**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, III$^{rd}$ 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-II**

**SYLLABUS**

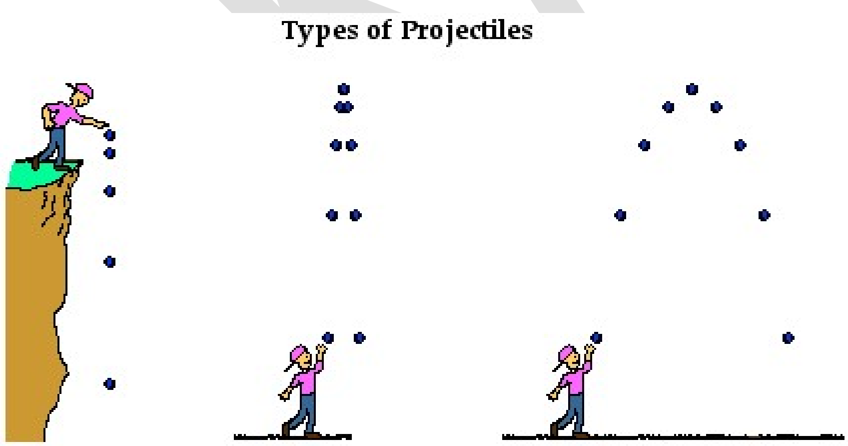
**MECHANICS:** Motion of bodies in 2–D - Newton's laws - projectile motion – range-maximum height – projectile from space flight- Rotational motion – Rotation with constant angular acceleration –angular momentum of particles – rigid body – spinning top – conservation of angular momentum – Planetary motion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

What is a Projectile?

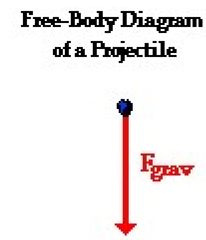
- What is a Projectile?
- Characteristics of a Projectile's Trajectory
- Horizontal and Vertical Components of Velocity
- Horizontal and Vertical Displacement
- Initial Velocity Components
- Horizontally Launched Projectiles - Problem-Solving
- Non-Horizontally Launched Projectiles - Problem-Solving

### 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.



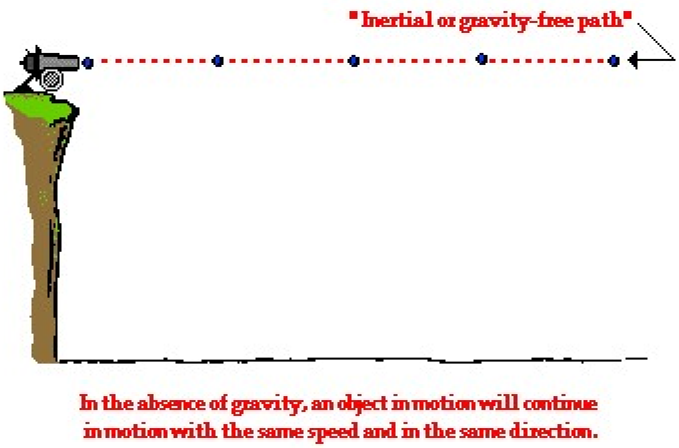
By definition, a projectile has a single force that acts upon it - the force of gravity. If there were any other force acting upon an object, then that object would not be a projectile. Thus, the free-body diagram of a projectile would show a single force acting downwards and labeled force of gravity (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

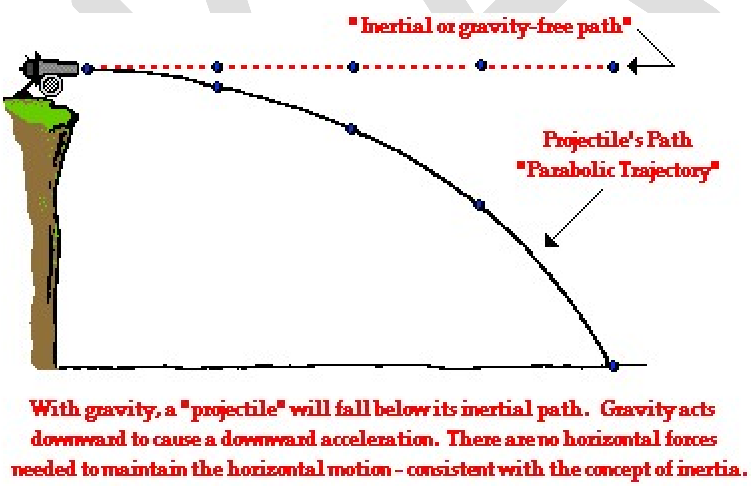
Many students have difficulty with the concept that the only force acting upon an upward moving projectile is gravity. Their conception of motion prompts them to think that if an object is moving upward, then there *must* be an upward force. And if an object is moving upward and rightward, there *must* 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.




**Animation**

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.




**Animation**

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 $\Delta t$. Now the planet moves future from P3 to P4 and the area covered is $\Delta t$.

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

$\Rightarrow GMr = 4\pi^2r^2T^2$
$T^2 = 4\pi2r3)GM$
$\Rightarrow T^2$ □ $r^3$

# 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.

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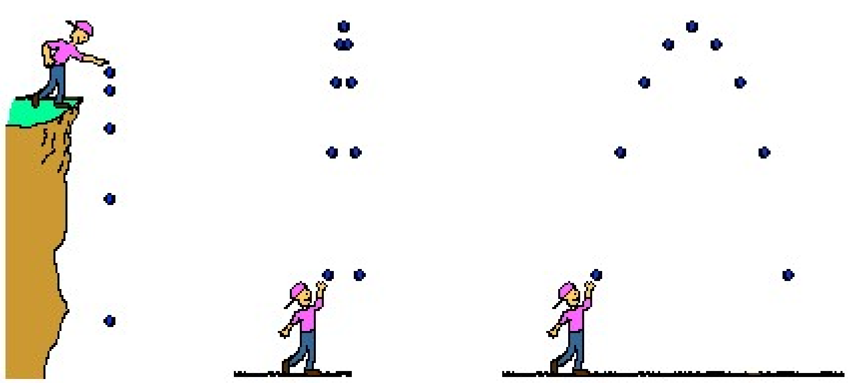
**Types of Projectiles**



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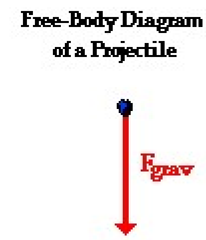


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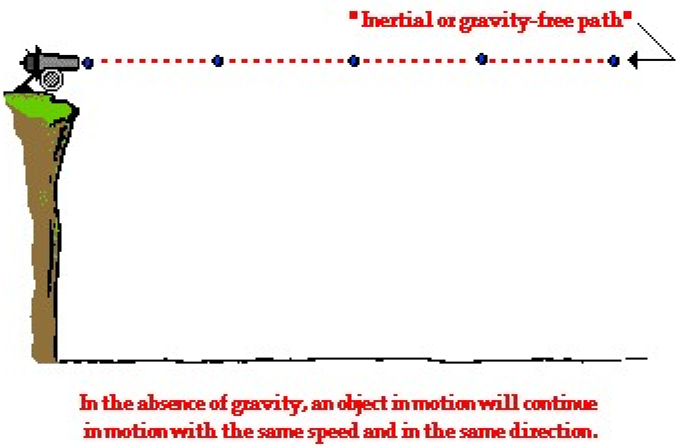



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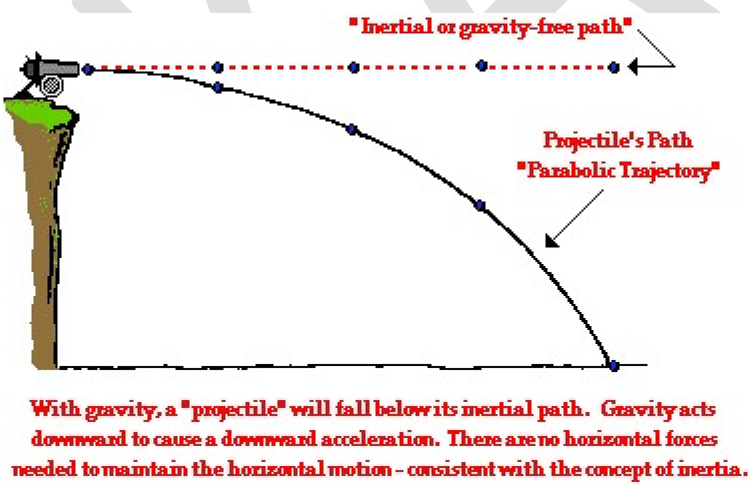


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Kepler's 1st Law of Orbits:

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:

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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 $\Delta t$. Now the planet moves future from P3 to P4 and the area covered is $\Delta t$.

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

$$F = GmMr^2$$

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$T^2 = 4\pi2r3)GM$
$\Rightarrow T^2$ □ $r^3$

# 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.

.

- 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 ($\Delta E$) 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)

$\lambda$ = Wavelength in m

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

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

$L_{e\lambda}$ ($\lambda$,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:

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

$\sigma$ 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 $\sigma$ 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, $\lambda_m$, and blackbody temperature, T:

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

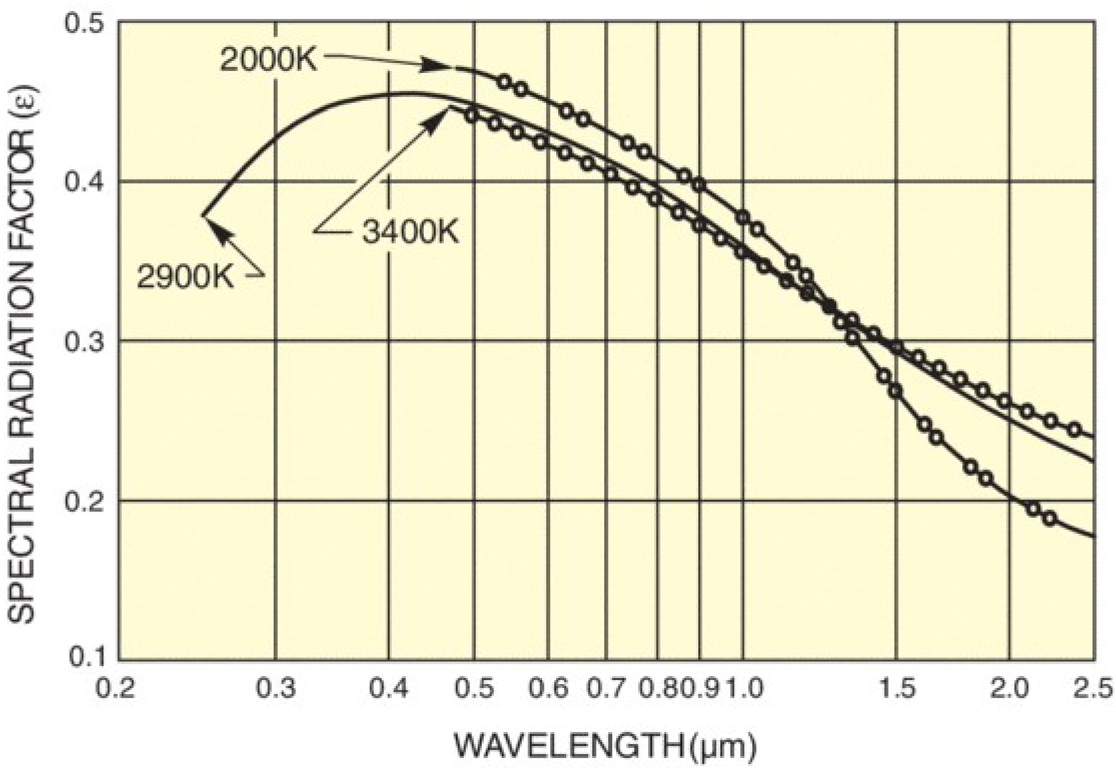



**Figure 2:** Emissivity (spectral radiation factor) of tungsten.

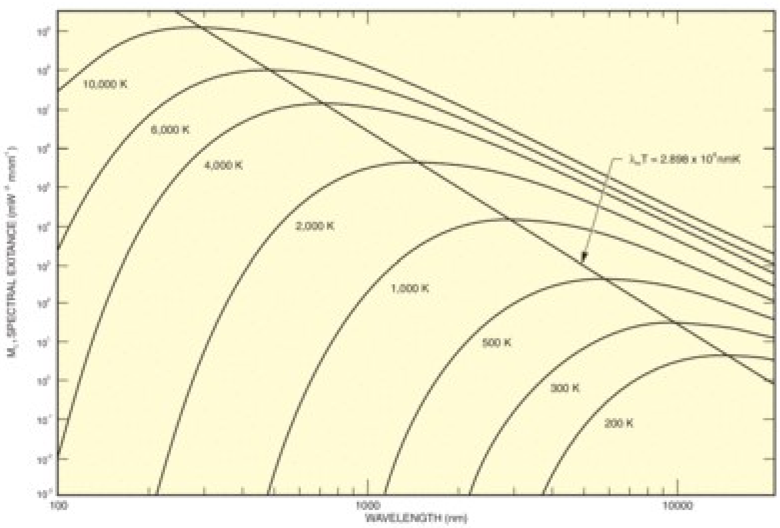



**Figure 3:** Spectral exitance for various blackbodies

**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.

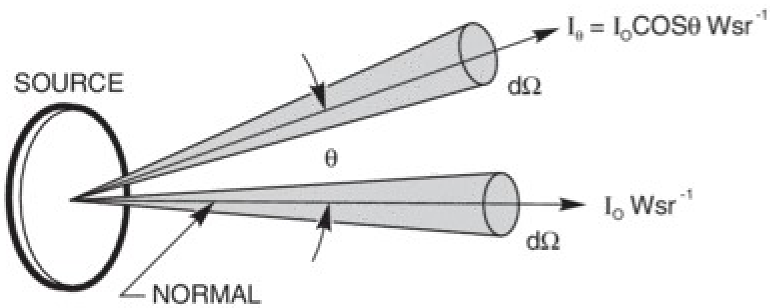



**Figure 4:** Lamberts cosine law indicates how the intensity, I, depends on angle.

***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).**

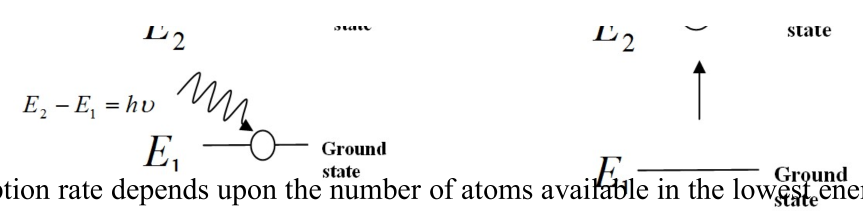
The predictable correlation of amplitude and phase at one point on the wave train w. r .t another point on a second wave, then the waves are said to be spatially coherence (or transverse coherence).

## 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 ρ(υ) 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 ∝ N1

$\propto \rho(\upsilon)$

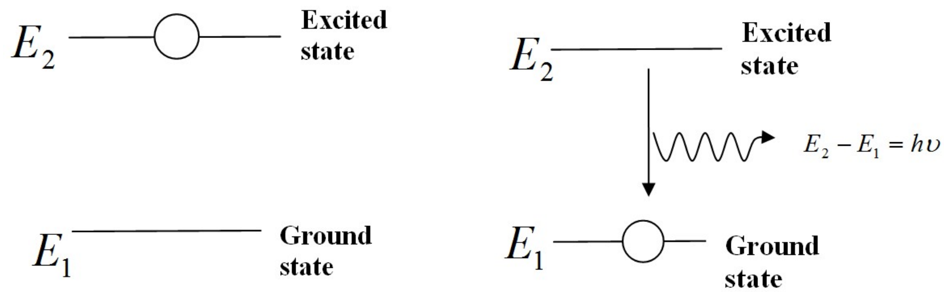
$\propto \rho(\upsilon)\, N1$

$= B_{12}\, \rho(\upsilon)\, N1$

Where $B_{12}$ 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 $A_{21}$ is known as Einstein coefficient of spontaneous emission

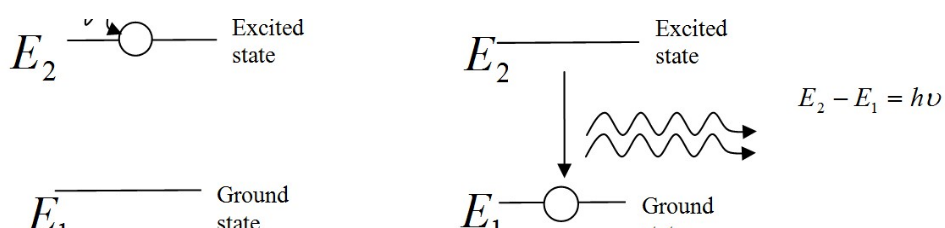
**Characteristics of spontaneous emitted radiation**

- Ø The emitted radiation is poly-monochromatic
- Ø The emitted radiation is Incoherent
- Ø The emitted radiation is less intense
- Ø The emitted radiation has less directionality
- Ø 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 $\propto N_2$

$\propto \rho$

$\propto N_2 \rho$

$= B_{21} N_2 \rho$

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

**Characteristics of stimulated emitted radiation**

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

***7. Spontaneous and Stimulated emission***

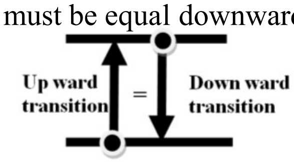
| Spontaneous emission | Stimulated emission |
|---|---|
| 1. The spontaneous emission was postulated by Bohr | 1. The stimulated emission was postulated by Einstein |
| 2. Additional photons are not required in spontaneous emission | 2. Additional photons are required in stimulated emission |
| 3. One 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 $r(u)$ 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 $\mu\ N_1$

$\mu\ r(u)$

$= B_{12} N_1\ r(u)$

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 $\mu\ N_2$

$= A_{21} N_2$

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.

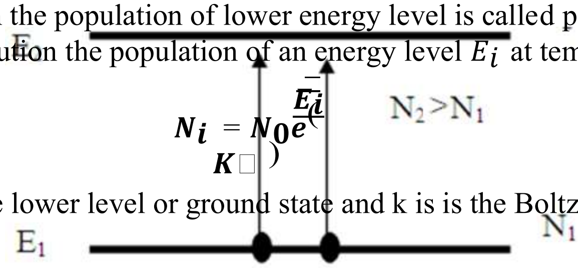
$$B_{21} = B_{12}$$

## *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

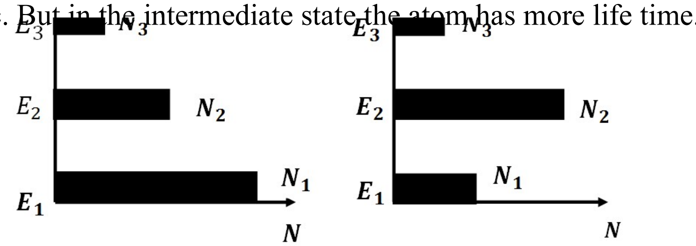
$$N_i = N_0 e^{\left(-\frac{E_i}{K\text{T}}\right)}$$

Where $N_0$ i 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 **E1, E2** and **E3** of populations, **N1, N2** and N3.At normal conditions, **E1,< E2<E3** and **N1, < N2** < N3. 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 E3. After their lifetime the atoms are transit into E2. Due to more lifetime of an atom in state **E2**, the atoms stay for longer time than compare with the state **E3**. Due to the accumulation of atoms instate **E2**, the population inversion is established in between the **E1** and E2 states.

## ***10. Types of lasers***

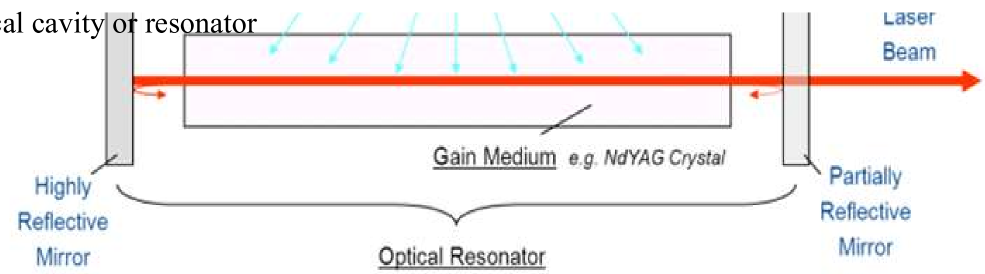
On the basis of active medium used in the laser systems, lasers are classified into several types

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**

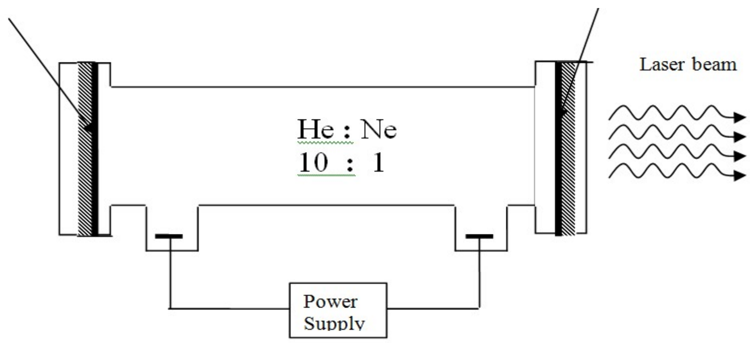
- This pumping mechanism is used in semiconductor lasers.
- In semiconductor lasers, by passing high currents across the junction, the population inversion will create.
- In semiconductors lasers the population inversion always creates among majority and minority charge carriers.
- Examples:- InP and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

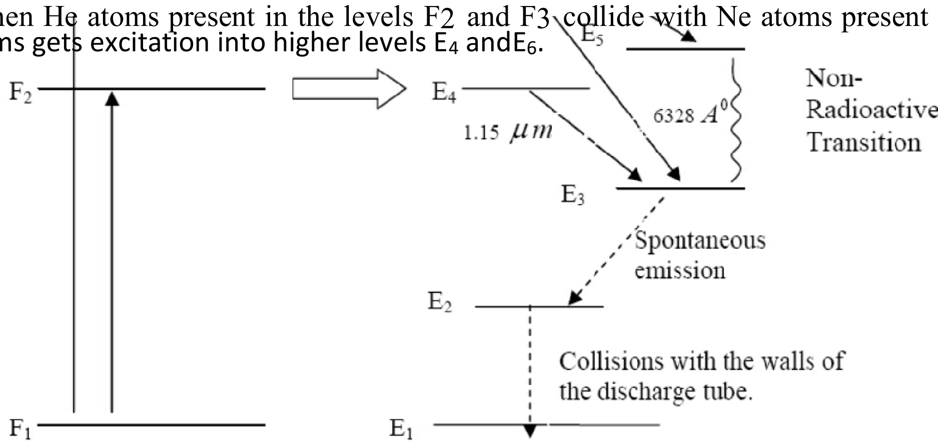
**Construction**

- 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 $6328A^0$.
- 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.

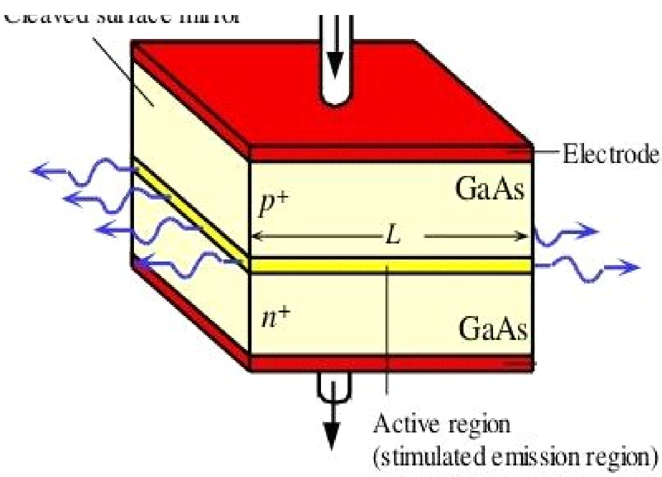
**Advantages:**

- 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

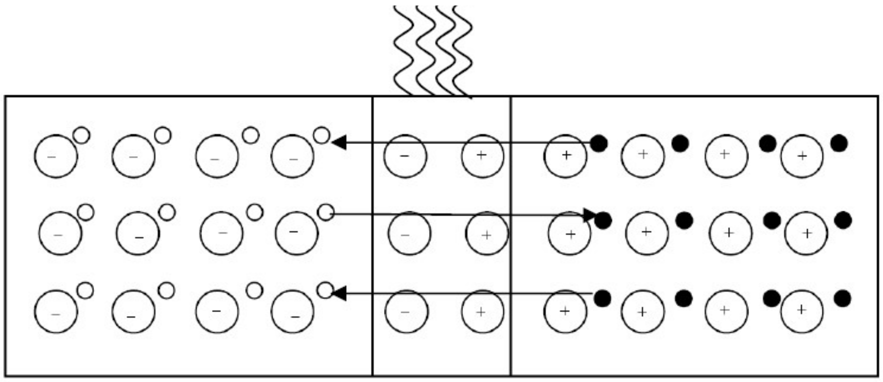
**Construction**




- 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 $E_g = hv = h_{\lambda}$

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

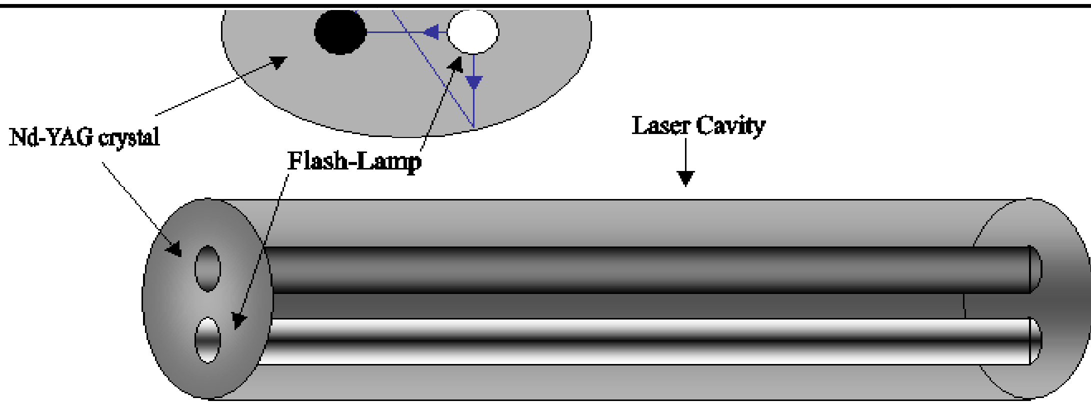
- In case of GaAs homo-junction which has an energy gap of 1.44eV gives a laser beam of wave length around 8874A$^0$.
- The wave length of emitted radiation depends up on the concentration of donor and acceptor atoms in GaAs.
- The efficiency of the laser emission is increases when we cool the GaAs diode.

## ***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 ($Y_3Al_5O_{12}$).
- 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.

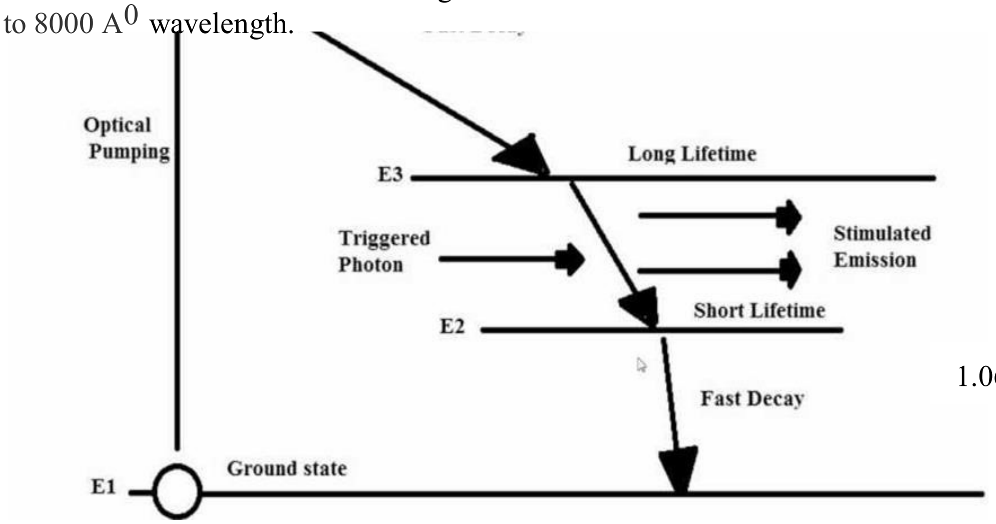
**Construction**

- An Nd-YAG laser consists of a crystalline cylindrical Nd-YAG rod [$Y_3Al_5O_{12}$].
- 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.




1.064 µm

- 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.

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

### 2. Computers

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

### 3. Chemistry

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

### 4. Photography

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

### 5. Industry

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

### 6. Medicine

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

### 7. Military

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

8. **Scientific field**

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

**UNIT-V**

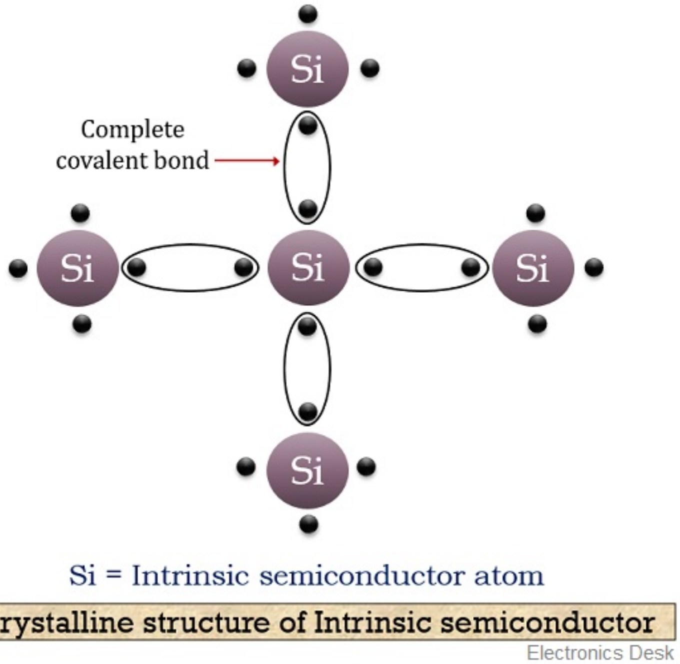
**SYLLABUS**

**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**:




Crystalline structure of Intrinsic semiconductor

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.

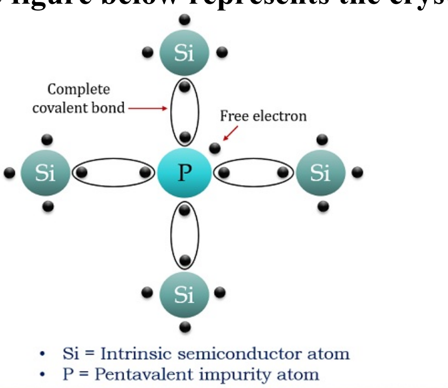
These are **highly conductive in nature**. However, unlike intrinsic semiconductor, extrinsic semiconductors are of two types **p-type** and an **n-type** semiconductor.

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**.

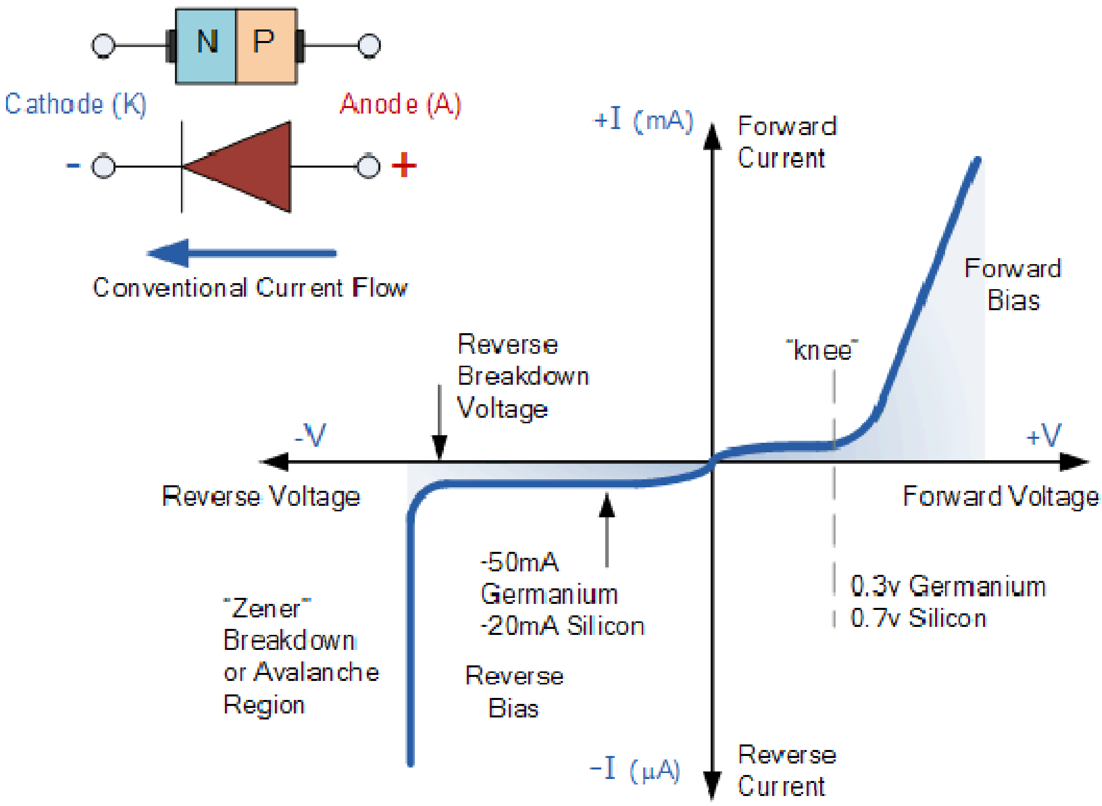
A *PN Junction Diode* is one of the simplest semiconductor devices around, and which has the characteristic of passing current in only one direction only. However, unlike a resistor, a diode does not behave linearly with respect to the applied voltage as the diode has an exponential current-voltage ( 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:

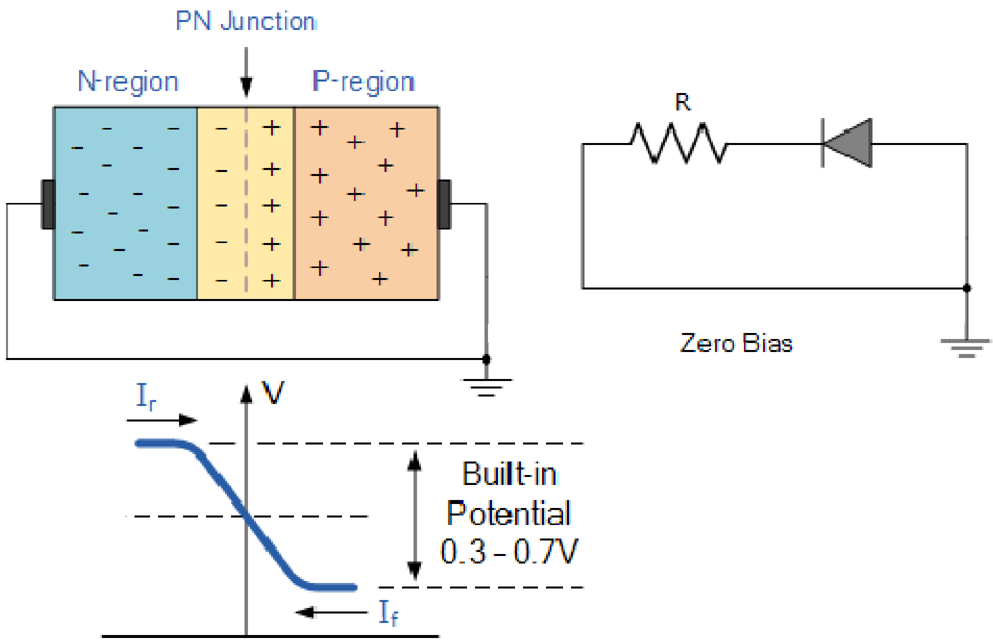
- 1. Zero Bias – No external voltage potential is applied to the PN junction diode.
- 2. Reverse Bias – The voltage potential is connected negative, (-ve) to the P-type material and positive, (+ve) to the N-type material across the diode which has the effect of **Increasing** the PN junction diode's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

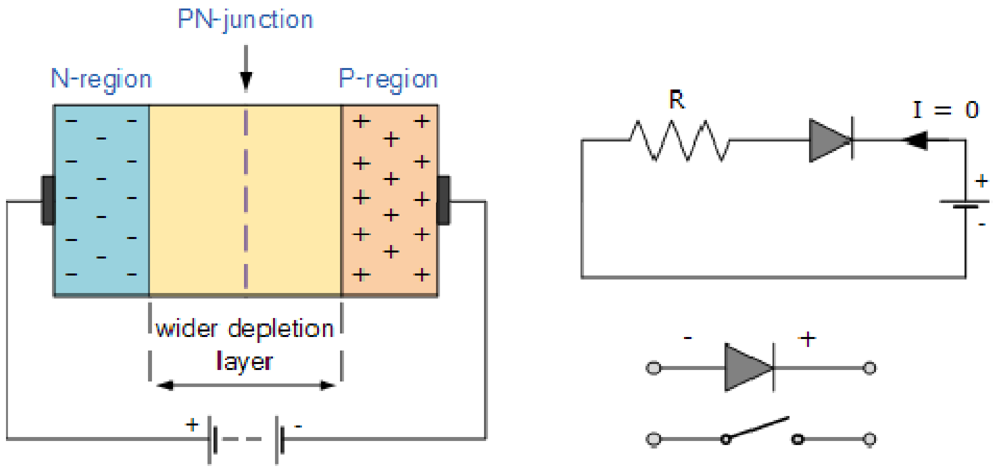
### Reverse Biased PN Junction Diode

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.

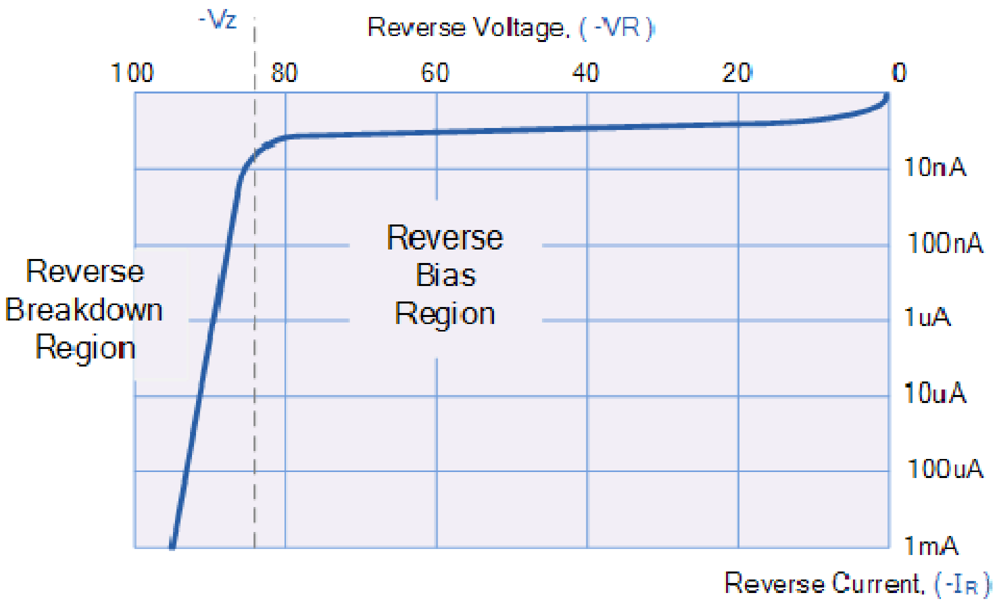
**Increase in the Depletion Layer due to Reverse Bias**




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**



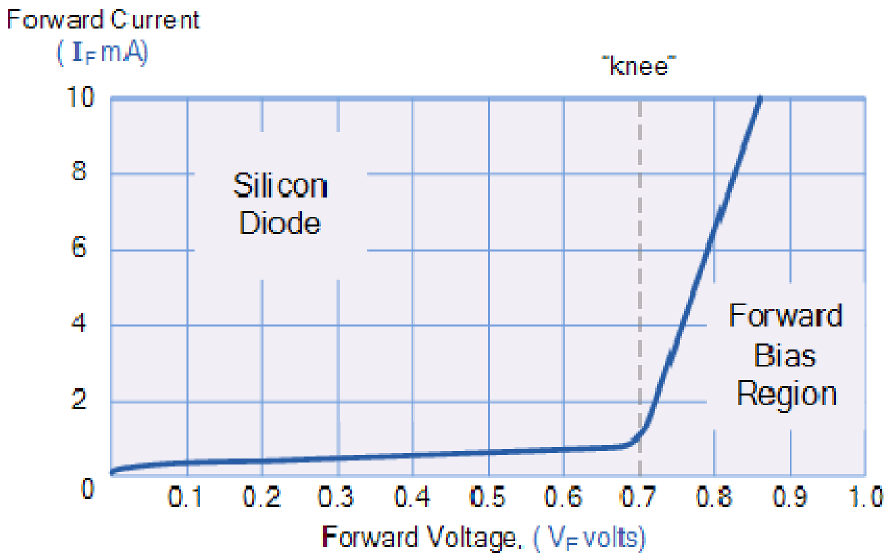

Sometimes this avalanche effect has practical applications in voltage stabilising circuits where a series limiting resistor is used with the diode to limit this reverse breakdown current to a preset maximum value thereby producing a fixed voltage output across the diode. These types of diodes are commonly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

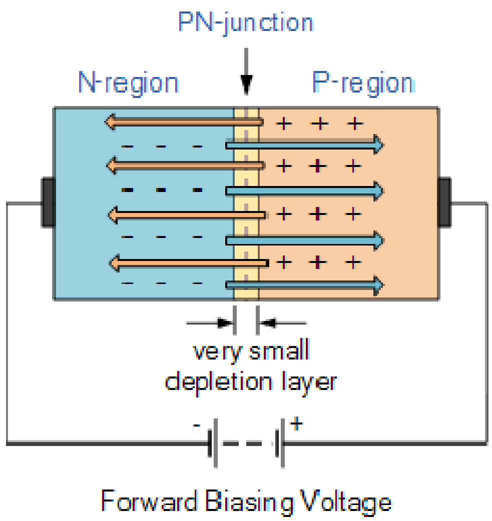
This is because the negative voltage pushes or repels electrons towards the junction giving them the energy to cross over and combine with the holes being pushed in the opposite direction towards the junction by the positive voltage. This results in a characteristics curve of zero current flowing up 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.

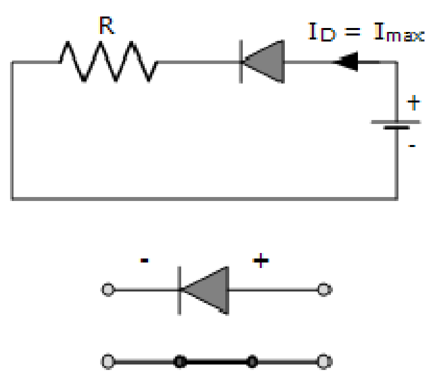
**Forward Characteristics Curve for a Junction Diode**




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**

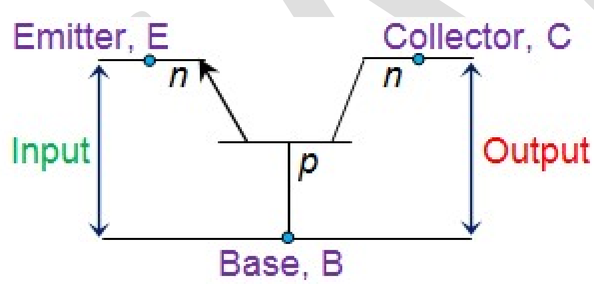



Figure 1 Common Base (CB) Configuration

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.

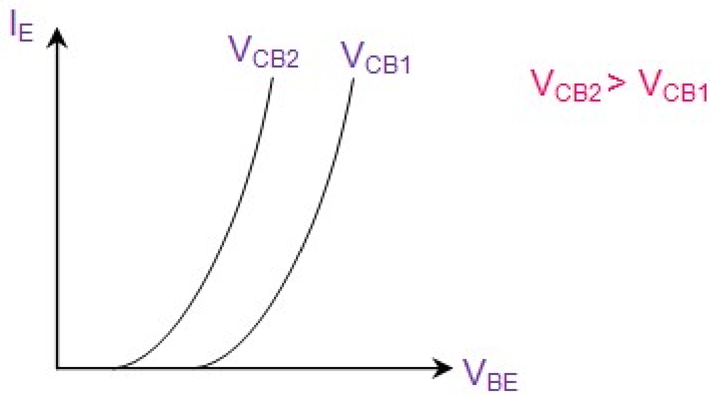



Figure 2 Input Characteristics for CB Configuration

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:

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

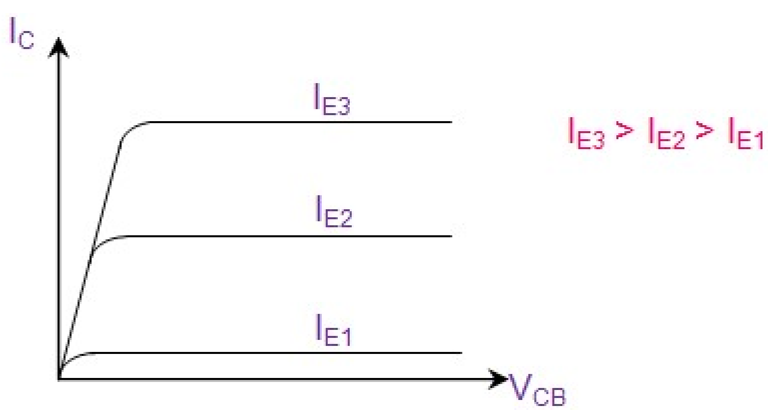



Figure 3 Output Characteristics for CB Configuration

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:

$$\alpha = \frac{\Delta I_C}{\Delta I_E}\bigg|_{V_{CB}=constant}$$

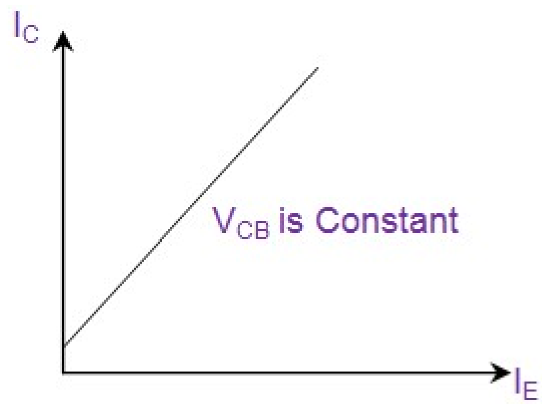



Figure 4 Current Transfer Characteristics for CB Configuration

**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.

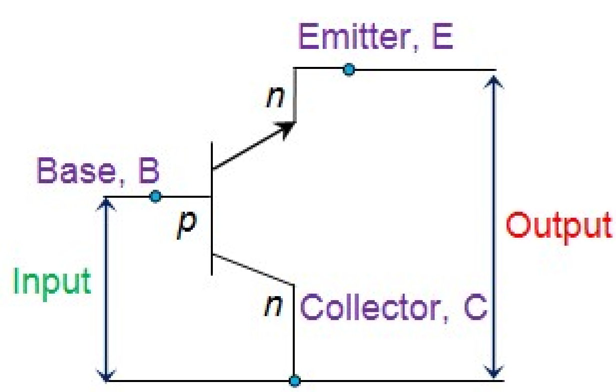



Figure 5 Common Collector (CC) Configuration

**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, $V_{CE}$.

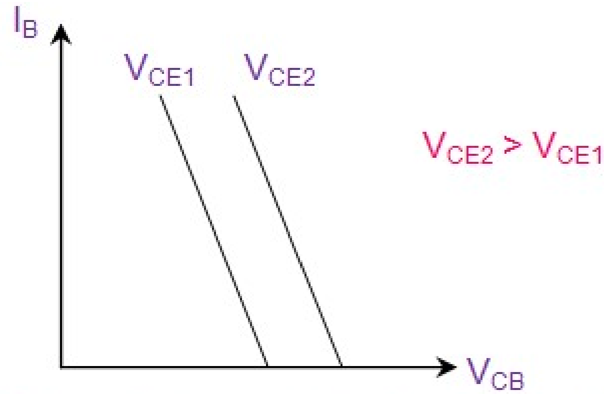



Figure 6 Input Characteristics for CC Configuration

**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 $I_B$.

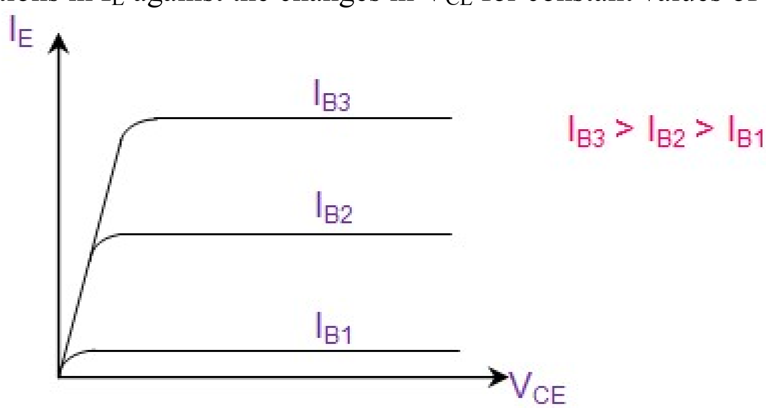



Figure 7 Output Characteristics for CC Configuration

**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.

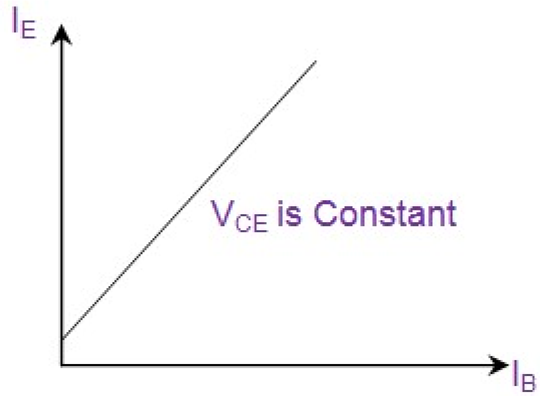



Figure 8 Current Transfer Characteristics for CC Configuration

**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.

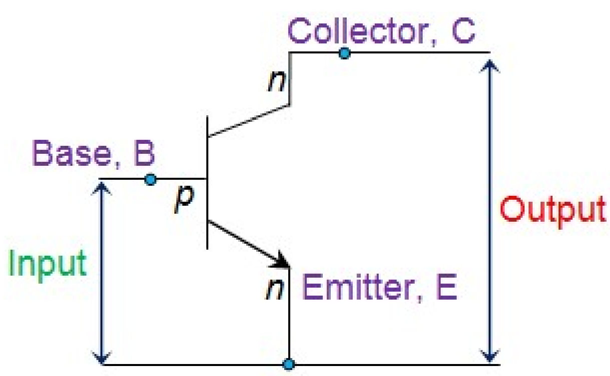



Figure 9 Common Emitter (CE) Configuration

**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.

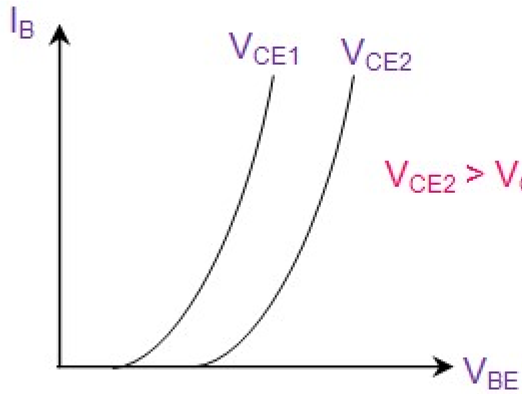



Figure 10 Input Characteristics for CE Configuration

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:

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

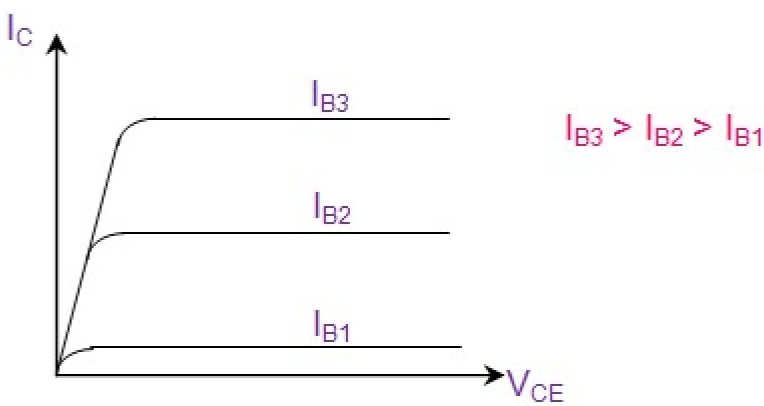



Figure 11 Output Characteristics for CE Configuration

**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

$$\beta = \frac{\Delta I_C}{\Delta I_B}\bigg|_{V_{CE}=constant}$$

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

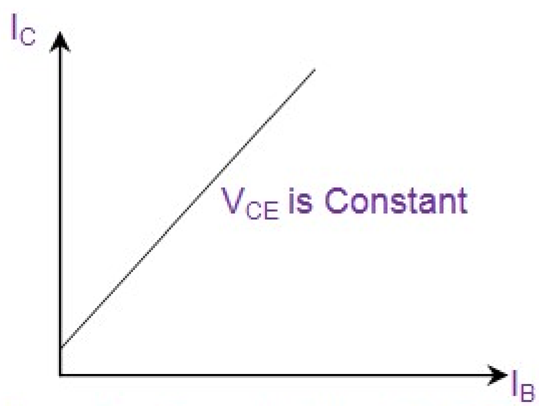



Figure 12 Transfer Characteristics for CE Configuration

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** | OPTION -1 | OPTION-II | OPTION-III | OPTION-IV | ANSWER |
|---|---|---|---|---|---|
| If the length of the wire and mass suspended are doubled in a young's modulus experiment, then, young's modulus of the wire ………… | remains unchanged | becomes double | becomes four times | becomes sixteen times | remains unchanged |
| For a Perefect rigid body, young's modulus is ………….. | zero | infinity | 1 | -1 | infinity |
| Two wires of the same radii and material have their lengths in the ratio 1:2. If these are stretched by the same force, the strains produced in the two wires will be in the ratio ………… | 1:04 | 2:01 | 1:02 | 1:01 | 1:01 |
| If the temperature of a liquid is raised, then its surface tension is ………… | decreased | increased | does not change | equal to viscosity | decreased |
| The excess of pressure inside two soap bubbles of diameters in the ratio 2:1 is ………… | 1:04 | 2:01 | 1:02 | 4:01 | 1:02 |
| . A square frame of side l is dipped in a soap solution. When the frame is taken out , a soap film is formed. The force on the frame | 8 Tl | 4 Tl | 10 Tl | 12 Tl | 8 Tl |
| The rain drops falling from the sky neither hit us hard nor make holes on the ground because they move with ………… | constant acceleration | variable acceleration | variable speed | constant velocity | constant velocity |
| The distinct properties of liquids are due to ………… | interatomic forces | inter molecular forces | random motion of molecules | all the above | all the above |
| Modulus of elasticity is ………… | strees/strain | strain/stress | elastic limit/stress | strain/elasticity | stress/strain |
| What is the reason for the existence of three different states of matter ? | force | Elasticity | surface tension | Inter atomic force | Inter atomic force |
| Which solids do not have definite melting point ? | Crystals | polycrystals | Amorphous solids | quartz | Amorphous solids |
| Which substance exists in both crystalline and amorphous state ? | Quartz | sugar | Rock salt | silicon dioxide | silicon dioxide |
| What is the dimension of stress ? | $MLT^2$ | $ML^{-1}T^{-2}$ | $MLT^{-2}$ | $M^{-1}LT^{-1}$ | $ML^{-1}T^{-2}$ |
| The ratio of shearing stress to the angle of shear is called as ………… | Young's modulus | rigidity modulus | bulk modulus | modulus of elasticity | rigidity modulus |
| To Which material, the elasticity remains unaffected for any change in temperature? | Iron | Aluminium | Copper | Invar | Invar |
| The change in the shape of a regular body is due to ………… | bulk strain | shearing strain | longitudinal strain | metallic strain | shearing strain |
| When a spring is loaded, the strain produced is …………. | longitudinal | volumetric | shearing | normal | longitudinal |
| Beyond permanent set of a body, addition of even a very small bad, enormous strain is produced. This region is called ………………. | elastic range | plastic range | breaking range | working range | plastic range |
| Which of the materials possess bulk modulus? | copper | Tungsten | steel | Aluminium | steel |
| ……………. Possess maximum value for rigidity modulus | Iron | copper | steel | Tungsten | Tungsten |
| ……………… has minimum young's modulus | Steel | Tungsten | Aluminium | copper | Aluminium |
| A liquid of density p having a height of h under gravitation pull has pressure about …………. | pg | hpg | hg | hp | hpg |
| What is the unit of surface tension ? | N | N-M | N-S | N/M | N/M |
| If T is the surface tension and R is the radius of a soap bubble then the excess of pressure inside it is ……………… | 2T/R | 4T/R | T/R | R/T | 4T/R |
| Which of the following decreases the surface tension of water ? | soap | soap nut | Wax | pitch | soap |
| Small insects can move about on surface of water because ………… | Surface tension of water is less | Surface tension of water is zero | Surface tension of water is large | water is stationary | Surface tension of water is large |
| On which factor does the capillary rise or fall in a capillary tube depend ? | Viscosity | Surface tension | Inter atomic force | force | Surface tension |
| Which factors affect surface tension? | Temperature | Contamination by impurities | Temperature & Contamination by impurities | Density | Temperature & Contamination by impurities |
| Which of the following has more viscous force? | Glycerine | Caster oil | Honey | All the three | All the three |
| _________ is defined as the restoring force per unit area | stress | strain | surface tension | poission ratio | stress |
| The ratio of change in length to original length is called | shearing starin | shearing stress | tensile strain | longitudinal strain | longitudinal strain |
| According to Hooke's law of elasticity, within elastic limits, if the stress is increased, the ratio of stress to strain | increases | decreases | reamins constant | zero | decreases |
| 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 | Becomes double | Becomes four time | Remain unchanged | Becomes half | Remain unchanged |
| On stretching wire, the elastic energy per unit volume is | ½ F/A x dl/L | ½ FA/l | ½ Fl/A | ½ F.l | ½ F/A x dl/L |
| The energy per unit volume of a stretched wire is | ½ load x extension | stress x strain | load/strain | ½ stress x strain | ½ stress x strain |
| Tensile strain is equal to | Force per unit area | Force per unit volume | Extension per unit length | Force per unit length | Extension per unit length |

| | | | | | |
|---|---|---|---|---|---|
| Hooke's law states that | the extension is proportional to the load when the elastic limit is not exceeded | the extension is inversely proportional to the load when the elastic limit is not exceeded | the extension is independent of the load when the elastic limit is not exceeded | load is dependent on extension | the extension is proportional to the load when the elastic limit is not exceeded |
| Body is said to be elastic if it | returns to original shape after applying pressure | doesn't return to original shape after applying pressure | density is equal to pressure applied | none of above | returns to original shape after applying pressure |
| Which law is also called as the elasticity law? | Bernoulli’s law | Stress law | Hooke’s law | Poisson’s law | Stress 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 | (2u sin θ) / g | (u2 sin θ) / 2g | 2ug sin θ | (2u sin θ) / g cos θ | (2u sin θ) / g |
| In projectile motion, which of the following factors affecting the actual path of motion are neglected? | Curvature of the earth | Rotation of earth | Both (a) and (b) | None of the above | None of the above |
| The spin angular momentum of an electron is also referred to as its | angular momentum | linear momentum | momentum | intrinsic angular momentum | intrinsic angular momentum |
| The external torque applied determines the rotation of the system about | gravity | center of mass | momentum | none | center of mass |
| Which two fundamental properties are used to describe motion? | mass and distance | length and time | speed and time | distance and speed | length and time |
| What feature of motion is described by acceleration? | The rate at which speed changes | How quickly final velocity is reached | The rate at which velocity changes. | Whether motion is speeding up or slowing down | The rate at which velocity changes. |
| If the forces on an object are balanced, the object will | remain at rest if initially at rest. | continue moving in a straight line if initially moving in a straight line | both A and B | none | both A and B |
| According to Newton's second law of motion, acceleration is proportional to force. That means a larger force | produces a smaller acceleration | doesn't affect acceleration | produces a smaller mass | produces a larger acceleration | produces a larger acceleration |
| According to Newton's second law of motion, what causes a change in the motion of an object? A (An) | decrease in inertia | change in velocity | net force | acceleration | net force |
| Which of the following indicate that an object has been subjected to an unbalanced force? | The object speeds up | The object slows down | The object changes direction | Any of the above | Any of the above |
| Which of the following correctly states Newton's third law of motion? Forces occur in matched pairs that are | equal in magnitude and equal in direction | opposite in magnitude and equal in direction | equal in magnitude and opposite in direction | opposite in magnitude and opposite in direction | equal in magnitude and opposite in direction |
| A person walking on a level surface moves forward because the forces of | his feet pushing forward on the ground | his feet pushing backward on the ground | the ground pushing forward on his feet | the ground pushing backward on his feet | the ground pushing forward on his feet |
| The Newton's first law of motion can also be called as ----------- | momentum | inertia | acceleration | impulse | inertia |
| The twisting force that will cause rotation in a body is known as ----------- | torque | couple | coplanar forces | none | torque |
| The torque T can be written as ------------ | rxF | rXp | FXp | ma | rxF |
| When the external torue applied is zero, then the total -------------- is conserved | energy | linear momentum | angular momentum | none | angular momentum |
| If a bus starts suddenly, the passengers in the bus will tend to fall | in the direction opposite to the direction of motion of bus | in the direction same to the direction of motion of bus | sideways | none | in the direction opposite to the direction of motion of bus |
| Kepler’s First Law: Every planet revolves around the Sun in _______ orbit | circular | rectangular | elliptical | none | elliptical |
| 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 _________ | Projection Velocity | Linear Velocity | Orbital Velocity | Angular Velocity | Orbital Velocity |
| Every body in the universe attracts every other body. This attraction is called _______ | gravitational force | electrostatic force | electromagnetic force | nuclear forces | gravitational force |
| Time of flight of body is given by formula | $t = 2v_i \times (sin/g)$ | $t = (2V_i + sin)/g$ | $t = (2V_i - sin)/g$ | $t = 2v_i/g$ | $t = 2v_i \times (sin/g)$ |
| Range of projectile will be minimum if angle of projectile is | 0 | 45 | 60 | 90 | 0 |
| for a projectile object, the physical quantity which remains constant | Vertical component of velocity and kinetic energy | Potential energy and kinetic energy | Horizontal component of velocity and acceleration | Velocity and acceleration | Horizontal component of velocity and acceleration |

| | | | | | |
|---|---|---|---|---|---|
| In the motion of a projectile freely under gravity | Total energy is conserved | Momentum is conserved | Energy and momentum are conserved | None is conserved | Energy and momentum are conserved |
| Which two angles will produce the same range | 40 and 60 degrees | 35 and 65 degrees | 30 and 60 degrees | 45 and 15 degrees | 30 and 60 degrees |
| The moment of inertia of a body comes into play ………. | in linear motion | in rotational motion | in projectile motion | in periodic motion | in rotational motion |
| Rotational analogue of mass in linear motion is ………. | weight | moment of inertia | torque | angular momentum | moment of inertia |
| The moment of inertia of a body does not depend on …………. | the angular velocity of the body | the mass of the body | the axis of rotation of the body | the distribution of mass in the body | the angular velocity of the body |
| A ring of radius r and mass m rotates about an axis passing through its centre and perpendicular to its plane with angular velocity  Its kinetic energy is ….. | mr | 1/2mr | I | 1/2 I | 1/2 I |
| The moment of inertia of a disc having mass Mand radius R,about an axis passing through its centre and perpendicular to its plane is ……………. | 1/2 MR | MR | 1/4 MR | 5/4 MR | 1/2 MR |
| Angular momentum is the vector product of ………….. | linear momentum and radius vector | moment of inertia and angular velocity | linear momentum and angular velocity | linear velocity and radius vector | moment of inertia and angular velocity |
| Angular momentum of the body is conserved ……….. | always | never | in the absence of external torque | in the presence of external torque | in the absence of external torque |
| A man is sitting on a rotating stool with his arms outstretched. Suddenly he folds his arm. The angular velocity …………... | decreases | increases | becomes zero | remains constant | increases |
| A point in the system at which whole mass of the body is supposed to be concentrated is called ……………….. | centre of gravity | centre of mass | centre of energy | centre of buoyancy | centre of mass |
| The centre of mass of a system in equilibrium remains same because ………….. | external force is acting on the system | no external force is acting on the system | internal force is acting on the system | it is not in motion | no external force is acting on the system |
| The gravitational forces present in a system are ………….. | unlike parallel forces | like parallel forces | like antiparallel forces | coplanar forces | like parallel forces |
| The resultant of the parallel gravitational forces is known as the …………… | mass of the body | centre of mass | weight of the body | centre of gravity | weight of the body |
| At the centre of gravity which of the following is supposed to act ? ………….. | mass of the body | Energy | Total weight | Resultant of forces | Total weight |
| When a body is in rotational motion, different constituent particles have ……………… | different angular velocity | same angular velocity | uniform velocity | uniform acceleration | same angular velocity |
| The mass of a body measures ……….. | density | centre of mass | moment of inertia | co efficient of inertia | co efficient of inertia |
| The dimension of moment of inertia is ……. | MLT -1 | ML2T0 | ML2T1 | ML2T2 | ML2T0 |
| The relation connecting moment of inertia (I) and rotational kinetic energy (ER) IS ………. | I= ER | I=ER/2 | I=2ER | I=4ER | I=2ER |
| Unit of angular momentum is …….. | $kgms^{-1}$ | $kgm2s^{2}$ | kgm2s1 | kgms | kgm2s1 |
| What is the dimension of angular momentum ? ……….. | MLT -1 | ML2T1 | ML2T2 | MLT -2 | ML2T1 |
| If I is the moment of inertia, α is the angular acceleration and  is the torque then they are related by ……….. | = I/α | = Iα | = α/I | = I/α2 | = Iα |
| The dimension of torque is ……. | ML2T2 | M2L2T-2 | ML2T-1 | MLT-2 | M2L2T-2 |
| The angular velocity in rad/sec of a flywheel making 300 rpm is …………. | 10 | 20 | 40 | 5 | 10 |
| Which of the following are fundamental forces ? ……………………. | Nuclear force | Gravitational force | Electromagnetic force | All the above | All the above |
| Out of the given forces ………. Force is the weakest among them ? ………. | Nuclear | electromagnetic | electrostatic | gravitational | gravitational |
| The gravitational force is  ………….. | greater in the case of heavier bodies | smaller in the case of heavier bodies | very small in the case of lighter bodies | greater in the case of lighter bodies | very small in the case of lighter bodies |
| For freely falling bodies under gravity ……………. | velocity decreases | velocity increases rapidly | velocity increases at a constant rate | acceleration increases at a constant rate | velocity increases at a constant rate |
| The gravitational potential at a point due to a point mass is v = …………. | GM/r | GM/r2 | GM/r2 | GM/r | GM/r |
| What is the value of gravitational field intensity due to a body of mass m at an infinite distance? …………… | Infinity | zero | unity | None | zero |
| The unit of gravitational potential is ……….. | NM-1 kg-1 | NM-1 kg | NM-2 kg-2 | Nmkg-1 | Nmkg-1 |
| The nature of gravitational potential is ……….. | positive | finite | negative | infinite | negative |

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|---|---|---|---|---|---|
| Gravitational potential energy ……….. | increases as the distance increases | decreases as the distance decreases | decreases as the distance increases | increases as the distance decreases | decreases as the distance decreases |
| At infinity, gravitational potential energy is ……………. | infinity | zero | increases | remains same | zero |

**UNIT-III**

| | | | | | |
|---|---|---|---|---|---|
| According to Clausius statement | it is impossible to construct a device that can transfer heat from a cooler body to a hotter body without any effect | it is impossible to construct a device that can transfer heat from a hotter body to a cooler body without any effect | it is possible to construct a device that can transfer heat from a cooler body to a hotter body without any effect | it is possible to construct a device that can transfer heat from a hotter body to a cooler body without any effect | it is impossible to construct a device that can transfer heat from a cooler body to a hotter body without any effect |
| Efficiency of a heat engine is defined as | total heat output / net work input | total heat input / net work out | net work output / total heat input | net work input / total heat out | net work output / total heat input |
| A thermal energy reservoir is a large body of | small heat capacity | large heat capacity | infinite heat capacity | zero heat cap | infinite heat capacity |
| A reversible carnot cycle has following processes. | 4 isothermal processes | 4 adiabatic process | 3 isothermal and 1 adiabatic process | 2 isothermal and 2 adiabatic proces | 2 isothermal and 2 adiabatic proces |
| Which device maintains a body at a temperature lower than the temperature of the surroundings? | PMM1 | PMM2 | refrigerator | heat pump | refrigerator |
| The amount of heat required to raise the temperature of the unit mass of gas through one degree at constant volume | Specific heat at constant volume | Specific heat at constant pressure | Specific heat at constant temperature | Specific heat at constant pressure and volume | Specific heat at constant volume |
| An adiabatic process is one in which | heat enters into system | the temperature of the gas never changes | the change in internal energy is equal to the mechanical workdone | the pressure of the gas changes | the change in internal energy is equal to the mechanical workdone |
| The ratio of specific heat at constant pressure (Cp) and specific heat at constant volume (Cv) is | equal to one | less than one | greater than one | zero | greater than one |
| The entropy __________ in an irreversible cyclic process. | remains constant | decreases | increases | Zero | remains constant |
| When two bodies are in thermal equilibrium with a third bodythey are also in thermal equilibrium with each other. This statement is called | Zeroth law of thermodynamics | First law of thermodynamics | Second law of thermodynamics | Kelvin Planck's law | Zeroth law of thermodynamics |
| The specific heat at constant volume is | the amount of heat required to raise the temperature of unit mass of gas through one degree at constant pressure | the amount of heat required to raise the temperature of unit mass of gas through one degree at constant volume | the amount of heat required to raise the temperature of 1 kg of water through one degree | the amount of heat required to change the mass of the gas | the amount of heat required to raise the temperature of unit mass of gas through one degree at constant volume |
| In an isothermal process | there is change in temperature | there is change in enthalpy | there is no change in internal energy | there is no change in pressure | there is no change in internal energy |
| Which of the following is the correct statement of the second law of thermodynamics? | It is possible to construct an engine working on a cyclic process, whose sole purpose is to convert heat energy into work. | It is possible to transfer heat from a body at a lower temperature to a higher temperature, without the aid of an external source. | There is a definite amount of mechanical energy, which can be obtained from a given quantity of heat energy. | it is impossible to construct a device that can transfer heat from a hotter body to a hotter body without any effect | There is a definite amount of mechanical energy, which can be obtained from a given quantity of heat energy. |
| The gas constant (R) is equal to the __________ of two specific heats. | sum | difference | product | ratio | difference |
| In an irreversible process,there is a | loss of heat | no loss of heat | gain of heat | no gain of heat | loss of heat |
| The efficiency of Carnot cycle depends upon | temperature limits | pressure ratio | volume compression ratio | cut-off ratio and compression ratio | temperature limits |
| Which of the following is an intensive property of a thermodynamic system? | Volume | Temperature | Mass | Energy | Temperature |
| According to First law of thermodynamics | total internal energy of a system during a process remains constant | total energy of a system remains constant | workdone by a system is equal to the heat transferred by the system | internal energy, enthalpy and entropy during a process remains constant | total energy of a system remains constant |

| | | | | | |
|---|---|---|---|---|---|
| Carnot cycle consists of | two constant volume and two isentropic processes | two isothermal and two isentropic processes | two constant pressure and two isentropic processes | one constant volume, one constant pressure and two isentropic processes | two isothermal and two isentropic processes |
| When a gas is heated at constant volume | its temperature will increase | its pressure will increase | both temperature and pressure will increase | neither temperature nor pressure will increase | both temperature and pressure will increase |
| The isothermal and adiabatic processes are regarded as | reversible process | irreversible process | mechanical process | chemical process | reversible process |
| The heat flows from a cold body to a hot body with the aid of an external source. This statement is given by | Kelvin | Joule | Clausis | Gay-Lussac | Clausis |
| The general gas equation is (where p = Pressure, v = Volume, m = mass, T = Absolute temperature, and R = Gas constant) | pv = nRT | pv = RT | $pv^n = C$ | $pv = (RT)_m$ | pv = nRT |
| The gas constant (R) is equal to the | sum of two specific heats | difference of two specific heats | product of two specific heats | D.ratio of two specific heats | difference of two specific heats |
| A perfectly black body | Absorbs all the incident radiation | Allow all the incident radiation to pass through it | Reflects all the incident radiation | Has its surface coated with lamp black or graphite | Absorbs all the incident radiation |
| Newton's Law of Cooling states that the rate at which an object cools is proportional to what? | Difference in temperature of the object and the temperature of its surroundings | Temperature of surroundings | Temperature of the object | Object's mass | Difference in temperature of the object and the temperature of its surroundings |
| Three black bodies are such that higher intensity wavelengths are in the ratio λm1 : λm2 : λm3 = 1 :(21)1/2: (3)1/2 which of the these is true for the temperatures | T1 < T3 > T2 | T1 > T2 > T3 | T3 > T2 > T1 | T3 > T1 > T2 | T3 > T2 > T1 |
| Suppose A body behaves like black body. When the temperature of blackbody increasesit is observed that the wavelength corresponding to maximum energy changes from λ to λ/2. Find the ratio of emissive power of the body at respective temperature | E1:E2=1:8 | E1:E2=1:2 | E1:E2=1:1 | E1:E2=2:1 | E1:E2=1:2 |
| According to Stefan's Law | $q = \alpha AT^4$ | $q = \alpha AT^2$ | $q = \alpha AT$ | $q = \alpha T^4$ | $q = \alpha AT^4$ |
| The Stefan-Boltzmann law of thermal radiation is applicable for | white body | hot body | black body | cold body | black body |
| According to the Stefan-Boltzmann law of thermal radiation for a perfect radiator,the rate of radiant energy per unit area is proportional to | the temperature of that radiator | the square of the temperature of that radiator | the cube of the temperature of that radiator | the fourth power of the temperature of that radiator | the fourth power of the temperature of that radiator |
| In the equation for the rate radiant heat energy from a perfect radiator q = α A T4 the constant α is called as | gas constant | Radiation constant | Stefan-Boltzmann constant | Planck's constant | Stefan-Boltzmann constant |
| Consider two black bodies at temperatures T1 and T2 (T1 > T2) having same surface area.A are placed in vacuum. What will be the correct formula for net rate of radiant heat transfer between these surfaces? | $q = \alpha A (T_1 – T_2)^4$ | $q = \alpha A (T_1^4 – T_2^4)$ | $q = \alpha A (T_1 – T_2)$ | $q = \alpha A (T_1 + T_2)$ | $q = \alpha A (T_1^4 – T_2^4)$ |
| The relationship (Wavelength) MAX T = constant, between the temperature of a black body and the wavelength at which maximum value of monochromatic emissive power occurs is | Planck's law | Kirchhoff's law | Lambert's law | Wein's law | Wein's law |
| The energy emitted by a black surface should not vary in accordance with | Wavelength | Temperature | Surface characteristics | Time | Time |
| Likewise the amount of emitted radiation is strongly influenced by the wavelength even if temperature of the body is | Constant | Increasing | Decreasing | It is not related with temperature | Constant |
| The law governing the distribution of radiant energy over wavelength for a black body at fixed temperature is referred to as | Kirchhoff's law | Planck's law | Wein's formula | Lambert's law | Planck's law |
| The Planck's constant h has the dimensions equal to | $M L^2 T^{-1}$ | $M L T^{-1}$ | $M L T^{-2}$ | M L T | $M L^2 T^{-1}$ |
| What is the wavelength band for solar radiation? | 1 * 10 -1 to 3 micron meter | 1 * 10 -1 to 2 micron meter | 1 * 10 -1 to 1 micron meter | 1 * 10 -1 to 10 micron meter | |
| If the body is not perfectly black, the Stefan's law becomes | $R=\alpha T^4$ | $R=eT^4$ | $R= \alpha T^4$ | e2 α2T4 | R= αT4 |
| For a perfect block body, the relative emittance e is | 0 | 1 | ½ | 3/4 | 1 |
| The ratio of emissive power to the absorptive power for particular wavelength at particular temprature is constant. This is | plank's law | kircoff's law | stefan's law | wien's law | kircoff's law |
| Stefan's Law applicable for | Hot body | cold body | low temperature difference | high temperature difference | Hot body |
| Newton's law applicable only for | Hot body | cold body | low temperature difference | high temperature difference | low temperature difference |
| According to third law of thermodynamis | H1/T1 = H2/T2 | H1/T1 ≠ H2/T2 | H1/T2 = H2/T1 | H1/T2 ≠ H2/T1 | H1/T1 ≠ H2/T2 |
| Third law of thermodynamics states that the entropy is ________ at absolute temperature | zero | c | constant | varied | zero |

| | | | | | |
|---|---|---|---|---|---|
| Planck’s law hold’s good in the region of ………. | Shorter wavelengths | longer wavelengths | all wavelengths | very short wavelengths | all wavelengths |
| The radiant energy emitted depends on _________ | temperature | material | volume | height | temperature |
| Absorptive power is represented by _____ | a | λ | λa | aλ | aλ |
| Which is considered as a perfect absorber as well as a perfect emitter? | Gray body | Black body | Real body | White body | Black body |
| Which body that emits a constant emissivity regardless of the wavelength? | Gray body | Black body | Real body | White body | Gray body |
| The transfer of heat by radiation | does not require any medium. | require any medium | does not require any space | require any space | does not require any medium. |
| The specific heat capacity of a substance is equal to | mass of the substance × heat capacity | heat capacity ⁄ mass of the substance | mass of the substance ⁄ heat capacity | mass of the substance | heat capacity ⁄ mass of the substance |
| What is the emissivity of a black body? | 0 | 1 | 0.5 | 0.25 | 1 |
| What is the absorptive of a black body? | 0 | 1 | 0.5 | 0.25 | 0 |
| Radiant energy is also called as ____ | latent heat | radiant heat | entropy | enthalpy | radiant heat |
| Entropy is transferred by ______. | Work | Heat | Energy | Work and heat | Heat |
| What is a process during which the specific volume remains constant? | Isobaric process | Isothermal process | Isochoric process | Isovolumetric process | Isochoric process |
| The first law of thermodynamics is based on which of the following principles? | mass of energy | Conservation of energy | The entropy-temperature relationship | Change in temperature | Conservation of energy |
| 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 ………… | 18.33 $J K^{-1} mol^{-1}$ | 33.27 $J K^{-1} mol^{-1}$ | 28.33 $J K^{-1} mol^{-1}$ | 8.33 $J K^{-1} mol^{-1}$ | 8.33 $J K^{-1} mol^{-1}$ |

**UNIT- IV**

| | | | | | |
|---|---|---|---|---|---|
| Image formed by plane mirror is | Real and erect | Real and inverted | Virtual and erect | Virtual and inverted | Virtual and erect |
| Power of the lens is -40, its focal length is | 4m | -40m | -0.25m | -25m | -0.25m |
| A concave mirror gives virtual, refracts and enlarged image of the object but image of smaller size than the size of the object is | At infinity | Between F and C | Between P and F | At E | Between P and F |
| In optics an object which has higher refractive index is called | Optically rarer | Optically denser | Optical density | Refractive index | Optically denser |
| The optical phenomena, twinkling of stars, is due to | Atmospheric reflection | Total reflection | Atmospheric refraction | Total refraction | Atmospheric refraction |
| Convex lens focus a real, point sized image at focus, the object is placed | At focus | Between F and 2F | At infinity | At 2F | At infinity |
| The unit of power of lens is | Metre | Centimeter | Diopter | $M^{-1}$ | Diopter |
| The radius of curvature of a mirror is 20cm the focal length is | 20cm | 10cm | 40cm | 5cm | 10cm |
| The Snell’s law can be derived from which type of incidence? | Incidence angle | Reflected angle | Refracted angle | Oblique incidence | Oblique incidence |
| The Snell’s law is given by | N1 sin θi = N2 sin θt | N2 sin θi = N1 sin θt | sin θi = sin θt | N1 cos θi = N2 cos θt | N1 sin θi = N2 sin θt |
| 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. | 0.71 | 1.4 | 2 | 3.99 | 0.71 |
| 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. | 0.5 | 1 | 2 | 4 | 2 |
| Snell's law can be derived from | Newton's principle | Fermat's principle | Faraday's principle | Pendry's principle | Fermat's principle |
| Angle of refraction is negative when refractive induces of two materials have | same direction | opposite direction | random direction | no direction | opposite direction |
| Materials exhibiting negative refractive indices are | most dielectric materials | most doped semiconductors | non-natural materials | ferrites | non-natural materials |
| Interference of light is evidence that | The speed of light is very large | light is a transverse wave | light is electromagnetic in character | Light is a wave phenomenon | Light is a wave phenomenon |
| A wavelength is commonly measured in which one of the following units? | Radians | Angstroms | Electron volts | Seconds | Angstroms |
| The phenomenon of diffraction can be understood using | Huygens principle | Fraunhofer | Uncertainty principle | Fresnel | Huygens principle |
| What is the name of the process whereby waves travel around corners and obstacles in their paths? | Reflection | Reflection | Interference | Diffraction | Diffraction |
| In Fraunhofer diffraction, the incident wave front should be ---------- | elliptical | Plane | Spherical | Cylindrical | Plane |
| The wave nature of light is demonstrated by which of the following? | The photoelectric effect | Color | The speed of light | Diffraction | Diffraction |
| The characteristic that distinguishes a laser beam from an ordinary light beam is: | The greater frequency of the laser beam | The coherence of the laser beam | The color of the laser beam | The greater polarization of the laser beam | The coherence of the laser beam |

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| Light travels fastest | In a vacuum | through water | Through glass | through diamond | In a vacuum |
| Optical fiber works on the | principle of refraction | total internal reflection | scattering | interference | total internal reflection |
| In Fraunhofer diffraction wave front used is __________. | Spherical | Circular | plane | Conical | Plane |
| The points of constructive interference of light are | Always bright | may be bright or dark | always dark | neither bright nor dark | Always bright |
| __________ of the following phenomenon cannot be explained on the particle nature of light. | Photo Electric Effect | Compton's Effect | Pair Production | Interference | Photo Electric Effect |
| There are two types of diffraction Fresnel and | Michelson | De Broglie | Fraunhofer | Huygens | Fraunhofer |
| Diffraction is special type of | Reflection | Refraction | Interference | Polarization | Refraction |
| Which of the following phenomenon produces colors in soap bubble? | Interference | Diffraction | Polarization | Dispersion | Interference |
| What is the wavelength of red light emitted by a helium-neon | 122 nanometers | 633 nanometers | 2.43 nanometers | 1.37 micrometers | 633 nanometers |
| What is the life time of electron in metastable state? | 10 -3 sec | 10 -5 Sec | 10 -8 sec | 10 -7 sec | 10 -8 sec |
| In the population inversion | 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 | None of them | The number of electrons in higher energy state is more than ground state |
| Laser beam is made a of | Electrons | Highly coherent photon | Elastic particles | Excited atoms | Highly coherent photon |
| In ruby Laser which ions give rise to laser action | Al2o3 | Cr 3+ | Al3+ | O – | Cr 3+ |
| Which of the laser have high efficiency | Ruby | Semiconductor | He- Ne | Co2 | Co2 |
| The method of population inversion to the laser action in He-Ne laser is | molecule collision | direction conversion | electric discharge | electron impact | molecule collision |
| Which of the laser have very low efficiency | Ruby | Semiconductor | He- Ne | Ammonia gas laser | Ammonia gas laser |
| The Ruby laser is | Continuous Laser | gas Laser | semiconductor laser | pulsed laser | pulsed laser |
| The method of achieving population inversion in Ruby Laser is | Optical pumping | inelastic Scattering | forward biasing | chemical reaction | Optical pumping |
| The He – Ne laser is | Continuous Laser | gas Laser | semiconductor laser | pulsed laser | Continuous Laser |
| The method of achieving population inversion in He – Ne Laser is | Optical pumping | inelastic Scattering | forward biasing | chemical reaction | inelastic Scattering |
| What type of laser is used in CD and DVD players? | Semiconductor | YAG | Alexandrite | Co2 | Semiconductor |
| What type of laser could cause skin cancer if not used properly? | Red semiconductor laser | Blue semiconductor | Eximer laser | YAG laser | Eximer laser |
| The transition zone for Raman spectra is | Between vibrational and rotational levels | Between electronic levels | Between magnetic levels of nuclei | Between magnetic levels of unpaired electrons | Between vibrational and rotational levels |
| Frequency of photons shifts electrons from one state to another in | Raman spectroscopy | spectroscopy | crystallization | vaporization | Raman spectroscopy |
| The correct order of different types of energies is | Eel >> Evib >> Erot >> E tr | Eel >> Erot >> Evib >> E tr | Eel >> Evib >> Etr >> E rot | Etr >> Evib >> Erot >> E el | Eel >> Evib >> Erot >> E tr |
| Select the correct statement from the following option | 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 | Spectroscopic methods require more time and less amount of sample than classical methods | Spectroscopic methods require less time and less amount of sample than classical methods |
| Sky looks blue because the sun light is subjected to | Rayleigh scattering | Compton scattering | both | none | Rayleigh scattering |
| In polarization, positive side attracts the | negative side of the water molecules | the positive side of the water molecules | the substance dissolves completely in water | metals of group VII | negative side of the water molecules |
| Polarizability is defined as the | Product of dipole moment and electric field | Ratio of dipole moment to electric field | Ratio of electric field to dipole moment | Product of dielectric constant and dipole moment | Ratio of dipole moment to electric field |
| Identify which type of polarisation depends on temperature. | Electronic | Ionic | Orientational | Interfacial | Orientational |
| In isotropic materials, which of the following quantities will be independent of the direction? | Permittivity | Permeability | Polarisation | Polarizability | Permittivity |
| What is the need to achieve population inversion? | To excite most of the atoms | To bring most of the atoms to ground state | To achieve stable condition | To reduce the time of production of laser | To excite most of the atoms |

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| Which of the following can be used in a vibrational analysis of structure? | Maser | Quarts | Electrical waves | Laser | Laser |
| A semiconductor diode Laser is | Four level | Three level | Two level | One level | Two level |
| A He - Ne laser is a | Four level | Three level | Two level | One level | Three level |
| The Nicol prism based on the action of | reflection | Double refraction | refraction | scattering | Double refraction |
| A color with a wavelength longer than that of yellow is: | Red | Blue | Violet | Green | Red |
| In Newton's Ring experiments, the diameter of bright rings is proportional to | Square root of Odd Natural numbers | Natural Number | Even Natural Number | Square root of natural number | Square root of Odd Natural numbers |

UNIT V

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|---|---|---|---|---|---|
| A transistor has how many pn junctions? | 1 | 2 | 3 | 4 | 2 |
| Asemiconductor is formed by ------------- bonds | covalent | electrovalent | co-ordinate | none of the above | covalent |
| The most commonly used semiconductor is | germanium | silicon | carbon | sulphur | silicon |
| A semiconductor has generally ------ valence electrons | 2 | 3 | 6 | 4 | 4 |
| The resistivity of pure silicon is about | 60 W cm | 6000 W cm | 600 W cm | 1.6 W cm | 6000 W cm |
| When a pentavlent impurity is added to a pure semiconductor, it becomes ------ | an insulator | an intrinsic semiconductor | p-type semiconductor | n-type semiconductor | n-type semiconductor |
| Addition of pentavalent impurity to semiconductor creates many --- | free electrons | holes | valence electrons | bound electrons | free electron |
| An n-type semiconductor is ------ | positively charged | negatively charged | electrically neutral | none of the above | electrically neutral |
| A forward biased pn junction has a resistance of the | order of W | order of KW | order of MW | none of the above | order of W |
| The battery connections required to forward bias a pn junction are | positive terminal to p and negative terminal to n | negative terminal to p and positive terminal to n | negative terminal to p and negative terminal to n | none of the above | positive terminal to p and negative terminal to n |
| The barrier voltage at a pn junction for germanium is about | 3.5 V | 3 V | Zero | 0.3 V | 0.3 V |
| In the depletion region of a pn junction, there is a shortage of ------- | acceptor ions | holes and electrons | donor ions | none of the above | holes and electrons |
| A reverse biased pn junction has | very narrow depletion layer | almost no current | very low resistance | large current flow | almost no current |
| A pn junction acts as a | controlled switch | bidirectional switch | unidirectional switch | none of the above | unidirectional switch |
| A reverse biased pn junction has resistance of the | order of W | order of KW | order of MW | none of the above | order of MW |
| The leakage current across a pn junction is due to | minority carriers | majority carriers | junction capacitance | none of the above | minority carriers |
| The leakage current across a pn junction is of the order of | A | mA | kA | mA | mA |
| In an intrinsic semiconductor, the number of free electrons | equals the number of holes | is greater than the number of holes | is less than the number holes | none of the above | equals the number of holes |
| At room temperature, an intrinsic semiconductor has | many holes only | a few free electrons and holes | many free electrons only | no holes or free electrons | a few free electrons and holes |
| In a half wave rectifier, the load current flows for what part of the cycle | 400 | 900 | 1800 | 3600 | 1800 |
| In a full wave rectifier, the current in each diode flows for | whole cycle of the input signal | half cycle of the input signal | more than half cycle of the input signal | none of these | half cycle of the input signal |

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| in a full wave rectifier, if the input frequency is 50 Hz, then output frequency will be | 50 Hz | 75 Hz | 100 Hz | 200 Hz | 100 Hz |
| The maximum efficiency of full wave rectification is | 40.60% | 100% | 81.20% | 85.60% | 81.20% |
| The maximum efficiency of half wave rectification is | 40.60% | 100% | 81.20% | 85.60% | 40.60% |
| The ripple factor of a bridge rectifier is | 0.482 | 0.812 | 1.11 | 1.21 | 0.482 |
| To get a peak load voltage of 40V out of a bridge rectifier. What is the approximate rms value of secondary voltage? | 0 V | 14.4 V | 28.3 V | 56.6 V | 28.3 V |
| If the line frequency is 50 Hz, the output frequency of bridge rectifier is | 25 Hz | 50 Hz | 100 Hz | 200 Hz | 100 Hz |
| The bridge rectifier is preferred to an ordinary two diode full wave rectifier because | it needs much smaller transformer for the same output | no center tap required | less PIV rating per diode | all the above | all the above |
| The basic purpose of filter is to | minimize variations in ac input signal | suppress harmonics in rectified output | remove ripples from the rectified output | stabilize dc output voltage | remove ripples from the rectified output |
| A half wave rectifier is equivalent to | clamper circuit | a clipper circuit | a clamper circuit with negative bias | a clamper circuit with positive bias | a clipper circuit |
| The basic reason why a full wave rectifier has a twice the efficiency of a half wave rectifier is that | it makes use of transformer | its ripple factor is much less | it utilizes both half-cycle of the input | its output frequency is double the line frequency | it utilizes both half-cycle of the input |
| Which rectifier requires four diodes? | half-wave voltage doubler | full-wave voltage doubler | full-wave bridge circuit | voltage quadrupler | full-wave bridge circuit |
| The number of depletion layers in a transistor is | four | three | one | two | two |
| The base of a transistor is ------ doped | heavily | moderately | lightly | none of the above | lightly |
| The element that has the biggest size in a transistor is --- | collector | base | emitter | collector-base junction | collector |
| In a pnp transistor, the current carriers are | acceptor ions | donor ions | free electrons | holes | holes |
| A transistor is a ----- operated device | current | voltage | both voltage and current | none of the above | current |
| In npn transistor, ---- are the minority carriers | free electrons | holes | donor ions | acceptor ions | holes |
| In a trnsistor, the base current is about ----- of emitter current | 25% | 20% | 35% | 5% | 5% |
| At the base-emitter junction of a transistor, one finds ---- | reverse bias | a wide depletion layer | low resistance | none of the above | low resistance |
| The input impedance of a transistor is ---- | high | low | very high | almost zero | low |
| The current I_B is ---- | electron current | hole current | donor ion current | acceptor ion current | electron current |
| In a transistor | Ic=Ie+Ib | Ib=Ic+Ie | Ie=Ic-Ib | Ie=Ic+Ib | Ie=Ic+Ib |
| The value of a transistor is | more than 1 | less than 1 | 1 | none of the above | less than 1 |
| The output impedance of a transistor is | high | zero | low | very low | high |
| The relation between a and b is | b=1/(1-a) | b=(1-a)/a | b=a/(1-a) | b=a/(1+a) | b=a/(1-a) |
| The value of b transistor is | 1 | less than 1 | between 20 and 500 | above 500 | between 20 and 500 |
| The most commonly used transistor arrangement is ----- arrangement | common emitter | common base | common collector | none of the above | common collector |
| The phase difference between the input and output voltages in a common base arrangement is | 180° | 90° | 270° | 0° | 0° |
| As the temperature of a transistor goes up, the base-emitter resistance | decreases | increases | remains the same | none of the above | decreases |
| BC 147 transistor indicates that it is made of | germanium | silicon | carbon | none of the above | silicon |
| A transistor is connected in CB mode. If it is now connected in CE mode with same bias voltages, the values of Ie, Ib and Ic will | remain the same | increases | decreases | none of the above | remain the same |
| The collector-base junction in a transistor has ---- | forward bias at all times | reverse bias at all times | low resistance | none of the above | reverse bias at all times |