Tribhuvan University
Institute of Science and Technology
2074

Bachelor Level / First Year/ First Semester/ Science
Computer Science and Information Technology (PHY. 113)
(Physics)

Full Marks: 60
Pass Marks: 24
Time: 3 hours.

Candidates are required to give their answers in their own words as for as practicable.
The figures in the margin indicate full marks.

Attempt <u>any two</u> questions: (10×2=20)

1. Explain equilibrium current across the *pn* junction? Use Fermi-Dirac statistics and Maxwell-Boltzmann distribution to show the flow *n* to *p* is equal to the flow from *p* to *n*. How electron current from p to n (that is, associated with minority carries) is not affected by the height of the potential energy barrier? Explain. (10)

2. Describe moment of inertia and torque for a rotating rigid body. Find the expression for rotational kinetic energy and discuss the conditions for conservation. (10)

3. Explain the theory of black body radiation. Why this theory needs quantum mechanical interpretation? How this interpretation became experimentally successful? Explain. (10)

Attempt <u>any eight</u> questions: (5×8=40)

4. Explain Hall effect and discuss the importance of Hall voltage while manufacturing electronic devices. (5)

5. Discuss effective mass of electrons and holes. (5)

6. Describe electrical conductivity of semiconductors. (5)

7. An oscillating block of mass 250 g takes 0.15 sec to move between the endpoints of the motion, which are 40 cm apart. (a) What is the frequency of the motion? (b) What is the amplitude of the motion? (c) What is the force constant of the spring? (5)

8. A current of 50 A is established in a slab of copper 0.5 cm thick and 2 cm wide. The slab is placed in a magnetic field B of 1.5 T. The magnetic field is perpendicular to the plane of the slab and to the current. The free electron concentration in copper is $8.4. \times 10^{28}$ electrons/m^3. What will be the magnitude of the Hall voltage across the width of the slab? (5)

9. The uncertainty in the position of a particle is equal to the de Broglie wavelength of the particle. Calculate the uncertainty in the velocity of the particle in terms of the velocity of the de Broglie wave associated with the particle. (5)

10. (a) How many atomic states are there in hydrogen with $n = 3$? (b) How are they distributed among the subshells? Label each state with the appropriate set of quantum numbers n, l, m_l, m_s. (c) Show that the number of states in a shell, that is, states having the same n, is given by $2n^2$. (5)

11. Copper has a face-centered cubic structure with a one-atom basis. The density of copper is 8.96 g/cm^3 and its atomic weight is 63.5 g/mole. What is the length of the unit cube of the structure? (5)

12. The output of a digital circuit (y) is given by this expression.

$$y = (B + \overline{CB} \cdot A)(\overline{A+C})$$

where A, B and C represent inputs

Draw a circuit of above question using OR, AND and NOT Gate and hence find its truth table (5)

Q.N;1

Explain equilibrium current across the P-N Junction Use Fermi-Dirac statistics and Maxwell Boltzmann distribution to show Flow n to P is equal to the flow from P to N. How electron current from P to N is not affected by the height of the potential energy barrier? Explain.

Equilibrium Current across the P-N Junction

When P-N junction is formed a potential barrier ie ∂V is formed that stops the flow of majority charge carrier across the junction. At junction equal amount of electrons and holes are continuously flowing in opposite direction so that net flow is zero. This is the equilibrium current across the P-n Junction

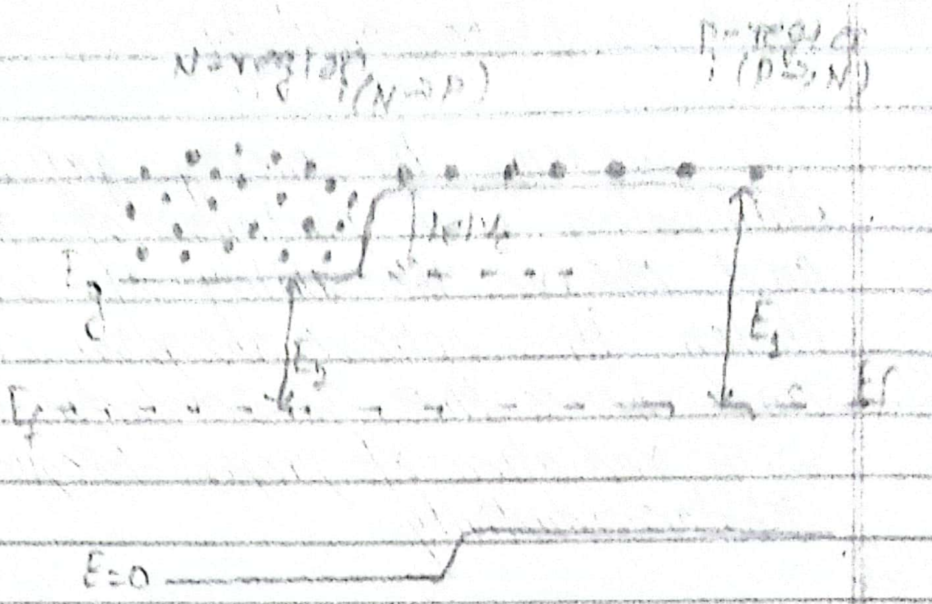


fig:- Equilibrium is established

Here, we consider flow of electrons in conduction band. So, N_e is given by

$$N_e = N_c \, e^{\frac{-(E_g - E_f)}{k_B T}} \quad \text{--- ①}$$

eq^n ① gives the free electrons concentration for both types of semiconductor $E_g - E_f$ is much greater for P types than N-types. The electron in the conduction band of P region are not impeded by the potential barrier crossing the Junction from P-side. So, N-side electron current from P to N is $i(P \to N)$. We can write this

$$i(P \to N) = A \, e^{\frac{-E_i}{k_B T}} \quad \text{--- ②}$$

where A is constant "$E_i = E_g - E_f$"

The electron current $i(N \to P)$ will be proportional to the no. of electrons in the N-region with energies greater than or equal to V_c.
i.e $i(N \to P) = A N_e f(E \geq |e|V_c)$ --- ③

where, N_e is the total numbers of electrons in the conduction band of N-side of $f(E \geq |e|V_c)$ is the fraction of these electrons with energies greater than or equal to $|e|V_c$. The Fermi Dirac distribution can be approximated by the Maxwell Boltzmann distribution. The system of ~~pra~~ particles having Maxwell Boltzmann distribution of energies the function of particles with energies greater than or equal to E_1 is $e^{-\left(\frac{E_1}{k_B T}\right)}$

we have relations

$$F(E \geq |e|V_c) = e^{\frac{-|e|V_c}{k_B T}} \quad --- ④$$

putting the value of $N_e = e^{-\frac{(E_c - E_f)}{k_B T}}$ and

$F(E \geq |e|V_c)$ in eq^n ③ we get,

$$i(N \to P) = A e^{-\frac{E_2 + |e|V_c}{k_B T}} \quad --- ⑤$$

where, $E_2 = E_g - E_f$ in N region
we have relation $E_2 + |e|V_c = E_1$

So eq^n ⑤ became

$$i(N \to P) = A\, e^{\frac{-E_1}{K_B T}} \quad ---- (6)$$

From eq^n (2) and (6)

$$i(N \to P) = i(P \to N) \quad --- (7)$$

Therefore the flow of electron from N to P is equal to P to N. Thus Net current is zero. This is the condition of equilibrium current across the P-N junction.

Net Flow of charge carries across the P-N Junction

When an external voltage V is applied across the diode in the Forward bias, the height of the potential barrier at P-N junction is $|e|(V_c - V)$. The net electron current from N-side to P-side is

$$i = i(N \to P) - i(P \to N) \quad ---- (8)$$

The first term represents the flow of electrons from (N to P) Height of barrier is $|e|(V_c - V)$ so we can write

$$i(N \to P) = A\, e^{\frac{-E_2 + |e|(V_c - V)}{K_B T}} \quad --- (9)$$

we know that $i(P \to N)$ represents the flow of electrons (minority carrier) from P to N is the same.

$$i(P \to N) = A\, e^{\frac{-E_1}{k_B T}} \quad --- (10).$$

using eq^n (10) and (9) in eq^n (8)

$$i = A\, e^{\frac{-E_2 + |e|(V_c - V)}{k_B T}} - A\, e^{\frac{-E_1}{k_B T}} \quad --- (11)$$

we have,

$$E_2 + |e| V_c = E_1 = E_g - E_f$$

$\boxed{V_c = \text{conduction band}}$

eq^n (11) becomes

$$i = A\, e^{\frac{-(E_1 - |e|V)}{k_B T}} - A\, e^{\frac{-E_1}{k_B T}}$$

$$i = A\, e^{\frac{-E_1}{k_B T}} \left(e^{\frac{|e|V}{k_B T}} - 1 \right)$$

let $I_0 = A\, e^{\frac{-E_1}{k_B T}}$ so that

$$\boxed{I = I_0 \left(e^{\frac{|e|V}{k_B T}} - 1 \right)}$$

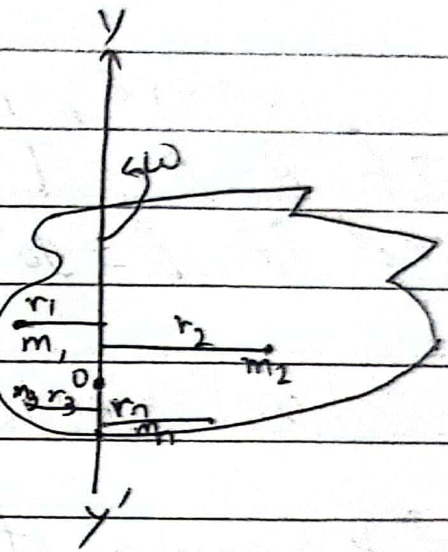
This equation is called diode equation

$I_0 = A\, e^{\frac{-E_1}{k_B T}}$ is the current associated with minority carries From P to N. which is not affected by the height of potential barrier is proved.

Explain moment of Inertia of the rigid body and Torque. Also find the Rotational kinetic energy of rigid body and condition of conservation.

Q.N;2

Moment of Inertia of the rigid body:-



Let M be the Total mass of rigid body, it has maximum number of particle having masses $m_1, m_2 \ldots m_n$ and distance from axis of rotation are $r_1, r_2 \ldots r_n$. The moment of inertia of particle becomes

$$I_1 = m_1 r_1^2$$
$$I_2 = m_2 r_2^2$$
$$\vdots \qquad \vdots$$
$$I_n = m_n r_n^2$$

The moment of Inertia of the rigid body becomes sum of the moment of individual particle.

$$I = I_1 + I_2 + I_3 + \cdots + I_n$$

$$I = m_1 r_1^2 + m_2 r_2^2 + \cdots + m_n r_n^2$$

$$\boxed{I = \sum_{i=1}^{n} m_i r_i^2}$$

Torque

Moment of the force is called Torque. It is denoted by τ. It is vector quantity. Mathematically It is the product of force and perpendicular from the axis of rotation.

$$\tau = \vec{r} \times \vec{f} \quad --- (1)$$

It's unit is Nm and Dimension is $[ML^2T^{-2}]$

eqn (1) can be written as

$$\tau = rf\sin\theta\,\hat{n}$$

where, $\hat{n}$ is the unit vector

If $\theta = 0°$, $\tau = 0$ which is minimum value

and if $\theta = 90°$, $\tau = Fr$ which is maximum value.

Rotational kinetic energy

Let M be the mass of rigid body. It consists of the number of particle of masses $m_1, m_2, m_3 \cdots m_n$ and distance from axis of rotation are $r_1, r_2, r_3 \cdots r_n$. which is shown in figure. The particle having same angular velocity ω but different Linear velocity

$$v_1 = r_1\omega, \quad v_2 = r_2\omega, \quad v_3 = r_3\omega \quad \cdots \quad v_n = r_n\omega$$

Rotational kinetic energy of individual particles are

$$E_1 = \frac{1}{2} m v_1^2 = \frac{1}{2} m_1 r_1^2 \omega^2$$

similarly,

$$E_2 = \frac{1}{2} m_2 r_2^2 \omega^2$$

$$E_3 = \frac{1}{2} m_3 r_3^2 \omega^2$$

$$\vdots$$

$$E_n = \frac{1}{2} m_n r_n^2 \omega^2$$

Total Rotational Kinetic energy of rigid body is equal to the sum of rotational Kinetic energy of individual particle.

$$E = E_1 + E_2 + E_3 + \cdots + E_n$$

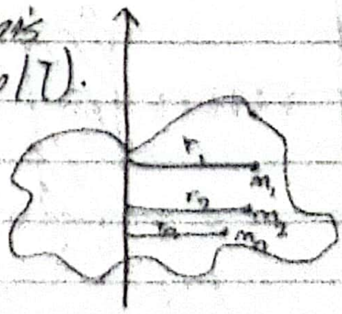
$$E = \frac{1}{2} m_1 r_1^2 \omega^2 + \frac{1}{2} m_2 r_2^2 \omega^2 + \frac{1}{3} m_3 r_3^2 \omega^2 + \cdots + \frac{1}{2} m_n r_n^2 \omega^2$$

$$E = \frac{1}{2} \left[\sum_{i=1}^{n} m_i r_i^2 \right] \omega^2$$

There are two conservation, They are conservation of momentum and Energy. The momentum is conserved if there are no application of Force or Torque. Energy is conserved if energy becomes constant in any point after certain intervall of time.

Relation between torque and moment of inertia

Consider a body rotating about an axis under the action of constant torque(τ). suppose the body consist of n number of particle of mass $m_1, m_2 \cdots m_n$ at perpendicular distance $r_1, r_2 \cdots r_n$.



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Then,
Linear acceleration of first particle is given by

$$a_1 = r_1 \alpha$$

Then,
the force acting on that particle is

$$F_1 = m_1 a_1$$

And
magnitude of torque on that particle is

$$\tau = r_1 F_1$$

$$\tau = r_1 m_1 a_1$$

$$\tau = r_1 m_1 r_1 \alpha$$

$$\tau = m_1 r_1^2 \alpha$$

Similarly,
Total torque on that body is

$$\tau = \tau_1 + \tau_2 + \tau_3 + \cdots + \tau_n$$

$$\tau = m_1 r_1^2 \alpha + m_2 r_2^2 \alpha + m_3 r_3^2 \alpha + \cdots + m_n r_n^2 \alpha$$

$$\tau = \left(\sum_{i=1}^{n} m_i r_i^2 \right) \alpha$$

$$\boxed{\tau = I\alpha}$$

Q.N;3

What is blackbody and blackbody radiation? Explain the characteristics of black body radiation.

→ A perfectly black body is the body which absorbed incident heat radiation of the wavelength that fall on it. The body neither reflects nor transmit heat when it is heated. It emit heat radiation is called black body radiation. The range of wavelength of black body is independent of the material of body and depends upon the temperature of body.

Characteristics

(i) The spectrum is continuous with Broad maximum. When graph is plotted, $I(f)$ verbs (f) gives the radiate energy per frequency, per unit time per unit area of black body.

(ii) The integral $I(f)$ over all (f) is called I_T. for the radiate energy per frequency gives rise to the 4th power of T. This is law of stefan Boltzmann law.

$$\int_0^\infty I(f)d(f) = \int_0^\infty I(f)df = \sigma T^4$$

where,

σ = stefan's constant $= 5.67 \times 10^{-8} Wm^{-2}K^{-4}$

(iii) The maximum frequency of the spectrum is directly proportional to Temperature which is shown in the graph.

i.e. $F_{max} \propto T$

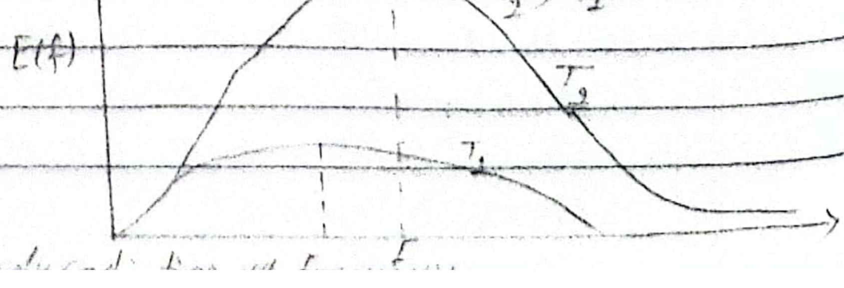

Fig: Intensity of Black body radiation ...

Hall Effect Q.N;4

When magnetic field is applied to the current carrying conductor the voltage is developed across the conductor. The direction ~~is~~ of voltage is perpendicular to the direction of both magnetic field and current. This phenomenon is called Hall effect and voltage developed is called Hall voltage.

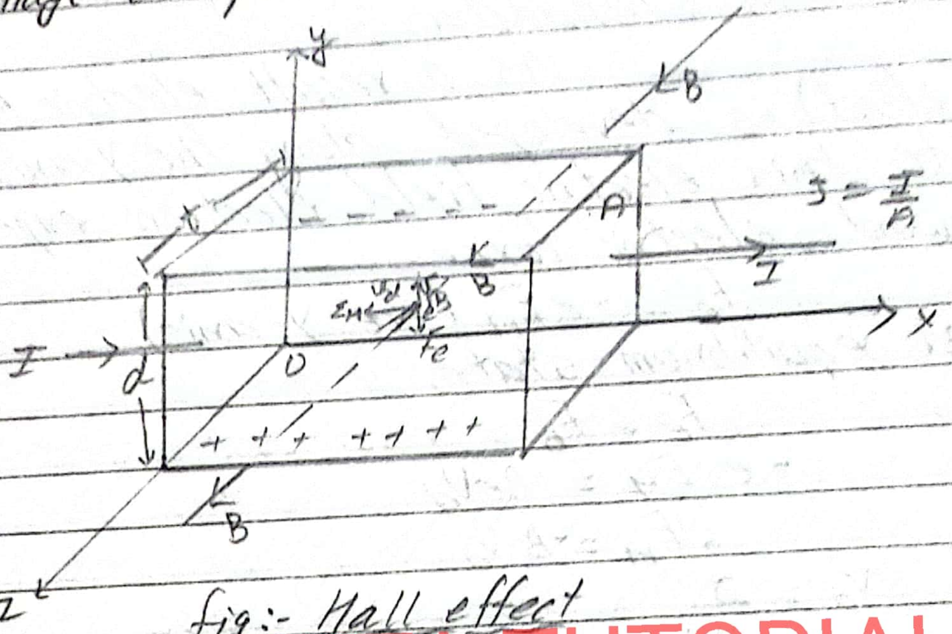

fig:- Hall effect

Explanation:-

Let us consider, a conductor in the form of rectangular strip of thickness 't' having cross sectional area 'A'. If current 'J' is flowing in the conductor along x-axis, then current density $(J = \frac{I}{A})$ is also along x-axis

So that drift velocity of electron,

$$v_d = \frac{J}{ne} \quad --- (1)$$

Now, magnetic field intensity B is applied in the conductor along z-axis. Hence, magnetic force experienced

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by electron $\boxed{F_B = BeV_d}$ acting upward (+ve Y-axis) due to this force, electrons are collected at the top of conductor resulting -ve charge. According to conservation of charge, +ve charge is developed at the bottom of conductor.

As a result electric field "E_H" (Hall effect) is developed along the Y-axis (+ve to -ve). Due to this electric field electron experienced downward electric force,

$$F_e = -eE_H \text{ (-ve Y-axis)}$$

At equilibrium state,

$$F_e = F_B$$

$$-e \cdot E_H = BeV_d$$

$$E_H = -B \cdot V_d$$

put $V_d = \frac{J}{ne}$

$$\boxed{E_H = -\frac{JB}{ne}}$$

$\frac{1}{ne}$ = constant for given conductor known as Hall coefficient (R_H)

$$E_H = -R_H \cdot JB$$

$$\boxed{R_H = -\frac{E_H}{JB}}$$

If "d" be the width of conductor then

Hall voltage $V_H = E_H \cdot d$

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$$V_H = \frac{-JB}{ne} \cdot d$$

Put $J = \frac{I}{A} = \frac{I}{t \times d}$

$$\Rightarrow \boxed{V_H = \frac{-BI}{net}}$$

$$\frac{-1}{ne} = \text{constant} = R_H$$

$$R_H = \frac{E_H}{JB}$$

Q.N Discuss effective mass of electron and holes.

Q.N;5

⇒ The electron in a crystal aren't completely free but interact with periodic potential of crystal lattices so their motion is different due to this, mass becomes altered. This altered value of periodic Mass (is) called effective mass. It is denoted by m^*

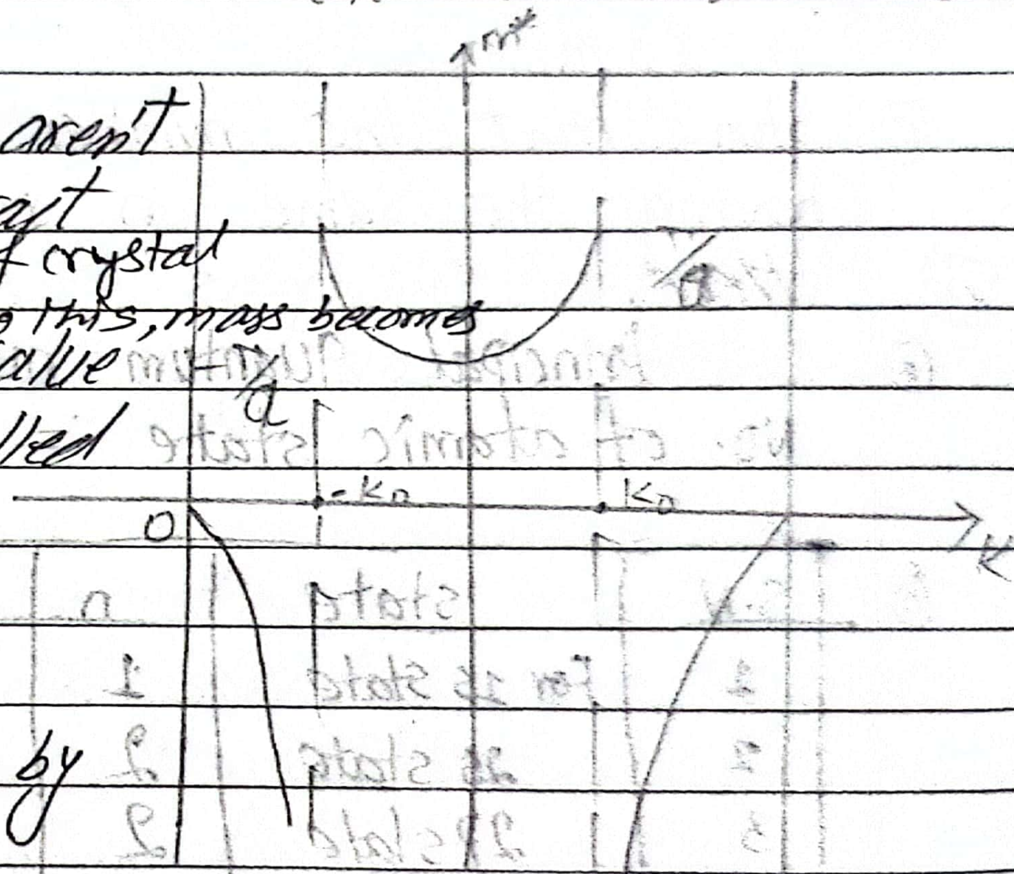

fig - Variation of effective mass with wave vector k

Group velocity V_g is given by

$$v_g = \frac{d\omega}{dK} \quad \text{---(1)}$$

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From debroglie equation

$$E = \hbar\omega \quad , \quad P = \hbar k$$

$$\omega = \frac{E}{\hbar}$$

$$d\omega = \frac{dE}{\hbar}$$

$$\frac{d\omega}{dk} = \frac{1}{\hbar}\left(\frac{dE}{dk}\right) \quad --- (2)$$

From eq^n (1) and (2)

$$v_g = \frac{1}{\hbar}\left(\frac{dE}{dk}\right) \quad ---- (3)$$

Differentiating eq^n (3) w.r. to 't'

$$\frac{dv_g}{dt} = \frac{1}{\hbar}\frac{d}{dt}\left(\frac{dE}{dk}\right)$$

$$a = \frac{1}{\hbar^2}\left(\frac{d^2E}{dk^2}\right)\left(\hbar\frac{dk}{dt}\right) \quad --- (4)$$

From Newton's 2nd Law

$$F = ma$$

$$a = \frac{F}{m} \quad --- (5)$$

equating eq^n (4) and (5) we get, (It is not free electron)

$$\frac{F}{m} = \frac{1}{\hbar^2}\left(\frac{d^2E}{dk^2}\right) \times \left(\hbar\frac{dk}{dt}\right)$$

$$\text{or,} \quad \frac{1}{m^*} = \frac{1}{\hbar^2}\left(\frac{d^2E}{dk^2}\right) \quad --- (6)$$

$$\therefore m^* = \left[\frac{\hbar^2}{\left(\frac{d^2E}{dk^2}\right)}\right] \quad --- (7)$$

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This expression gives the effective mass electron on crystal.

In case of free electron

Taking

$$E = \frac{p^2}{2m}$$

$$\frac{dE}{dk} = \frac{\hbar^2 k}{m}$$

$$\frac{d^2E}{dk^2} = \frac{\hbar^2}{m}$$

$$\therefore m = \left[\frac{\hbar^2}{\left(\frac{d^2E}{dk^2}\right)}\right] \quad \text{---} \quad (8)$$

Thus from equation (7) and (8) calculate that, when electron is free effective mass is true.

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Electrical Conductivity of an intrinsic Semiconductor

Electrical conductivity of intrinsic semiconductor due to electrons and holes

Q.N;6

$$J_e = \sigma_e E$$
$$J_h = \sigma_h E \quad \text{---} (1)$$

where J_e and J_h are current density of electrons and holes. Current density including drift velocity is given by.

$$J_e = n(-e) v_{de} \quad \text{---} (2)$$
$$J_e = nev$$
$$J_e = ne\mu_e E \quad \text{---} (3)$$

Similarly for holes,

$$J_h = Pe\mu_h E \quad \text{---} (4)$$

from eq^n (1) (3) and (4)

$$\sigma_e = ne\mu_e$$
$$\sigma_h = Pe\mu_h \quad \text{---} (5)$$

Total electrical conductivity

$$\sigma = \sigma_e + \sigma_h$$
$$\sigma = ne\mu_e + Pe\mu_h$$
$$\sigma = e(n\mu_e + P\mu_h) \quad \text{---} (6)$$

In Intrinsic semiconductor $n = p = n_i$

but

$$\cancel{n_i =}\; n_i = \sqrt{N_c N_v}\; e^{-\frac{E_g}{2k_BT}}$$

where,

$$N_v = 2\left(\frac{m_e k_B T}{2\pi\hbar^2}\right)^{3/2}, \quad N_c = 2\left(\frac{m_e k_B T}{2\pi\hbar^2}\right)^{3/2}$$

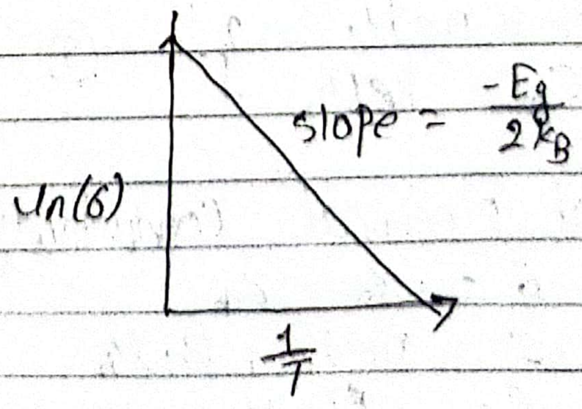
so,

$$\sigma = e n_i(\mu_e + \mu_h)$$

or, $$\sigma = e(\mu_e + \mu_h)\sqrt{N_c N_v}\; e^{-\frac{E_g}{2k_BT}}$$

$$\therefore \boxed{\sigma = \sigma_0\, e^{-\frac{E_g}{2k_BT}}}$$

where, $\sigma_0 = \sqrt{N_c N_v}\,|e|(\mu_e + \mu_h)$ is constant and independent of temperature.
Graph between $\ln(\sigma)$ and $\frac{1}{T}$ is given in figure which shows that conductivity is exponentially dependent $e^{-\frac{E_g}{2k_BT}}$



An oscillating block of mass 250kg takes 0.15sec to move between the end points of the motion which are 40cm apart

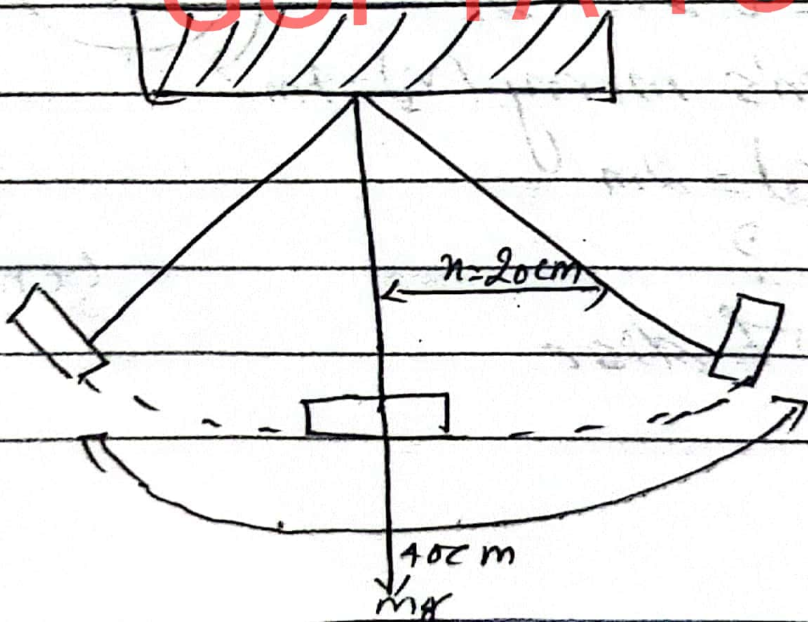
Q.N;7

ⓐ What is the frequency of motion?

ⓑ What is the amplitude of motion?

ⓒ What is force constant of the spring.

20)



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Given,

Block of mass $(m) = 250\,kg$

Time taken $(T) = 0.15\,sec$

ⓐ Frequency $(f) = ?$

ⓑ Amplitude of motion $(X_m) = ?$

ⓒ Force constant $(K) = ?$

we know,

ⓐ $$F = \frac{1}{T} = \frac{1}{0.15} = 6.66\,Hz$$

ⓑ X_m = midpoint of Total amplitude (40cm)

$$= \frac{40}{2} = 20\,cm$$

ⓒ $$T = 2\pi\sqrt{\frac{m}{K}}$$

or, $$\frac{T}{2\pi} = \sqrt{\frac{m}{K}}$$

s.b.s

$$\frac{T^2}{4\pi^2} = \frac{m}{K}$$

$$K = \frac{m4\pi^2}{T^2} = \frac{250 \times 4 \times \pi \times \pi}{(0.15)^2}$$

$= \cancel{439,621.22\,N/m}$ $438649.08\,N/m$

The current of 50A is established in a slab of copper 0.5cm ~~wide~~ thick and 2cm wide. The slab is placed in a magnetic field B of 1.5T. The magnetic field is perpendicular to the plane of slab and to the current. The free electron concentration in copper is 8.9×10^{28} electrons/m^3. What will be the magnitude of Hall voltage across the width of slab.

Q.N;8

Sol Given,

Current $(I) = 50A$

Magnetic field $(B) = 1.5T$

Wide $(b) = 2\times10^{-2} m^2$

Concentration of copper $(N) = 8.4\times10^{28}$ electrons/m^3.

Hall voltage $(V_H) = ?$

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$$Area (A) = b \times wide$$

$$= 0.5 \times 10^{-2} \times 2 \times 10^{-2}$$

$$= 1 \times 10^{-4} m^2$$

we know,

$$\text{Hall voltage } (V_H) = \frac{IBb}{NqA}$$

$$= \frac{50 \times 1.5 \times 2 \times 10^{-2}}{8.4 \times 10^{28} \times 1.6 \times 10^{-19} \times 1 \times 10^{-4}}$$

$$= 1.12 \times 10^{-6} V_{//}$$

The uncertainty in the position of the particle is equal to the debroglie wavelength of particle. Calculate the uncertainty in the velocity of the particle in terms of the velocity of the de-broglie wave associated with the particle.

Q.N;9

Sol we know that,

$$\Delta x \cdot \Delta P = \frac{h}{2\pi}$$

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$$\Delta x = \frac{h}{2\pi m \Delta v} \quad \text{---} \quad (1)$$

Again from de-broglie hypothesis

$$\lambda = \frac{h}{mv} \quad \text{---} \quad (11)$$

According to question, from eqn (1) and (11) we get,

$$\frac{h}{2\pi \cancel{m} \Delta v} = \frac{h}{\cancel{m} v}$$

$$\Delta v = \frac{v_{wave}}{2\pi}$$

Hence, the uncertainty in velocity is equal to the $\frac{1}{2\pi}$ times velocity of the de-broglie wave.

(a) How many atomic states are there in hydrogen atom n=3.
(b) How are they distributed among the subshell label each states with appropriate set of quantum number n, l, m_l, m_s.

Q.N;10

(c) Show that the number of state in shell that is states having the same n is given by $2n^2$

Here,

(a) Principal quantum number (n) = 3

$$\text{No. of atomic state} = \frac{n(n+1)}{2} = \frac{3(3+1)}{2} = 6$$

(b)

S.N	state	n	l	m_l	m_s	No. of state in shell
1	For 1s state	1	0	0	½	1
2	2s state	2	0	0	½	1
3	2P state	2	1	0, ±1	½	3
4	3s ~~3ls~~ state	3	0	0	½	1
5	3P state	3	1	0, ±1	½	3
6	3d state	3	2	0, ±1, ±2	½	5

(n-1)

s=1 No. of state in shell
p=3
d=5

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(c) Now,

The number of states in shell having quantum number $1s^2, 2s^2 2p^6, 3s^2 3p^6 = 18$

Copper has face centered cubic structure with one atom basis. The density of copper is 8.96 gm/cm^3 and it's at. wt is 63.5 gm/mole. What is the length of the unit of the structure

Q.N;11

length (a) = ?

Density (ρ) = 8.96 gm/cm^3

No. of atoms per unit cell (N) = 4

Atomic wt of copper (m) = 63.5 gm/mole

Face centered cubic st (N) = 4

For body centered cubic st (N) = 2

For simple centered cubic st (N) = 1

using Formula,

$$\frac{N}{V} = \frac{\rho N_A}{m}$$

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or, $\frac{N}{a^3} = \frac{\rho N_A}{m}$

or, $a^3 = \frac{Nm}{\rho N_A} = \frac{4 \times 63.5}{8.96 \times 6.023 \times 10^{23}}$

or, $a^3 = 4.71 \times 10^{-23}$

or, $a = 3.61 \times 10^{-8}$ cm

$\therefore \boxed{a = \cancel{3.61 A^0}}$ $\cancel{0.361}$ $3.61 A^0$

$\therefore$ The length of unit cube of the structure is $3.61 A^0$

The output of a digital circuit Y is given by $Y = (B + \bar{C}\bar{B}A)(\overline{A+C})$ where A, B, C are inputs. Draw circuit of above equation using OR, AND and NOT gate. find it's Truth table.

Q.N;12

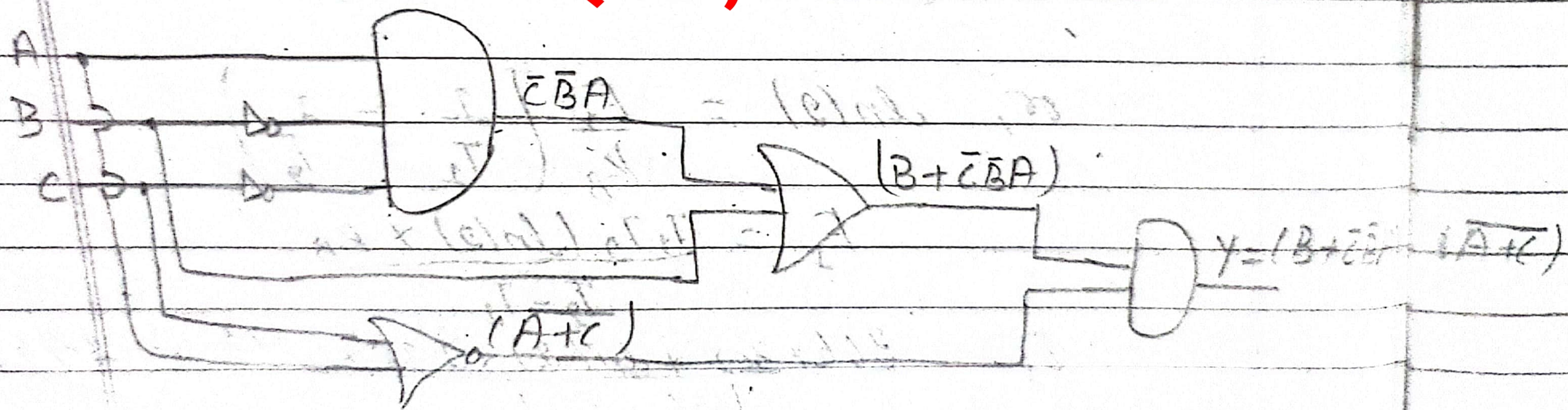

fig:- Circuit diagram

Truth Table

Input			Intermediated state							output
A	B	C	$\bar{C}$	$\bar{B}$	$A+C$	$\overline{A+C}$	$\bar{C}\bar{B}$	$\bar{C}\bar{B}A$	$B+\bar{C}\bar{B}A$	Y
0	0	0	1	1	0	1	1	0	0	0
0	0	1	0	1	1	0	0	0	0	0
0	1	0	1	0	0	1	0	0	1	1
0	1	1	0	0	1	0	0	0	1	0
1	0	0	1	1	1	0	1	1	1	0
1	0	1	0	1	1	0	0	0	0	0
1	1	0	1	0	1	0	0	0	1	0
1	1	1	0	0	1	0	0	0	1	0