PHY 1007 - Assignment

1. convert the differential form of Ampere - Maxwells. law into integral form.

sol :-

$$\nabla \times B = \mu_0 \left(J + \varepsilon_0 \frac{dE}{dt} \right)$$

$$\int (\nabla \times B)\, ds = \left(\int \mu_0 (J)\, ds + \varepsilon_0 \frac{d}{dt} \int E \cdot ds \right)$$

$$\oint_l B \cdot dl = \mu_0 \left(\int J\, ds + \varepsilon_0 \frac{d}{dt} \int E \cdot ds \right)$$

$$\oint_l B \cdot dl = \mu_0 \left(I + \varepsilon_0 \frac{d}{dt} \int E \cdot ds \right)$$

2. (a) part of a fish tank made of glass is shown in fig. A ray starting from the left passes through the glass and is totally internally reflected at the water - air interface. Take the index of refraction for the glass and water to be 1.5 and 1.33, respectively. Find the critical angle, θ_c for the total internal reflection at the water - air boundary.

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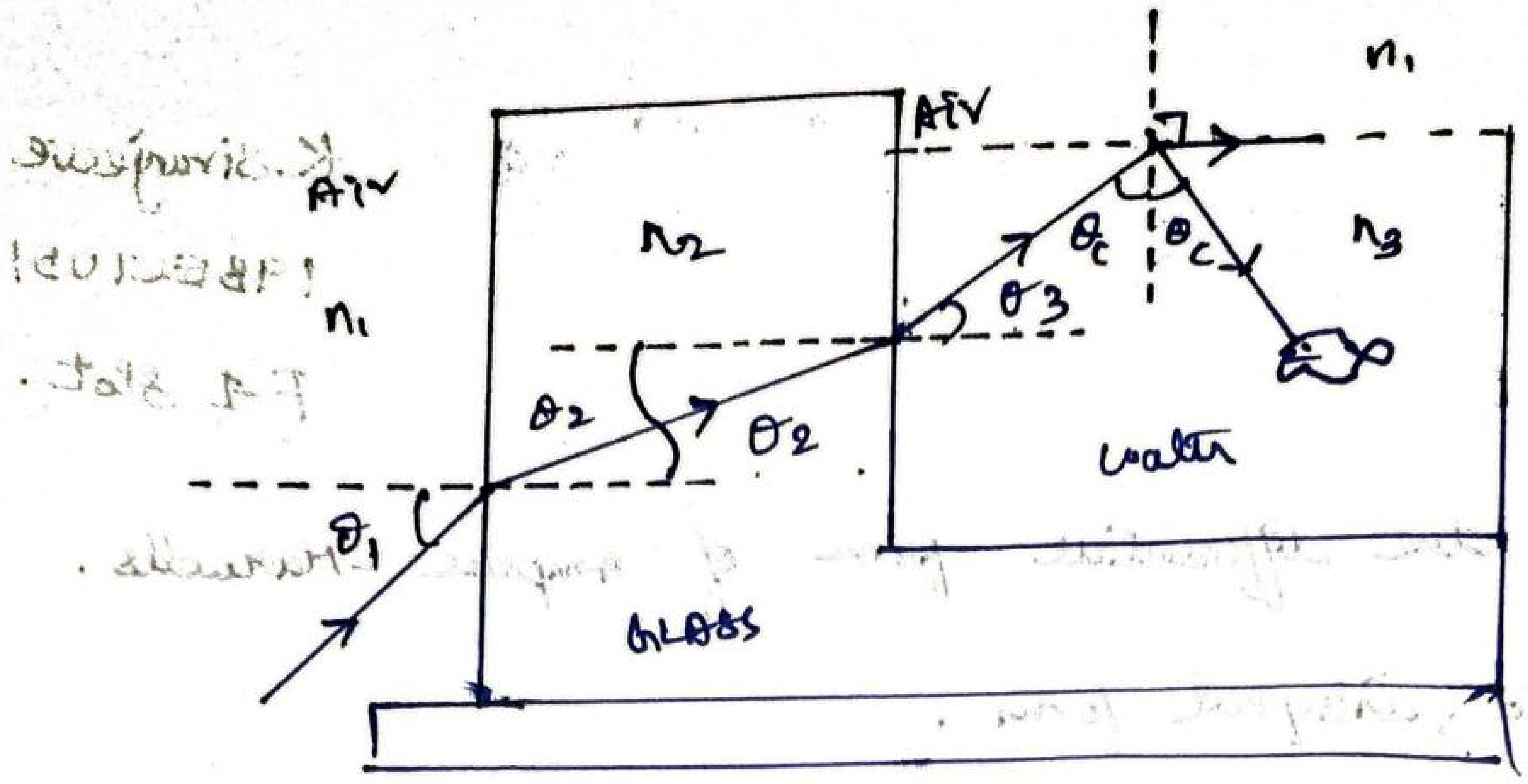

By Snell's law of water air surface

$$n_3 \sin\theta_c = n_1 \sin 90^\circ$$

$$\theta_c = \sin^{-1}\left(\frac{n_1}{n_3}\right)$$

$$= \sin^{-1}\left(\frac{1}{1.33}\right)$$

$$\theta_c = 48.8^\circ$$

(b) If refractive indices of core and clad of a optical fibre are 1.46 and 1.45 respectively. then find the numerical aperture and the maximum acceptance angle at the air-core boundary of the fiber.

Let $n_1 = 1.46$ & $n_2 = 1.45$

$\therefore$ Numerical Aperture $= \sqrt{n_1^2 - n_2^2}$

$$= \sqrt{1.46^2 - 1.45^2}$$

$$= \sqrt{0.291}$$

$$= 0.1705$$

$\therefore \sin \theta a = N.A.$

$$\theta a = \sin^{-1}(N.A)$$

$$\theta a = \sin^{-1}(0.1703)$$

$$= 9.81^\circ$$

$\therefore$ Acceptance angle is 9.81°.

3. (a) The intrinsic carrier concentration in pure Germanium is $2.5 \times 10^{19}/m^3$ at room temperature. Mobility of free e^- and holes are 0.38 and 0.18 $m^2/V.s$. Find the intrinsic conductivity of Ge.

Sol:-

$$\sigma i = q \cdot n_i (\mu_n + \mu_p)$$

$$= 1.6 \times 10^{-19} \times 2.5 \times 10^{19} (0.38 + 0.18)$$

$$= 2.24 \ (\Omega m)^{-1}$$

(b) If a pentavalent element like antimony is doped to an extent of 1 atom in 10 Ge atoms, what will be resistivity of the sample.

(A) $$N_p = \frac{4.4 \times 10^{28}}{10^7} = 4.4 \times 10^{21} / m^3$$

$$\sigma = qn(\mu n + \mu p)$$

$$= 1.6 \times 10^{-19} \times 4.4 \times 10^{21} (0.38 + 0.18)$$

$$= 394.24 \ (\Omega \ m)^{-1}.$$

$$\rho = \frac{1}{\sigma}$$

$$= \frac{1}{394.24}$$

$$= 2.83 \times 10^{-3} \ \Omega.m$$

4). The internal quantum efficiency of Si is 0.7. Find the responsibility of the Si photodetector used at a wavelength of 900nm. Find the maximum wavelength that a Si photodetector can be operated on.

Soln:-

$$R = \frac{\eta e \lambda}{hc}$$

$$= \frac{0.7 \times 1.6 \times 10^{-19} \times 900 \times 10^{-9}}{6.6256 \times 10^{-34} \times 3 \times 10^{8}}$$

$$= 50.709 \times 10^{-2}$$

$$R = 507.09 \ mA/w$$

E_g of Si = 1.14 eV

$$\lambda_{max} = \frac{1240}{E_g} = \frac{1240}{1.14}$$

$$\lambda_{max} = 1088 \ nm.$$

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5. Find the maximum energy level of an e^- in Na for which the probability the e^- to occupy is 0.5 at absolute zero. The fermi energy of sodium is 3.13 eV.

soln:-

No e^- can be above the fermi level at 0K.

Since no one have energy above the fermi level and there also no available energy states in the band gap.

$$F(E) = \frac{1}{1 + e^{(E - E_F/KT)}}$$

$$0.5 + 0.5\, e^{(E - E_F/KT)} = 1$$

$$0.5\, e^{(E - E_F/KT)} = 0.5$$

$$\frac{E - E_F}{KT} = 0$$

$$E = E_F$$

$$E = 3.13 eV$$