ANSWER KEY OF
F.E. Semester – I (RC 2019-20) Examination, Jan/Feb 2023
PHYSICS
Part – A

Answer **any two** questions:

1. a) **Band theory of solids**

Diagram showing band structure of conductors, insulators & semiconductors **……. 2 marks**

Explanation of each with two examples **…..3marks**

b) **Types of magnetic materials**

Diamagnetic, paramagnetic & ferromagnetic materials

Brief explanation of each type **…..1mark each**

Three examples of each **…..2marks**

c) **Diameter of bright rings in Newton's Rings for reflected light**

Obtaining general expression for diameter of Newton's rings using theorem of intersecting chords. $D_n^2 = 8\,R\,t$ **….2marks**

Using the theory of interference in thin films for reflected light, condition for maximas is: $2\,\mu\,t\cos r = (2n+1)\lambda/2$

Using normal incidence assumption we get $2\,\mu\,t = (2n+1)\lambda/2$

$\Rightarrow t = \frac{(2n+1)\lambda}{4\,\mu}$ **…..1mark**

Substituting in general expression and solving we get,

$$D_n = \sqrt{\frac{2\lambda R}{\mu}} \cdot \sqrt{(2n+1)}$$

$= C \cdot \sqrt{(2n+1)}$ where $C = \sqrt{\frac{2\lambda R}{\mu}}$ is a constant

Thus, $D_n \propto \sqrt{(2n+1)}$ (square root of odd natural numbers) **…..2marks**

d) **Numerical Problem**

Magnetostriction definition **….. 1mark**

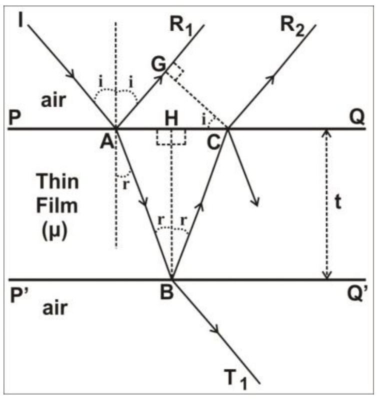
$f_n = \frac{1}{2L}\sqrt{\frac{Y}{\rho}}$ **….. 1mark**

$= \frac{1}{2\times 8.2\times 10^{-2}}\sqrt{\frac{11.6\times 10^{10}}{7.6\times 10^{3}}}$ **…….. 1 mark**

$= 23{,}822\ Hz$ **……. 1 mark**

It can be used to generate USW since $f_n >$ 20,000Hz **……. 1 mark**

2. a) **Interference in parallel thin film due to reflected light**



Ray Diagram **…. 1 mark**

The optical path difference between the rays R1 and R2 is:

Δ = (AB + BC) in film – AG in air

= μ (AB + BC) – (AG + λ/2) **…….1mark**

Solving and obtaining:

$\Delta = 2\,\mu\,t\cos r - \frac{\lambda}{2}$ **…….2marks**

Conditions for maxima & minima:

$2\,\mu\,t\cos r = (2n+1)\frac{\lambda}{2}$

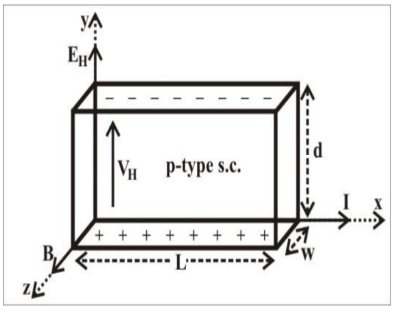
$2\,\mu\,t\cos r = n\,\lambda$ **….1mark**

b) Piezoelectric oscillator

Circuit diagram of piezoelectric oscillator **…….2 marks**

Explanation of working of circuit and generation of USW **……3 marks**

c) Hall Effect and expression Hall Voltage



Hall Effect definition **…… 1mark**

Diagram **……1 mark**

Explanation about magnetic and electric forces in opposite direction and obtaining $V_H = dv_dB$ **……. 2 marks**

Replacing v_d using expressions for current density and obtaining the final expression $V_H = \frac{IB}{pew}$ **……. 1mark**

d) Numerical problem

Magnetic susceptibility, $\chi = \frac{M}{H}$ **…….1mark**

$= \frac{4100}{300} = 13.67$ **…….2marks**

Relative permeability, $\mu_r = 1 + \chi = 1 + 13.67 = 14.67$ **…….2marks**

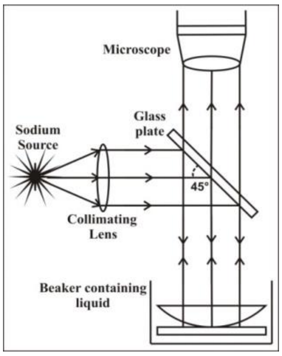
3. a) Hysteresis Loop

Diagram of hysteresis loop **……1 mark**

Explanation of hysteresis loop **…..2marks**

Definition of retentivity and coercivity **………1 mark each**

b) Determination of refractive index using Newton's rings



Ray diagram **….1mark**

Equations in air **….. 1 mark**

Equations in liquid **…… 1mark**

Solving & obtaining final formula, $\mu = \frac{D_{n+p}^2 - D_n^2}{D'^2_{n+p} - D'^2_n}$ **…….2marks**

c) Applications of US waves

(i) Echo sounding to determine depth of ocean floor (brief explanation)**……2½ marks**

(ii) Cavitation in cleaning applications (brief explanation) **……2½ marks**

d) Numerical problem

For intrinsic semiconductor,

$\sigma_i = e\, n_i(\mu_e + \mu_h)$ **……1mark**

$= 1.6 \times 10^{-19} \times 2.4 \times 10^{9} \times (0.34 + 0.11)$ **….1mark**

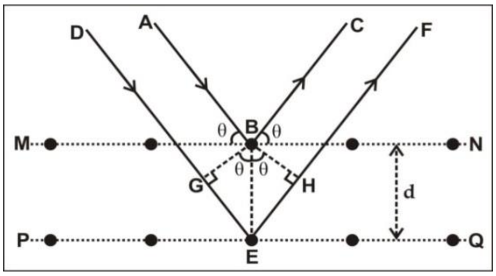
$= 1.73 \times 10^{-10}\ ohm^{-1}m^{-1}$ **…….1mark**

Current density, $J = \sigma_i E = 1.73 \times 10^{-10} \times 1200 = 2.07 \times 10^{-7}\ A / m^2$ **…..2marks**

Part – B

Answer **any two** questions:

4. a) Bragg's Law of X-ray diffraction



Brief explanation about x-ray diffraction ……**1 mark**

Diagram ……**1 mark**

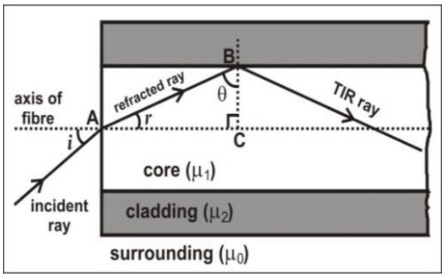
Path difference between the rays ABC & DEF is:

$\Delta = GE + EH$ ……**1 mark**

Obtaining expression for Δ and then using condition for constructive interference and finally obtaining:

$2d\sin\theta = m\lambda$ ......**2 mark**

b) **Expression for Acceptance Angle and Numerical Aperture**



Ray diagram ...... **1 mark**

Limiting condition: when $i = i_{max}, \theta = i_c$ ...... **1 mark**

Using Snell's Law and critical angle formula and finally obtaining the expression:

$$\mathrm{i}_{\max} = \sin^{-1}\left(\frac{\sqrt{(\mu_1^2 - \mu_2^2)}}{\mu_0}\right)$$ ...... **1 mark**

$$N.A. = \sin i_{max} = \left(\frac{\sqrt{(\mu_1^2 - \mu_2^2)}}{\mu_0}\right)$$ ...... **1 mark**

Brief explanation about acceptance cone ...... **1 mark**

c) **Properties and industrial applications of Laser**

Any three properties of laser ....**1 mark each**

Any two industrial applications of laser ....**1 mark each**

d) **Numerical problem**

i) For cricket ball

$\lambda = \frac{h}{mv} = \frac{6.63\times10^{-34}}{1\times19} = 3.49 \times 10^{-35}\mathrm{m}$ ...... **2 marks**

ii) For electron

$\mathrm{E} = 50\mathrm{keV} = 50 \times 10^3 \times 1.6 \times 10^{-19} = 8 \times 10^{-15}\mathrm{Joules}$ ...... **1 mark**

$\lambda = \frac{h}{\sqrt{2mE}} = \frac{6.63\times10^{-34}}{\sqrt{2\times9.1\times10^{-31}\times8\times10^{-15}}} = 5.49 \times 10^{-12}\mathrm{m}$ ...... **2 marks**

5. a) **Step Index (SI) and Graded Index (GRIN) fibres**

R.I. profile of Step Index (SI) fibre ....**1 mark**

R.I. profile of Graded Index (GRIN) fibre ....**1 mark**

Explanation of Step Index fibre **1½marks**

Explanation of Graded Index fibre **1½marks**

b) **Moseley's Law**

Statement of Moseley's Law **1½marks**

Equation of Moseley Law **1½marks**

Significance of Moseley's Law: Correction of periodic table & determination of atomic number of new elements .....**2 marks**

c) **Davisson-Germer Experiment (experiment to demonstrate wave nature of electrons)**

Diagram of experimental setup **1mark**

Brief explanation of setup **1½mark**

Oservations, analysis and inference from experiment showing that electrons behave like waves ....**2½ marks**

d) **Numerical Problem**

Definition of population inversion **1mark**

$$\left.\begin{aligned} E_2 - E_1 &= h\nu = \frac{hc}{\lambda} \\ &= \frac{6.63\times10^{-34}\times 3\times10^8}{6337\times10^{-10}} \\ &= 3.14 \times 10^{-19}\ \text{Joules} \end{aligned}\right\}$$ ..... **1 marks**

$\frac{N_2}{N_1} = e^{-(E_2-E_1)/KT}$ **….. 1 marks**

$= e^{-(3.14\times10^{-19})/(1.38\times10^{-23}\times323)}$ **….. 1mark**

$= 2.55 \times 10^{-31}$ **….. 1mark**

6. a) <u>Characteristic X-ray spectra</u>

Diagram showing collision of electron and target atom **…… 1 mark**

Diagram showing spectral lines (Lynman & Balmer series) **…… 1 mark**

Explanation of origin of Characteristic X-ray spectra **…..3 marks**

b) <u>Structure of Optical fibre cable</u>

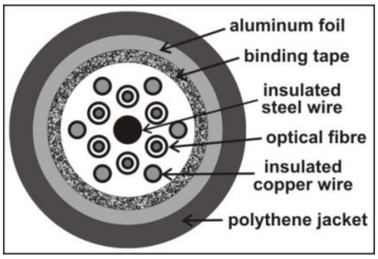


Diagram **……1 mark**

Explanation of different regions and their purpose **………3marks**

Propagation of light in an optical fibre using multiple TIR**…… 1 mark**

c) <u>Three-level pumping scheme</u>

Energy level diagram (before/after) **….. 1 mark**

Explanation of process of pumping and obtaining population inversion **…..3marks**

Drawbacks: requires high pumping power **….. 1 mark**

d) <u>Numerical problem</u>

Given R.I. of core, μ_1 = 1.5, R.I. of cladding, μ_2 = 1.48,

Assume surrounding medium as air, μ_0 = 1

Critical Angle, $i_c = \sin^{-1}\left(\frac{\mu_2}{\mu_1}\right) = \sin^{-1}\left(\frac{1.48}{1.5}\right) = 80.6°$ **…..2 mark**

Acceptance angle, $i_{max} = \sin^{-1}\left(\frac{\sqrt{(\mu_1^2-\mu_2^2)}}{\mu_0}\right) = \sin^{-1}\left(\frac{\sqrt{(1.5^2-1.48^2)}}{1}\right) = 14.13°$ **…2mark**

Numerical Aperture, $N.A. = \sin i_{max} = \sin 14.13 = 0.2441$ **……1mark**

Part – C

Answer **any one** question:

7. a) <u>Detection of Ultrasonic waves</u>

Brief explanation of any three methods of detection of USW: Piezoelectric method, Kundt's tube method, Sensitive flame method, Thermal detector method **….5 marks**

b) <u>Cathode ray oscilloscope (CRO)</u>

Block diagram of CRO **……3marks**

Brief explanation about using CRO to measure frequency of ac signal **…….2mark**

c) <u>He-Ne Laser</u>

Diagram of He-Ne laser setup **…….½marks**

Explanation of setup **……. 1mark**

Energy level diagram of He-Ne laser **…….1½marks**

Brief explanation of working **……. 2marks**

d) <u>Numerical Problem</u>

In a parallel thin film, due to reflected light, condition for minima (dark) is:

$2\,\mu\, t \cos r = n\lambda$ **……1mark**

$\Rightarrow\ t = \frac{n\,\lambda}{2\mu\cos r}$ } **1mark**

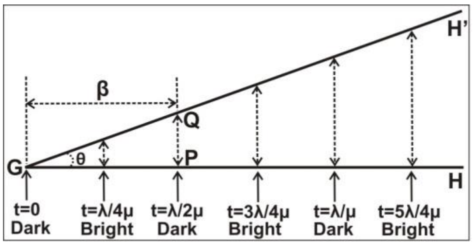
For smallest thickness, n = 1

$$t_{min} = \frac{\lambda}{2\,\mu\cos r} = \frac{5890 \times 10^{-10}}{2 \times 1.38 \times \cos 45}$$ **.......2marks**

$= 3.02 \times 10^{-7}$ m **......1 mark**

8. a) <u>Interference in Wedge shaped film</u>

Ray diagram **.....1mark**



Applying the theory of thin film interference for reflected light, using conditions for minima & maxima:

$2\,\mu\, t\cos r = n\,\lambda$

$2\,\mu\, t\cos r = (2n+1)\frac{\lambda}{2}$ **..... 1mark**

Using normal incidence assumption and then putting n = 0,1,2,3.... and obtaining different values of 't' **..... 1mark**

From the figure, obtaining expression for fringe width:

$\beta = \frac{\lambda}{2\,\mu\,\theta}$ **....2marks**

b) <u>Expression for Compton Shift</u>

Brief explanation of Comton effect **...... 2 marks**

Diagram showing collision between photon and electron **....1mark**

Equation of law of conservation of energy,

$hv + m_0c^2 = hv' + mc^2$ **....1mark**

Equation of law of conservation of momentum along horizontal direction,

$\frac{hv}{c} + 0 = \frac{hv'}{c}cos\theta + mvcos\varphi$ **....1mark**

Equation of law of conservation of momentum along vertical direction,

$0 + 0 = \frac{hv'}{c}sin\theta - mvsin\varphi$ **....1mark**

Working on above equations and finally obtaining expression for Compton Shitf:

$\lambda' - \lambda = \frac{h}{m_0c}(1 - cos\theta)$ **....4mark**

c) <u>Numerical Problem</u>

$\frac{1}{\lambda_{K_\alpha}} = \frac{3}{4}R(z-1)^2$ **....1mark**

$(z-1)^2 = \frac{4}{3\,\lambda_{K_\alpha}R} = \frac{4}{3 \times 1.65 \times 10^{-10} \times 1.097 \times 10^{7}} = 737$

$z - 1 = \sqrt{737} = 27$

$z = 27 + 1 = 28$ **3 marks**

The target element is Nickel (atomic number 28) **.......1mark**

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