Shri Swami Vivekanand Shikshan Sanstha's

Vivekanand College, Kolhapur (Empowered Autonomous).

Department of Physics

Date: 02/09/2024

Internal Examination Notice

The students of B.Sc. I, II and III are hereby informed that the internal examination of current semester is scheduled as per following time table:

Sr. No.	Class and Sem	Paper No.	Title of the paper	Date and time
1.	B.Sc. I, SEM I	I	Mechanics I	24/09/2024 10: 00 to 11:00 am
2.	B.Sc. I, SEM I	II	Electricity and Magnetism I	25/09/2024 10: 00 to 11:00 am
3.	B.Sc. II, SEM III	V	Thermal and statistical mechanics I	24/09/2024 10: 00 to 11:00 am
4.	B.Sc. II, SEM III	VI	Waves and Oscillations	25/09/2024 10: 00 to 11:00 am
5.	B.Sc. III, SEM V	IX	Mathematical Physics	24/09/2024 12:00 to 01:00 pm
6.	B.Sc. III, SEM V	X	Nuclear and Particle Physics	25/09/2024 12:00 to 01:00 pm
7.	B.Sc. III, SEM V	XI	Quantum physics	26/09/2024 12:00 to 01:00 pm
8.	B.Sc. III, SEM V	XII	Solid state physics I	27/09/2024 12:00 to 01:00 pm

Nature of question paper

- **For B.Sc. I and II**

Total Marks (for each paper) = 10

Q: 1) Select correct alternative (4 marks)

Q: 2) Short answer question (any two out of three) (08 marks)

- **For B.Sc. III**

Total Marks (for each paper) = 15

Q: 1) Select correct alternative (3 marks)

Q: 2) Short answer question (any three out of four) (12 marks)

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SSPatil

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DEPARTMENT OF PHYSICS
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Department of Physics

B.Sc. / M.Sc. Part – III, Semester – V, PHYSICS Paper - IX, X, XI, XII

Title of the Paper: ~~Mathematical~~ Physics

Name of Teacher: Mr. A. N. Gore

Attendance Sheet

Sr. No.	Name of the Student	24/09/24 Paper IX	25/09/24 X	26/09/24 XIV	27/9/24 Paper XII			
1)	Sakshi Biranje	S.R.Biranje	S.R.Biranje	S.R.Biranje				
2)	Seema Hiremath	[signature]	[signature]	[signature]	[signature]			
3)	Ritu. R. Nishad	R.Nishad	R.Nishad	R.Nishad	R.Nishad			
4)	Samruddhi S. Ranmale	P.Ranmale	P.Ranmale	P.Ranmale	P.Ranmale			
5)	Surekha T. Desai	S.Desai	S.Desai	S.Desai	S.Desai			
6)	Ritesh S. Savtekar	[signature]	[signature]	[signature]				
7)	Gaurav A Dadarne	[signature]	[signature]	[signature]	[signature]			
8)	Atharv H. Kagnolkar	AHK.	AHK.	AHK.	AHK.			
9)	Tanishq A. Mude	[signature]	[signature]	[signature]	[signature]			
10)	Saad Sanjay Hasbe	Shaad	Shaad	Shaad	Shaad			
11)	Sahil Chetan Patnekar	Sahil.	Sahil.	Sahil.	Sahil.			
12)	Riya Dattatray Patil	R.D.Patil	R.D.Patil	R.D.Patil	R.D.Patil			
13)	~~Surekha T. Desai~~							
14)								
15)								
16)								
17)								
18)								
19)								
20)								

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"Education for Knowledge, Science and Culture"
-Shikshanmaharshi Dr. Bapuji Salunkhe
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Department of Physics

B.Sc. Part-III SEM V Examination (2024-25)
Mathematical Physics
Paper IX (Paper code: DSC-1001E1)

Date : 24 /09 /2024 — Total Marks: 15
Day : 12.00 to 1.00 pm — Time :-

Instructions:-

1) All questions are compulsory.
2) Figures to the right indicate full marks.
3) Use of log table and calculator is allowed.

Q.1) Select correct alternative **(3)**

1. The 'i' in complex number is represented by--------.

   (a)) 1 (b) -1
   (c) $\sqrt{4}$ (d) $\sqrt{-2}$

2. If f(z) is analytic and its derivative is continuous at all points inside and an simple closed curve C, then $\int_c^{\square} f(z)dz =$ --------.

   (a) 0 (b) π
   (c) 2π (d) ∞

3. A point at which function f(z) is not analytic is known as ---------

   (a) singular point (b) analytic point
   (c) isolated point (d) removable point

Q.2 Attempt any THREE **(12)**

1. Derive the necessary condition for function f(z) to be analytic in given region R.
2. Evaluate $\int_c^{\square} \frac{e^z}{z^2+1} dz$; $|z| = 2$
3. Discuss the analyticity of the function $f(z)=z^3$
4. Evaluate $\int_c^{\square} \frac{z+4}{z^2+2z+5} dz$ over the circle $|z + 1| = 1$

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Name - Sakshi Raju Bizanje

Date: 24/07/2024

$\frac{15}{15}$

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VIVEKANAND COLLEGE, KOLHAPUR (AUTONOMOUS)

SUPPLIMENT	Signature of Supervisor
Suppliment No. : 1	Subject : - physics mathematical (Internal) Exam
Roll No. : 8201	Test / Tutorial No. :
Class : BSC-TY	Div. :

Q1

Q 1 c] $\sqrt{-1}$ 1

2 a] 0 1

3 a] singular point 1

03

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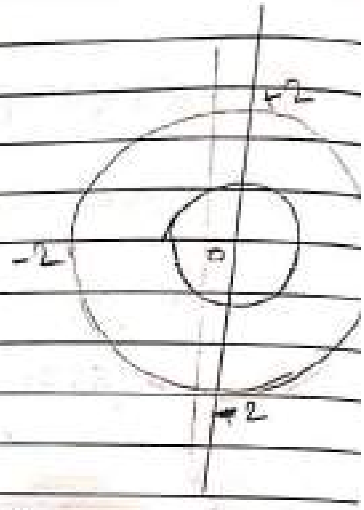
Given

Q2 $\displaystyle\int_c \frac{e^z}{z^2+1}\,dz \quad |z|=2$



sol^n.

$z^2+1=0$

$z^2=-1$

$\underline{z=\pm i}$

$z=i$	$z=-i$
$x+iy=i$	$x+iy=-i$
$x=0$	$x=0$
$y=1$	$y=-1$

$|z-z_0|=r$

$c=z_0=0$

$\underline{r=2}$

$$\int_c \frac{e^z}{z^2+1}\,dz = \int_c e^z\left\{-\frac{1}{2i}\left[\frac{1}{z+i}-\frac{1}{z-i}\right]\right.$$

$$= -\frac{1}{2i}\int_c \frac{e^z}{z+i}\,dz + \frac{1}{2i}\int_c \frac{e^z}{z-i}\,dz$$

$$= -\frac{1}{2i}2\pi i\,e^{-1} + \frac{1}{2i}2\pi i\,e^{1}$$

$$= \pi\left(e^{1}-e^{-1}\right)$$

Ans

$$\therefore \int \frac{e^z}{z^2+1}\,dz = \pi\left(e^{1}-e^{-1}\right)$$

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Q3 Analytical function :-
single valued function $f(z)$ which is differentiable at $z = z'$ called as Analytical function

Given function $f(z) = z^3$

$$f(z) = \cancel{u}\,x + iy$$
$$z^3 = (x + iy)^3$$
$$= x^3 + 3x^2 iy + 3x(iy)^2 + (iy)^3$$
$$= x^3 + 3x^2 iy + (-3xy^2) - iy^3$$

$$\because \boxed{\begin{matrix} i^2 = -1 \\ i^3 = -i \end{matrix}}$$

$$= x^3 + 3x^2 iy - 3xy^2 - iy^3$$
$$= (x^3 - 3xy^2) + (3x^2 iy - iy^3)$$
$$z^3 = (x^3 - 3xy^2) + (3x^2y - y^3)\,i$$

we got $u = x^3 - 3xy^2$ $v = 3x^2y - y^3$

Now

$\frac{\partial u}{\partial x} = 3x^2 - 3y^2$ ①	$\frac{\partial v}{\partial x} = 6xy - 0$ ③
$\frac{\partial u}{\partial y} = \cancel{6} - 6yx$ ②	$\frac{\partial v}{\partial y} = \cancel{8x}\ 3x^2 - 3y^2$ ④

$\therefore$ from ① ② ③ ④

$$\boxed{\frac{\partial u}{\partial x} = \frac{\partial v}{\partial y}} \quad \boxed{\frac{\partial u}{\partial y} = -\frac{\partial v}{\partial x}}$$

$\therefore$ Given function $f(z) = z^3$ is analytical.

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Given

Q4 $\int_c \frac{z+4}{z^2+2z+5}\,dz$ over the circle $|z+1| = 1$

To Polar indicator to given we are going to ~~et~~ consider denominator equal to 0

$$z^2 + 2z + 5 = 0$$

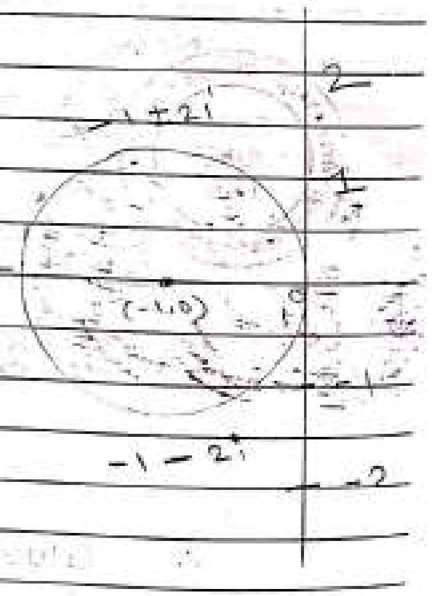
$$z = \frac{-2 \pm \sqrt{4-20}}{2} \qquad \because x = \frac{-b \pm \sqrt{b^2-4ac}}{2a}$$

$$= \frac{-2 \pm 4i}{2}$$

$$z = -1 \pm 2i$$

The given circle $|z+1| = 1$ at centre ~~$|z+1| = 1$~~ $z = -1$ and Radius of unity does not enclose in singularity function

$$\therefore \boxed{\int \frac{z+4}{z^2+2z+5} = 0}$$



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SUPPLIMENT

Signature of Supervisor

Suppliment No. :

Roll No. :

Class :

Subject :

Test / Tutorial No. :

Div. :

The Analytical function

The ~~singule~~ ~~po~~ valued function $f(z)$ which is differentiable at $z = z'$ called as analytical function

The necessary conditions for analytical functions.

$$f(z) = u + iv$$

where u & v are function of x and y

$$\therefore \frac{\partial u}{\partial x} = \frac{\partial v}{\partial y} \qquad \frac{\partial y}{\partial y} = -\frac{\partial v}{\partial y}$$

$$\therefore \frac{\partial u}{\partial y} = -\frac{\partial v}{\partial x}$$

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To Proof above conditions

Let's consider $f(z)$ is an analytical function

$$f(z) = u + iv$$

where u and v are functions of x and y respectively

Let δu and δv are elimpliments of u and v respectively and δx and δy are elimpliments of x and y.

$$\cancel{d}(d f(z) = u + iv$$

$$d(\cancel{f}(z) - \delta z) = u +$$

$$f(z) = u + iv$$
$$f(z) - \delta z = u + \delta u + iv + \delta v$$

$$(f(z) - \delta z) - f(z) = \delta u + i\delta v$$

$$f(z) = x + iy$$
$$\delta z = \delta x + i\delta y$$

Now

$$f(z) = \lim_{z \to 0} \frac{d(f(z) - \delta z) - f(z)}{f(z)}$$

$$= \lim_{z \to 0} \frac{\delta u + i\delta v}{\delta x + i\delta y}$$

$$= \frac{\partial u}{\partial x} + \frac{i\,\partial v}{i\,\partial y}$$

Along x axis real axis

$$\delta y \to 0 \quad \therefore \quad \delta x = \delta z$$

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$$f(z) = \lim_{x \to 0} \frac{\delta u}{\delta x} + \frac{i\delta v}{i\delta x}$$

$$f(z) = \frac{\partial u}{\partial x} + \frac{\partial v}{\partial x} \quad \text{--- } ①$$

For imaginary axis.

$$\delta x = 0 \qquad i\delta y = \delta z$$

$$= \lim_{i\delta z \to 0} \frac{\delta u + i\delta v}{\delta y + i\delta y}$$

$$= i\frac{\partial u}{\partial y} + \frac{\partial v}{\partial y}$$

$$f(z) = -i\frac{\partial u}{\partial y} + \frac{\partial v}{\partial y} \quad \text{--- } ②$$

By comparing eq^n ① and ② equality of real no. and complex no

$$\boxed{\frac{\partial u}{\partial x} = \frac{\partial v}{\partial y}} \qquad \boxed{\frac{\partial v}{\partial x} = -\frac{\partial u}{\partial y}}$$

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15/15

Date :- 24/9/2024

SUPPLIMENT

Name :- Riya Dattatray Patil

Signature of Supervisor	

Suppliment No. : 1+1 = 2.

Roll No. : 8207

Class : B.Sc III

Subject : Physics (Mathematical Physics)

Test / Tutorial No. : Internal examination

Div. :

Q.1

1) → c) $\sqrt{-1}$

2) → a) 0

3) → a) singular point.

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Q.2

2)

Poles of integrand given by putting denominator equal to zero.

$\therefore z^2+1=0$

$z^2=-1$

$z^2=j^2$

$\boxed{z=\pm j}$

$z_1=+j$ $\quad$ $z_2=-j$

$x=0$ $\quad$ $x=0$

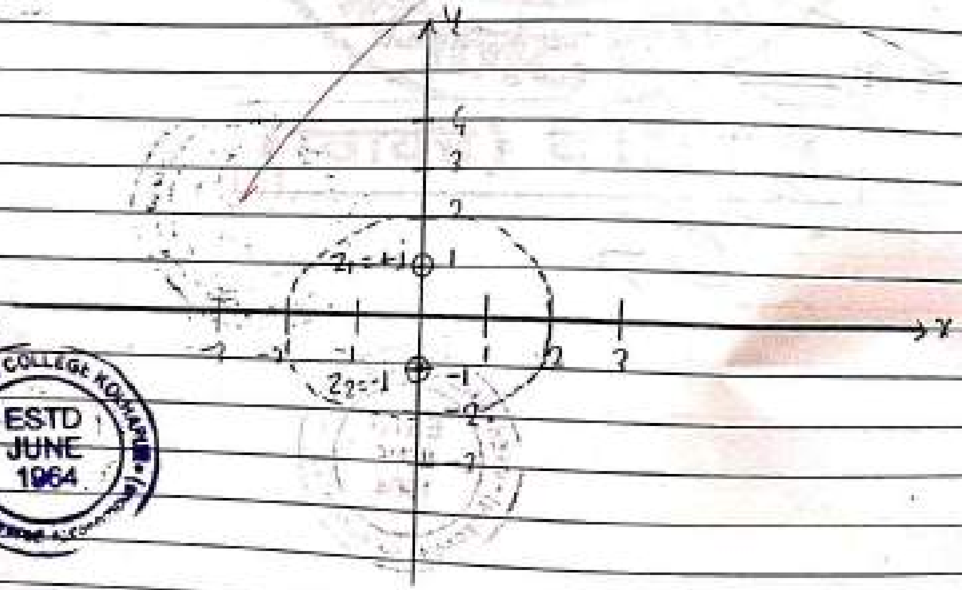
$y=+1$ $\quad$ $y=-1$

$|z|=2$ comparing with equation of circle

$\therefore z-z_0=r$

$\therefore z_0=0,0$ $\quad$ i.e $x=0$, $y=0$

$r=2$



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Both the poles are inside the circle with origin centre and radius 2

$$\int_C \frac{e^z}{z^2+1}\,dz = \int_C \left(\frac{-1}{2i}\right)\left[\frac{e^z}{z+i} - \frac{e^z}{z-i}\right] dz$$

$$= \int_C \frac{-1}{2i}\,\frac{e^z}{z+i}\,dz - \int_C \frac{-1}{2i}\,\frac{e^z}{z-i}\,dz$$

$$= \frac{-1}{2i}\,2\pi i\, e^z_{(z=-i)} + \frac{1}{2i}\,2\pi i\, e^z_{(z=+i)}$$

$$= \frac{-1}{2i}\,2\pi i\, e^{-i} + \frac{1}{2i}\,2\pi i\, e^{+i}$$

$$\boxed{= -\pi\left[e^{+i} + e^{-i}\right]}$$

$$= \pi\,(2i\sin 1)$$

$$\therefore \int \frac{e^z}{z^2+1}\,dz = 2\pi i \sin 1$$

3]

→ Let $f(z) = u + iv$

$f(z) = e^x z^3$

$\therefore f(z) = e^x (x+iy)^3$

$\cancel{\therefore (x+iy)^3 = x^3 + 3x^2iy - 3xy^2 - iy^3}$

$\therefore (x+iy)^3 = x^3 + 3x^2iy + 3xi^2y^2 + i^3y^3$

$(x+iy)^3 = x^3 + 3x^2iy - 3xy^2 - iy^3$

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Separating real and imaginary part

$\therefore u = x^3 - 3xy^2$ —①

$v = 3x^2y - y^3$ —②

Differentiating eqⁿ ① and ② w.r.t x and y

$\therefore \dfrac{\partial u}{\partial x} = 3x^2 - 3y^2$ —③

$\dfrac{\partial u}{\partial y} = -6xy$ —④

$\dfrac{\partial v}{\partial x} = 3x^2 - 3y^2$ —⑤

$\dfrac{\partial v}{\partial y} = +6xy$ —⑥

From eqⁿ ③, ④, ⑤ & ⑥

$\dfrac{\partial u}{\partial x} = \dfrac{\partial v}{\partial x}$ and $\dfrac{\partial u}{\partial y} = -\dfrac{\partial v}{\partial y}$.

$\therefore$ Cauchy's reimann eqⁿ is satisfied. Hence $f(z) = z^3$ is analytic function.

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4] → Poles of integrand given by putting denominator equal to zero

$\therefore z^2 + 2z + 5 = 0$

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SUPPLIMENT

Signature of Supervisor

Suppliment No. : 1

Roll No. :

Class :

Subject :

Test / Tutorial No. :

Div. :

$$z = \frac{-b^2 \pm \sqrt{4ac}}{2a}$$

$$= \frac{\cancel{-6} \pm \sqrt{20}}{2} \quad \frac{-2 \pm 4i}{2}$$

$$= -6 \pm \quad = -1 + 2i$$

$$\boxed{\therefore z_1 = -1 + 2i} \qquad \boxed{z_2 = -1 - 2i}$$

$x = -1$ $\qquad$ $x = -1$

$y = +2$ $\qquad$ $y = -2$.

$|z+1|$ comparing with eq^n of circle

$\therefore z - z_0 = r$

$\cancel{z + 1 = 1}$

$\therefore z_0 = -1, 0$

$x = -1$

$y = 0$

and $\boxed{r = 1}$

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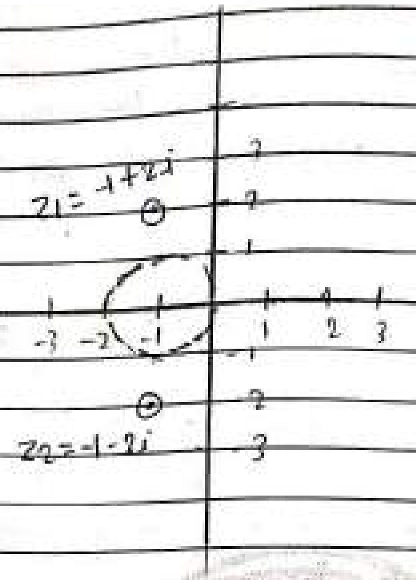

The poles of integrand of circle $|z+1| = 1$ with centre $z = -1$ and radius unity does not enclose any singularity of function $\frac{z+4}{z^2+2z+5} dz$

$$\therefore \int_C \frac{z+4}{z^2+2z+5} = 0$$

→ Theorem :- The necessary condition for $f(z)$ i.e. $f(z) = u+iv$ to be analytic at all points in region R provided that they are exist

$$\frac{\partial u}{\partial x} = \frac{\partial v}{\partial x} \qquad 2) \frac{\partial u}{\partial y} = -\frac{\partial v}{\partial y}$$

Proof :- Let $f(z)$ be analytic in region R

Let $f(z) = u + iv$.

Where u and v are ~~con~~ constant function of x and y

Let δu and δv be increments of u and v corresponding to δx and δy increments of x and y.

Let $f(z) = u + iv$

$$f(z+\delta z) = (u+\delta u) + i(v+\delta v)$$
$$= u + \delta u + iv + i\delta v$$

$$\therefore f(z+\delta z) - f(z) = u + \delta u + iv + i\delta v - u - iv$$

$$= \delta u + i\delta v$$

Let $f(z) = x + iy$

$$\frac{\delta f(z)}{\delta z} = \lim_{\delta z \to 0} \frac{\delta u + i\delta v}{\delta z}$$

$$\frac{\delta f(z)}{\delta z} = \lim_{\delta z \to 0} \frac{\delta u}{\delta z} + i\frac{\delta v}{\delta z} \quad \text{—— (1)}$$

A) Along real axis

$$\delta y = 0 \qquad \delta z = \delta x$$

$$\therefore \frac{\delta f(x)}{\delta x} = \lim_{\delta x \to 0} \frac{\delta u}{\delta x} + \frac{i\delta v}{\delta x} \quad \text{—— (2)}$$

B) Along imaginary axis

$$\delta x = 0 \qquad \delta z = \delta y$$

$$\therefore \frac{\delta f(y)}{\delta y} = \lim_{\delta y \to 0} \frac{\delta u}{\delta y} + \frac{i\delta v}{\delta y}$$

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$$= \lim_{\delta y \to 0} \frac{\delta v}{\delta y} - i\frac{\delta u}{\delta y} \quad \text{--- (3)}$$

since given function are analytic both direction are same.

$$(2) = (3)$$

$$\therefore \frac{\delta u}{\delta x} + i\frac{\delta v}{\delta x} = \frac{\delta v}{\delta y} - i\frac{\delta u}{\delta y}$$

Equating real and imaginary part

$$\frac{\delta u}{\delta x} = \frac{\delta v}{\delta y} \quad \text{and} \quad \frac{\delta u}{\delta y} = -\frac{\delta v}{\delta y}$$

cauchy's reimann equation satisfied.

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Atharv Hariprasad Kognolikar 24-9-24

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15/15

SUPPLIMENT

Signature of Supervisor:

Suppliment No. : 01

Roll No. : 8204

Class : Bsc-TY

Subject : Physics - I

Test / Tutorial No. : Internal exam

Div. : A

Q.1

1) c) $\sqrt{-1}$

2) a) 0

3) a) Singular point

03

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Q.2

3) $f(z) = z^3$

We know that,

$z = x + iy$

$z^3 = x^3 + (iy)^3 + 3x^2 iy + 3x(iy)^2$

$= x^3 + - iy^3 + 3x^2 iy + - 3xy^2$

$\therefore = x^3 - 3xy^2 + 3x^2 iy - iy^3$

$\therefore x^3 - 3xy^2 + i(3x^2y - y^3)$

$f(z) = x^3 - 3xy^2 + i(3x^2y - y^3)$

Now compare withe $f(z) = u + iv$

$\therefore u = x^3 - 3xy^2$

$\therefore v = 3x^2y - y^3$

Now, $\frac{\partial u}{\partial x} = 3x^2 - 3y^2$

$\frac{\partial u}{\partial y} = -6xy$

$\frac{\partial v}{\partial x} = 6xy$

$\frac{\partial v}{\partial y} = 3x^2 - 3y^2$

$\therefore \frac{\partial u}{\partial x} = \frac{\partial v}{\partial y}, \quad \frac{\partial u}{\partial y} = -\frac{\partial v}{\partial x}$

The condition are satisfied

Hence given function is analytical function.

05

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4) $\int_C \frac{z+4}{z^2+2z+5}\,dz$, $|z+1| = 1$

equating denominator is equal to zero

$$z^2+2z+5=0$$

$$z = \frac{-b \pm \sqrt{b^2-4ac}}{2a}$$

$$= \frac{-2 \pm \sqrt{4-20}}{2}$$

$$= \frac{-2 \pm \sqrt{-16}}{2}$$

$$= \frac{-2 \pm 4i}{2}$$

$\therefore z = -1 \pm 2i$

$z = -1+2i$ or $z = -1-2i$

Comparing with $z = x+iy$, we get

$x = -1$ $\quad$ $x = -1$

$y = 2$ $\quad$ $y = -2$

Now compare the eq^n of circle $|z+1| = 1$ with $|z - z_0| = r$

we get,

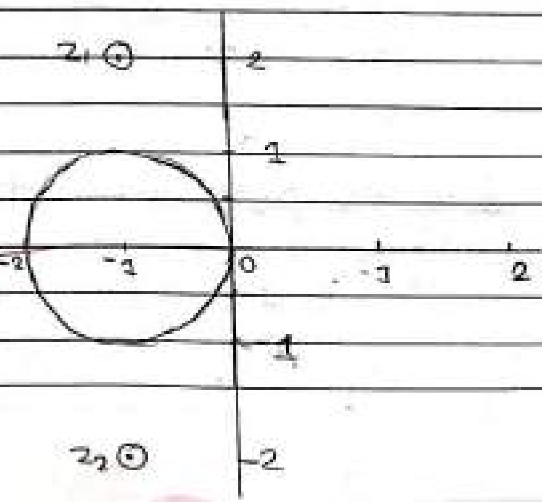
$r = 1$

$z_0 = -1$

$x = -1$

$y = 0$

The graph is given as.



$\because$ The two points are outside the circle.

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2) $\int \frac{e^z}{z^2+1} dz$; $|z|=2$

equating denominator is equal to zero.

$z^2+1=0$

$z^2=-1$

$z^2=i^2$

$z=\pm i$

$z=+i$ or $z=-i$

Compairing this with $z=x+iy$

$x=0$ $x=0$

$y=1$ $y=-1$

Now compare $|z|=2$ with the eq^n of circle $|z-z_0|=r$ we get,

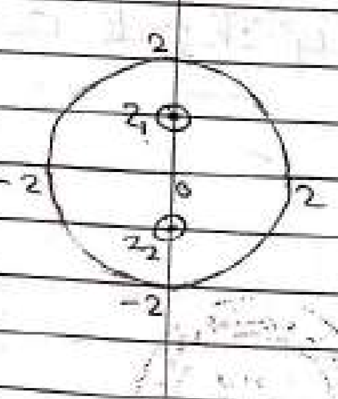
$\therefore r=2$

$\therefore z_0=0$

$\therefore x=0$

$\therefore y=0$

The graph is given as,



Both the points are inside the circle.

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Atharv Hariprasad Koynolikar 24-9-24

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Suppliment No. : 02

Roll No. : 8204

Class : BSc - TY

Subject : Physics - I

Test / Tutorial No. : Internal Exam

Div. : A

$$\int_c \frac{1}{2i}\left[\frac{e^z}{z-i} - \frac{e^z}{z+i}\right] = \int_c \frac{1}{2i}\frac{e^z}{z-i} - \int_c \frac{1}{2i}\frac{e^z}{z+i}$$

$$= \frac{1}{2i}\int_c \frac{e^z}{z-i} - \frac{1}{2i}\int_c \frac{e^z}{z+i}$$

$$= -\frac{1}{2i}\left[2\pi i e^{-i} + 2\pi i e^{i}\right]$$

$$= \frac{2\pi i}{2i}\left[e^{i} - e^{-i}\right]$$

$$= \pi\left[e^{i} - e^{-i}\right]$$

25 Edu

1)

Statement :- The necessary condition for function $f(z)$ to be analytic in given region R is,

$$\frac{\partial u}{\partial x} = \frac{\partial v}{\partial y}, \quad \frac{\partial u}{\partial y} = -\frac{\partial v}{\partial x}$$

Proof :-

let the function $f(z)$ is analytical in the Region

let $f(z) = u + iv$

where u and v are functions of x and y.

Suppose ∂u and ∂v be the impliments of u and v and ∂x and ∂y be the impliments of x and y

$$f(z) = u + iv$$

$$f(z + \partial z) = u + iv + \partial u + i\partial v$$

Now $f(z + \partial z) - f(z) = \partial u + i\partial v$

Then $z = x + iy$

$\partial z = \partial x + i\partial y$

So, $$\frac{\partial[f(z)]}{\partial z} = \lim_{\partial z \to 0}\left[\frac{\partial u}{\partial z} + \frac{i\partial v}{\partial z}\right] \quad \text{--- (I)}$$

i) Along real axis,

$\partial y = 0 \quad , \partial z = \partial x$

put this in eq^n (I),

$$\frac{\partial[f(z)]}{\partial z} = \lim_{\partial x \to 0}\left[\frac{\partial u}{\partial x} + \frac{i\partial v}{\partial x}\right]$$

$$= \frac{\partial u}{\partial x} + \frac{i\partial v}{\partial x} \quad \text{--- (II)}$$

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ii) Along imaginary axis,

$$\partial x = 0 \quad , \quad \partial z = i\partial y$$

Put this in eq^n (I),

$$\frac{\partial [f(z)]}{\partial z} = \lim_{\partial y \to 0} \left[\frac{\partial u}{i\partial y} + \frac{i\partial v}{i\partial y} \right]$$

$$= \frac{\partial v}{\partial y} - i\frac{\partial u}{\partial y} \quad \text{— (III)}$$

we know that LHS of eq^n (II) and eq^n (III) are same.

~~Hn~~ Hence eq^n (II) = eq^n (III)

$$\frac{\partial u}{\partial x} + i\frac{\partial v}{\partial x} = \frac{\partial v}{\partial y} - i\frac{\partial u}{\partial y}$$

Compairing real part and imaginary part,
we get,

$$\therefore \frac{\partial u}{\partial x} = \frac{\partial v}{\partial y} \quad \text{and} \quad \frac{\partial v}{\partial x} = -\frac{\partial u}{\partial y}$$

Hence proved.

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Seat No.	

Que. Paper Code	

VIVEKANAND COLLEGE, KOLHAPUR (EMPOWERED AUTONOMOUS)

B.Sc. Part- III (Physics) (Sem-V)

Internal Examination: September– 2024

PAPER – X (Nuclear and Particle Physics)

Day and Date: Wednesday, 25/09/2024

Time: 12 PM — Marks: 15

Instructions:

1) *All questions are compulsory.*
2) *Figures to the right indicate full marks.*
3) *Draw neat labelled diagrams wherever necessary.*
4) *Use of log table/calculator is allowed.*

Q.1. A) Select Correct Alternative **(03)**

1) The nucleus of an atom consists of ....

   a) Electrons and protons b) Electrons and neutrons

   c) Nucleons d) protons, electrons and neutrons

2) Nuclear forces are ....

   a) short range force b) long range force

   c) electromagnetic force d) none of the above

3) The number of neutrons in an atom of atomic number Z and mass number A is

   a) zero b) Z

   c) A-Z d) A

Q.2) Attempt any THREE of the following questions **(12)**

1) What is binding energy of a nucleus? Explain in brief.
2) Explain liquid drop model for a nucleus.
3) What are nucleons? Explain their intrinsic properties.
4) Write a note on Magic Numbers.

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51762

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SUPPLIMENT

Desai surekha Tanaji.

Suppliment No. :

Roll No. : 8203

Class : BSC TY

Signature of Supervisor

Subject : Physics

Test / Tutorial No. : Internal Exam

Div. : Date → 25/09/2024

Q.1

1] The nucleus of an atom consists of
Nucleons

2] Nuclear Forces are
short range Force

3] The number of neutrons in an atom of atomic number Z and mass number A is
A-Z

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Q.2

1. ① liquid drop model was 1st Purposed by Niles Bohr's in 1937

② This model makes comparision between the Nucleus of an atom and drop of liquid.

③ Nucleus is the very small quantum Particle.

④ This is central core of an atom.

⑤ drop of liquid microscopic collection of molecules.

⑥ By assuming the nucleus behave like drop of liquid. we can make the very accurate Predictions of some of Properties of ~~liquid~~. Nucleus.

⑦ The similiarities in the Nucleus and drop of liquid.

① Both Nucleus and drop of liquid contain the large no. of Particles

② Both Nucleus and drop of liquid are Homogenous and incompressible.

③ Nucleus in mass density is constant throughout the entire volume as like the drop is zero near its boundry Surface

④ In Nucleus the Nucleons intreact very strongly nearest neighbouring Nucleons. and the drop of liquid the molecules interact nearest neighbouring molecules.

⑤ Both Nucleous and drop of liquid show surface tension because as like drop of liquid tends spherical shape in the absence of other forces.

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Binding energy of a nucleus.

① The expected mass of the nucleus is sum of masses of the constituent part Namely z Protons and (A-z) neutrons

② But for all elements in Periodic table the actual mass M(A,z) of the nucleus less than the total mass of its constituent Particles.

③ And this difference in mass is called mass difference or mass defect $\Delta M = (M(A \cdot z) - A$.

④ When a nucleons come together to form a nucleus some energy equal to ΔMC^2 is lost which is the workdone in bringing the nucleons to form Nucleus

⑤ In other words that having loss this energy MC^2 the nucleons in nucley are bound together

⑥ So in order to brake the nucleus into its constituent Particle energy equal to Δmc^2 must be supplied to the nucleus

⑦ Therefore this energy lost during the formation of nucleus is known the binding energy of a Nucleus.

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4] Magic No.

① The observation of Binding curve shows few Peaks over the smooth curve.

② These Peaks indicates the that these element abnormally more stable as compair to their neighbouring elements.

③ The calculation of Binding energy and study of the abundance elements more stable.

④ All such observations clearly depicts that nuclei having the no. of Protons and neutrons is equal to 2, 8, 20, 28, 50, 82 and 126 are Particularly more stable.

⑤ Hence the series of no referred as magic no.
A no of evidences for magic nos are obtained by measuring the Percentage abundant.
For eg.

$^{16}_{8}O \Rightarrow (Z = N = 8)$

$^{208}_{82}Pb \Rightarrow (Z = 82)$

$^{120}_{50}Sn = (Z = 50)$

are abundant in nature and more stable.

⑥ The Z value is the magic no. that those elements have large no. of Isotopes.
eg. $^{16}_{8}O$ $^{17}_{8}O$ $^{18}_{8}O$

Also strongsium (Sn) have 10 Isotopes.

⑦ Neutrons is the magic no. $N = (A - Z)$
It no. of Isotones
Maximum Isotones occure $N = (A - Z)$ 82 and 50
Z = 50 about 5 Isotones has near by.

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Suppliment No. :

Roll No. : 8203

Class : BSC-TY

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Subject : Physics

Test / Tutorial No. : Internal Exam

Div. : Date → 25/09/2024

① krypton - 86
② ytrium - 89
③ zirconium - 90
④ Molybdium - 92
⑤ Radium - 88

⑧ Both Z and N belongs to Value of magic no.
In the Nucleids are Particullarly ~~more~~ most stable.

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Sakshi Raju Birange date: 25/09/24

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Suppliment No. :

Roll No. : 8201

Class : BSC-TY

Subject : Nuclear and Particle physics

Test / Tutorial No. : Internal exam

Div. :

Q1 1) c) Nucleons

2) a) short range forces.

3) c) A - Z

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Q2

2] liquid drop model

i) liquid drop model was first proposed by Nie bohr in 1937.

ii) This model gives comparision betⁿ nucleous of at and liquid drop.

iii) Nucleous is very small quantum particle.

iv) Nucleus is at centre core of atom. where most of mass of atom is concentrated.

v) liquid drop is macroscopic particle.

vi) By assumming liquid drop as a nucleus we can accurately predict some properties of nucleus

vii) There are some similarities in both liquid drop and nucleus are as following

1) There are large number of particle in liquid drop as well as in nucleous
2) They both are incompressible and Homogeneous
3) Nucleus mass density throught volume of atom is constant just like liquid drop.
4) They both shows surface tension effect due to they are spherical in shape

5) evaporation of liquid drop after heating is similar as loss of nucleons from nucleus after providing external energy

6) Nucleus ~~p~~ reactions fission and fussion is similar in liquid drop. Two liquid drops are merge together to form one liquid drop and one liquid drop ~~merge~~ breaks apart to produce two indivisal liquid drops.

7) They both strongly interact with neighbouring nuclei

viii) thats why By assumption of liquid drop as a nuclei gives accurate preditation in properties of nucleus.

xi) By liquid drop model properties of nucleus such as fusion is accurately predited and ~~By~~ This model we ~~can ex~~ is use in expression for nuclear mass.

x) Calculated atomic mass or nuclear mass of different elements in periodic table by liquid drop model is fairly accurate.

Q3 Nucleons :-

The nucleus is formed by no of protons and no. of neutrons.

Protons and neutrons are together turm Nucleons

Intrinsic properties of nucleus

1] Charge

Nucleus is formed by protons and neutron Proton having positive charge. It is numer y equal to charge on electrons.

$$\text{Charge on Proton} = 1.6 \times 10^{-19}\, C$$

Neutrons are electrically neutral particles.

2] Mass

Mass of proton and neutrons are almost equal.

$$1\,amu = \frac{1}{12} \text{ mass of carbon}$$

$$1\,amu = 1.66 \times 10^{-27}\, kg.$$

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mass of proton $= 1.0073$ amu

mass of neutron $= 1.0087$ amu

mass of electron $= 0.00053$ amu

3] Nuclear Binding forces

i) Nucleons (Protons and neutrons) in nucleus are bound together by a strong, short rang attractive Force called as nuclear Binding forces

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Subject :

Test / Tutorial No. :

Div. :

Nuclear binding forces betⁿ Proton - Proton neutron - neutron, Proton - neutron are almost ~~en~~ equal.

4) Spring angular momentum

Nucleus are fermi particles they have spring angular momentum is $\frac{\hbar^2}{2}$

The follows fermi dera statastical distribution and paulies exclusion

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5) Magnetic moment

due to ~~the~~ spinning of charge particles magnetic moments is Produce

~~magn~~ $\mu_p = 2.793\ \mu_n$

magnetic moment of Proton $= \mu_p$

magnetic moment of neutron $= \mu_n$

Magic Numbers.

i) curve of Binding energy / nucleons ~~to~~ againt ~~ato~~ mass no. (A) is called as binding energy curve.

ii) By observation of Binding energy curve there are some peaks in smoth curve.

iii) These peaks indicates ~~abnorty~~ abnormaly stable elements as comparively neighbouring elements.

iv) calculated binding energy and study of abundant elements in nature it shows some elements are more stable in nature.

v) It is clearly shows that elements having no. of protons or no. neutrons are 2, 8, 20, 28, 50, 82 and 126 are more stable.

vi) series of this number are called magic numbers.

Ex $^{16}_{8}O$, $(Z=8)$ $^{208}_{82}Pb$ $(Z=82)$ $^{102}_{50}Sn$ $(Z=50)$

The above elements are more abundant Hence they are more stable.

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Class :	Test / Tutorial No. :
	Div. :

vii) Elements having atomic number is magical ~~mu~~ number they ~~are~~ ~~ar~~ have more isotopes Ex.

$^{16}_{8}O$ $^{17}_{8}O$ $^{18}_{8}O$ $z=8$

Sn - strongsium has 10 isotopes.

Elements having ~~are~~ neutron number is magical number then they have large no. isotones.

atomic number
86
89
90
92

Ex N=50 has 5 istones.

ix) magical number is more precisely by ~~Stud~~. observed in periodic table elements are more stable

x) elements have proton and neutron are same magical no. are most ~~e~~ stable in nature ex $^{16}_{8}O$ ~~O~~ $^{9}_{4}C$ $^{4}_{2}He$

NAME: RITU. R. NISHAD DATE: 25-09-2024.

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SUPPLIMENT

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Suppliment No. : 1+1

Roll No. : 8206

Class : BSC- TY

Subject : Nuclear and particle Physics

Test / Tutorial No. : Internal Exam - physics paper-X

Div. :

Q1

A] Select Correct Alternative.

1 c) Nucleons

2 a) short range force

3. c) A-Z

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Q2 Attempt any Three

2. Explain liquid drop model for a nucleus.

→

1. Liquid drop model was 1st proposed by Neil Bohr in 1937

2. Liquid drop model makes comparison between nucleus of an atom & drop of a liquid

3. Nucleus is a quatum particle

4. Nucleus is the central core of an atom

5. drop of liquid is a macroscopic collection.

6. By assuming a nucleus of an atom like a drop of liquid we can make accurate prediction of some.

7. The similarities are as follows:

i. Both the nucleus and the drop of liquid ~~are~~ contains large no. of particles.

ii. Both the nucleus and the drop of liquid are homogeneous and incompressible

iii. Both the nucleus and

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iii. There is surface tension constant through'out the volume and drops to zero abruptly.

iv. The nucleons strongly ~~are~~ interact with the neighbouring elements. The same is with the drop of liquid they interact with nearest molecules & exchange energies

v. Binding energy of nucleus is analogous to heat of vaporization of liquid i.e; evaporation of molecules from liquid drop is similar to loss of nucleons from nucleus when provided external energy.

vi. This is similar with fission & fusion.
If we want a larger drop then we can merge two drops together but & we can also seperate them in smaller individuals. The same way is with the nucleons.

8. This liquid drop model can be used for nuclear fission and also for getting expressions for nuclear masses.

9. Hence the calculation is fairly accurate.

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4. Write a note on Magic Numbers.

→

1. In the B.E curve few peaks are seen on a smooth curve

2. The peaks indicates they are abnormally more stable then neighbouring elements.

3. The calculation of binding energy & study abundance of elements in nature ~~certai~~ show that certain elements are more stable.

4. All such observation clearly depicts that nuclei having no. of proton & neutron equal no 2, 8, 20, 28, 50, 82, 126 are particularly more stable

5. Hence they are referred as magic numbers.

6. A no. of evidences for magic no. are obtained by measuring the percentage abundance for eg: $^{16}_{8}O\ (Z = N = 8)$ $^{208}_{82}Pb\ (Z=82)$ $^{120}_{50}Sn\ (Z=50)$

are more abundant in nature & hence they are more stable.

7. Also if Z value is magic no then those elements have large no. of isotopes

eg:- $^{16}_{8}O$, $^{17}_{8}O$, $^{18}_{8}O$ where Z=8 is Magic no.

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Class :

Subject :

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Div. :

8. Also strongleum (sn) has 6 isotopes.

9. If no. of neutrons N= (A-Z) is magic no, it gives a large no. of isotones. for eg:- maximum no. of isotones occurs for N=(A-Z)= 50 & 82

10 For N= 50 about 5 isotones namely
Krypton = 86
Ytbraium = 89
zironium = 90
molybdenum = 92
Radium = 88

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~~11 To given explanation~~

11. If both Z & N values belong to magic no. then these nucleids are particularly most stable.
For eg:- $^{16}_{8}O$, $^{40}_{20}Ca$, $^{4}_{2}He$.

12 To given explanation for the occurance of magic no & no. of nuclear phenomenon like a spectrum phenomenon.

13 A new model for nucleus shell model was suggested the shell model for nucleus is quite analogous to atomic model where in electron are dictributed to quantised shell.

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3. What are nucleons ? Explain their intrinsic properties

→

1. Nucleus is the central core of an atom.

2. It contains Z protons & N = (A - Z) neutrons where A is the mass no. & Z is the atomic no.

3. The atomic no is used to determine the no of proton in nucleus.

4. The mass no is used to determine the no of protons & neutrons combinely.

5. The intrinsic properties are as follows.

1. Charge :- The protons are positively charged and ~~electr~~ numerically equal to electron number (1.6×10^{-19}) & neutrons are neutral.

2. Mass :- The mass no. of protons & neutrons are equal in amu.

$\frac{1}{12} \times {}^{12}C$ isotopes

$= \frac{1}{12} \times \frac{12}{N_0}$

$= 6.023 \times 10^{26}$ kg / mol

$= \frac{1}{6.023 \times 10^{26}}$

$= 1.66\times10^{-27}$ ~~amu~~ Kg

∴ The mass no of protons = M_p 1.0073 amu
The mass no of neutrons = M_n 1.0087 amu
The mass no of electrons = 0.00055 amu

3. Nuclear binding energy :-
- It is strong short range force to bound nucleons together in a nucleus.
- ~~Proton~~ The force of energy of proton - proton, proton - neutron, neutron - neutron is same

4. Spin angular momentum :-
- The nucleons are fermi particles having intersic angular momentum $= \frac{\hbar}{2}$
- It obeys fermic - dirac statastics paulis exclusion properties.

5. Magnetic moment.
- The spinnig particle create magnitic moment.

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Department of Physics

B.Sc. Part-III SEM V Examination (2024-25)
Solid state physics
Paper XII (Paper code: DSC-1001E4)

Date : 27 /09 /2024 Total Marks: 15
Day : 12.00 to 1.00 pm Time :-

Instructions:-

1) All questions are compulsory.
2) Figures to the right indicate full marks.
3) Use of log table and calculator is allowed.

Q.1) Select correct alternative **(3)**

1. The primitive cell of the crystal contains -----------atoms per unit cell.
   (a)) one (b) two
   (c) more than two (d) two or more than two
2. The full crystallographic symmetry of a cube is --------.
   (a) 13 (b) 9
   (c) 23 (d) 20
3. The Miller indices of a plane which cut the x-axis at half way of the unit cube are given by ----
   (a) (2 0 0) (b) ($\frac{1}{2}$ 0 0)
   (c) (0 $\frac{1}{2}$ 0) (d) (0 0 $\frac{1}{2}$)

Q.2 Attempt any THREE **(12)**

1. Discuss plane of symmetry of cubic crystal.
2. Calculate the packing fraction of Hexagonal closely packed structure.
3. Write a note on NaCl crystal structure.
4. Write a note two dimensional Bravise lattices.

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Sakshi Raju Birange Date - 27-09-24

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Signature of Supervisor 14/15

Suppliment No. : 1

Roll No. : 8201

Class : BSC-TY

Subject : Solid state physics

Test / Tutorial No. : - Internal exam

Div. :

Q1 1) a) one 1

2) c) 23 1

3) b) $(\frac{1}{2}, 0, 0)$ 0

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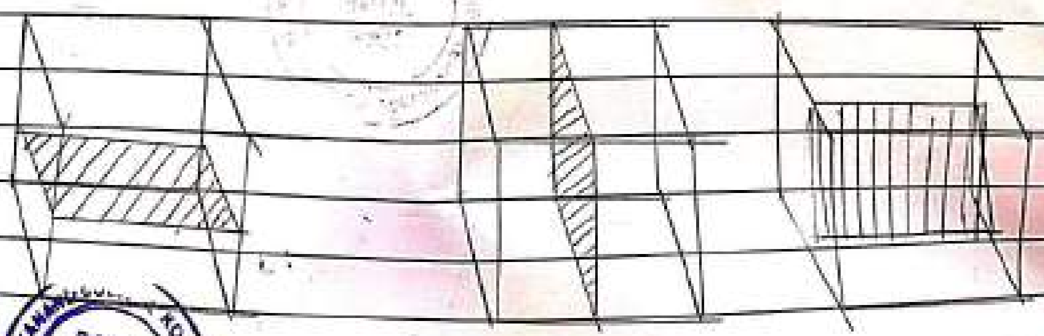
Q1 Plane of symmetry of cubic structure

1) Cubic crystal is bilateral.
If we ~~cut~~ divide a cube we got we 1st half hables which is mirror image of 2nd another half haves

2) the planes of cubic crystal. in a plane If we cut cubic crystal such that one part of plane of cubic crystal is placed in front of mirror it will reflection (mirror image of other) This planes of cubic crystal called as plane of symmetry of cubic structure

3) There are three plane of symmetry of cubic structure of ~~parral~~ parallel to face of cubic structure. ~~as~~ Are given in following diagrams.



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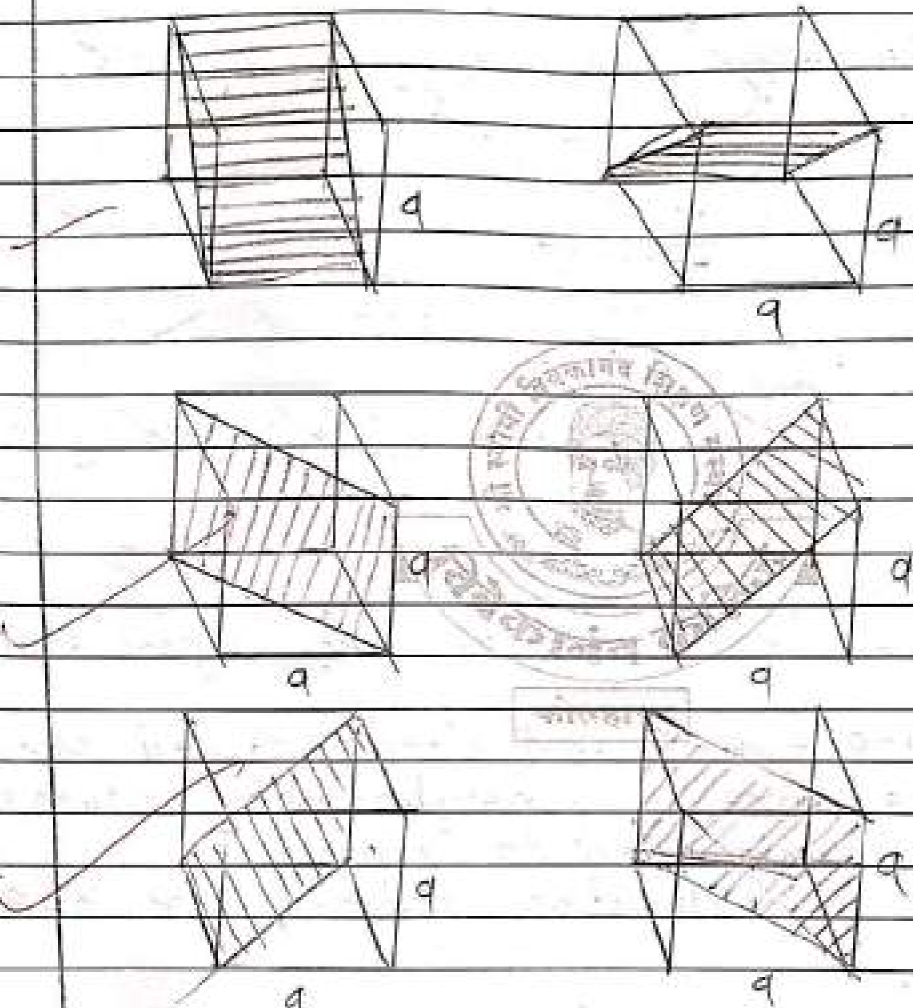
4) In additional there are 6 Diagonal plane of symmetry of cubic structure due to opposite parallel edges.



5) There are 3- parallel to face plane and Symmetry and 6- Diagonal plane of Symmetry. Hence $(3+6) = 9$
$\therefore$ There are 9 plane of symmetry of cubic crystal

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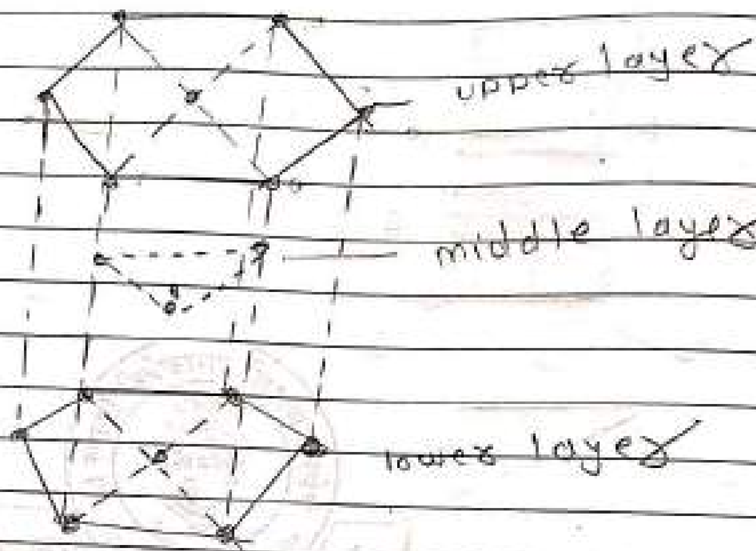
Q2 Packing fraction of Hexagonal closed packed structure



Above fig represents hcp crystal structu[re]

In HCP - Hexagonal closed packed struct[ure]
There are 12 neighbouring atoms are surrounded to a atom.
The co-ordination number for hcp is 12

Packing fraction of hcp

$$= \frac{\text{volume of atom/ unit cell}}{\text{volume of unit cell}}$$

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Suppliment No. : 2

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Div. :

- Determine atom in hcp.

lower layer consist 6 atoms atoms share by $\frac{1}{6} \times 12$

middle layer consist of 3 ~~lay~~ atoms atom share by is 3

central atom - 1 atom share by $\frac{1}{2} \times 2$

$\therefore$ Total atoms consist in hcp =

$$= \left(\cancel{6} \cdot \frac{1}{6} \times 12 + 3 \times \frac{1}{2} \times 2 \right)$$

$$= 6$$

Determine volume of atom per unit cell

volume of atom = volume of sphere

($\because$ atom is in spherical shature)

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volume of atom $= \frac{4}{3}\pi r^3$

where r - is atomic radius.

But in hcp structure there are 6 atoms are consist

$\therefore$ volume of atom $= \frac{4}{3}\pi r^3 \times 6$

$= 8\pi r^3$

- Now we have to find volume of unit cell from fig.

volume of unit cell = area of triangle $\times$ height of cube $\times$ 6.

$= \sqrt{\frac{3}{4}}\, a^2 \times c \times 6.$

$= 2a^2 \cdot \quad 2a^3$

a- is intermolecular distance

$\therefore$ Packing fraction is

$= \frac{8\pi r^3}{\sqrt{\frac{3}{4}}\, a^2 c\, 6}$

$= \frac{16\pi r^3}{3\sqrt{3}\, a^2}$

where $r = \frac{a}{2}$

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$$= \frac{16\pi \frac{a^3}{8}}{3\sqrt{3}\, a^2 c}$$

$$= \frac{16\pi \frac{a}{8}}{3\sqrt{3}\, c}$$

$$= \frac{2\pi a}{3\sqrt{3}\, c}$$

but from fig. $\frac{c}{a} = 1.64$.

$\therefore$ Packing fraction $= \frac{2\pi}{3\sqrt{3} \times 1.64}$

$= \underline{0.74}$

04 $\therefore$ Packing fraction of hcp is 0.74

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Q4 Two Dimensional Bravise lattice

If all lattice points in a crystal are identical then it is called Bravise lattice

If lattice points is in plane and if also identical then it is called as Bravise lattice.

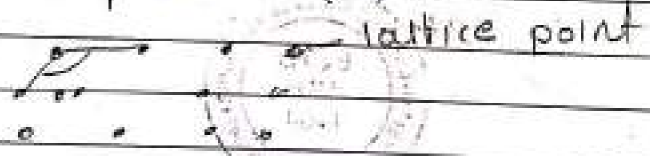
There are 5 2-Dimentional Bravise lattice
As following

1) oblic lattice

If a is length and b is breath then in oblic lattice

$a \neq b$ ϕ - angle betn a and b

ϕ $\phi > 90°$



2) cubic lattice

where in cubic lattice structure $a = b$ and angle betn it

$\phi = 90°$

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Roll No. : 8201

Class : BSC-TY

Subject :

Test / Tutorial No. :

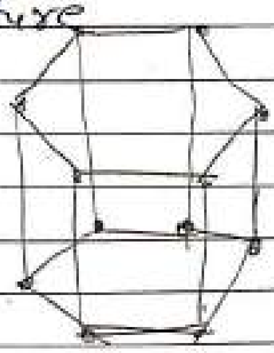
Div. :

3) rectangular lattice stucture.

$a \neq b \quad \phi = 90^\circ$

4) Hexagonal lattice structure.

Hexagonal lattice structure is as given below



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orthogonal lattice structure.

$a = b \quad \phi = 120^\circ$

4

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NAME: RITU. R. NISHAD DATE:- 27-09-2024

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Suppliment No. :

Roll No. : 8206

Class : BSC-TY

Subject : Solid state physics

Test / Tutorial No. : Internal exam Paper XII

Div. :

Q1 Select correct alternative

1 a) one

2 ~~d) 20~~ c) 23

3 a) (200)

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Q2. Attempt any Three.

2. Calculate the packing fraction of Hexagonal closely packed structure.

→

Determination of packing fraction of Hexagonal closely packed structure.

$$P.F = \frac{\text{vol. of atom / no. of unit cell}}{\text{vol. of unit cell}} \quad \text{—— (1)}$$

Lower layer

6 atoms share unit cell $= \frac{1}{6}$

- Calculation of Volume of atom per unit cell.

Downward layer (A) contains 6 atoms & upward (A) contains 6 atoms

Thus it's part in unit cell $= \frac{1}{6}$

2nd layer contains 3 atoms

Thus, its part in unit cell = 3

2 atoms are present at middle

It's part in unit cell $= \frac{1}{2}$

$\therefore$ No. of unit cell $= \left[\frac{1}{6} \times 12 + 3 + \frac{1}{2} \times 2\right]$

$= 2 + 3 + 1$

$= 6$

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Volume of atom = volume of sphere

$\therefore$ Volume of atom $= \frac{4}{3}\pi r^3$

$\therefore$ Volume of atom per unit cell $= \frac{4}{\cancel{3}} \pi r^3 \times \cancel{6}^{2}$

$= 8\pi r^3$

- Calculating volume of unit cell
  If middle atom is attached to adjacent atoms in downward layer then 6 equilateral traingle are form
  $\therefore$ Volume of unit cell = Area of traingle $\times$ height of unit cell $\times 6$

Area of traingle $= \frac{\sqrt{3}}{4} a^2$

height of unit cell $= c$
c = Interatomic distance

$\therefore$ Packing fraction $= \frac{8\pi r^3}{\frac{\sqrt{3}}{4} a^2 c \times 6}$

$\because r = \frac{a}{2}$

Thus, Packing fraction $= \frac{8\pi \left(\frac{a}{2}\right)^3}{\frac{\sqrt{3}}{4} a^2 c \times 6}$

$= \frac{\cancel{8}\pi a^{\cancel{3}} \times 4}{\cancel{2\times2\times2}\times \cancel{a^2} \times c \times \cancel{6}_3 \sqrt{3}}$

$= \frac{2\pi a}{3\sqrt{3}c}$

$= \frac{2\pi}{3\sqrt{3}\times 1.64}$ — As $\frac{c}{a} = 1.64$

$\boxed{\therefore \text{ Packing Fraction} = 0.74}$

4

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3. Write a note on NaCl crystal structure.

→

1. It is also called as rock salt.
2. The sodium losses its outermost electron & aquire ~~Na^+ ion~~ +ve charge resulting in Na^+ ion.
3. The lose of electron from sodium is gain by Chlorine & aquires -ve charge resulting in Cl^- ion.
4. There are 14 Cl^- and 13 Na^+ ion
5. Chlorine occupies 8 ~~corn~~ mid edges and 6 face centered & hence 14 Cl^- ions are present.
6. Sodium occupies 12 corners & remaining ion is at center & hence 13 Na^+ ions are present.
7. The unit cell of NaCl crystal structure is shown below.
8. ~~1 Na^+ ion & 1 Cl^- ion~~

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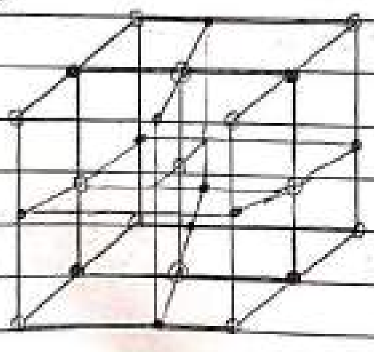
3. NaCl crystal structure.



• - 13 Na^+

o - 14 Cl^-

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Date:- 27/9/2024

SUPPLIMENT

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Signature of Supervisor

13/15

Suppliment No.: 1+1 = 2

Subject: physics = solid state physics

Roll No. : 8207

Test / Tutorial No.: Internal exam

Class : B.Sc III

Div.:

Q.1

1]

a) one

2]

c) 23

3]

b) $\left(\frac{1}{2}, 0, 0\right)$

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Q.2.
27]

* Packing fraction of HCP structure :-

$$\boxed{\text{Packing fraction} = \frac{\text{volume of atom per unit cell}}{\text{volume of unit cell}}}$$

I] Determination of volume of atom per unit cell :-

crystal structure contain

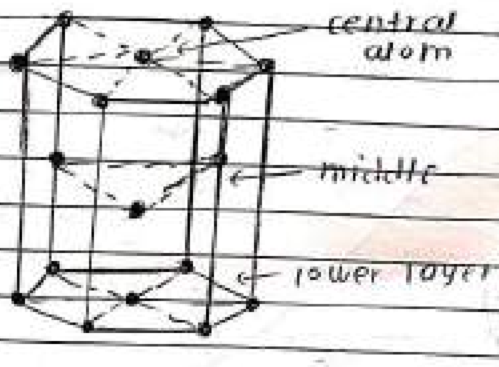
i] lower layer consist of 6 atoms and its share among each unit cell is $\frac{1}{6}$

ii] middle layer consist of 3 atoms.

iii) central 2 atom and its contribution is $\frac{1}{2}$

$\therefore$ Total number of atoms per unit cell $= \left[\frac{1}{6} \times 12 + 3 + \frac{1}{2} \times \right.$

$= 6$ atoms.



HCP structure

volume of atom = volume of sphere

$$\therefore V = \frac{4}{3}\pi r^3 \times 6$$

$$\boxed{V = 8\pi r^3}$$

ii) Determination of volume of unit cell:-

If we join central atom with adjacent atoms at lower layer we get 6 equilateral triangle.

$\therefore$ volume of unit cell $= \frac{\sqrt{3}}{4} a^2 \times$ Height of unit cell (c) $\times 6$

$$= \frac{3\sqrt{3}}{2} a^2 c$$

$$\therefore P.F = \frac{8\pi r^3}{3\sqrt{3}/2\, a^2 c}$$

Here $\boxed{r = \frac{a}{2}}$

$$\therefore \frac{8\pi (a/2)^3}{\frac{3\sqrt{3}}{2} a^2 c}$$

$$= \frac{8\pi a^3 \times 2}{8\, 3\sqrt{3} \times a^2 \times c}$$

$$= \frac{2\pi a}{3\sqrt{3}\, c}$$

Here $\frac{c}{a} = 1.64$

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$\therefore$ Packing fraction = 0.74

Packing efficiency = 74%

$\therefore$ Packing fraction of hcp = 0.74

0.5

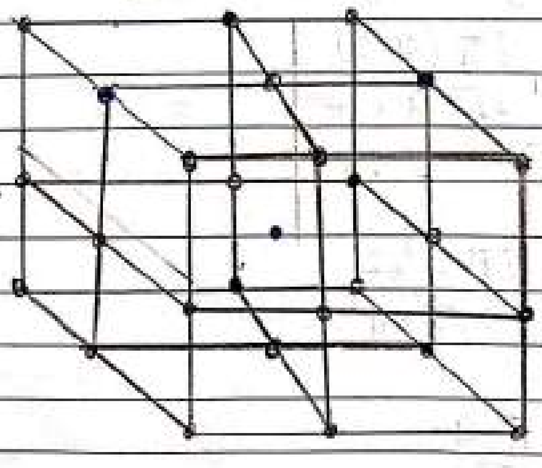
3) →

* Sodium chloride crystal structure :-

1) Sodium chloride is also called as rock salt.

2) Sodium chloride crystal contains Na^+ ion and Cl^- ion. where sodium losses one outermost electron to acquire positive charge and become Na^+ ion and chloride gain one electron to acquire negative charge and become Cl^- ion.

3) crystal structure of sodium chloride is,



Na^+ ion •

Cl^- ion = •

NaCl structure

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Class : BSC III

Subject :

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4) chloride ions occupy corners of unit cell and face centred of unit cell is 14

i.e. corners atom = 8

Face centered = 6

5) sodium atoms / ions occupy edges of cell and one is at centre hence total ions are 13

6) Therefore NaCl crystal structure consist of 14 Cl^- ions and 13 Na^+ ions.

7) sodium crystal structure is face centered cubic unit cell.

04

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17)

* Plane of symmetry of cubic structure :-

1) The crystal can be divided into two halves such ~~thane~~ that one half is reflection of other half.

2) So that if we cut crystal along the planes and get one half keep on mirror, mirror image will reproduce other half such symmetry is called as plane of symmetry.

3) Plane of symmetry is denoted by 'm' where m is in mirror planes.

4) Plane of symmetry also known as mirror planes and reflection planes.

5) The cube has 3 plane of symmetry which is parallel to opposite faces of cube as shown in fig (a).

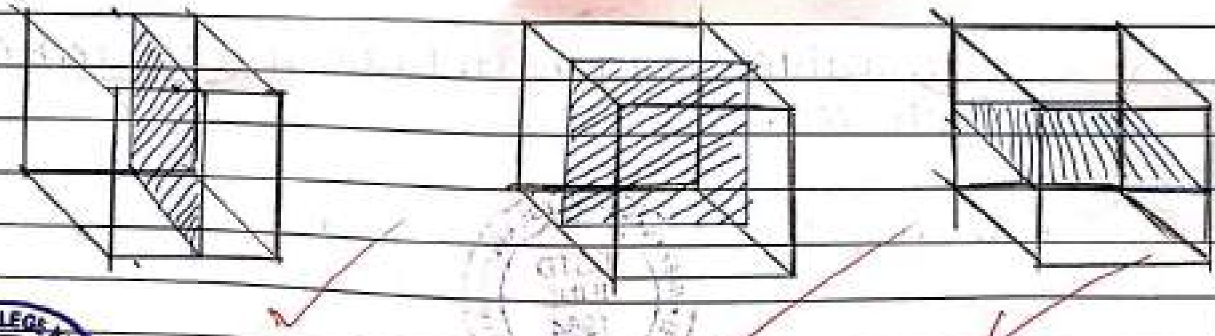

fig (a) Plane of symmetry

6) Cube also has 6 diagonal symmetry along opposite edges of cube. One of the diagonal symmetry is as shown in fig (b).

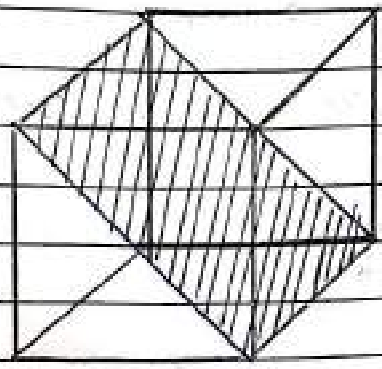

Fig (b) one of the diagonal symmetry

7) The cube has total 9 plane of symmetry

3 = Along planes.
6 = Diagonal symmetry.

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* Two dimentional bravise lattices.

1) If group of atoms at the plane at lattice point it is called 2-D space lattice.

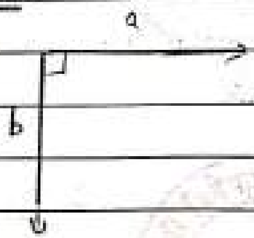
2) 3 types of two dimentional bravis lattices are,

i) Oblique
ii) Square
iii) Hexagonal.

A) Oblique lattice.

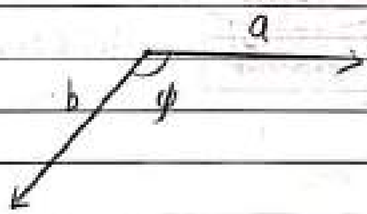
In oblique lattice $a = b$ and $\phi \neq 90^\circ$

B) square lattice.



In square lattice $a = b$ and $\phi = 90^\circ$

C) hexagonal lattice.



In hexagonal lattice $a = b$ and $\phi = 120^\circ$

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Department of Physics

B.Sc. Part-III SEM VI Examination (2024-25)
Quantum Mechanics
Paper XIV (Paper code: DSE-1001E3)

Date : 26/09/2024 | Total Marks: 15
Day : 12.00 to 1.00 pm | Time :- 1 hour

Instructions:-
1) All questions are compulsory.
2) Figures to the right indicate full marks.
3) Use of log table and calculator is allowed.

Q.1) Select correct alternative **(3)**

1) Quantum Numbers are solutions of ____________

a) Heisenberg's Uncertainty Principle b) Einstein's mass energy relation

c) Schrodinger's Wave Equation d) Hamiltonian Operator

2) The Schrodinger time independent equation can be written as

a) $H\psi = E\psi$ b) $H\psi = (E-V)\psi$ c) $H\psi = (E+V)\psi$ d) $H\psi + E\psi = 0$

3)The quantum mechanical operator for the momentum of a particle in one dimension is given by

a) $i\hbar\frac{d}{dx}$ b) $-i\hbar\frac{d}{dx}$ c) $i\hbar\frac{\partial}{\partial t}$ d) $-\frac{\hbar^2}{2m}\frac{d^2}{dx^2}$

Q.2 Attempt any Three **(12)**

1. Give requirements of wave function
2. Explain orthogonality and orthonormality of wave function.
3. Obtain Schrodinger s time dependent equation
4. Normalize the wave function $\psi = e^{\frac{-ax^2}{2}}$

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Supplimen No. : 1+1 = 2

Subject : Physics - Quantum Physics.

Roll No. : 8207

Test / Tutorial No. : Internal exam

Class : B.Sc III

Div. :

13/15

Q-1

1]

→ c) Schrodinger's wave equation.

2]

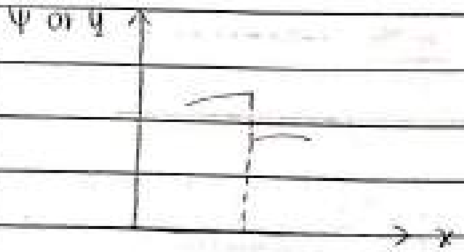
→ b) $H\psi = (E-V)\psi$

3]

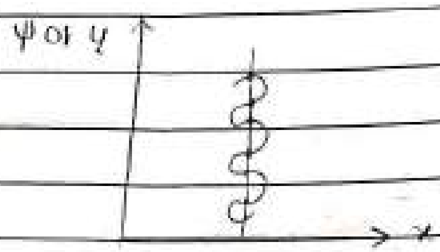
→ b) $-i\hbar \frac{\partial}{\partial x}$ d) $-\frac{\hbar^2}{2m}\frac{d^2}{dx^2}$ b) $-i\hbar\frac{\partial}{\partial x}$

2

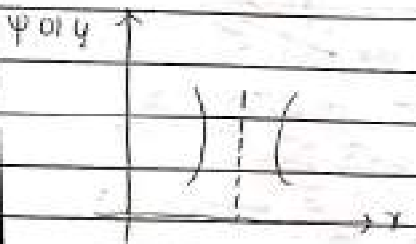
Q.2
1)
→ **Requirements of wave function:-**



Discontinuous.



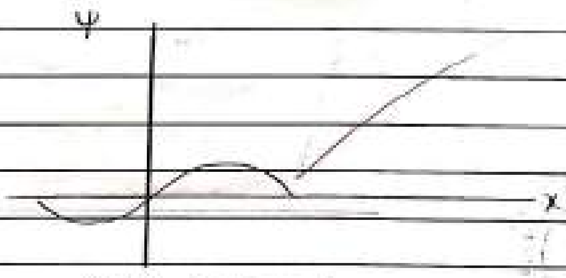
Not single valued.



Not finite.

Not well behaved.

ψ should be continuous, single valued and finite i.e. it should be well behaved.



Well behaved.

4]

Given :- $\psi = e^{-\frac{ax^2}{2}}$

To normalise the given function multiply by A to RHS

$$\therefore \psi = Ae^{-\frac{ax^2}{2}} \quad \text{or} \quad \psi^* = A^* e^{-\frac{ax^2}{2}} \quad \text{or} \quad Ae^{-\frac{ax^2}{2}} \qquad \text{—— (1)}$$

Using normalisation condition

$$\therefore \int_{-\infty}^{\infty} \psi \psi^* \, d\tau = 1$$

$$\therefore \int_{-\infty}^{\infty} Ae^{-\frac{ax^2}{2}} Ae^{-\frac{ax^2}{2}} dx = 1$$

$$\therefore A^2 \int_{-\infty}^{\infty} e^{-ax^2} dx = 1$$

$\because$ standard result for

$$\int_{-\infty}^{\infty} e^{-ax^2} dx = \sqrt{\frac{\pi}{a}}$$

$$\therefore A^2 \sqrt{\frac{\pi}{a}} = 1$$

$$A^2 = \sqrt{\frac{a}{\pi}}$$

$$A = \left(\frac{a}{\pi}\right)^{1/2} \qquad \text{—— (2)}$$

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Putting this in eq^n ① we get

$$\psi = A e^{-\frac{ax^2}{2}} dx$$

$$\boxed{\psi = \frac{a^{1/2}}{\pi^{1/2}} e^{-\frac{ax^2}{2}}}$$

This is normalised equation of $\psi = e^{-\frac{ax^2}{2}}$

2]

* Orthogonality of wave function :-

If the product of first wave function $\psi_1(x)$ a[nd] $\psi_2^*(x)$ vanishes, when integrate w.r.t x over interv[al] $a \le x \le b$ then ψ_1 and ψ_2 are said to be mut[ually] orthogonal (perpendicular).

i.e.

$$\int_a^b \psi^* \psi \, dx = 0$$

or

$$\int_a^b \psi \psi^* \, dx = 0.$$

* Normality of wave function :-

The wave function satisfy the condition

$$\int_{-\infty}^{\infty} \psi \psi^* d\tau = \int_{-\infty}^{\infty} \psi^* \psi \, d\tau = \int_{-\infty}^{\infty} |\psi|^2 d\tau = \int_{-\infty}^{\infty} P \, d\tau = 1$$

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Suppliment No. : 1

Roll No. : 8207

Class : B.Sc III

Subject : Physics

Test / Tutorial No. : Internal exam.

Div. :

then it said to be normalise to unity i.e. total probability of finding particle at entire space is one. If

2) If the wave function is not normalise it made normalise by multiplying with particular constant 'A' so that new resultant function also give solution of equation

i.e.

$$\int_{-\infty}^{\infty} (A\psi)^* (A\psi)\, d\tau = 1$$

$$\int_{-\infty}^{\infty} A^2 \psi^* \psi \, d\tau = 1$$

5

$$\therefore A^2 = \frac{1}{\int_{-\infty}^{\infty} \psi^* \psi \, d\tau}$$

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37

→ *Schrodinger's time dependent equation :-

According to de-broglie and planks theory.

$$\lambda = \frac{h}{p}$$

$$h = p\lambda$$

Position operator = $-i\hbar \frac{\partial}{\partial x}$

Energy operator = $i\hbar \frac{\partial}{\partial t}$

Time dependent wave eq^n is :

$$i\hbar \quad -\frac{\hbar^2}{2m} + \frac{\partial^2\psi}{\partial x^2} + V\psi = E = i\hbar \frac{\partial\psi}{\partial t}$$

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॥ ज्ञान, विज्ञान आणि सुसंस्कार यांसाठी शिक्षण प्रसार ॥
— शिक्षणमहर्षी डॉ. बापूजी साळुंखे

Shri Swami Vivekanand Shikshan Sanstha Kolhapur's 51532

VIVEKANAND COLLEGE, KOLHAPUR (AUTONOMOUS)

26/09/2024

SUPPLIMENT

Signature of Supervisor	

Desai Surekha Tanaji

Suppliment No. :

Roll No. : 8203

Class : BSC·TY

Subject : Physics

Test / Tutorial No. : Internal Exam

Div. :

13/15

Q1

① Quantum Numbers are solution of Schrodinger's wave Equation.

② The schrodinger time independent equation can be writen as
$H\psi = (E-V)\psi$

③ The quantum mechanical operator for the momentum of a Particle in one dimension is given by.

$-i\hbar \frac{d}{dx}$

2

1

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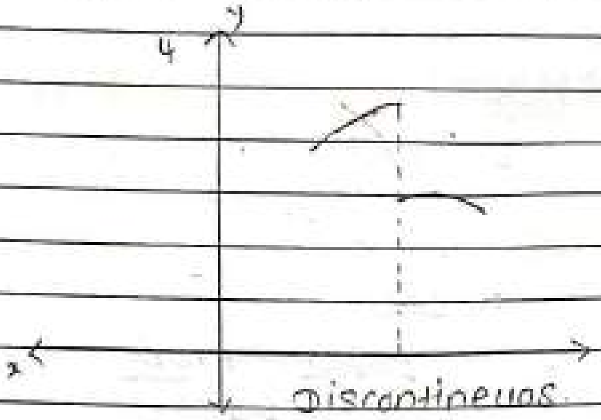
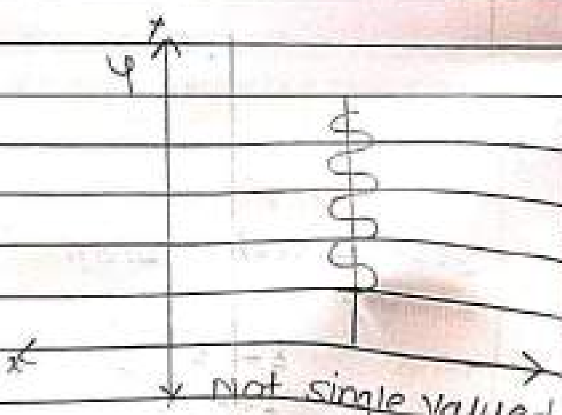
Q.2

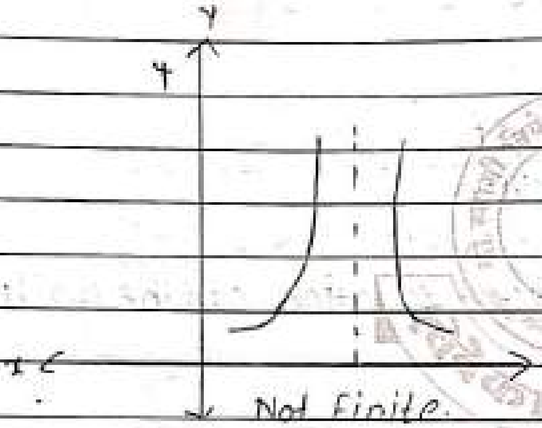
1. Requirements of wave function.



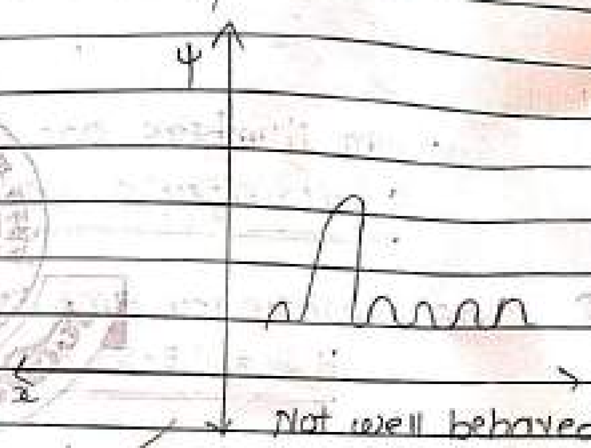
Discontineuos



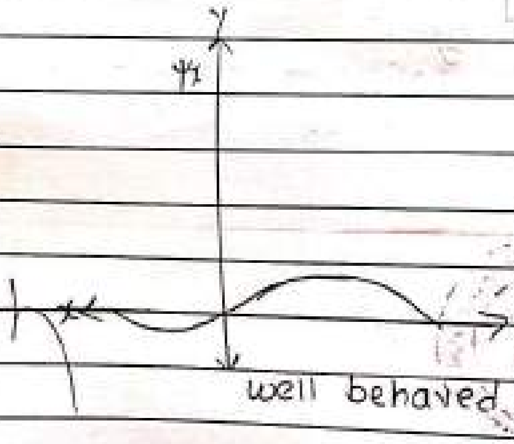
Not single valued



Not finite



Not well behaved



well behaved

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Orthogonality /orthonormality of wave Function.

The Product of 1^{st} wave Function $\psi_1(x)$ and $\psi_2^*(x)$ are vanish. when integrate with respect to x over the Interval $a \leq x \leq b$ is said the Mutually orthogonality.

$$\int_a^b \psi_1(x)\,\psi_2^*(x) = 0$$

2

$$\int_a^b \psi_1^*(x)\,\psi_2(x) = 0$$

9. Schrodinger's time dependent equation.

It equation explain the help of Schrodinger's time independent equation.

$$\frac{-\hbar^2}{2m}\frac{\partial^2\psi}{\partial x^2} + V\psi = E\psi = i\hbar\frac{\partial\psi}{\partial t} \quad \text{--- ①}$$

This equation solved can be help of the seprable and variable

$$\psi = \psi(x)\,\phi(t) \quad ②$$

This equation Putting in the value of equation ①

$$\frac{-\hbar^2}{2m}\frac{\partial^2\psi\phi}{\partial x^2} + V\psi\phi = i\hbar\frac{\partial\psi\phi}{\partial t}$$

$$\frac{-\hbar^2}{2m}\phi\frac{\partial^2\psi}{\partial x^2} + V\psi\phi = i\hbar\psi\frac{\partial\phi}{\partial t}$$

divided this equation by $(\psi\phi)$

$$\frac{-\hbar^2}{2m}\frac{\phi}{\psi\phi}\frac{\partial^2\psi}{\partial x^2} + \frac{V\psi\phi}{\psi\phi} = \frac{i\hbar\psi}{\psi\phi}\frac{\partial\phi}{\partial t}$$

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$$\frac{-\hbar^2}{2m}\frac{1}{\psi}\frac{\partial^2\psi}{\partial x^2} + V = \frac{i\hbar}{\phi}\frac{\partial\phi}{\partial t}$$

The eliminate the time (t)
As the L.H.S = E
L.H.S = E = R.H.S

$$\frac{-\hbar^2}{2m}\frac{1}{\psi}\frac{\partial^2\psi}{\partial x^2} + V = E$$

multiply this equation by $\frac{2m}{-\hbar^2}\psi$

Now equation become.

$$\frac{\partial^2\psi}{\partial x^2} - \frac{2m}{\hbar^2}V\psi = -\frac{2m}{\hbar^2}E\psi$$

$$\boxed{\frac{\partial^2\psi}{\partial x^2} + \frac{2m}{\hbar^2}(E-V)\psi = 0}$$

Above equation is the schrodinger's time dependent equation. Proof.

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VIVEKANAND COLLEGE, KOLHAPUR (AUTONOMOUS)

26/09/2024

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Subject : Physics

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4. Normalisation.

$$\int_{-\infty}^{\infty} \psi\psi^* d\tau \quad \int_{-\infty}^{\infty} |\psi|^2 d\tau \quad \int_{-\infty}^{\infty} P d\tau \quad \int_{-\infty}^{\infty} \psi^*\psi \, d\tau$$

It is called as the Normality to unity that is the total Probability ~~these for the Pro~~ of the Finding the Particle in the entire space is one. the wave Function is not Normalise It can made normalise by multiplying the Particular constant (A) The Result in the wave of Function also is the Solution of wave Equation.

$$\int_{-\infty}^{\infty} (A\psi)^* (A\psi) \, d\tau = 1$$

4

$$\int_{-\infty}^{\infty} A\psi^* A\psi \, d\tau = 1$$

$$A^2 \int_{-\infty}^{\infty} \psi^* \psi \, d\tau = 1$$

$$A^2 = \frac{1}{\int_{-\infty}^{\infty} \psi^* \psi \, d\tau}$$

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$$\psi = e^{-\frac{\alpha x^2}{2}}$$

The normlize by the equation multiplying by A

$$\psi = A e^{-\frac{\alpha x^2}{2}}$$

$$\psi^* = A^* e^{-\frac{\alpha x^2}{2}}$$

$$\int_{-\infty}^{\infty} \psi \psi^* dx = 1$$

$$\int_{-\infty}^{\infty} (A e^{-\frac{\alpha x^2}{2}})(A^* e^{-\frac{\alpha x^2}{2}}) \, dx = 1$$

$$\int_{-\infty}^{\infty} A e^{-\frac{\alpha x^2}{2}} . A^* e^{-\frac{\alpha x^2}{2}} \, dx = 1$$

$$A^2 \int_{-\infty}^{\infty} \frac{-\alpha x^2}{2} \, dx = 1$$

Standard equantion

$$\int_{-\infty}^{\infty} e^{-\alpha x} dx = \sqrt{\frac{\pi}{\alpha}}$$

$$A^2 . \sqrt{\frac{\pi}{\alpha}} = 1$$

$$A^2 = \sqrt{\frac{\alpha}{\pi}}$$

$$A^2 = \left(\frac{\alpha}{\pi}\right)^{\frac{1}{2}}$$

$$A^{2 \times \frac{1}{2}} = \left(\frac{\alpha}{\pi}\right)^{\frac{1}{2} \times \frac{1}{2}}$$

$$A^2 = \sqrt{\frac{\alpha}{\pi}}$$

$$A^2 = \left(\frac{\alpha}{\pi}\right)^{\frac{1}{2}}$$

$$A^{2 \times \frac{1}{2}} = \left(\frac{\alpha}{\pi}\right)^{\frac{1}{2} \times \frac{1}{2}}$$

$$A = \left(\frac{\alpha}{\pi}\right)^{\frac{1}{4}}$$

$$\boxed{\psi = \frac{\alpha^{\frac{1}{4}} e^{-\frac{\alpha x^2}{2}}}{\pi^{1/4}}}$$

ESTD JUNE 1964

Sahil Chetan Patnekar

॥ ज्ञान, विज्ञान आणि सुसंस्कार यांसाठी शिक्षण प्रसार ॥

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Shri Swami Vivekanand Shikshan Sanstha Kolhapur's

VIVEKANAND COLLEGE, KOLHAPUR (AUTONOMOUS)

SUPPLIMENT

Signature of Supervisor	

Date : 26/09/2024

Suppliment No. :

Roll No. : 8208

Class : B.Sc III

Subject : Quantum Mechanics

Test / Tutorial No. :

Div. :

13/15

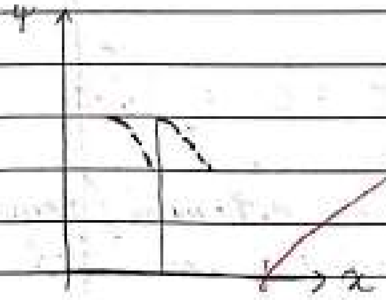
Q1.

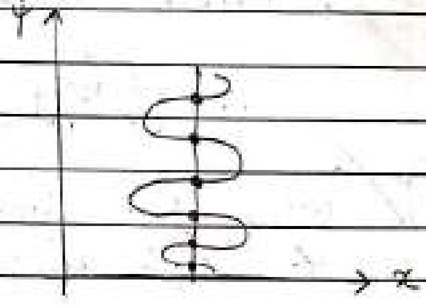
1. (c) Schrodinger's Wave equation
2. (a) $H\psi = E\psi$
3. b) $-i\hbar \frac{\partial}{\partial x}$

3

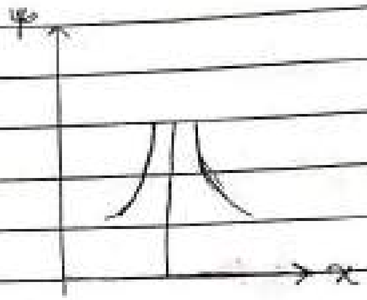
Q2.

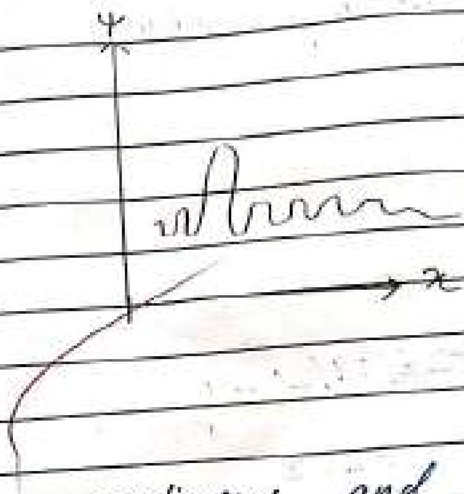
1 Requirements of wave function:





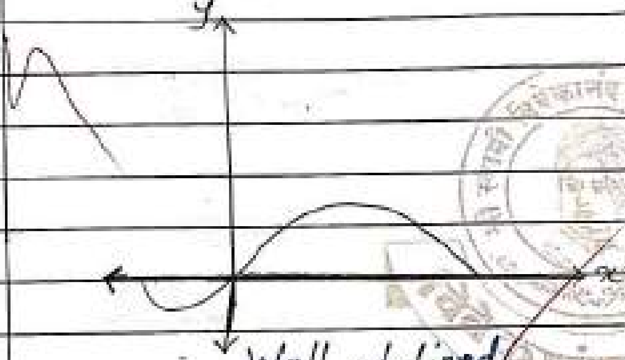
discontinuous





Infinite.

A wave function must be continuous and well defined.



Well defined.

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2\. Let us suppose, there are two wave function $\Psi_{1(x)}$ & $\Psi_{2(x)}$, they are said orthogonal when the integral product of $\Psi_{1(x)}$ & $\Psi_{2(x)}$ lies in between $a \leq 2m \leq b$.

$$\therefore \int_{-\infty}^{\infty} \Psi_{1(x)} \Psi_{2(x)} d\tau = \int_{-\infty}^{\infty} \Psi\Psi^* \tau = 0 = \int_{-\infty}^{\infty} P\tau =$$

When two wave function are orthogonal / perpendicular to each other, their product is zero.

3. Let us consider a wave travelling in +ve direction. It can be represented as,

$$\Psi = Ae^{i(kx-\omega t)} \quad \text{--- (1)}$$

where $(kx-\omega t)$ = phase of the wave.
A = Amplitude of the wave

In Quantum Mechanics variables are replaced by operators, as QM is quiet complex.

~~Now diff. eqⁿ (1)~~

Now according to de-Broglie and planks constant,

$$\lambda = \frac{h}{p} \quad \& \quad E = h\nu$$

$$\therefore p = \frac{h}{\lambda} \qquad \therefore E = \frac{h\nu}{1}$$

multiply by 2π on numerator and denominator on RHS,

$$\therefore p = \frac{h}{2\pi} \times \frac{2\pi}{\lambda} \qquad \therefore E = \frac{h \times 2\pi\nu}{2\pi}$$

$\therefore p = \hbar k$ [$\because k$ = propogation constant] $\qquad \therefore E = \hbar\omega$ $\boxed{\because \omega = 2\pi\nu}$

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

$\therefore$ Now diff. eqⁿ (1) w.r.t 'x' and w.r.t 't'.

$\therefore$ ~~$k = \frac{\hbar}{p}$~~

$$\therefore k = \frac{p}{\hbar}$$

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For 'x'

$$\frac{\partial\psi}{\partial x} = A e^{i(kx-\omega t)} \cdot (ik) \cdot (1)$$

$\therefore A$

$\therefore \psi \cdot ik$

$$\therefore \cancel{\frac{\partial\psi}{\partial x} = \psi i\left(\frac{\hbar}{p}\right)}$$

$$\therefore \frac{\partial\psi}{\partial x} = \psi i\left(\frac{p}{\hbar}\right)$$

For 't'

$$\frac{\partial\psi}{\partial t} = A e^{i(kx-\omega t)} \cdot (-i\omega)(1)$$

$$\frac{\partial\psi}{\partial t} = \psi - i\left(\frac{E}{\hbar}\right)$$

$$\therefore \frac{\partial\psi}{\partial t} = \psi - i\left(\frac{E}{\hbar}\right)$$

Multiplying by i on numerator and denominator on RHS

$$\therefore \frac{\partial\psi}{\partial x} = \frac{-\psi p}{i\hbar} \qquad \therefore \frac{\partial\psi}{\partial t} = \frac{\psi E}{i\hbar}$$

$$\therefore -i\hbar\frac{\partial\psi}{\partial x} = p\psi \qquad \therefore i\hbar\frac{\partial\psi}{\partial t} = E\psi$$

$$\boxed{\therefore P = -i\hbar\frac{\partial\psi}{\partial x}} \qquad \boxed{\therefore E = +i\hbar\frac{\partial}{\partial t}}$$

momentum of the wave. Energy of the wave.

w.k.t Total Energy = K.E + P.E

$$\therefore T.E = \frac{\hbar^2}{2m} + V$$

$$\therefore E\psi = \frac{\hbar^2}{2m}\psi + V\psi$$

This is the schrodingers wave eq^n in one direction

$$\boxed{\therefore E\psi = \frac{-i\hbar^2\partial^2\psi}{2m\,\partial x^2} + V\psi}$$

$$\therefore E\psi = \frac{-i\hbar^2}{2m}\left(\frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2} + \frac{\partial^2}{\partial z^2}\right)\psi + V\psi$$ — This is schrodingers wave eq^n in 3-Dimension.

$$\boxed{\therefore E\psi = \frac{-i\hbar^2}{2m}\nabla\psi + V\psi}$$

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