University of Mumbai Examination

Program: _First Year (All Branches) Engineering - SEM-II

Curriculum Scheme: Rev 2019

Engineering Physics-II

Question Bank

==

Q1.	Choose the correct option for following questions. All the Questions are compulsory and carry equal marks
1.	In holography, which of the following optical phenomena are involved?
Option A:	interference, diffraction
Option B:	polarization, diffraction
Option C:	interference, refraction
Option D:	reflection, diffraction
2.	By observing the diffraction pattern, the two spectral lines are said to be just resolved when _________
Option A:	The central maxima of one coincides with central maxima of the other
Option B:	The central maxima of one do not coincide with first maxima of the other
Option C:	The central maxima of one coincides with the first minimum of the other
Option D:	The central maxima of one do not coincide with the first minimum of other
3.	A step-index fibre has a numerical aperture of 0.26, a core refractive index of 1.5 and a core diameter of 100 μ m. Calculate the acceptance angle.
Option A:	1.47 degree
Option B:	15.07 degree
Option C:	2.18 degree
Option D:	24.15 degree
4.	Find the divergence of the field $\bar{F} = 30\hat{\imath} + 2xy\hat{\jmath} + 5xz^2\,\hat{k}$ in Cartesian co-ordinates
Option A:	2x(1+5Z)
Option B:	2x(1+5k)
Option C:	12
Option D:	10
5.	Which ratio decides the efficiency of nano substances?
Option A:	Weight/volume
Option B:	Surface area/volume
Option C:	Volume/weight
Option D:	Pressure/volume
6.	_____________ transformation are replaced by the Lorentz transformation which confirms the postulate of relativity
Option A:	Galilean
Option B:	Maxwell
Option C:	Planck's
Option D:	Newtons
7.	Maximum number of orders available with a grating is
Option A:	Independent of grating element.
Option B:	Directly proportional to grating element.

Option C:	Inversely proportional to grating element
Option D:	Directly proportional to wavelength.
8.	In holography
Option A:	only phase information is recorded
Option B:	only amplitude information is recorded
Option C:	both phase and amplitude get recorded
Option D:	neither phase nor amplitude gets recorded
9.	Find the value of "a" for which the vector 3i+2j+9k and i+aj+3k are perpendicular
Option A:	-40
Option B:	-13
Option C:	-15
Option D:	-10
10.	Calculate acceptance angle for an optical fibre whose core R.I.is 1.48 & cladding R.I.is 1.39
Option A:	10^0
Option B:	40.5^0
Option C:	30.5^0
Option D:	20^0
11.	An object whose length is 60m moves at a speed of 0.6 c. What is the length of the object according to a stationary observer?
Option A:	48m
Option B:	60m
Option C:	21m
Option D:	40m
12.	Scanning Electron Microscope (SEM) produces
Option A:	3-dimensional image
Option B:	2-dimensional image
Option C:	4-dimensional image
Option D:	6-dimensional image
13.	What is the principle of fibre optical communication?
Option A:	Frequency modulation
Option B:	Population inversion
Option C:	Total Internal Reflection
Option D:	Doppler effect
14.	The radiation emission process (emission of a photon at frequency) can occur in ___________ ways.
Option A:	Two
Option B:	Three
Option C:	Four
Option D:	One
15.	Which property of nanoparticles provides a driving force for diffusion?
Option A:	Optical Properties
Option B:	High surface area to volume ratio

Option C:	Sintering
Option D:	There is no such property
16.	If ‘a’ is the width of the slits and b the distance between the slits, then a + b is called as_____
Option A:	Opacities
Option B:	Grating constant
Option C:	Transparency
Option D:	Lattice constant
17.	Which of the following is not an example of bottom-up approach for the preparation of nanomaterials?
Option A:	Sol-Gel
Option B:	Molecular self-assembly
Option C:	Mechanical grinding
Option D:	Chemical Vapour Deposition
18.	A beam of monochromatic light is incident on a plane transmission grating having 5000 lines/cm and the second order spectral line is found to be diffracted at 30°. The wavelength of the light is _______
Option A:	4000 Å
Option B:	5000 Å
Option C:	6000 Å
Option D:	7000 Å
19.	The length of a rod in a moving frame will be ____________ to the observer in a rest frame.
Option A:	unchanged
Option B:	dilated
Option C:	contracted
Option D:	doubled
20.	Where type of pumping is used in ND: YAG Laser?
Option A:	Electrical pumping
Option B:	Direct conversion
Option C:	Collision of electron
Option D:	Optical pumping
21	A frame of reference has four coordinates, x, y, z, and t is referred to as the_____________
Option A:	Inertial frame of reference
Option B:	Non-inertial frame of reference
Option C:	Space-time reference
Option D:	Four-dimensional plane
22.	The total electric flux through any closed surface surrounding charges is equal to the amount of charge enclosed". The above statement is associated with
Option A:	Coulomb's square law
Option B:	Gauss's law
Option C:	Maxwell's first law
Option D:	Maxwell's second law
23.	Maxwell's equation derived from Faraday’s law is
Option A:	$\vec{\nabla} . \vec{H} = J$

Option B:	$\vec{\nabla} . \vec{D} = I$
Option C:	$\vec{\nabla} \times \vec{E} = -dB/dt$
Option D:	$\vec{\nabla} \times \vec{B} = -dH/dt$
24.	A vector V is irrotational if
Option A:	$\vec{\nabla} . \vec{V} = 0$
Option B:	$\vec{\nabla} \times \vec{V} = 0$
Option C:	$\vec{\nabla} . \vec{V} = \vec{\nabla} \times \vec{V}$
Option D:	$(\vec{\nabla} \times \vec{V}) . V = 0$
25.	According to Einstein theory of relativity, _____________ in vacuum is the same in every inertial frame.
Option A:	the speed of light
Option B:	the intensity of light
Option C:	the speed of particle
Option D:	the mass of particle
26.	Which of the following Einstein's coefficient represents stimulated emission
Option A:	A_{12}
Option B:	A_{21}
Option C:	B_{12}
Option D:	B_{21}
27.	What is the effective distance between the source of light and the screen in Fraunhofer Diffraction?
Option A:	Focal length of the convex lens
Option B:	Less than Focal Length of the convex lens
Option C:	Greater than the focal length of the convex lens and less than infinite
Option D:	Infinite
28.	Pumping is done in order to achieve
Option A:	Steady state
Option B:	Population inversion
Option C:	Equilibrium
Option D:	Photon emission
29.	The Maxwell's equation, $\vec{\nabla} . \vec{B} = 0$ signifies
Option A:	No electric field
Option B:	Non-existence of a mono pole
Option C:	Variation of magnetic field
Option D:	No magnetic field
30.	Nanomaterials are the materials with at least one dimension measuring less than
Option A:	1nm
Option B:	10nm
Option C:	100nm
Option D:	1000nm
31.	What is the meaning of grating element for a diffraction grating
Option A:	It is the width of a single slit
Option B:	It is the width of the opaque space
Option C:	It is the distance between two slits
Option D:	It is the width of diffraction grating

32.	Which of the following is an example of top-down approach for the preparation of nanomaterials?
Option A:	Gas phase agglomeration
Option B:	Molecular self-assembly
Option C:	Ball milling
Option D:	Sol-Gel
33.	The numerical aperture of a fiber if the angle of acceptance is 15 degrees, is
Option A:	0.17
Option B:	0.26
Option C:	0.50
Option D:	0.75
34.	According to Einstein's Special Theory of Relativity, laws of physics can be formulated based on
Option A:	Inertial Frame of Reference
Option B:	Non-Inertial Frame of Reference
Option C:	Both Inertial and Non-Inertial Frame of Reference
Option D:	Quantum State
35.	Maximum number of modes supported in step index fibre is ________.
Option A:	$\frac{V^2}{2}$
Option B:	$\frac{V^2}{3}$
Option C:	$\frac{V^2}{4}$
Option D:	$\frac{V}{2}$
36	Which type fibre can overcome multimode dispersion?
Option A:	step index fibre
Option B:	graded index fibre
Option C:	single mode step index fibre
Option D:	multi mode step index fibre
37.	Which of the following is Einstein's mass energy relation?
Option A:	$E_k = (m - m_0)c^2$
Option B:	$E = mc^2$
Option C:	$E^2 - p^2c^2 = m_0^2c^4$
Option D:	$E_k = mv^2/c^2$
38.	What is the region enclosed by the optical cavity called?
Option A:	Optical Region
Option B:	Optical System
Option C:	Optical box
Option D:	Optical Resonator
39.	Which of the following is not a property of emitted light in stimulated emission?
Option A:	incoherent
Option B:	unidirectional
Option C:	monochromatic
Option D:	high intensity

40.	In semiconductor diode laser, the lasing action takes place when the diode is _______
Option A:	unbiased
Option B:	reverse biased
Option C:	forward biased
Option D:	in equilibrium

Descriptive Questions

1.	Explain the construction and reconstruction of hologram.
2.	Explain top down and bottom up approaches to prepare nanomaterials.
3.	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.
4.	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.
5.	Find the divergence and curl of a vector $\vec{A} = x^2 y \hat{i} + (x-y) \hat{k}$.
6.	State the advantages of optical fiber cables on conventional electrical cables.
7.	What are different techniques to synthesize nanomaterials? Explain any one of them in detail.
8.	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?
9.	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.
10.	What is a grating? Define grating element? Discuss the phenomenon of Fraunhofer's diffraction at a grating and obtain the expression for the intensity?
11.	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.
12.	What is population inversion state? Explain its significance in the operation of LASER.
13.	Draw the schematic diagram of Scanning Electron Microscope and explain its construction, working, advantages, disadvantages and applications.
14.	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.
15.	Distinguish between step index and graded index optical fiber.
16.	Distinguish between single mode and multimode optical fiber.
17.	How is multipath dispersion overcome in Graded index fibre?
18.	What is importance of resonant cavity in the operation of laser?
19.	A diffraction grating used at normal incidence gives a line, $\lambda1 = 6000$ A° in a certain order superimposed on another line$\lambda2 = 4500$ A° of the next higher order. If the angle of diffraction is 30°, how many lines are there in a cm in the grating?
20.	Explain the working of atomic force microscope in detail.
21.	If $\phi(x,y,z) = 3x^2y - y^3z^2$, Find $\vec{\nabla}\phi$ at the point (-1, -2, 1).
22.	Given $\vec{A} = x^2yi + (x-y)\ k$, find $\vec{\nabla} . \vec{A}$
23.	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.
24.	Derive Gauss law for static electric and magnetic field in differential and integral form.
25.	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?
26.	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.
27.	Explain the construction and working of a Transmission Electron microscope with a schematic diagram.
28.	State Maxwell's equations in differential form in a medium, in the presence of charges and currents.

29.	Describe any two methods to synthesize nanomaterials.
30.	Describe the physical significance of gradient, Divergence and Curl.
31.	If $\vec{A} = xy\,\boldsymbol{i} - 8xy^2\boldsymbol{z^2}\,\boldsymbol{j} + 2\boldsymbol{xyzk}$. Find $\vec{\nabla}\,.\,\vec{A}$ at point (1,-2, 4).
32.	Derive the expression for the Numerical aperture for a step index fiber.
33.	Draw and explain energy level diagram of Nd: YAG Laser.
34.	Prove that $x^2+y^2+z^2-c^2t^2$ is invariant under Lorentz transformation.
35.	What is length contraction? Derive the expression for the same?
36.	State Maxwell's all four equations and give the significance of each.
37.	Calculate the number of modes of a step index optical fibre of diameter 40 $\boldsymbol{\mu m}$ if its core and cladding refractive indices are 1.5 and 1.46, respectively. Wavelength of light used is 1.5 $\boldsymbol{\mu}$m
38.	When a frame of reference is said to be a non-inertial frame of reference? Give an example.
39.	What is Galilean transformation? Derive Galilean transformation equations for position and time.
40.	Describe the fiber optics communication system with block diagram

40.	In semiconductor diode laser, the lasing action takes place when the diode is _______
Option A:	unbiased
Option B:	reverse biased
Option C:	forward biased
Option D:	in equilibrium

Descriptive Questions

1. Explain the construction and reconstruction of hologram.

Holography is a two-step process. First step is the **recording** of hologram where the object is transformed into a photographic record and the second step is the **reconstruction** in which the hologram is transformed into the image. Unlike in the conventional photography, lens is not required in either of the steps.

A hologram is the result of interference occurring between two waves, an object beam which is the light scattered off the object and a coherent background, the reference beam that is the light reaching the photographic plate directly.

Recording of the Hologram: A broad laser beam is divided into two beams, namely a **reference beam** and an **object beam** by a beam splitter as shown in figure below. The reference beam goes directly to the photographic plate. The second beam of light is directed onto the object to be photographed.

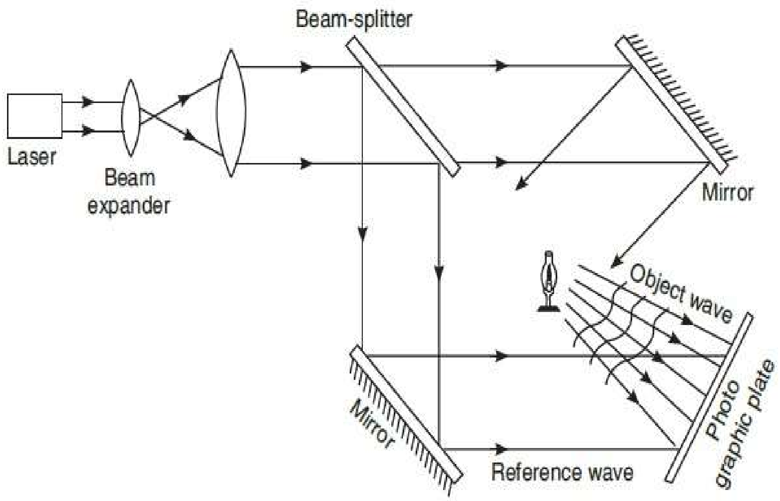
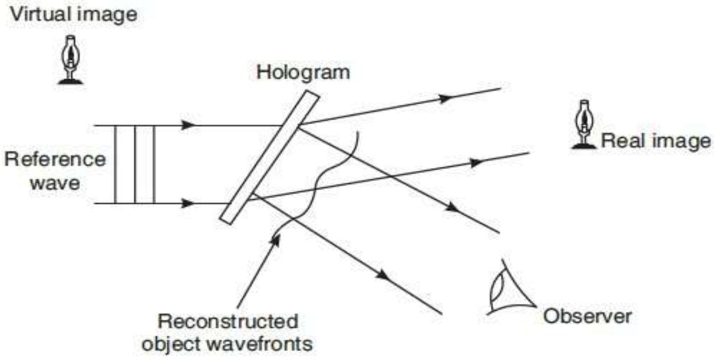


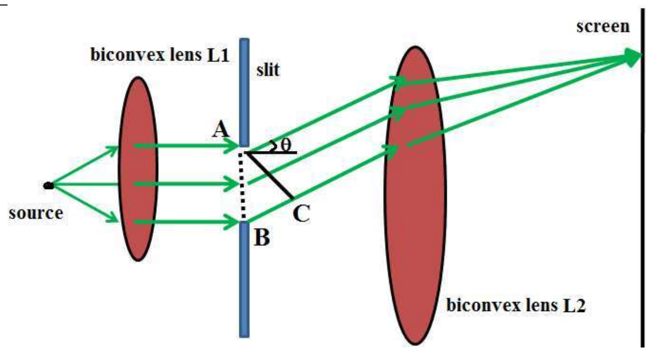
Fig.1

Each point of the object scatters the incident light and acts as the source of spherical waves. Part of the light, scattered by the object, travels towards the photographic plate. At the photographic plate the innumerable spherical waves from the object combine with the plane light wave from the reference beam. The sets of light waves are coherent because they are from the same laser. They interfere and form interference fringes on the plane of the photographic plate. The developed negative of these interference fringe-patterns is a hologram. Thus, the hologram does not contain a distinct image of the object but carries a record of both the intensity and the relative phase of the light waves at each point.

Reconstruction of the Image: Whenever required, the object can be viewed. For **reconstruction** of the image, the hologram is illuminated by a parallel beam of light from the laser (Fig. 2) Most of the light passes straight through, but the complex of fine fringes acts as an elaborate diffraction grating. Light is diffracted at a fairly wide angle. The diffracted rays form two images: a virtual image and a real image.

	 Fig.2 The virtual image appears at the location formerly occupied by the object and is sometimes called as the true image. The real image is formed in front of the hologram. Since the light rays pass through the point where the real image is, it can be photographed. The virtual image of the hologram is only for viewing. Observer can move to different positions to get the three dimensional perception of the real object.
2.	Explain top down and bottom up approaches to prepare nanomaterials.
3.	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. Q3 $d = \frac{\text{Width in cm}}{\text{No of lines per cm}}$ $= \frac{0.25}{1250}$ cm $= 2\times10^{-4}$ cm. Let $\lambda_1 = 5895 A^\circ$ $\lambda_2 = 5901 A^\circ$ $n = 1$ $n\lambda = d \sin\theta$ $\theta = \sin^{-1}\left(\frac{n\lambda}{d}\right)$ $\theta_1 = \sin^{-1}\left(\frac{5895\times10^{-8}}{2\times10^{-4}}\right)$ $= 17.14^\circ$ $\theta_2 = \sin^{-1}\left(\frac{5901\times10^{-8}}{2\times10^{-4}}\right)$ $= 17.16^\circ$ $\theta_2 - \theta_1 = 0.02^\circ$ The lines are not resolved.
4.	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.
5.	Find the divergence and curl of a vector $\vec{A} = x^2\, y\, \hat{i} + (x-y)\, \hat{k}$. (5) $\vec{A} = x^2y\, i + (x-y)\hat{k}$ $\text{div } A = \vec{\nabla}\cdot\vec{A}$ $= \frac{\partial}{\partial x}(x^2y) + 0 + \frac{\partial}{\partial z}(x-y)$ $= 2xy$ $\text{Curl } A = \begin{vmatrix} i & j & k \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ x^2y & 0 & (x-y) \end{vmatrix}$ $i(-1-0) - j(1-0) + k(0-x^2)$ $= -i - j - x^2 k$
6.	State the advantages of optical fiber cables on conventional electrical cables.

7.	What are different techniques to synthesize nanomaterials? Explainany one of them in detail. The entire ranges of fabrication (or) production methods are basically divided in to three basic methods. **1. Chemical Methods** Sol-gel processes Chemical combustion Spray pyrolysis **2. Mechanical Process** Grinding Milling Mechanical alloying **3. Physical Methods** Electrical wire explosion method Chemical vapour deposition Laser ablation **Chemical-vapor deposition (CVD)** In this method of preparation, substrate is coated with a thin film of gaseous reactants. The gas molecules are combined at ambient temperature in a reaction chamber to carry out deposition. Upon heating substrate comes in vicinity of combined gas where a chemical reaction occurs and a thin film is formed on the surface of substrate. This thin film can be recovered and reused for different applications. The basic influencing factor in this method is the temperature of the substrate. The nanoparticles achieved through this method are highly pure, uniform in size, strong and have high mechanical stability. The disadvantages of CVD include the use of special equipment as well as the high toxicity of the gaseous by-products. **Mechanical milling** One of the most widely used top down techniques to produce nano-particles is mechanical milling. In this method various elements are milled under an inert atmosphere and during this process particles are milled and post annealed. The influencing factor in this method is plastic distortion which end up with particle size, breakage that ends up in particle size, and cold-soldering that ends up to increased particle size.
8.	With neat energy level diagram describe theconstruction and working of a He-Ne Laser. What are its merits and demerits? What is the role of helium atoms?
9.	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. **Fraunhofer diffraction - single slit:** The arrangement to obtain the Fraunhofer diffraction by a single slit is as shown figure. Lens L1 renders the beam parallel while second lens L2 focus the parallel diffracted ray on a screen. Consider a narrow slit AB of width a, illuminated by parallel monochromatic light of wavelength λ. What we obtain on a screen is a slit image of maximum brightness at center followed by secondary maxima on the either side. This intensity distribution is known as Fraunhofer diffraction pattern.



The path difference Δ between extreme rays is,

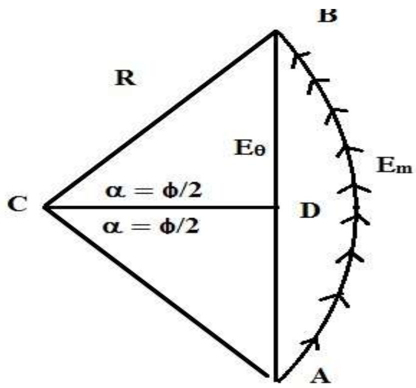
$\Delta = BC = AB \sin\theta = a \sin\theta$

Phase difference $\phi = (2\pi/\lambda)\,\Delta = (2\pi/\lambda)\, a \sin\theta$

Consider the slit now divided into N parts of equal widths Δx, then path difference between waves transmitted by two adjacent parts is $\delta = \Delta x \sin\theta$

$\Rightarrow$ Phase difference $= \Delta\phi = (2\pi/\lambda)\,\Delta x \sin\theta$

As there are N sections, there will be N phasors originating from each section, with the same amplitude ΔE and successive phase difference $\Delta\phi$. These N phasors of equal amplitude and same phase difference between adjacent phasors forms an arc of a circle AB as shown in fig. with center at C and radius R.



Consider arc AB represents the maximum amplitude E_m obtained by adding the phasors, and length of chord AB represents the amplitude E_θ of diffracted wave at an angle of diffraction θ at a fixed point on the screen.

From figure AC = BC = R (radius of circle),

$\alpha = \phi/2 = (\pi/\lambda)\, a \sin\theta$

Also $AD = BD = E_\theta/2$

In ΔACD, $\sin\alpha = AD/AC = (E_\theta/2)/R$

$\Rightarrow R = (E_\theta/2 \sin\alpha)$

Also, $AB = R\,\phi$ and $E_m = R\, 2\alpha$

$\Rightarrow R = E_m/2\alpha$

Comparing R we get,

$(E_\theta/2 \sin\alpha) = E_m/2\alpha$

$(E_\theta)^2 = (E_m \sin\alpha / \alpha)^2$

We know intensity is proportional to square of amplitude,

$(I_\theta) = K (E_m \sin\alpha/\alpha)^2 = I_m (\sin\alpha/\alpha)^2$ where $I_m = K (E_m)^2$

a) Principal Maximum:

We have

$E_\theta = E_m \sin\alpha / \alpha$

$= E_m[(\alpha - (\alpha^2/ 3!) + (\alpha^5/5!)-\dots\quad)/\alpha]$

When $\alpha = 0$ E_θ will be maximum.

$\Rightarrow (\pi/\lambda)\, a \sin\theta = 0 \Rightarrow \theta = 0$,

Thus a principal maximum is formed along the incident direction and hence is called central maxima.

b) Minimum:

For minimum intensity,

$I_\theta = 0$

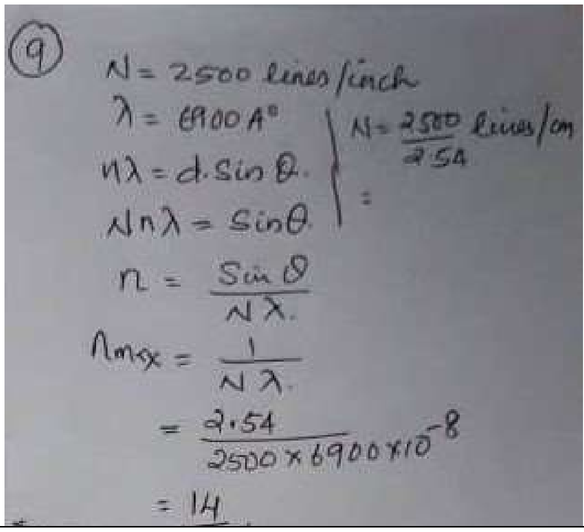
$\Rightarrow I_m (\sin\alpha/\alpha)^2 = 0$

$\sin\alpha = 0 \Rightarrow \quad \alpha = n\pi = (\pi/\lambda)\, a \sin\theta$

$\Rightarrow (\pi/\lambda)\, a \sin\theta = n\pi$,

$\Rightarrow \quad a\sin\theta = n\lambda$ where n – 1,2,3,4,…

Therefore the first minimum intensity is formed at angle, $\theta = [\sin^{-1}(\lambda/a)]$



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

11. 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.

(11) $\mu_1 = 1.5$, & $\mu_2 = 1.48$

$\lambda = 1500\,nm$

For Single mode

$V < 2.405$

ie $\frac{2\pi a}{\lambda}\sqrt{\mu_1^2 - \mu_2^2} < 2.405$

or $a < \frac{2.405 \times \lambda}{2\pi \times \sqrt{\mu_1^2 - \mu_2^2}}$

or $a < \frac{2.405 \times 1500 \times 10^{-9}}{2\pi \times \sqrt{1.5^2 - 1.48^2}}$

$a < 2.35 \times 10^{-6}\,m$

∴ The radius must be less than $2.35\,\mu m$

12. What is population inversion state? Explain its significance in the operation of LASER.

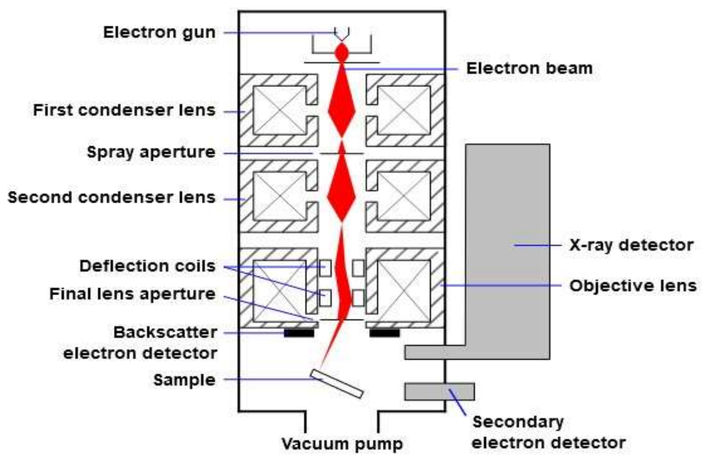
13. Draw the schematic diagram of Scanning Electron Microscope and explain its construction, working, advantages, disadvantages and applications.

An SEM is a kind of electron microscope that uses a fine beam of focused electrons to scan a sample's surface. The microscope records information about the interaction between the electrons and the sample, Tiny electron beam scan across surface of specimen. Backscattered or secondary electrons detected. Signal output to synchronized display creating a magnified image. SEM has the potential to magnify an image up to 2 million times.

SEM images give insight into a sample's topography and elemental composition. SEM is able to capture 3-D black-and-white images of thin or thick samples. The sample's size is limited only by the size of the electron microscope chamber.

To obtain a high-resolution image, an electron source (also known as an electron gun) emits a stream of high-energy electrons towards a sample. The electron beam is focused using electromagnetic lenses. Once the focused stream reaches the sample, it scans its surface in a rectangular raster.

The interaction between the electron beam and the sample creates secondary electrons, backscattered electrons, and X-rays. These interactions are captured to create a magnified image.



14. 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.

15. Distinguish between step index and graded index optical fiber.

Differences between step index fibers and graded index fibers:-

Step index fiber	Graded index fiber
1. In step index fibers the refractive index of the core medium is uniform through and undergoes an abrupt change at the interface of core and cladding.	1. In graded index fibers, the refractive index of the core medium is varying in the parabolic manner such that the maximum refractive index is present at the center of the core.
2. The diameter of core is about 10micrometers in case of single mode fiber and 50 to 200 micrometers in multi mode fiber.	2. The diameter of the core is about 50 micro meters.
3. The transmitted optical signal will cross the fiber axis during every reflection at the core cladding boundary.	3. The transmitted optical signal will never cross the fiber axis at any time.
4. The shape of propagation of the optical signal is in zigzag manner.	4. The shape of propagation of the optical signal appears in the helical or spiral manner
5. Attenuation is more for multi mode step index fibers but Attenuation is less in single mode step index fibers	5. Attenuation is very less in graded index fibers
6. Numerical aperture is more for multi mode step index fibers but it is less in single mode step index fibers	6. Numerical aperture is less in graded index fibers

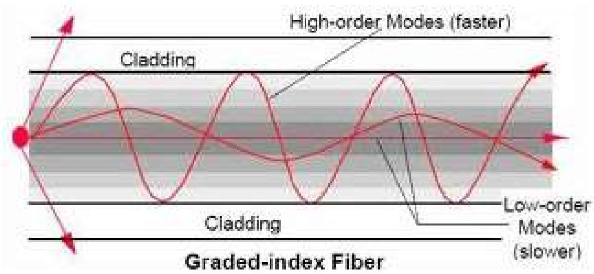
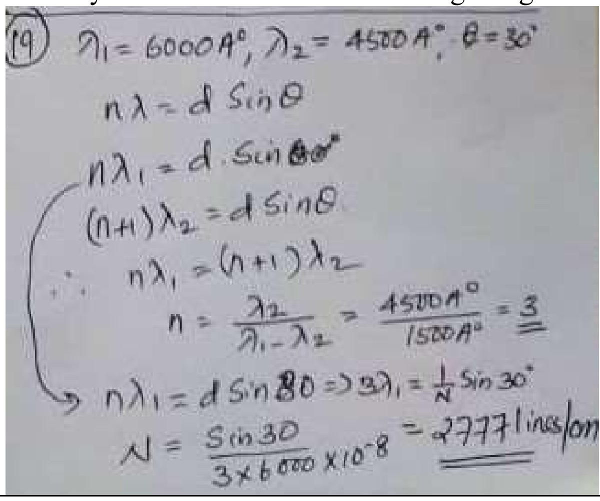
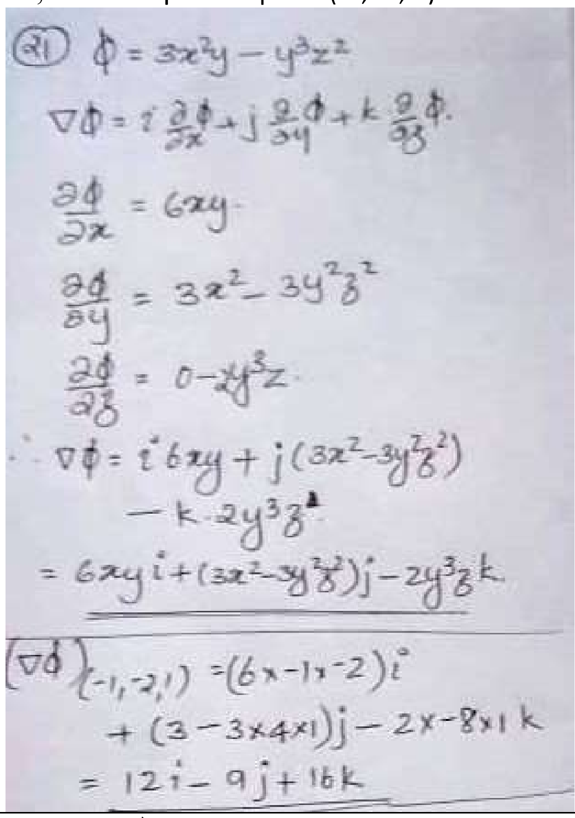
16. Distinguish between single mode and multimode optical fiber.

Differences between single mode and multi mode fibers:-

Single mode fiber	Multi mode fiber
1. 1. In single mode optical fibers only one mode of propagation is possible	1. In multi mode optical fibers many mummer of modes of propagation are possible.
2. In case of single mode fiber the diameter of core is about 10micrometers	case of in multi mode fiber the diameter of core is 50 to 200 micrometers.
3. The difference between the refractive indices of core and cladding is very small.	2. The difference between the refractive indices of core and cladding is also large compared to the single mode fibers.
4. 3. In single mode fibers there is no dispersion, so these are more suitable for communication.	3. Due to multi mode transmission, the dispersion is large, so these fibers are not used for communication purposes.
5. 4. The process of launching of light into single mode fibers is very difficult	4. The process of launching of light into single mode fibers is very easy.
6. The condition for single mode operation is $V = \frac{2\pi}{\lambda} a\, NA$	5. The condition for multi mode propagation is $N = 4.9\left(\frac{d \bullet NA}{\pi}\right)^2$
7. 6. Fabrication is very difficult and the fiber is costly.	6. Fabrication is very easy and the fiber is cheaper.

17. How is multipath dispersion overcome in Graded index fibre?

This fiber is called graded index because there are many changes in the refractive index with larger values towards the center. As light travels faster in a lower index of refraction. So, the farther the light is from the center axis, the grater is its speed. Each layer of the core refracts the light. Instead of being sharply reflected as it is in a step index fiber, the light is now bent or continuously refracted in an almost sinusoidal pattern. Those rays that follow the longest path by travelling near the outside of the core have a faster average velocity. The light travelling near the center of the core has the slowest average velocity. As a result all rays tend to reach the end of the fiber at the same time. That causes the end travel time of different rays to be nearly equal, even though they travel different paths.

<table>
<tr><td></td><td>
</td></tr>
<tr><td>18.</td><td>What is importance of resonant cavity in the operation of laser?</td></tr>
<tr><td>19.</td><td>A diffraction grating used at normal incidence gives a line, λ1 = 6000 A˚ in a certain order superimposed on another lineλ2 = 4500 A˚ of the next higher order. If the angle of diffraction is 30˚, how many lines are there in a cm in the grating?

(19) $\lambda_1 = 6000 A^\circ, \lambda_2 = 4500 A^\circ, \theta = 30^\circ$
$n\lambda = d \sin\theta$
$n\lambda_1 = d \cdot \sin\theta$
$(n+1)\lambda_2 = d \sin\theta$
$\therefore n\lambda_1 = (n+1)\lambda_2$
$n = \frac{\lambda_2}{\lambda_1 - \lambda_2} = \frac{4500 A^\circ}{1500 A^\circ} = 3$
$n\lambda_1 = d \sin\theta \Rightarrow 3\lambda_1 = \frac{1}{N} \sin 30^\circ$
$N = \frac{\sin 30}{3 \times 6000 \times 10^{-8}} = 2777$ lines/cm</td></tr>
<tr><td>20.</td><td>Explain the working of atomic force microscope in detail.</td></tr>
<tr><td>21.</td><td>If $\phi(x,y,z) = 3x^2y - y^3z^2$, Find $\vec{\nabla}\phi$ at the point (-1, -2, 1).

(21) $\phi = 3x^2y - y^3z^2$
$\nabla\phi = i\frac{\partial\phi}{\partial x} + j\frac{\partial\phi}{\partial y} + k\frac{\partial\phi}{\partial z}$
$\frac{\partial\phi}{\partial x} = 6xy$
$\frac{\partial\phi}{\partial y} = 3x^2 - 3y^2z^2$
$\frac{\partial\phi}{\partial z} = 0 - 2y^3z$
$\therefore \nabla\phi = i\,6xy + j(3x^2 - 3y^2z^2) - k\,2y^3z$
$= 6xy\,i + (3x^2 - 3y^2z^2)j - 2y^3z\,k$
$(\nabla\phi)_{(-1,-2,1)} = (6\times -1 \times -2)i + (3 - 3\times 4\times 1)j - 2\times -8\times 1\,k$
$= 12i - 9j + 16k$</td></tr>
<tr><td>22.</td><td>Given $\vec{A} = x^2yi + (x-y)k$, find $\vec{\nabla}.\vec{A}$</td></tr>
<tr><td>23.</td><td>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</td></tr>
</table>

transmitted through the fiber, determine. Normalized frequency of the fiber.

(23) $d = 29 \times 10^{-6} m$

$\mu_1 = 1.52, \quad \mu_2 = 1.5189$

$\lambda = 1.3 \mu m.$

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

$$= \frac{\pi \times 29 \times 10^{-6}}{1.3 \times 10^{-6}} \sqrt{1.52^2 - 1.5189^2}$$

$$= 4.052$$

24. Derive Gauss law for static electric and magnetic field in differential and integral form.

25. 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?

(25) $\lambda = 6000 Å, \quad N = 5000$ lines/cm

$n\lambda = d \cdot Sin\theta.$

or $n = \frac{d}{\lambda} \cdot Sin\theta = \frac{1}{N\lambda} Sin\theta$

$max\ n = \frac{1}{N\lambda}.$

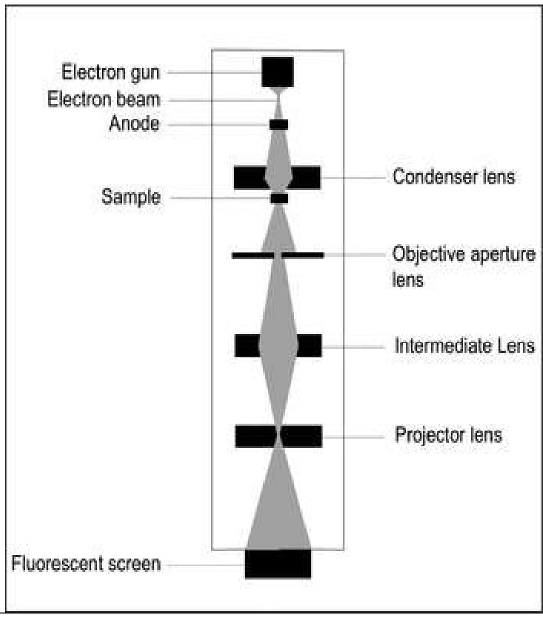
$$= \frac{1}{6000 \times 10^{-8} \times 5000}$$

$$n_{max} = 3$$

26. 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.

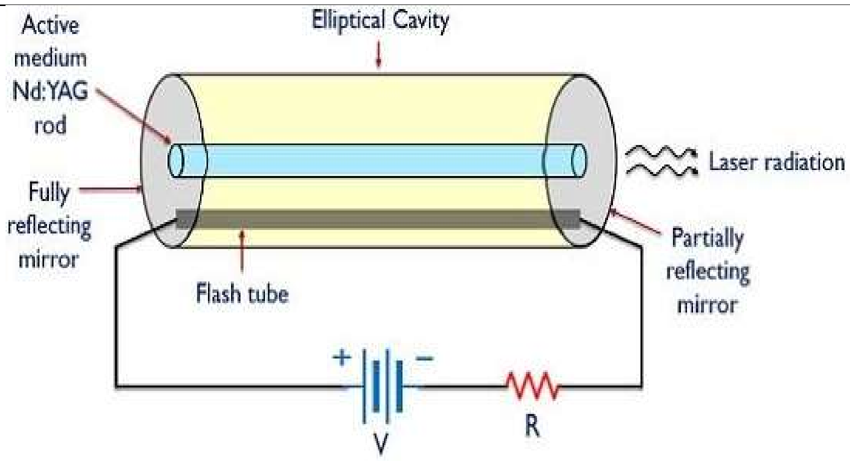
27. Explain the construction and working of a Transmission Electron microscope with a schematic diagram.

A TEM is a type of electron microscope that uses a broad beam of electrons to create an image of a sample's internal structure. A beam of electrons is transmitted through a sample, creating an image that details a sample's morphology, composition, and crystal structure.



	An electron gun at the top of a TEM emits electrons that travel through the microscope. TEM employs an electromagnetic lens which focuses the electrons into a very fine beam. This beam then passes through the specimen. The electrons either scatter or hit a fluorescent screen at the bottom of the microscope. An image of the specimen is shown in different shades according to its density appears on the screen. This image can be then studied directly within the TEM or photographed. Samples must be incredibly thin, often less than 150 nm thick, to allow electrons to pass through them. After the transmission of the electrons through the sample, they arrive at a detector below and a 2-D image is created. TEMs have an incredible magnification potential of 10-50 million times. The details provided are at the atomic level, the highest resolution of any electron microscope. TEMs are often used to examine molecular and cellular structures.
28.	State Maxwell's equations in differential form in a medium, in the presence of charges and currents.
29.	Describe any two methods to synthesize nanomaterials. **Sol gel Method** The sol is a colloid where the aggregates of fine particle are distributed in liquid phase. They are larger in size ranging from 1 nm to 1 µm than nano-particles. Whereas, solid macromolecules immersed in a solvent, called as gel. Sol gel is one of the simplest and, most commonly used methods for the synthesis of nano-particles. It is a chemical method which comprises of a solution working as a precursor for an assimilated system of distinct particles. In this method, metal oxides, metal chlorides and alkoxysilanes are most commonly used as precursors. The precursor is mixed by means of mixing, quivering sonicating or stirring and is then spread in second liquid which form a solid–liquid phase. Catalyst is commonly used to start the reaction and to control the pH of the system. Sedimentation, filtration and centrifugation are the typical methods used for phase separation to get nano-particles and then the sample is dried to remove moistness. The main advantages of this process are to attain uniform nano-structures even at a very low temperature, having controlled chemical composition and purity. This process is not easily scalable having different drying steps involved as well as it is difficult to control synthesis during this process. **Nano-lithography** Nanolithography is the investigation of manufacturing nano-scale structures of one dimension at least, with size ranging from 1 to 100 nm. There are different nano-lithographic forms, for example optical, electron-pillar, multiphoton, nanoimprint and filtering test lithography. Mostly lithography is the way towards printing a required shape or structure of a light sensitive material, which specifically evacuates a bit of material to make the ideal shape and structure. The primary advantage of nanolithography is to create a bunch from a solitary nano-particle with desired shape and size. Sophisticated equipments are required in this method.
30.	Describe the physical significance of gradient, Divergence and Curl.
31.	If $\vec{A}= xy\boldsymbol{i}-8xy^2\boldsymbol{z^2}\boldsymbol{j} + 2\boldsymbol{xyzk}$. Find $\vec{\nabla}.\vec{A}$at point (1,-2, 4).

<table>
<tr><td></td><td>
(31) $\vec{A} = xy\hat{i} - 8xy^2z^2\hat{j} + 2xyz\hat{k}$
$\vec{\nabla}\cdot\vec{A}$ at $(1,-2,4)$
$\vec{\nabla}\cdot\vec{A} = \frac{\partial}{\partial x}A_1 + \frac{\partial}{\partial y}A_2 + \frac{\partial}{\partial z}A_3$.
$\frac{\partial A_1}{\partial x} = y$, $\frac{\partial A_2}{\partial y} = -16xyz^2$
$\frac{\partial}{\partial z}A_3 = 2xy$.
$\therefore \vec{\nabla}\cdot\vec{A} = \cancel{y} + y - 16xyz^2 + 2xy$
$(\vec{\nabla}\cdot\vec{A})_{(1,-2,4)}$
$= \cancel{-2}$
$= -2 - [16\times1\times-2\times16] + 2\times1\times-2$
$= -2 + 512 - 4$
$= \underline{506}$
</td></tr>
<tr><td>32.</td><td>Derive the expression for the Numerical aperture for a step index fiber.</td></tr>
<tr><td>33.</td><td>Draw and explain energy level diagram of Nd: YAG Laser.
Neodymium-doped Yttrium Aluminium Garnet (Nd: YAG) laser is a solid state laser in which Nd: YAG rod is used as an active medium.
The dopant, triply ionized neodymium, Nd3+, typically replaces a small fraction of the yttrium ions in the host crystal structure of the yttrium aluminium garnet (YAG). It is the neodymium ion which proves the lasing activity in the crystal.
Nd: YAG laser is a four-level laser system, which means that the four energy levels are involved in laser action. These lasers operate in both pulsed and continuous mode.
Active medium
The active medium or laser medium of the Nd:YAG laser is made up of a synthetic crystalline material (Yttrium Aluminum Garnet (YAG)) doped with a chemical element (neodymium (Nd)). The lower energy state electrons of the neodymium ions are excited to the higher energy state to provide lasing action.
Pumping source
The energy source or pump source supplies energy to the active medium to achieve population inversion.
In Nd: YAG laser, light energy sources such as flashtube or laser diodes are used as pump source.
Optical resonator
The Nd:YAG crystal is placed between two mirrors. These two mirrors are optically coated or silvered. One mirror is fully silvered whereas, another mirror is partially silvered.
</td></tr>
</table>



Working of Nd-YAG Laser

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.

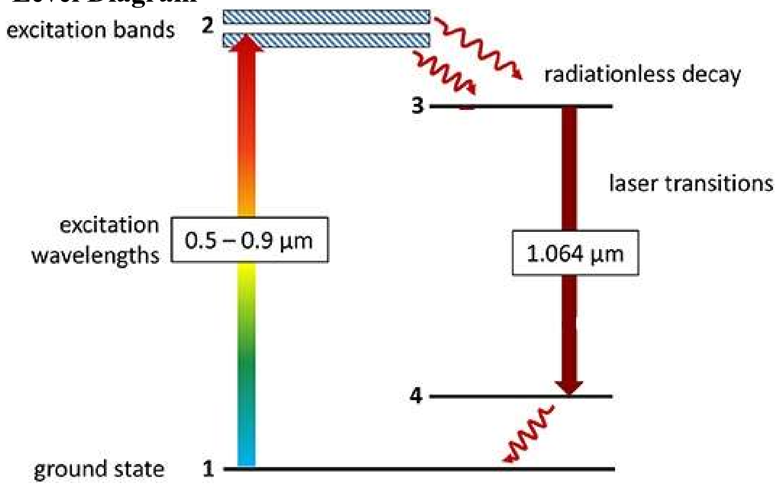
All higher energy level except E3 are non-metastable levels and non radiative transitions occur to E3.

Energy level E3 is metastable level and population inversion is achieved between E3 & E4.

Stimulated emission results due to the transition between E3 & E4 with a wave length 1.06 micro meters.

E4 to E1 transition is spontaneous non-radiative.

The Energy Level Diagram



34. Prove that $x^2+y^2+z^2-c^2t^2$ is invariant under Lorentz transformation.

35. What is length contraction? Derive the expression for the same?

Length Contraction (11)

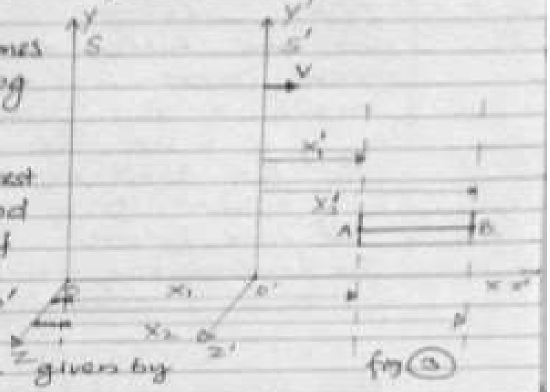
In classical mechanics the length of an object is independent of ~~the~~ speed of the moving observer relative to it. On the contrary according to theory of Relativity length of an object depends on the speed of the observer relative to the object.

Consider two inertial frames S & S'. S' is moving along the +ve x direction as shown in fig 3
Let a Rod AB be at rest in the moving frame and let L_o be the length of the rod in S' frame measured by observer O' at any instant
The length L_o will be given by

$$L_o = x_2' - x_1' \quad —(1)$$

where x_2' & x_1' are the coordinates of the ends in S'
~~At the~~ At the same time length of the rod measured by observer O in S frame is

$$L = x_2 - x_1 \quad —(2)$$



By Lorentz transformations

$$x_1' = \frac{x_1 - Vt}{\sqrt{1 - V^2/c^2}}, \quad x_2' = \frac{x_2 - Vt}{\sqrt{1 - V^2/c^2}}$$

$$\therefore x_2' - x_1' = \frac{x_2 - x_1}{\sqrt{1 - V^2/c^2}} \Rightarrow L_o = \frac{L}{\sqrt{1 - \frac{V^2}{c^2}}} \quad —(3)$$

i.e. $\boxed{L = L_o \sqrt{1 - V^2/c^2}}$

from the above eqn, $L < L_o$ since $V < c$
thus the length is reduced for the observer moving with velocity V w.r.t the rod. This is known as length contraction.

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

37. 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.

(37) $d = 40\mu m$, $\mu_1 = 1.5$, $\mu_2 = 1.46$
$\lambda = 1.5\mu m$

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

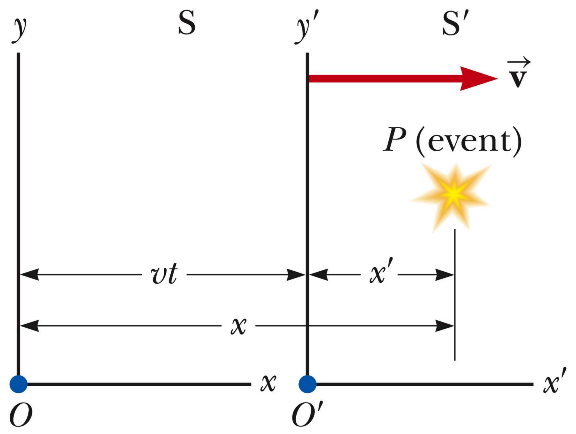
$$= \frac{\pi \times 40\mu}{1.5\mu}\sqrt{1.5^2 - 1.46^2}$$

$$= \underline{28.83}$$

No. of modes, $N_m = \frac{V^2}{2} = \frac{28.83^2}{2}$

$$= \underline{415}$$

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

	example.
39.	What is Galilean transformation? Derive Galilean transformation equations for position and time. Galilean relativity To describe a physical event, a frame of reference must be established. There is no absolute inertial frame of reference. This means that the results of an experiment performed in a vehicle moving with uniform velocity will be identical to the results of the same experiment performed in a stationary vehicle. Objects subjected to no forces will experience no acceleration. Any system moving at constant velocity with respect to an inertial frame must also be in an inertial frame. According to the **principle of Galilean relativity**, the laws of mechanics must be the same in all inertial frames of reference. An *event* is some physical phenomenon. Assume the event occurs and is observed by an observer at rest in an inertial reference frame. The event's location and time can be specified by the coordinates (x, y, z, t). Consider two inertial frames, S and S'. S' moves with constant velocity along the common x and x' axes. The velocity is measured relative to S. Assume the origins of S and S' coincide at t = 0.  An observer in S describes the event with space-time coordinates (x, y, z, t). An observer in S' describes the same event with space-time coordinates (x', y', z', t'). The relationship among the coordinates are: $x' = x - vt$ $y' = y$ $z' = z$ $t' = t$ These equations are known as Galilean transformation equations for position and time.
40.	Describe the fiber optics communication system with block diagram

Q.2 Explain Top down and bottom up approaches to prepare nanomaterials.

→ Two main approaches are used in Nanotechnology for the production of Nanomaterials.

(I) Top - Down Approach:

"In the top-down" physical approach, nano - objects are constructed from larger size of materials.

Techniques are used in this category.

i) Thermal plasma is a mixtures of molecules, atoms, e-s and photon's at a very high temp.
ii) Solid state silicon method.
iii) "microelectrochemical" system (MEMS) - used in Nanotechnology.
iv) Lithography
v) Ball milling method.
vi) "Dip pen nanolithography.

(II) Bottom up Approach:

In the "Bottom - Up" approach, materials and devices are built from molecular components which assemble themselves chemically by principles of molecular recongnition.

These methods are used today to produce a wide variety of useful chemicals such as pharmaceuticals or commercial polymers.

Techniques are used in this Category.

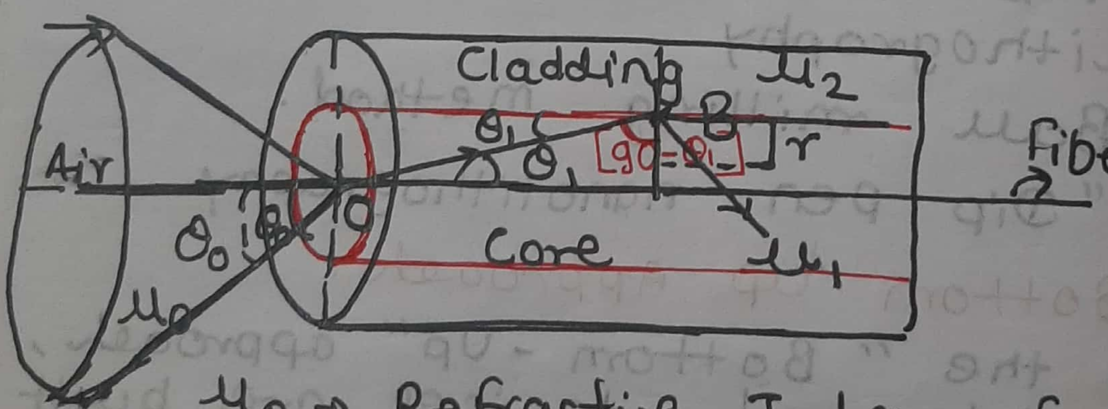
i) Chemical Vapour Deposition.

(ii) Electrodeposition

(iii) Molecular Beam Epitaxy.

iv) Single Crystal method.

Q.4 Derive the expression of numerical aperture for a step Index fibre. A light ray enters an optical fiber from air. The fibre has core & cladding refractive indices are 1.52 and 1.41. Find the critical angle and Numerical aperture.



$\mu_0 \rightarrow$ Refractive Index of Air.

$\mu_1 \rightarrow$ Refractive Index of Core.

$\mu_2 \rightarrow$ Refractive Index of Cladd.

$\mu_1 > \mu_2 > \mu_0$:

$\theta_0 \rightarrow$ Acceptance angle

$\theta_1 \rightarrow$ Angle of refraction

Incident light ray makes an angle of incidence θ_0 with the axis of the core.

Part I : light ray travel from Air to Core.

when light ray travel from Air to core at O,
Angle of Incidence is θ_0 &
Angle of Refraction is θ_1.
Snell's law at O is,

$$\boxed{\therefore \mu_0 \sin\theta_0 = \mu_1 \sin\theta_1} \quad - \langle 1 \rangle$$

Part II : light ray travel from core to cladding.

light travel from core - cladding at B.
angle of incidence is i, i_c

$$i = i_c = [90^\circ - \theta_1]$$

angle of refraction is $r = 90^\circ$.

$$\therefore \mu_1 \sin i = \mu_2 \sin r \quad - \langle 2 \rangle$$

$$\therefore \mu_1 \sin i_c = \mu_2 \sin(90^\circ)$$

$$\therefore \mu_1 \sin[90^\circ - \theta_1] = \mu_2 \quad - \langle 3 \rangle$$

$$\therefore \mu_1 \cos\theta_1 = \mu_2$$

$$\boxed{\therefore \cos\theta_1 = \frac{\mu_2}{\mu_1}} \quad - \langle 4 \rangle$$

$$\therefore \sin\theta_1 = \sqrt{1-\cos^2\theta_1}$$

$$= \sqrt{1-\frac{\mu_2^2}{\mu_1^2}} = \frac{\sqrt{\mu_1^2-\mu_2^2}}{\mu_1}$$

Scanned with CamScanner

$\therefore \sin\theta_1 = \frac{\sqrt{\mu_1^2-\mu_2^2}}{\mu_1}$ - put this value in eqn ①

$\mu_0 = 1$

$\therefore \mu_0 \sin\theta_0 = \mu_1 \cdot \sin\theta_1$ <1>

$\therefore \sin\theta_0 = \mu_1 \cdot \frac{\sqrt{\mu_1^2-\mu_2^2}}{\mu_1}$

$\therefore \sin\theta_0 = \sqrt{\mu_1^2-\mu_2^2}$ <5>

where $\theta_0 = \theta_{max}$ = Angle of acceptance.

$\therefore \boxed{\sqrt{\mu_1^2-\mu_2^2} = N \cdot A}$ = Numerical Aperture.

$\therefore \sin\theta_{max} = N \cdot A$ <6>

$\Downarrow$

$\therefore$ Angle of acceptance = N.A.

§ Given: $\mu_1 = 1.52$, $\mu_2 = 1.41$

$\therefore i_c \Rightarrow$ Critical Angle = ... ?

$\therefore$ NA $\Rightarrow$ Numerical Aperture = ... ?

(I) Critical Angle:

$\therefore i_c = \sin^{-1}\left[\frac{\mu_2}{\mu_1}\right]$ - [1]

$i_c = \sin^{-1}\left[\frac{1.4}{1.52}\right]$

$\therefore \boxed{i_c = 67.08}$ - [2]

(II) Numerical Aperture (N.A):

$\therefore N \cdot A = \sqrt{(\mu_1)^2-(\mu_2)^2}$

$= \sqrt{(1.52)^2-(1.4)^2}$

$\therefore \boxed{N \cdot A = 0.59}$ - [3]

Q.6 State the advantages of optical fiber cables on conventional electrical cables.

→ Advantages of fiber optics cables on Electrical cables.

(I) Band width :

In optical fibre cables - light waves are used to transmit information at a higher rate than copper cabes.

(II) Size and weight :

Optical fibre are light - weight, smaller diameter and flexible. So they can be handled more easily than copper cables.

(III) Cross - talk :

This cross talk is negligible in optical fibres even when many fibres are coupled together.

(IV) Easy maintenance :

Optical cables are more reliable and easy to maintain than copper cables.

(V) Temperature resistant :

In contrast to copper cables, they have high tolerance to temperature extremes.

(VI) Longer life - spam :

The life - span of optical fibre is expected to be 20 - 30 years as compared to copper cables, which have a life - spam of 12 - 15 years.

Q.8 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?

→ (a) Construction: ...
Three to Four lines explanation

(b) Working and Energy Level Diagram:
Explanation and show transitions of beth. M.S & U.S.

(c) Merits and Demerits:
1) Highly stable
2) Continuous o/p Laser
→ low efficiency
low power o/p.

(d) Role of He atoms:
i) He atoms being lighter than Ne atoms can absorb the energy from the high energy electrons easily and very fast.
ii) It helps to achieve the population inversion for a longer time.
iii) He atoms are act as a coolant and no seperate cooling system is required.

Q.10 What is a grating? Define grating element? Discuss the phenomenon of diffraction at Fraunhofer's a grating with and obtain the expression for the Intensity?

→ Grating :

Defination

Grating element:

$\therefore d = a + b \quad | \therefore d = \frac{1}{N}$

Grating element (d), slit width (a), width of opaque space (b).

Fraunhofer's Diffraction at a grating:

or

{Fraunhofer's Diffraction at N slits:}

Expression for Intensity:

→ There are N number of slits,

→ We have N- Central diff. wave.

→ Path difference betn. two consecutive rays from two consecutive slits is $(a+b)\sin\theta$

The corresponding phase difference is,

$$\frac{2\pi}{\lambda}(a+b)\sin\theta = 2\beta$$

$$\therefore \beta = \frac{\pi}{\lambda}(a+b)\sin\theta$$

Again by using the method of vector addition of amplitude,

The resultant amplitude from N slits in a direction θ will be

$$\therefore A^* = na'\frac{\sin\alpha}{\alpha}\cdot\frac{\sin N(2\beta/2)}{\sin(2\beta/2)} \quad -\langle 1\rangle$$

$$\therefore A^* = na'\frac{\sin\alpha}{\alpha}\cdot\frac{\sin N\beta}{\sin\beta} \quad -\langle 2\rangle$$

$\therefore$ Intensity $= I$

$= A^{*2}$

$= I_0 \frac{(\sin \alpha)^2}{\alpha^2} \frac{(\sin N\beta)^2}{(\sin \beta)^2}$

The maximum intensity will come for $\alpha = 0$ & $\beta = 0$ from eqn. (3).

It gives the position of central maximum m_0.

$\frac{\sin \alpha}{\alpha} = 1$ and $\frac{\sin N\beta}{\sin \beta} = N$

where $\alpha = 0$ $\quad \beta = 0$

So the maximum Intensity at central maxima m_0,

$\therefore I = I_0 \cdot N^2$

$$\boxed{\therefore I = N^2 I_0} \text{ --- } \langle 4 \rangle$$

Thus,

General intensity distribution for a diffraction grating is,

$$\therefore I = I_0 \left[\left(\frac{\sin^2 \alpha}{\alpha^2} \right) \left(\frac{\sin^2 N\beta}{\sin^2 \beta} \right) \right] \text{ --- } \langle 5 \rangle$$

$\boxed{Q \cdot 12}$ What is population inversion state & Explain its significance in the operation of LASER.

→ Population Inversion:

Role in LASER:

Q.14 Derive Maxwell's 3rd eqn. in integral & differential form. Given that $\vec{D} = 20xi + 10\hat{j}$. Determine the flux crossing $1m^2$ area that is normal to the x-axis at $x = 5$ m.

→ **Maxwell's 3rd Equation:**

$$e.m.f = e = -\frac{d\phi}{dt} \quad -(1)$$

The induced e.m.f. in a closed loop is the rate of change of mag. flux per unit time & it's direction is opposite to the cause of production.

$$\therefore \phi = \int_s \vec{B} \cdot \vec{ds} \quad -(2)$$

$$\therefore e.m.f(e) = -\frac{d}{dt}\iint \vec{B}\cdot\vec{ds}$$

$$\boxed{\therefore e.m.f(e) = -\iint_s \frac{d\vec{B}}{dt} \cdot \vec{ds}} \quad -(3)$$

Again,

$$\therefore e.m.f(e) = \oint_c \vec{E}\cdot\vec{dl} \quad -(4)$$

Compare eqn. (3) & (4), we get

$$\therefore \oint_c \vec{E}\cdot\vec{dl} = -\iint_s \frac{d\vec{B}}{dt}\cdot\vec{ds} \quad -(5)$$

Stoke's Thm → Using, L.H.S of eqn. (5) is converted into,

$$\therefore \oint_c \vec{E}\cdot\vec{dl} = \iint_s (\vec{\nabla}\times\vec{E})\,\vec{ds} \rightarrow (A)$$

put this in eqn. (5)

$$\iint_s (\vec{\nabla}\times\vec{E})\,\vec{ds} = -\iint_s \frac{d\vec{B}}{dt}\cdot\vec{ds} \rightarrow (6)$$

Eqn. (6) is true for any arbitrary surface. so Integrands of both sides must be same.

$$\boxed{\therefore \vec{\nabla} \times \vec{E} = -\frac{d\vec{B}}{dt}} \rightarrow (7)$$

This is the maxwell's third Eqn. in differential form.

$$\boxed{\therefore \oint_c \vec{E}.d\vec{l} = -\oint_s \frac{d\vec{B}}{dt}\, d\vec{s}} \rightarrow (8)$$

This is the maxwell's 3rd eqn. in Integral form.

Q.16 Distinguish between single mode and multimode optical fibre.

⇒ Single mode optical fiber || multimode optical fiber.

i)

Q.18 what is the importance of resonant cavity in the operation of laser?

→ Explanation with Diagram.
 & It gives the details

Q.20 Explain the working of Atomic force microscope in details.

→ Explanation:
 Diagram:

Q.22 Given $\vec{A} = x^2 y \hat{i} + (x-y) k$, find $\vec{\nabla} \cdot \vec{A}$.

→ Soln:

$$\vec{A} = x^2 y \hat{i}_x + (x-y)\hat{k}_z$$

$$\vec{\nabla}\cdot\vec{A} = \frac{\partial \vec{A}_x}{\partial x} + \frac{\partial \vec{A}_y}{\partial y} + \frac{\partial \vec{A}_z}{\partial z} \quad \langle 1\rangle$$

$$\frac{\partial \vec{A}_x}{\partial x} = \frac{\partial}{\partial x}(x^2 y) = 2xy \quad \Big| \quad \frac{\partial \vec{A}_y}{\partial y} = \frac{\partial}{\partial y}(0) = 0$$

$$\frac{\partial \vec{A}_z}{\partial z} = \frac{\partial}{\partial z}(x-y) = 0$$

put all these in eqn. ①,

$$\therefore \vec{\nabla}\cdot\vec{A} = \frac{\partial \vec{A}_x}{\partial x} + \frac{\partial \vec{A}_y}{\partial y} + \frac{\partial \vec{A}_z}{\partial z} \quad \langle 1\rangle$$

$$= 2xy + 0 + 0$$

$$\boxed{\therefore \vec{\nabla}\cdot\vec{A} = 2xy} \quad \langle 2\rangle$$

Q.24 Derive Gauss law for static electric and magnetic field in differential and Integral form.

→ ① Gauss's law for static Electric field :

The total electric flux ϕ thro' the closed surface is equal to the total charge enclosed by that surface.

$$\therefore \phi = \oint_S \vec{E}\cdot d\vec{s} \quad \langle 1\rangle$$

$$\therefore \oint_S \vec{E}\cdot d\vec{s} = \frac{1}{\epsilon_0}\int_v \rho \, d^3v \quad - \langle 2\rangle$$

Applying divergence thm, the surface integral is converted to a volume integral,

$$\therefore \oint_S \vec{E}\cdot d\vec{s} = \frac{1}{\epsilon_0}\int_v (\vec{\nabla}\cdot\vec{E})\, dv \quad - \langle 3\rangle$$

put this in eqn. ②,

$$\int_v (\vec{\nabla}\cdot\vec{E})\, dv = \frac{1}{\epsilon_0}\int_v \rho \, d^3v \quad - \langle 4\rangle$$

Integral form.

$\therefore (\vec{\nabla}\cdot\vec{E}) = \frac{1}{\varepsilon_0}$

$\therefore (\vec{\nabla}\cdot\vec{E}) = \frac{\rho}{\varepsilon_0}$ — <5>

Differential form.

$\boxed{\therefore \vec{\nabla}\cdot\vec{D} = \rho}$ — <6> | $\varepsilon_0 \cdot E = \vec{D}$

(II) Gauss's law for static magnetic field:

In a magnetic field the magnetic lines are closed in nature.

"The total outgoing magnetic flux through a closed surface is zero."

$\therefore \oint_S \vec{B}\cdot d\vec{s} = 0$ — <1>

Eqn. (1) represents Gauss's law for magnetic field in integral form.

Using divergence thm. the magnetic Gauss's law,

$\therefore \oint_S \vec{B}\cdot d\vec{s} = \oint_S (\vec{\nabla}\cdot\vec{B})\, dv$ — <2>

$\therefore \oint_S (\vec{\nabla}\cdot\vec{B})\, dv = 0$ — <3>

$\boxed{\therefore \vec{\nabla}\cdot\vec{B} = 0}$ — <4>

Eqn. (4) represents Gauss's law for magnetic field in differential form.

Q.26 Explain the concept of time dilation and deduce an expression for it. A particle moving with a speed 0.7c. Calculate the ratio of the rest mass and mass while in motion.

⇒ Time dilation:

"Time Interval recorded by a moving frame s' is greater than the time Interval recorded by a stationary frame s."

stationary clock is faster than the moving clock.

Expression:

$$\Delta t_0 = t_A - t_B \quad \text{—①}$$ Proper Time Interval.

t_A → Time recorded by a clock c when A is at x_1.

t_B → Time recorded by a clock c when B is at x_1.

$$\therefore \Delta t = t'_A - t'_B \quad \text{—②}$$ Improper Time Interval.

t'_A → Time recorded by a clock when A is at x_1'.

t'_B → Time recorded by a clock when B is at x_1'.

By using Lorentz Transformation

$$\therefore t'_A = \frac{t_A - \frac{vx_1}{c^2}}{\sqrt{1-\frac{v^2}{c^2}}} \quad \text{—<3>}$$

$$\therefore t'_B = \frac{t_B - \frac{vx_1}{c^2}}{\sqrt{1-\frac{v^2}{c^2}}} \quad \text{—<4>}$$

$$\therefore \Delta t = t'_A - t'_B \quad -\langle 2 \rangle$$

$$= \frac{t_A - \frac{v x_1}{c^2}}{\sqrt{1-\frac{v^2}{c^2}}} - \frac{t_B - \frac{v x_1}{c^2}}{\sqrt{1-\frac{v^2}{c^2}}}$$

$$\therefore \Delta t = \frac{t_A - t_B}{\sqrt{1-\frac{v^2}{c^2}}} \quad -\langle 5 \rangle$$

$$\therefore \Delta t = \frac{\Delta t_0}{\sqrt{1-\frac{v^2}{c^2}}} \quad -\langle 6 \rangle$$

Time recorded by an Observer in S' frame. | Time recorded by an observer in S frame.

"No material body can move with velocity of light".

⇒ Solution :

Given $v = 0.7c$.

$$\therefore m = \frac{m_0}{\sqrt{1-\frac{v^2}{c^2}}} \quad \langle 1 \rangle$$

$m_0 \rightarrow$ Rest mass

$m \rightarrow$ mass with velocity $v = 0.7c$.

$$\therefore \frac{m_0}{m} = \sqrt{1-\frac{v^2}{c^2}} \quad \langle 1 \rangle$$

$$\therefore \frac{m_0}{m} = \frac{\text{Rest mass}}{\text{Mass while in motion}} \langle 2 \rangle$$

$$\therefore \frac{\text{Rest mass}(m_0)}{\text{moving mass}(m)} = \sqrt{1-\frac{v^2}{c^2}} \quad \langle 2 \rangle$$

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

$$\therefore \frac{m_0}{m} = 0.71 \quad -\langle 3 \rangle$$

Q. 28 State Maxwells Equations in differential form in a medium in the presence of charges and in currents.

→ Maxwell's Equations in differential form :

$$\vec{\nabla}\cdot\vec{E} = \frac{\rho}{\epsilon_0}$$ — <1> maxwell's 1st Eqn.

$$\vec{\nabla}\cdot\vec{B} = 0$$ — <2> maxwells 2nd Eqn.

$$\vec{\nabla}\times\vec{E} = -\frac{d\vec{B}}{dt}$$ — <3> maxwells 3rd Equation.

$$\vec{\nabla}\times\vec{B} = \mu_0\vec{J} + \mu_0\epsilon_0\frac{\partial\vec{E}}{\partial t}$$ — <4> maxwells 4th Eqn.

Q. 30 Describe the physical significanse of Gradient, Divergence and Curl.

→ (I) Gradient:

It gives the maximum rate of change of a function over a space in a speeified direetion and is ⊥er to the equipotential surface.

(II) Divergence ;

It gives a spreadness of a veetor field.

"It is a measure of how much the veetor field $\vec{v}$ spread (diverges) from the point of consideration".

Curl:
"It is a measure of how much the vector field $\vec{V}$ curl around the point of consider."
Simply "It is a measure of number of rotation."

Q.32 Derive the expression for the Numerical aperture for a step Index fiber.
⇒ please refer ~~Q.4 fo.~~ answer of Q.4 upto
$\therefore \sin\theta_{max} = \sqrt{\mu_1^2 - \mu_2^2}$ <6>.

Q.34 Prove that $x^2+y^2+z^2-c^2t^2$ is invariant under Lorentz Transformation.
⇒ According to Lorentz transformation, we have

$$\therefore x' = \frac{x-vt}{\sqrt{1-\frac{v^2}{c^2}}}, \quad y' = y, \quad z' = z$$

$$\therefore t' = \frac{t - vx/c^2}{\sqrt{1-\frac{v^2}{c^2}}}$$

$$\therefore x'^2 + y'^2 + z'^2 - c^2t'^2 \quad \text{— (1)}$$

$$\therefore x'^2+y'^2+z'^2-c^2t'^2 = \left\{\left[\frac{x-vt}{\sqrt{1-\frac{v^2}{c^2}}}\right]^2 + y^2+z^2-c^2\left[\frac{t-\frac{vx}{c^2}}{\sqrt{1-\frac{v^2}{c^2}}}\right]^2\right\}$$

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

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

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

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

$$\therefore L.H.S = \left[\frac{x^2 + v^2t^2 - \cancel{c^2t^2} - v^2x^2}{\frac{c^2 - v^2}{c^2} \cdot \cancel{c^2}} + y^2 + z^2 \right]$$

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

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

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

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

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

$$\therefore R.H.S = x^2 + y^2 + z^2 - c^2t^2 \quad \langle 2 \rangle$$

$$\therefore x_1^2 + y_1^2 + z_1^2 - c^2t_1^2 = x^2 + y^2 + z^2 - c^2t^2 \quad \langle 3 \rangle$$

$\therefore$ L.H.S = R.H.S

Hence it is proved.

Q.36 State maxwell's all four Equations and give the significance of each.

→

① // Maxwell's 1st Equation //

$\therefore \vec{\nabla} \cdot \vec{E} = \rho / \epsilon_0$ — <1>

$\vec{E} \rightarrow$ An Electric field, $\rho \rightarrow$ charge Density.

$\epsilon_0 \rightarrow$ permitivity.

physical Significance:

1) It gives charge density (ρ) is a scalar Quantity.

2) Electric lines of forces are open in nature.

$+q \rightarrow$ Act as a source.

$-q \rightarrow$ Act as a sink.

② Maxwells 2nd Equation

$\therefore \vec{\nabla} \cdot \vec{B} = 0$ — <2>

$\vec{B} \rightarrow$ magnetic field.

physical significance:

1) It gives magnetic lines of forces are closed in nature.

2) magnetic monopoles are not exist magnetic dipoles are exist.

③ Maxwells 3rd Equation

$$\therefore \vec{\nabla} \times \vec{E} = -\frac{d\vec{B}}{dt} \quad <3>$$

physical significance:

1) It gives an Unified nature of $\vec{E}$ & $\vec{B}$.

2) It is a common eqn. For lenz law & faraday's electro magnetic Induction

(IV) maxwell's 4th Equation:

$$\vec{\nabla} \times \vec{B} = \mu_0 \vec{J} + \mu_0 \epsilon_0 \frac{\partial \vec{E}}{\partial t} \quad \Big| \ \vec{D} = \epsilon_0 \vec{E}$$

$$\therefore \vec{\nabla} \times \vec{H} = \vec{J}_c + \underbrace{\frac{\partial \vec{D}}{\partial t}}_{\vec{J}_D} \quad \text{<4>} \quad \Big| \ \vec{H} = \frac{\vec{B}}{\mu_0}$$

$\frac{\partial \vec{D}}{\partial t}$ ⇒ Is called maxwell's correction and It is known as Displacement current.

$\vec{J}_c$ ⇒ Conduction Current density.

Physical Signifance:

i) Hence both $\vec{E}$ and $\vec{B}$ vary periodically in space with time to constitude an Electromagnetic wave.

$$\therefore c = \frac{1}{\sqrt{\mu_0 \epsilon_0}}$$

Q. 38 when a frame of reference is said to be a non-inertia frame of reference. Give an Example.

⇒ Non- Inertial frame of Reference:

Explanation.

Example:

Q. 40 Describe the fiber Optics communication system with block diagram:

→ Explain with proper Block diagram.

Q.14 $\vec{D} = 20x\,\hat{i}_x + 10\hat{j}\ (C/m^2)$. Determine the flux crossing area that is normal to the x-axis at $x = 5\,m$.

→ Given $\vec{D} = 20x\,\hat{i}_x + 10\hat{J}_y$.

$x = 5\,m$,

Formula: Total flux =

$$\therefore \phi = \int_S \vec{D} \cdot \vec{ds}$$

soln:

$$\int_S \vec{D} \cdot \vec{ds} = \int (\hat{i}_x D_x + \hat{J}_y D_y + \hat{k}_z D_z) \cdot (\hat{i}_x ds_x + \hat{J}_y ds_y + \hat{k}_z ds_z) \quad \langle 1 \rangle$$

$$= \int [D_x ds_x + D_y ds_y + D_z ds_z]$$

$$= \int D_x ds_x + \int D_y ds_y + 0$$

$$= D_x \int ds_x + D_y \int ds_y$$

$$= D_x (1) + D_y (1)$$

$$= \underline{20x}\,(1) + 10\,(1)$$

$$\therefore \int_S \vec{D} \cdot \vec{ds} = 20x + 10 \quad - \langle 2 \rangle$$

At $x = 5m$,

$$\therefore \int_S \vec{D} \cdot \vec{ds} = 20(5) + 10$$

$$\boxed{\therefore \text{flux} = 110} \quad \langle 3 \rangle$$

Scanned with CamScanner