Physics Solution

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Q1) Explain the construction and reconstruction of hologram.

Answer: Holography technique to obtain 3D image of an object:

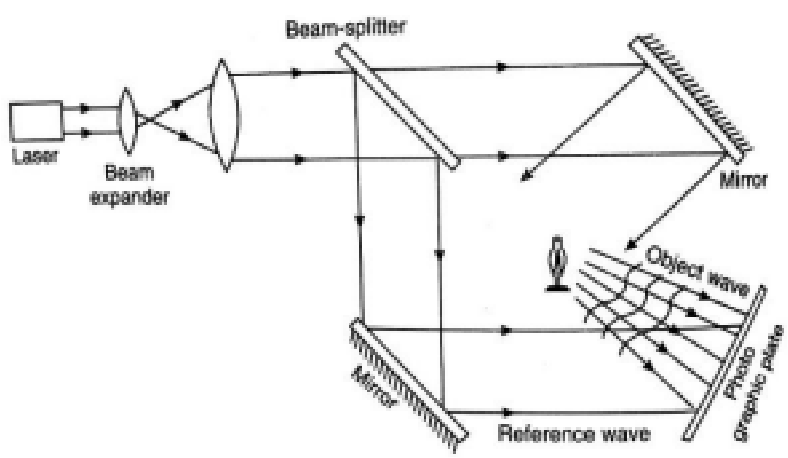
1. Holography is the science and practice of making holograms. Holography is actually a recording of interference pattern formed between two beams of coherent light coming from the same source.

2. In this process,both the amplitude and phase components of a light wave are recorded on a light sensitive medium such as a photographic plate. The recording is known as a hologram.

3. Holography requires an intense coherent light source.It became a practical proposition only after the invention of LASERS.

4. Holography is a two step process.In the first step,recording of hologram is done where the object is transformed into a photographic record and the second step is the reconstruction in which the hologram is transformed into image.

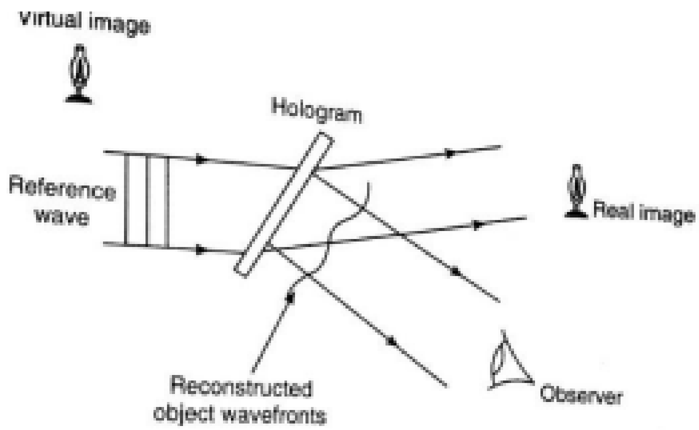
Construction process :



1.During the recording process we superimpose on the scattered wave emanating from the object,the another coherent wave(called as reference beam) of the same wavelength.

2.These 2 waves interfere in the plane of recording medium and produce interference fringes.This is the recording process of hologram.

Reconstruction process :



1.The reproduction of the image from the hologram is known as reconstruction of the hologram.

2.In this process,a wave identical to reference beam is used.

3.When the hologram is illuminated by the reconstruction wave,2waves are produced. **4**.One wave appears to diverge from the object and provides the virtual image of the object.

5.The second wave converges to form the real image of the object.

Q2) Explain top down and bottom up approaches to prepare nanomaterials.

Answer:

Q1)g) Explain top down and bottom up approaches to prepare nanomaterials . (3M)

Ans : In nano science, we are supposed to arrive at nano scale assembly .This can be achieved by two different approaches namely :

1.Bottom up Approach :In this approach, nano materials are made by building atom by atom or molecule by molecule.It involves building of nanomaterials from the atomic scale (assembling materials from atoms/molecules). For synthesis of nanomaterials, colloidal dispersion is a good example of Bottom-up Approach .

2.Top down Approach :In this approach, a bulk material is broken or reduced in size or pattern. The technique developed under this tile are modified or improved one which we have in use to fabricate micro-processors, Micro-Electro-Mechanical Systems (MEMS) etc. Attrition or ballmilling is a typical example of Top-down Approach .

Q3) Light is incident normally on a grating 0.25 cm wide with 1250 lines. Find the angular separation of the two sodium lines in the first order spectrum. Can they be seen distinctively if the lines are 5895 Å & 5901 Å.

Answer ::

Data : Number of lines / cm (N)= 5000

m=1

$\lambda 1=5895$ Å

$\lambda 2=5901$ Å

Formula :

$(a+b)\sin\theta=N\lambda$

$mN=\lambda/d\lambda$

Calculations :

$$(a+b)\sin\theta_1 = \lambda_1$$
$$\theta_1 = \sin^{-1}(\frac{\lambda_1}{a+b})$$
$$\theta_1 = \sin^{-1}(5895 \times 10^{-8} \times 5000)$$
$$\theta_1 = 17.1425^\circ$$

---1

$$(a+b)\sin\theta_2 = \lambda_2$$
$$\theta_2 = \sin^{-1}(\frac{\lambda_2}{a+b})$$
$$\theta_2 = \sin^{-1}(5901 \times 10^{-8} \times 5000)$$
$$\theta_2 = 17.1605^\circ$$

----2

$$\theta_2 - \theta_1 = 17.1605 - 17.1425$$
$$= 0.0180$$

---3

$$N = \frac{\lambda}{md\lambda} = \frac{5898 \times 10^{-8}}{1 * 6 \times 10^{-8}} = 983$$

Number of lines / cm required for grating is 983

Number of lines / cm available for grating is 5000

angular separation is 0.0180

This lines will be resolved well by grating

Q4) Derive the expression of numerical aperture for a step index fiber. A light ray enters an optical fiber from air. The fiber has core refractive index 1.52 and cladding refractive index 1.41. Find the Critical angle and Numerical aperture.

Answer ::

Q4// B/ Numerical

Data: Core refractive index $\mu_1 = 1.52$
Cladding refractive index $\mu_2 = 1.41$

To find: Critical angle (α)
Numerical aperture (NA)

Formula: $NA = \sqrt{\mu_1^2 - \mu_2^2}$

$\sin\alpha_{min} = \frac{\mu_2}{\mu_1}$

Calculations:

$$NA = \sqrt{\mu_1^2 - \mu_2^2} = \sqrt{(1.52)^2 - (1.41)^2} = 0.5677$$

$$\alpha_{min} = \sin^{-1}\left(\frac{\mu_2}{\mu_1}\right) = \sin^{-1}\left(\frac{1.41}{1.52}\right) = 68.06^\circ$$

Result:
Numerical Aperture, $NA = 0.5677$
Critical angle, $\alpha_{min} = 68.06^\circ$

Q5) Find the divergence and curl of a vector $\vec{A} = x^2 y\,\hat{i} + (x-y)\,\hat{k}$.

Answer :

Q5// Find the divergence and curl of a vector $\vec{A} = x^2y\hat{i} + (x-y)\hat{k}$

→ We have $\vec{A} = x^2y\hat{i} + (x-y)\hat{k}$

Divergence $= \vec{\nabla}\cdot\vec{A}$

$$= \left(\frac{\partial}{\partial x}\hat{i} + \frac{\partial}{\partial y}\hat{j} + \frac{\partial}{\partial z}\hat{k}\right)\cdot\left[x^2y\hat{i} + (x-y)\hat{k}\right]$$

$$= \frac{\partial}{\partial z}(x^2y) + \frac{\partial}{\partial z}(x-y) = 2xy$$

Curl $= \vec{\nabla}\times\vec{A}$

$$= \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ \partial/\partial x & \partial/\partial y & \partial/\partial z \\ x^2y & 0 & x-y \end{vmatrix}$$

$$= i\left[\frac{\partial}{\partial y}(x-y)\right] + \hat{j}\left[\frac{\partial}{\partial z}(x^2y) - \frac{\partial}{\partial x}(x-y)\right] + \hat{k}\left[-\frac{\partial}{\partial y}(x^2y)\right]$$

$$= \hat{i}(-1) + \hat{j}(-1) + \hat{k}(x^2)$$

$$= -\hat{i} - \hat{j} + (-x^2)\hat{k}$$

$$= -\hat{i} - \hat{j} - x^2\hat{k}$$

Div $\vec{A} = 2xy$

Curl $\vec{A} = -\hat{i} - \hat{j} - x^2\hat{k}$

Q6) State the advantages of optical fiber cables on conventional electrical cables.

Answer :: Advantages of optical fiber cables on conventional electrical cables.

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1. Large Potential bandwidth: As the optical carrier frequency is in the range of 10^{12} to 1^{15} Hz it yields a far greater potential transmission bandwidth, than metallic cable systems. Therefore the information carrying capacity of optical fiber system is superior to the best copper cable system.
2. Small size and weight: Optical fiber have very small diameter which are often no greater than the diameter of human hair. Small size and light weight property of an optical fiber is somewhat advantageous in various applications like aircraft, satellites and even ships.
3. Electrical isolation: Optical fibers which are fabricated from glass or sometimes a plastic polymer are electrical insulator, they do not exhibit earth loop and interface problems. Hence no hazards of short circuit as in metal wires.
4. Immunity to interference and crosstalk: Optical fibers form a dielectric waveguides and are therefore free from electromagnetic interference (EMI), radio frequency (RF), etc. Hence the operation of an optical fiber communication system is unaffected by transmission through an electrically noisy environment and fiber cable requires no shielding from EMI.
5. Signal security: The light from optical fibers does not radiate significantly and therefore they provide a high degree of signal security:
6. Low transmission loss: Fibers have been fabricated with losses as low as 0.2dB/km and this feature has become a major advantage of optical fiber communication.
7. System reliability and ease of maintenance: The low loss property of optical fiber cable reduces the requirement for intermediate repeaters or line amplifiers to boost the transmitted signal strength. Hence with fewer repeaters the system reliability is

greatly enhanced. High reliability reduces its expenditure on maintenance.

8. Ruggedness and Flexibility: Optical fibers have a very high tensile strength. The fibers may also be bent to quite small radii or twisted without damage.
9. Low cost and availability: The fibers are made from silica which is available in abundance. Hence there is no shortage of material and its cost is also less. So optical fiber offers a very low cost Communication.

Q 7) What are different techniques to synthesize nanomaterials? Explain any one of them in detail.

Answer :: The different techniques to synthesis nanomaterial are :

1.Ball milling

2.Sputtering

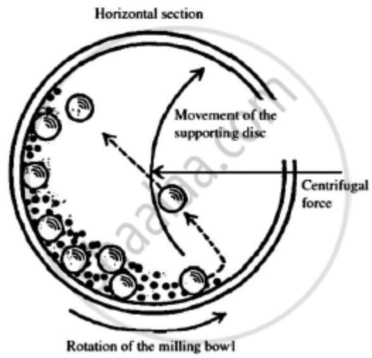
3.Vapour deposition

4.Sol gel technique

5.LASER synthesis

6.Inert gas condensation

BALL MILLING PROCESS :



1. As the name suggests, the ball milling method consists of balls and a mill chamber. Therefore over all a ball mill contains a stainless steel container and many small iron, hardened steel, silicon carbide, or tungsten carbide balls are made to rotate inside a mill (drum).

2. The powder of a material is taken inside the steel container. This powder will be made into nanosize using the ball milling technique. A magnet is placed outside the container to provide the pulling force to the material and this magnetic force increases the milling energy when milling container or chamber rotates the metal balls.

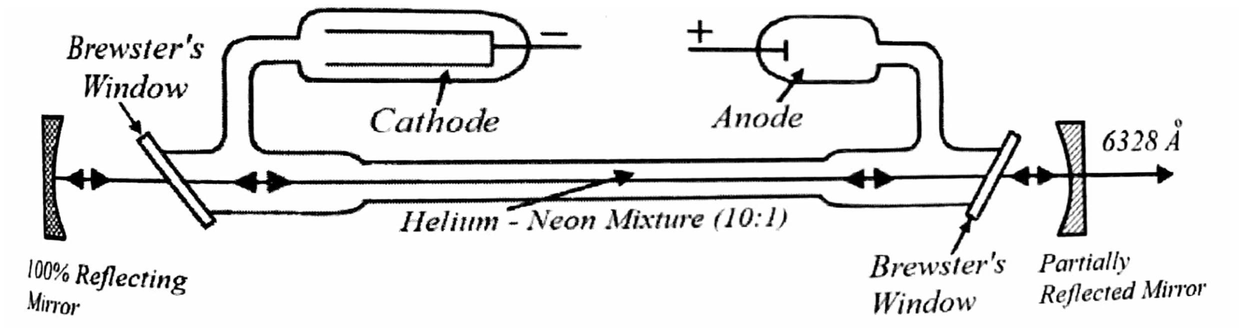
3. The ball to material mass ratio is normally maintained at 2 : 1.These silicon carbide balls provide very large amount of energy to the material powder and the powder then get crushed. This process of ball milling is done approximately 100 to 150 hrs to get uniform fine powder.

4. Ball milling is a mechanical process and thus all the structural and chemical changes are produced by mechanical energy.

Q8) With neat energy level diagram describe the construction and working of a He-Ne Laser. What are its merits and demerits? What is the role of helium atoms?

Answer :

It consists of a long discharge tube of length 50 cm and diameter 1 cm. The tube is filled with a mixture of He and Ne in the ratio 10:1. Electrodes are provided to produce a discharge in the gas and they are connected to high voltage power supply. The tube is sealed by inclined windows arranged at its end. On the axis of tube two reflectors are fixed which forms resonator.



He Ne gas laser employ four level pumping schemes. When the power is switched on the electric field ionizes some of the atoms in the mixture of He and Ne gases. Due to electric field, the electrons and ions will be accelerated towards anode and cathode. Since electron have smaller mass they acquire higher velocity and He atoms are lighter in weight and therefore readily excitable.

The energetic electrons excite He atoms to excited states F2 and F3 which lies at 19 ev and 20 ev above the ground state. These are metastable states for helium.

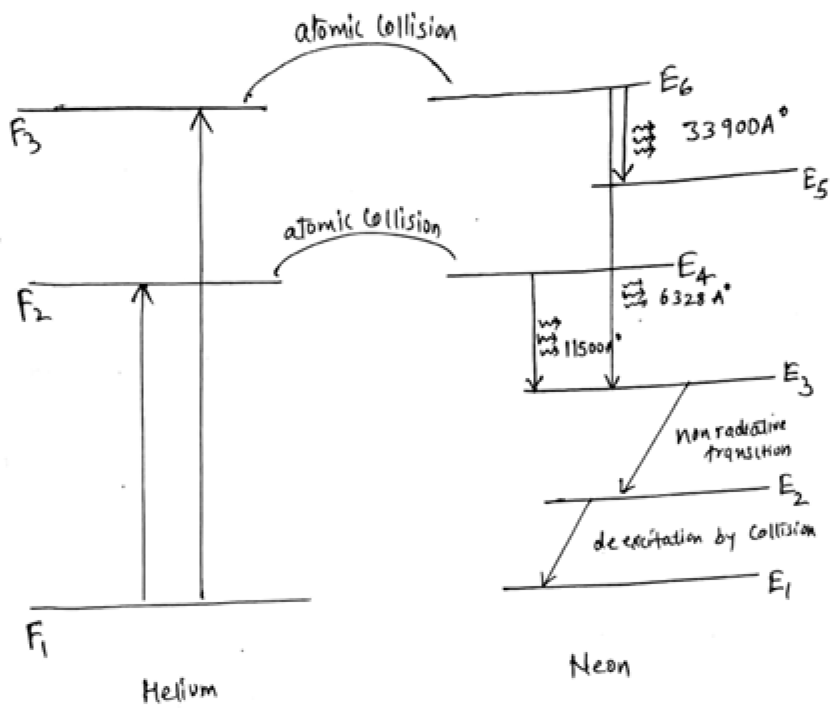
Though the radiative transitions is forbidden, the excited He atom can return to the ground state by transferring their energy to Ne atoms through collision. Such an energy transfer can take place only when the two colliding atoms have identical energy states. E6 and E4 level of Ne atom nearly coincides with F3 and F2 of Helium.

Ne atoms acquires energy and goes to excited state and helium atoms return to ground state by transferring their energy to Ne atoms. This is main pumping mechanism. Ne atoms are active centers and Helium plays the role of pumping agent.

The probability of energy transfer from Ne to He atom is less as there are 10 Helium atoms to 1 Neon atom. E6 and E4 states are metastable states as collision goes on neon atoms accumulate in these states whereas E5 and E3 level of neon are sparsely populated.

Therefore, a state of population inversion is achieved between E6and E5, E6 and E3 and E4 and E3. Consequently, three laser transitions take place.

E6-----E5 33900 A° (far IR region) E6-------E3 6328 A° (visible) E4----E3 11500 A° (IR region)



As the terminal levels of lasing transitions are sparsely populated the fraction of Ne atom that must be excited to upper level can be much less. As such the power required for pumping is low. Random photons emitted spontaneously sets stimulated emission and coherent radiation is produced.

From E5 and E3 level neon atom can make downward transition to E2 level. Incoherent light is emitted due to spontaneous transition. As lower levels depopulate faster than upper levels it is easier to maintain population inversion throughout laser operation. E2 is again a metastable state.

Therefore, Ne atoms tends to accumulate at this level again. However, they are made to collide with the walls of discharge tube and they give up their energy and returns to ground state.

Merits:

- Continuous output laser source
- Highly stable
- No separate cooling is required

Demerits :

- Low efficiency and low power output
- Gases are novel medium for laser as gases are found in the purest form so their optical properties are well defined.

Role of Helium atoms:

- Being a good conductor of heat, He acts as a coolant and no separate cooling system is required.
- He atoms being lighter than Ne atoms absorbs the energy from the high energy electrons easily and very fast.
- The ratio He : Ne=10:1 makes the probability of energy transfer for He atoms to Ne atoms much higher than that of the reverse.

Q9) Discuss the phenomenon of Fraunhofer's diffraction at a single slit and obtain the condition for the first minimum. Calculate the maximum order of diffraction maxima seen from plane transmission grating with 2500 lines per inch if light of wavelength 6900 Å falls normally on it.

Answer ::

FRAUNHOFER DIFFRACTION AT SINGLE SLIT

1. Let us first consider a parallel beam of light incident normally on a slit AB of width 'a' which is of order of the wavelength of light.

2. A real image of diffraction pattern is formed on the screen with the help of converging lens placed in the path of the diffracted beam.

3. All the rays that starts from slit AB in the same phase reinforce each other and produce brightness at point O on the axis of slit as they arrive there in the same phase.

*4. * The intensity of diffracted beam will be different in different directions and there are some directions where there is no light.

5. Thus diffraction pattern on screen consists of a central bright band and alternate dark band bright bands of decreasing intensity on both sides.

6. Now consider a plane wave front PQ incident on the narrow slit AB. According to Huygens principle each point t on unblocked portion of wavefront PQ sends out secondary wavelets in all directions.

7. Their combined effect at any distant point can be found by summing the numerous waves arriving there from the principle of superposition.

8. Let C be the center of the slit AB. The secondary waves, from point equidistant from center C of the slit lying on portion CA and CB of wave front travel the same distance in reaching O and hence the path difference between them is zero.

9. These waves reinforce each other and give rise to the central maximum at point O.

condition for minima

1. We now consider the intensity at point P1 above O on the screen where another set of rays diffracted at a angle theta have been bought to focus by the lens and contribution from different elements of the slit do not arise in phase at P1.

2. If we drop a perpendicular from point A to the diffracted ray from B then AE as shown in figure constitutes the diffracted wavefront and BE is the path difference between the rays from the two edges A and B of the slit.

3. Let us imagine this path difference to be equal to one wavelength.

4. The wavelets from different parts of the slit do not reach point P1 in the phase because they cover unequal distance in reaching P1. Thus they would interface and cancel out each other effect. for this to occur

BE = λ

Since BE = ABsinθ

asinθ = λ

or sinθ = λ/a

or **θ = λ/a** ---(1)

As angle of diffraction is usually very small so that sinθ = θ

$N = 2500$ /inch

$N = \frac{2500}{2.54} = 984$ /cm

$\lambda = 6900\ A^{\circ} = 6900 \times 10^{-8}$ cm

$n_{max} = \frac{a+b}{\lambda} = \frac{1}{N \cdot \lambda}$

$= \frac{1}{984 \times 6900 \times 10^{-8}}$

$n_{max} = 14.72$

$\boxed{N_{max} \approx 14}$

Q10) What is a grating? Define grating element? Discuss the phenomenon of Fraunhofer's diffraction at a grating and obtain the expression for the intensity?

Answer :

{I have not proper answer for this }

Q11) Compute the maximum radius allowed for a fiber having core refractive index 1.5 and 1.48. the fiber is to support only one mode at a wavelength of 1500 nm.

Answer :

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Q 11 QB/ Solution / Quesnit.com

Data: $\mu_1 = 1.5$ $\mu_2 = 1.48$

$\lambda = 1500 \, nm = 1500 \times 10^{-9} \, m$

$V_{max} = 2.405$ for SIF

Formula: $V = \frac{2\pi r}{\lambda} \sqrt{\mu_1^2 - \mu_2^2}$

Calculations:

$$r_{max} = \frac{V_{max} \cdot \lambda}{2\pi \cdot \sqrt{\mu_1^2 - \mu_2^2}}$$

$$= \frac{2.405 \times 1500 \times 10^{-9}}{2 \times 3.14 \sqrt{1.5^2 - 1.48^2}}$$

$$= 2.353 \times 10^{-6} \, m$$

$$= 2.353 \, \mu m$$

Result:

radius, $r = 2.353 \, \mu m$

Q12) What is population inversion state? Explain its significance in the operation of LASER

Answer::

1.Normally atoms have the tendency to return to ground state releasing the absorbed energy. Hence, the population of atoms in ground state is greater than that of excited state.

2.For laser action, there should be more number of atoms in higher energy state.

3.Population inversion is the state in which the number of atoms in higher energy state is more than those in lower energy state.

4.Artificially creating more number of atoms in a higher energy states than the lower energy state is called population inversion. The chances of stimulated emission taking place increases when the state of population inversion is achieved in the medium.

Significance of population inversion in the operation of LASER :

(a) To increase the probability of stimulated emission,the number of atoms in the higher energy state must be greater than the number of atoms in the lower energy state.This is a precondition of LASER.

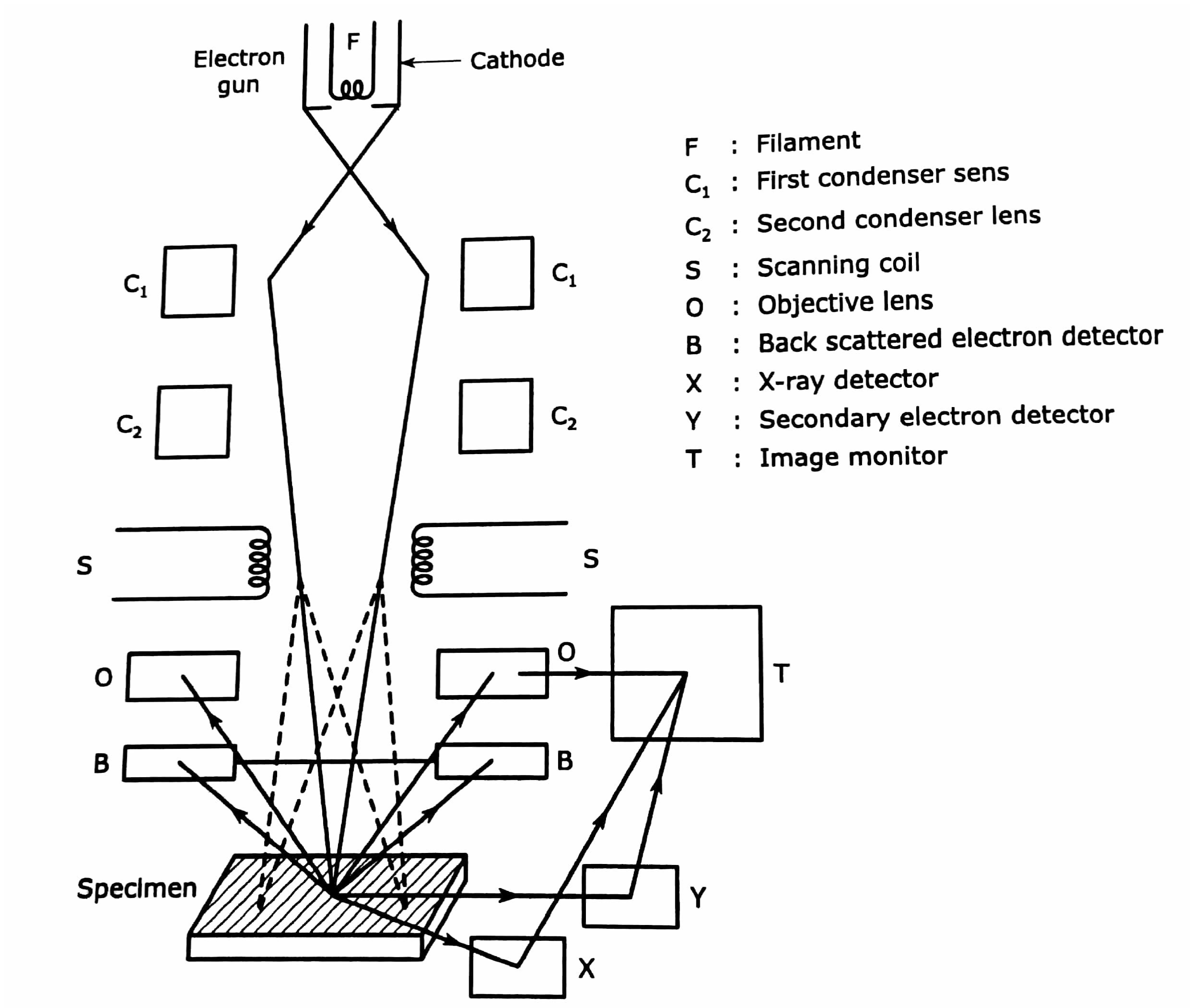
(b) It makes LASER possible with the help of metastable state.

(c) Amplification of light is ensured because of population inversion.

Q13) Draw the schematic diagram of Scanning Electron Microscope and explain its construction, working, advantages, disadvantages and applications.

Answer :

SEM is a type of electron microscope that uses electron beam which is focused on the specimen and by detecting the signals from the interaction of incident electron with sample surface.



The sample is placed inside the microscope's vacuum column through an air tight door. The electron gun assembly produces a high energy electron beam which travels through a series of magnetic lens which helps in focusing the electron beam as a small spot on the specimen surface. It scans the specimens in the raster pattern.

When the high energy electron strikes the surface, some electrons are scattered due to electron scattering. Some are knocked off from the surface, some electrons penetrate deep into inner shells to knock off inner shells electron due to which x rays are produced.

These electrons detected using detector. the signals are amplified and displayed on TV monitor. The final image is built up from the number of electron emitted from each spot of the sample.

If the scattering is high at particular spot, the corresponding point on the screen is bright and vice versa. This creates an image of the objects.

Advantages:-

1. High magnification range
2. Good image resolution

Limitations:-

1. Vacuum needed
2. gives only surface image of specimen
3. the specimen must be conductive

Application: - useful in material science, forensic science, solid state physics, medical science

Q14) Derive Maxwell's third equation in integral and differential form. Given that D= 20x î +10 ĵ (C/m2). Determine the flux crossing 1 m2 area that is normal to the x-axis at x = 5m.

Derive Maxwell's third equation in integral and differential form. Given that $\vec{D} = 20x\,\hat{i} + 10\,\hat{j}$ (C/m^2). Determine the flux crossing 1 m^2 area that is normal to the x-axis at x = 5m.

Answer:

{answer will be added here if i found}

Q15) Distinguish between step index and graded index optical fiber.

Answer :

Sr.no.	Step index fibre	Graded index fibre.
1	The refractive index of the core of step index fiber is constant throughout the core.	The refractive index of the core of the graded index fiber is maximum at center,core and then it decreases towards core-cladding interface.
2	Step index fiber is of two types viz; mono mode fiber and multi mode fiber.	Graded index fiber is of only one type,that is multi mode fiber.
3	The light rays propagate in zig-zag manner inside the core.	The light rays,propagate in the form of skew rays or helical rays.
4	The rays cross the fiber axis for every reflection.	The rays will not cross the,fiber axis.
5	They can be manufactured easily.	They manufacturing process is complex.

Q16) Distinguish between single mode and multimode optical fiber.

Answer ::

Monomode:

1. It supports only 1 mode of propagation
2. It has very small core diameter of the order 5 to 10μm
3. Transmission losses are very small
4. It has higher bandwidth
5. It requires laser diode as source of light
6. It is used for long distance.
7. It is by default step index fibre
8. Mostly it is made up of glass

Multimode:

1. It supports large on of modes of propagation
2. It has larger core diameter of the order 50 to 150μm
3. Transmission losses are more
4. It has lower bandwidth
5. It can work with LED also
6. It is used for long distance communication
7. It can be step index or graded index fibre
8. It is made preferably from plastic

Q17) How is multipath dispersion overcome in Graded index fibre?

Answer ::

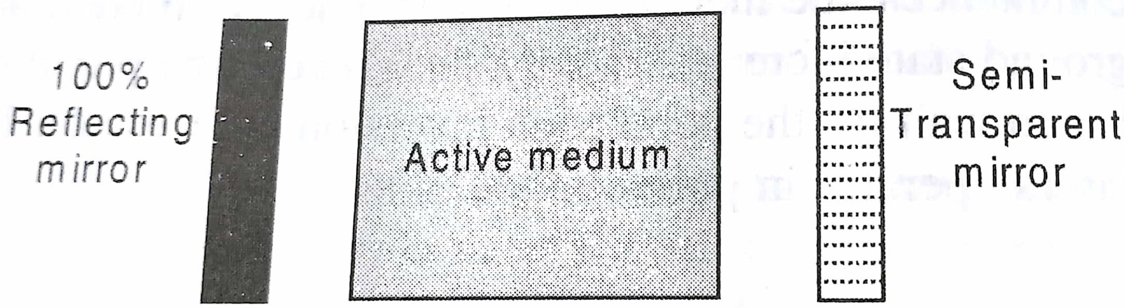
{Answer will be added here }

Q18) What is importance of resonant cavity in the operation of laser?

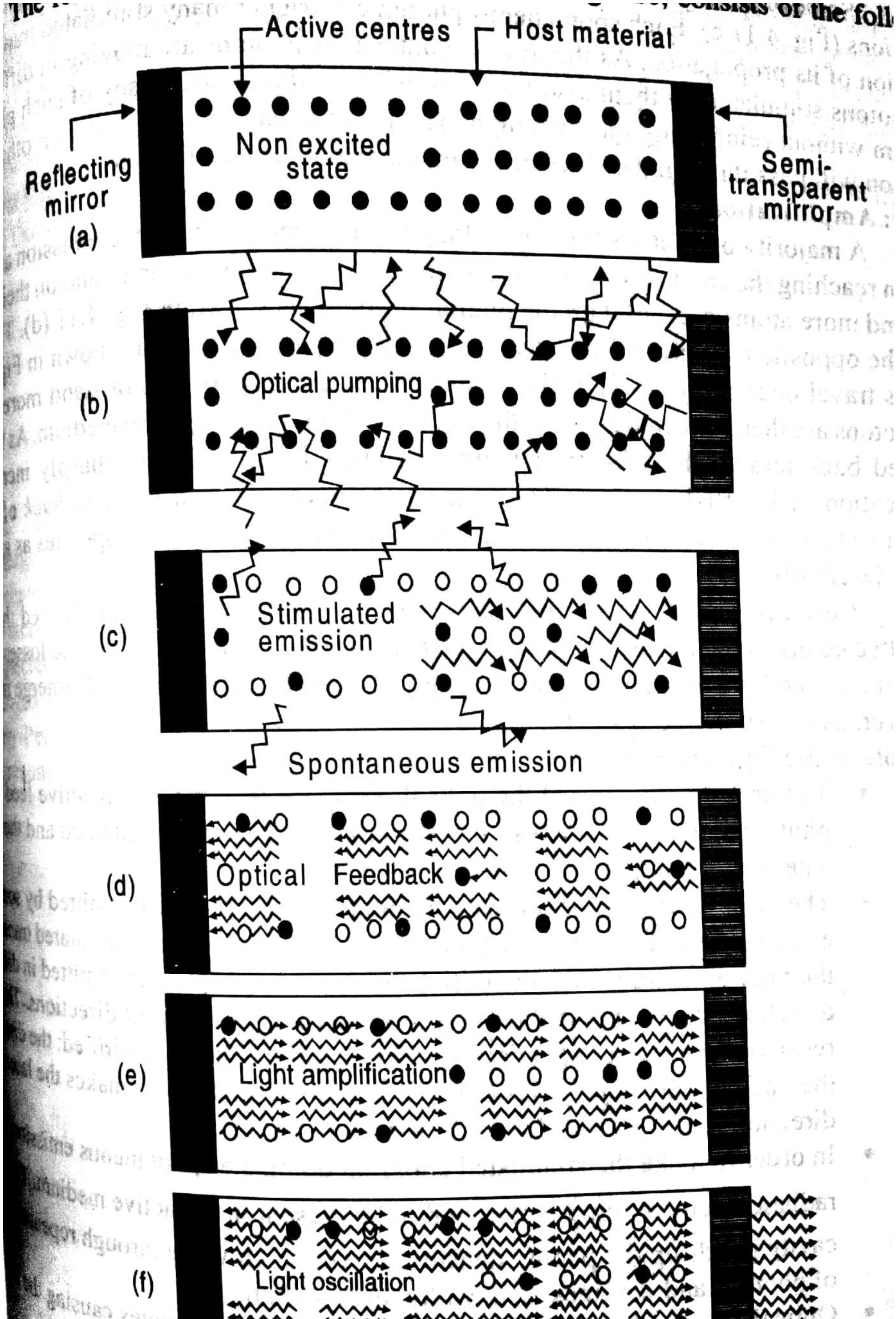
Answer::

Light can be amplified by an active medium taken into the state of population inversion. To achieve stimulated emission, N2 should be made greater than N1 and radiation density should be high. These requirements are met with the help of an optical cavity resonator.

An optical resonator consists of two opposing plane parallel mirrors with active material placed in between them. One of the mirror is semitransparent while other is made 100 % reflecting. The mirrors are set normal to the optic axis of the material.



Initially active centers in the medium are in ground state. Through suitable pumping the material is taken into the state of population inversion. Spontaneous photons are emitted in every direction. To generate coherent output, it is imperative that photons with specific directions are selected and others are rejected. Secondly, to attain maximum possible amplification the photons are made to pass through the medium number of times. Photons traveling parallel to axis, on reaching semitransparent mirror, some are transmitted and many are reflected back. While propagating in the opposite direction they deexcite some more atoms and builds up their strength. At 100 % reflecting mirror some of the photons are absorbed are reflected back and likewise it undergoes multiple reflections at the mirror and gains in strength. laser oscillation begins when amount of amplified light becomes equal to amount of light transmitted and absorbed by mirror. As the oscillation builds up to enough intensity, it emerges through the mirror which is semitransparent as a highly collimated intense beam.


Active centres
Host material
Reflecting mirror
Semi-transparent mirror
(a)
Non excited state
(b)
Optical pumping
(c)
Stimulated emission
Spontaneous emission
(d)
Optical Feedback
(e)
Light amplification
(f)
Light oscillation

Q19) A diffraction grating used at normal incidence gives a line, $\lambda 1 = 6000$ A$^\circ$ in a certain order superimposed on another line$\lambda 2 = 4500$ A$^\circ$ of the next higher order. If the angle of diffraction is 30°, how many lines are there in a cm in the grating?

Answer::

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Q19) / QB / Solution

Data: $\lambda_1 = 6000 A^\circ = 6000 \times 10^{-8}$ cm $m = ?$

$\lambda_2 = 4500 A^\circ = 4500 \times 10^{-8}$ cm, ~~order~~ = $m+1$

$\theta = 30^\circ$

To find: $N = \frac{1}{a+b}$

Solution

$$(a+b)\sin\theta = m\lambda \quad - \text{Formula}$$

for λ_1

$$(a+b) = \frac{m\lambda_1}{\sin 30} \quad --(i)$$

for λ_2

$$(a+b) = \frac{(m+1)\lambda_2}{\sin 30} \quad -(ii)$$

Equating (i) & (ii)

$$m\lambda_1 = (m+1)\lambda_2$$

$$\frac{m}{m+1} = \frac{4500 \times 10^{-8}}{6000 \times 10^{-8}} = \frac{3}{4}$$

$$\therefore \boxed{m = 3}$$

Now $a+b = \frac{1}{N}$

$$\therefore \frac{1}{N} = \frac{m\lambda_1}{\sin 30} \quad \therefore N = \frac{\sin 30}{m\lambda_1}$$

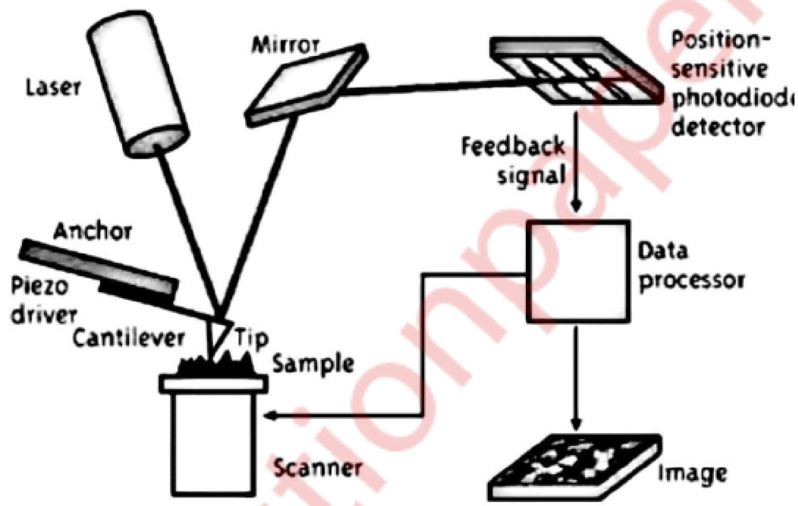
$$\therefore = \frac{0.5}{3 \times 6000 \times 10^{-8}} = 2778 \text{ lines/cm}$$

Result:

2778 lines are there in a cm in the grating.

Q20) Explain the working of atomic force microscope in detail.

Answer::



An Atomic Force microscope (AFM) consists of following components:

1.LASER

2.Photodiode

3. Cantilever with a sharp tip

4.Detector and feedback circuit

5.Pizoelectric scanner

WORKING OF ATOMIC FORCE MICROSCOPE :

1.AFM consists of microscope cantilever with a sharp tip (probe) at its end used to scan the specimen surface.

2.The cantilever is typically silicon or silicon nitride with the tip radius of curvature of the orders of nm. Basically, AFM is modified TEM in which limitations of TEM is overcomed. When the tip is bought close to the sample, force between the tip and sample leads to the deflection of the cantilever according to the Hook`s law. Instead of using an electrical signal, the AFM relies on forces between the atom on the tip and in the sample.

3.The force present in the tip is kept constant and the scanning is done. As the scanning continues, the tip will have vertical movements depending upon the topography of the sample. The force present in the tip is kept constant and the scanning is done. As the scanning continue the tip will have vertical movement depending upon the topography o the sample.

4.A LASER beam is used to have a record of vertical movement of the needle. This information is later converted into visible from using photo diode. Depending upon the situation, AFM measures different types of forces like a Vander Waal's forces, capillary force, mechanical contact force etc.

Q21) If $\phi(x,y,z) = 3x^2y - y^3z^2$, Find $\vec{\nabla}\phi$ at the point (-1, -2, 1).

Answer::

[Answer will be added her]

Q22) Given $\vec{A} = x^2yi + (x-y)k$, find $\vec{\nabla} \cdot \vec{A}$

Answer::

We have $\vec{A} = x^2 y\,\hat{i} + (x-y)\,\hat{k}.$

$$\text{Div}\,\vec{A} = \vec{\nabla} \cdot \vec{A}$$

$$= \left(\frac{\partial}{\partial x}\hat{i} + \frac{\partial}{\partial y}\hat{j} + \frac{\partial}{\partial z}\hat{k}\right) \cdot [x^2 y\,\hat{i} + (x-y)\hat{k}]$$

$$= \frac{\partial}{\partial x}(x^2 y) + \frac{\partial}{\partial z}(x-y) = 2xy$$

Q23) A step index fiber has a core diameter of 29 x10-6 m. the refractive indices of core and cladding are 1.52 And 1.5189 respectively. If the light of wavelength 1.3 μm is transmitted through the fiber, determine. Normalized frequency of the fiber.

Answer::

Problem 21

A step index fibre has core diameter 29×10^{-6} m. The refractive indices of the core and the cladding are 1.52 and 1.5189 respectively. If the light of wavelength 1.3 μm is transmitted through the fibre, determine :

(i) Normalized frequency of the fibre,

(ii) The number of modes the fibre will support. **(M.U. May 2013)**

Solution :

Data : $d = 29 \times 10^{-6}$ m, $\mu_1 = 1.52$, $\mu_2 = 1.5189$,

$\lambda = 1.3\ \mu m = 1.3 \times 10^{-6}$ m.

Formula :

$$V = \frac{2\pi r}{\lambda}\sqrt{\mu_1^2 - \mu_2^2}$$

$$N_m = \frac{V^2}{2} \quad \text{for MMSIF } (\mu_1 = \text{constant})$$

Calculations :

$$V = \frac{3.14 \times 29 \times 10^{-6}}{1.3 \times 10^{-6}} \times \sqrt{(1.52)^2 - (1.5189)^2}$$

$$\therefore \quad V = 4.049$$

$$N_m = \frac{V^2}{2} = \frac{(4.049)^2}{2} = 8$$

Result : Normalized frequency, $V = 4.049$,

Number of modes, $N_m = 8$.

Problem 22

Q24) Derive Gauss law for static electric and magnetic field in differential and integral form

Answer:

(A) Gauss' Law for Electric Field

Gauss' law : The electric flux passing through any closed surface is equal to the total charge enclosed by that surface. This is mathematically stated as "the surface integral of the normal component of electric flux density $\vec{D}$ over any closed surface equals the charge enclosed" and is written as

$$\phi = \oint_S \vec{D} \cdot \vec{ds} = Q_{enclosed} \quad \text{........ (3.30)}$$

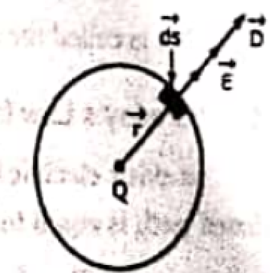


Fig. 3.13

Here, Q being the total charge enclosed by the closed surface as shown in Fig. 3.13. This may be expressed as the volume integral of the charge density ρ_v. So Gauss' law is written in ***integral form*** as

$$\boxed{\oint_S \vec{D} \cdot \vec{ds} = \int_v \rho_v \, dv} \quad \text{............... (3.31)}$$

Applying divergence theorem, the surface integral is converted to a volume in... and we write

$$\oint_S \vec{D} \cdot \vec{ds} = \int_v (\vec{\nabla} \cdot \vec{D}) dv \quad \text{.......(3...}$$

Hence, equation (3.31) becomes

$$\int_v (\vec{\nabla} \cdot \vec{D}) dv = \int_v \rho_v \, dv \quad \text{.......(3...}$$

Hence, Gauss' law for electric field in *differential form or point form* is writ...

$$\vec{\nabla} \cdot \vec{D} = \rho_v \quad \text{.......(3...}$$

In an electric or a magnetic field, any closed surface, real or imaginary, is ca... a Gaussian surface.

(B) Gauss' Law for Static Magnetic Field

In a magnetic field the magnetic lines are closed on themselves as seen in Fig 3... Hence, **the total outgoing magnetic flux is zero**. This is written as

$$\oint_S \vec{B} \cdot \vec{ds} = 0 \quad \text{.......(3...}$$

and is called the ***Gauss' law*** for magnetic field in integral form.

Using divergence theorem the magnetic Gauss' law can be written as

$$\oint_S \vec{B} \cdot \vec{ds} = \oint_S (\vec{\nabla} \cdot \vec{B}) dv = 0 \quad \text{.......(3...}$$

or $\vec{\nabla} \cdot \vec{B} = 0$ ....(3...

This is called the *differential or point form of magnetic Gauss' law.*

Q25) What is the highest order spectrum, which may be seen with monochromatic light of wavelength 6000 A˚ by means of a diffraction grating with 5000 lines/cm?

Answer :

Date
Page

1125/1Q B

Data : $\lambda = 6000\ A^\circ = 6000 \times 10^{-8}\ cm$

$N = 5000$ lines/cm

Formula : $(a+b)\sin\theta = n\lambda$

$(a+b) = \frac{1}{N}$

Calculation :

$\sin\theta \propto n$ for max

$\therefore \sin\theta_{max} = 1$

$(a+b) = n_{max}\ \lambda$

$\therefore n_{max} = \frac{(a+b)}{\lambda} = \frac{1}{N\lambda}$

$= \frac{1}{5000 \times 6000 \times 10^{-8}}$

$= 3.33$

$\therefore n_{max} = 3$

Q26) Explain the concept of time dilation and deduce an expression for it. A particle moving with a speed of 0.7c. Calculate the ratio of the rest mass and mass while in motion.

Answer :

4.4 Time Dilation

The meaning of time dilation is extension of time. Time dilation is a difference in the elapsed time measured by two clocks due to a relative motion between them. To explain it let us consider two frames of reference S and S' with S' moving with a velocity v along X direction with respect to S as shown in Fig. 4.3. Imagine a gun placed at a fixed position P (x', y', z') in the frame S'. Suppose it fires two shots at instants t_1' and t_2' measured by the observer O' in the frame S'.

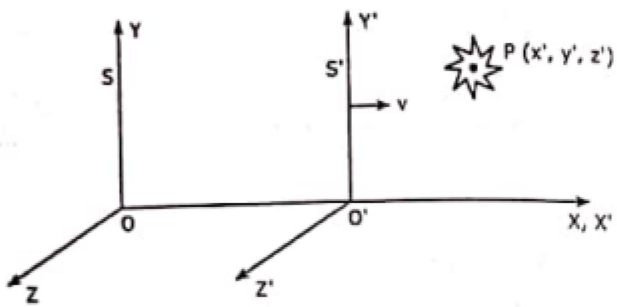


Fig. 4.3 : Time dilation

The time interval $(t_2' - t_1')$ of the two shots measured by O' at rest in the moving frame S' is called the proper time interval and is given by

$$T_O = t_2' - t_1' \qquad \text{.................... (4.15)}$$

As the motion between the two frames is relative, we may assume that the frame S is moving with velocity – v along the – X direction relative to frame S'. In frame S, the observer O who is at rest hears these two shots at different times t_1 and t_2.

The time interval appears to him is given by

$$t = t_2 - t_1 \qquad \text{.................... (4.16)}$$

From inverse Lorentz transformation equations, we get

$$t_1 = \frac{t_1' + (vx'/c^2)}{\sqrt{1-(v^2/c^2)}} \qquad \text{.................... (4.17)}$$

$$t_2 = \frac{t_2' + (vx'/c^2)}{\sqrt{1-(v^2/c^2)}} \qquad \text{.................... (4.18)}$$

Substituting equations (4.17) and (4.18) in equation (4.16), we get

$$T = \frac{t_2' - t_1'}{\sqrt{1-(v^2/c^2)}} \qquad \text{.................... (4.19)}$$

Using equation (4.15) in equation (4.19), we have

$$T = \frac{T_o}{\sqrt{1-(v^2/c^2)}} \quad \text{.................. (4.20)}$$

which shows that $T > T_o$.

Here, T_o is called the **proper time which is defined as the time measured in the frame of reference in which the object is at rest.**

This verifies that the actual time interval in the moving frame appears to be lengthened by a factor $\frac{1}{\sqrt{v^2 - c^2}}$ when it is measured by an observer in the fixed frame, v being the relative velocity between the two frames.

Q26/Q8/ A particle moving with speed 0.7C, Calculate ratio of rest mass and mass while in motion.

→ Data: $v = 0.7c$

Formula: $m = \dfrac{m_0}{\sqrt{1-(v^2/c^2)}}$

Calculation:

m_0 is rest mass

m is mass in motion

$$\therefore \frac{m_0}{m} = \sqrt{1-(v^2/c^2)}$$

$$= \sqrt{1-\frac{(0.7c)^2}{c^2}}$$

$$= \sqrt{1-\frac{0.49c^2}{c^2}}$$

$$= \sqrt{1-\frac{0.49}{1}}$$

$$= \sqrt{0.51}$$

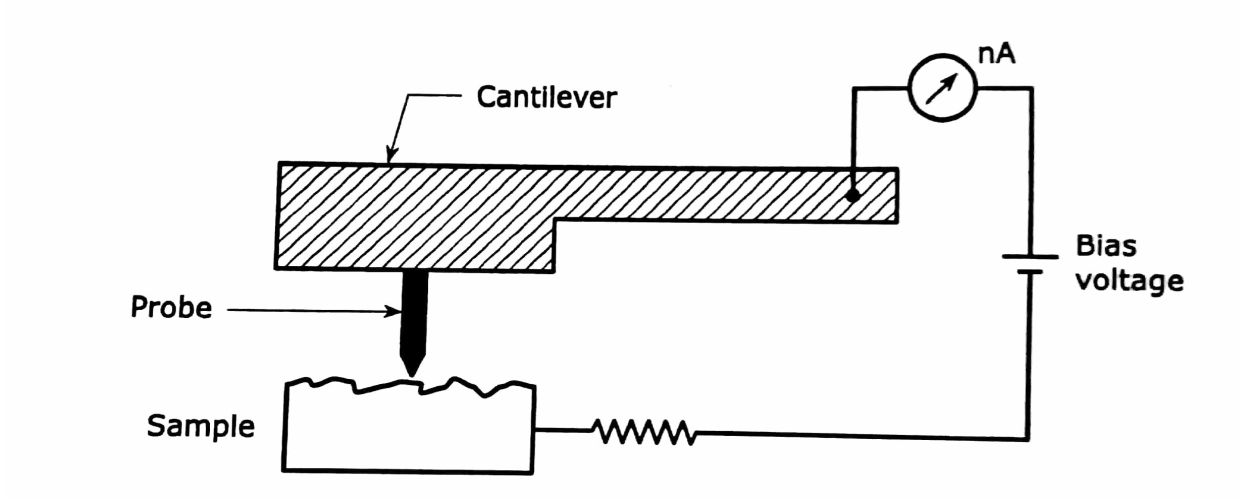
or

$$= \underline{0.7141}$$

Q27) Explain the construction and working of a Transmission Electron microscope with a schematic diagram.

Answer:

https://www.ques10.com/p/21666/draw-the-schematic-diagram-of-tem-and-explain-its-/



It uses quantum mechanical concept according to which wave nature of electron allow them to tunnel through a very thin electrically insulating layer of vacuum or air.

STM scans an electric probe over a surface to be imaged to detect a weak electric current flowing between the tip and the surface. It employs principle of electron tunneling of quantum mechanics.

A very sharp needle is brought close to the surface to be imaged. The distance is of the order of few A0. At such a distance, electron from the surface tunnel across the gap and set up a measurable tunneling current in the needle.

This current is a precise indicator of distance between tip and the surface. the needle can now be moved across the surface, at each point height being adjusted to maintain tunneling current at a constant value.

Thus, a vertical position of a needle becomes equivalent to a record of surface topography and can be converted into an observable picture.

Advantages :

1.Provide 3D profile of surface

2.Useful for charactering surface roughness

Applications :-

1. Observing surface defect
2. Determining size of molecule

3. STM tips are used to rotate individual bonds within molecules
4. High quality STM can reach significant resolution to show single atom

Disadvantage :

Required extremely clean, stable surface and conducting specimen.

Q28) State Maxwell's equations in differential form in a medium, in the presence of charges and currents

Answer::

https://ask.quesnit.com/36/maxwells-equations-differential-presence

Q29) Describe any two methods to synthesize nanomaterials

Answer ::

5.5 Methods to Synthesize

Various methods used for the production of nanomaterials are described here.

(a) Mechanical Method : Ball Milling Method

In this method small hard steel balls are kept in a container filled with the powder of the bulk material. The container spins about itself while rotating in a circular path about a central axis like a planet moves around the sun. The size of the steel balls used in milling is inversely proportional to the size of the nanoparticles they produce. This is a simple, economical method that can be used at room temperature. This is used to make nanoparticles of metals and alloys.

(b) RF Plasma Technique : Sputtering

- In this technique the bulk material is kept in a pestle which is kept in an evacuated chamber as shown in Fig. 5.7.

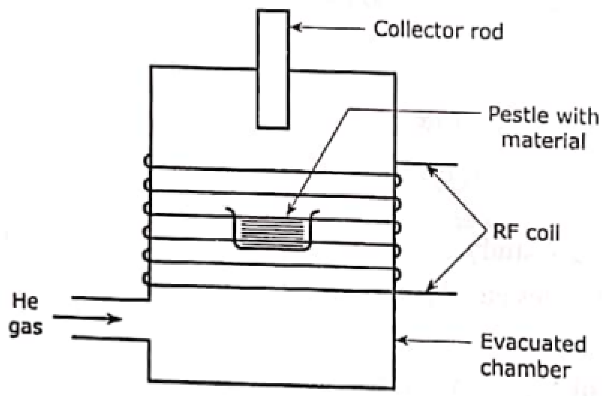


Fig. 5.7 : RF Plasma

- When a high voltage is applied to the RF coils heat in generated and the evaporation of the metal begins. Then cold He gas is allowed to enter the chamber. This results in high temperature plasma in the region of the coils. Nanoparticles are formed from the metal vapor and are collected by the collector.

Q30) Describe the physical significance of gradient, Divergence and Curl.

Answer ::

3.4 Physical Significance of Gradient, Divergence and Curl

3.4.1 : The Del Operator : $\vec{\nabla}$

We introduce a vector differential operator which is essential for the study of electrodynamics.

The del operator expressed in Cartesian coordinates, as

$$\vec{\nabla} = \hat{i}_x \frac{\partial}{\partial x} + \hat{i}_y \frac{\partial}{\partial y} + \hat{i}_z \frac{\partial}{\partial z} \quad \text{.............. (3.}$$

3.4.2 : Gradient of a Scalar Field

Gradient is a mathematical operation performed on a scalar field which results in a vector field. Gradient is a vector that represents both the magnitude and the direction of maximum space rate of increase of a scalar.

If V = V (x, y, z) is a scalar function the gradient operation is written in Cartesian coordinates, as

$$\vec{\nabla} V = \frac{\partial V}{\partial x}\hat{i}_x + \frac{\partial V}{\partial y}\hat{i}_y + \frac{\partial V}{\partial z}\hat{i}_z \quad \text{.............. (3.}$$

Gradient is the multidimensional rate of change of a given function.

At any point in the scalar field.

(i) the magnitude of the resulting vector field is the maximum rate of increase of the scalar field.

(ii) the direction of the resulting vector field is the direction in which the maximum rate of increase occurs.

3.4.3 : Divergence of a Vector Field

The rate of change of a vector field is complex. *The divergence of a vector field indicates how much the vector field spreads out from a certain point.*

Imagine a fluid, with the vector field representing the velocity of the fluid at each point in space. Divergence measures the net flow of the fluid out of a given point. If the fluid is flowing into that point, the divergence will be negative. *The divergence of a vector is a scalar.*

In Cartesian coordinates, $\vec{B}$ is a vector field given by

$$\vec{B} = B_x \hat{i}_x + B_y \hat{i}_y + B_z \hat{i}_z \quad \text{............ (3.24)}$$

and its divergence is written as

$$\vec{\nabla} \cdot \vec{B} = \frac{\partial B_x}{\partial x} + \frac{\partial B_y}{\partial y} + \frac{\partial B_z}{\partial z} \quad \text{............ (3.25)}$$

3.4.4 : Curl of a Vector Field

The curl of a vector field at any point signifies how much the vector quantity curls or twists around that point. As an example, we may consider water going down the drain. In this motion water swirls in rotation. The curl of the velocity field of water describes its local rotation. The rotation has a direction and is about the direction of motion. The curl of a vector field is a vector field and is written as $\vec{\nabla} \times \vec{B}$.

Mathematical expression for the curl $\vec{B}$ in Cartesian coordinates can be obtained by solving the determinant as given below.

For $$\vec{B} = B_x \hat{i}_x + B_y \hat{i}_y + B_z \hat{i}_z \quad \text{............ (3.26)}$$

$$\text{Curl } \vec{B} = \vec{\nabla} \times \vec{B} = \begin{vmatrix} \hat{i}_x & \hat{i}_y & \hat{i}_z \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ B_x & B_y & B_z \end{vmatrix}$$

$$\vec{\nabla} \times \vec{B} = \hat{i}_x \left(\frac{\partial B_z}{\partial y} - \frac{\partial B_y}{\partial z} \right) + \hat{i}_y \left(\frac{\partial B_x}{\partial z} - \frac{\partial B_z}{\partial x} \right) + \hat{i}_z \left(\frac{\partial B_y}{\partial x} - \frac{\partial B_x}{\partial y} \right) \quad \text{............ (3.27)}$$

If the curl of a vector field is zero the filed is irrotational and is called a conservative field.

Q31)

If $\vec{A} =$ xy $\boldsymbol{i} - 8xy^2\boldsymbol{z^2}\,\boldsymbol{j} + 2\boldsymbol{xyzk}$. Find $\vec{\nabla} \cdot \vec{A}$ at point (1,-2, 4).

Answer::

(22) (31) $\frac{2+4+1}{7}$

Date________
Page________

Q31/(Q8) If $\vec{A} = xy\hat{i} - 8xy^2z^2\hat{j} + 2xyzk$ Find $\vec{\nabla}\cdot\vec{A}$ at point (1, -2, 4)

→

$$\vec{\nabla}\cdot\vec{A} = \left(\frac{\partial}{\partial x}\hat{i} + \frac{\partial}{\partial y}\hat{j} + \frac{\partial}{\partial z}\hat{k}\right)\cdot\left(xy\hat{i} - 8xy^2z^2\hat{j} + 2xyz\hat{k}\right)$$

$$= \frac{\partial}{\partial x}(xy) - \frac{\partial}{\partial y}(8xy^2z^2) + \frac{\partial}{\partial z}(2xyz)$$

$$= y - 16xyz^2 + 2xy$$

At point (1, -2, 4)

$$= (-2) - 16(1)(-2)(4)^2 + 2\times1\times(-2)$$

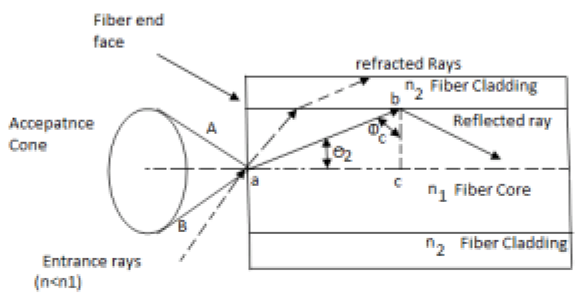
$$= -2 + 512 - 4$$

$$\therefore \boxed{\vec{\nabla}\cdot\vec{A} = 506}$$

Q32) Derive the expression for the Numerical aperture for a step index fiber.

Answer::

Numerical Aperture is the ability of fiber to collect the light from the source and save the light inside it by maintaining the condition of total internal reflection.



Consider a light ray entering from a medium air of refractive index n_0 into the fiber with a core of refractive index n_1 which is slightly greater than that of the cladding n_2.

Applying Snell's law of reflection at point A,

$\sin\theta_1 / \sin\theta_2 = n_1 / n_0 = n_1$ as $n_0 = 1$

In right angled Δabc

$\theta_2 = \pi / 2 - \phi_c$

$\sin\theta_1 = n_1 \sin(\pi / 2 - \phi_c)$

$= n_1 \cos\phi_c$

$\cos\phi_c = (1 - \sin\phi_c^2)^{1/2}$

From the above equation

$\sin\theta_1 = n_1(1 - \sin\phi^2_c)^{1/2}$

When the TIR takes place, $\phi_c = \theta_c$ and $\theta_1 = \theta_a$

$\sin\theta_a = n_1(1 - \sin\theta_c^2)^{1/2}$

$\sin\theta_c = n_2/n_1$

$\sin\theta_a = n_1[1 - (n2/n1)^2]^{1/2}$

N.A. $= \sin\theta_a$

N.A. $= \sin\theta_a = \sqrt{n_1^2 - n_2^2}$

Thus,the formula for numerical aperture of step index fibre has been derived.

Q33) Draw and explain energy level diagram of Nd: YAG Laser.

Answer::

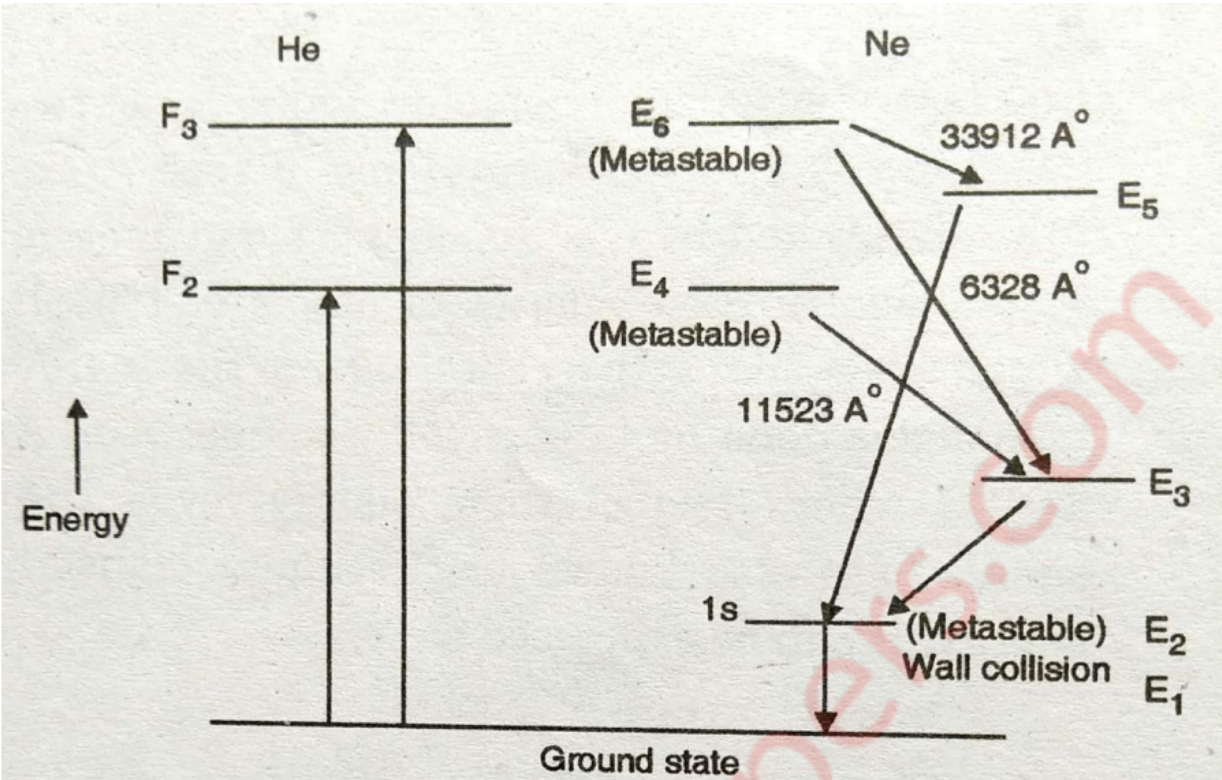


Fig. 4.11.2 : Energy level diagram of He-Ne

1) Nd: YAG laser is a four-level laser system, which means that the four energy levels are involved in laser action. The light energy sources such as flashtubes or laser diodes are used to supply energy to the active medium. In Nd:YAG laser, the lower energy state electrons in the neodymium ions are excited to the higher energy state to achieve population inversion.

2) Consider a Nd:YAG crystal active medium consisting of four energy levels E1, E2, E3, and E4 with N number of electrons. The number of electrons in the energy states E1, E2, E3, and E4will be N1, N2, N3, and N4. Let us assume that the energy levels will be E1 < E2 <E3 <E4. The energy level E1 is known as ground state, E2 is the next higher energy state or excited state, E3 is the metastable state or excited state and E4 is the pump state or excited state. Let us assume that initially, the population will be N1 > N2 > N3 > N4.

3) When flashtube or laser diode supplies light energy to the active medium (Nd:YAG crystal), the lower energy state (E1) electrons in the neodymium ions gains enough energy and moves to the pump state or higher energy state E4.

4) The lifetime of pump state or higher energy state E4 is very small (230 microseconds (µs)) so the electrons in the energy state E4 do not stay for long period. After a short period, the electrons will fall into the next lower energy state or metastable state E3 by releasing non radiation energy (releasing energy without emitting photons).

5) The lifetime of metastable state E3 is high as compared to the lifetime of pump state E4. Therefore, the electrons reach E3 much faster than they leave E3. This results in an increase in the number of electrons in the metastable E3 and hence population inversion is achieved.

6) After some period, the electrons in the metastable state E3 will fall into the next lower energy state E2 by releasing photons or light. The emission of photons in this manner is called spontaneous emission. Population Inversion takes place between E3 and E2 .A continuous laser of 10600 Å in infrared region is given out due to stimulate emission taking place between E3 and E2 .

Q34) Prove that $\overline{x^2+y^2+z^2-c^2t^2}$ is invariant under Lorentz transformation.

Answer:

If a quantity is invariant it remains the same in all frames of reference. Consider frames S and S' with a relative velocity v. P is an event with coordinates (x, y, z, t) in S and (x', y', z', t') in S'.

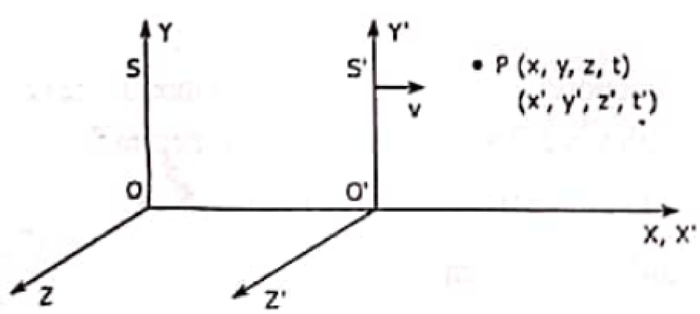


Fig. 4.9

According to Lorentz transformation, we have

$$x' = \frac{x - vt}{\sqrt{1-(v^2/c^2)}},\quad y' = y,\quad z' = z,\quad t' = \frac{t-(vx/c^2)}{\sqrt{1-(v^2/c^2)}}$$

If $(x^2 + y^2 + z^2 - c^2 t^2)$ is invariant, we should have

$$(x^2 + y^2 + z^2 - c^2 t^2) = x'^2 + y'^2 + z'^2 - c^2 t'^2$$

$$\text{R.H.S.} = x'^2 + y'^2 + z'^2 - c^2 t'^2$$

$$= \left[\frac{x - vt}{\sqrt{1-(v^2/c^2)}}\right]^2 + y^2 + z^2 - c^2\left[\frac{t-(vx/c^2)}{\sqrt{1-(v^2/c^2)}}\right]^2$$

$$= \frac{(x-vt)^2 - c^2[t-(vx/c^2)]^2}{1-(v^2/c^2)} + y^2 + z^2$$

$$= \frac{x^2 - 2x\,vt + v^2t^2 - c^2\left(t^2 - 2\frac{vxt}{c^2} + \frac{v^2x^2}{c^4}\right)}{1-(v^2/c^2)} + y^2 + z^2$$

$$= \frac{x^2 - 2x\,vt + v^2t^2 - c^2t^2 + 2x\,vt - \frac{v^2x^2}{c^2}}{1-(v^2/c^2)} + y^2 + z^2$$

$$= \frac{x^2\left[1-(v^2/c^2)\right] - c^2t^2\left[1-(v^2/c^2)\right]}{1-(v^2/c^2)} + y^2 + z^2$$

$$= \frac{x^2 - c^2t^2\left[1-(v^2/c^2)\right]}{1-(v^2/c^2)} + y^2 + z^2$$

$$= x^2 + y^2 + z^2 - c^2 t^2$$

$$\text{R.H.S.} = \text{L.H.S.}$$

Hence, proved.

Q35) What is length contraction? Derive the expression for the same?

Answer ::

4.5 Length Contraction

In classical mechanics the length of an object is independent of the velocity of the observer moving relative to the object. However, in the theory of relativity, the length of an object depends on the relative velocity between the observer and the object.

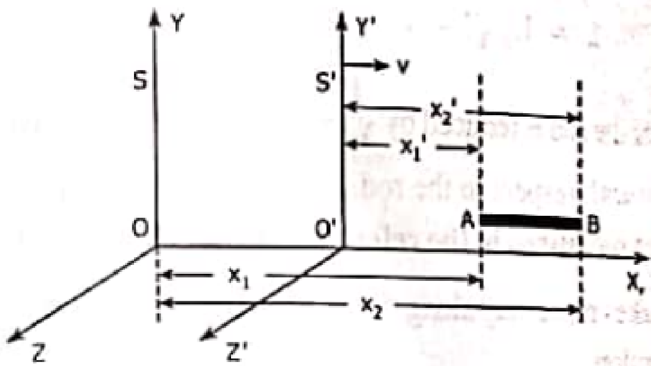


Fig. 4.4

To explain this, let us consider two inertial frames S and S' with S' moving with a velocity v in the X direction with respect to S.

Let a rod AB be at rest the moving frame S'. Its actual length is L_o at any instant as measured by the observer O' also at rest in the frame S'. So,

$$L_o = x_2' - x_1' \qquad \text{......... (4.21)}$$

where, x_1' and x_2' are the x coordinates of the rod in frame S' as shown in the Fig. 4.4.

At the same time, the length of AB measured by an observer O in the stationary frame S is given by

$$L = x_2 - x_1 \quad \text{.................... (4.22)}$$

x_1 and x_2 being the x coordinates of the rod in frame S.

From Lorentz transformation.

$$x_1' = \frac{x_1 - vt}{\sqrt{1-(v^2/c^2)}} \quad \text{.................... (4.23)}$$

$$x_2' = \frac{x_2 - vt}{\sqrt{1-(v^2/c^2)}} \quad \text{.................... (4.24)}$$

Substituting equations (4.23) and (4.24) in equation (4.21), we get the actual length as

$$L_0 = \frac{x_2 - x_1}{\sqrt{1-(v^2/c^2)}} \quad \text{.................... (4.25)}$$

Using equation (4.22) in equation (4.25), we have

$$L_0 = \frac{L}{\sqrt{1-(v^2/c^2)}}$$

$$\therefore \quad L = L_0\sqrt{1-(v^2/c^2)} \quad \text{.................... (4.26)}$$

Thus, the length of the rod is reduced by $\sqrt{1-(v^2/c^2)}$ when measured by an observer moving with velocity v with respect to the rod. Here, L_0 is the proper length defined as **the length of the object measured in the reference frame in which the object is at rest.**

The contraction takes place only along the direction of motion and remains unchanged in a perpendicular direction.

Q36) State Maxwell's all four equations and give the significance of each.

Answer::

Ans : The Maxwell's equation and their physical significances are :

1.Maxwell's first equation is $\nabla . D = p$

Integration this over an arbitrary volume V we get

$\int v\nabla \cdot D \cdot dV = \int vp\, dV$

But from Gauss Theorem, we get

$\int s\, D.ds = \int v\, p\, DV = q$

Here, q is the net charge contained in volume V.S is the surface bounding volume V. Therefore,

Maxwell's first equation signifies that: The total electric displacement through the surface enclosing a volume is equal to the total charge within the volume.

2. Maxwell's second equation is $\nabla . B = 0$

Integrating this over an arbitrary volume V, we get

$\int v\nabla \cdot B = 0$

Using gauss divergence theorem to change volume integral into surface integral, we get

$\int s\, B.ds = 0.$

Maxwell's second equation signifies that: The total outward flux of magnetic induction B through any closed surface S is equal to zero.

3. Maxwell's third equation is$\nabla \times E = (-\,\partial B / \partial t).ds$

Converting the surface integral of left hand side into line integral by stoke's theorem, we get
$\emptyset\, c\, E. = -\int s\, \partial B\, /\, \partial t.ds.$

Maxwell's third equation signifies that: The electromotive force (e.m.f.e = $\int C\, E.dl$) around a closed path is equal to negative rate of change of magnetic flux linked with the path (since magnetic flux $\emptyset = \int s\, B.ds$)

4. Maxwell's fourth equation is $\nabla \times H = J + \partial D / \partial t$

Taking surface integral over surface S bounded by curve C, we obtain

$$\int s\, \nabla \times H.ds = \int s\, (J + \partial D / \partial t) ds$$

Using stoke's theorem to convert surface integral on L.H.S of above equation into line integral, we get $\oint c. H. dl = \int s (J + \partial D / \partial t). ds$

Maxwell's fourth equation signifies that:

The magneto motive force (m.m.f. = $\oint c. H. dl$ around a closed path is equal to the conduction current plus displacement current through any surface bounded by the path.

Q37) Calculate the number of modes of a step index optical fibre of diameter 40 μm if its core and cladding refractive indices are 1.5 and 1.46, respectively. Wavelength of light used is 1.5 μm

Answer::

used is 1.5 μm.

Solution :

Data : $d = 40\ \mu m = 40 \times 10^{-6}$ m, $\mu_1 = 1.5$, $\mu_2 = 1.46$,

$\lambda = 1.5\ \mu m = 1.5 \times 10^{-6}$ m.

Formula : $V = \dfrac{\pi d}{\lambda} \sqrt{\mu_1^2 - \mu_2^2}$, $N = \dfrac{V^2}{2}$ for SI fibre

Calculations :

$$V = \frac{3.14 \times 40 \times 10^{-6}}{1.5 \times 10^{-6}} \times \sqrt{(1.5)^2 - (1.46)^2} = 28.81$$

$$N = \frac{(28.81)^2}{2} = 415$$

Result : Number of modes, N = 415.

Q38) When a frame of reference is said to be a non-inertial frame of reference? Give an example.

Answer ::

upon by an exter... moves with a constant velocity. ... an object is not acted

(2) **Non inertial frame**

A frame of reference which is in an accelerated motion with respected to an inertial frame of reference is called a non-inertial frame of reference. In such frame an object even without an external force acting on it, is accelerated. In non-inertial frame the Newton's laws are not valid.

Example : A ball placed the floor of a train moves to the rear if the train accelerates forward even though no forces act on it. In this case, the train moves in an inertial frame of reference and the ball is in a non-inertial frame of reference.

Galilean Transformations

Q39) What is Galilean transformation? Derive Galilean transformation equations for position and time.

Answer::

https://ask.quesnit.com/37/transformation-transformation-equations

Q40) Describe the fiber optics communication system with block diagram

Answer::

2.13.1 : Fibre Optic Communication System

- Communication may be defined as the transfer of information from one pla another. For this a communication system is necessary.
- Within a communication system the information signal is superimposed on a ca wave and the carrier wave is modulated by the information signal. The modu carrier wave is then transmitted through the communication channel to the destin where it is received and demodulated to extract the original information.

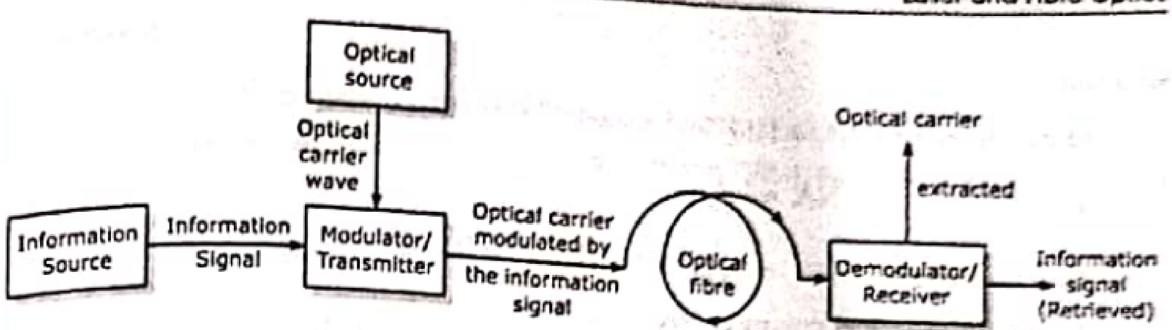


Fig. 2.29 : Optical fibre communication system

The carrier waves are elect...

... optical fibre communication system

- The carrier waves are electromagnetic waves . Earlier there has been a frequent use of either the radio waves (frequency ~ 3 kHz to 300 GHz), the microwaves (frequency ~ 3 GHz to 30 GHz) or the millimeter waves (frequency ~ 30 GHz to 300 GHz), as a carrier wave.
- It has been found theoretically that the greater the carrier frequency, the larger is the transmission bandwidth and thus the information carrying capacity of the communication system.
- After the advent of laser in 1960, communication has become possible with an electromagnetic carrier selected from the optical range of frequencies.
- At higher optical frequencies (~ 10^{15} Hz) a large frequency bandwidth (~ 10^4 times the bandwidth available with a microwave carrier signal) and a high information carrying capacity (~ 10^5 times the information carrying capacity of a microwave carrier signal) are available.
- However, light energy gets dissipated in open atmosphere by inverse square law.

$$I \propto \frac{1}{d^2}$$

where 'I' is the intensity of the light beam and 'd' is the distance travelled.

This dissipation is caused by the diffraction and scattering of light by dust particles, water vapour etc. and due to absorption in the medium.

- Hence, to transmit an optical carrier signal over a long distance a guiding channel is required. This is done by sending an optical beam or pulse through an optical fibre.