PHY/V/CC/11

#### Student's Copy

2024

(CBCS)

(5th Semester)

#### PHYSICS

#### SEVENTH PAPER

#### ( Classical Mechanics and Nuclear Physics-II )

Full Marks: 75

Time : 3 hours

The figures in the margin indicate full marks for the questions

( SECTION : A-OBJECTIVE )

( Marks : 10 )

Put a Tick (1) mark against the correct answer in the brackets provided : 1×10=10

- 1. Hamiltonian equations of motion are given by
  - $(a) \quad \dot{q} = -\frac{\partial H}{\partial p}, \quad \dot{p} = \frac{\partial H}{\partial q} \qquad ( )$   $(b) \quad \dot{q} = -\frac{\partial H}{\partial q}, \quad \dot{p} = \frac{\partial H}{\partial p} \qquad ( )$   $(c) \quad \dot{q} = \frac{\partial H}{\partial q}, \quad \dot{p} = \frac{\partial H}{\partial q} \qquad ( )$   $(d) \quad \dot{q} = \frac{\partial H}{\partial p}, \quad \dot{p} = -\frac{\partial H}{\partial q} \qquad ( )$

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- 2. If there are no external forces acting on a system of particles, then
  - (a) the total momentum of the system is constant ()
  - (b) the velocity of centre of mass is constant ()
  - (c) momentum and velocity of the system are constant ()
  - (d) momentum and velocity of the system vary ( )
- If the nuclear radius of a nucleus with mass number 125 is 1.5 Fermi, then radius of Cu<sup>64</sup> is (in Fermi)
  - (a) 0·48 ( )
  - (b) 0·96 ( )
  - (c) 2·4 ()
  - (d) 1·2 ()

4. The electron emitted in the radioactive decay process originates from

- (a) inner orbits of the atom ( )
- (b) free electrons existing inside the nucleus ( )
- (c) photons escaping from the nucleus ( )
- (d) decay of a neutron to a proton inside the nucleus ()
- 5. Complete the nuclear reaction :

$$_{17}\text{Cl}^{35} + ... \rightarrow _{16}\text{S}^{32} + _{2}\text{He}^{4}$$

- (a)  $_{1}H^{1}$  ( )
- (b)  $_0n^1$  ()
- (c)  $_{1}H^{2}$  ( )
- $(d)_{0}e^{1}$  ()

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- 6. The number of neutrons produced in a nuclear chain reaction is in
  - (a) algebraic progression ( )
  - (b) arithmetic progression ( )
  - (c) geometric progression ( )
  - (d) harmonic progression ( )
- 7. In a linear accelerator, charged particle is accelerated
  - (a) by oscillating electric field ( )
  - (b) by oscillating magnetic field ()
  - (c) by charged motion of electrons ( )
  - (d) due to flux in magnetic field ()
- 8. Frequency-modulated cyclotron is also called
  - (a) synchro-cyclotron ( )
  - (b) synchrotron ( )
  - (c) linear cyclotron ( )
  - (d) accelerator ( )
- The Zenith angle distribution of cosmic ray in the East-West plane to the magnetic equator is
  - (a) symmetrical ( )
  - (b) linear ( )
  - (c) non-linear ()
  - (d) asymmetrical ( )

Which of the following particles is a meson? 10.

(a) Proton (

(b) Neutron (

(c) Electron (

(d) Pion ( )

# (SECTION : B-SHORT ANSWERS

( Marks : 15 )

Answer the following questions :

UNIT-I

the and maximum compression when they arc moving along the same direction Two bodies of masses 3 kg and 6 kg arc connected by a spring, Find respectively. 2 m/s m/s and S velocities (Given : k = 100 N / m). have they ÷

0K

2. What are constraints and constrained motion? Give examples.

UNIT-II

3. What are isotopes and isobars? Give an example of each to support your answer.

0 B Calculate the binding energy of a deuteron in Joule ; Given : Mass of proton = 1.007276 a.m.u. 4

Mass of deuteron nucleus = 2.013553 a.m.u. Mass of neutron = 1.008665 a.m.u. 1 a.m.u. = 931 MeV

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3×5=15

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UNITII	Write a brief note on electric quadrupole moment. Define packing fraction. What is its significance? Explain how the B-E curve explains nuclear fission and nuclear fusion.	<b>OR</b> What do you mean by semi-empirical mass formula? Using the formula, calculate the most stable isobar for a nucleus having odd mass number A. State and explain Geiger-Nuttall law.	UNIT—III Write a short note on liquid drop model. What are natural and artificial transmutation? Give one nuclear reaction for each. Find the Q-value of a nuclear reaction in terms of rest mass. 2	What is Fermi's four-factor formula of a nuclear reactor of infinite size? Explain all the factors involved in the formula. 2+4=6 Explain nuclear fusion as the source of stellar energy. 4	cribe the construction and working of a cyclotron. Discuss its tations. How does it overcome? 6+2+2=10 OR What are counters? Discuss the construction and working of Geiger-Müller counter.	What do you mean by the counter efficiency and dead time of a GM counter? $G$
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Э C 3+2=5 What do you mean by baryon number (B), hypercharge (Y) and strangeness (S) of elementary particles? Estimate their relations. What are different conservation laws of elementary particles? What are anti-particles? (a) (q) (c) 6

### OR

Discuss Bhabha's theory of electron showers. (a) 10.

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Explain the conservation of lepton number. (q)

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(5th Semester)

# PHYSICS

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# (SECTION : A-OBJECTIVE )

(Marks: 10)

 $1 \times 10 = 10$ Put a Tick ( $\checkmark$ ) mark against the correct answer in the brackets provided :

1. Hamiltonian equations of motion are given by

(a) 
$$\dot{q} = -\frac{\partial H}{\partial p}$$
,  $\dot{p} = \frac{\partial H}{\partial q}$  ( )  
(b)  $\dot{q} = -\frac{\partial H}{\partial q}$ ,  $\dot{p} = \frac{\partial H}{\partial p}$  ( )  
(c)  $\dot{q} = \frac{\partial H}{\partial q}$ ,  $\dot{p} = \frac{\partial H}{\partial q}$  ( )

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<ul> <li>(b) the velocity of centre of mass is constant ()</li> <li>(c) momentum and velocity of the system are constant ()</li> <li>(d) momentum and velocity of the system vary (.)</li> <li>(d) momentum and velocity of the system vary (.)</li> <li>3. If the nuclear radius of a nucleus with mass number 125 is 1.5 Fermi, th radius of Cu<sup>64</sup> is (in Fermi)</li> <li>(a) 0.48 ()</li> <li>(b) 0.96 ()</li> <li>(c) 2.4 ()</li> <li>(d) 1.2 ()</li> <li>(e) 2.4 ()</li> <li>(d) 1.2 ()</li> <li>(e) 2.4 ()</li> <li>(f) 1.2 ()</li> <li>(g) 1.2 ()</li> <li>(g) 2.4 ()</li> <li>(g) 1.2 ()</li> <li>(h) redective decay process originates from (a) inner orbits of the atom ()</li> <li>(h) free electrons existing finside the nucleus ()</li> <li>(e) photons escaping from the nucleus ()</li> <li>(f) decay of a neutron to a proton inside the nucleus ()</li> <li>(g) 1.1<sup>1</sup> ()</li> <li>(</li></ul>	(a)	the tote	aln	noment	m of the s	ystem is	consta	unt	-	-	
<ul> <li>(c) momentum and velocity of the system arc constant ()</li> <li>(d) momentum and velocity of the system vary ( .)</li> <li>(d) momentum and velocity of the system vary ( .)</li> <li>3. If the nuclear radius of a nucleus with mass number 125 is 1.5 Fermi, th radius of Cu<sup>64</sup> is (in Fermi)</li> <li>(a) 0.48 ( )</li> <li>(b) 0.96 ( )</li> <li>(c) 2.4 ( )</li> <li>(d) 1.2 ( )</li> <li>(d) 1.2 ( )</li> <li>(d) 1.2 ( )</li> <li>(e) 2.4 ( )</li> <li>(f) 1.2 ( )</li> <li>(g) inner orbits of the atom ( )</li> <li>(h) free electron existing inside the nucleus ( )</li> <li>(c) photons escaping from the nucleus ( )</li> <li>(d) ecay of a neutron to a proton inside the nucleus ( )</li> <li>(d) 1.7Cl<sup>35</sup> + → 16S<sup>32</sup> + 2He<sup>4</sup></li> <li>(e) 1H<sup>1</sup> ( )</li> <li>(f) 1H<sup>1</sup> ( )</li> <li>(g) 1H<sup>2</sup> ( )</li> </ul>	(q)	the velc	ocit	r of cei	rc of mass	is const	tant	-	-		
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$ \begin{array}{cccc} (b) & 0n^{1} & ( & ) \\ (c) & 1H^{2} & ( & ) \\ (d) & 0e^{1} & ( & ) \\ \end{array} $	(a)	$_{1}H^{1}$	_	(							
(c) $_{1}H^{2}$ ( ) (d) $_{0}e^{1}$ ( ) <b>164</b> 2 2 $_{1}Cont^{2}$	(q)	$_{0}n^{1}$	_	-							
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- 7. In a linear accelerator, charged particle is accelerated

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- 9. The Zenith angle distribution of cosmic ray in the East-West plane to the magnetic equator is
- (a) symmetrical ( )

Test leaved.

- (b) linear ( )
- (c) non-linear (
- (d) asymmetrical (

3

10. Which of the following particles is a meson?

(a) Proton ( )

(b) Neutron (

(c) Electron (

(d) Pion ( )

# (SECTION : B-SHORT ANSWERS

( Marks : 15 )

Answer the following questions :

UNIT-I

3×5=15

and the when they arc moving along the same direction 3 kg and 6 kg arc connected by a spring, Find respectively. 2 m/s m/s and ŝ Two bodies of masses maximum compression velocities (Given : k = 100 N / m). have they ÷

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UNIT-II

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Write three points of distinction between nuclear fission and nuclear fusion ທ່

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6. Find the ground state spin quantum number of  ${}_{6}C^{12}$  and  ${}_{5}B^{11}$ 

## UNIT-IV

7. Describe briefly the need of particle accelerator and name the location of accelerators in India.

#### B

8. Write the theory and working principle of proton-synchrotron.

### UNIT-V

9. What are cosmic rays? Explain the altitude effect of cosmic rays.

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10. What arc quarks? Explain the flavour and colour in quarks.

# (SECTION : C-DESCRIPTIVE )

# ( Marks : 50 )

 $10 \times 5 = 50$ 

Answer the following questions :

### UNIT--I

- S Find the equation of motion of reduced mass for a two-body problem. 1. (a)
- ŝ What is uniqueness of centrc of mass? Prove that the total linear momentum of a system of particles about the centre of mass is zero. Q

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- 5 Using Hamiltonian formulation, obtain the equations of motion for a simple pendulum. a) 6
  - If the Lagrangian of a system is given by  $L = \frac{1}{2}m\dot{q}^2 \frac{\lambda}{2}q\dot{q}^2$ , where  $\lambda$  is (q)

a constant, find the Hamiltonian for the system.

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Write a brief note on electric quadrupole moment. a) ë.

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- Define packing fraction. What is its significance? (q)
- nuclear fission and Explain how the B-E curve explains nuclear fusion. 0

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- 2+4=6 semi-empirical mass formula? Using the formula, calculate the most stable isobar for a nucleus having odd What do you mean by mass number A. 4. (a)
- State and explain Geiger-Nuttall law. (q)

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### UNIT--III

- Write a short note on liquid drop model. (a) ທ່
- 2+2=4one nuclear artificial transmutation? Give and are natural reaction for each. What (q)
- Find the Q-value of a nuclear reaction in terms of rest mass. 3

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#### g

- 2+4=6 What is Fermi's four-factor formula of a nuclear reactor of infinite size? Explain all the factors involved in the formula. Ø . ف
- Explain nuclear fusion as the source of stellar energy. (q)

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# UNIT-IV

Discuss its cyclotron. g of working limitations. How does it overcome? and construction the Describe 5

6+2+2=10

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- 2+6=8 б and working construction the Discuss Geiger-Müller counter. counters? What are (a) œ.
- 3 What do you mean by the counter efficiency and dead time of a GM counter? (q)

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d 3+2=5	<b>с</b> р (	2	t	- 0	n
a) What do you mean by baryon number (B), hypercharge (Y) and strangeness (S) of elementary particles? Estimate their relations. $3+$	b) What are different conservation laws of elementary particles?	(c) What are anti-particles?	OR	(a) Discuss Bhabha's theory of electron showers.	(b) Explain the conservation of lepton number.

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