Semester – I/III/V

17MMU504 **PHYSICS – I** **4H - 4C**

Instruction Hours / week: L: 4 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives:

- To understand basic theories and experiments in Physics.
- To understand the fundamentals of physics.
- To educate and motivate the students in the field of science

Course Outcomes:

- Students will demonstrate proficiency in mathematics and the mathematical concepts to understand physics.
- Students will design and conduct an experiment (or series of experiments) demonstrating their understanding of the scientific method and processes.
- Students will demonstrate an understanding of the analytical methods required to interpret and analyze results and draw conclusions as supported by their data.

UNIT-I

PROPERTIES OF MATTER: Elastic constants of an isotropic solid -Stress – Strain - Relations connecting them - Poisson's ratio - Bending of beams - Uniform and non-uniform bending - Bending moment of a bent beam - cantilever - Static and dynamic methods - Torsion in a wire - Rigidity modulus determination by Static and dynamic methods.

Surface tension and Surface energy- Pressure difference across a spherical surface- Pressure difference across a curved surface.

UNIT-II

MECHANICS: Motion of bodies in 2–D - Newton's laws - projectile motion – range- maximum height – projectile from space flight- Rotational motion – Rotation with constant angular acceleration –angular momentum of particles – rigid body – spinning top – conservation of angular momentum – Planetary motion – Kepler's laws – universal law of gravitation.

UNIT-III

THERMAL PHYSICS: Laws of thermodynamics – Reversible and irreversible process – Heat engine – Carnot's theorem.

Black body – Stefan's law – Newton's law of cooling – Newton's law of cooling from Stefan's law – Experimental determination of Stefan's constant – Wien's displacement law – Rayleigh – Jean's law – Planck's law.

UNIT-IV

OPTICS AND LASER PHYSICS: Reflection – Refraction – Snell's law – Total internal reflection – Interference – Diffraction – Polarization – Coherence

Stimulated emission and absorption – Einstein's theory of radiation - population inversion – optical pumping – meta stable state – conditions for laser actions – Ruby laser – Helium – neon laser – applications of lasers – Raman effect – Raman shift – stokes and anti-stokes lines.

UNIT-V

BASIC ELECTRONICS: Intrinsic and extrinsic semiconductor – PN Junction diode – Biasing of PN junction – V-I characteristics of junction diode – Rectifiers – Half wave – Full wave and bridge rectifiers – Zener diode – Characteristics of Zener diode – Voltage regulator – Transistor – Characteristics of transistor – CB, CE mode – Transistors as an amplifier.

SUGGESTED READINGS

1. Murugesan. R., Modern Physics, S.Chand & Co, New Delhi.
2. Brijlal and N. Subramanyam, 2004, Properties of matter, S. Chand & Company, New Delhi.
3. Aruldhas and P.Rajagopal, Modern Physics, Prentice Hall of India, New Delhi.
4. Mathur. D.S., 2003, Elements of properties of matter - Shyamlal Charitable Trust, New Delhi.
5. Principles of Electronics, V K Mehta and Rohit Mehta, S.Chand & Company Ltd. Revised Eleventh Edition 2008.
6. F. W. Sears and G. L. Salinger, Thermodynamics, Kinetic theory, and Statistical Thermodynamics, IIIrd ed., Narosa Publishing House (1998).
7. Ghatak and Thygarajan, Lasers, Theory and applications, Macmillan India Ltd., New Delhi, (1984)

SEMESTER –I/III/V

19MMU411/19CHU412 PHYSICS PRACTICALS – I 4H - 2C

Instruction Hours / week: L: 4 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objective

- To acquire basic understanding of laboratory technique and to educate and motivate the students in the field of Physics
- To allow the students to have a deep knowledge of fundamentals of optics.

Course outcome

Students can able to

- Perform basic experiments in mechanics and electricity and analyze the data.
- Acquire engineering skills and Practical knowledge, which help the student in their everyday life.
- know the physical Principles and applications of Electronics.

ANY EIGHT EXPERIMENTS

Experiments

1. Young's Modulus-Non Uniform bending-Pin and Microscope
2. Young's Modulus-Static cantilever
3. Acceleration due to gravity-Compound pendulum
4. Determination of spring constant of the given spring.
5. Determine the radius of capillary tube using microscope.
6. Refractive Index of a solid prism (I-d) curve-Spectrometer
7. Co-efficient of thermal conductivity-Lee's disc method
8. Wavelength of spectral lines -Grating-minimum deviation method-Spectrometer.
9. Characteristics of a Zener and Junction diode
10. μ of a lens-Newton's ring method
11. Thickness of a thin wire-Air wedge method
12. Determine the surface tension - Drop weight method
13. Determine the wavelength of He-Ne laser.

14. Determination of the Coefficient of Viscosity of a given liquid using Burette method
15. Construct a single stage amplifier using transistor

SUGGESTED READINGS:

1. Ouseph C.C., U.J. Rao and V. Vijayendran 2007, Practical Physics and Electronics, S.Viswanathan (Printers & Publishers) Pvt. Ltd., Chennai
2. Singh S.P., 2003, Advanced Practical Physics – 1, 13th Edition, Pragathi Prakashan, Meerut
3. Singh S.P., 2000, Advanced Practical Physics – 2, 12th Edition, Pragathi Prakashan, Meerut

SEMESTER – II/IV/VI

19MMU504/19CHU503 **PHYSICS – II** **4H - 4C**

Instruction Hours / week: L: 4 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives:

- To give the basic knowledge on material properties.
- To acquire knowledge on magnetism and digital electronics.
- To educate and motivate the students in the field of science.

Course Outcomes:

Students can able to

- Explain how physics applies to phenomena in the world around them.
- Recognize how and when physics methods and principles can help address problems in their major and then apply those methods and principles to solve problems.

UNIT – I

Electrostatics: Coulombs law – electric field – Gauss's law and its applications – potential – potential due to various charge distribution. Parallel plate capacitors – dielectrics- current – galvanometer – voltmeter – ammeter- potentiometric measurements.

UNIT - II

Magnetism: Magnetic field – Biot Savart's law – B due to a solenoid – Amperes law – Faradays law of induction – Lenz's law. Magnetic properties of matter –Dia, para and ferro - Cycle of magnetization – Hysteresis – B-H curve – Applications of B-H curve.

UNIT - III

Modern Physics: Einstein's Photoelectric effect-characteristics of photoelectron –laws of photoelectric emission-Einstein's photo electric equations- Compton effect-matter waves-De-Broglie Hypothesis. Heisenberg's uncertainty principle-Schrödinger's equation- particle in a box.

UNIT-IV

Atomic and Nuclear Physics: Atom Models : Sommerfield's and Vector atom Models – Pauli's exclusion Principle – Various quantum numbers and quantization of orbits. X-rays : Continuous and Characteristic X-rays – Mosley's Law and importance – Bragg's Law.

Nuclear forces –characteristics - nuclear structure by liquid drop model – Binding energy – mass defect – particle accelerators – cyclotron and betatron – nuclear Fission and nuclear Fusion.

UNIT - V

Digital Electronics: Decimal – binary – octal and hexadecimal numbers– their representation, inter-conversion, addition and subtraction, negative numbers. Sum of products – product of sums – their conversion – Simplification of Boolean expressions - K-Map – min terms – max terms - (2, 3 and 4 variables). Basic logic gates – AND, OR, NOT, NAND, NOR and EXOR gates – NAND and NOR as universal building gates – Boolean Algebra – Laws of Boolean Algebra – De Morgan's Theorems – Their verifications using truth tables.

SUGGESTED READINGS

1. Narayanamurthi, Electricity and Magnetism, The National Publishing Co, First edition,1988.
2. J. B. Rajam, Atomic Physics., S. Chand & Company Limited, New Delhi, First edition, 1990.
3. B. N. Srivastava, Basic Nuclear Physic, Pragati Prakashan, Meerut, 2005.
4. Albert Paul Malvino, Digital principles and Applications, McGraw-Hill International Editions, New York, 2002.
5. Digital fundamentals – by Floyd 8th edition Pearson education 2006
6. R. S. Sedha, A text book of Digital Electronics, S. Chand & Co, New Delhi, First edition ,2004.

SEMESTER – II/IV/VI

19MMU311/19CHU312 PHYSICS PRACTICALS –II 4H– 2C

Instruction Hours / week: L: 4 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objective

- To enhance the students to understand the concepts in integrated chips.
- To understand the optical and electronic properties of solids through experimentations

Course Outcomes:

Students can able to

- Perform basic experiments in mechanics, heat and electricity and analyze the data
- Acquire engineering skills and Practical knowledge, which help the student in their everyday life.
- know the physical Principles and applications of Electronics.

Any 8 Experiments

1. Determine the magnetic dipole moment (*m*) of a bar magnet - Tan A
2. Determine the magnetic dipole moment (*m*) of a bar magnet - Tan B
3. Field Intensity-Circular coil- Vibration magnetometer
4. Moment of a magnet-Circular coil-Deflection Magnetometer
5. Study of logic gates using IC's.
6. Study of NOR gate as Universal building block.
7. Study of NAND gate as Universal building block.
8. Verification of Basic logic gates using discrete components.
9. To study the variation in current and voltage in a series LCR circuit
10. To study the variation in current and voltage in a parallel LCR circuit
11. Transistor characteristics – CE &CB

SUGGESTED READINGS

1. Ouseph C.C., U.J. Rao and V. Vijayendran 2007, Practical Physics and Electronics, S.Viswanathan (Printers & Publishers) Pvt. Ltd., Chennai
2. Singh S.P., 2003, Advanced Practical Physics – 1, 13th Edition, Pragathi Prakashan, Meerut
3. Singh S.P., 2000, Advanced Practical Physics – 2, 12th Edition, Pragathi Prakashan, Meerut

UNIT-I

SYLLABUS

PROPERTIES OF MATTER: Elastic constants of an isotropic solid -Stress – Strain - Relations connecting them - Poisson's ratio - Bending of beams - Uniform and non-uniform bending - Bending moment of a bent beam - cantilever - Static and dynamic methods - Torsion in a wire - Rigidity modulus determination by Static and dynamic methods.

Surface tension and Surface energy- Pressure difference across a spherical surface- Pressure difference across a curved surface.

Elasticity: Stress and Strain

Hooke's Law

where is the amount of deformation (the change in length, for example) produced by the force *, and is a proportionality constant that depends on the shape and composition of the object and the direction of the force.*

A graph of deformation versus applied force . The straight segment is the linear region where Hooke's law is obeyed. The slope of the straight region is . For larger forces, the graph is curved but the deformation is still elastic— will return to zero if the force is removed. Still greater forces permanently deform the object until it finally fractures. The shape of the curve near fracture depends on several factors, including how the force is applied. Note that in this graph the slope increases just before fracture, indicating that a small increase in is producing a large increase in near the fracture.

The proportionality constant depends upon a number of factors for the material. For example, a guitar string made of nylon stretches when it is tightened, and the elongation is proportional to the force applied (at least for small deformations). Thicker nylon strings and ones made of steel stretch less for the same applied force, implying they have a larger (see [link]). Finally, all three strings return to their normal lengths when the force is removed, provided the deformation is small. Most materials will behave in this manner if the deformation is less than about 0.1% or about 1 part in .

The same force, in this case a weight ( ), applied to three different guitar strings of identical length produces the three different deformations shown as shaded segments. The string on the left is thin nylon, the one in the middle is thicker nylon, and the one on the right is steel.

Stretch Yourself a Little

How would you go about measuring the proportionality constant of a rubber band? If a rubber band stretched 3 cm when a 100-g mass was attached to it, then how much would it stretch if two similar rubber bands were attached to the same mass—even if put together in parallel or alternatively if tied together in series?

We now consider three specific types of deformations: changes in length (tension and compression), sideways shear (stress), and changes in volume. All deformations are assumed to be small unless otherwise stated.

Changes in Length—Tension and Compression: Elastic Modulus

A change in length is produced when a force is applied to a wire or rod parallel to its length , either stretching it (a tension) or compressing it. (See [link].)

(a) Tension. The rod is stretched a length when a force is applied parallel to its length. (b) Compression. The same rod is compressed by forces with the same magnitude in the opposite direction. For very small deformations and uniform materials, is approximately the same for the same magnitude of tension or compression. For larger deformations, the cross-sectional area changes as the rod is compressed or stretched.

Experiments have shown that the change in length ( ) depends on only a few variables. As already noted, is proportional to the force and depends on the substance from which the object is made. Additionally, the change in length is proportional to the original length and inversely proportional to the cross-sectional area of the wire or rod. For example, a long guitar string will stretch more than a short one, and a thick string will stretch less than a thin one. We can combine all these factors into one equation for :

where is the change in length, the applied force, *is a factor, called the elastic modulus or Young's modulus, that depends on the substance, is the cross-sectional area, and is the original length. [link] lists values of for several materials—those with a large are said to have a large tensile stiffness because they deform less for a given tension or compression.*

Elastic Moduli[1]

Material	**Young's modulus (tension–compression)** ***Y***	**Shear modulus** ***S***	**Bulk modulus** ***B***
Aluminum	70	25	75
Bone – tension	16	80	8
Bone – compression	9		
Brass	90	35	75
Brick	15		
Concrete	20		

Elastic Moduli[1]

Material	**Young's modulus (tension–compression)** Y	**Shear modulus** S	**Bulk modulus** B
Glass	70	20	30
Granite	45	20	45
Hair (human)	10		
Hardwood	15	10	
Iron, cast	100	40	90
Lead	16	5	50
Marble	60	20	70
Nylon	5		
Polystyrene	3		
Silk	6		

Elastic Moduli[1]

Material	Young's modulus (tension–compression) *Y*	Shear modulus *S*	Bulk modulus *B*
Spider thread	3		
Steel	210	80	130
Tendon	1		
Acetone			0.7
Ethanol			0.9
Glycerin			4.5
Mercury			25
Water			2.2

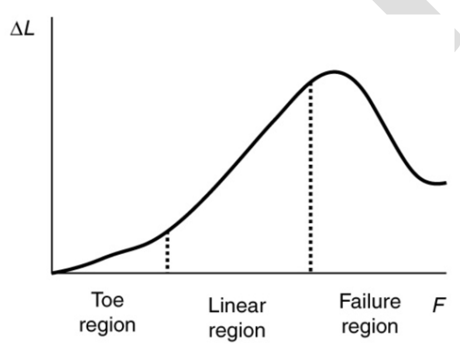
Young's moduli are not listed for liquids and gases in [link] because they cannot be stretched or compressed in only one direction. Note that there is an assumption that the object does not accelerate, so that there are actually two applied forces of magnitude acting in opposite directions. For example, the strings in [link] are being pulled down by a force of magnitude and held up by the ceiling, which also exerts a force of magnitude .

This is quite a stretch, but only about 0.6% of the unsupported length. Effects of temperature upon length might be important in these environments.

Bones, on the whole, do not fracture due to tension or compression. Rather they generally fracture due to sideways impact or bending, resulting in the bone shearing or snapping. The behavior of bones under tension and compression is important because it determines the load the bones can carry. Bones are classified as weight-bearing structures such as columns in buildings and trees. Weight-bearing structures have special features; columns in building have steel-reinforcing rods while trees and bones are fibrous. The bones in different parts of the body serve different structural functions and are prone to different stresses. Thus the bone in the top of the femur is arranged in thin sheets separated by marrow while in other places the bones can be cylindrical and filled with marrow or just solid. Overweight people have a tendency toward bone damage due to sustained compressions in bone joints and tendons.

Another biological example of Hooke's law occurs in tendons. Functionally, the tendon (the tissue connecting muscle to bone) must stretch easily at first when a force is applied, but offer a much greater restoring force for a greater strain. [link] shows a stress-strain relationship for a human tendon. Some tendons have a high collagen content so there is relatively little strain, or length change; others, like support tendons (as in the leg) can change length up to 10%. Note that this stress-strain curve is nonlinear, since the slope of the line changes in different regions. In the first part of the stretch called the toe region, the fibers in the tendon begin to align in the direction of the stress—this is called *uncrimping*. In the linear region, the fibrils will be stretched, and in the failure region individual fibers begin to break. A simple model of this relationship can be illustrated by springs in parallel: different springs are activated at different lengths of stretch. Examples of this are given in the problems at end of this chapter. Ligaments (tissue connecting bone to bone) behave in a similar way.

Typical stress-strain curve for mammalian tendon. Three regions are shown: (1) toe region (2) linear region, and (3) failure region.



Unlike bones and tendons, which need to be strong as well as elastic, the arteries and lungs need to be very stretchable. The elastic properties of the arteries are essential for blood flow. The pressure in the arteries increases and arterial walls stretch when the blood is pumped out of the heart. When the aortic valve shuts, the pressure in the arteries drops and the arterial walls relax to maintain the blood flow. When you feel your pulse, you are feeling exactly this—the elastic behavior of the arteries as the blood gushes through with each pump of the heart. If the arteries were rigid, you would not feel a pulse. The heart is also an organ with special elastic properties. The lungs expand with muscular effort when we breathe in but relax freely and elastically when we breathe out. Our skins are particularly elastic, especially for the young. A young person can go from 100 kg to 60 kg with no visible sag in their skins. The elasticity of all organs reduces with age. Gradual physiological aging through reduction in elasticity starts in the early 20s.

This small change in length seems reasonable, consistent with our experience that bones are rigid. In fact, even the rather large forces encountered during strenuous physical activity do not compress or bend bones by large amounts. Although bone is rigid compared with fat or muscle, several of the substances listed in [link] have larger values of Young's modulus . In other words, they are more rigid.

The equation for change in length is traditionally rearranged and written in the following form:

The ratio of force to area, , is defined as **stress** (measured in), and the ratio of the change in length to length, , is defined as **strain** (a unitless quantity). In other words,

In this form, the equation is analogous to Hooke's law, with stress analogous to force and strain analogous to deformation. If we again rearrange this equation to the form

we see that it is the same as Hooke's law with a proportionality constant

This general idea—that force and the deformation it causes are proportional for small deformations—applies to changes in length, sideways bending, and changes in volume.

Stress

The ratio of force to area, , is defined as stress measured in N/m^2.

Strain

The ratio of the change in length to length, , is defined as strain (a unitless quantity). In other words,

Sideways Stress: Shear Modulus

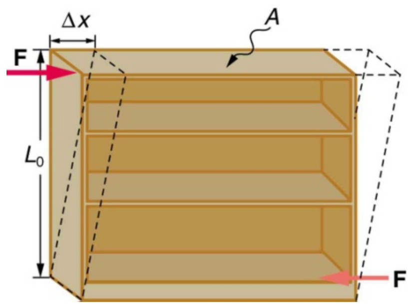
[link] illustrates what is meant by a sideways stress or a *shearing force*. Here the deformation is called and it is perpendicular to , rather than parallel as with tension and compression. Shear deformation behaves similarly to tension and compression and can be described with similar equations. The expression for **shear deformation** is

where is the shear modulus (see [link]) and is the force applied perpendicular to and parallel to the cross-sectional area . Again, to keep the object from accelerating, there are actually two equal and opposite forces applied across opposite faces, as illustrated in [link]. The equation is logical—for example, it is easier to bend a long thin pencil (small) than a short thick one, and both are more easily bent than similar steel rods (large).

Shear Deformation

where is the shear modulus and is the force applied perpendicular to and parallel to the cross-sectional area .

Shearing forces are applied perpendicular to the length and parallel to the area , producing a deformation . Vertical forces are not shown, but it should be kept in mind that in addition to the two shearing forces, , there must be supporting forces to keep the object from rotating. The distorting effects of these supporting forces are ignored in this treatment. The weight of the object also is not shown, since it is usually negligible compared with forces large enough to cause significant deformations.



Examination of the shear moduli in [link] reveals some telling patterns. For example, shear moduli are less than Young's moduli for most materials. Bone is a remarkable exception. Its shear modulus is not only greater than its Young's modulus, but it is as large as that of steel. This is why bones are so rigid.

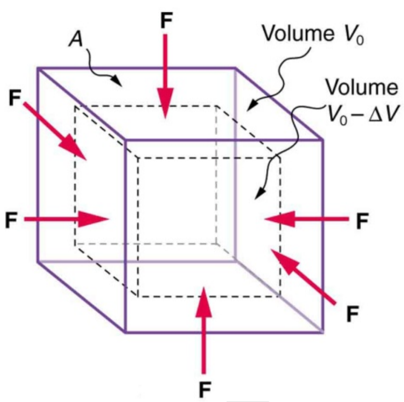
The spinal column (consisting of 26 vertebral segments separated by discs) provides the main support for the head and upper part of the body. The spinal column has normal curvature for stability, but this curvature can be increased, leading to increased shearing forces on the lower vertebrae. Discs are better at withstanding compressional forces than shear forces. Because the spine is not vertical, the weight of the upper body exerts some of both. Pregnant women and people that are overweight (with large abdomens) need to move their shoulders back to maintain balance, thereby increasing the curvature in their spine and so increasing the shear component of the stress. An increased angle due to more curvature increases the shear forces along the plane. These higher shear forces increase the risk of back injury through ruptured discs. The lumbosacral disc (the wedge shaped disc below the last vertebrae) is particularly at risk because of its location.

The shear moduli for concrete and brick are very small; they are too highly variable to be listed. Concrete used in buildings can withstand compression, as in pillars and arches, but is very poor against shear, as might be encountered in heavily loaded floors or during earthquakes. Modern structures were made possible by the use of steel and steel-reinforced concrete. Almost by definition, liquids and gases have shear moduli near zero, because they flow in response to

Changes in Volume: Bulk Modulus

An object will be compressed in all directions if inward forces are applied evenly on all its surfaces as in [link]. It is relatively easy to compress gases and extremely difficult to compress liquids and solids. For example, air in a wine bottle is compressed when it is corked. But if you try corking a brim-full bottle, you cannot compress the wine—some must be removed if the cork is to be inserted. The reason for these different compressibilities is that atoms and molecules are separated by large empty spaces in gases but packed close together in liquids and solids. To compress a gas, you must force its atoms and molecules closer together. To compress liquids and solids, you must actually compress their atoms and molecules, and very strong electromagnetic forces in them oppose this compression.

An inward force on all surfaces compresses this cube. Its change in volume is proportional to the force per unit area and its original volume, and is related to the compressibility of the substance.



We can describe the compression or volume deformation of an object with an equation. First, we note that a force "applied evenly" is defined to have the same stress, or ratio of force to area on all surfaces. The deformation produced is a change in volume , which is found to behave very similarly to the shear, tension, and compression previously discussed. (This is not surprising, since a compression of the entire object is equivalent to compressing each of its three dimensions.) The relationship of the change in volume to other physical quantities is given by

where is the bulk modulus (see [link]), is the original volume, and is the force per unit area applied uniformly inward on all surfaces. Note that no bulk moduli are given for gases.

What are some examples of bulk compression of solids and liquids? One practical example is the manufacture of industrial-grade diamonds by compressing carbon with an extremely large force per unit area. The carbon atoms rearrange their crystalline structure into the more tightly packed pattern of diamonds. In nature, a similar process occurs deep underground, where extremely large forces result from the weight of overlying material. Another natural source of large compressive forces is the pressure created by the weight of water, especially in deep parts of the oceans. Water exerts an inward force on all surfaces of a submerged object, and even on the water itself. At great depths, water is measurably compressed, as the following example illustrates.

Surface Energy

Surfaces have energy associated with them because work is needed to form them.
Surface energy is the ***work per unit area*** done by the force that creates the new surface.

Surface Tension

In dealing with liquids, it is more usual to use the idea of *Surface Tension* rather than *Surface energy*, even though they refer to the same dimensional quantity. This is shown in the following dimensional analysis.

$$\begin{aligned}\text{Surface Energy} &= \frac{\text{Energy}}{\text{area}} \\ &= \frac{\text{Joule}}{\text{m}^2} = \frac{\text{Newton} \times \text{m}}{\text{m}^2} = \frac{\text{Newton}}{\text{m}} \\ &= \frac{\text{Force}}{\text{length}}\end{aligned}$$

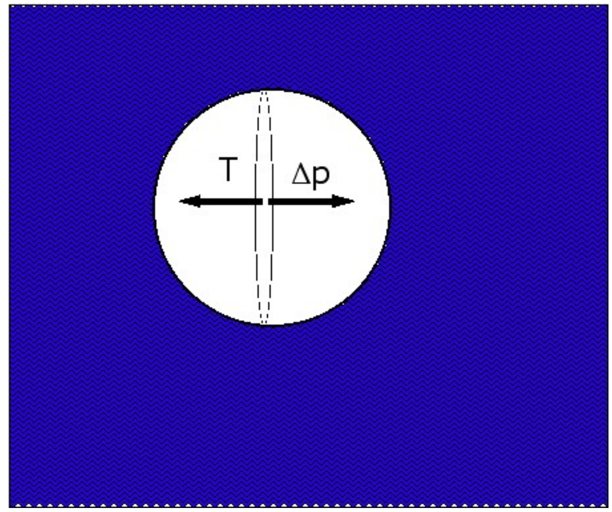
The net inward force on the surface of a liquid makes the surface act as if it was an elastic skin that constantly tries to decrease its area.

$\text{Surface tension} = \frac{\text{Force}}{\text{length}}$, acts in the surface and normal to an imaginary line in the surface.

Pressure difference for a gas bubble in a liquid

A gas bubble in a liquid has two balancing forces that determine its size.

These are the outward force from internal gas pressure, and the inward force from surface tension trying to reduce the surface area.



Changing to energy, and using (force)×(distance) = (pressure)×(volume)

The surface energy of the gas bubble is due to the difference between the bubble filled with gas and the bubble filled with liquid.

$$T = \frac{\text{force}}{\text{length}} = \frac{\text{energy}}{\text{area}} = \frac{dW}{dA}$$

$$= \frac{\left(p_{gas} - p_{liquid}\right)dV}{dA}$$

Divide top and bottom by the radius.

$$= \frac{\left(p_{gas} - p_{liquid}\right)\left(\frac{dV}{dR}\right)}{\left(\frac{dA}{dR}\right)}$$

How the volume and surface area change with radius is now calculated.

$$\text{now } V = \frac{4\pi R^3}{3} \text{ so } \frac{dV}{dR} = 4\pi R^2$$

$$\text{and } A = 4\pi R^2 \text{ so } \frac{dA}{dR} = 8\pi R$$

$$T = \frac{\left(p_{gas} - p_{liquid}\right)\left(4\pi R^2\right)}{\left(8\pi R\right)} = \frac{\left(p_{gas} - p_{liquid}\right)R}{2}$$

The final result is that the pressure difference between the inner gas and the outer liquid is directly proportional to the surface tension and inversely proportional to the radius of the bubble.

$$\left(p_{gas} - p_{liquid}\right) = \frac{2T}{R}$$

UNIT-II

SYLLABUS

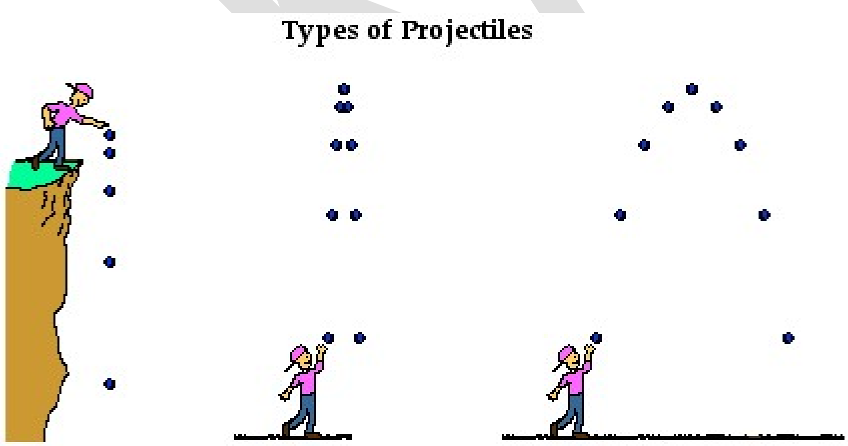
MECHANICS: Motion of bodies in 2–D - Newton's laws - projectile motion – range-maximum height – projectile from space flight- Rotational motion – Rotation with constant angular acceleration –angular momentum of particles – rigid body – spinning top – conservation of angular momentum – Planetary motion – Kepler's laws – universal law of gravitation.

What is a Projectile?

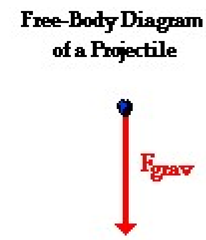
- What is a Projectile?
- Characteristics of a Projectile's Trajectory
- Horizontal and Vertical Components of Velocity
- Horizontal and Vertical Displacement
- Initial Velocity Components
- Horizontally Launched Projectiles - Problem-Solving
- Non-Horizontally Launched Projectiles - Problem-Solving

Defining Projectiles

A projectile is an object upon which the only force acting is gravity. There are a variety of examples of projectiles. An object dropped from rest is a projectile (provided that the influence of air resistance is negligible). An object that is thrown vertically upward is also a projectile (provided that the influence of air resistance is negligible). And an object which is thrown upward at an angle to the horizontal is also a projectile (provided that the influence of air resistance is negligible). A projectile is any object that once *projected* or dropped continues in motion by its own inertia and is influenced only by the downward force of gravity.



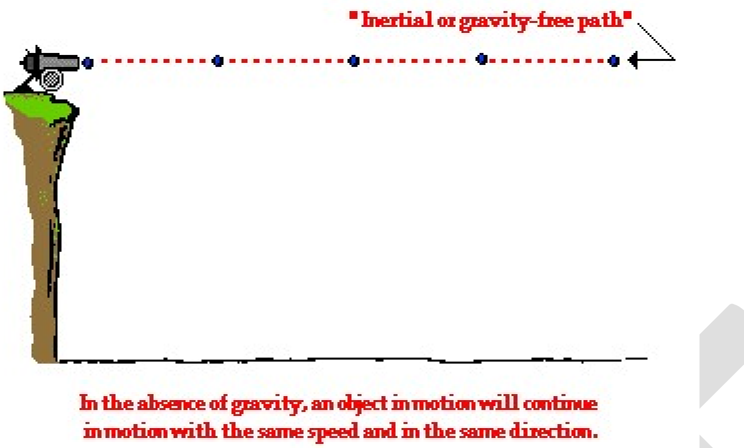
By definition, a projectile has a single force that acts upon it - the force of gravity. If there were any other force acting upon an object, then that object would not be a projectile. Thus, the free-body diagram of a projectile would show a single force acting downwards and labeled force of gravity (or simply F_{grav}). Regardless of whether a projectile is moving downwards, upwards, upwards and rightwards, or downwards and leftwards, the free-body diagram of the projectile is still as depicted in the diagram at the right. By definition, a projectile is any object upon which the only force is gravity.



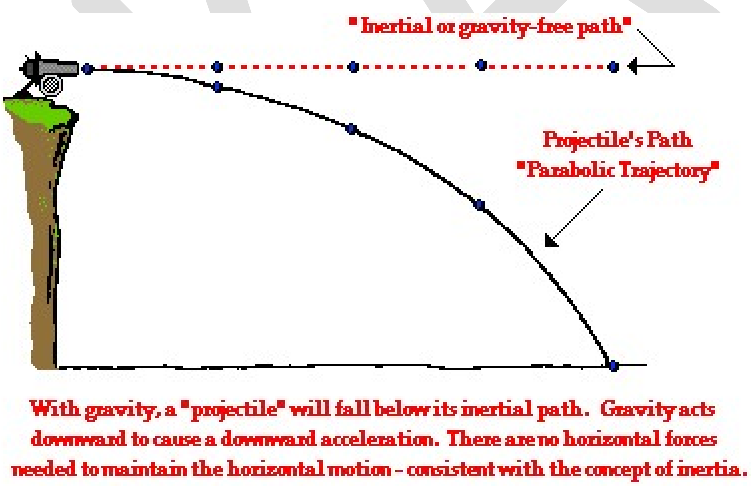
Projectile Motion and Inertia

Many students have difficulty with the concept that the only force acting upon an upward moving projectile is gravity. Their conception of motion prompts them to think that if an object is moving upward, then there *must* be an upward force. And if an object is moving upward and rightward, there *must* be both an upward and rightward force. Their belief is that forces cause motion; and if there is an upward motion then there must be an upward force. They reason, "How in the world can an object be moving upward if the only force acting upon it is gravity?" Such students do not *believe* in Newtonian physics (or at least do not believe strongly in Newtonian physics). Newton's laws suggest that forces are only required to cause an acceleration (not a motion). Recall from the Unit 2 that Newton's laws stood in direct opposition to the common misconception that a force is required to keep an object in motion. This idea is simply not true! A force is not required to keep an object in motion. A force is only required to maintain an acceleration. And in the case of a projectile that is moving upward, there is a downward force and a downward acceleration. That is, the object is moving upward and slowing down.

To further ponder this concept of the downward force and a downward acceleration for a projectile, consider a cannonball shot horizontally from a very high cliff at a high speed. And suppose for a moment that the *gravity switch* could be *turned off* such that the cannonball would travel in the absence of gravity? What would the motion of such a cannonball be like? How could its motion be described? According to Newton's first law of motion, such a cannonball would continue in motion in a straight line at constant speed. If not acted upon by an unbalanced force, "an object in motion will ...". This is Newton's law of inertia.



Now suppose that the *gravity switch* is turned on and that the cannonball is projected horizontally from the top of the same cliff. What effect will gravity have upon the motion of the cannonball? Will gravity affect the cannonball's horizontal motion? Will the cannonball travel a greater (or shorter) horizontal distance due to the influence of gravity? The answer to both of these questions is "No!" Gravity will act downwards upon the cannonball to affect its vertical motion. Gravity causes a vertical acceleration. The ball will drop vertically below its otherwise straight-line, inertial path. Gravity is the downward force upon a projectile that influences its vertical motion and causes the parabolic trajectory that is characteristic of projectiles.



A projectile is an object upon which the only force is gravity. Gravity acts to influence the vertical motion of the projectile, thus causing a vertical acceleration. The horizontal motion of the projectile is the result of the tendency of any object in motion to remain in motion at constant velocity. Due to the absence of horizontal forces, a projectile remains in motion with a constant horizontal velocity. Horizontal forces are not required to keep a projectile moving horizontally. The only force acting upon a projectile is gravity!

Kepler's Three Law:

1. **Kepler's Law of Orbits** – The Planets move around the sun in elliptical orbits with the sun at one of the focii.
2. **Kepler's Law of Areas** – The line joining a planet to the Sun sweeps out equal areas in equal interval of time.
3. **Kepler's Law of Periods** – The square of the time period of the planet is directly proportional to the cube of the semimajor axis of its orbit.

Kepler's 1st Law of Orbits:

This law is popularly known as the **law of orbits**. The orbit of any planet is an ellipse around the Sun with Sun at one of the two foci of an ellipse. We know that planets revolve around the Sun in a circular orbit. But according to Kepler, he said that it is true that planets revolve around the Sun, but not in a circular orbit but it revolves around an ellipse. In an ellipse, we have two focus. Sun is located at one of the foci of the ellipse.

Kepler's 2nd Law of Areas:

This law is known as the **law of areas**. The line joining a planet to the Sun sweeps out equal areas in equal interval of time. The rate of change of area with time will be constant. We can see in the above figure, the Sun is located at the focus and the planets revolve around the Sun.

Assume that the planet starts revolving from point P_1 and travels to P_2 in a clockwise direction. So it revolves from point P_1 to P_2, as it moves the area swept from P_1 to P_2 is Δt. Now the planet moves future from P3 to P4 and the area covered is Δt.

As the area traveled by the planet from P_1 to P_2 and P_3 to P_4 is equal, therefore this law is known as the Law of Area. That is the aerial velocity of the planets remains constant. When a planet is nearer to the Sun it moves fastest as compared to the planet far away from the Sun.

Kepler's 3rd Law of Periods:

This law is known as the **law of Periods.** The square of the time period of the planet is directly proportional to the cube of the semimajor axis of its orbit.

$$T^2 \propto a^3$$

That means the time ' T ' is directly proportional to the cube of the semi major axis i.e. 'a'. Let us derive the equation of Kepler's 3rd law. Let us suppose,

- m = mass of the planet
- M = mass of the Sun
- v = velocity in the orbit

So, there has to be a force of gravitation between the Sun and the planet.

$$F = GmMr^2$$

Since it is moving in an elliptical orbit, there has to be a centripetal force.

$$F_c = mv^2r^2$$

Now, $F = F_c$

$\Rightarrow GMr = v^2$
Also, v = circumferencetime = $2\pi rt$

Combining the above equations, we get

$\Rightarrow GMr = 4\pi^2 r^2 T^2$
$T^2 = 4\pi 2r3)GM$
$\Rightarrow T^2$ □ r^3

UNIT-III

SYLLABUS

THERMAL PHYSICS: Laws of thermodynamics – Reversible and irreversible process – Heat engine – Carnot's theorem. Black body – Stefan's law – Newton's law of cooling – Newton's law of cooling from Stefan's law – Experimental determination of Stefan's constant – Wien's displacement law – Rayleigh – Jean's law – Planck's law.

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- Laws of thermodynamics

System or Surroundings

In order to avoid confusion, scientists discuss thermodynamic values in reference to a system and its surroundings. Everything that is not a part of the system constitutes its surroundings. The system and surroundings are separated by a boundary. For example, if the system is one mole of a gas in a container, then the boundary is simply the inner wall of the container itself. Everything outside of the boundary is considered the surroundings, which would include the container itself.

The boundary must be clearly defined, so one can clearly say whether a given part of the world is in the system or in the surroundings. If matter is not able to pass across the boundary, then the system is said to be *closed*; otherwise, it is *open*. A closed system may still exchange energy with the surroundings unless the system is an isolated one, in which case neither matter nor energy can pass across the boundary.

The First Law of Thermodynamics

The first law of thermodynamics, also known as Law of Conservation of Energy, states that energy can neither be created nor destroyed; energy can only be transferred or changed from one form to another. For example, turning on a light would seem to produce energy; however, it is electrical energy that is converted.

A way of expressing the first law of thermodynamics is that any change in the internal energy (ΔE) of a system is given by the sum of the heat (q) that flows across its boundaries and the work (w) done on the system by the surroundings:

[latex]\Delta E = q + w[/latex]

This law says that there are two kinds of processes, heat and work, that can lead to a change in the internal energy of a system. Since both heat and work can be measured and quantified, this is the same as saying that any change in the energy of a system must result in a corresponding change in the energy of the surroundings outside the system. In other words, energy cannot be created or destroyed. If heat flows into a system or the surroundings do work on it, the internal energy increases and the sign of q and w are positive. Conversely, heat flow out of the system or work done by the system (on the surroundings) will be at the expense of the internal energy, and q and w will therefore be negative.

The Second Law of Thermodynamics

The second law of thermodynamics says that the entropy of any isolated system always increases. Isolated systems spontaneously evolve towards thermal equilibrium—the state of maximum entropy of the system. More simply put: the entropy of the universe (the ultimate isolated system) only increases and never decreases.

A simple way to think of the second law of thermodynamics is that a room, if not cleaned and tidied, will invariably become more messy and disorderly with time – regardless of how careful one is to keep it clean. When the room is cleaned, its entropy decreases, but the effort to clean it has resulted in an increase in entropy outside the room that exceeds the entropy lost.

The Third Law of Thermodynamics

The third law of thermodynamics states that the entropy of a system approaches a constant value as the temperature approaches absolute zero. The entropy of a system at absolute zero is typically zero, and in all cases is determined only by the number of different ground states it has. Specifically, the entropy of a pure crystalline substance (perfect order) at absolute zero temperature is zero. This statement holds true if the perfect crystal has only one state with minimum energy.

Laws of Radiation

Overview

Everything radiates and absorbs electro-magnetic radiation. Many important radiation laws are based on the performance of a perfect steady state emitter called a blackbody or full radiator. These have smoothly varying spectra that follow a set of laws relating the spectral distribution and total output to the temperature of the blackbody. Sources like the sun, tungsten filaments, or Infrared Emitters, have blackbody-like emission spectra. However, the spectral distributions of them differ from those of true blackbodies; they have slightly different spectral shapes and in the case of the sun, fine spectral detail.

Figure 1: The spectrum of radiation from the sun is similar to that from a 5800K blackbody.

Planck's Law

This law gives the spectral distribution of radiant energy inside a blackbody.

$$W_{e\lambda}(\lambda, T) = 8\pi hc\lambda^{-5}(e^{ch/k\lambda T}-1)^{-1}$$

Where:

T = Absolute temperature of the blackbody

h = Planck’s constant (6.626 x 10-34 Js)

c = Speed of light (2.998 x 108 m s-1)

k = Boltzmann's constant (1.381 x 10-23 JK-1)

λ = Wavelength in m

The spectral radiant exitance from a non perturbing aperture in the blackbody cavity, $M_{e\lambda}$ (λ,T), is given by:

$$M_{e\lambda}(\lambda, T) = (c/4)W_{e\lambda}(\lambda,T),$$

$L_{e\lambda}$ (λ,T), the spectral radiance at the aperture is given by:

$$L_{e\lambda}(\lambda,T) = (c/4\pi)W_{e\lambda}(\lambda,T)$$

The curves in Figure 3 show $M_{B\lambda}$ plotted for blackbodies at various temperatures. The output increases and the peak shifts to shorter wavelengths as the temperature, T, increases.

Stefan-Boltzman Law

Integrating the spectral radiant exitance over all wavelengths gives:

$$\int M_{e\lambda}(\lambda,T)d\lambda = M_e(T) = \sigma T^4$$

σ is called the Stefan-Boltzmann constant

This is the Stefan-Boltzmann law relating the total output to temperature.

If M_e(T) is in W m-2, and T in kelvins, then σ is 5.67 x 10-8 Wm-2 K-4.

At room temperature a 1 mm2 blackbody emits about 0.5 mW into a hemisphere. At 3200 K, the temperature of the hottest tungsten filaments, the 1 mm2, emits 6 W.

Wien Displacement Law

This law relates the wavelength of peak exitance, λ_m, and blackbody temperature, T:

$\lambda_m T = 2898$ where T is in kelvins and λ_m is in micrometers.

The peak of the spectral distribution curve is at 9.8 µm for a blackbody at room temperature. As the source temperature gets higher, the wavelength of peak exitance moves towards shorter wavelengths. The temperature of the sun's surface is around 5800K. The peak of a 6000 blackbody curve is at 0.48 µm, as shown in Fig. 3.

Emissivity

The radiation from real sources is always less than that from a blackbody. Emissivity (ε) is a measure of how a real source compares with a blackbody. It is defined as the ratio of the radiant power emitted per area to the radiant power emitted by a blackbody per area. (A more rigorous definition defines directional spectral emissivity ε(θ,φ,λ,T). Emissivity can be wavelength and temperature dependent (Fig. 2). As the emissivity of tungsten is less than 0.4 where a 3200 K blackbody curve peaks, the 1 mm2 tungsten surface at 3200 K will only emit 2.5 W into the hemisphere.

If the emissivity does not vary with wavelength then the source is a "graybody".

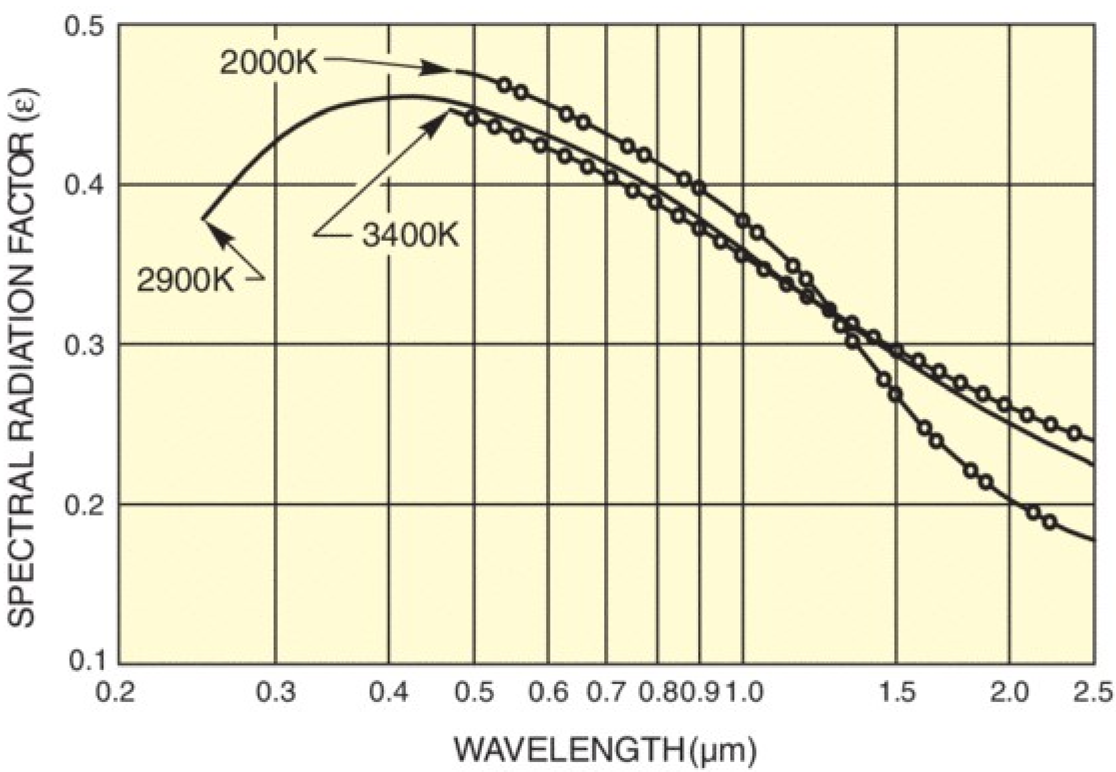


Figure 2: Emissivity (spectral radiation factor) of tungsten.

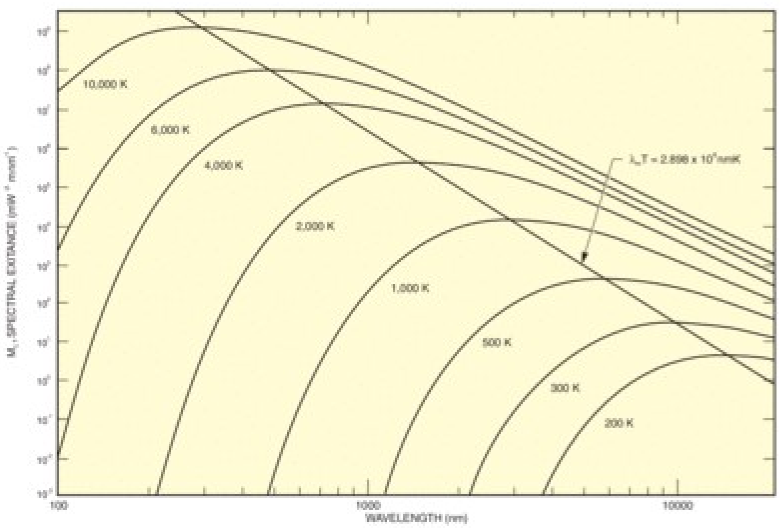


Figure 3: Spectral exitance for various blackbodies

Tech Note

Sometimes you prefer to have low emissivity over a part of the spectrum. This can reduce out of band interference. Our Ceramic Elements have low emissivity in the near infrared; this makes them more suitable for work in the mid IR. Normally one wants a high blackbody temperature for high output, but the combination of higher short wavelength detector responsivity and high near IR blackbody output complicates mid infrared spectroscopy. Because of the emissivity variation, the Ceramic Elements provide lower near IR than one would expect from their mid IR output.

Kirchoff's Law

Kirchoff's Law states that the emissivity of a surface is equal to its absorptance, where the absorptance (α) of a surface is the ratio of the radiant power absorbed to the radiant power incident on the surface.

$$\int_T \alpha(\lambda, T)\,d\lambda = \int_T \varepsilon(\lambda, T)\,d\lambda$$

$$\alpha = \varepsilon$$

Lambert's Law

Lambert's Cosine Law holds that the radiation per unit solid angle (the radiant intensity) from a flat surface varies with the cosine of the angle to the surface normal (Figure 4). Some Oriel® Light Sources, such as arcs, are basically spherical. These appear like a uniform flat disk as a result of the cosine law. Another consequence of this law is that flat sources, such as some of our low power quartz tungsten halogen filaments, must be properly oriented for maximum irradiance of a target. Flat diffusing surfaces are said to be ideal diffusers or Lambertian if the geometrical distribution of radiation from the surfaces obeys Lambert's Law. Lambert's Law has important consequences in the measurement of light. Cosine receptors on detectors are needed to make meaningful measurements of radiation with large or uncertain angular distribution.

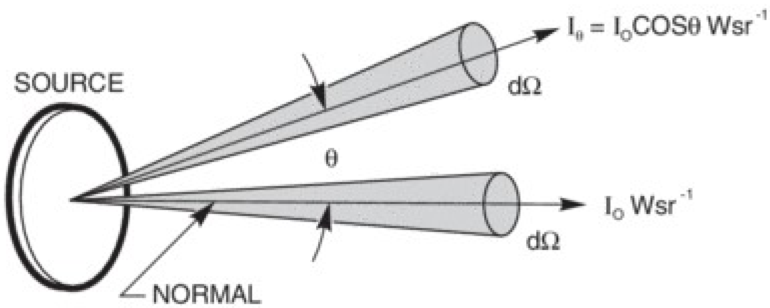


Figure 4: Lamberts cosine law indicates how the intensity, I, depends on angle.

Syllabus:-
Characteristics of laser – spontaneous and stimulated emission of radiation – Einstein's coefficients - population inversion – excitation mechanism and optical resonator – Nd:YAG laser –He-Ne laser – semiconductor diode laser – applications of lasers.

1. A short sketch of laser history

1917: Einstein – stimulated absorption and emission of light
1954: Charles Townes and Schawlow – maser, prediction of the optical laser - Nobel Prize (1964)
1960: Maimann – first demonstration of a laser: Ruby laser
Rapid progress in the 1960s:

- 1961: first gas laser, first Nd laser
- 1962: first semiconductor laser
- 1963: CO_2 laser (IR)

2. Introduction

- v A laser is a device that generates light by a process called **STIMULATED EMISSION**.
- v The acronym LASER stands for Light Amplification by Stimulated Emission of Radiation

3. Characteristic of laser

Th The laser light exhibits some peculiar properties than compare with the convectional light. Those are

- Highly directionality
- Highly monochromatic
- Highly intense
- Highly coherence

Highly directionality

- The light ray coming ordinary light source travels in all directions, but laser light travels in single direction.
- For example the light emitted from torch light travels 1km distance it spreads around 1 km wide.
- But the laser light spreads a few centimetres distance even it travels lacks of kilometre distance.

- The directionality of laser beam is expressed in terms of divergence Ø

$$\phi = \frac{a}{aiu} = \frac{2 - 1}{2 - 1}$$

Where 2 and 1 are the diameters of laser spots at distances of 2 and 1 respectively from laser source.

- For laser light divergence $\phi = 10^{-3} aian.$
- Since the divergence of light is very low, so we say that the laser light having highly directional.

Highly monochromatic

- In laser radiation, all the photons emitted between discrete energy levels will have same wavelength.
- As a result the radiation is monochromatic in nature.
- Due to the stimulated characteristic of laser light, the laser light is more monochromatic than that of a convectional light.
- laser radiation -the wavelength spread = 0.001 nm
- So it is clear that the laser radiation is highly monochromatic

Highly intense

- Laser light is highly intense than the convectional light.
- one mill watt He-Ne laser is highly intense than the sun intensity
- when two photons each of amplitude are in phase with other; the resultant amplitude of two photons is **2a** and the intensity is $\mathbf{4a^2}$
- in laser much number of photons are in phase with each other, the amplitude of the resulting wave becomes na and hence the intensity of laser is proportional to $\mathbf{n^2a^2}$
- So 1mW He-Ne laser is highly intense than the sun

Highly coherence

- Coherence is the property of the wave being in phase with itself and also with another wave over a period of time, and space or distance. There are two types of coherence
- Temporal coherence
- Spatial coherence.
- For laser radiation all the emitted photons are in phase, the resultant radiation obeys spatial and temporal coherence.

Temporal coherence (or longitudinal coherence):-

The predictable correlation of amplitude and phase at one point on the wave train w .r. t another point on the same wave train, then the wave is said to be temporal coherence.

spatially coherence (or transverse coherence).

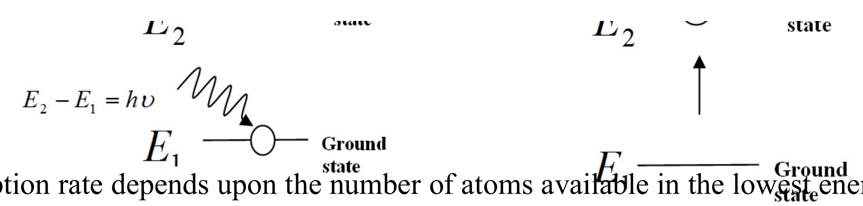
The predictable correlation of amplitude and phase at one point on the wave train w. r .t another point on a second wave, then the waves are said to be spatially coherence (or transverse coherence).

4. *Stimulated absorption*

Let **E1** and **E2 are** the energies and N1 and N2 are the number of atoms per unit volume of ground and excited states and $\rho(\upsilon)$ be the density of photon density.

Suppose, if a photon of energy $E_2 - E_1 = h\upsilon$ interacts with an atom present in the ground state, the atom gets excitation form ground state to excited state by absorbing the photon energy.

It is the *process of excitation of atom into excited state from ground state by absorbing the incident photon*.



Stimulated absorption rate depends upon the number of atoms available in the lowest energy state as well as the energy density photons.

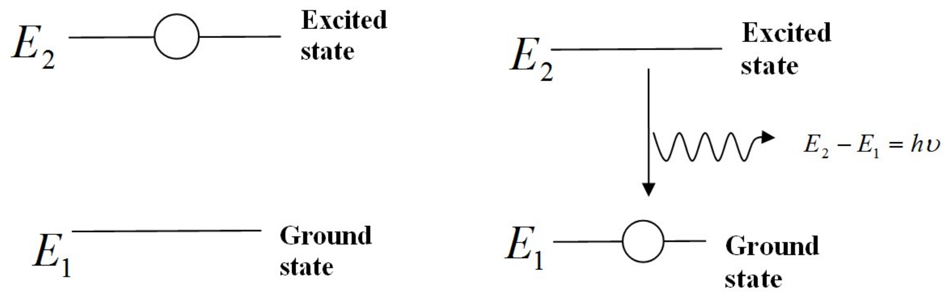
Stimulated absorption rate $\propto$ N1

$$\propto \rho(\upsilon)$$
$$\propto \rho(\upsilon)\, N1$$
$$= B12\, \rho(\upsilon)\, N1$$

Where B12 is known as Einstein coefficient of stimulated absorption

5. *Spontaneous emission*

- Spontaneous emission was postulated by Bohr.
- The excited atom does not stay in a long time in the excited state.
- The lifetime of excited atom in higher state E_2 is up to 10^{-8} seconds.
- After the life time of the excited atom, gets de-excited into ground by emitting a photon of energy $E_2 - E_1 = h\upsilon$.



It is the process of de-excitation of atom itself into ground state after its life time from excited state by emitting a photon

Spontaneous emission rate $\propto N_2$

$$= A_{21} N_2$$

Where $\mathbf{A_{21}}$ is known as Einstein coefficient of spontaneous emission

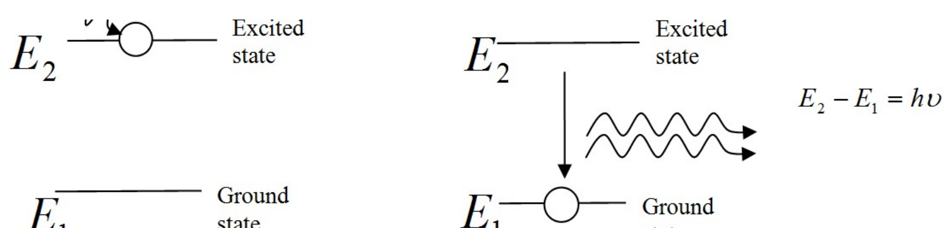
Characteristics of spontaneous emitted radiation

- The emitted radiation is poly-monochromatic
- The emitted radiation is Incoherent
- The emitted radiation is less intense
- The emitted radiation has less directionality
- Example: light from sodium or mercury lamp

6. *Stimulated emission*

Stimulated emission was postulated by Einstein.

Let, a photon of energy $E_2 - E_1 = h\upsilon$ interacts with the excited atom with in their life time; the atom gets de-excitation into ground state by emitting of additional photon.



It is the ***process of de-excitation of atom into ground state from excited state by interacting with an additional photon within its life time by emitting of an additional photon.***

Stimulated emission rate depends upon the number of atoms available in the excited state as well as the energy density of photons.

Stimulated emission rate $\propto N_2$

$$\propto \rho$$

$$\propto N_2 \rho$$

$$= B_{21} \rho N_2$$

Where B_{21} is known as Einstein coefficient of stimulated emission

Characteristics of stimulated emitted radiation

- The emitted radiation is monochromatic
- The emitted radiation is Coherent
- The emitted radiation is high intense
- The emitted radiation has high directionality
- Example: light from laser source

7. Spontaneous and Stimulated emission

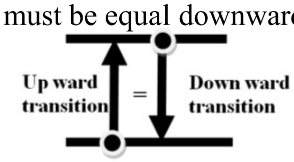
Spontaneous emission	Stimulated emission
1. The spontaneous emission was postulated by Bohr	1. The stimulated emission was postulated by Einstein
2. Additional photons are not required in spontaneous emission	2. Additional photons are required in stimulated emission
3. One photon is emitted in spontaneous emission	3. Two photons are emitted in stimulated emission
4. The emitted radiation is poly-monochromatic	4. The emitted radiation is monochromatic
5. The emitted radiation is Incoherent	5. The emitted radiation is Coherent
6. The emitted radiation is less intense	6. The emitted radiation is high intense
7. The emitted radiation have less directionality	7. The emitted radiation have high directionality
8. Example: : light from sodium or mercury lamp	8. Example: light from laser source

8. Einstein coefficients

It establishes the relation between the three coefficients i.e. stimulated absorption, spontaneous emission, and stimulated emission coefficients

Let N_1 be the number of atoms per unit volume with energy E_1 and $\mathbf{N}_2$ be the number of atoms per unit volume with energy E_2 and $\rho(\nu)$ be the the density of photons. When the photons interact with ground level atoms, both upward (absorption) and downward (emission) transition occurs.

At the equilibrium the upward transitions must be equal downward transitions.



Upward transition

Stimulated absorption rate depends upon the number of atoms available in the lowest energy state as well as the energy density photons.

Stimulated absorption rate $\propto N_1$

$\propto \rho(\nu)$

$= B_{12} N_1 \rho(\nu)$

Where B_{12} is the Einstein coefficient of stimulated absorption.

Downward transition

The spontaneous emission rate depends up on the number of atoms present in the excited state.

Spontaneous emission rate $\propto N_2$

$= A_{21} N_2$

Where A_{21} is the Einstein coefficient of spontaneous

$= B_{21}N_2\, \rho(\upsilon)$

Where B_{21} is the Einstein coefficient of stimulated emission.
If the system is in equilibrium the upward transitions must be equal downward transitions.

$_{12}N_1\rho(\upsilon) = {}_{21}N_2 + {}_{21}N_2\rho(\upsilon)$

$_{12}N_1\rho(\upsilon) - {}_{21}N_2\rho(\upsilon) = {}_{21}N_2$

$\rho(\upsilon)({}_{12}N_1 - {}_{21}N_2) = {}_{21}N_2$

$$\rho(\upsilon) = \frac{{}_{21}N_2}{({}_{12}N_1 - {}_{21}N_2)}$$

Divide with $_{21}N_2$ in numerator and denominator in right side of the above equation

$$\rho(\upsilon) = \frac{{}_{21}N_2 / {}_{21}N_2}{({}_{12}N_1 - {}_{21}N_2)/{}_{21}N_2} = \frac{{}_{21}/{}_{21}}{\frac{B_{12}N_1}{B_{21}N_2} - 1} \qquad (1)$$

$$\rho(\upsilon) = \frac{{}_{21}N_2 / {}_{21}N_2}{({}_{12}N_1 - {}_{21}N_2)/{}_{21}N_2} = \frac{{}_{21}/{}_{21}}{\frac{B_{12}}{B_{21}} e^{(E_2 - E_1)/KT} - 1} \qquad (2)$$

From Maxwell Boltzmann distribution law

$$\frac{N_1}{N_2} = e^{(E_2 - E_1)/KT}$$

From Planck's law, the radiation density

$$\rho(\upsilon) = \frac{8\pi h\upsilon^3 / c^3}{e^{(E_2-E_1)/kT} - 1} \qquad (3)$$

Comparing the two equations (2) and (3)

$$\frac{A_{21}}{B_{21}} = \frac{8\pi h\upsilon^3}{C^3} \quad \text{and} \quad \frac{B_{12}}{B_{21}} = 1$$

The above relations referred to as Einstein coefficients relations.
From the above equation for non degenerate energy levels the stimulated emission rate is equal to the stimulated absorption rate at the equilibrium condition.

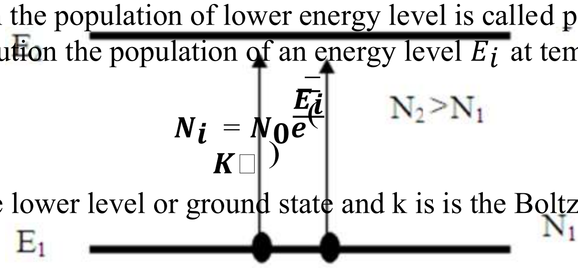
$B_{21} = B_{12}$

9. Population inversion

Let us consider two level energy system of energies **E1** and **E2** as shown in figure. Let **N1** and **N2** be the populations of energy levels **E1** and **E2**. The number of atoms present in an energy level is known as population of that energy level. At ordinary conditions, i.e., the population in the ground or lower state is always greater than the population in the excited or higher states. The stage of making, population of higher energy level is greater than the population of lower energy level is called population inversion.
According to Boltzmann's distribution the population of an energy level E_i at temperature T is given by

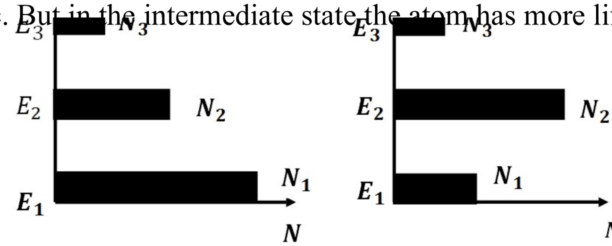
$$N_i = N_0 e^{\left(-\frac{E_i}{KT}\right)}$$

Where N_0 is the population of the lower level or ground state and k is is the Boltzmann's constant.



The process of raising the particles from ground state to excited state to achieve population inversion is called pumping. (Or the process of achieving of population inversion is called pumping)

To understand the concept of laser emission (stimulated emission) let us consider a three energy level system with energies **E_1, E_2** and **E_3** of populations, **N_1, N_2** and N_3. At normal conditions, **$E_1 < E_2 < E_3$** and **$N_1 < N_2$** $< N_3$. In the ground state the life time of atom is more and the life time of atom in the excited state is 10^{-8} sec. But in the intermediate state the atom has more life time. So it is called metastable state.



At normal conditions $N_1 > N_2 > N_2$

After population inversion is achieved $N_2 > N_1$

When a suitable energy is supplied to the system, atoms get excited into E_3. After their lifetime the atoms are transit into E_2. Due to more lifetime of an atom in state **E_2**, the atoms stay for longer time than compare with the state **E_3**. Due to the accumulation of atoms instate **E_2**, the population inversion is established in between the **E_1** and E_2 states.

10. Types of lasers

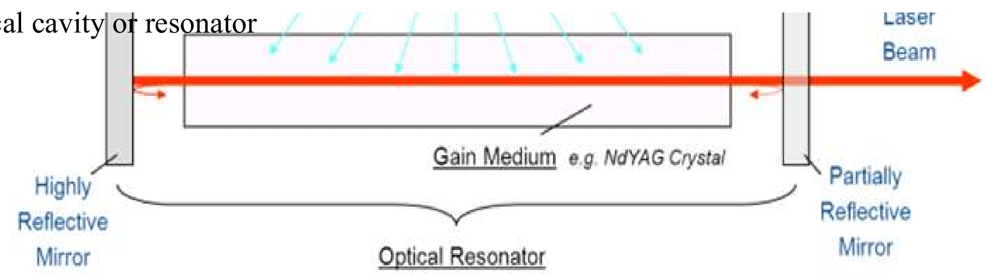
On the basis of active medium used in the laser systems, lasers are classified into several types

I. Solid lasers : Ruby laser, Nd;YAG laser, Nd;Glass
II. Liquid lasers : Europium Chelate laser, $SeOCl_2$
III. Gas lasers : CO_2, He-Ne, Argon-Ion Laser
IV. Dye lasers : Rhodamine
6G V. Semiconductor lasers : InP, GaAs.
VI. Chemical lasers : HF, DF.

11. Construction and components of laser

Generally, every laser system consists of three components. They are

a. Energy source
b. Active medium
c. Optical cavity or resonator



Energy source

- To get laser emission, first we must have population inversion in the active medium.
- The energy source supplies the energy to the active medium.
- By absorbing that energy, the atoms or molecules or ions can be excited into higher levels.
- As a result we get population inversion in the active medium.

Active medium

Definition: - ***In which medium we are creating population inversion to get stimulated emission of radiation is called active medium.***

- After receiving the energy from the source, the atoms or molecules or ions get excites into higher energy levels.
- While de-excitation to lower energy level, the emitted photons starts stimulated emission which results laser emission.
- Depending upon the active medium the lasers or classified as solid state, liquid state, gaseous state and semiconductor lasers.

Optical cavity or resonator

- ***The active medium is enclosed between a fully reflective mirror and partially reflective mirror. These mirrors constitute the optical cavity or resonator.***
- The reflectors enhance the stimulated emission process by reflecting the photons into the active medium.
- As a result we get high-intensity monochromatic and coherent laser light through the partially reflecting portion of the mirror.

12. Excitation mechanisms

Excitation of atom can be done by number of ways. The most commonly used excitation methods are

- Optical pumping
- Electrical discharge pumping
- Chemical pumping
- Injection current pumping

Optical pumping

- Optical pumping is a process in which light is used to raise the atoms from a lower energy level to higher level to create population inversion.
- Optical pumping is used in solid laser.
- The solid materials have very broad absorption band, so sufficient amount of energy is absorbed from the emission band of flash lamp to create population inversion.
- Xenon flash tubes are used for optical pumping.
- Examples: - Ruby laser, Nd:YAG Laser (Neodymium: Yttrium Aluminum Garnet), Nd: Glass Laser

Electrical discharge pumping

- In electric discharge pumping, atoms are excited into excited sate by collisions with fast moving electrons in electric discharge tube.
- Electrical discharge pumping is used in gas lasers.
- Since gas lasers have very narrow absorption band, so optical pumping is not suitable for gas lasers.
- Examples:- He-Ne laser, CO_2 laser, argon-ion laser, etc

Chemical pumping

- In this method the chemical energy released during the chemical process, that energy will excite the atoms to higher level and create population inversion.
- Whenever hydrogen reacts with fluorine, it liberates lot of heat energy. By utilizing this heat energy the atoms excites into higher states and create population inversion.
- Examples:-HF and DF lasers.

Injection current pumping

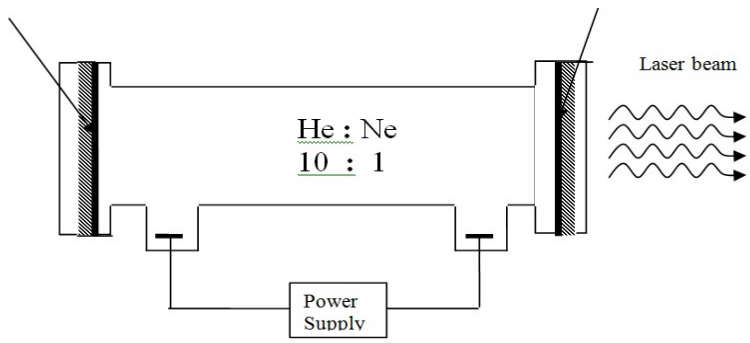
- This pumping mechanism is used in semiconductor lasers.
- In semiconductor lasers, by passing high currents across the junction, the population inversion will create.
- In semiconductors lasers the population inversion always creates among majority and minority charge carriers.
- Examples:- InP and GaAs lasers

13. He-Ne laser

- In 1960, the first laser device was developed by T.H. Mainmann.
- Ruby laser is a pulse laser, even it have high intense output.
- For continuous laser beam gas lasers are used.
- The output power of the gas laser is generally in few milli watts.
- The first He-Ne gas laser was fabricated by Ali Javan and others.

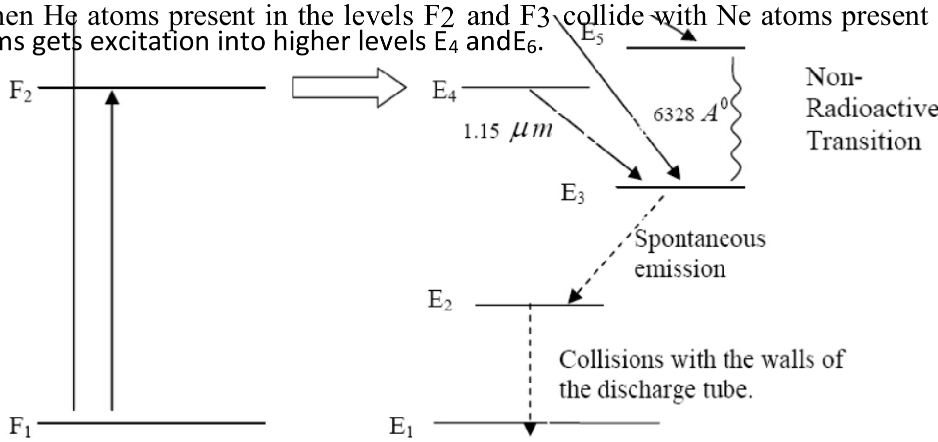
Construction

- In He-Ne gas laser, the He and Ne gases are taken in the ratio 10:1 in the discharge tube.
- Two reflecting mirrors are fixed on either ends of the discharge tube, in that, one is partially reflecting and the other is fully reflecting which serve as optical cavity or resonator.
- In He-Ne laser 80 cm length and 1 cm diameter discharge tube is generally used.
- The out power of these lasers depends on the length of the discharge tube and pressure of the gas mixture.
- When the two windows are set at Brewster's angle, the output laser is linearly polarized.



Working

- When the electric discharge (fast moving electrons) is passing through the gas mixture, the electrons collide with the He gas atoms excites into higher levels F2 and F3 form F1 by absorbing the electrons energy.
- In He atoms higher levels F2 and F3, the life time of He atoms is more.
- Since F2 and F3 states are acting as metastable states, so the He atom cannot return to ground ground level through spontaneous emission.
- So there is a maximum possibility of energy transfer between He and Ne atoms through atomic collisions.
- When He atoms present in the levels F2 and F3 collide with Ne atoms present ground state E1, the Ne atoms gets excitation into higher levels E_4 and E_6.



- Due to the continuous excitation of Ne atoms, we can achieve the population inversion between the higher levels E4 (E6) and lower levels E3 (E5).
- The various transitions $E_6 \rightarrow E_5$, $E_4 \rightarrow E_3$ and $E_6 \rightarrow E_3$ leads to the emission of wavelengths

  $3.39\mu m, 1.15\mu m$ *and* $6328 A^0$.
- The first two corresponding to the infrared region while the last wavelength is corresponding to the visible region.
- The Ne atoms present in the E3 level are de-excited into E2 level, by spontaneously emitting a photon of around wavelength $6000A^0$.
- When a narrow discharge tube is used, the Ne atoms present in the level E2 collide with the walls of the tube and get de-excited to ground level E1.
- The excitation and de-excitation of He and Ne atoms is a continuous process and thus it gives continuous laser radiations.

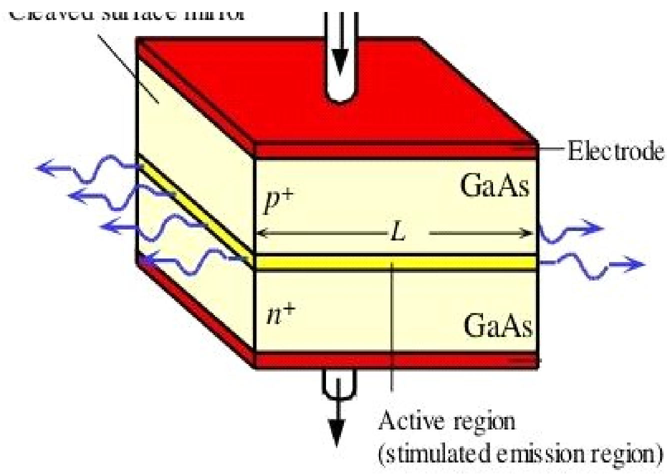
Advantages:

- He-Ne laser emits continuous laser radiation.
- Due to the setting of end windows at Brewster's angle, the output laser is linearly polarized.
- Gas lasers are more monochromatic and directional when compared with the solid state laser.

14. Semiconductor diode laser

- Laser diode is a specially fabricated *p-n* junction device that emits coherent radiation.
- It is operated at forward biased condition.
- Direct band gap semiconductors are preferred in the fabrication of semiconductor laser diodes because they emit energy in terms of light when an electron and hole recombination takes place.
- Compound semi-conductors like GaAs and InP are examples for direct band gap semiconductors

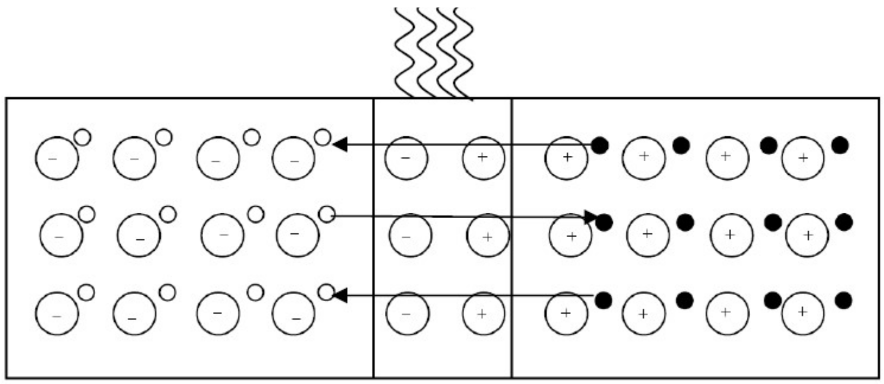
Construction



- In this laser system, the active medium is a p-n junction diode made from crystalline gallium arsenide.
- The p-region and n-region in the diode are obtained by heavily doping with germanium and tellurium respectively in GaAs.
- The thickness of the p-n junction is very narrow so that the emitted radiation has large divergence and poor coherence.
- At the junction two sides are roughed to avoid laser emission and the remaining two faces one is partially polished and the other is fully polished.
- The laser emission takes place from the partially polished face.
- To provide bias two metal contacts are provided in the top and bottom of the diode as shown in figure.

Working

- The semiconductor laser device is always operated in forward bias condition.
- Electrons and the holes are the minority charge carriers in n-region and p-region semiconductors.
- When a huge current (10^4 Amp/mm^2) is passing through the p-n junction, p-region is positively biased, holes are injected into n-region from p-region and n-region is negatively biased electrons are injected into p-region from n-region as shown in figure.



- The continuous injection of charge carriers creates the population inversion of minority carriers in n and p sides' respectively.
- The electrons and holes recombine and release of light energy takes place in or near the junction as shown in figure.
- The emitted photons increase the rate of recombination of injected electrons from the n-region and holes in p-region by inducing more recombinations.

From Planck's law $E_g = hv = h_\lambda$

$$\lambda = \frac{h}{E_g} = \frac{6.63 \times 10^{-34} \times 3 \times 10^{8}}{1.4 \times 1.6 \times 10^{-19}} = 8874^0$$

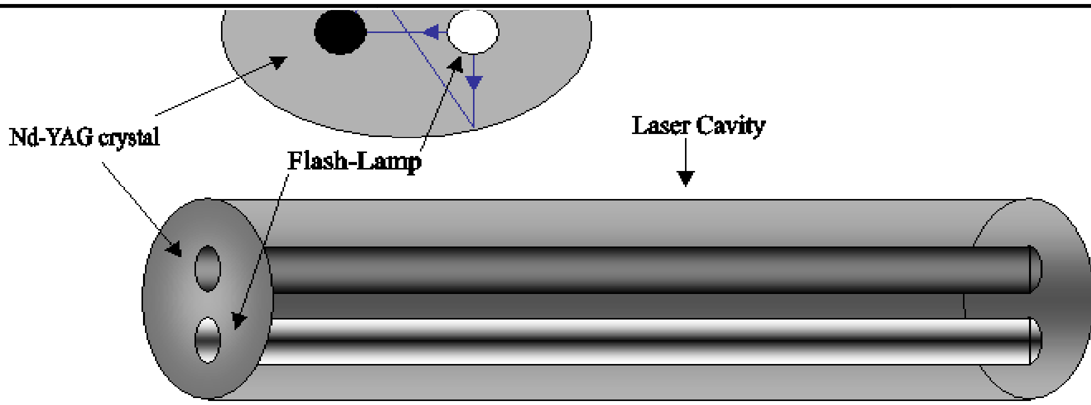
- In case of GaAs homo-junction which has an energy gap of 1.44eV gives a laser beam of wave length around 8874A^0.
- The wave length of emitted radiation depends up on the concentration of donor and acceptor atoms in GaAs.
- The efficiency of the laser emission is increases when we cool the GaAs diode.

15. Nd:YAG [Neodymium-Yttrium Aluminium Garnet] laser

- Nd: YAG laser is a solid state four level laser.
- Nd stands for Neodymium and YAG for Yttrium Aluminium Garnet ($Y3Al5O12$). Nd-YAG rod, Nd^{3+} ions are act as active medium.
- It is developed by H.M Marcos and L.G Van Vitert in 1964.

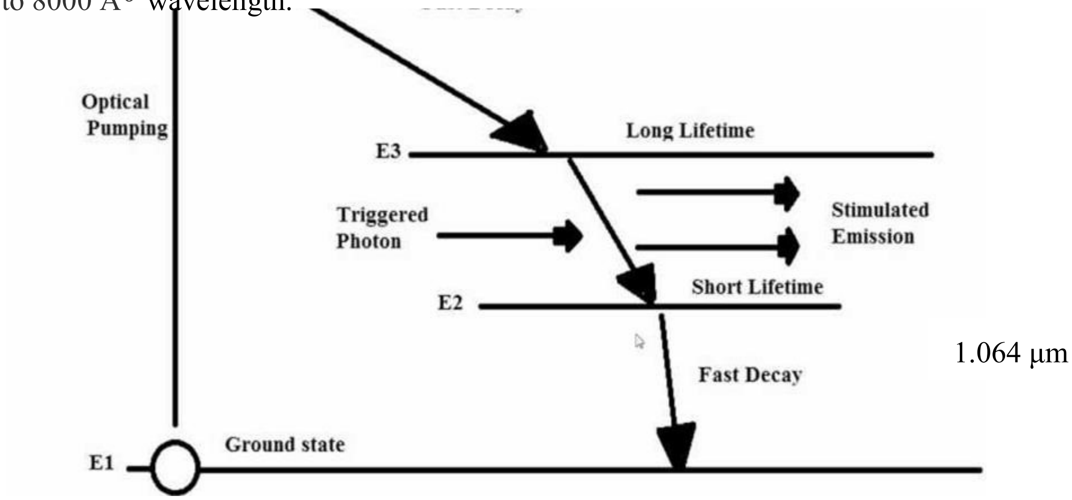
Construction

- An Nd-YAG laser consists of a crystalline cylindrical Nd-YAG rod [$Y3Al5012$].
- Nd: YAG crystalline material is formed by 1% Y^{3+} replaced by the triply ionised neodymium (Nd^{3+})
- The dimensions of the Nd: YAG rod is 10 cm length and 6-9 cm diameter.
- One end of the Nd-YAG rod is fully silvered and the other end is partially silvered which serve as optical cavity or resonator.
- The Nd-YAG rod surrounded by elliptical glass cavity which in turn is enclosed by xenon flash lamp filled with xenon gas s shown in fig1.



Working

- When xenon flash lamp is switched on, it emits thousand joules of light energy is discharged in a few milliseconds. A part of this light energy will be flashes on the Nd-YAG rod.
- Then the Nd^{3+} are excited to higher energy states E4 from ground state E1 by absorbing the light 7200 A^0 to 8000 A^0 wavelength.



- The excited Nd^{3+} ions then make a transition from these energy levels.
- In the excited state E4 the life time of Nd^{3+} ions are very small so it de-excites into E3 state through non-radioactive transition.
- In E3 state the life time of Nd^{3+} ions is large, so it will act as Meta stable state.
- In Meta stable state, the Nd^{3+} ions remain for longer duration of the order 10^{-3} second, so population inversion takes place between Meta stable E3 and E2 state.
- The Nd^{3+} Ions are de-excited into ground E1 state through fast decay.
- Hence, pulsed form of laser beam of wavelength 1.064 µm is emitted during transition from E2to E1.

Applications of Nd-YAG Laser

- These lasers are widely used for cutting, drilling, welding in the industrial products.
- It is used in long haul communication systems.
- It is also used in the endoscopic applications

16. Applications of lasers

Due to high intensity, high monocromacity and high directionality of lasers, they are widely used in various fields like

1. communication
2. computers
3. chemistry
4. photography
5. industry
6. medicine
7. military
8. scientific research

1. communication

In case of optical communication semiconductors laser diodes are used as optical sources and its band width is (10^{14}Hz) is very high compared to the radio and microwave communications.

- Ø More channels can be sent simultaneously
- Ø Signal cannot be tapped
- Ø As the band width is large, more data can be sent.
- Ø A laser is highly directional and less divergence, hence it has greater potential use in space crafts and submarines.

2. Computers

- Ø In LAN (local area network), data can be transferred from memory storage of one computer to other computer using laser for short time.
- Ø Lasers are used in CD-ROMS during recording and reading the data.

3. Chemistry

- Ø Lasers are used in molecular structure identification
- Ø Lasers are also used to accelerate some chemical reactions.
- Ø Using lasers, new chemical compounds can be created by breaking bonds between atoms are molecules.

4. Photography

- Ø Lasers are also used in the construction of holograms.
- Ø Lasers can be used to get 3-D lens less photography.

5. Industry

- Ø Lasers can be used to blast holes in diamonds and hard steel
- Ø Lasers are also used as a source of intense heat
- Ø Lasers are used to drill holes in ceramics.
- Ø Lasers are used to cut glass and quartz.
- Ø Lasers are used for heat treatment in the tooling and automotive industry.
- Ø Lasers are used in electronic industry in trimming the components of ICS.
- Ø High power lasers are used to weld or melt any material.
- Ø Lasers are also used to cut teeth in saws and test the quality of fabric.

6. Medicine

- Ø Lasers are used for cataract removal.
- Ø Lasers are used for eye lens curvature corrections.
- Ø Lasers are used in bloodless surgery.
- Ø Lasers are used in cancer diagnosis and therapy.
- Ø Lasers are used in destroying kidney stones and gallstones.
- Ø Argon and carbon dioxide lasers are used in the treat men of liver and lungs.
- Ø Lasers used in endoscopy to scan the inner parts of the stomach.
- Ø Lasers used in the elimination of moles and tumours which are developing in the skin tissue.
- Ø Lasers are used in plastic surgery.
- Ø Lasers are used in the treatment of mouth diseases.

7. Military

- Ø Lasers can be used as a war weapon.
- Ø High energy lasers are used to destroy the enemy air-crofts and missiles.

8. **Scientific field**

- Lasers are used for isotope preparation.
- Lasers are employed to create plasma.
- Lasers are used in air pollution, to estimate the size of the dust particles.
- Lasers are used in the field of 3D-photography
- Lasers used in Recording and reconstruction of hologram.
- Lasers used to produce certain chemical reactions.
- Lasers are used in Raman spectroscopy to identify the structure of the molecule.
- Lasers are used in the Michelson- Morley experiment.

UNIT-V

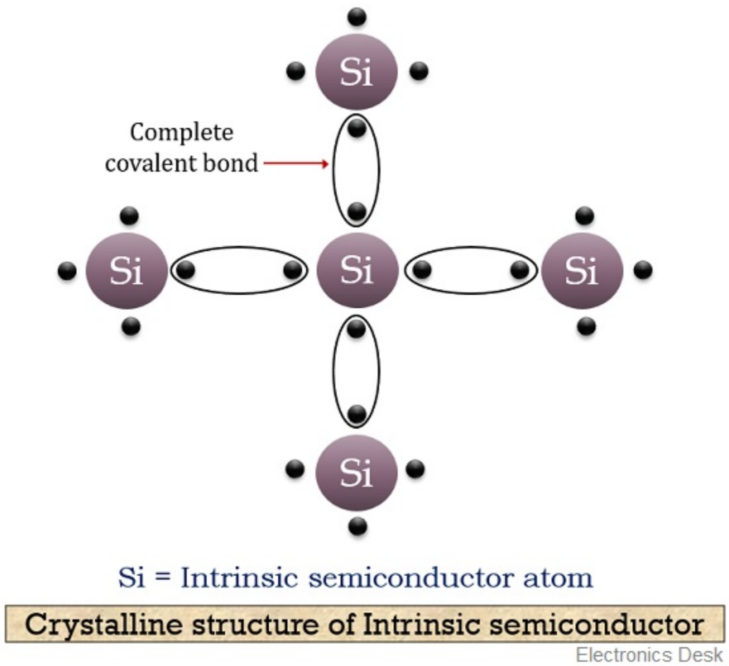
SYLLABUS

BASIC ELECTRONICS: Intrinsic and extrinsic semiconductor – PN Junction diode – Biasing of PN junction – V-I characteristics of junction diode – Rectifiers – Half wave – Full wave and bridge rectifiers – Zener diode – Characteristics of Zener diode – Voltage regulator – Transistor – Characteristics of transistor – CB, CE mode – Transistors as an amplifier.

Definition of Intrinsic Semiconductor

An intrinsic semiconductor is formed from a **highly pure semiconductor** material thus also known as pure semiconductors. These are basically undoped semiconductors that do not have doped impurity in it.
At room temperature, intrinsic semiconductors exhibit almost **negligible conductivity**. As no any other type of element is present in its crystalline structure.
The group IV elements of the periodic table form an intrinsic semiconductor. However, mainly **silicon and germanium** are widely used. This is so because in their case only small energy is needed in order to break the covalent bond.

The figure below shows the crystalline structure of silicon:



The figure above clearly shows that silicon consists of 4 electrons in the valence shell. Here, 4 covalent bonds are formed between the electrons of the silicon atom.

When the temperature of the crystal is increased then the electrons in the covalent bond gain kinetic energy and after breaking the covalent bond it gets free. Thus, the movement of free electrons generates current.

The rise in temperature somewhat increases the number for free electrons for conduction.

Definition of Extrinsic Semiconductor

Extrinsic Semiconductors are those that are the result of adding an impurity to a pure semiconductor. These are basically termed as an impure form of semiconductors.

The process by which certain amount of impurity is provided to a pure semiconductor is known as **doping**. So, we can say a pure semiconductor is doped to generate an extrinsic semiconductor.

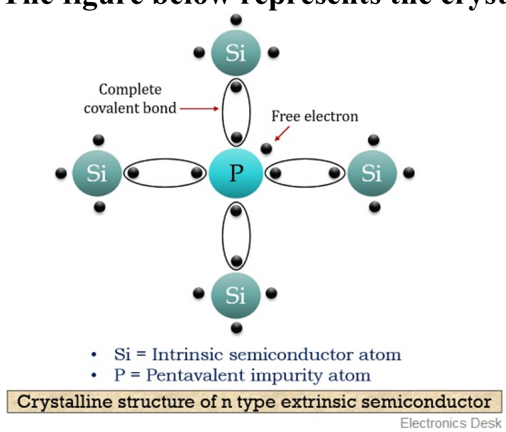
These are **highly conductive in nature**. However, unlike intrinsic semiconductor, extrinsic semiconductors are of two types **p-type** and an **n-type** semiconductor.

It is noteworthy here that the classification of the extrinsic semiconductor depends on the type of element doped to the pure semiconductor.

The p-type semiconductors are formed by introducing group III elements or trivalent impurity into the pure semiconductor. These are also known as an **acceptor impurity**, as a trivalent impurity has only 3 electrons in the valence shell.

The n-type semiconductors are formed by the addition of group V elements or pentavalent impurity to a pure semiconductor. These are termed as **donor impurity**, as a pentavalent impurity holds 5 electrons in its valence shell.

The figure below represents the crystalline structure of n-type semiconductor:



Crystalline structure of n type extrinsic semiconductor

Here, the above figure clearly shows that a pentavalent impurity is doped to a pure silicon crystal. In this case, 4 electrons of phosphorus are covalently bonded with the adjacent silicon atom. But, still, a free electron is left in this case.

Thus, the movement of these free electrons generates high conduction. Also, when the temperature is increased then it causes the covalent bond to get a breakdown. Hence generating more free electrons.

So, this is the reason why an n-type extrinsic semiconductor has electrons as the majority charge carrier.

Key Differences Between Intrinsic and Extrinsic Semiconductor

Parameter	Intrinsic Semiconductor	Extrinsic Semiconductor
Form of semiconductor	Pure form of semiconductor.	Impure form of semiconductor.
Conductivity	It exhibits poor conductivity.	It possesses comparatively better conductivity than intrinsic semiconductor.
Band gap	The band gap between conduction and valence band is small.	The energy gap is higher than intrinsic semiconductor.
Fermi level	It is present in the middle of forbidden energy gap.	The presence of fermi level varies according to the type of extrinsic semiconductor.
Dependency	The conduction relies on temperature.	The conduction depends on the concentration of doped impurity and temperature.
Carrier concentration	Equal amount of electron and holes are present in conduction and valence band.	The majority presence of electrons and holes depends on the type of extrinsic semiconductor.
Type	It is not further classified.	It is classified as p type and n type semiconductor.
Example	Si, Ge etc.	GaAs, GaP etc.

PN Junction Diode

A PN-junction diode is formed when a p-type semiconductor is fused to an n-type semiconductor creating a potential barrier voltage across the diode junction

The effect described in the previous tutorial is achieved without any external voltage being applied to the actual PN junction resulting in the junction being in a state of equilibrium.

However, if we were to make electrical connections at the ends of both the N-type and the P-type materials and then connect them to a battery source, an additional energy source now exists to overcome the potential barrier.

The effect of adding this additional energy source results in the free electrons being able to cross the depletion region from one side to the other. The behaviour of the PN junction with regards to the potential barrier's width produces an asymmetrical conducting two terminal device, better known as the **PN Junction Diode**.

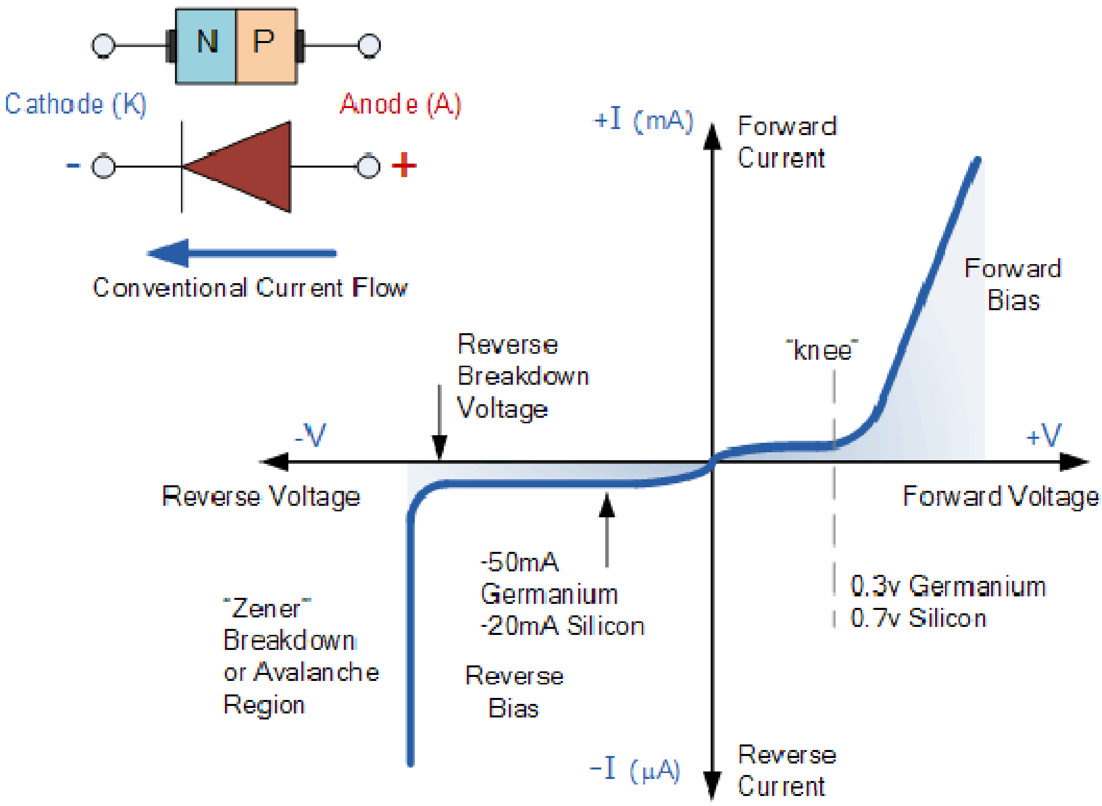
A *PN Junction Diode* is one of the simplest semiconductor devices around, and which has the characteristic of passing current in only one direction only. However, unlike a resistor, a diode does not behave linearly with respect to the applied voltage as the diode has an exponential current-voltage (I-V) relationship and therefore we can not described its operation by simply using an equation such as Ohm's law.

If a suitable positive voltage (forward bias) is applied between the two ends of the PN junction, it can supply free electrons and holes with the extra energy they require to cross the junction as the width of the depletion layer around the PN junction is decreased.

By applying a negative voltage (reverse bias) results in the free charges being pulled away from the junction resulting in the depletion layer width being increased. This has the effect of increasing or decreasing the effective resistance of the junction itself allowing or blocking current flow through the diode.

Then the depletion layer widens with an increase in the application of a reverse voltage and narrows with an increase in the application of a forward voltage. This is due to the differences in the electrical properties on the two sides of the PN junction resulting in physical changes taking place. One of the results produces rectification as seen in the PN junction diodes static I-V (current-voltage) characteristics. Rectification is shown by an asymmetrical current flow when the polarity of bias voltage is altered as shown below.

Junction Diode Symbol and Static I-V Characteristics



But before we can use the PN junction as a practical device or as a rectifying device we need to firstly **bias** the junction, ie connect a voltage potential across it. On the voltage axis above, "Reverse Bias" refers to an external voltage potential which increases the potential barrier. An external voltage which decreases the potential barrier is said to act in the "Forward Bias" direction.

There are two operating regions and three possible "biasing" conditions for the standard **Junction Diode** and these are:

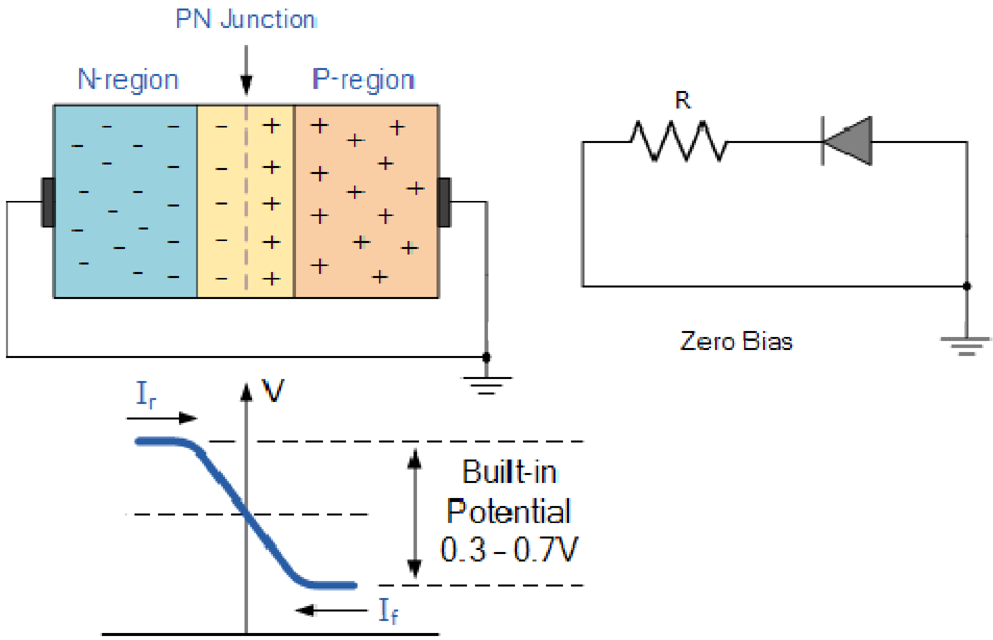
- 1. Zero Bias – No external voltage potential is applied to the PN junction diode.
- 2. Reverse Bias – The voltage potential is connected negative, (-ve) to the P-type material and positive, (+ve) to the N-type material across the diode which has the effect of **Increasing** the PN junction diode's width.
- 3. Forward Bias – The voltage potential is connected positive, (+ve) to the P-type material and negative, (-ve) to the N-type material across the diode which has the effect of **Decreasing** the PN junction diodes width.

Zero Biased Junction Diode

When a diode is connected in a **Zero Bias** condition, no external potential energy is applied to the PN junction. However if the diodes terminals are shorted together, a few holes (majority carriers) in the P-type material with enough energy to overcome the potential barrier will move across the junction against this barrier potential. This is known as the "**Forward Current**" and is referenced as I_F

Likewise, holes generated in the N-type material (minority carriers), find this situation favourable and move across the junction in the opposite direction. This is known as the "**Reverse Current**" and is referenced as I_R. This transfer of electrons and holes back and forth across the PN junction is known as diffusion, as shown below.

Zero Biased PN Junction Diode



The potential barrier that now exists discourages the diffusion of any more majority carriers across the junction. However, the potential barrier helps minority carriers (few free electrons in the P-region and few holes in the N-region) to drift across the junction.

Then an "Equilibrium" or balance will be established when the majority carriers are equal and both moving in opposite directions, so that the net result is zero current flowing in the circuit. When this occurs the junction is said to be in a state of "**Dynamic Equilibrium**".

The minority carriers are constantly generated due to thermal energy so this state of equilibrium can be broken by raising the temperature of the PN junction causing an increase in the generation of minority carriers, thereby resulting in an increase in leakage current but an electric current cannot flow since no circuit has been connected to the PN junction.

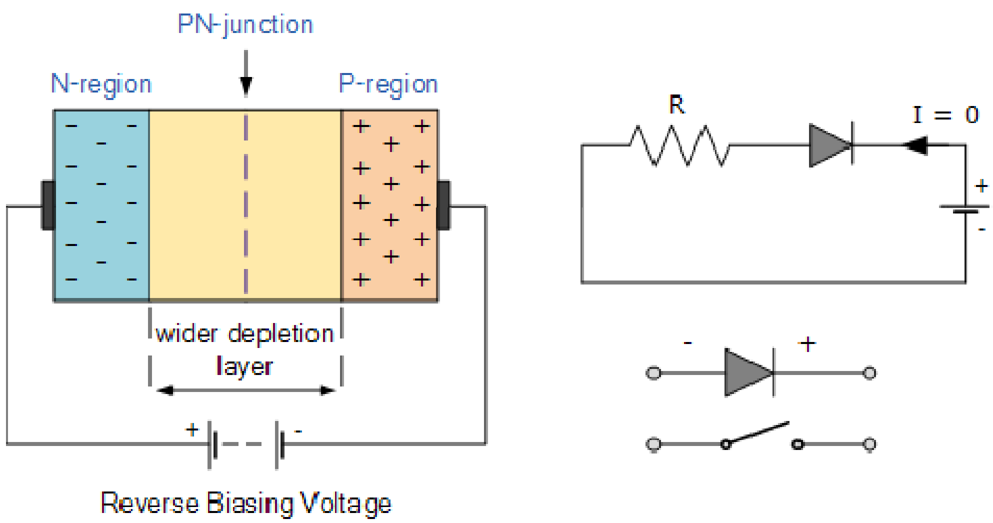
Reverse Biased PN Junction Diode

When a diode is connected in a **Reverse Bias** condition, a positive voltage is applied to the N-type material and a negative voltage is applied to the P-type material.

The positive voltage applied to the N-type material attracts electrons towards the positive electrode and away from the junction, while the holes in the P-type end are also attracted away from the junction towards the negative electrode.

The net result is that the depletion layer grows wider due to a lack of electrons and holes and presents a high impedance path, almost an insulator. The result is that a high potential barrier is created thus preventing current from flowing through the semiconductor material.

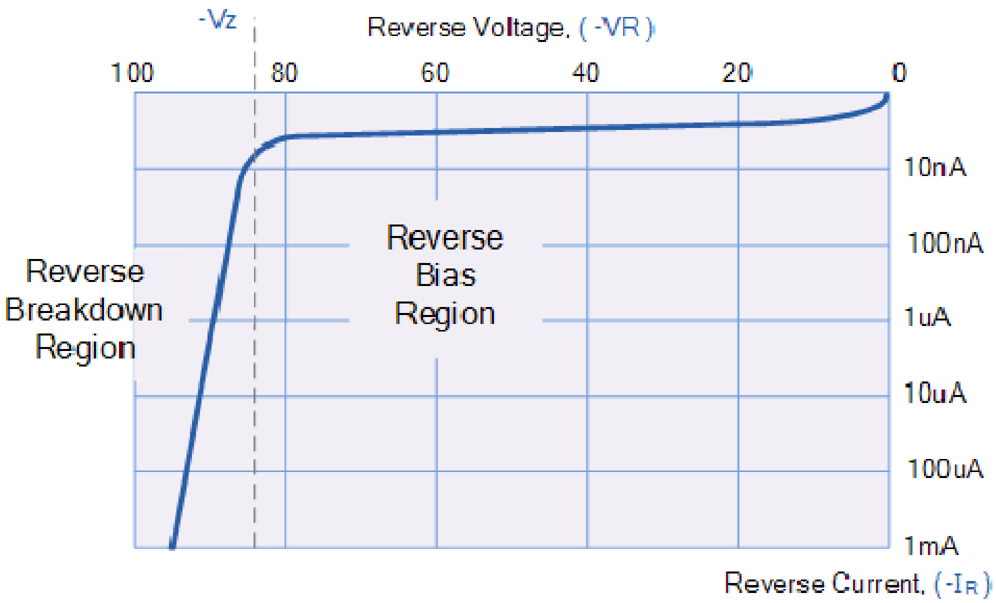
Increase in the Depletion Layer due to Reverse Bias



This condition represents a high resistance value to the PN junction and practically zero current flows through the junction diode with an increase in bias voltage. However, a very small **leakage current** does flow through the junction which can be measured in micro-amperes, (μA).

One final point, if the reverse bias voltage Vr applied to the diode is increased to a sufficiently high enough value, it will cause the diode's PN junction to overheat and fail due to the avalanche effect around the junction. This may cause the diode to become shorted and will result in the flow of maximum circuit current, and this shown as a step downward slope in the reverse static characteristics curve below.

Reverse Characteristics Curve for a Junction Diode



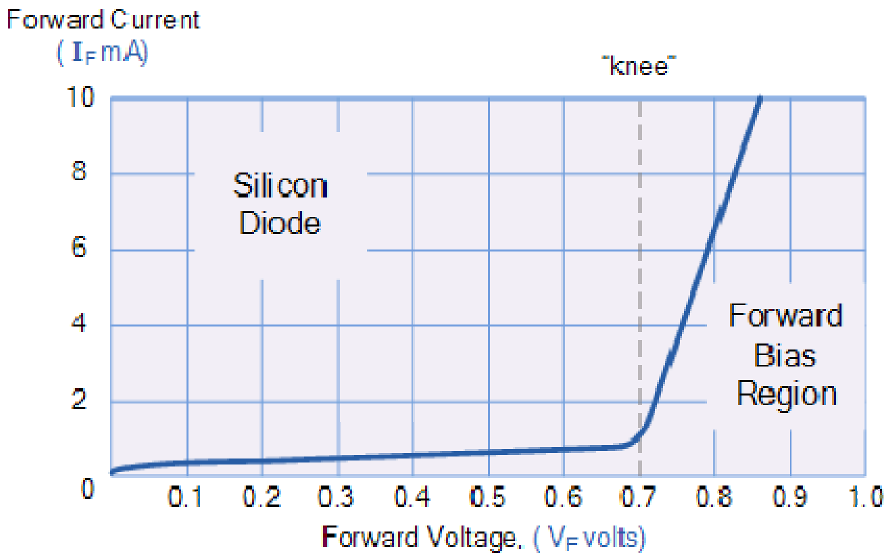
Sometimes this avalanche effect has practical applications in voltage stabilising circuits where a series limiting resistor is used with the diode to limit this reverse breakdown current to a preset maximum value thereby producing a fixed voltage output across the diode. These types of diodes are commonly known as Zener Diodes and are discussed in a later tutorial.

Forward Biased PN Junction Diode

When a diode is connected in a **Forward Bias** condition, a negative voltage is applied to the N-type material and a positive voltage is applied to the P-type material. If this external voltage becomes greater than the value of the potential barrier, approx. 0.7 volts for silicon and 0.3 volts for germanium, the potential barriers opposition will be overcome and current will start to flow.

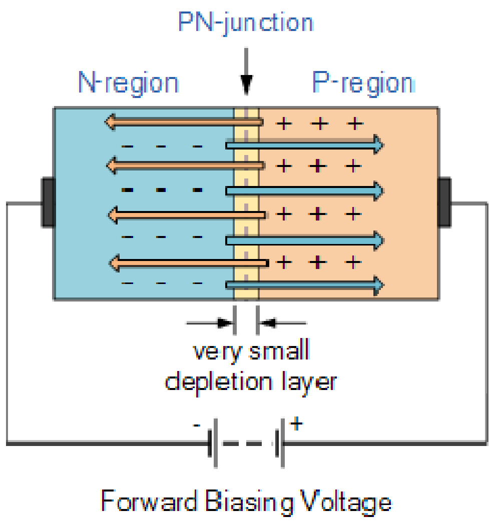
This is because the negative voltage pushes or repels electrons towards the junction giving them the energy to cross over and combine with the holes being pushed in the opposite direction towards the junction by the positive voltage. This results in a characteristics curve of zero current flowing up to this voltage point, called the "knee" on the static curves and then a high current flow through the diode with little increase in the external voltage as shown below.

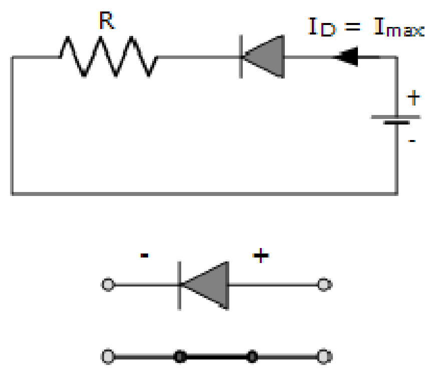
Forward Characteristics Curve for a Junction Diode



The application of a forward biasing voltage on the junction diode results in the depletion layer becoming very thin and narrow which represents a low impedance path through the junction thereby allowing high currents to flow. The point at which this sudden increase in current takes place is represented on the static I-V characteristics curve above as the “knee” point.

Reduction in the Depletion Layer due to Forward Bias





This condition represents the low resistance path through the PN junction allowing very large currents to flow through the diode with only a small increase in bias voltage. The actual potential difference across the junction or diode is kept constant by the action of the depletion layer at approximately 0.3v for germanium and approximately 0.7v for silicon junction diodes.

Since the diode can conduct “infinite” current above this knee point as it effectively becomes a short circuit, therefore resistors are used in series with the diode to limit its current flow.

Exceeding its maximum forward current specification causes the device to dissipate more power in the form of heat than it was designed for resulting in a very quick failure of the device.

Transistor Characteristics are the plots which represent the relationships between the current and the voltages of a transistor in a particular configuration. By considering the transistor configuration circuits to be analogous to two-port networks, they can be analyzed using the characteristic-curves which can be of the following types

1. Input Characteristics: These describe the changes in input current with the variation in the values of input voltage keeping the output voltage constant.
2. Output Characteristics: This is a plot of output current versus output voltage with constant input current.
3. Current Transfer Characteristics: This characteristic curve shows the variation of output current in accordance with the input current, keeping output voltage constant.

Common Base (CB) Configuration of Transistor

In CB Configuration, the base terminal of the transistor will be common between the input and the output terminals as shown by Figure 1. This configuration offers low input impedance, high output impedance, high resistance gain and high voltage gain.

Input Characteristics for CB Configuration of Transistor

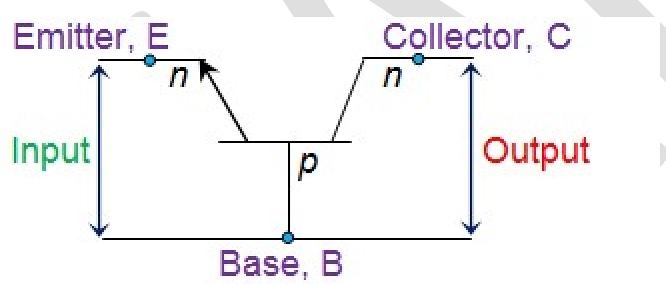


Figure 1 Common Base (CB) Configuration

Figure 2 below shows the input characteristics of a CB configuration circuit which describes the variation of emitter current, I_E with Base-Emitter voltage, V_{BE} keeping Collector-Base voltage, V_{CB} constant.

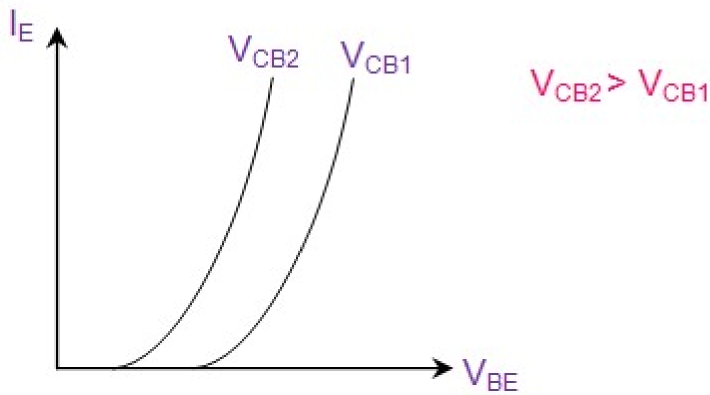


Figure 2 Input Characteristics for CB Configuration

This leads to the expression for the input resistance as

$$R_{in} = \left.\frac{\Delta V_{BE}}{\Delta I_E}\right|_{V_{CB}=constant}$$

Output Characteristics for CB Configuration of Transistor

The output characteristics of CB configuration (Figure 3) show the variation of collector current, I_C with V_{CB} when the emitter current, I_E is held constant. From the graph shown, the output resistance can be obtained as:

$$R_{out} = \left.\frac{\Delta V_{CB}}{\Delta I_C}\right|_{I_E=constant}$$

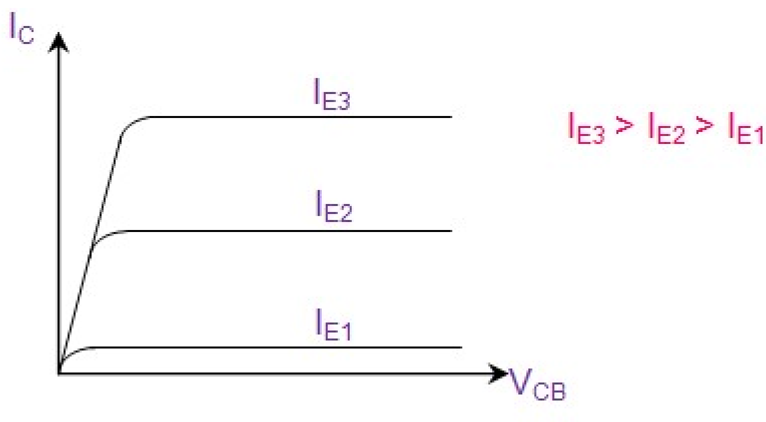


Figure 3 Output Characteristics for CB Configuration

igure 4 below shows the current transfer characteristics for CB configuration which illustrates the variation of I_C with the I_E keeping V_{CB} as a constant. The resulting current gain has a value less than 1 and can be mathematically expressed as:

$$\alpha = \left.\frac{\Delta I_C}{\Delta I_E}\right|_{V_{CB}=constant}$$

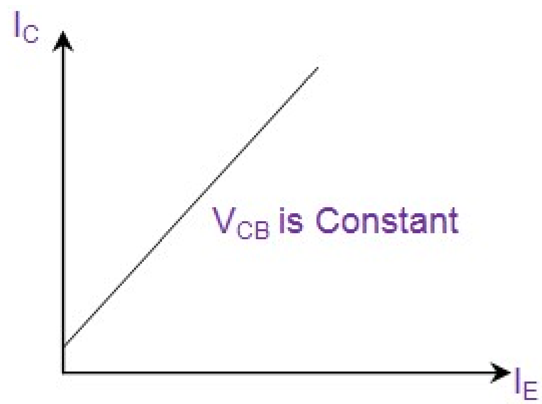


Figure 4 Current Transfer Characteristics for CB Configuration

Common Collector (CC) Configuration of Transistor

This transistor configuration has the collector terminal of the transistor common between the input and the output terminals (Figure 5) and is also referred to as emitter follower configuration. This offers high input impedance, low output impedance, voltage gain less than one and a large current gain.

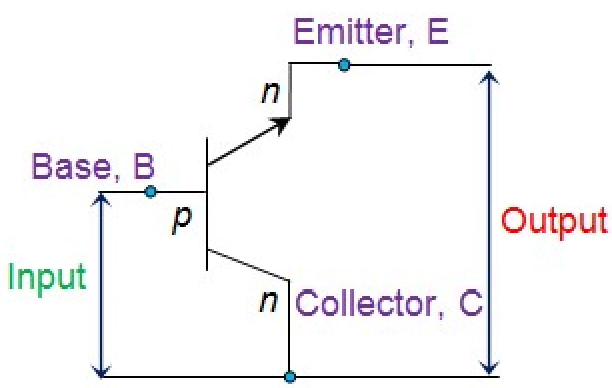


Figure 5 Common Collector (CC) Configuration

Input Characteristics for CC Configuration of Transistor

Figure 6 shows the input characteristics for CC configuration which describes the variation in I_B in accordance with V_{CB}, for a constant value of Collector-Emitter voltage, V_{CE}.

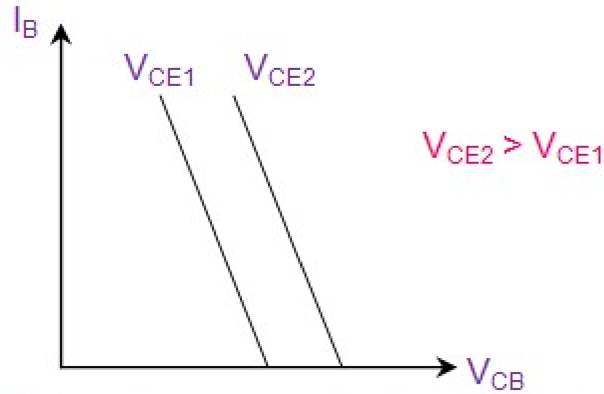


Figure 6 Input Characteristics for CC Configuration

Output Characteristics for CC Configuration of Transistor

Figure 7 below shows the output characteristics for the CC configuration which exhibit the variations in I_E against the changes in V_{CE} for constant values of I_B.

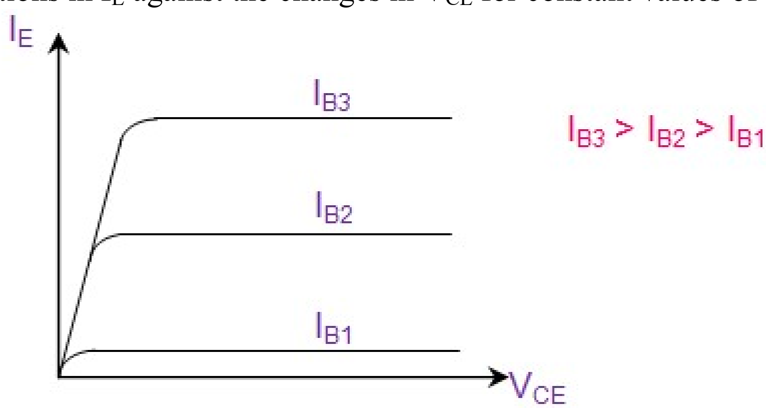


Figure 7 Output Characteristics for CC Configuration

Current Transfer Characteristics for CC Configuration of Transistor

This characteristic of CC configuration (Figure 8) shows the variation of I_E with I_B keeping V_{CE} as a constant.

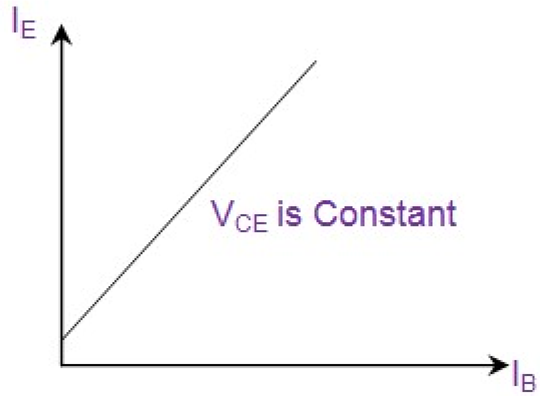


Figure 8 Current Transfer Characteristics for CC Configuration

Common Emitter (CE) Configuration of Transistor

In this configuration, the emitter terminal is common between the input and the output terminals as shown by Figure 9. This configuration offers medium input impedance, medium output impedance, medium current gain and voltage gain.

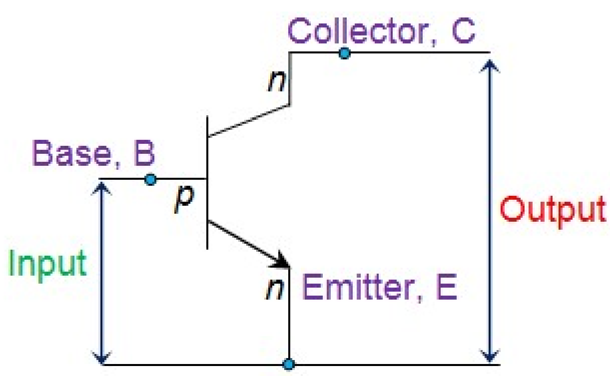


Figure 9 Common Emitter (CE) Configuration

Input Characteristics for CE Configuration of Transistor

Figure 10 shows the input characteristics for the CE configuration of transistor which illustrates the variation in I_B in accordance with V_{BE} when V_{CE} is kept constant.

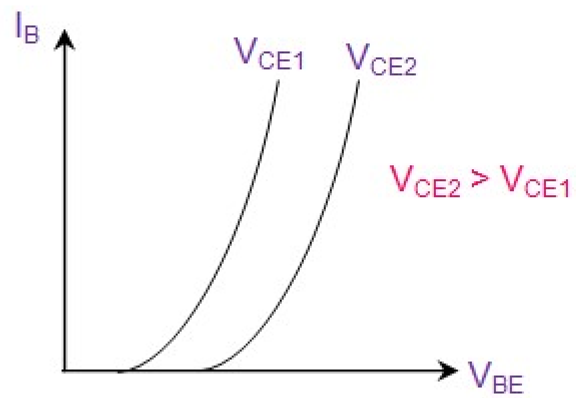


Figure 10 Input Characteristics for CE Configuration

From the graph shown in Figure 10 above, the input resistance of the transistor can be obtained as

$$R_{in} = \left.\frac{\Delta V_{BE}}{\Delta I_B}\right|_{V_{CE}=constant}$$

Output Characteristics for CE Configuration of Transistor

The output characteristics of CE configuration (Figure 11) are also referred to as collector characteristics. This plot shows the variation in I_C with the changes in V_{CE} when I_B is held constant. From the graph shown, the output resistance can be obtained as:

$$R_{out} = \left.\frac{\Delta V_{CE}}{\Delta I_C}\right|_{I_B=constant}$$

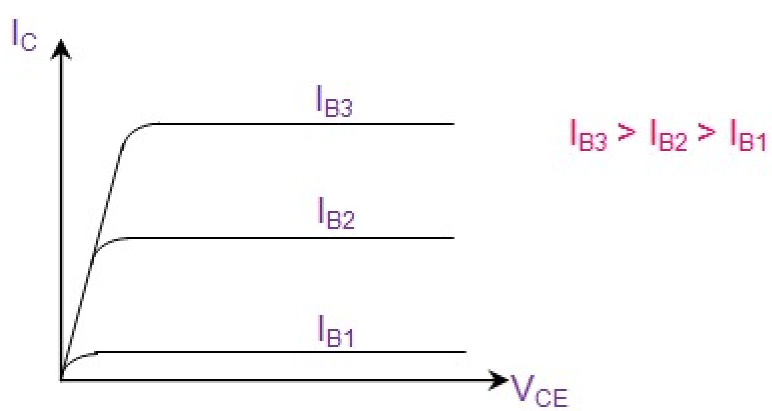


Figure 11 Output Characteristics for CE Configuration

Current Transfer Characteristics for CE Configuration of Transistor

This characteristic of CE configuration shows the variation of I_C with I_B keeping V_{CE} as a constant. This can be mathematically given by

$$\beta = \left.\frac{\Delta I_C}{\Delta I_B}\right|_{V_{CE}=constant}$$

This ratio is referred to as common-emitter current gain and is always greater than 1.

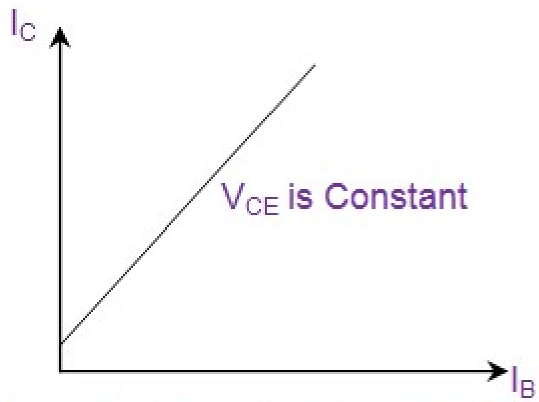


Figure 12 Transfer Characteristics for CE Configuration

Lastly, it is to be noted that although the characteristic curves explained are for BJTs, similar analysis holds good even in the case of FETs.

Physics -I for I,II,III BSc Maths, III Chemistry (A,B)

UNIT - I

If the length of the wire and mass suspended are doubled in a young's modulus experiment, then, young's
For a Perefect rigid body, young's modulus is …………..
Two wires of the same radii and material have their lengths in the ratio 1:2. If these are stretched by the sa
If the temperature of a liquid is raised, then its surface tension is …………
The excess of pressure inside two soap bubbles of diameters in the ratio 2:1 is …………

. A square frame of sidel is dipped in a soap solution. When the frame is taken out , a soap film is formed.
The rain drops falling from the sky neither hit us hard nor make holes on the ground because they move wi
The distinct properties of liquids are due to …………
Modulus of elasticity is …………
What is the reason for the existence of three different states of matter ?
Which solids do not have definite melting point ?
Which substance exists in both crystalline and amorphous state ?

What is the dimension of stress ?
The ratio of shearing stress to the angle of shear is called as …………
To Which material, the elasticity remains unaffected for any change in temperature?
The change in the shape of a regular body is due to …………
When a spring is loaded, the strain produced is ………….
Beyond permanent set of a body, addition of even a very small bad, enormous strain is produced. This regi
Which of the materials possess bulk modulus?
……………. Possess maximum value for rigidity modulus
……………… has minimum young's modulus
A liquid of density p having a height of h under gravitation pull has pressure about ………….
What is the unit of surface tension ?

If T is the surface tension and R is the radius of a soap bubble then the excess of pressure inside it is …….
Which of the following decreases the surface tension of water ?

Small insects can move about on surface of water because …………
On which factor does the capillary rise or fall in a capillary tube depend ?

Which factors affect surface tension?
Which of the following has more viscous force?

_________ is defined as the restoring force per unit area
The ratio of change in length to original length is called
According to Hooke's law of elasticity, within elastic limits, if the stress is increased, the ratio of stress to

In an experiment to determine the Young's modulus of the material of a wire, the length of the wire and the suspended mass are doubled. Then the Young's modulus of the wire

On stretching wire, the elastic energy per unit volume is
The energy per unit volume of a stretched wire is

Tensile strain is equal to

Hooke's law states that

Body is said to be elastic if it
Which law is also called as the elasticity law?

UNIT -II
Which of the following formulae is used determine the time of flight for projectile motion, when point of projection and point of landing are on same level of horizontal plane
In projectile motion, which of the following factors affecting the actual path of motion are neglected?
The spin angular momentum of an electron is also referred to as its
The external torque applied determines the rotation of the system about
Which two fundamental properties are used to describe motion?

What feature of motion is described by acceleration?

If the forces on an object are balanced, the object will
According to Newton's second law of motion, acceleration is proportional to force. That means a larger force
According to Newton's second law of motion, what causes a change in the motion of an object? A (An)
Which of the following indicate that an object has been subjected to an unbalanced force?
Which of the following correctly states Newton's third law of motion? Forces occur in matched pairs that are

A person walking on a level surface moves forward because the forces of
The Newton's first law of motion can also be called as -----------
The twisting force that will cause rotation in a body is known as -----------
The torque T can be written as ------------
When the external torue applied is zero, then the total -------------- is conserved

If a bus starts suddenly, the passengers in the bus will tend to fall

Kepler's First Law: Every planet revolves around the Sun in _______ orbit
The horizontal velocity given to a satellite so as to put it into a circular orbit round the Earth is called "Critical Velocity". This is also called as _________
Every body in the universe attracts every other body. This attraction is called _______
Time of flight of body is given by formula
Range of projectile will be minimum if angle of projectile is

for a projectile object, the physical quantity which remains constant

In the motion of a projectile freely under gravity

Which two angles will produce the same range

The moment of inertia of a body comes into play ……….
Rotational analogue of mass in linear motion is ……….
The moment of inertia of a body does not depend on …………
A ring of radius r and mass m rotates about an axis passing through its centre and perpendicular to its plan
The moment of inertia of a disc having mass Mand radius R,about an axis passing through its centre and p
Angular momentum is the vector product of …………..
Angular momentum of the body is conserved ………..
A man is sitting on a rotating stool with his arms outstretched. Suddenly he folds his arm. The angular vel
A point in the system at which whole mass of the body is supposed to be concentrated is called …………
The centre of mass of a system in equilibrium remains same because …………..
The gravitational forces present in a system are …………..
The resultant of the parallel gravitational forces is known as the ……………
At the centre of gravity which of the following is supposed to act ? …………..
When a body is in rotational motion, different constituent particles have ………………
The mass of a body measures ………..
The dimension of moment of inertia is …….
The relation connecting moment of inertia (I) and rotational kinetic energy (ER) IS ……….
Unit of angular momentum is ……..
What is the dimension of angular momentum ? ………..
If I is the moment of inertia, α is the angular acceleration and is the torque then they are related by ……..
The dimension of torque is …….
The angular velocity in rad/sec of a flywheel making 300 rpm is …………
Which of the following are fundamental forces ? …………………….
Out of the given forces ………. Force is the weakest among them ? ……….
The gravitational force is …………..
For freely falling bodies under gravity …………….

The gravitational potential at a point due to a point mass is v = …………
What is the value of gravitational field intensity due to a body of mass m at an infinite distance? …………
The unit of gravitational potential is ………..
The nature of gravitational potential is ………..
Gravitational potential energy ………..
At infinity, gravitational potential energy is …………….

UNIT-III

According to Clausius statement
Efficiency of a heat engine is defined as
A thermal energy reservoir is a large body of
A reversible carnot cycle has following processes.
Which device maintains a body at a temperature lower than the temperature of the surroundings?
The amount of heat required to raise the temperature of the unit mass of gas through one degree at constan
An adiabatic process is one in which
The ratio of specific heat at constant pressure (Cp) and specific heat at constant volume (Cv) is
The entropy ___________ in an irreversible cyclic process.
When two bodies are in thermal equilibrium with a third bodythey are also in thermal equilibrium with eac
The specific heat at constant volume is
In an isothermal process
Which of the following is the correct statement of the second law of thermodynamics?
The gas constant (R) is equal to the ___________ of two specific heats.
In an irreversible process,there is a
The efficiency of Carnot cycle depends upon
Which of the following is an intensive property of a thermodynamic system?
According to First law of thermodynamics
Carnot cycle consists of
When a gas is heated at constant volume
The isothermal and adiabatic processes are regarded as
The heat flows from a cold body to a hot body with the aid of an external source. This statement is given b
The general gas equation is (where p = Pressure, v = Volume, m = mass, T = Absolute temperature, and R
The gas constant (R) is equal to the
A perfectly black body
Newton's Law of Cooling states that the rate at which an object cools is proportional to what?
Three black bodies are such that higher intensity wavelengths are in the ratio λm1 : λm2 : λm3 = 1 :(21)1/2
Suppose A body behaves like black body. When the temperature of blackbody increasesit is observed that
According to Stefan’s Law
The Stefan-Boltzmann law of thermal radiation is applicable for
According to the Stefan-Boltzmann law of thermal radiation for a perfect radiator,the rate of radiant energy
In the equation for the rate radiant heat energy from a perfect radiator q = α A T4 the constant α is called a
Consider two black bodies at temperatures T1 and T2 (T1 > T2) having same surface area.A are placed in
The relationship (Wavelength) MAX T = constant, between the temperature of a black body and the wavel

The energy emitted by a black surface should not vary in accordance with
Likewise the amount of emitted radiation is strongly influenced by the wavelength even if temperature of
The law governing the distribution of radiant energy over wavelength for a black body at fixed temperatur
The Planck's constant h has the dimensions equal to
What is the wavelength band for solar radiation?
If the body is not perfectly black, the Stefan's law becomes
For a perfect block body, the relative emittance e is
The ratio of emissive power to the absorptive power for particular wavelength at particular temprature is c
Stefan's Law applicable for
Newton's law applicable only for
According to third law of thermodynamis
Third law of thermodynamics states that the entropy is _________ at absolute temperature

Planck's law hold's good in the region of ……….

The radiant energy emitted depends on __________

Absorptive power is represented by _____

Which is considered as a perfect absorber as well as a perfect emitter?

Which body that emits a constant emissivity regardless of the wavelength?

The transfer of heat by radiation

The specific heat capacity of a substance is equal to

What is the emissivity of a black body?

What is the absorptive of a black body?

Radiant energy is also called as ____

Entropy is transferred by ______.

What is a process during which the specific volume remains constant?

The first law of thermodynamics is based on which of the following principles?

If C_P and C_V of a gas are 20.8 $J K^{-1} mol^{-1}$ and12.47 $J K^{-1} mol^{-1}$ then the value of R is …………

UNIT- IV

Image formed by plane mirror is
Power of the lens is -40, its focal length is
A concave mirror gives virtual, refracts and enlarged image of the object but image of smaller size than the size of the object is
In optics an object which has higher refractive index is called
The optical phenomena, twinkling of stars, is due to
Convex lens focus a real, point sized image at focus, the object is placed
The unit of power of lens is
The radius of curvature of a mirror is 20cm the focal length is
The Snell's law can be derived from which type of incidence?
The Snell's law is given by
Calculate the ratio of sine of incident angle to the sine of reflected angle when the refractive indices of medium 1 and 2 are given as 2.33 and 1.66 respectively.

Find the ratio of the refractive index of medium 1 to that of medium 2, when the incident and reflected angles are given by 300 and 450 respectively.
Snell's law can be derived from
Angle of refraction is negative when refractive induces of two materials have
Materials exhibiting negative refractive indices are
Interference of light is evidence that
A wavelength is commonly measured in which one of the following units?
The phenomenon of diffraction can be understood using
What is the name of the process whereby waves travel around corners and obstacles in their paths?
In Fraunhofer diffraction, the incident wave front should be ----------
The wave nature of light is demonstrated by which of the following?
The characteristic that distinguishes a laser beam from an ordinary light beam is:
Light travels fastest
Optical fiber works on the
In Fraunhofer diffraction wave front used is __________.
The points of constructive interference of light are
__________ of the following phenomenon cannot be explained on the particle nature of light.
There are two types of diffraction Fresnel and
Diffraction is special type of
Which of the following phenomenon produces colors in soap bubble?
What is the wavelength of red light emitted by a helium-neon laser?
What is the life time of electron in metastable state?
In the population inversion
Laser beam is made a of
In ruby Laser which ions give rise to laser action
Which of the laser have high efficiency
The method of population inversion to the laser action in He-Ne laser is
Which of the laser have very low efficiency
The Ruby laser is
The method of achieving population inversion in Ruby Laser is
The He – Ne laser is
The method of achieving population inversion in He – Ne Laser is
What type of laser is used in CD and DVD players?
What type of laser could cause skin cancer if not used properly?
The transition zone for Raman spectra is
Frequency of photons shifts electrons from one state to another in

The correct order of different types of energies is
Select the correct statement from the following option
Sky looks blue because the sun light is subjected to
In polarization, positive side attracts the
Polarizability is defined as the
Identify which type of polarisation depends on temperature.
In isotropic materials, which of the following quantities will be independent of the direction?
What is the need to achieve population inversion?
Which of the following can be used in a vibrational analysis of structure?
A semiconductor diode Laser is
A He - Ne laser is a
The Nicol prism based on the action of
A color with a wavelength longer than that of yellow is:
In Newton's Ring experiments, the diameter of bright rings is proportional to

UNIT V

A transistor has how many pn junctions?
Asemiconductor is formed by ------------- bonds
The most commonly used semiconductor is
A semiconductor has generally ------ valence electrons
The resistivity of pure silicon is about
When a pentavlent impurity is added to a pure semiconductor, it becomes ------
Addition of pentavalent impurity to semiconductor creates many ---
An n-type semiconductor is ------
A forward biased pn junction has a resistance of the
The battery connections required to forward bias a pn junction are
The barrier voltage at a pn junction for germanium is about
In the depletion region of a pn junction, there is a shortage of -------
A reverse biased pn junction has
A pn junction acts as a
A reverse biased pn junction has resistance of the
The leakage current across a pn junction is due to
The leakage current across a pn junction is of the order of
In an intrinsic semiconductor, the number of free electrons
At room temperature, an intrinsic semiconductor has
In a half wave rectifier, the load current flows for what part of the cycle
In a full wave rectifier, the current in each diode flows for
in a full wave rectifier, if the input frequency is 50 Hz, then output frequency will be
The maximum efficiency of full wave rectification is
The maximum efficiency of half wave rectification is
The ripple factor of a bridge rectifier is
To get a peak load voltage of 40V out of a bridge rectifier. What is the approximate rms value of secondar
If the line frequency is 50 Hz, the output frequency of bridge rectifier is
The bridge rectifier is preferred to an ordinary two diode full wave rectifier because
The basic purpose of filter is to
A half wave rectifier is equivalent to
The basic reason why a full wave rectifier has a twice the efficiency of a half wave rectifier is that
Which rectifier requires four diodes?
The number of depletion layers in a transistor is
The base of a transistor is ------ doped
The element that has the biggest size in a transistor is ---
In a pnp transistor, the current carriers are
A transistor is a ----- operated device
In npn transistor, ---- are the minority carriers
In a trnsistor, the base current is about ----- of emitter current

At the base-emitter junction of a transistor, one finds ----
The input impedance of a transistor is ----
The current I_B is ----
In a transistor
The value of a transistor is
The output impedance of a transistor is
The relation between a and b is
The value of b transistor is
The most commonly used transistor arrangement is ----- arrangement
The phase difference between the input and output voltages in a common base arrangement is
As the temperature of a transistor goes up, the base-emitter resistance
BC 147 transistor indicates that it is made of
A transistor is connected in CB mode. If it is now connected in CE mode with same bias voltages, the valu
The collector-base junction in a transistor has ----

OPTION -1	OPTION-II	OPTION-III
remains unchanged	becomes double	becomes four times
zero	infinity	1
01:04	02:01	01:02
decreased	increased	does not change
01:04	02:01	01:02
8 Tl	4 Tl	10 Tl
constant acceleration	variable acceleration	variable speed
interatomic forces	inter molecular forces	random motion of molecules
strees/strain	strain/stress	elastic limit/stress
force	Elasticity	surface tension
Crystals	polycrystals	Amorphous solids
Quartz	sugar	Rock salt
MLT^2	$ML^{-1}T^{-2}$	MLT^{-2}
Young's modulus	rigidity modulus	bulk modulus
Iron	Aluminium	Copper
bulk strain	shearing strain	longitudinal strain
longitudinal	volumetric	shearing
elastic range	plastic range	breaking range
copper	Tungsten	steel
Iron	copper	steel
Steel	Tungsten	Aluminium
pg	hpg	hg
N	N-M	N-S
2T/R	4T/R	T/R
soap	soap nut	Wax
Surface tension of water is less	Surface tension of water is z	Surface tension of water is large
Viscosity	Surface tension	Inter atomic force
Temperature	Contamination by impuritie	Temperature & Contamination by imp
Glycerine	Caster oil	Honey
stress	strain	surface tension
shearing starin	shearing stress	tensile strain
increases	decreases	reamins constant

Becomes double	Becomes four time	Remain unchanged
½ F/A x dl/L	½ FA/l	½ Fl/A
½ load x extension	stress x strain	load/strain
Force per unit area	Force per unit volume	Extension per unit length
the extension is proportional to	the extension is inversely p	the extension is independent of the lo
returns to original shape after a	doesn't return to original sh	density is equal to pressure applied
Bernoulli's law	Stress law	Hooke's law
(2u sin θ) / g	(u2 sin θ) / 2g	2ug sin θ
Curvature of the earth	Rotation of earth	Both (a) and (b)
angular momentum	linear momentum	momentum
gravity	center of mass	momentum
mass and distance	length and time	speed and time
The rate at which speed changes	How quickly final velocity is reached	The rate at which velocity changes.
remain at rest if initially at rest.	continue moving in a straight line if initially moving in a straight line	both A and B
produces a smaller acceleration	doesn't affect acceleration	produces a smaller mass
decrease in inertia	change in velocity	net force
The object speeds up	The object slows down	The object changes direction
equal in magnitude and equal in direction	opposite in magnitude and equal in direction	equal in magnitude and opposite in direction
his feet pushing forward on the ground	his feet pushing backward on the ground	the ground pushing forward on his feet
momentum	inertia	acceleration
torque	couple	coplanar forces
rxF	rXp	FXp
energy	linear momentum	angular momentum

in the direction opposite to the direction of motion of bus	in the direction same to the direction of motion of bus	sideways
circular	rectangular	elliptical
Projection Velocity	Linear Velocity	Orbital Velocity
gravitational force	electrostatic force	electromagnetic force
$t = 2v_i \times (\sin/g)$	$t = (2V_i + \sin)/g$	$t = (2V_i - \sin)/g$
0	45	60
Vertical component of velocity	Potential energy and kinetic energy	Horizontal component of velocity and acceleration
Total energy is conserved	Momentum is conserved	Energy and momentum are conserved
40 and 60 degrees	35 and 65 degrees	30 and 60 degrees
in linear motion	in rotational motion	in projectile motion
weight	moment of inertia	torque
the angular velocity of the body	the mass of the body	the axis of rotation of the body
mr	1/2mr	I
1/2 MR	MR	1/4 MR
linear momentum and radius ve	moment of inertia and angu	linear momentum and angular velocit
always	never	in the absence of external torque
decreases	increases	becomes zero
centre of gravity	centre of mass	centre of energy
external force is acting on the s	no external force is acting o	internal force is acting on the system
unlike parallel forces	like parallel forces	like antiparallel forces
mass of the body	centre of mass	weight of the body
mass of the body	Energy	Total weight
different angular velocity	same angular velocity	uniform velocity
density	centre of mass	moment of inertia
MLT -1	ML2T0	ML2T1
I= ER	I=ER/2	I=2ER
$kgms^{-1}$	$kgm2s^{2}$	kgm2s1
MLT -1	ML2T1	ML2T2
= I/α	= Iα	= α/I
ML2T2	M2L2T-2	ML2T-1
10	20	40
Nuclear force	Gravitational force	Electromagnetic force
Nuclear	electromagnetic	electrostatic
greater in the case of heavier bo	smaller in the case of heavie	very small in the case of lighter bodie
velocity decreases	velocity increases rapidly	velocity increases at a constant rate

GM/r	GM/r2	GM/r2
Infinity	zero	unity
NM-1 kg-1	NM-1 kg	NM-2 kg-2
positive	finite	negative
increases as the distance increas	decreases as the distance de	decreases as the distance increases
infinity	zero	increases

it is impossible to construct a de	it is impossible to construct	it is possible to construct a device that
total heat output / net work inpu	total heat input / net work o	net work output / total heat input
small heat capacity	large heat capacity	infinite heat capacity
4 isothermal processes	4 adiabatic process	3 isothermal and 1 adiabatic process
PMM1	PMM2	refrigerator
Specific heat at constant volume	Specific heat at constant pre	Specific heat at constant temperature
heat enters into system	the temperature of the gas n	the change in internal energy is equal
equal to one	less than one	greater than one
remains constant	decreases	increases
Zeroth law of thermodynamics	First law of thermodynamic	Second law of thermodynamics
the amount of heat required to r	the amount of heat required	the amount of heat required to raise th
there is change in temperature	there is change in enthalpy	there is no change in internal energy
It is possible to construct an eng	It is possible to transfer heat	There is a definite amount of mechani
sum	difference	product
loss of heat	no loss of heat	gain of heat
temperature limits	pressure ratio	volume compression ratio
Volume	Temperature	Mass
total internal energy of a system	total energy of a system rem	workdone by a system is equal to the
two constant volume and two is	two isothermal and two isen	two constant pressure and two isentro
its temperature will increase	its pressure will increase	both temperature and pressure will inc
reversible process	irreversible process	mechanical process
Kelvin	Joule	Clausis
$pv = nRT$	$pv = RT$	$pv^n = C$
sum of two specific heats	difference of two specific he	product of two specific heats
Absorbs all the incident radiatio	Allow all the incident radia	Reflects all the incident radiation
Difference in temperature of the	Temperature of surrounding	Temperature of the object
$T1 < T3 > T2$	$T1 > T2 > T3$	$T3 > T2 > T1$
E1:E2=1:8	E1:E2=1:2	E1:E2=1:1
$q = \alpha AT^4$	$q = \alpha AT^2$	$q = \alpha AT$
white body	hot body	black body
the temperature of that radiator	the square of the temperatu	the cube of the temperature of that rad
gas constant	Radiation constant	Stefan-Boltzmann constant
$q = \alpha A (T_1 - T_2)^4$	$q = \alpha A (T_1^4 - T_2^4)$	$q = \alpha A (T_1 - T_2)$
Planck’s law	Kirchhoff’s law	Lambert’s law

Wavelength	Temperature	Surface characteristics
Constant	Increasing	Decreasing
Kirchhoff’s law	Planck’s law	Wein’s formula
$M L^2 T^{-1}$	$M L T^{-1}$	$M L T^{-2}$
1 * 10 -1 to 3 micron meter	1 * 10 -1 to 2 micron meter	1 * 10 -1 to 1 micron meter
$R=\alpha T^4$	$R=eT^4$	$R= \alpha T^4$
0	1	½
plank's law	kircoff's law	stefan's law
Hot body	cold body	low temperature difference
Hot body	cold body	low temperature difference
H1/T1 = H2/T2	H1/T1 ≠ H2/T2	H1/T2 = H2/T1
zero	c	constant
Shorter wavelengths	longer wavelengths	all wavelengths
temperature	material	volume
a	λ	λa
Gray body	Black body	Real body
Gray body	Black body	Real body
does not require any medium.	require any medium	does not require any space
mass of the substance × heat ca	heat capacity ∕ mass of the su	mass of the substance ∕ heat capacity
0	1	0.5
0	1	0.5
latent heat	radiant heat	entropy
Work	Heat	Energy
Isobaric process	Isothermal process	Isochoric process
mass of energy	Conservation of energy	The entropy-temperature relationship
18.33 $J K^{-1} mol^{-1}$	33.27 $J K^{-1} mol^{-1}$	28.33 $J K^{-1} mol^{-1}$

Real and erect	Real and inverted	Virtual and erect
4m	-40m	-0.25m
At infinity	Between F and C	Between P and F
Optically rarer	Optically denser	Optical density
Atmospheric reflection	Total reflection	Atmospheric refraction
At focus	Between F and 2F	At infinity
Metre	Centimeter	Diopter
20cm	10cm	40cm
Incidence angle	Reflected angle	Refracted angle
N1 sin θi = N2 sin θt	N2 sin θi = N1 sin θt	sin θi = sin θt
0.71	1.4	2

0.5	1	2
Newton's principle	Fermat's principle	Faraday's principle
same direction	opposite direction	random direction
most dielectric materials	most doped semiconductors	non-natural materials
The speed of light is very large	light is a transverse wave	light is electromagnetic in character
Radians	Angstroms	Electron volts
Huygens principle	Fraunhofer	Uncertainty principle
Reflection	Reflection	Interference
elliptical	Plane	Spherical
The photoelectric effect	Color	The speed of light
The greater frequency of the laser beam	The coherence of the laser beam	The color of the laser beam
In a vacuum	through water	Through glass
principle of refraction	total internal reflection	scattering
Spherical	Circular	plane
Always bright	may be bright or dark	always dark
Photo Electric Effect	Compton’s Effect	Pair Production
Michelson	De Broglie	Fraunhofer
Reflection	Refraction	Interference
Interference	Diffraction	Polarization
122 nanometers	633 nanometers	2.43 nanometers
10 -3 sec	10 -5 Sec	10 -8 sec
The number of electrons in higher energy state is more than ground state	The number of electrons in lower energy state is more than higher energy state	The number of electrons in lower energy state and higher energy state are same
Electrons	Highly coherent photon	Elastic particles
Al2o3	Cr 3+	Al3+
Ruby	Semiconductor	He- Ne
molecule collision	direction conversion	electric discharge
Ruby	Semiconductor	He- Ne
Continuous Laser	gas Laser	semiconductor laser
Optical pumping	inelastic Scattering	forward biasing
Continuous Laser	gas Laser	semiconductor laser
Optical pumping	inelastic Scattering	forward biasing
Semiconductor	YAG	Alexandrite
Red semiconductor laser	Blue semiconductor	Eximer laser
Between vibrational and rotational levels	Between electronic levels	Between magnetic levels of nuclei
Raman spectroscopy	spectroscopy	crystallization

Eel >> Evib >> Erot >> E tr	Eel >> Erot >> Evib >> E tr	Eel >> Evib >> Etr >> E rot
Spectroscopic methods require less time and more amount of sample than classical methods	Spectroscopic methods require more time and more amount of sample than classical methods	Spectroscopic methods require less time and less amount of sample than classical methods
Rayleigh scattering	Compton scattering	both
negative side of the water molecules	the positive side of the water molecules	the substance dissolves completely in water
Product of dipole moment and electric field	Ratio of dipole moment to electric field	Ratio of electric field to dipole moment
Electronic	Ionic	Orientational
Permittivity	Permeability	Polarisation
To excite most of the atoms	To bring most of the atoms to ground state	To achieve stable condition
Maser	Quarts	Electrical waves
Four level	Three level	Two level
Four level	Three level	Two level
reflection	Double refraction	refraction
Red	Blue	Violet
Square root of Odd Natural numbers	Natural Number	Even Natural Number

1	2	3
covalent	electrovalent	co-ordinate
germanium	silicon	carbon
2	3	6
60 W cm	6000 W cm	600 W cm
an insulator	an intrinsic semiconductor	p-type semiconductor
free electrons	holes	valence electrons
positively charged	negatively charged	electrically neutral
order of W	order of KW	order of MW
positive terminal to p and negat	negative terminal to p and p	negative terminal to p and negative te
3.5 V	3 V	Zero
acceptor ions	holes and electrons	donor ions
very narrow depletion layer	almost no current	very low resistance
controlled switch	bidirectional switch	unidirectional switch
order of W	order of KW	order of MW
minority carriers	majority carriers	junction capacitance
A	mA	kA
equals the number of holes	is greater than the number o	is less than the number holes
many holes only	a few free electrons and hol	many free electrons only
400	900	1800
whole cycle of the input signal	half cycle of the input signa	more than half cycle of the input signa
50 Hz	75 Hz	100 Hz
40.60%	100%	81.20%
40.60%	100%	81.20%
0.482	0.812	1.11
0 V	14.4 V	28.3 V
25 Hz	50 Hz	100 Hz
it needs much smaller transform	no center tap required	less PIV rating per diode
minimize variations in ac input	suppress harmonics in rectif	remove ripples from the rectified outp
clamper circuit	a clipper circuit	a clamper circuit with negative bias
it makes use of transformer	its ripple factor is much less	it utilizes both half-cycle of the input
half-wave voltage doubler	full-wave voltage doubler	full-wave bridge circuit
four	three	one
heavily	moderately	lightly
collector	base	emitter
acceptor ions	donor ions	free electrons
current	voltage	both voltage and current
free electrons	holes	donor ions
25%	20%	35%

reverse bias	a wide depletion layer	low resistance
high	low	very high
electron current	hole current	donor ion current
Ic=Ie+Ib	Ib=Ic+Ie	Ie=Ic-Ib
more than 1	less than 1	1
high	zero	low
b=1/(1-a)	b=(1-a)/a	b=a/(1-a)
1	less than 1	between 20 and 500
common emitter	common base	common collector
180°	90°	270°
decreases	increases	remains the same
germanium	silicon	carbon
remain the same	increases	decreases
forward bias at all times	reverse bias at all times	low resistance

OPTION-IV	ANSWER
becomes sixteen times	remains unchanged
-1	infinity
01:01	01:01
equal to viscosity	decreased
04:01	01:02
12 Tl	8 Tl
constant velocity	constant velocity
all the above	all the above
strain/elasticity	stress/strain
Inter atomic force	Inter atomic force
quartz	Amorphous solids
silicon dioxide	silicon dioxide
$M^{-1}LT^{-1}$	$ML^{-1}T^{-2}$
modulus of elasticity	rigidity modulus
Invar	Invar
metallic strain	shearing strain
normal	longitudinal
working range	plastic range
Aluminium	steel
Tungsten	Tungsten
copper	Aluminium
hp	hpg
N/M	N/M
R/T	4T/R
pitch	soap
water is stationary	Surface tension of water is large
force	Surface tension
Density	Temperature & Contamination by impurities
All the three	All the three
poission ratio	stress
longitudinal strain	longitudinal strain
zero	decreases

Becomes half

½ F.l
½ stress x strain

Force per unit length

load is dependent on extension

none of above
Poisson's law

$(2u \sin \theta) / g \cos \theta$
None of the above
intrinsic angular momentum
none
distance and speed
Whether motion is speeding up or slowing down

none

produces a larger acceleration
acceleration
Any of the above
opposite in magnitude and opposite in direction
the ground pushing backward on his feet
impulse
none
ma
none

Remain unchanged

½ F/A x dl/L
½ stress x strain

Extension per unit length

the extension is proportional to the load when the elastic limit is not exceeded
returns to original shape after applying pressure
Stress law

$(2u \sin \theta) / g$
None of the above
intrinsic angular momentum
center of mass
length and time
The rate at which velocity changes.

both A and B
produces a larger acceleration
net force
Any of the above
equal in magnitude and opposite in direction
the ground pushing forward on his feet
inertia
torque
rxF
angular momentum

none	in the direction opposite to the direction of motion of bus
none	elliptical
Angular Velocity	Orbital Velocity
nuclear forces	gravitational force
$t = 2v_i/g$	$t = 2v_i \times (\sin/g)$
90	0
Velocity and acceleration	Horizontal component of velocity and acceleration
None is conserved	Energy and momentum are conserved
45 and 15 degrees	30 and 60 degrees
in periodic motion	in rotational motion
angular momentum	moment of inertia
the distribution of mass in the body	the angular velocity of the bod
1/2 I	1/2 I
5/4 MR	1/2 MR
linear velocity and radius vector	moment of inertia and angular
in the presence of external torque	in the absence of external torq
remains constant	increases
centre of buoyancy	centre of mass
it is not in motion	no external force is acting on t
coplanar forces	like parallel forces
centre of gravity	weight of the body
Resultant of forces	Total weight
uniform acceleration	same angular velocity
co efficient of inertia	co efficient of inertia
ML2T2	ML2T0
I=4ER	I=2ER
kgms	kgm2s1
MLT -2	ML2T1
= I/α2	= Iα
MLT-2	M2L2T-2
5	10
All the above	All the above
gravitational	gravitational
greater in the case of lighter bodies	very small in the case of lighte
acceleration increases at a constant rate	velocity increases at a constan

GM/r
None
Nmkg-1
infinite
increases as the distance decreases
remains same

GM/r
zero
Nmkg-1
negative
decreases as the distance decre
zero

it is possible to construct a device that can transfer heat from a hotter bo		it is impossible to construct a
net work input / total heat out		net work output / total heat inp
zero heat cap		infinite heat capacity
2 isothermal and 2 adiabatic proces		2 isothermal and 2 adiabatic p
heat pump		refrigerator
Specific heat at constant pressure and volume		Specific heat at constant volur
the pressure of the gas changes		the change in internal energy i
zero		greater than one
Zero		remains constant
Kelvin Planck's law		Zeroth law of thermodynamics
the amount of heat required to change the mass of the gas		the amount of heat required to
there is no change in pressure		there is no change in internal e
it is impossible to construct a device that can transfer heat from a hotter		There is a definite amount of r
ratio		difference
no gain of heat		loss of heat
cut-off ratio and compression ratio		temperature limits
Energy		Temperature
internal energy, enthalpy and entropy during a process remains constant		total energy of a system remai
one constant volume, one constant pressure and two isentropic processe		two isothermal and two isentro
neither temperature nor pressure will increase		both temperature and pressure
chemical process		reversible process
Gay-Lussac		Clausis
$pv = (RT)_m$		$pv = nRT$
D.ratio of two specific heats		difference of two specific heat
Has its surface coated with lamp black or graphite		Absorbs all the incident radiat
Object's mass		Difference in temperature of th
T3 > T1 > T2		T3 > T2 > T1
E1:E2=2:1		E1:E2=1:2
$q = \alpha T^4$		$q = \alpha A T^4$
cold body		black body
the fourth power of the temperature of that radiator		the fourth power of the temper
Planck’s constant		Stefan-Boltzmann constant
$q = \alpha A (T_1 + T_2)$		$q = \alpha A (T_1^4 – T_2^4)$
Wein’s law		Wein’s law

Time		Time
It is not related with temperature		Constant
Lambert’s law		Planck’s law
M L T		$M L^2 T^{-1}$
1 * 10 -1 to 10 micron meter		
e2 α2T4		R= αT4
3/4		1
wien's law		kircoff's law
high temperature difference		Hot body
high temperature difference		low temperature difference
$H1/T2 \neq H2/T1$		$H1/T1 \neq H2/T2$
varied		zero

very short wavelengths		all wavelengths
height		temperature
aλ		aλ
White body		Black body
White body		Gray body
require any space		does not require any medium.
mass of the substance		heat capacity ⁄ mass of the substance
0.25		1
0.25		0
enthalpy		radiant heat
Work and heat		Heat
Isovolumetric process		Isochoric process
Change in temperature		Conservation of energy
$8.33\ J\ K^{-1}\ mol^{-1}$		$8.33\ J\ K^{-1}\ mol^{-1}$

Virtual and inverted		Virtual and erect
-25m		-0.25m
At E		Between P and F
Refractive index		Optically denser
Total refraction		Atmospheric refraction
At 2F		At infinity
M^{-1}		Diopter
5cm		10cm
Oblique incidence		Oblique incidence
N1 cos θi = N2 cos θt		N1 sin θi = N2 sin θt
3.99		0.71

4
Pendry's principle
no direction
ferrites
Light is a wave phenomenon
Seconds
Fresnel
Diffraction
Cylindrical
Diffraction
The greater polarization of the laser beam
through diamond
interference
Conical
neither bright nor dark
Interference
Huygens
Polarization
Dispersion
1.37 micrometers
10 -7 sec
None of them
Excited atoms
O –
Co2
electron impact
Ammonia gas laser
pulsed laser
chemical reaction
pulsed laser
chemical reaction
Co2
YAG laser
Between magnetic levels of unpaired electrons
vaporization

2
Fermat's principle
opposite direction
non-natural materials
Light is a wave phenomenon
Angstroms
Huygens principle
Diffraction
Plane
Diffraction
The coherence of the laser beam
In a vacuum
total internal reflection
Plane
Always bright
Photo Electric Effect
Fraunhofer
Refraction
Interference
633 nanometers
10 -8 sec
The number of electrons in higher energy state is more than ground state
Highly coherent photon
Cr 3+
Co2
molecule collision
Ammonia gas laser
pulsed laser
Optical pumping
Continuous Laser
inelastic Scattering
Semiconductor
Eximer laser
Between vibrational and rotational levels
Raman spectroscopy

Etr >> Evib >> Erot >> E el
Spectroscopic methods require more time and less amount of sample than classical methods
none
metals of group VII
Product of dielectric constant and dipole moment
Interfacial
Polarizability
To reduce the time of production of laser
Laser
One level
One level
scattering
Green
Square root of natural number

Eel >> Evib >> Erot >> E tr
Spectroscopic methods require less time and less amount of sample than classical methods
Rayleigh scattering
negative side of the water molecules
Ratio of dipole moment to electric field
Orientational
Permittivity
To excite most of the atoms
Laser
Two level
Three level
Double refraction
Red
Square root of Odd Natural numbers

4	2
none of the above	covalent
sulphur	silicon
4	4
1.6 W cm	6000 W cm
n-type semiconductor	n-type semiconductor
bound electrons	free electron
none of the above	electrically neutral
none of the above	order of W
none of the above	positive terminal to p and nega
0.3 V	0.3 V
none of the above	holes and electrons
large current flow	almost no current
none of the above	unidirectional switch
none of the above	order of MW
none of the above	minority carriers
mA	mA
none of the above	equals the number of holes
no holes or free electrons	a few free electrons and holes
3600	1800
none of these	half cycle of the input signal
200 Hz	100 Hz
85.60%	81.20%
85.60%	40.60%
1.21	0.482
56.6 V	28.3 V
200 Hz	100 Hz
all the above	all the above
stabilize dc output voltage	remove ripples from the rectif
a clamper circuit with positive bias	a clipper circuit
its output frequency is double the line frequency	it utilizes both half-cycle of th
voltage quadrupler	full-wave bridge circuit
two	two
none of the above	lightly
collector-base junction	collector
holes	holes
none of the above	current
acceptor ions	holes
5%	5%

none of the above	low resistance
almost zero	low
acceptor ion current	electron current
Ie=Ic+Ib	Ie=Ic+Ib
none of the above	less than 1
very low	high
b=a/(1+a)	b=a/(1-a)
above 500	between 20 and 500
none of the above	common collector
0°	0°
none of the above	decreases
none of the above	silicon
none of the above	remain the same
none of the above	reverse bias at all times

ly

velocity
ue

the system

er bodies
t rate

eases

device that can transfer heat from a cooler body to a hotter body without any effect
out

roces

ne
s equal to the mechanical workdone

s
raise the temperature of unit mass of gas through one degree at constant volume
energy
nechanical energy, which can be obtained from a given quantity of heat energy.

ns constant
opic processes
will increase

s
ion
he object and the temperature of its surroundings

rature of that radiator

s of the substance

ative terminal to n

ied output

e input