsed.

### What is the equation of motion for projectile motion in the y direction?

**Answer:** The equation of motion for projectile motion in the y direction is  $y = y_0 + v_{0y}t - \frac{1}{2}gt^2$ , where  $y$  is the final position,  $y_0$  is the initial position,  $v_{0y}$  is the initial velocity in the y direction,  $g$  is the acceleration due to gravity, and  $t$  is the time elapsed.

### What is circular motion?

**Answer:** Circular motion is the motion of an object along a circular path.

### What is centripetal force?

**Answer:** Centripetal force is the force acting on an object that causes the circular motion and is directed toward the center of the circle.

### What is the relationship between centripetal force, mass, velocity, and radius?

**Answer:** The relationship between centripetal force, mass, velocity, and radius is  $F = \frac{mv^2}{r}$ .

### What is the period of the circular motion?

**Answer:** The period of circular motion is the time taken for one complete revolution around the circle.

### What is the frequency of circular motion?

**Answer:** The frequency of circular motion is defined as the number of revolutions per unit of time.

**How are period and frequency related?**

**Answer:** Period and frequency are related by  $T = 1/f$ , where T is the period and f is the frequency.

## **Lec 4 - Force and Newton's Laws**

### **What is force in physics?**

**Answer:** Force is any influence that can cause an object to undergo a change in motion. It can be a push, a pull, or any other effect that produces acceleration.

### **What are the units of force?**

**Answer:** The units of force are newtons (N).

### **What is Newton's first law of motion?**

**Answer:** Newton's first law of motion, also known as the law of inertia, states that an object at rest will remain at rest, and an object in motion will continue to move at a constant velocity, in a straight line, unless acted upon by an external force.

### **What is Newton's second law of motion?**

**Answer:** Newton's second law of motion states that the acceleration of an object is directly proportional to the net force acting on the object and inversely proportional to its mass. Mathematically, it can be expressed as  $F = ma$ , where  $F$  is the net force,  $m$  is the mass of the object, and  $a$  is the acceleration of the object.

### **What is the relationship between force and acceleration?**

**Answer:** The greater the force applied to an object, the greater its acceleration will be, and the greater the mass of the object, the smaller its acceleration will be.

### **What is the SI unit of mass?**

**Answer:** The SI unit of mass is kilogram (kg).

### **What is Newton's third law of motion?**

**Answer:** Newton's third law of motion states that for every action, there is an equal and opposite reaction.

### **How can Newton's third law of motion be applied in everyday life?**

**Answer:** Newton's third law of motion can be seen in everyday life, such as when we walk on the ground. When we push our foot down on the ground, the ground pushes back on our foot with an equal and opposite force, allowing us to walk forward.

**What is the difference between weight and mass?**

**Answer:** Weight is the force exerted on an object due to gravity, while mass is a measure of the amount of matter in an object.

**How do Newton's laws of motion help in the design of vehicles?**

**Answer:** Newton's laws of motion are important in the design of vehicles, as they help engineers understand the forces acting on the vehicle and how it will respond to those forces. This allows for the design of safer and more efficient vehicles.

## **Lec 5 - Applications of Newton's Laws – I**

**What is Newton's first law of motion?**

**Answer:** Newton's first law of motion states that an object at rest will remain at rest, and an object in motion will remain in motion at a constant velocity unless acted upon by an external force.

**What is the law of inertia?**

**Answer:** The law of inertia is another name for Newton's first law of motion, which states that an object will resist changes in its state of motion.

**How do seat belts in cars demonstrate the first law of motion?**

**Answer:** Seat belts in cars provide an external force that acts on passengers, preventing them from moving forward and reducing the risk of injury in a sudden stop.

**What external forces are used to ensure the stability of skyscrapers?**

**Answer:** Engineers use external forces, such as dampers and braces, to counteract the motion caused by wind and earthquakes and ensure the stability of skyscrapers.

**What is Newton's second law of motion?**

**Answer:** Newton's second law of motion states that the force acting on an object is equal to its mass multiplied by its acceleration ( $F = ma$ ).

**How is Newton's second law relevant in the sport of baseball?**

**Answer:** The force applied by a pitcher to a baseball is determined by the mass of the ball and the desired acceleration, as described by Newton's second law.

**What is the principle behind rocket propulsion?**

**Answer:** The principle behind rocket propulsion is Newton's third law of motion, which states that for every action, there is an equal and opposite reaction.

**How do jet engines operate based on Newton's third law of motion?**

**Answer:** Jet engines operate by expelling exhaust gases at high speed in one direction, which propels the aircraft in the opposite direction, in accordance with Newton's third law.

**How is Newton's third law relevant in the launch of spacecraft?**

**Answer:** The force of the exhaust gases expelled from the rocket engine propels the spacecraft in the opposite direction, in accordance with Newton's third law.

**What is the significance of Newton's laws of motion in daily life?**

**Answer:** Newton's laws of motion are fundamental concepts in physics that have a wide range of applications in our daily lives, from the design of safety devices to the construction of buildings and the operation of vehicles and machinery.

## Lec 6 - Applications of Newton's Laws – II

**Explain the concept of terminal velocity.**

**Answer:** Terminal velocity is the maximum velocity that an object can achieve when falling through a fluid, such as air or water. As the object falls, the fluid resistance increases, slowing down its acceleration until the upward force due to the fluid resistance equals the downward force due to gravity. At this point, the net force acting on the object becomes zero, and the object continues to fall at a constant velocity, known as the terminal velocity.

**What is the difference between static and kinetic friction?**

**Answer:** Static friction is the force that resists the motion of an object at rest, while kinetic friction is the force that opposes the motion of an object in motion. Static friction is generally greater than kinetic friction, and it must be overcome to set an object in motion.

**Can an object be in equilibrium if it is accelerating?**

**Answer:** No, an object cannot be in equilibrium if it is accelerating. Equilibrium means that the net force acting on an object is zero, which means that the object is either at rest or moving at a constant velocity. If an object is accelerating, then the net force acting on it is not zero, and it is not in equilibrium.

**Explain the concept of tension force.**

**Answer:** Tension force is the force that is transmitted through a string, rope, cable or wire when it is pulled tight by forces acting on either end. It acts in the direction of the string, pulling the object in that direction. Tension force can be found in many situations, such as when lifting an object with a crane or pulling an object with a pulley.

**What is the relationship between mass and weight?**

**Answer:** Mass is a measure of the amount of matter in an object, while weight is a measure of the force of gravity acting on an object. The weight of an object is equal to its mass multiplied by the acceleration due to gravity. Therefore, the weight of an object will vary depending on the strength of the gravitational field it is in, while its mass will remain constant.

**How does air resistance affect the motion of an object?**

**Answer:** Air resistance is a force that opposes the motion of an object through the air. It increases as the speed of the object increases and can eventually become equal in magnitude to the force of gravity, causing the object to reach its terminal velocity. Air resistance can also affect the trajectory of an object, causing it to deviate from its expected path.

**What is the difference between elastic and inelastic collisions?**

**Answer:** In an elastic collision, the total kinetic energy of the objects involved is conserved, meaning that no energy is lost to other forms, such as heat or sound. In an inelastic collision, some or all of the kinetic energy is lost to other forms of energy. The objects may stick together after the collision, and the final velocity of the objects may be different from their initial velocities.

**What is impulse and how is it related to force and time?**

**Answer:** Impulse is the product of force and time and is equal to the change in momentum of an object. It is related to force and time because a greater force acting for a longer period of time will produce a greater change in momentum, and therefore a greater impulse.

**What is the law of action and reaction?**

**Answer:** The law of action and reaction, also known as Newton's third law, states that for every action, there is an equal and opposite reaction. This means that when one object exerts a force on another object, the second object will exert an equal and opposite force back on the first object.

**How does friction affect the motion of an object on an inclined plane?**

**Answer:** Friction opposes the motion of an object on an inclined plane

## **Lec 7 - Work and Energy**

Define work done by a force on an object.

**Answer:** Work done by a force on an object is defined as the product of the force and the displacement of the object in the direction of the force.

What is kinetic energy?

**Answer:** Kinetic energy is the energy possessed by an object due to its motion. It is defined as half the product of the mass of the object and the square of its velocity.

**What is potential energy?**

**Answer:** Potential energy is the energy possessed by an object due to its position or configuration. It is dependent on the height of the object above a reference point and the force acting on it.

**State the law of conservation of energy.**

**Answer:** The law of conservation of energy states that energy can neither be created nor destroyed. It can only be transformed from one form to another.

**Define power.**

**Answer:** Power is defined as the rate at which work is done or energy is transferred. It is the product of force and velocity.

**What is the work-energy theorem?**

**Answer:** The work-energy theorem states that the work done by the net force on an object is equal to the change in its kinetic energy.

**State the difference between conservative and non-conservative forces.**

**Answer:** Conservative forces are those which do not dissipate the energy of a system and are dependent only on the initial and final positions of the object. Non-conservative forces are those which dissipate the energy of a system, such as friction.

**What is the law of conservation of mechanical energy?**

**Answer:** The law of conservation of mechanical energy states that the sum of the kinetic and potential energy of a system remains constant if only conservative forces act on the system.

**How is work related to potential energy?**

**Answer:** Work done by a conservative force can change the potential energy of an object. The work done by the force is equal to the negative of the change in potential energy.

**What is the principle of work and energy?**

**Answer:** The principle of work and energy states that the work done by all forces acting on a system is equal to the change in its kinetic energy and the change in its potential energy.

## Lec 8 - Momentum

**Define momentum in physics.**

**Answer:** Momentum is a physical quantity that describes an object's motion. It is the product of an object's mass and velocity. The momentum of an object is a vector quantity, meaning it has both magnitude and direction.

**What is the formula for momentum?**

**Answer:** The formula for momentum is momentum = mass x velocity, which can be expressed as  $p = mv$ .

**What is the principle of conservation of momentum?**

**Answer:** The principle of conservation of momentum states that the total momentum of a system of objects remains constant if no external forces act on the system.

**What is the difference between elastic and inelastic collisions?**

**Answer:** In an elastic collision, both the total momentum and kinetic energy of the system are conserved, while in an inelastic collision, only the total momentum is conserved.

**What is impulse?**

**Answer:** Impulse is the change in momentum of an object resulting from an applied force. It is equal to the force multiplied by the time during which it acts.

**What is the relationship between force, time, and impulse?**

**Answer:** The impulse of a force is equal to the product of the force and the time during which it acts. This can be expressed as  $J = Ft$ .

**What is the difference between linear momentum and angular momentum?**

**Answer:** Linear momentum is the product of an object's mass and velocity, while angular momentum is the product of an object's moment of inertia and angular velocity.

**What is the law of conservation of angular momentum?**

**Answer:** The law of conservation of angular momentum states that the total angular momentum of a system remains constant if no external torques act on the system.

**How is momentum used in real-world applications?**

**Answer:** Momentum is used in a variety of real-world applications, such as in the design of car safety features, the understanding of fluid dynamics, and the development of rocket propulsion systems.

**How can momentum be used to solve problems in physics?**

**Answer:** Momentum can be used to solve a wide range of problems in physics, such as collisions, motion in a gravitational field, and fluid flow. It provides a useful tool for analyzing the behavior of objects and systems in motion.

## **Lec 9 - Collisions**

**What is meant by an elastic collision?**

**Answer:** An elastic collision is one in which both kinetic energy and momentum are conserved.

**What is the difference between an elastic and inelastic collision?**

**Answer:** In an elastic collision, both momentum and kinetic energy are conserved, whereas in an inelastic collision, only momentum is conserved.

**What is the law of conservation of momentum?**

**Answer:** The law of conservation of momentum states that the total momentum of a system of objects is conserved if there are no external forces acting on the system.

**What happens to the total momentum of a system of objects during a collision?**

**Answer:** The total momentum of a system of objects is conserved during a collision.

**What is the difference between a head-on collision and a rear-end collision?**

**Answer:** In a head-on collision, two objects collide with each other while moving in opposite directions, whereas, in a rear-end collision, one object collides with another object from behind.

**Can kinetic energy be conserved during an inelastic collision?**

**Answer:** No, kinetic energy is not conserved during an inelastic collision.

**What is the difference between a perfectly inelastic collision and a partially inelastic collision?**

**Answer:** In a perfectly inelastic collision, the objects stick together after the collision, whereas in a partially inelastic collision, the objects do not stick together but some kinetic energy is lost.

**What is the difference between a one-dimensional collision and a two-dimensional collision?**

**Answer:** In a one-dimensional collision, the objects collide along a straight line, whereas in a two-dimensional collision, the objects collide in a plane.

**What is the difference between a center of mass and a reference frame?**

**Answer:** A center of mass is the point at which the mass of an object is concentrated, whereas a reference frame is a coordinate system used to describe the motion of an object.

**Can momentum be conserved in a system with external forces acting on it?**

**Answer:** No, momentum cannot be conserved in a system with external forces acting on it, as the external forces will cause a change in momentum.

## Lec 10 - Rotational Kinematics

What is rotational kinematics?

Ans: Rotational kinematics is the branch of physics that deals with the motion of objects that are rotating or spinning around a fixed axis.

What is angular velocity?

Ans: Angular velocity is the rate of change of angular displacement with respect to time. It is a vector quantity, and its SI unit is rad/s.

What is angular acceleration?

Ans: Angular acceleration is the rate of change of angular velocity with respect to time. It is a vector quantity, and its SI unit is rad/s<sup>2</sup>.

What is centripetal acceleration?

Ans: Centripetal acceleration is the acceleration of an object that is moving in a circular path. It always points towards the center of the circle and is given by the formula  $a = v^2/r$ , where  $v$  is the velocity of the object and  $r$  is the radius of the circle.

What is the relationship between linear velocity and angular velocity?

Ans: The linear velocity of an object is equal to the product of its angular velocity and the radius of the circle it is moving in. This is given by the formula  $v = \omega r$ , where  $v$  is the linear velocity,  $\omega$  is the angular velocity, and  $r$  is the radius of the circle.

What is rotational inertia?

Ans: Rotational inertia is the property of an object that resists changes to its rotational motion. It is dependent on the object's mass distribution and its distance from the axis of rotation.

What is torque?

Ans: Torque is the measure of the force that causes an object to rotate around an axis or pivot point. It is given by the formula  $\tau = r \times F$ , where  $\tau$  is the torque,  $r$  is the distance from the axis of rotation to the point where the force is applied, and  $F$  is the force applied.

**What is the relationship between torque and angular acceleration?**

**Ans:** The torque applied to an object is directly proportional to its angular acceleration. This is given by the formula  $\tau = I\alpha$ , where  $\tau$  is the torque,  $I$  is the moment of inertia, and  $\alpha$  is the angular acceleration.

**What is the moment of inertia?**

**Ans:** The moment of inertia is a measure of an object's resistance to changes in its rotational motion. It is dependent on the object's mass distribution and its distance from the axis of rotation.

**What is the conservation of angular momentum?**

**Ans:** The conservation of angular momentum states that the total angular momentum of a system remains constant if no external torque is acting on the system. This is similar to the conservation of linear momentum, which states that the total linear momentum of a system remains constant if no external forces are acting on the system.

## **Lec 11 - Conservation of Energy**

**What is the law of conservation of energy?**

**Ans:** The law of conservation of energy is a fundamental principle of physics that states that the total amount of energy in a closed system remains constant.

**What is the first law of thermodynamics?**

**Ans:** The first law of thermodynamics states that the change in the internal energy of a system is equal to the heat added to the system minus the work done by the system.

**What are some applications of the conservation of energy in physics?**

**Ans:** Conservation of energy has many applications in physics, including mechanics, thermodynamics, and electromagnetism.

**How is conservation of energy used in the design of engines?**

**Ans:** In the design of engines and other devices that convert thermal energy into mechanical work, the principle of conservation of energy is used to ensure that the heat energy added to the system is equal to the work done by the system.

**How does conservation of energy apply to electromagnetism?**

**Ans:** In electromagnetism, the energy stored in a magnetic field is equal to the work that can be done by the field. When the current is turned off, the energy stored in the magnetic field is released and can be used to do work.

**Is energy created or destroyed in a closed system?**

**Ans:** Energy cannot be created or destroyed in a closed system, only transformed from one form to another.

**What happens to the potential energy of an object as it falls?**

**Ans:** The potential energy

## Lec 12 - Physics of Many Particles

**What is the definition of a many-particle system?**

**Answer:** A many-particle system is a collection of multiple particles that interact with each other through forces.

**What is the difference between microstates and macrostates in a many-particle system?**

**Answer:** Microstates refer to the specific arrangement of particles in a system, while macro states refer to the overall properties of the system, such as its temperature, pressure, and energy.

**What is statistical mechanics, and how does it relate to many-particle systems?**

**Answer:** Statistical mechanics is a branch of physics that uses statistical methods to understand the behavior of a large number of particles. It provides a way to connect the microscopic properties of individual particles to the macroscopic properties of a system.

**What is entropy, and how is it related to many-particle systems?**

**Answer:** Entropy is a measure of the number of possible arrangements of particles in a system. In many-particle systems, entropy tends to increase as particles move towards more disordered configurations.

**What is the difference between an ideal gas and a real gas?**

**Answer:** An ideal gas is a theoretical gas that follows the gas laws perfectly, while a real gas deviates from these laws due to intermolecular forces and other factors.

**What is the meaning of the term "equilibrium" in a many-particle system?**

**Answer:** Equilibrium refers to a state in which the macroscopic properties of a system do not change over time. In many-particle systems, this typically means that the system is in thermal, mechanical, and chemical equilibrium.

**What is the difference between classical and quantum many-particle systems?**

**Answer:** Classical many-particle systems can be described using classical mechanics, while quantum many-particle systems require the use of quantum mechanics.

**What is Bose-Einstein condensation, and what are its properties?**

**Answer:** Bose-Einstein condensation is a phenomenon that occurs when a collection of bosons is cooled to a very low temperature, causing them to "condense" into a single quantum state. This leads to a variety of interesting properties, such as superfluidity and coherence.

**What is the significance of the Fermi-Dirac distribution in many-particle systems?**

**Answer:** The Fermi-Dirac distribution is used to describe the distribution of fermions (particles with half-integer spin) in a many-particle system. It is important in understanding the behavior of materials such as metals and semiconductors.

**What are some real-world applications of many-particle physics?**

**Answer:** Many-particle physics has numerous applications, including the study of materials science, quantum computing, and condensed matter physics. It is also important in understanding the behavior of stars and other astronomical objects.

## **Lec 13 - Angular Momentum**

### **What is angular momentum?**

Angular momentum is a measure of an object's rotational motion. It is a vector quantity that depends on both the object's moment of inertia and its angular velocity.

### **How is angular momentum related to torque?**

Angular momentum is directly proportional to torque, which is the force that causes an object to rotate. The greater the torque applied to an object, the greater its angular momentum will be.

### **How is angular momentum conserved?**

Angular momentum is conserved when there is no external torque acting on a system. This means that the total angular momentum of a system before an event will be equal to the total angular momentum after the event.

### **What is the difference between linear momentum and angular momentum?**

Linear momentum is a measure of an object's motion in a straight line, while angular momentum is a measure of an object's rotational motion. Linear momentum depends on an object's mass and velocity, while angular momentum depends on its moment of inertia and angular velocity.

### **What is a moment of inertia?**

Moment of inertia is a measure of an object's resistance to rotational motion. It depends on the object's mass distribution and its shape. Objects with a larger moment of inertia require more torque to produce the same angular acceleration as objects with a smaller moment of inertia.

### **How does the moment of inertia affect an object's angular momentum?**

The moment of inertia affects an object's angular momentum by determining how quickly it can rotate for a given amount of torque. Objects with a larger moment of inertia will have a smaller angular velocity for a given torque and thus a smaller angular momentum.

### **What is the conservation of angular momentum?**

The conservation of angular momentum states that the total angular momentum of a system is conserved when there is no external torque acting on the system. This means that the sum of the angular momenta of all the objects in the system will remain constant.

**How is angular momentum related to the Earth's rotation?**

The angular momentum of the Earth's rotation is what keeps it spinning on its axis. The Earth's moment of inertia and its rotation rate determine its angular momentum.

**How do you calculate angular momentum?**

Angular momentum is calculated by multiplying an object's moment of inertia by its angular velocity. The equation for angular momentum is  $L = I\omega$ , where  $L$  is the angular momentum,  $I$  is the moment of inertia, and  $\omega$  is the angular velocity.

**How can you increase an object's angular momentum?**

An object's angular momentum can be increased by either increasing its angular velocity or increasing its moment of inertia. This can be achieved by applying torque to the object or by changing its shape or mass distribution.

## **Lec 14 - Equilibrium of Rigid Bodies**

### **What is meant by the equilibrium of a rigid body?**

Answer: The state of a rigid body when it is at rest and all the forces acting on it are balanced is called the equilibrium of a rigid body.

### **What are the conditions for the equilibrium of a rigid body?**

Answer: The conditions for the equilibrium of a rigid body are:

The net force acting on the body must be zero.

The net torque (or moment) acting on the body about any axis must be zero.

### **What is meant by the center of gravity of a rigid body?**

Answer: The center of gravity of a rigid body is the point where the entire weight of the body can be considered to be concentrated, and the body behaves as if all its weight is acting through this point.

### **How is the center of gravity of a uniform object located?**

Answer: The center of gravity of a uniform object is located at the geometric center of the object.

### **What is the difference between stable, unstable, and neutral equilibrium?**

Answer: In stable equilibrium, if the body is displaced from its equilibrium position, it will tend to return to its original position. In unstable equilibrium, if the body is displaced from its equilibrium position, it will tend to move away from its original position. In neutral equilibrium, if the body is displaced from its equilibrium position, it will remain in its new position.

### **What is meant by torque or moment of a force?**

Answer: The torque or moment of a force is the measure of the force's ability to cause rotational motion. It is the product of the force and the perpendicular distance between the force's line of action and the axis of rotation.

### **What is the principle of moments?**

Answer: The principle of moments states that in equilibrium, the sum of the clockwise moments about any point must be equal to the sum of the anticlockwise moments about the same point.

**How can the weight of an irregularly shaped object be determined?**

Answer: The weight of an irregularly shaped object can be determined by suspending it from different points and measuring the angle of the supporting string or rod. The weight can be calculated using the principle of moments.

**What is meant by the term 'couple'?**

Answer: A couple is a pair of equal and opposite forces acting on a body but not along the same line. It causes the body to rotate without any translational motion.

**How can the stability of a structure be increased?**

Answer: The stability of a structure can be increased by:

Lowering the center of gravity

Increasing the base area

Providing adequate support

Increasing the weight of the structure at the base.

## Lec 15 - Oscillations – I

### What is an oscillation?

**Ans:** An oscillation is the repetitive motion of an object or a system about a fixed point or an equilibrium position.

### What is the difference between amplitude and frequency?

**Ans:** Amplitude is the maximum displacement of an oscillating object from its equilibrium position, while frequency is the number of oscillations per unit time.

### What is simple harmonic motion?

**Ans:** Simple harmonic motion occurs when the restoring force is proportional to the displacement from the equilibrium position, and the motion is periodic and sinusoidal.

### What is Hooke's law?

**Ans:** Hooke's law states that the force required to stretch or compress a spring is proportional to the displacement.

### What is the equation of motion for a simple harmonic oscillator?

**Ans:** The equation of motion

### Define simple harmonic motion.

**Answer:** Simple harmonic motion is a type of periodic motion where the displacement of an object is proportional to the force acting on it and is directed toward the equilibrium position. The motion is characterized by a constant frequency, amplitude, and sinusoidal waveform.

### What is the difference between a period and frequency of oscillation?

**Answer:** Period and frequency are two different ways to describe the motion of a system undergoing oscillation. Period is the time required for one complete cycle of oscillation, whereas frequency is the number of complete cycles that occur per unit of time. They are related by the formula  $T = 1/f$ , where  $T$  is the period and  $f$  is the frequency.

### What is meant by the amplitude of an oscillation?

**Answer:** Amplitude is the maximum displacement of an oscillating system from its equilibrium position. It is a measure of the extent to which the system deviates from its mean position during the course of its oscillation.

**What is resonance?**

**Answer:** Resonance occurs when an oscillating system is subjected to a periodic driving force that has the same frequency as its natural frequency of vibration. As a result, the amplitude of the oscillation of the system becomes very large, which can lead to catastrophic failure if not properly managed.

**What is the difference between damped and undamped oscillations?**

**Answer:** Damped oscillations occur when the amplitude of an oscillating system decreases over time due to the presence of friction or other dissipative forces. Undamped oscillations, on the other hand, occur when the amplitude of the oscillating system remains constant over time in the absence of any external forces.

**What is meant by the period of oscillation of a pendulum?**

**Answer:** The period of oscillation of a pendulum is the time required for the pendulum to complete one full oscillation, i.e., to swing from one extreme position to the other and back again.

**What is the relationship between the mass of an object and its period of oscillation in a simple harmonic oscillator?**

**Answer:** The period of oscillation of a simple harmonic oscillator is independent of the mass of the object undergoing oscillation. This is because the restoring force acting on the object is proportional to its displacement, not its mass.

**What is the relationship between the spring constant and the period of oscillation in a mass-spring system?**

**Answer:** The period of oscillation of a mass-spring system is directly proportional to the square root of the mass attached to the spring and inversely proportional to the square root of the spring constant. This relationship is given by the formula  $T = 2\pi\sqrt{m/k}$ , where  $T$  is the period,  $m$  is the mass, and  $k$  is the spring constant.

**What is meant by the term "phase" in the context of oscillations?**

**Answer:** Phase refers to the relative position of an oscillating system at a given point in time with respect to its starting position. It is often expressed in terms of the angle of displacement from the equilibrium position, or as a fraction of the period completed.

**What is the relationship between the period of a wave and its wavelength?**

**Answer:** The period of a wave is directly proportional to its wavelength and inversely proportional to its frequency. This relationship is given by the formula  $T = \lambda/f$ , where  $T$  is the period,  $\lambda$  is the wavelength, and  $f$  is the frequency.

## Lec 16 - Oscillations – II

### What is damping in oscillations?

**Answer:** Damping is the process of reducing the amplitude of oscillations over time due to some external factors, such as friction or air resistance.

### What is the equation that describes damped oscillations?

**Answer:** The equation that describes damped oscillations is the damped harmonic oscillator equation, which takes into account the damping force proportional to the velocity of the oscillator.

### What happens to the amplitude of damped oscillations over time?

**Answer:** The amplitude of damped oscillations decreases exponentially over time.

### What are forced oscillations?

**Answer:** Forced oscillations occur when a periodic external force is applied to a system, and the behavior of the oscillator is affected by the frequency and amplitude of the external force.

### What is resonance in forced oscillations?

**Answer:** Resonance occurs in forced oscillations when the frequency of the external force is equal to the natural frequency of the oscillator, resulting in a large amplitude of oscillation.

### What are coupled oscillations?

**Answer:** Coupled oscillations occur when two or more oscillators are connected in some way, such that the motion of one oscillator affects the motion of the other(s).

### What is beating in coupled oscillations?

**Answer:** Beating occurs in coupled oscillations when two oscillators of slightly different frequencies are connected, and the amplitude of the oscillation varies periodically.

### What is the equation that describes coupled oscillations?

**Answer:** The behavior of a system of coupled oscillators can be described using a set of coupled differential equations, one for each oscillator.

**What is synchronized behavior in coupled oscillations?**

**Answer:** Synchronized behavior occurs in coupled oscillations when the oscillators all oscillate with the same frequency and phase.

**Why is the study of oscillations important in science and engineering?**

**Answer:** The study of oscillations is important in science and engineering because it helps us understand the behavior of natural systems and design stable and reliable systems that exhibit oscillatory behavior.

## Lec 17 - Physics of Materials

### What is a materials science, and why is it important?

**Answer:** Materials science is the study of the physical and chemical properties of materials. It is important because it forms the foundation of many technological advancements and enables the development of new materials that can withstand extreme conditions.

### What are the three main categories of materials, and what are their properties?

**Answer:** The three main categories of materials are metals, ceramics, and polymers. Metals are known for their high electrical and thermal conductivity, good strength, and malleability. Ceramics are hard, brittle, and have high melting points, making them useful for high-temperature applications. Polymers are lightweight, flexible, and have good insulating properties.

### What is X-ray diffraction, and how is it used in materials science?

**Answer:** X-ray diffraction is a technique used to study the structure of materials at the atomic and molecular level. It involves shining X-rays on a sample and observing how the X-rays scatter. By analyzing the scattering pattern, researchers can determine the atomic and molecular structure of the material.

### Why is the study of the mechanical properties of materials important?

**Answer:** The study of the mechanical properties of materials is important for understanding how materials respond to forces such as stress and strain. This knowledge is critical for the development of new materials that can withstand extreme conditions.

### What are the key thermal properties of materials, and why are they important?

**Answer:** The key thermal properties of materials are thermal conductivity, specific heat, and thermal expansion. These properties are important for the development of materials that can withstand high temperatures and are used in high-temperature applications.

### What are the key electrical properties of materials, and why are they important?

**Answer:** The key electrical properties of materials are conductivity, resistivity, and dielectric constant. These properties are important for the development of materials used in electronic devices.

### What is the role of polymers in materials science?

**Answer:** Polymers are a class of materials that are lightweight, flexible, and have good insulating properties. They are used in a variety of applications, including packaging, textiles, and medical devices.

**What is the role of ceramics in materials science?**

**Answer:** Ceramics are a class of materials that are hard, brittle, and have high melting points, making them useful for high-temperature applications. They are used in a variety of applications, including aerospace and defense.

**What is the role of metals in materials science?**

**Answer:** Metals are a class of materials that have high electrical and thermal conductivity, good strength, and are malleable and ductile. They are used in a variety of applications, including construction and transportation.

**What are the key optical properties of materials, and why are they important?**

**Answer:** The key optical properties of materials are refractive index, absorption, and reflection. These properties are important for the development of materials used in optical devices such as lenses and mirrors.

## Lec 18 - Physics of Fluids

**What is the Navier-Stokes equation, and what does it describe?**

**Answer:** The Navier-Stokes equation is a set of equations that describe the conservation of momentum and mass in a fluid. It describes the motion of fluids, including liquids and gases, under various conditions.

**What is turbulence, and how does it occur in fluids?**

**Answer:** Turbulence is a chaotic and unpredictable flow behavior that occurs when fluids are subjected to high velocities or shear forces. It is characterized by eddies and vortices that cause fluctuations in velocity and pressure.

**What is viscosity, and how is it affected by temperature and pressure?**

**Answer:** Viscosity is the resistance of a fluid to flow. It is dependent on the internal friction between the molecules of a fluid and can be affected by temperature, pressure, and the presence of other substances in the fluid.

**What is surface tension, and how does it influence the behavior of liquids?**

**Answer:** Surface tension is the tendency of the surface of a liquid to minimize its surface area, which causes liquids to form spherical droplets or to wet surfaces. This property is important in the behavior of liquids in capillary tubes, where the surface tension can cause the liquid to rise or fall depending on the angle of the tube.

**What is Bernoulli's principle, and how is it used in engineering?**

**Answer:** Bernoulli's principle states that as the velocity of a fluid increases, the pressure of the fluid decreases. This principle is used in a variety of applications, including the design of airplane wings and the operation of carburetors in engines.

**How does the behavior of gases differ from that of liquids?**

**Answer:** Gases are much more compressible than liquids and have no definite volume or shape. The behavior of gases is described by the ideal gas law, which relates the pressure, temperature, and volume of a gas.

**What is compressibility, and how does it relate to the behavior of gases?**

**Answer:** Compressibility is the ability of a substance to be compressed or expanded under different conditions. Gases are highly compressible, which makes them useful in a variety of applications, such as in the operation of internal combustion engines.

**What is the role of fluid dynamics in medicine?**

**Answer:** Fluid dynamics is used in medicine to study blood flow and respiratory systems. Understanding the behavior of fluids in the human body can help diagnose and treat a variety of medical conditions.

**How does the study of fluid mechanics contribute to the design of ships and boats?**

**Answer:** The study of fluid mechanics is important in the design of ships and boats because it allows engineers to understand the behavior of water and waves under different conditions. This knowledge is used to design vessels that are safe and efficient in a variety of weather and water conditions.

**What is the practical application of the physics of fluids in weather forecasting?**

**Answer:** The physics of fluids is used in weather forecasting to study the behavior of atmospheric gases and water vapor. This information is used to predict weather patterns, including the movement of storms and the development of severe weather conditions.

## **Lec 20 - Physics of Sound**

### **What is sound?**

**Answer:** Sound is a form of energy that travels through a medium in the form of longitudinal waves.

### **How is sound created?**

**Answer:** Sound is created by the vibration of an object, which causes a disturbance in the surrounding medium.

### **What are the properties of sound waves?**

**Answer:** The properties of sound waves include frequency, wavelength, amplitude, and velocity.

### **How are sound waves described?**

**Answer:** Sound waves can be described as either longitudinal or transverse waves.

### **What is pitch?**

**Answer:** Pitch is the perceived highness or lowness of a sound and is related to the frequency of the sound wave.

### **What is loudness?**

**Answer:** Loudness is the perceived volume of a sound and is related to the amplitude of the sound wave.

### **What is the decibel scale?**

**Answer:** The decibel scale is a logarithmic scale that measures the intensity of sound.

### **What is the difference between reflection and refraction of sound waves?**

**Answer:** Reflection occurs when sound waves bounce back from a surface, while refraction occurs when sound waves change direction as they pass through different mediums.

### **What is timbre?**

**Answer:** Timbre is the quality of a sound that distinguishes it from other sounds of the same pitch and loudness.

**What are some practical applications of the physics of sound?**

**Answer:** The physics of sound has many practical applications in fields such as music production, communication, and medicine, among others.

## Lec 21 - Wave Motion

**What is the difference between transverse waves and longitudinal waves?**

**Answer:** Transverse waves are characterized by particles moving perpendicular to the direction of wave propagation, while longitudinal waves are characterized by particles moving parallel to the direction of wave propagation.

**What is the formula for calculating the speed of a wave?**

**Answer:** The speed of a wave can be calculated using the formula  $v = f\lambda$ , where  $v$  is the speed,  $f$  is the frequency, and  $\lambda$  is the wavelength.

**What is the electromagnetic spectrum?**

**Answer:** The electromagnetic spectrum is the range of all types of electromagnetic radiation, which is divided into several regions including radio waves, microwaves, infrared radiation, visible light, ultraviolet radiation, X-rays, and gamma rays.

**What is wave interference?**

**Answer:** Wave interference occurs when two or more waves interact with each other, resulting in a change in the amplitude of the resulting wave.

**What is constructive interference?**

**Answer:** Constructive interference occurs when two or more waves combine to produce a wave with a larger amplitude than any of the individual waves.

**What is destructive interference?**

**Answer:** Destructive interference occurs when two or more waves combine to produce a wave with a smaller amplitude than any of the individual waves.

**What are standing waves?**

**Answer:** Standing waves occur when two waves of the same frequency and amplitude are traveling in opposite directions and interfere with each other. This results in a wave pattern that appears to be stationary, with points along the wave that do not move.

**What is the difference between mechanical waves and electromagnetic waves?**

**Answer:** Mechanical waves require a medium to travel through, while electromagnetic waves can travel through a vacuum.

**What is the frequency of a wave?**

**Answer:** The frequency of a wave is the number of waves that pass a point in one second.

**What is the wavelength of a wave?**

**Answer:** The wavelength of a wave is the distance between two consecutive points on a wave that are in phase.

## Lec 22 - Gravitation

**What is the formula for gravitational force between two objects?**

**Answer:** The formula for gravitational force between two objects is  $F = Gm_1m_2/r^2$ , where  $F$  is the gravitational force,  $m_1$  and  $m_2$  are the masses of the two objects,  $r$  is the distance between them, and  $G$  is the gravitational constant.

**What is the difference between gravitational force and weight?**

**Answer:** Gravitational force is the force of attraction between any two objects with mass, while weight is the force experienced by an object due to the gravitational pull of a larger object such as a planet or star.

**How is planetary motion affected by gravitation?**

**Answer:** Gravitation is responsible for keeping planets in orbit around their stars. The gravitational force acting on the planets causes them to follow a curved path around the star.

**What is gravitational lensing?**

**Answer:** Gravitational lensing is the bending of light by the gravitational pull of a massive object such as a galaxy cluster.

**What is the theory of general relativity?**

**Answer:** The theory of general relativity, proposed by Albert Einstein, suggests that the force of gravitation is not actually a force, but a curvature of space-time caused by the presence of matter and energy.

**What is the significance of the 1919 solar eclipse?**

**Answer:** The 1919 solar eclipse provided the first experimental confirmation of the theory of general relativity, as observations showed that the sun's gravitational field was bending the light from distant stars, just as Einstein had predicted.

**What is a black hole?**

**Answer:** A black hole is an object with such a strong gravitational field that nothing, not even light, can escape its pull.

**What is the challenge facing theoretical physicists in the study of gravitation?**

**Answer:** The challenge facing theoretical physicists is to reconcile the theory of general relativity with quantum mechanics, which describes the behavior of particles on a very small scale.

**How does gravitation affect the behavior of light?**

**Answer:** Gravitation can cause the bending of light around massive objects, which is known as gravitational lensing.

**What is the role of gravitation in the universe?**

**Answer:** Gravitation is a fundamental force that is responsible for many of the phenomena we observe in the universe, from the motion of planets to the behavior of light.

