UGC POINT

LEADING INSTITUE FOR CSIR-JRF/NET,GATE & JAM

BOOKLET CODE **B**

SUBJECT CODE **05**

PHYSICAL SCIENCE

TEST SEREIS # 1

CLASSICAL MECHANICS+ ATOMIC MOLECULAR

Date: 22/5/2015

Timing: 2:00 H

Maximum Marks: 80

Instructions

1. This test paper has a total of 40 questions carrying 80 marks. All Question are compulsory
2. Read the Questions carefully and mark your appropriate response to the OMR sheet
3. There is Negative marking of 1/4 for Each wrong answer
4. Mark the response by **Black** or **Blue** Ball Pen only
5. Any other belongings like Book/ Notes / Electronic device etc are not permitted in the examination hall.
6. Submit your answer sheet (OMR Sheet) to the invigilator before leaving the examination hall

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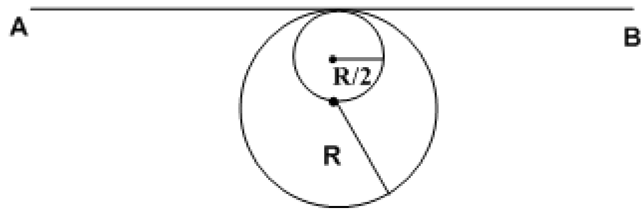
1. From a uniform disc of radius R & mass m, a disc of radius $R/2$ has been removed as shown in the figure, the moment of inertia about line AB is

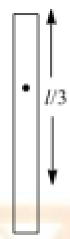


(1) $\frac{64}{75}mR^2$ (2) $\frac{75}{64}mR^2$ (3) $\frac{5}{4}mR^2$ (4) $\frac{65}{64}mR^2$

2. A pendulum is made of a uniform rod of mass m and length l. The point of suspension is at distance $\frac{l}{3}$ from one end (see figure). The time period of small oscillation about the equilibrium position is

(1) $2\pi\sqrt{\frac{2}{3}\frac{l}{g}}$ (2) $2\pi\sqrt{\frac{3}{2}\frac{l}{g}}$

(3) $4\pi\sqrt{\frac{l}{3g}}$ (4) $2\pi\sqrt{\frac{3l}{g}}$

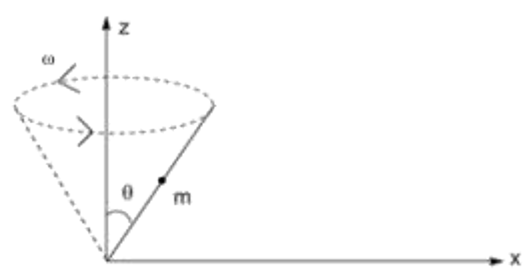


3. The radius of earth is approximately 6400 km. The depth h at which the acceleration due to Earth's gravity differs from g at the Earth's surface by 10% is:
(1) 320 km (2) 6400 km (3) 64 km (4) 640 km

4. A point particle of mass m carrying an electric charge q is attached to a spring. An electric field along the direction of the spring is switched on for some time then
(1) Energy of system remains constant
(2) Kinetic energy of system remains constant
(3) Potential energy of system remains constant
(4) Energy is not conserved

5. A bead of mass m can slide without friction along a massless rod kept at an angle θ with the vertical as shown in the figure. The rod is rotating about the vertical axis with a constant angular speed ω. The number of generalized coordinates required to describe the motion of bead is

(1) 4 (2) 3
(3) 2 (4) 1



6. The Lagrangian of a particle of mass m system is given as

$$L = \frac{1}{2}m\left(\dot{x}^2 + \dot{y}^2 + \dot{z}^2\right) + k\left(x^2 + y^2\right)$$

Where K is a constant. The conserved quantities ar (symbols have their usual meaning)

(1) Only p_z (2) L_z *and* p_z

(3) Energy L_z *and* p_z (4) L_x, L_y, L_z, p_z and energy

7. The Lagrangian of a system is given as

$$L = e^{\gamma t}\left[\frac{1}{2}m\dot{q}^2 - \frac{1}{2}kq^2\right]$$

The correct statement is

(1) Kinetic energy of the system is conserved

(2) Potential energy of the system is conserved

(3) Total energy of the system is conserved

(4) Total energy of the system is not conserved

8. A spaceship is orbiting the earth in a particular orbit commander of spaceship decides to come back to Earth. In order to do this the rockets of spaceship should be turned on in the direction

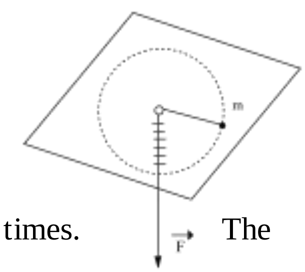
(1) Radially towards the Earth

(2) Radially away from the Earth

(3) Tangentially in the direction of the motion of spaceship

(4) Tangentially in the direction opposite to the motion of spaceship

9. A mass m is constrained to move on a horizontal frictionless surface. It is set in circular motion with radius r_0 and angular speed ω_0 by an applied force $\vec{F}$ communicated through an inextensible thread that passes through a hole on the surface as shown in figure given below then this force is suddenly increased five times. The work done by this force is



(1) Positive (2) Negative (3) Zero (4) Both (1) and (2)

10. Kinetic energy of a relativistic particle of rest mass m is mc^2. The momentum of the particle is

(1) $\sqrt{3}mc$ (2) $3\,mc$ (3) $\sqrt{2}\,mc$ (4) $2\,mc$

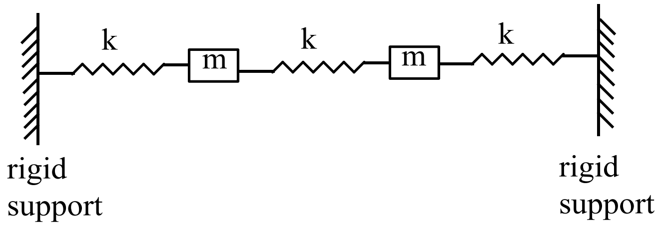
11. In the laboratory frame *a* particle *p* is moving in *x*-direction with speed c/3, another particle *Q* moves with speed c/2 in negative *x*-direction (in the same frame) the velocity of *P* in the rest frame of *Q* is

(1) $\frac{-5}{7}c\,\hat{x}$ (2) $+\frac{5}{7}c\,\hat{x}$ (3) $\frac{-c}{5}\,\hat{x}$ (4) $\frac{c}{5}\,\hat{x}$

12. Two identical particles each with rest mass m are moving with speed c/5 each in opposite directions in laboratory frame. The ratio of total energy in the laboratory frame E_0 to the total energy (of both particles) in the rest frame of one of the particle E' is

(1) $\frac{E_0}{E'} = \frac{\sqrt{5}}{3}$ (2) $\frac{E_0}{E'} = 1$ (3) $\frac{E_0}{E'} = \frac{2\sqrt{6}}{5}$ (4) $\frac{E_0}{E'} = \frac{5}{2\sqrt{6}}$

13. Two identical masses (each having mass *m*) are connected to identical springs each having spring constant k (see the figure). The normal mode frequencies are (assuming that only spring forces acts on masses)



(1) $\sqrt{\frac{k}{m}}$ & $\sqrt{\frac{3k}{m}}$ (2) $\sqrt{\frac{2k}{m}}$ & $\sqrt{\frac{3k}{m}}$ (3) $\sqrt{\frac{k}{m}}$ & $\sqrt{\frac{2k}{m}}$ (4) $\sqrt{\frac{3k}{m}}$ & $\sqrt{\frac{5k}{m}}$

14. If the earth is suddenly stopped on its orbit about the sun, and starts falling towards the sun under gravitational force, after what time will it collide with the sun? Assume that the orbit is circular and ignore the size of earth and sun (the radii of earth and sun are very small as compared to the radius of the Earth's orbit). The time period of earth is 365 days
(1) 165 days approximately
(2) 130 days approximately
(3) 65 days approximately
(4) 365 days approximately

15. A train is running along equator towards east direction, the Coriolis force on the train is:
(1) Towards the centre of earth
(2) Towards the north direction
(3) Towards south direction
(4) Radially outwards

16. A particle of mass m is moving in a plane under the potential $V(r)=\frac{1}{2}Kr^2$. Then
(1) For bound motion energy should be negative
(2) For bound motion potential energy should be negative
(3) Unbound motion is not possible under this potential
(4) Bound motion is not possible under this potential

17. A particle of mass m is moving under the potential $V(r)=\frac{1}{2}Kr^2$. The total energy is E. then
(1) $\langle T\rangle=\langle V\rangle=\frac{E}{2}$ (2) $\langle T\rangle=-\frac{1}{2}\langle V\rangle=-E$
(3) $\langle T\rangle=-2\langle V\rangle=2E$ (4) $\langle T\rangle=2\langle V\rangle=E$

18. The centrifugal force on the earth is maximum when it is
(1) Farthest from the sun
(2) Closest to the sun
(3) At distance equal to the major axis of its orbit
(4) Centrifugal force is always same

19. Consider the simple pendulum of length l and with mass of bob being m. As the pendulum oscillates in the vertical plane

(1) Its angular momentum is not conserved because the gravitation potential is not spherically symmetric

(2) Its angular momentum is not conserved because the potential felt by the mass depends on θ

(3) Angular momentum is conserved

(4) Total energy is not conserved

20. The Hamiltonian for a particle of mass m moving under the potential $V(r)$ can be expressed most appropriately

(1) $H = \frac{p_r^2}{2m} + \frac{p_\theta^2}{2mr^2} + V(r)$ (2) $H = \frac{p_r^2}{2m} + \frac{p_\theta^2}{2mr^2} - V(r)$

(3) $H = \frac{1}{2}m\dot{r}^2 + \frac{1}{2}mr^2\dot{\theta}^2 + V(r)$ (4) $H = \frac{p_r^2}{2m} + \frac{p_\theta^2}{2mr^2} + \frac{p_\phi^2}{2mr^2} - V(r)$

21. Lagrangian of a system is given by

$$L = \frac{1}{2}\dot{q}_1^2 - \frac{1}{2}\dot{q}_2^2 + \dot{q}_1\dot{q}_2$$

The Hamiltonian of the system is given by

(1) $\frac{p_1^2}{4} + \frac{p_2^2}{4} + \frac{p_1p_2}{2}$ (2) $\frac{p_1^2}{4} - \frac{p_2^2}{4} - \frac{p_1p_2}{2}$

(3) $\frac{p_1^2}{2} - \frac{p_2^2}{2} + p_1p_2$ (4) $\frac{p_1^2}{4} - \frac{p_2^2}{4} + \frac{p_1p_2}{2}$

22. If the Hamiltonian for a relativistic particle is given as

$$H = \sqrt{p^2c^2 + m_0^2c^4} + V$$

Then the Lagrangian is $\left(\beta = \frac{v}{c}\right)$

(1) $L = m_0c^2\sqrt{1-\beta^2}$ (2) $L = -m_0c^2\sqrt{1-\beta^2} - V$

(3) $L = m_0c^2\sqrt{1-\sqrt{1-\beta^2}} - V$ (4) $L = -m_0c^2\sqrt{1-\sqrt{1-\beta^2}} - V$

23. A canonical transformation relates the old coordinates (q,p) to the new ones (Q, P) by the relations $Q = p - q$ and $P = -p$.

The corresponding time independent generating function is

(1) $\frac{(q+Q)^2}{2}$ (2) $\frac{(q-Q)^2}{2}$ (3) $\frac{q^2+Q^2}{2}$ (4) $\frac{q^2-Q^2}{2}$

24. For a one dimensional Hamiltonian

$$H = \frac{p^2}{2} - \frac{1}{2q^2}$$

The constant of motion is

(1) $\frac{pq}{2} + Ht$ (2) $\frac{pq}{2} - Ht$ (3) $\frac{pq}{2} + \frac{Ht}{2}$ (4) $2(pq + Ht)$

25. If the transformation

$Q = q\cos\alpha - p\sin\alpha$

$P = q\sin\alpha + p\cos\alpha$

Is canonical then α is

(1) $\frac{\pi}{2}$ (2) $\frac{\pi}{6}$ (3) π (4) Any real value

26. For Hamilton's characteristic function W choose the correct relation

(1) $\frac{dW}{dt} = H$ (2) $\frac{dW}{dt} = L$ (3) $\frac{dW}{dt} = \sum_i p_i q_i$ (4) $\frac{dW}{dt} = \sum_i p_i q_i - H$

27. The effective spin-orbit interaction between the spin of $\vec{s}$ and the orbit angular momentum $\vec{l}$ of electron in the hydrogen atom is given by $\lambda \vec{l}.\vec{s}$, where λ is a constant. As a result of this interaction, the energy levels split by an amount

(1) $\frac{\lambda l \hbar^2}{2}$ (2) $\lambda\left(l - \frac{1}{2}\right)\hbar^2$ (3) $\lambda l \hbar^2$ (4) $\lambda\left(l + \frac{1}{2}\right)\hbar^2$

28. The moment of Inertia of HCl is $2.66 \times 10^{-40}\ gm - cm^2$. The energy difference between the rotational levels J=0 and J=1 of HCl is

(1) $2.6 \times 10^{-3} eV$ (2) $2.6 \times 10^{-4} eV$ (3) $2.6 \times 10^{-5} eV$ (4) $2.6 \times 10^{-2} eV$

29. In the vibrational Raman spectrum of HF are adjacent Raman lines of wavelengths $2670\,\dot{A}$ and $3430\,\dot{A}$. The fundamental vibrational frequency of molecule is

(1) $6.2 \times 10^{13} Hz$ (2) $1.2 \times 10^{14} Hz$ (3) $1.24 \times 10^{13} Hz$ (4) $6.2 \times 10^{14} Hz$

30. On application of weak magnetic field number of components in the spectrum of sodium become: (Originally there are two)

(1) 4 (2) 6 (3) 8 (4) 10

31. Light of wavelength $1.5\mu m$ incident on a material. The stokes-shifted wavelength is $1.67\,\mu m$. The characteristic Raman frequency is

(1) $20 \times 10^{12} Hz$ (2) $15 \times 10^{12} Hz$ (3) $7.5 \times 10^{12} Hz$ (4) $5 \times 10^{12} Hz$

32. The number of hyper fine components observed in the electronic transition $^2D_{1/2} \rightarrow {}^2P_{1/2}$ of an atom with nuclear spin $\frac{1}{2}$ is

(1) 4 (2) 5 (3) 6 (4) 7

33. The total number of Zeeman components observed in an electronic transition $^2f_{7/2} \rightarrow {}^2D_{5/2}$ of an atom in a weak field is

(1) 4 (2) 6 (3) 10 (4) 12

34. The coherence length of sodium D_2 line $\left(\lambda = 5890\,\dot{A}\right)$ is 2.5 cm. The purity of this line is

(1) 4.2×10^3 (2) 4.2×10^4 (3) 2.1×10^3 (4) 2.1×10^4

35. For the light source of wavelength $\lambda = 6000\,\dot{A}$, at $10^3\,K$ temperature, the ratio of rates of self emission to the rate of stimulated emission is

(1) 2.4×10^{10} (2) 4×10^{-11} (3) 1.2×10^{10} (4) 8×10^{-11}

36. The total electronic angular momentum of a one-electron atom in $^2F_{5/2}$ state is

(1) $\frac{\sqrt{30}}{4\pi}h$ (2) $\frac{\sqrt{35}}{2\pi}h$ (3) $\frac{\sqrt{35}}{4\pi}h$ (4) $\frac{\sqrt{30}}{2\pi}h$

37. The doublet splitting for the first excited state $^2P \rightarrow {}^2P_{3/2}$ of hydrogen atom is $0.365\,cm^{-1}$. The corresponding split for Li^{++} is

(1) $1.095\,cm^{-1}$ (2) $3.285\,cm^{-1}$ (3) $29.565\,cm^{-1}$ (4) $5.84\,cm^{-1}$

38. With exciting line $4358\,\dot{A}$ a sample gives stokes line $4458\,\dot{A}$. The wavelength of the anti-stokes line is

(1) $4348\,\dot{A}$ (2) $4368\,\dot{A}$ (3) $4468\,\dot{A}$ (4) $4262\,\dot{A}$

39. The simple harmonic force constant for DCl is 4.903×10^5 dynes/cm. The frequency of radiation (in cm^{-1}) absorbed is

(1) $2097\,cm^{-1}$ (2) $209.7\,cm^{-1}$ (3) $1097\,cm^{-1}$ (4) $109.7\,cm^{-1}$

40. If the K_α-radiation of $M_o\,(Z=42)$ has a wavelength of $0.71\,\dot{A}$, the wavelength of the corresponding radiation of is

(1) $3.04\,\dot{A}$ (2) $1.52\,\dot{A}$ (3) $6.08\,\dot{A}$ (4) $9.12\,\dot{A}$

ANSWER KEY

TEST SEREIS # 1

CLASSICAL MECHANICS+ ATOMIC MOLECULAR

1.(2)	11.(2)	21.(4)	31.(1)
2.(1)	12.(4)	22.(2)	32.(*)
3.(4)	13.(1)	23.(1)	33.(3)
4.(4)	14.(3)	24.(2)	34.(2)
5.(4)	15.(4)	25.(4)	35.(1)
6.(3)	16.(3)	26.(3)	36.(1)
7.(4)	17.(1)	27.(4)	37.(3)
8.(4)	18.(2)	28.(1)	38.(4)
9.(4)	19.(2)	29.(2)	39.(1)
10.(1)	20.(1)	30.(4)	40.(3)