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UNIVERSITY OF PETROLEUM AND ENERGY STUDIES

End Semester Examination, December 2017

Program: BTech Non-CIT	**Semester – I**
Subject (Course): PHYSICS-I	**Max. Marks : 100**
Course Code : PHYS 1001	**Duration : 3Hrs**
No. of page/s: 3	

permeability of free space $\mu_0 = 4\pi\times10^{-7}$ H/m, permitivity of free space $\varepsilon_0 = 8.854\times10^{-12}$ F/m
$\vec{k} = \vec{\gamma}$ = propagation vector, ω = angular frequency, n = refractive index of medium.
$c = \frac{1}{\sqrt{\varepsilon_0\mu_0}} = 3\times10^8 ms^{-1}$

	SECTION A(Attempt all the Questions)		
Q1.	A monochromatic laser light (λ=540 nm) falls on a diffraction grating normally. 5^{th} diffraction maximum is observed at 60 degree on a screen placed 1.25 meter away from the grating. Calculate grating element (d).	**[4]**	**CO1**
Q2.	Construct a $(0\,\bar{1}\,1)$ plane within a cubic unit cell. Also draw a [110] direction within the same unit cell.	**[4]**	**CO2**
Q3.	Using Maxwell's equations prove that, $\vec{k}\times\vec{E} = \mu\omega\vec{H}$. Consider wave has $e^{j(kx-\omega t)}$) dependence. The directions of $\vec{E}$ and $\vec{H}$ are along y axis and z axis, respectively.	**[4]**	**CO3**
Q4.	Calculate the electromagnetic impedance for an electromagnetic wave travelling through a pure dielectric medium (non magnetic) with relative permittivity ε_r = 2.5.	**[4]**	**CO3**
Q5.	An auditorium is found to have reverberation time of 1.5 seconds. Calculate the decay constant for the sound energy that falls exponentially in the auditorium.	**[4]**	**CO4**
	SECTION B (Attempt all the Questions), **Q9** has internal choice		
Q6.	**(a)** Describe hexagonal closed packed structure and derive the expression for packing fraction.	**[6]**	**CO2**

(b) State Moseley's law. Calculate the minimum X-ray wavelength for electrons when they are completely decelerated by target. Initial kinetic energy of electrons = 8.25 keV. **[4]**

Q7. Plot a graph between electric field E (in volts/m along y-axis) and propagation distance x (in nanometer along x-axis) for an electromagnetic wave travelling through a conducting medium. Consider, E changes according to, $E = E_0 e^{-x/\delta}$, where E_0 is constant. Calculate skin depth (δ) and attenuation constant from the plotted graph. The given data table can be used for the plot. **[10]** **CO3**

X	0	100	200	400	600	800	1000	1500	2000	3000
E	5.0	4.5	4.0	3.2	2.5	2.0	1.5	1.0	0.5	0.1

Q8. Describe briefly the production of ultrasonic wave by piezo-electric method with a neat diagram. Mention advantages and disadvantages of this method. **[8+2]** **CO4**

Q9. **(a)** Describe construction and working of ruby laser with the help of neat diagrams.
(b) A ray of light enters from air to an optical fiber. Calculate critical angle, the fractional refractive index, acceptance angle and numerical aperture. Given n_{air} =1, n_{clad} = 1.46 and n_{core} = 1.49. **[5+5]** **CO1**

OR

(a) Describe propagation of light through step index multimode fiber and graded index fiber with neat diagram.
(b) A He-Ne laser (λ = 633.9 nm) of 50×10^{-3} W power is focused to an area of $1mm^2$. Calculate the intensity of the laser, and energy of each photon in eV.

SECTION C (Attempt all the Questions), **Q11** has internal choice

Q10. **(a)** Describe construction of hologram with the neat diagram. **[5]** **CO1**

(b) A 15 km long optical fiber has a loss of 1.5 dB/km. The fiber is joined every kilometer with connectors, which give attenuation loss of 0.8 dB each. Determine the minimum optical power at the input to maintain 0.3×10^{-6} W power at the detector (receiving end). **[5]** **CO1**

(c) Show that the expression for inter-planar spacing between two consecutive parallel planes of Miller indices (h k l) is **[10]** **CO2**

$$d_{hkl} = \frac{1}{\sqrt{\frac{h^2}{a^2} + \frac{k^2}{b^2} + \frac{l^2}{c^2}}}$$

where, a, b, c are intercepts along the three axes.

Q11.	**(a)** Using Maxwell's equations derive the differential equation for electric field ($\nabla^2\vec{E} + \varepsilon_0\mu_0\omega^2\vec{E} = 0$) associated with an electromagnetic wave travelling through vacuum (along x-direction). Calculate free space impedance Z_0.	**[8]**	**CO3**
	(b) Calculate ultrasonic frequency that can be generated using magnetostriction method using the given parameters for iron: Young's modulus = 11.5×10^{10} N/m^2, density = 7.5×10^3 kg/m^3, length of the rod, l = 0.05 meter.	**[4]**	**CO4**
	(c) Describe the interferometer method to determine velocity of ultrasonic wave.	**[8]**	**CO4**
	OR		
	(a) The complex propagation constant for a conducting medium has the real and imaginary part of the form, $k = \gamma = \sqrt{\mu\varepsilon\omega^2 + j\sigma\mu\omega} = \alpha + j\beta$. Deduce the expression for α and β in terms of μ, ε and ω. Show that for good conductor α= β. ($j = i = \sqrt{(-1)}$)	**[8]**	**CO3**
	(b) The volume of a room is 600 $m^3$with total wall area of 220 m^2, floor area of 120 m^2, and ceiling area of 120 m^2. The average absorption coefficients for walls = 0.03, for ceiling = 0.80 and for floor = 0.06. Calculate the average absorption coefficient and reverberation time.	**[4]**	**CO4**
	(c) Using Sabine's reverberation theory derive the expression for total absorption per unit time in the form $$W_A = \frac{Ev}{4}\sum \alpha ds = \frac{EvA}{4}$$ Where, E = energy per unit volume, A = total absorption, v = velocity of sound.	**[8]**	**CO4**

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Instructions:
1. **All questions are compulsory.**
2. **This question paper has three sections; Section A, Section B, and Section C**
3. **In section A there are total 4 questions, each carrying 5 marks**
4. **In Section B there are total 4 questions, each carrying 10 marks. Question no. 8 is having an internal choice.**
5. **In Section C there are total 2 questions, each carrying 20 marks. Question no. 10 is having an internal choice.**
6. **Draw suitable diagrams wherever required.**
7. **Your answer should be concise and to the point.**

Values of some physical constants:

Velocity of light, $c = 3 \times 10^{8} ms^{-1}$
Mass of electron, $m_e = 9.1 \times 10^{-31} kg$;
Boltzmann Constant (K_B) $=1.38 \times 10^{-23}\ JK^{-1}$
Permittivity of free space $(\epsilon_0) = 8.854 \times 10^{-12} Fm^{-1}$
Charge of electron, $e = 1.6 \times 10^{-19}\ C$
Mass of proton/neutron $= 1.67 \times 10^{-27} kg$
Planck's Constant (h) = $6.6 \times 10^{-34}\ J$sec;
Permeability of free space $(\mu_0) = 4\pi \times 10^{-7} Hm^{-1}$

	SECTION A (All questions are compulsory)		
Ques 1	Discuss different types of dispersion mechanisms in an Optical Fiber.	**[5]**	**CO1**
Ques 2	Illustrate the primitive cell of a FCC (face centered cubic) structure.	**[5]**	**CO2**
Ques 3	Write down the Maxwell's equations (in differential form) for time varying fields. Also explain them briefly.	**[5]**	**CO3**
Ques 4	Discuss in brief any one mechanism for generation of ultrasonic waves.	**[5]**	**CO4**
	SECTION B (All questions are compulsory)		
Ques 5	**(i)** Discuss the important features of spontaneous and stimulated Emission. **(ii)** A cubic meter of atomic hydrogen at 0°C and at atmospheric pressure contains about 2.7×10^{5} atoms (in ground state). Determine the number of atoms in their first excited state (n=2) at 0°C and 5000 °C (Hint: Energy of Hydrogen atom, $E_n = -13.6\ eV/n^2$)	**[5 + 5]**	**CO1**

Ques 6	**(i)** Calculate the velocity and kinetic energy with which the electron strike the target of an X-ray tube operated at 50,000 volts. What is the short-wavelength limit of the continuous spectrum emitted and maximum energy per quantum of radiation? **(ii)** In 3-dimension (orthogonal coordinates), there are seven crystal systems and fourteen Bravais lattices possible due to crystal symmetry. Name any four crystal systems and corresponding Bravais lattices along with unit cell characteristics.	**[5 + 5]**	**CO2**
Ques 7	**(i)** Derive Maxwell's correction of Ampere's law and explain the significance of displacement current. **(ii)** A radio station transmits power radially around a spherical region. The desired electric field intensity at a distance of 10 km from the station is $2\mu V/m$. Calculate the corresponding magnetic field, intensity and power transmitted by the station.	**[5 + 5]**	**CO3**
Ques 8	A room of volume 90 m^3 has a total sound absorption of 20 metric Sabine. A sound source having 10 microwatts power output is turned on. If velocity of sound in air 344 m/s, tabulate and plot a graph for the decay of sound energy density (in $10^{-9} Jm^{-3}$) for given times: 0, 0.05, 0.1, 0.15, 0.2 and 0.25 sec after the source is switch off (t=0). OR A classroom of $4 \times 6 \times 10$ meters has an average sound absorption coefficient of 0.104. **(a)** Determine the reverberation time of the class room. **(b)** Forty students are in classroom and each is equivalent to 0.5 open window unit (OWU) of sound absorption. Evaluate the new reverberation time.	**[10]**	**CO4**
	SECTION C (All questions are compulsory)		
Ques 9	**(i)** With necessary diagrams, explain the construction and working principle of a ruby laser. **(ii)** Calculate the skip distance and number of reflections per meter for a fiber in which light is entering from air at an angle of 30° with $n_1 = 1.599$ and fiber diameter 60 μm. **(iii)** Show that the expression for inter-planar spacing between two consecutive parallel planes of Miller indices {h k l} is given by $d_{hkl} = \frac{1}{\sqrt{\frac{h^2}{a^2}+\frac{k^2}{b^2}+\frac{l^2}{c^2}}}$.,	**[5]** **[5]** **[10]**	**CO1** **CO1** **CO2**
Ques 10	**(i)** Derive an energy conservation principle (Poynting's Theorem) from Maxwell equations. **(ii)** Show that the rate of absorption of sound energy by the walls of an enclosure is given by $\frac{E_d v A}{4}$, where, E_d is sound energy density, v is velocity and A is total absorption of the enclosure. Also write expression for intensity of absorbed sound energy.	**[10]** **[10]**	**CO3** **CO4**

	OR **(i)**The time varying wave equation (in $\vec{E}$ filed) for propagation in a linear homogenous and isotropic lossy dielectric medium with conductivity (σ), permeability (μ) and permittivity (ε) is given by $\nabla^2\vec{E} - \gamma^2\vec{E} = 0,$ where $\gamma^2 = i\mu\omega(\sigma + i\omega\epsilon);\ \gamma = \alpha + i\beta$ is a propagation constant and ω is angular frequency. (a) Derive the expression for phase constant (β) and Attenuation constant (α) (b) Deduce the α and β from above relation for a lossless dielectric, good conductor and free space.	**[10]**	**CO3**
	(ii) Derive the expression for the following: (a) Growth of sound energy in reverberation chamber (b) Decay of sound energy in reverberation chamber and Reverberation time	**[10]**	**CO4**