Vivekanand College, Kolhapur. (Autonomous)
Department of Physics
Internal Examination Notice
2018-19

Date:30/09/2018

All students of class B.Sc. I, B.Sc. II and B.Sc. III are hereby noticed that the first term internal evaluation examination is scheduled as per following time table.

Nature of question paper:

For B.Sc. I : Long answer question (Any one from given two questions) for 10 marks

Short answer question (Any two from given three questions) for 10 marks

For B.Sc. II : Long answer question (Any one from given two questions) for 10 marks

Short answer question (Any two from given three questions) for 10 marks

For B.Sc. II (Astro) : Long answer question (Any one from given two questions) for 10 marks

Short answer question (Any two from given three questions) for 10 marks

For B.Sc. III : Long answer question (Any one from given two questions) for 10 marks

Short answer question (Any two from given three questions) for 10 marks

Internal Evaluation Examination 2018-19.
SEM I, SEM III and SEM V
Time Table

Sr. No.	Class	Paper	Date	Time
1.	B.Sc. I	Paper I	11/10/2018	11:00 am to 12:00 pm
2.	B.Sc. II	Paper III	11/10/2018	11:00 am to 12:00 pm
3.	B.Sc. II (Astrophysics)	Paper I	12/10/2018	11:00 am to 12:00 pm
4.	B.Sc. III	Paper V (section I)	15/10/2018	11:00 am to 12:00 pm
		Paper V (section II)		01:00 am to 2:00 pm
		Paper VI (section I)	16/10/2018	11:00 am to 12:00 pm
		Paper VI (section II)		01:00 am to 2:00 pm

VIVEKANAND COLLEGE ESTD JUNE 1964 KOLHAPUR - 416003

HOD

Head of the Department of Physics Vivekanand College, Kolhapur

Vivekananda College Kolhapur (Autonomous).
Department of Physics: Internal examination 2018-19
B.Sc. III Semester V
Subject: Atomic and Molecular Spectra, Astronomy and Astrophysics

Marks: 20 (Each question carry one mark) Time : 20 min

Q.1 Attempt any ONE **(10)**

1. Discuss the principle of proton-synchrotron with a special reference to two step acceleration.
2. Explain the principle of electron-synchrotron with special reference to two-step acceleration.

Q.2 Attempt any TWO **(10)**

1. Discuss different methods used to measure nuclear radius.
2. What are nucleons? Explain their intrinsic properties.
3. What is the shape and size of nucleus?

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

Shri Swami Vivekanand Shikshan Sanstha's

Vivekanand College, Kolhapur

(Autonomous)

Department of Physics

Internal exam

B.Sc. III Sem V

Attendance Sheet

Roll No.	Name Of The Student	Signature			
		15-10-2018	15-10-2018	16-10-2018	16-10-2018
8501	Aniket Nandkumar Chile	Achile	Achile	Achile	Achile
8502	Shubham Nandkumar Chodankar	Chodankar	[illegible]	Chodan	Chodan
8503	Ankita Jayawant Chougule	A	A	A	A
8504	Patil Pramod Dashrath	Ppatil	Ppatil	Ppatil	Ppatil
8505	Ankita Ravindra Digraje	A	A	A	A
8506	Pooja Lagamana Ghulanawar	Pooja	Pooja	Pooja	Pooja
8507	Prasad Rajaram Gulavani	[illegible]	[illegible]	[illegible]	[illegible]
8508	Vinayak Baburao Kesarkar	VK	VK	VK	VK
8509	Aishwarya Sanjay Kumbhar	Sanjay	Sanjay	Sanjay	Sanjay
8510	Karale Prajakta Mansing	Prajakta	Prajakta	Prajakta	Prajakta
8511	Shamal Vijay Mohite	SM	SM	SM	SM
8512	Tejaswini Tanaji Musale	Musale	Musale	Musale	Musale
8513	Anisa Ajij Nadaf	Anisa	Anisa	Anisa	Anisa
8514	Somesh Krishnat Nerlekar	Nerlekar	[illegible]	[illegible]	[illegible]
8515	Sourabh Sanjay Patil	Patil	Patil	Patil	Patil
8516	Anuja Uday Patil	Apatil	Apatil	Apatil	Apatil
8517	Pranil Yuvraj Patil	Patil	Patil	Patil	Patil
8518	Pratiraj Sampat Patil	Tporth	Tporth	Tporth	Tporth
8519	Satish Shivaji Patil	Spatil	Spatil	Spatil	Spatil
8520	Sheral Shivaji Patil	Patil	Patil	Patil	Patil
8521	Shrinath Dhondiram Shinde	Shinde	Shinde	Shinde	Shinde
8522	Kumbhar Swaroop Sunil	K	K	K	K
8523	Ajit Sadashiv Thorat	Athorat	Athorat	Athorat	Athorat
8524	Ruhan Eliyas Ustad	Ruhan	Ruhan	Ruhan	Ruhan
8525	Vaibhav Vasant Yadav	Vyadav	Vyadav	Vyadav	Vyadav

Internal Examinar........[illegible]........

VIVEKANAND COLLEGE KOLHAPUR
ESTD
JUNE
1964
(Autonomous)

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

34049

Shri Swami Vivekanand Shikshan Sanstha Kolhapur's

VIVEKANAND COLLEGE, KOLHAPUR (AUTONOMOUS)

SUPPLIMENT

10/20

Signature of Supervisor	
Subject: Atomic & molecular Physics	
Test / Tutorial No.: Internal Exam	
Div.:	

Suppliment No.:

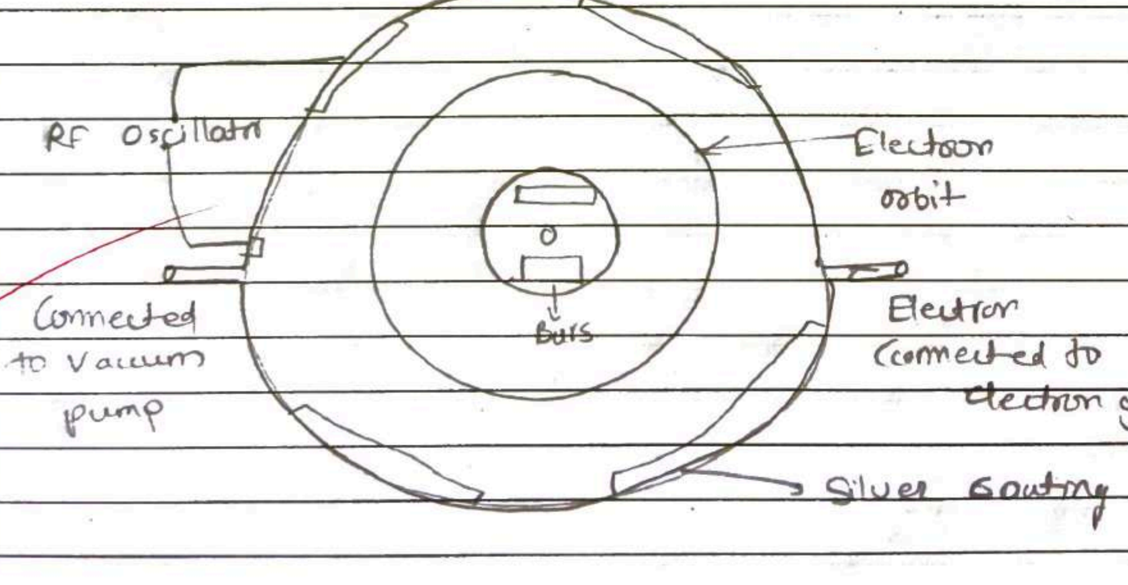
Roll No. : 8516

Class : B.Sc III, Sem-

Q.1)

2) Electron - Synchroton →

Construction- Synchrotron also uses doughter - shaped Vaccum chamber in AC magnetic field. The weight of the magnet is reduced in synchrotron. The vaccum chamber inside c- shaped magnet. The magnetic focusing is required, the pole faces are constructed to provide maximum field at centre.



Working -

With the help of electron gun, electrons are injected into the vaccum chamber with energy range of up to 100 keV. After the electrons are accelerated to high energy, then the electrons may attain velocity comparable to that of light.
The bars play a very important role. Once the steel bars get Saturated, they no longer obey Faraday's law of electromagnetic induction. The electrons gain energy after every revolution. The magnetic field and orbit radius decide the energy of electrons. After the electrons gain maximum energy, radio-frequency oscillator is turned off and larger current is sent through auxiliary coils so that the electrons change their orbit radius due to unstable magnetic field. The target decreases highly energetic X-Rays when electrons strike the target. The electrons can attain energy up to 330 MeV by sychrotron action and 7-8 MeV by betatron action.

10

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

34043

Shri Swami Vivekanand Shikshan Sanstha Kolhapur's

VIVEKANAND COLLEGE, KOLHAPUR (AUTONOMOUS)

SUPPLIMENT

14/20

Signature of Supervisor	
Subject :	(Atomic and molecular physics)
Test / Tutorial No. :	Internal
Div. :	

Suppliment No. :

Roll No. : 8522

Class : B.Sc III

Q.1

1. Proton synchrotron can be used to accelerate deutrons, alpha particles in addition to protons.

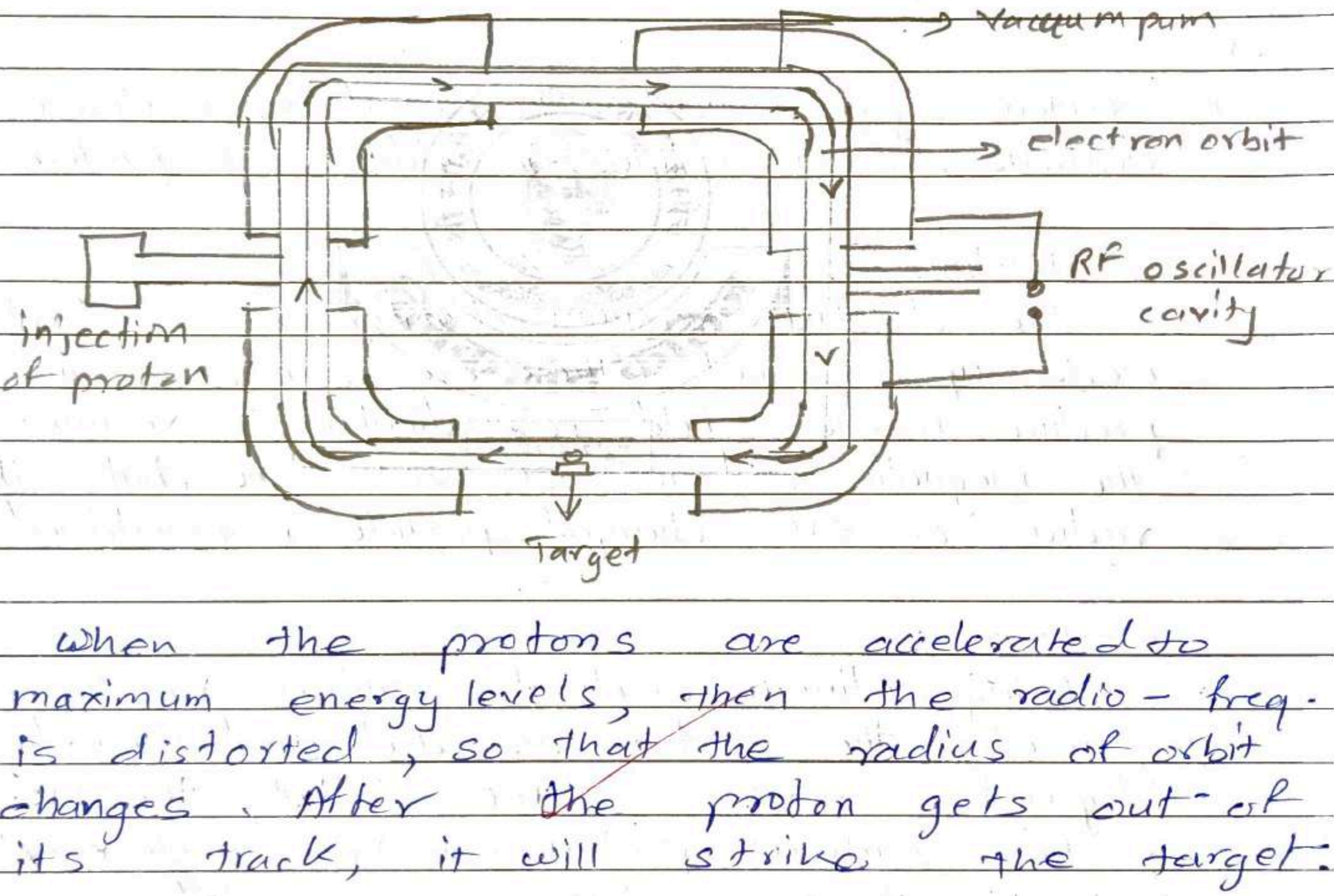
construction :-

The doughnut vacuum chamber of synchrotron is made up of steel. There are four quadrants that produce magnetic field perpendicular to vacuum chamber. The magnetic field increases with time, but the radius of "+ve" charged particle is maintained constant.

working :-

Using a linear accelerator such as Van de Graff generator, the protons are accelerated towards the doghnut chamber hence, initially the "+ve" particle such as proton can be accelerated up to 10 MeV. These particles are injected when the magnetic field is small. These electrons then come under the influence of radio frequency oscillator. Moreverever, the magnetic field

These electrons ~~then~~ also increased to keep the electrons in circular orbit ~~frequency oscillators~~ ~~at~~ at constant radius. As proton completes its revolution, it almost gains an impulse of 1 kV/turn which increases its energy as well as frequency. Hen to maintain the phase stability the freq. of radiofreq. oscillator is also increased in order to synchronize it with the freq. of proton. The range up to which protons can be accelerated is higher than the range of electrons.



When the protons are accelerated to maximum energy levels, then the radio-freq. is distorted, so that the radius of orbit changes. After the proton gets out of its track, it will strike the target.

frequency of of revolution of positive particle to be

$$f = \frac{(q\,Bc^2)(2\pi r)}{2\pi(k + m_0c^2)(2\pi r_0 + 4l)}$$

Q.2
3. The nucleus makes up much less than 0.01% of the volume of the atom, but typically contains more than 99.9% of the mass of the atom. The chemical properties of substance are determined by the negatively charged electrons enshrouding the nucleus. Most nuclei are spherical or ellipsoidal, though some exotic shapes exist. Nuclei can vibrate and rotate when struck by other particles. Some are unstable and will break apart or change their relative number of protons and neutrons.

04

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

34047

Shri Swami Vivekanand Shikshan Sanstha Kolhapur's

VIVEKANAND COLLEGE, KOLHAPUR (AUTONOMOUS)

SUPPLIMENT

(12)/20

Signature of Supervisor	
Subject : Atomic and molecular	
Test / Tutorial No. : Internal	
Div. :	

Suppliment No. :
Roll No. : 8525
Class : B.Sc-III

Q.1.2. proton Synchrotron Can be used to accelerate deutrons, alpha particles in addition to protons

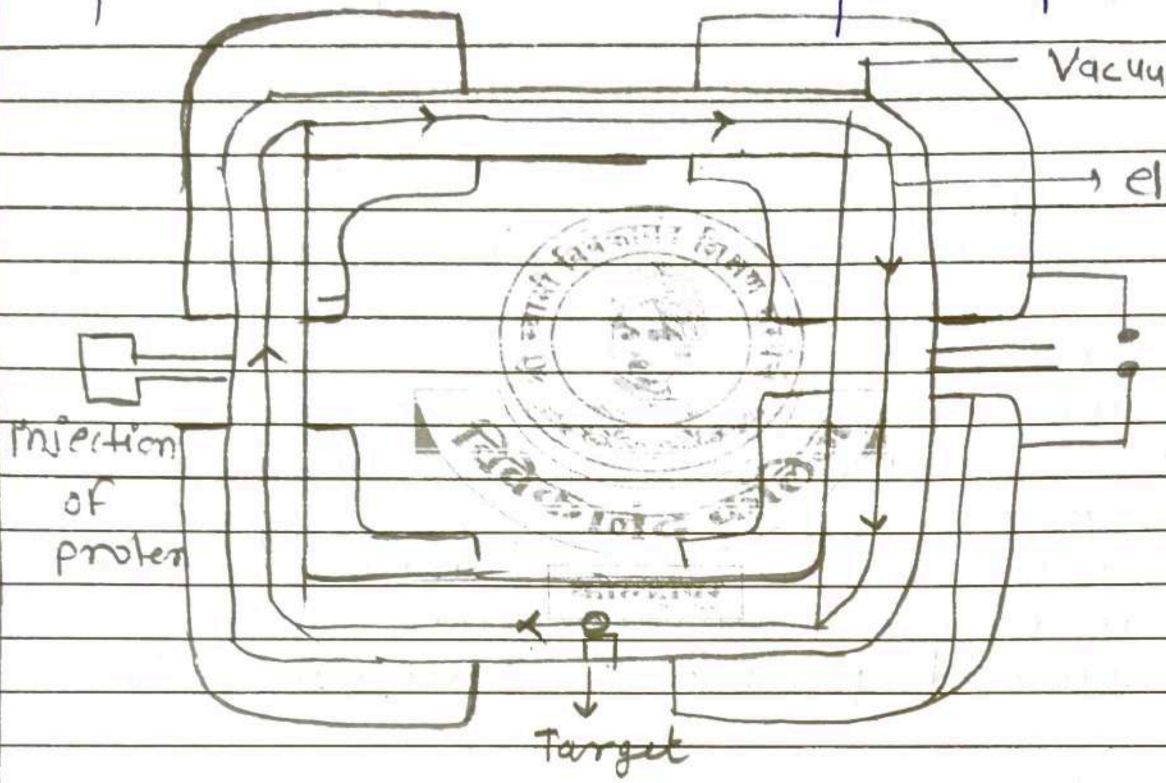
Construction -

The doughnut Vaccum chamber of Synchrotron is made up of Steel. There are four quadrants that produce magnetic field perpendicular to vaccum chamber. The magnetic field increases with time, but the radius of +ve charged particle is maintained constant

Working -

Using linear accelerator such as Van de graff generator, the protons are accelerated towards the doughnut chamber, hence initially the +ve particle such as proton can be accelerated up to 10 MeV. These particles are injected when the magnetic field is small. These electrons then come under the influence of Oscillator.

Also increased to keep the electrons in Circular orbit constant radius. As proton Completes its revolution, it almost gains an impulse of 1 kV/turn which increases its energy as well as frequency. Hence to maintain the phase stability the frequency of radiofrequency Oscillator is also increased in order to synchronise it with freq of proton.



when the protons are accelerated to maximum energy levels then radio-frequency is distored, so that the radius of orbit changes. After the proton gets out of its track it will strike.

frequency of revolution of positive particle to be

$$F = \frac{(qBc^2)(2\pi\varepsilon)}{2\pi(K + m_0c^2)(2\pi r_0 + 4l)}$$

0

Q2.

3. The nucleus makes up much less than 0.01 of the volume of atom, but typically Contains more than 99.9 λ of the mass of the atom. The chemical properties of substance are determined by the negativity charged e-

2

Vivekananda College Kolhapur (Autonomous).

Department of Physics: Internal examination 2018-19

B.Sc. III Semester V

Subject: Mathematical Physics

Marks: 20 (Each question carry one mark) **Time : 20 min**

Q.1 Attempt any ONE **(10)**

1. Discuss Hamilton variational principle.
2. Derive Hamilton's canonical equation of motion from variational principle.

Q.2 Attempt any TWO **(10)**

1. State equivalence of Lagrange's and Newton's equations.
2. Write a note on degree of freedom and constraints.
3. What is relation between H and L?

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

34025

Shri Swami Vivekanand Shikshan Sanstha Kolhapur's

VIVEKANAND COLLEGE, KOLHAPUR (AUTONOMOUS)

SUPPLIMENT

Signature of Supervisor	

$\frac{20}{20}$

Suppliment No. :

Roll No. : 8517

Class : B Sc-III, Sem-V

Subject : Mathematical & Statastical Physics

Test / Tutorial No. :

Div. :

Q.1)

1) The curl of a vector in orthogonal curvilinear co-ordin-
-ate system

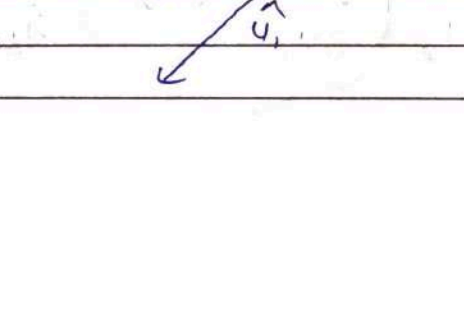
$$\iint_S (\nabla \times \vec{A})\, ds = \oint \vec{A}\, dl$$

Using mean value theorem for integral

$$\text{curl}\vec{A} \iint_S ds = \oint \vec{A}\, dl$$

$$\oint \vec{A}\, dl = \oint \vec{A}\, dl + \oint \bar{A}\, dl + \oint \bar{A}\, dl + \oint \vec{A}\, dl$$

let $\bar{A} = A_1 \bar{u}_1 + A_2 \bar{u}_2 + A_3 \vec{u}_3$



$$\oint \bar{A}\, dl = A_2 h_2 du_2 + \left(A_3 h_3 du_3 + \frac{\partial}{\partial u_2} A_3 h_3 du_2 du_3\right)$$

$$+\left(-A_2 h_2 du_2 - \frac{\partial}{\partial u_3} A_2 h_2 du_2 du_3\right) + \left(-A_3 h_3 \partial u_3\right)$$

$$\oint \bar{A}\, dl = \left[\frac{\partial A_3 h_3}{\partial u_2} - \frac{\partial A_2 h_2}{\partial u_3}\right] du_2 du_3$$

$$(\nabla \times \vec{A})u_1 = \frac{\left[\frac{\partial A_3}{\partial u_2} - \frac{\partial A_2 h_2}{\partial u_3}\right] du_2 du_3}{h_2 h_3 du_2 \partial u_3}$$

$$= \frac{1}{h_1 h_3}\left(\frac{\partial A_3 h_3}{\partial u_2} - \frac{\partial A_2 h_2}{\partial u_3}\right)$$

similarly by coosing areas S_2 & S_3

$$(\nabla \times \vec{A})u_2 = \frac{1}{h_3 h_1}\left(\frac{\partial (A_1 h_1}{\partial u_3} - \frac{\partial (A_3 h_3)}{\partial u_1}\right)$$

$$\nabla \times \vec{A})u_3 = \frac{1}{h_1 h_2}\left(\frac{\partial}{\partial u_1}(A_2 h_2 - \frac{\partial}{\partial u_2}(A_1 h_1)\right)$$

$$\text{curl } \vec{A} = \nabla \times \vec{A} = \frac{\hat{u}_1}{h_2 h_3}\left(\frac{\partial}{\partial u_2}(A_3 h_3) - \frac{\partial}{\partial u_3}(A_2 h_2)\right)$$

$$+ \frac{\hat{u}_2}{h_3 h_1}\left(\frac{\partial}{\partial u_3}(A_3 h_3) - \frac{\partial}{\partial u_1}(A_2 h_2)\right)$$

$$+ \frac{u_3}{h_1 h_2}\left(\frac{\partial}{\partial u_1}(A_2 h_2) - \frac{\partial}{\partial u_2}(A_1 h_1)\right)$$

$$\text{curl } \bar{A} = \vec{\nabla} \times \vec{A} = \frac{1}{h_1 h_2 h_3} \begin{vmatrix} u_1 h_1 & u_2 h_2 & u_3 h_3 \\ \partial/\partial u_1 & \partial/\partial u_2 & \partial/\partial u_3 \\ A_1 h_1 & A_2 h_2 & A_3 h_3 \end{vmatrix}$$

Q2- Gradient.

let us consider, $\phi(u_1 u_2 u_3)$ a scalar function.

$$(\text{grad } \phi)_{u_1} = (\nabla \phi)_{u_1} = \lim_{\delta u_1 \to 0} \frac{\phi(B) - \phi(A)}{AB}$$

where $\phi(B)$ and $\phi(A)$ are the values of scalar function ϕ at B and A separated by distance AB ~~hdu~~

$AB = h_1 du_1$ $$(\text{grad } \phi)_{u_1} = (\nabla \phi)_{u_1} = \lim_{\delta u_1 \to 0} \left(\frac{\delta \phi}{h_1 du_1} \right)$$

$$(\nabla \phi)_{u_1} = \frac{1}{h_1} \frac{\partial \phi}{\partial u_1}$$

similarly, the component of gradient of ϕ in the direction ~~o~~ u_2 & u_3

$$(\text{grad } \phi)_{u_2} = (\nabla \phi)_{u_2} \frac{1}{h_2} \frac{\partial \phi}{\partial u_2}$$

$$(\text{grad } \phi)_{u_3} = (\nabla \phi)_{u_3} \frac{1}{h_3} \frac{\partial \phi}{\partial u_3}$$

If $\hat{u}_1 \hat{u}_2 u_3$ are unit

$$\text{grad} = \nabla \phi = \frac{u_1}{h_1} \frac{\partial \phi}{\partial u_1} + \frac{u_2}{h_2} \frac{\partial \phi}{\partial u_2} + \frac{u_3}{h_3} \frac{\partial \phi}{\partial u_3}$$

$$\nabla \phi = \left(\frac{\hat{u}_1}{h_1} \frac{\partial}{\partial u_1} + \frac{\hat{u}_2}{h_2} \frac{\partial}{\partial u_2} + \frac{\hat{u}_3}{h_3} \frac{\partial}{\partial u_3} \right) \phi$$

It gives the operator $(\vec{\nabla})$ in orthogonal curvilinear

$$\vec{\nabla} = \frac{\hat{u}_1}{h_1} \frac{\partial}{\partial u_1} + \frac{\hat{u}_2}{h_2} \frac{\partial}{\partial u_2} + \frac{\hat{u}_3}{h_3} \frac{\partial}{\partial u_3}$$

Q3 Laplacian operator ∇^2 in orthogonal curvilinear.

we know that.

$$\operatorname{div} \vec{A} = \vec{\nabla} \cdot \vec{A} = \frac{1}{h_1 h_2 h_3}\left(\frac{\partial}{\partial u_1}(\bar{A}_1 h_2 h_3) + \frac{\partial}{\partial u_2}(\bar{A}_2 h_1 h_3) + \frac{\partial}{\partial u_3}(\bar{A}_3 h_1 h_2) \right)$$

let $\vec{A} = \vec{\nabla} f$, where f is scalar field substituting we

$$\operatorname{div} \vec{A} = \vec{\nabla} \cdot \vec{\nabla} f = \nabla^2 f$$

$$= \frac{1}{h_1 h_2 h_3}\left[\frac{\partial}{\partial u_1}(h_2 h_3 \vec{\nabla} f_{u_1}) + \frac{\partial}{\partial u_2}(h_3 h_1 \nabla f_{u_2}) + \frac{\partial}{\partial u_3} h_1 h_2 \nabla f_{u_3} \right]$$

$$\nabla^2 f = \frac{1}{h_1 h_2 h_3}\left[\frac{\partial}{\partial u_1}\left(\frac{h_2 h_3}{h_1}\frac{\partial f}{\partial u_1}\right) + \frac{\partial}{\partial u_2}\left(\frac{h_1 h_3}{h_2}\frac{\partial f}{\partial u_2}\right) + \frac{\partial}{\partial u_3}\left(\frac{h_1 h_2}{h_3}\frac{\partial f}{\partial u_3}\right) \right]$$

The Laplacian operator ∇^2 in orthogonal curvilinear coordinate is

$$\nabla^2 = \frac{1}{h_1 h_2 h_3}\left[\frac{\partial}{\partial u_1}\left(\frac{h_2 h_3}{h_1}\frac{\partial}{\partial u_1}\right) + \frac{\partial}{\partial u_2}\left(\frac{h_3 h_1}{h_2}\frac{\partial}{\partial u_2}\right) + \frac{\partial}{\partial u_3}\left(\frac{h_1 h_2}{h_3}\frac{\partial}{\partial u_3}\right) \right]$$

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

34045

Shri Swami Vivekanand Shikshan Sanstha Kolhapur's

VIVEKANAND COLLEGE, KOLHAPUR (AUTONOMOUS)

SUPPLIMENT

Suppliment No. :	Signature of Supervisor
Roll No. : 8519	Subject : Mathematical & statistical Physics
Class : BSc. III Sem-V	Test / Tutorial No. :
	Div. :

15/20

Laplacean operator :-

We know that.

$$\text{div.} \vec{A} = \vec{\nabla}\cdot\vec{A} = \frac{1}{h_1h_2h_3}\left[\frac{\partial}{\partial u_1}(A_1h_2h_3) + \frac{\partial}{\partial u_2}(A_2h_3h_1) + \frac{\partial}{\partial u_3}(A_3h_1h_2)\right]$$

Let $\vec{A} = \vec{\nabla}\cdot f$, where f is scalar field

substitute we get.

$$\text{div.} \vec{A} = \vec{\nabla}\cdot\vec{\nabla}f = \nabla^2 f$$

$$= \frac{1}{h_1h_2h_3}\left[\frac{\partial}{\partial u_1}(h_2h_3(\vec{\nabla}f)_{u_1}) + \frac{\partial}{\partial u_2}h_3h_1(\vec{\nabla}f)_{u_2} + \frac{\partial}{\partial u_3}h_1h_2(\vec{\nabla}f)_{u_3}\right]$$

5

$$\nabla^2 f = \frac{1}{h_1h_2h_3}\left[\frac{\partial}{\partial u_1}\left(\frac{h_2h_3}{h_1}\frac{\partial f}{\partial u_1}\right) + \frac{\partial}{\partial u_2}\left(\frac{h_1h_3}{h_2}\frac{\partial f}{\partial u_2}\right) + \frac{\partial}{\partial u_3}\left(\frac{h_1h_2}{h_3}\frac{\partial f}{\partial u_3}\right)\right]$$

The Laplacian operator ∇^2 in orthogonal curvilinear co-ordinate is given by,

$$\nabla^2 = \frac{1}{h_1h_2h_3}\left[\frac{\partial}{\partial u_1}\left(\frac{h_2h_3}{h_1}\frac{\partial}{\partial u_1}\right) + \frac{\partial}{\partial u_2}\left(\frac{h_1h_3}{h_2}\frac{\partial}{\partial u_2}\right) + \frac{\partial}{\partial u_3}\left(\frac{h_1h_2}{h_3}\frac{\partial}{\partial u_3}\right)\right]$$

Curl of Vector in OCCS -

The curl of a vector may be obtained by using stoke's theorem which is given by,

$$\iint_S (\nabla \times \vec{A}) ds = \oint \vec{A} dl$$

Using mean value theorem for integral

$$\text{curl} \vec{A} \iint_S ds = \oint \vec{A} dl \quad \text{or} \quad \text{curl} \vec{A} = \lim_{ds \to 0} \frac{\oint \vec{A} dl}{\iint_S ds}$$

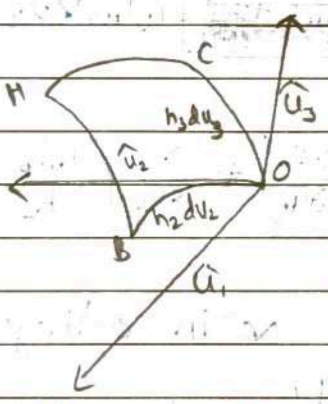
To evalute this consider surface (S_1) OBHC of a parallelopiped normal to $\hat{u}_1$ at O. Refer Fig. 1.6. Boudary of surface denotes closed line.

Then closed line integral can be written as

$$\oint_{OBHC} \vec{A} dl = \oint_{OB} \vec{A} dl + \oint_{BH} \vec{A} dl + \oint_{HC} \vec{A} dl + \oint_{CO} \vec{A} dl$$

Let,

$$\vec{A} = A_1 \hat{u}_1 + A_2 \hat{u}_2 + A_3 \hat{u}_3$$



Evaluating integral, we get.

$$\oint_{OBHC} \vec{A} dl = A_2 h_2 du_2 + \left(A_3 h_3 du_3 + \frac{\partial}{\partial u_2} A_3 h_3 du_2 du_3 \right)$$

$$+ \left(-A_2 h_2 du_2 - \frac{\partial}{\partial u_3} A_2 h_2 du_2 du_3 \right) + \left(-A_3 h_3 du_3 \right)$$

$$\therefore \oint_{OBHC} \vec{A} dl = \left[\frac{\partial A_3 h_3}{\partial u_2} - \frac{\partial A_2 h_2}{\partial u_3} \right] du_2 du_3$$

Dividing by area of S_1 (OBHC) equal to $h_2 h_3\, du_2 du_3$ and taking limit du_2 & du_3 approaches to zero.

$$(\nabla \times \vec{A})_{u_1} = \frac{\left[\frac{\partial A_3 h_3}{\partial u_2} - \frac{\partial A_2 A_2}{\partial u_3}\right] du_2 du_3}{h_2 h_3\, du_2 du_3}$$

$$= \frac{1}{h_1 h_3}\left(\frac{\partial A_3 h_3}{\partial u_2} - \frac{\partial A_2 h_2}{\partial u_3}\right)$$

Similarly by choosing areas S_2 & S_3 perpendicular to $\hat{u}_2$ and $\hat{u}_3$ at respectively.

$$(\nabla \times \vec{A})_{u_2} = \frac{1}{h_3 h_1}\left(\frac{\partial (A_1 h_1)}{\partial u_3} - \frac{\partial (A_3 h_3)}{\partial u_1}\right)$$

$$(\nabla \times \vec{A})_{u_3} = \frac{1}{h_1 h_2}\left(\frac{\partial}{\partial u_1}(A_2 h_2) - \frac{\partial}{\partial u_2}(A_1 h_1)\right)$$

From these three components resultant eq^n is,

$$\text{curl}\,\vec{A} = \nabla \times \vec{A} = \frac{\hat{u}_1}{h_2 h_3}\left(\frac{\partial}{\partial u_2}(A_3 h_3) - \frac{\partial}{\partial u_3}(A_2 h_2)\right)$$
$$+ \frac{\hat{u}_2}{h_3 h_1}\left(\frac{\partial}{\partial u_3}(A_1 h_1) - \frac{\partial}{\partial u_1}(A_3 h_3)\right)$$
$$+ \frac{\hat{u}_3}{h_1 h_2}\left(\frac{\partial}{\partial u_1}(A_2 h_2) - \frac{\partial}{\partial u_2}(A_1 h_1)\right)$$

$$\text{curl}\,\bar{A} = \nabla \times \vec{A} = \frac{1}{h_1 h_2 h_3}\begin{vmatrix} \hat{u}_1 h_1 & \hat{u}_2 h_2 & \hat{u}_3 h_3 \\ \frac{\partial}{\partial u_1} & \frac{\partial}{\partial u_2} & \frac{\partial}{\partial u_3} \\ A_1 h_1 & A_2 h_2 & A_3 h_3 \end{vmatrix}$$

10

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

34044

Shri Swami Vivekanand Shikshan Sanstha Kolhapur's

VIVEKANAND COLLEGE, KOLHAPUR (AUTONOMOUS)

SUPPLIMENT

17/20

Suppliment No. :		Signature of Supervisor	
Roll No.	: 8516	Subject : Mathematical & statistical Physics	
Class	: BSc. III Sem V	Test / Tutorial No. :	
		Div. :	

Gradient of scalar field in OCCS -

Let us consider $\phi(u_1, u_2, u_3)$ a scalar function. The gradient of the scalar field ϕ in direction of u_1 - axis can be written as.

$$(\text{grad}\,\phi)_{u_1} = (\nabla\phi)_{u_1} = \lim_{\delta u_1 \to 0} \frac{\phi(B) - \phi(A)}{AB}$$

where $\phi(B)$ and $\phi(A)$ are values of scalar function ϕ at B and A seperated by distance $AB = h_1 du_1$. The quantity $[\phi(B) - \phi(A)]$ may be taken as increase in ϕ on travelling distance $AB = h_1 du_1$. This may be written as $\partial\phi$ for the limiting case where $\delta u_1 \to 0$

$$(\text{grad}\,\phi)_{u_1} = (\nabla\phi)_{u_1} = \lim_{\delta u_1 \to 0} \left(\frac{\delta\phi}{h_1 du_1}\right)$$

$$(\nabla\phi)_{u_1} = \frac{1}{h_2} \frac{\partial\phi}{\partial u_1}$$

5

Similarly, the component of gradient of ϕ in the direction u_2 and u_3 axes are.

$$(\text{grad}\,\phi)_{u_2} = (\nabla\phi)_{u_2} = \frac{1}{h_2} \frac{\partial\phi}{\partial u_2}$$

$$(\text{grad}\,\phi)_{u_3} = (\nabla\phi)_{u_3} = \frac{1}{h_3} \frac{\partial\phi}{\partial u_3}$$

If $\hat{u}_1, \hat{u}_2, \hat{u}_3$ are unit vectors along the u_1, u_2, u_3 directions respectively then we can write,

$$\text{grad } \phi = \nabla\phi = \frac{\hat{u}_1}{h_1}\frac{\partial\phi}{\partial u_1} + \frac{\hat{u}_2}{h_2}\frac{\partial\phi}{\partial u_2} + \frac{\hat{u}_3}{h_3}\frac{\partial\phi}{\partial u_3}$$

or

$$\nabla\phi = \left[\frac{\hat{u}_1}{h_1}\frac{\partial}{\partial u_1} + \frac{\hat{u}_2}{h_2}\frac{\partial}{\partial u_2} + \frac{\hat{u}_3}{h_3}\frac{\partial}{\partial u_3}\right]\phi$$

It gives the del operator ($\vec{\nabla}$) in orthogonal curvilinear co-ordinates.

$$\vec{\nabla} = \frac{\hat{u}_1}{h_1}\frac{\partial}{\partial u_1} + \frac{\hat{u}_2}{h_2}\frac{\partial}{\partial u_2} + \frac{\hat{u}_3}{h_3}\frac{\partial}{\partial u_3}$$

Laplacean operator in OCCS -

We know that,

$$\text{div. } \vec{A} = \vec{\nabla}\cdot\vec{A} = \frac{1}{h_1h_2h_3}\left[\frac{\partial}{\partial u_1}(A_1h_2h_3) + \frac{\partial}{\partial u_2}(A_2h_1h_3) + \frac{\partial}{\partial u_3}(A_3h_1h_2)\right]$$

Let $A = \vec{\nabla} f$ where f is scalar field.

$$\text{div. } \vec{A} = \vec{\nabla}\cdot\vec{\nabla} f = \nabla^2 f$$

Curl of Vector –

The curl of vector function obtained by Stoke's theorem,

$$\iint_S (\nabla \times \vec{A})\, ds = \oint \vec{A}\, dl$$

Using mean value –

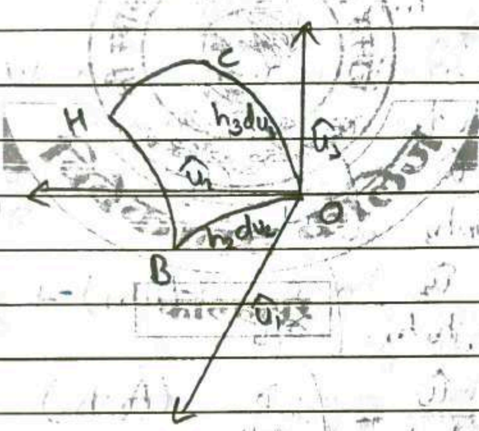
$$\text{curl}\,\vec{A} \iint_S ds = \oint \vec{A}\, dl \quad \text{or} \quad \text{curl}\,\vec{A} = \lim_{\delta s \to 0} \frac{\oint \vec{A}\, ds}{\iint_S ds}$$

To evaluate this consider surface (S_1) OBHC

$$\oint_{OBHC} \vec{A}\, dl = \oint_{OB} \vec{A}\, dl + \oint_{BH} \vec{A}\, dl + \oint_{HC} \vec{A}\, dl + \oint_{CO} \vec{A}\, dl$$

Let,

$$\vec{A} = \vec{A}_1 \hat{u}_1 + A_2 \hat{u}_2 + A_3 \hat{u}_3$$



Evaluating integral.

$$\oint_{OBHC} \vec{A}\, dl = A_2 h_2 du_2 + \left(A_3 h_3 du_3 + \frac{\partial}{\partial u_2} A_3 h_3 du_2 du_3\right) + \left(-A_2 h_2 du_2 - \frac{\partial}{\partial u_3} A_2 h_2 du_2 du_3\right) + \left(-A_3 h_3 du_3\right)$$

$$\oint_{OBHC} \vec{A}\, dl = \left[\frac{\partial A_3 h_3}{\partial u_2} - \frac{\partial A_2 h_2}{\partial u_3}\right] du_2 du_3.$$

Dividing by area of S_1 (OBHC) equal to $h_2 h_3 du_2 du_3$ and taking limit du_2 and du_3 approaches to zero, then component of curl $\vec{A}$ along $\hat{u}_1$.

$$(\nabla \times \vec{A})_{u_1} = \frac{\left(\frac{\partial A_3 h_3}{\partial u_2} - \frac{\partial A_2 h_2}{\partial u_3}\right) du_2\, du_3}{h_2 h_3\, du_2\, du_3}$$

$$= \frac{1}{h_2 h_3}\left(\frac{\partial A_3 h_3}{\partial u_2} - \frac{\partial A_2 h_2}{\partial u_3}\right)$$

Similarly by choosing areas S_2 and S_3 perpendicular to $\hat{u}_2$ and $\hat{u}_3$ at O respectively, we find component of curl $\vec{A}$ along $\vec{u}_2$ and $\hat{u}_3$. This leads to the result

$$(\nabla \times \vec{A})_{u_2} = \frac{1}{h_3 h_1}\left[\frac{\partial A_1 h_1}{\partial u_3} - \frac{\partial (A_3 h_3)}{\partial u_1}\right]$$

$$(\nabla \times \vec{A})_{u_3} = \frac{1}{h_1 h_2}\left[\frac{\partial}{\partial u_1}(A_2 h_2) - \frac{\partial}{\partial u_2}(A_1 h_1)\right]$$

From these three components, resultent equation for curl of vector field can be written as

$$\text{curl } \vec{A} = \nabla \times \vec{A} = \frac{\hat{u}_1}{h_2 h_3}\left[\frac{\partial}{\partial u_2}(A_3 h_3) - \frac{\partial}{\partial u_3}(A_2 h_2)\right] + \frac{\hat{u}_2}{h_3 h_1}\left[\frac{\partial}{\partial u_3}(A_1 h_1) - \frac{\partial}{\partial u_1}(A_3 h_3)\right] + \frac{\hat{u}_3}{h_1 h_2}\left(\frac{\partial}{\partial u_1}(A_2 h_2) - \frac{\partial}{\partial u_2}(A_1 h_1)\right]$$

10

$$\text{Curl } \vec{A} = \nabla \times \vec{A} = \frac{1}{h_1 h_2 h_3}\begin{vmatrix} \hat{u}_1 h_1 & \hat{u}_2 h_2 & \hat{u}_3 h_3 \\ \frac{\partial}{\partial u_1} & \frac{\partial}{\partial u_2} & \frac{\partial}{\partial u_3} \\ A_1 h_1 & A_2 h_2 & A_3 h_3 \end{vmatrix}$$

This is the required result.

Vivekananda College Kolhapur (Autonomous).
Department of Physics: Internal examination 2018-19
B.Sc. III Semester V
Subject: Classical mechanics

Marks: 20 (Each question carry one mark) Time : 20 min

Q.1 Attempt any ONE **(10)**

1. Obtain an expression for the curl of vector field in orthogonal curvilinear co-ordinates.
2. Obtain an expression for the divergence of vector field in orthogonal curvilinear co-ordinate system. Extend the above formula in spherical polar co-ordinate system.

Q.2 Attempt any TWO **(10)**

1. Obtain Laplacian operator in orthogonal curvilinear co-ordinate. Extend the result in cylindrical co-ordinates.
2. Obtain an expression for gradient of a scalar field in orthogonal curvilinear co-ordinate system.
3. Describe spherical polar co-ordinate system.

COLLEGE KOLHAPUR ESTD JUNE 1964 (Autonomous)

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

34828

Shri Swami Vivekanand Shikshan Sanstha Kolhapur's

VIVEKANAND COLLEGE, KOLHAPUR (AUTONOMOUS)

SUPPLIMENT

15/20

Signature of Supervisor	

Suppliment No. :

Subject : Classical mechanics

Roll No. : 8524

Test / Tutorial No. : Internal Exam

Class : B.Sc-III, Sem V

Div. :

Q2.

1. Equivalence of Lagrange and Newton's equations

⇒ In Newtonian mechanics the eqⁿ of motion involves vector quantities like force, momentum, which increase complexity in solving the problem. This approach can't avoid constraints present in problem.

These force of constraints, if not known make solution of problem difficult and even if they are known, use of rectangular / other commonly used co-ordinates may make solⁿ of problem impossible. These drawback removed in Lagrangian mechanics where the technique involve scalar like potential and kinetic energies instead of vectors.

5

Q2.

2. Write note on Degree of freedom and Constraint

⇒

Degrees of Freedom -

The number of independent ways in which a mechanical system can move without violating any constraint which may be imposed on system is called number of degrees of freedom.

It is indicated by least possible number of Co-ordinates to describe system completely

Eg - when single particle moves freely in space (x, y, z) it has three degrees of freedom

* Constraint -

when motion of particle / system of particle is restricted in some way then constraint have been introduced

Classification of constraint -

ⓐ Scleronomic

ⓑ. Rheonomic

ⓒ. Holonomic

ⓓ Non-holonomic

5

Q1.

2. Hamilton's Canonical equation of motion from Varional Principle

The Hamiltonian of system Specified its total energy i.e kinetic energy and potential energy in terms of

$\therefore \quad L = T - V$

$\therefore \quad H = \sum p_i \dot{q}_i - L$

$$H = m\dot{q}_i q_i - (T - V)$$

$$= 2 \cdot \left(\frac{1}{2} m \dot{q}_i^2 \right) - (T - V)$$

$$= 2T - T + V$$

$\therefore \quad H = T + V$

Hamilton Canonical Equation

$\therefore \quad H = H(q_i, p_i, t)$

$$\therefore \quad dH = \sum \frac{\partial H}{\partial q_i} dq_i + \sum \frac{\partial H}{\partial p_i} dp_i + \frac{\partial H}{\partial t} dt$$

5

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

34019

Shri Swami Vivekanand Shikshan Sanstha Kolhapur's

VIVEKANAND COLLEGE, KOLHAPUR (AUTONOMOUS)

SUPPLIMENT

10/20

Signature of Supervisor

Suppliment No. :

Subject : classical mechanics

Roll No. : 8523

Test / Tutorial No. : Internal Exam

Class : B.Sc-III, Sem V

Div. : 2018-19

Q1.

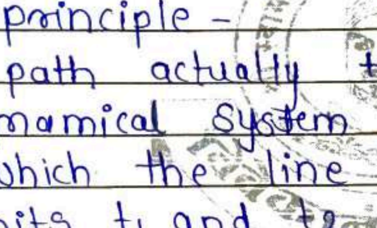
1. Hamilton Variational principle

⇒ Hamilton's principle -

The path actually transversed by Conservative holonomic dynamical system from time t_1 to t_2 is one over which the line integral of Lagrangian between limits t_1 and t_2 is stationary.

$$J = \int_{t_1}^{t_2} L\, dt = \text{extremum}$$

Let us consider that Conservative holonomic dynamical system moves from initial state P at t_1 to final state Q at t_2.



To obtain Hamilton's principle following conditions must be satisfied

1> $\delta t = 0$ at the end points, i.e at t_1 the particle must be at P and at t_2 the particle must be Q

2) $\delta r = 0$ at the end points P and Q are fixed in space,

Acc. to Newton's 2nd law of motion the force F_i acting on ith particle of system

$$\therefore \quad F_i = m_i \ddot{r}_i$$

$\therefore$ From D' Alembert Principle,

$$\therefore \sum_{i=1}^{n} (F_i - m_i \ddot{r}_i)\delta r_i = 0$$

$$\therefore \sum_{i=1}^{n} F_i \delta r_i - \sum_{i=1}^{n} m_i \ddot{r}_i \delta r_i = 0 \quad \text{——} (2)$$

But we have,

$$\dot{r}_i \delta r_i = \frac{d}{dt}(\dot{r}_i \delta r_i) - \dot{r}_i \frac{d}{dt}(\delta r_i)$$

$$\therefore \frac{d}{dt}(\dot{r}_i \delta r_i) = \ddot{r}_i \delta r_i + \dot{r}_i \frac{d}{dt}(\delta r_i)$$

$$= \ddot{r}_i \delta r_i + \dot{r} \cdot \frac{d}{dt}(\delta r_i)$$

$$= \dot{r}_i \, \delta r_i + \delta \frac{1}{2} (\dot{r}_i^2)$$

$$\therefore \ddot{r}_i \delta r_i = \frac{d}{dt} (\dot{r}_i \delta r_i) - \delta \frac{1}{2} (\dot{r}_i^2)$$

The eq^n ② becomes,

$$\therefore \sum_{i=1}^{n} F_i \delta r_i - \left\{ \sum_{i=1}^{n} m_i \left[\frac{d}{dt} (\dot{r}_i \delta r_i) - \delta \frac{1}{2} (\dot{r}_i^2) \right] = 0 \right.$$

$$\therefore \sum_{i=1}^{n} F_i \delta r_i + \delta \sum_{i=1}^{n} \frac{1}{2} m_i \dot{r}_i^2 = \sum_{i=1}^{n} \frac{d}{dt} (m_i \dot{r}_i) \delta r_i \quad \text{--- ③}$$

$$\therefore \sum_{i=1}^{n} F_i \delta r_i = \delta W = \text{work done by force } F_i \text{ during displacement}$$

$$\therefore \sum_{i=1}^{n} \frac{1}{2} m_i \dot{r}_i^2 = T = \text{K.E of system}$$

$\therefore$ Therefore eq^n ③ becomes,

$$\therefore \delta W + \delta T = \sum_i \frac{d}{dt} (m_i \dot{r}_i) \delta r_i$$

$\therefore$ Integrating above eq^n bet^n limits t_1 and t_2

$$\therefore \int_{t_1}^{t_2} (\delta W + \delta T)\, dt = \int_{t_1}^{t_2} \sum_{i=1}^{n} \frac{d}{dt} (m_i \dot{r}_i) \delta r_i \, dt$$

$$= \int_{t_1}^{t_2} \sum_{i=1}^{n} d(m_i \dot{r}_i) \delta r_i$$

$$= \left[\sum_{i=1}^{n} (m_i \dot{r}_i)\, \delta r_i \right]_P^Q$$

$$= 0$$

Since $\delta r_i = 0$ at the end points P and Q

$$\therefore \int_{t_1}^{t_2} (\delta W + \delta T)\, dt = 0 \quad \text{--- (4)}$$

But for conservative system, we have $\delta W = -\delta V$
δV is change in potential energy.

$$\therefore \int_{t_1}^{t_2} (-\delta V + \delta T)\, dt = 0$$

$$\therefore \delta \int_{t_1}^{t_2} (T - V)\, dt = 0$$

$$\therefore \delta J = \delta \int_{t_1}^{t_2} L\, dt = 0$$

$$\therefore J = \int_{t_1}^{t_2} L\, dt = \text{Extremum}$$

10

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

34026

Shri Swami Vivekanand Shikshan Sanstha Kolhapur's

VIVEKANAND COLLEGE, KOLHAPUR (AUTONOMOUS)

SUPPLIMENT

18/20

Signature of Supervisor

Suppliment No. :

Subject : classical mechanics

Roll No. : 8510

Test / Tutorial No. : Internal Exam

Class : BSc-III Sem V

Div. :

Q2

1. In newtonian mechanics the eqn of motion involves vectors quantities like force, momentum which increase complexity in solving the problem. This approach can't avoid constraints present in probleme.

These force of constraints if not known make solution of problem difficult and even if they are known, use of rectangular and other commonly used co-ordinates may make soln of problem impossible. These drawbacks removed in Lagrangian mechanics

where the technique involves scalers like potential and kinetic energies instead of vectors

5

~~3. relation between H and L~~

2\. Note on Degree of freedom and constraint

⇒ when motion of particle / system of particle is restricted in some way then constraints have been introduced

classification of constraints -

a. Scleronomic -

If constraint relation do not explicitly depend time e.g. in case of rigid body.

b. rheonomic - If constraint relation depend explicitly on time a bead sliding on moving wire in force free space.

c. Holonomic - Let $r_1, r_2 \dots r_n$ be the position co-ordinates of system and t denotes time then condition of all constraints are expressed as equations having the form $(r_1, r_2, \dots r_n, t) = 0$

d. Non - holonomic -

If the condition of constraints are not so expressed as non-holonomic called as non-holonomic constraints.

5

Vivekananda College Kolhapur (Autonomous).

Department of Physics: Internal examination 2018-19

B.Sc. III Semester V

Subject: Quantum mechanics

Marks: 20 (Each question carry one mark) **Time : 20 min**

Q.1. Long Answer question (Attempt any ONE) . **[10]**

i) Obtain Schrodinger , s time independent equation and time dependent equation

ii) Explain quantum mechanical treatment of linear harmonic oscillator and show that zero point energy of oscillator is $E\,0 = \frac{1}{2}\hbar\omega$

Q.2. Short Answer question (Attempt any TWO). **[10]**

i) Show that $[x , P x] = i\hbar$ give its physical significance

ii) Give physical significance of wave function

iii) Obtain Schrodingers equation in spherical polar coordinate system for hydrogen atom

॥ ज्ञान, विज्ञान आणि सुसंस्कार यांसाठी शिक्षण प्रसार ॥

– शिक्षणमहर्षी डॉ. बापूजी साळुंखे

34020

Shri Swami Vivekanand Shikshan Sanstha Kolhapur's

VIVEKANAND COLLEGE, KOLHAPUR (AUTONOMOUS)

SUPPLIMENT

Signature of Supervisor

Suppliment No. :

$\frac{10}{20}$

Subject : Quantum mechanics

Roll No. : 8515

Test / Tutorial No. : Internal exam

Class : B.Sc III

Div. :

Q.1

i) a) Time-independent Schrodinger's equation:-

1) Total energy is given by

$$E = K.E + P.E.$$

$$E = \frac{1}{2} mv^2 + V$$

$$E = \frac{1}{2} \frac{m^2 v^2}{m} + V$$

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

$$p^2 = 2m(E - V)$$

$$p = [2m(E-V)]^{1/2} \quad \text{--- (1)}$$

$\therefore$ de-Broglie wavelength $\lambda = \frac{h}{p} = \frac{h}{[2m(E-V)]^{1/2}}$

2) He assumed that the wave funct^n ψ is governed by the equation

$$\psi = \psi_0 e^{-i\omega t} \quad \text{--- (2)}$$

Wave equation in Cartesian co-ordinates is given by

$$\frac{\partial^2 \psi}{\partial x^2} + \frac{\partial^2 \psi}{\partial y^2} + \frac{\partial^2 \psi}{\partial z^2} = \frac{1}{u^2}\frac{\partial^2 \psi}{\partial t^2} \quad \text{--- (3)}$$

Differentiating eq^n (3) twice with respect to t we get

$$\frac{\partial^2 \psi}{\partial t^2} = -\omega^2 \psi_0 e^{-i\omega t} = -\omega^2 \psi$$

Substituting this value in eq^n 3

$$\frac{\partial^2 \psi}{\partial x^2} + \frac{\partial^2 \psi}{\partial y^2} + \frac{\partial^2 \psi}{\partial z^2} = -\left(\frac{\omega^2}{u^2}\right)\psi$$

$$\frac{\omega^2}{u^2} = \frac{(2\pi \nu)^2}{(\nu \lambda)^2} = \frac{4\pi^2}{\lambda^2}$$

$$\therefore \frac{\partial^2 \psi}{\partial x^2} + \frac{\partial^2 \psi}{\partial y^2} + \frac{\partial^2 \psi}{\partial z^2} = -\left(\frac{4\pi^2}{\lambda^2}\right)\psi$$

$$\nabla^2 \psi + \frac{4\pi^2}{\lambda^2}\psi = 0 \quad \text{--- (4)}$$

Eq^n (4) is general eq^n and is independent of time

Substituting this value of λ in eq^n 4

$$\nabla^2 \psi + \frac{4\pi^2 [2m(E-V)]\psi}{h^2} = 0$$

$$\nabla^2 \psi + \left(\frac{8\pi^2 m}{h^2}\right)(E-V)\psi = 0$$

Also, $\hbar = \frac{h}{2\pi}$

$$\therefore \nabla^2 \psi + \left(\frac{2m}{\hbar^2}\right)(E-V)\psi = 0 \quad \text{--- (5)}$$

This is the Schrodinger's time-independent wave eq^n

b) Time - dependent schrodinger's eq^n

The wave funct^n

$$\psi = \psi_0 e^{-i\omega t}$$

$$\frac{\partial \psi}{\partial t} = -i\omega \psi_0 e^{-i\omega t}$$

$$\frac{\partial \psi}{\partial t} = -i(2\pi \nu)\psi$$

$$\frac{\partial \psi}{\partial t} = -i(2\pi)\left(\frac{E}{h}\right)\psi$$

$$E\psi = -\frac{1}{i}\left(\frac{h}{2\pi}\right)\frac{\partial \psi}{\partial t}$$

$$E\psi = i\hbar \frac{\partial \psi}{\partial t} \quad \left(\because \hbar = \frac{h}{2\pi} \text{ and } i^2 = -1\right)$$

We know

$$\nabla^2 \psi + \frac{2m}{\hbar^2} E\psi - \frac{2m}{\hbar^2} V\psi = 0$$

substituting value of $E\psi = i\hbar \frac{\partial \psi}{\partial t}$ in above eq^n

$$\nabla^2 \psi + \frac{2m}{\hbar^2} i\hbar \frac{\partial \psi}{\partial t} - \frac{2m}{\hbar^2} V\psi = 0$$

$$\nabla^2 \psi - \left(\frac{2m}{\hbar^2}\right) V\psi = -\left(\frac{2m}{\hbar^2}\right) i\hbar \frac{\partial \psi}{\partial t}$$

or

$$-\left(\frac{\hbar^2}{2m}\right)\nabla^2 \psi + V\psi = i\hbar \frac{\partial \psi}{\partial t}$$

$$\left(-\frac{\hbar^2}{2m}\nabla^2 + V\right)\psi = i\hbar \frac{\partial \psi}{\partial t}$$

$$H\psi = E\psi$$

This is the schrodinger's time - dependent wave eq^n

10

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

34022

Shri Swami Vivekanand Shikshan Sanstha Kolhapur's

VIVEKANAND COLLEGE, KOLHAPUR (AUTONOMOUS)

SUPPLIMENT

Signature of Supervisor

$\frac{13}{20}$

Suppliment No. :

Subject : Quantum Mechanics.

Roll No. : 8519

Test / Tutorial No. : Internal Exam

Class : B.Sc III, Sem-V (18-19)

Div. :

Q.2)

1) Consider the action of commutator $[x, P_x]$ on wave fn $\psi(x,y,z)$.

$$[x, P_x]\psi = [x, -i\hbar\, \partial/\partial x]\psi$$

$$= -i\hbar\left[x, \frac{\partial}{\partial x}\right]\psi$$

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

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

5

$$= -i\hbar\left\{x\frac{\partial\psi}{\partial x} - x\frac{\partial\psi}{\partial x} - \psi\right\}$$

$$= -i\hbar(-\psi)$$

$$= i\hbar\psi$$

$$[x, P_x]\psi = i\hbar\psi$$

$$\therefore [x, P_x] = i\hbar.$$

Q. 1)

1) (a) Time independent schrödinger's equation →

The de- Borglie wavelength for any particle moving in a field of force with potential energy v. Therefore, total energy is given by,

$$E = KE + PE$$

$$= \frac{1}{2}mv^2 + V$$

$$= \frac{1}{2}\frac{m^2v^2}{m} + V$$

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

$$p^2 = 2m(E-V)$$

$$p = [2m(E-V)]^{1/2} \quad \text{--- (1)}$$

De-Borglie wavelength $\lambda = \frac{h}{p} = \frac{h}{[2m(E-V)]^{1/2}}$ — (2)

The wave function ψ is governed by the equation

$$\psi = \psi_0 e^{-i\omega t} \quad \text{--- (3)}$$

The wave equation in cartesian co-ordinates is given by,

$$\frac{\partial^2\psi}{\partial x^2} + \frac{\partial^2\psi}{\partial y^2} + \frac{\partial^2\psi}{\partial z^2} = \frac{1}{u^2}\frac{\partial^2\psi}{\partial t^2} \quad \text{--- (4)}$$

Now, differentiate eq^n (3) twice w.r.to t we get,

$$\frac{\partial^2\psi}{\partial t^2} = -\omega^2\psi_0 e^{-i\omega t} = -\omega^2\psi$$

Putting this value in eq^n (4) we get,

$$\frac{\partial^2\psi}{\partial x^2} + \frac{\partial^2\psi}{\partial y^2} + \frac{\partial^2\psi}{\partial z^2} = -\left(\frac{-\omega^2}{u^2}\right)\psi$$

where, $\frac{\omega^2}{u^2} = \frac{(2\pi\nu)^2}{(\nu\lambda)^2} = \frac{4\pi^2}{\lambda^2}$

$$\therefore \frac{\partial^2\psi}{\partial x^2} + \frac{\partial^2\psi}{\partial y^2} + \frac{\partial^2\psi}{\partial z^2} = \left(\frac{4\pi^2}{\lambda^2}\right)\psi$$

$$\nabla^2\psi + \frac{4\pi^2}{\lambda^2}\psi = 0 \quad \text{---} (5)$$

Eq^n (5) is general eq^n & is independent of time.

By the concept of wave mechanics de-Borglie wavelength

$$\lambda = \frac{h}{P} = \frac{h}{[2m(E-V)]^{1/2}} \quad (\text{from eq}^n (1))$$

Putting this value of λ in eq^n (5) we get,

$$\nabla^2\psi + \frac{4\pi^2[2m(E-V)]\psi}{h^2} = 0$$

$$\nabla^2\psi + \left(\frac{8\pi^2 m}{h^2}\right)(E-V)\psi = 0 \quad \text{---} (6)$$

Also, $\hbar = \frac{h}{2\pi}$

$$\therefore \nabla^2\psi + \left(\frac{2m}{\hbar^2}\right)(E-V)\psi = 0 \quad \text{---} (7)$$

Eq^n (7) represents schrödinger's time independent wave eq^n.

8

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

34021

Shri Swami Vivekanand Shikshan Sanstha Kolhapur's

VIVEKANAND COLLEGE, KOLHAPUR (AUTONOMOUS)

SUPPLIMENT

Signature of Supervisor

Suppliment No. :

$\frac{20}{20}$

Subject : Quantum Mechanics.

Roll No. : 8505

Test / Tutorial No. : Internal Exam

Class : B.Sc III , Sem-V (18-19)

Div. :

Q.1)

1) (a) Time independent Schrödinger's Equation -

Assumed that de-Borglie wavelength for any particle moving in a field of force with potential energy V. Therefore total Energy is given by,

$$E = KE + PE$$

$$= \frac{1}{2}mv^2 + V$$

$$= \frac{1}{2}\frac{m^2v^2}{m} + V$$

$$E = \frac{P^2}{2m} + V$$

$$P^2 = 2m(E-V)$$

$$P = [2m(E-V)]^{1/2} \quad \text{—— (1)}$$

∴ De-Borglie wavelength $\lambda = \frac{h}{P} = \frac{h}{[2m(E-V)^{1/2}]}$ —— (2)

The wave function ψ is governed by the equation

$$\psi = \psi_0 e^{-i\omega t} \quad (3)$$

The wave equation in cartesian co-ordinates is given by,

$$\frac{\partial^2\psi}{\partial x^2} + \frac{\partial^2\psi}{\partial y^2} + \frac{\partial^2\psi}{\partial z^2} = \frac{1}{u^2}\frac{\partial^2\psi}{\partial t^2} \quad \text{—— (4)}$$

Now, differentiate eqn (3) twice w.r.to 't' we get,

$$\frac{\partial^2\psi}{\partial t^2} = -\omega^2 \psi_0 e^{-i\omega t} = -\omega^2\psi$$

Putting this value in eq^n 4 we get,

$$\frac{\partial^2\psi}{\partial x^2} + \frac{\partial^2\psi}{\partial y^2} + \frac{\partial^2\psi}{\partial z^2} = -\left(\frac{\omega^2}{u^2}\right)\psi$$

where, $\frac{\omega^2}{u^2} = \frac{(2\pi\nu)^2}{(\nu\lambda)^2} = \frac{4\pi^2}{\lambda^2}$

$$\therefore \frac{\partial^2\psi}{\partial x^2} + \frac{\partial^2\psi}{\partial y^2} + \frac{\partial^2\psi}{\partial z^2} = -\left(\frac{4\pi^2}{\lambda^2}\right)\psi$$

$$\therefore \nabla^2\psi + \frac{4\pi^2}{\lambda^2}\psi = 0 \quad \text{——— (5)}$$

Eq^n 5 is general eq^n & is independent of time.

By the concept of wave mechanics, de-Borglie wavelength

$$\lambda = \frac{h}{p} = \frac{h}{[2m(E-V)]^{1/2}} \quad (\text{from eq}^n\ 1)$$

Putting this value of λ in eq^n 5 we get,

10

$$\nabla^2\psi + \frac{4\pi^2[2m(E-V)]\psi}{h^2} = 0$$

$$\nabla^2\psi + \left(\frac{8\pi^2 m}{h^2}\right)(E-V)\psi = 0 \quad \text{——— (6)}$$

Also, $\hbar = \frac{h}{2\pi}$

$$\therefore \nabla^2\psi + \left(\frac{2m}{\hbar^2}\right)(E-V)\psi = 0 \quad \text{——— (7)}$$

Eq^n 7 represents schrödinger's time independent wave eq^n.

(b) Time dependent schrödinger's equation →

The wave function, $\psi = \psi_0 e^{-i\omega t}$

$$\frac{\partial\psi}{\partial t} = -i\omega\,\psi_0 e^{-i\omega t}$$

$$\frac{\partial\psi}{\partial t} = -i(2\pi\nu)\psi$$

$$\frac{\partial\psi}{\partial t} = -i(2\pi)\left(\frac{E}{h}\right)\psi$$

$$E\psi = -\frac{1}{i}\left(\frac{h}{2\pi}\right)\frac{\partial\psi}{\partial t}$$

$$E\psi = i\hbar\frac{\partial\psi}{\partial t} \quad \left(\because \hbar = \frac{h}{2\pi} \;\&\; i^2 = -1\right) \quad \text{--- (8)}$$

From eq^n (7)

$$\nabla^2\psi + \frac{2m}{\hbar^2}E\psi - \frac{2m}{\hbar^2}V\psi = 0 \quad \text{--- (9)}$$

Putting the value of $E\psi = i\hbar\frac{\partial\psi}{\partial t}$ in eq^n (9) we get,

$$\nabla^2\psi + \frac{2m}{\hbar^2}\frac{\partial\psi}{\partial t} - \frac{2m}{\hbar^2}V\psi = 0$$

$$\nabla^2\psi - \left(\frac{2m}{\hbar^2}\right)V\psi = -\left(\frac{2m}{\hbar^2}\right)i\hbar\frac{\partial\psi}{\partial t}$$

$$\left(-\frac{\hbar^2}{2m}\right)\nabla^2\psi + V\psi = i\hbar\frac{\partial\psi}{\partial t} \quad \text{--- (10)}$$

Eq^n (10) Represents Schrödinger's time dependent wave eq^n.

Q.2)

1) Consider the action of commutator $[x, P_x]$ on wave f^n $\psi(x,y,z)$

$$[x, P_x]\psi = [x, -i\hbar\,\partial/\partial x]\psi$$

$$= -i\hbar\left[x, \frac{\partial}{\partial x}\right]\psi$$

5

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

$$[x, P_x]\psi = -i\hbar\left\{x\frac{\partial\psi}{\partial x} - \frac{\partial}{\partial x}(x\psi)\right\}$$

$$= -i\hbar\left\{x\frac{\partial\psi}{\partial x} - x\frac{\partial\psi}{\partial x} - \psi\right\}$$

$$= -i\hbar(-\psi)$$

$$\therefore [x, P_x]\,\psi = i\hbar\,\psi$$

$$\therefore [x, P_x] = i\hbar$$

Q.2)

3) The variable quantity or oscillatory function characterising, de-Borglie wave is called as wave function denoted by symbol ψ. It is always associated with moving particle. The value of wave function associated with moving particle at a particwor point x, y, z in space and the time t is reladed to the finding a particle at that time ψ.

i. ψ must be finite for all values of x, y and z.

ii. ψ must be single valued i.e. for each set of values of x, y and z, ψ must have only one value.

5

iii. ψ must be continuous in all regions, except in those regions where the potential energy $V(x, y, z) = \infty$

iv. The partial derivatives of ψ i.e $\frac{\partial \psi}{\partial x}, \frac{\partial \psi}{\partial y}, \frac{\partial \psi}{\partial z}$ must also be finite, single-valued and continuous at all points, except at points where the potential $V(x)$ is infinite.

v. ψ must vanish at infinity i.e. $\psi = 0$, as $x \to \pm\infty$ $y \to \pm\infty$ or $z \to \pm\infty$.