TEST SERIES CSIR-NET/JRF JUNE 2019

BOOKLET SERIES B

Paper Code 05 **Test Type: TEST SERIES**

[Classical Mechanics, Thermo. & Stats. Physics, Nuclear & Particle]

PHYSICAL SCIENCES

Duration: 02:30 Hours

Date: 26-05-2019

Maximum Marks: 160

Read the following instructions carefully:

* Single Paper Test is divided into **THREE** Parts.

Part - A: This part shall carry **10** questions. Each question shall be of **2 marks.**

Part - B: This part shall contain **20** questions. Each question shall be of **2 marks**.

Part - C: This part shall contain **25** questions. Each question shall be of **4 marks**.

* Darken the appropriate bubbles with HB pencil/Ball Pen to write your answer.

* There will be negative marking @25% for each wrong answer.

* The candidates shall be allowed to carry the Question Paper Booklet after completion of the exam.

* For rough work, blank sheet is attached at the end of test booklet.

PART – A

1. Three men, four women and six children can complete a work in seven days. A woman does double the work a man does and a child does half the work a man does. How many women alone can complete this work in 7 days ?
(a) 7 (b) 9 (c) 12 (d) 0

2. A and B take part in a 100 m race. A runs at 5 km/hr. A gives B a start of 10 m and still beats B by 8 seconds. What is the speed of B in km/hr ?
(a) 3 (b) 4.5 (c) 3.5 (d) 4.05

3. If in a certain code language 'MANGO' is coded as PGWSD, and 'ORANGE' is coded as RXJZVW, then in the same language code for 'APPLE' would be
(a) DUXXT (b) DUXVT (c) DVYXT (d) DUXTX

4. A hemispherical bowl of internal radius 9 cm contains a liquid. This liquid is to be filled into cylindrical shaped small bottles of diameter 3 cm and height 4 cm. How many bottles will be needed to empty the bowl?
(a) 54 (b) 40 (c) 30 (d) 60

5. Sneha started from her house and travelled 4 km towards the east. Then she turned left and travelled 6 km. Then she turned right and travelled 4 km. Now at what distance is she from her starting point and to which direction of her starting point ?
(a) 14 km, North-east (b) 8 km, North (c) 5 km, North (d) 10 km, North-east

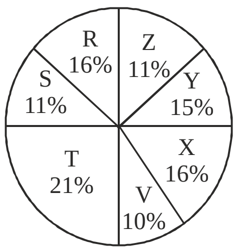
6. A speaks the truth in 75 % cases, and B speaks the truth in 80 % cases. In what percentage of cases they are likely to contradict each other while narrating the same incident ?
(a) 30 (b) 20 (c) 50 (d) 35

7. If $\log_a(ab) = x$, then the value of $\log_b(ab)$ in terms of x is
(a) $\frac{x}{x+1}$ (b) $\frac{x}{x-1}$ (c) $\frac{x^2}{x+1}$ (d) $\frac{2x}{x-1}$

8. Mr. Rahul, a businessman had the income in the year 2000, such that he earned a profit of 20 % on his investment in the business. In the next year, his investment was less by ` 5000, but still had the same income as that in 2000. Thus, the percentage profit earned in 2001 increased by 6 %. What was his investment in 2001? [Provided, profit = income – investment]
(a) ` 100000 (b) ` 105000 (c) ` 110000 (d) ` 115000

9. Study the following pie-chart and the table and answer the question based on them.

PROTON OF POPULATION OF SEVEN VILLAGES IN 2018



Village	% Population Below Poverty Line
X	38
Y	52
Z	42
R	51
S	49
T	46
V	58

The ratio of population of village T below poverty line to that of village Z below poverty line in 2018 is :
(a) 11 : 23 (b) 13 : 11 (c) 23 : 11 (d) 11 : 13

10. **Direction:** In each question below are few statements followed by the conclusions numbered accordingly. You have to take the given statements to be true even if they seem to be at variance from commonly known facts and then decide which of the given conclusions logically follows from the statements disregarding commonly known facts.

Statements:	Conclusions:
1. All X are Y	I. Some P are Y
2. Some Y are Z	II. Some X are Z
3. Some X are P	III. All Y are X

(a) Only I follows (b) All follows (c) None follows (d) Only III follows

PART – B

11. Consider the following reactions:

(I) $p+n \to \Lambda^0 + \Sigma^+$ (II) $\Sigma^+ \to \Lambda^0 + k^+$ (III) $\Xi^- \to \Lambda^0 + \pi^-$ (IV) $p+p \to k^+ + \Sigma^+$

Which of the following statement is true?

(a) Process (I) conserve baryon number and strangeness number but violates third component of isospin

(b) Process (II) conserve baryon number and angular momentum but violates total energy

(c) Process (III) is forbidden

(d) Process (IV) do not conserve baryon number and third component of isospin but conserve isospin.

12. If the reaction $X^- \to k^0 + \pi^-$ is governed by weak interaction and third component of isospin of X^- is $-\frac{1}{2}$ and bottom number and top number of X^- are zero, then the charm number and spin of X^- respectively are

(a) -1 and $\frac{1}{2}$ (b) $+1$ and $\frac{1}{2}$ (c) 0 and 0 (d) -1 and 0

13. The k^0 meson decays in rest into two charged pions according to reaction $k^0 \to \pi^+ + \pi^-$. The rest mass of pions is 140 MeV/c^2 and that of k^0 meson is 498 MeV/c^2.

Consider the following statements:

(P) The momentum of each pion is 206 MeV/c

(Q) The speed of each pion is $v = 0.827c$

(R) The total energy of each pion is 249 MeV.

Which of the following statements is true?

(a) P and Q (b) P and R (c) Q and R (d) P, Q and R

14. The quadrupole moment of ${}_{19}K^{39}$ nucleus according to shell model is equal to 0.039745 barn. The mean square radius of ${}_{19}k^{39}$ nucleus in its ground state is

(a) 1.59×10^{-30} m^2 (b) 9.94×10^{-30} m^2 (c) 9.94×10^{28} m^2 (d) 1.59×10^{-28} m^2

15. The spin-parity J^P of ground state of ${}_7N^{14}$ and ${}_{30}Zn^{67}$ by single particle shell model are respectively

(a) 1^+ and $\frac{5}{2}^-$ (b) 1^+ and $\frac{3}{2}^-$ (c) 2^+ and $\frac{5}{2}^-$ (d) 2^+ and $\frac{7}{2}^-$

16. The energy released when two ${}_1H^2$ nucleus fuse together to form the ${}_2He^4$ nucleus is Q MeV. If the binding energy per nucleon of ${}_1H^2$ is 1.1 MeV, then the binding energy per nucleon of ${}_2He^4$ and value of Q respectively are

[Given: $m_n = 1.007825\ amu$, $m_p = 1.008665\ amu$ and $m\left({}_2He^4 \text{ nucleus}\right) = 4.002603\ amu$]

(a) 4 MeV and Q = 20.6 MeV (b) 6 MeV and Q = 23.9 MeV

(c) 7 MeV and Q = 23.9 MeV (d) 8 MeV and Q = 20.6 MeV

17. A physical system is composed of N distinguishable particles, and each particle can be found in a state with energy either 0 or $\varepsilon > 0$. The excited state has degeneracy 4 while the ground state is non-degnerate. The total energy of the system is given by $E = n\varepsilon$, with n is a positive integer $(n \le N)$. The total number of accessible microstates corresponding to the macrostate with energy $n\varepsilon$ is

(a) $\frac{N!}{n!(N-n)!}$ (b) $\frac{N!4^n}{n!(N-n)!}$ (c) $\frac{N!Z^n}{n!(N-n)!}$ (d) $\frac{N!}{n!(N-n)!4^n}$

18. Consider a statistical system composed of two photons moving in a segment of length L. The volume of the phase space enclosed by the surface at constant energy E is (where c is the speed of the light).

(a) $\frac{2E^2L^2}{c^2}$ (b) $\frac{E^2L^2}{c^2}$ (c) $\frac{E^2L^2}{2c^2}$ (d) $\frac{4E^2L^2}{c^2}$

19. A classical gas in a volume V is composed of N independent and indistinguishable particles. The single particle Hamiltonian is $H = \frac{p^2}{2m}$, with m is the mass of the particle and p the absolute value of the momentum. Moreover, for each particle, we find 2 internal energy levels: a ground state with energy 0 and degeneracy g_1 and an excited state with energy $E > 0$ and degeneracy g_2. The canonical partition of function of the system (with $\beta = \frac{1}{k_B T}$) is

(a) $\left[\frac{V}{h^3}\left(\frac{\beta}{2\pi m}\right)^{3/2}\left(g_1 + g_2\, e^{-\beta E}\right)\right]^N$ (b) $\frac{1}{N!}\left[\frac{V}{h^3}\left(\frac{\beta}{2\pi m}\right)^{3/2}\left(g_1 + g_2\, e^{-\beta E}\right)\right]^N$

(c) $\left[\frac{V}{h^3}\left(\frac{2\pi m}{\beta}\right)^{3/2}\left(g_1 + g_2\, e^{-\beta E}\right)\right]^N$ (d) $\frac{1}{N!}\left[\frac{V}{h^3}\left(\frac{2\pi m}{\beta}\right)^{3/2}\left(g_1 + g_2\, e^{-\beta E}\right)\right]^N$

20. Consider a free gas with N particles and internal energy E inside a container of volume V where

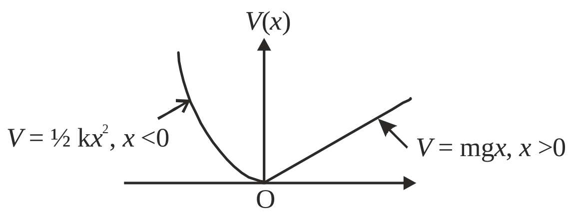
$$E = \left(\frac{3\pi\hbar^2}{m}\right)\frac{N^{5/3}}{V^{2/3}}\exp\left\{\frac{25}{3Nk_B} - \frac{5}{3}\right\}$$

where m is the particle of the gas and S is the entropy of the gas.
The pressure of the gas is

(a) $\frac{2E}{3V}$ (b) $\frac{2E}{V}$ (c) $\frac{E}{3V}$ (d) $\frac{E}{V}$

21. A heat pump is to be used to maintain a building at an average temperatures of 27ºC. How much minimum power will be required to do this when the outside temperature is –3ºC and the average total heat loss is 10^9 cal per hour?
(a) 0.48 MW (b) 0.36 MW (c) 0.12 MW (d) 0.24 MW

22. A particle of mass m moves in the potential shown in figure. The period of the motion when the particle has energy E is



(a) $2\pi\sqrt{\frac{m}{k}} + 4\sqrt{\frac{2E}{mg^2}}$

(b) $2\pi\sqrt{\frac{m}{k}}$

(c) $2\sqrt{\frac{2E}{mg^2}}$

(d) $\pi\sqrt{\frac{m}{k}} + 2\sqrt{\frac{2E}{mg^2}}$

23. One gram of water at 300K is poured down gently into a lake of 400K. The change in the entropy of the universe when the temperature of the water has reached 400K is

(a) $\ln\left(\frac{4}{3}\right)+\frac{1}{4}$ (b) $\ln\left(\frac{4}{3}\right)-\frac{1}{4}$ (c) $\ln\left(\frac{2}{3}\right)+\frac{1}{4}$ (d) $\ln\left(\frac{2}{3}\right)-\frac{1}{4}$

24. The specific heat per molecule of an ideal gas of linear triatomic molecules such that its vibrational modes are also active is

(a) $4k_B$ (b) $4.5k_B$ (c) $6k_B$ (d) $6.5k_B$

25. A particle moves under the influence of a central force given by $F(r)=-\frac{k}{r^n}$. If the particle's orbit is circular and passes through the force center, then the value of n is

(a) 3 (b) 2 (c) 5 (d) 10

26. A body of mass m is projected with speed u in a medium that exerts a resistance force of magnitude $F=mk|\vec{v}|^2$, where k are positive constants and $\vec{v}$ is the velocity of the body. Gravity can be ignored. Assuming that the motion starts from the origin and takes place along the positive x-axis, then which among the following statements is incorrect?

(a) The magnitude of velocity of body at time t is $v=\frac{u}{kut+1}$

(b) The displacement of body at time t is $x=\frac{1}{k}\ln(kut+1)$

(c) The motion is bounded

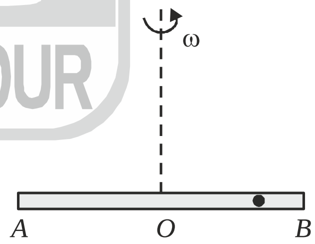
(d) As t tends to infinity, displacement x tends to infinity.

27. A photon of energy E travelling in the positive x-direction collides elastically with an electron of rest mass m_e moving in the opposite direction. After the collision, the photon travels back along the negative x-direction with the same energy E. The final electron's speed is given by

(a) $\frac{c}{2}\left(1-\frac{m_e^2c^4}{E^2}\right)^{-1/2}$ (b) $c\left(1+\frac{m_e^2c^4}{E^2}\right)^{-1/2}$ (c) $\frac{E}{m_ec}$ (d) $c\left(1-\frac{m_e^2c^4}{E^2}\right)^{-1/2}$

28. A hollow cylindrical pipe of length 4 m rotates with constant angular speed $\omega=1\,rad/s$ about a vertical axis through the centre O. A particle is initially at rest in the pipe at a distance $\sqrt{3}\,m$ from O. Assuming no frictional forces, the speed of the particle as it leaves the pipe is

(a) 2 m/s
(b) 1 m/s
(c) 3 m/s
(d) 0.5 m/s



29. The Lagrangian of a free particle is given by $L=\dot{x}^2-x\dot{x}$. If the Lagrangian L is modified to L' by any transformation of the form

$$L'=L+\alpha x\dot{x}, \text{ where } \alpha \text{ is constant,}$$

then the modified Lagrangian L' represents.

(a) A particle under constant acceleration
(b) A particle executing simple harmonic motion
(c) A particle experiencing velocity dependent damping
(d) A free particle

30. A solid cylinder of mass M and radius R has volume mass density $\rho = \alpha r^2$, where α is a constant and r is the distance from axis of cylinder. The moment of inertia about its axis is

(a) $\frac{1}{4}MR^2$ (b) $\frac{1}{3}MR^2$ (c) $\frac{2}{3}MR^2$ (d) $\frac{2}{5}MR^2$

PART – C

31. The activity of a radioactive substance decreases to $\frac{1}{64}$ of its original value in 10 years. The half-life of the substance is

(a) 1.66 years (b) 3.5 years (c) 4.8 years (d) 5.6 years

32. A reaction is developing nuclear energy at a rate of 32, 000 killowatts. Assuming an average energy of 200 MeV released per fission, the mass of $_{92}U^{235}$ thta would be used up in 1000 hours of operation is

(a) 0.68 kg (b) 1.41 kg (c) 3.25 kg (d) 5.46 kg

33. A nucleus has a size of 10^{-15} m. The average velocity of nucleons inside the nucleus is of the order of

(a) 3×10^8 m/s (b) 6×10^7 m/s (c) 3×10^6 m/s (d) 6×10^6 m/s

34. The reaction, $_{36}kr^{85} \rightarrow {}_{37}Rb^{85} + \beta^- + \bar{v}_e$ is first forbidden β^--decay by

(a) Only Fermi selection rule
(b) Only Gamow-Teller selection rule
(c) Both Fermi and Gamow-Teller selection rule
(d) Neither Fermi nor Gamow-Teller selection rule

35. According to the shell model, the nuclear magnetic dipole moment of the $_{51}Sb^{125}$ nucleus is [Given that for a proton $g_\ell = 1, g_s = 5.586$ and for a neutron $g_\ell = 0, g_s = -3.826$)

(a) 2.626 μ_N (b) 3.793 μ_N (c) 4.793 μ_N (d) 5.793 μ_N

36. In the nuclei of mass number A = 216, the binding energy calculated from liquid drop model (given a_c = 0.7 MeV and a_{asym} = 22.5 MeV) is a maximum for atomic number Z equal to

(a) 82 (b) 84 (c) 86 (d) 88

37. Which of the following do not corresponds to magnetic octupole gamma transition?

(a) $1^+ \rightarrow 3^+$ (b) $2^- \rightarrow 3^-$ (c) $2^+ \rightarrow 1^+$ (d) $2^- \rightarrow 0^-$

38. $^{27}_{14}Si$ and $^{27}_{13}Al$ are mirror nuclei. If their Coulomb energy difference is 8 MeV and their radius is given by $R = R_0 A^{1/3}$, where A is mass number, then the value of R_0 is

(a) 0.785 fm (b) 0.972 fm (c) 1.235 fm (d) 1.461 fm

39. The rotational band spectrum of $^{238}_{92}U$ is based on O^+ ground state. If the energy of 2^+ state is 44 KeV, then the spin parity of the state with energy 528 keV is

(a) 6^+ (b) 8^+ (c) 10^+ (d) 12^+

40. A system, in thermal equilibrium at temperature T, has average energy proportional to T^β, where β is some constant. The root mean square fluctuation in energy is proportional to

(a) T^β (b) $T^{\beta/2}$ (c) $T^{\beta+1}$ (d) $T^{(\beta+1)/2}$

41. A hypothetical one mole of gas follows the equation of state given by

$$P = \frac{RT}{V-b} - \frac{a}{T(V+c)^2}, \text{ where } a, b \text{ and } c \text{ are constants.}$$

The critical temperature for this gas is

(a) $\sqrt{\frac{8a}{27R(b-c)}}$ (b) $\sqrt{\frac{8a}{27R(b+c)}}$ (c) $\sqrt{\frac{8a(b+c)}{27R}}$ (d) $\sqrt{\frac{8a(b-c)}{27R}}$

42. Consider a system of N independent particles each of mass m with momentum p and energy energy $E = \frac{p^2}{2m}$.
The system is maintained at temperature T, volume V and chemical potential μ. The grand canonical partition function of the system is

(a) $\exp\left[V\left(\frac{2\pi mk_BT}{h^3}\right)^{2/3} e^{\mu/k_BT}\right]$ (b) $\exp\left[V\left(\frac{2\pi mk_BT}{h^2}\right)^{3/2} e^{\mu/k_BT}\right]$

(c) $V\left(\frac{2\pi mk_BT}{h^3}\right)^{2/3} e^{\mu/k_BT}$ (d) $V\left(\frac{2\pi mk_BT}{h^2}\right)^{3/2} e^{\mu/k_BT}$

43. A fully degnerate Fermi gas with spin ½ and N particles, each of mass m, is placed in a cylindrical container with base A and height H. The gas is under the effect of a constant gravitational acceleration g. The Fermi energy of the gas is

(a) mgH (b) $\frac{mgH}{2}$ (c) $2mgH$ (d) $\frac{mgH}{3}$

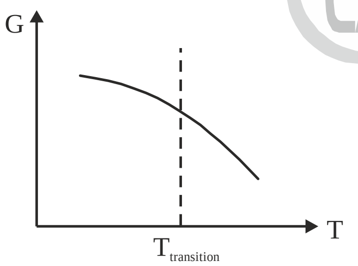
44. In how many ways 4 identical protons can be filled in three non-degenerate distinct energy levels?
(a) 0 (b) 4 (c) 6 (d) 8

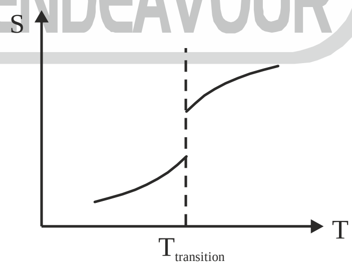
45. Consider a two-dimensional gas with dispersion relation $\varepsilon = ap^2c^2$, where p is the momentum, c is the speed of light and a is some constant. The density of state depends on energy as

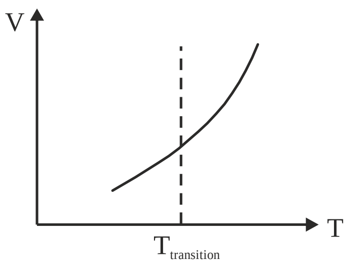
(a) E^{-1} (b) E^1 (c) E^0 (d) $E^{1/2}$

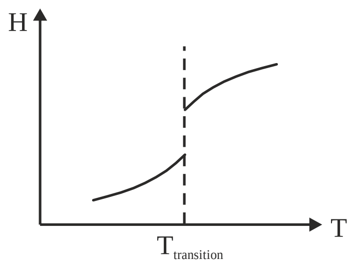
46. A blackbody, having volume 10^{-5} m^3, is kept at a temperature of 2500K. If the volume of the body is reduced reversibly and adiabatically to one-hundredth of its initial volume, the final temperature of the body is
(a) 31204 K (b) 321 K (c) 25213 K (d) 11604 K

47. A student was observing various properties of first order phase transition. He observed the following four graphs:

(I) 

(II) 

(III) 

(IV) 

Which of the above graph the student did not measure appropriately?
(a) I (b) II (c) III (d) IV

48. Consider a simple pendulum consisting of a mass m attached to a string of length ℓ. After the pendulum is set into motion, the length of the string is shortened at a constant rate.

$$\frac{d\ell}{dt} = -\alpha = \text{constant}$$

The suspension point remains fixed. The Hamiltonian of the system is (in the following p_θ is generalized momentum corresponding to θ).

(a) $\frac{p_\theta^2}{2m\ell^2} - \frac{1}{2}m\alpha^2 - mg\ell\cos\theta$ (b) $\frac{p_\theta^2}{2m\ell^2} - \frac{1}{2}m\alpha^2 + mg\ell\cos\theta$

(c) $\frac{p_\theta^2}{2m\ell^2} + \frac{1}{2}m\alpha^2 - mg\ell\cos\theta$ (d) $\frac{p_\theta^2}{2m\ell^2} - \frac{1}{2}m\alpha^2 + mg\cos\theta$

49. Assume the Lagrangian for a certain one-dimensional motion is given by

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

where, γ, m, k are positive constants. Suppose a point transformation is made to another generalised coordinate S, given by

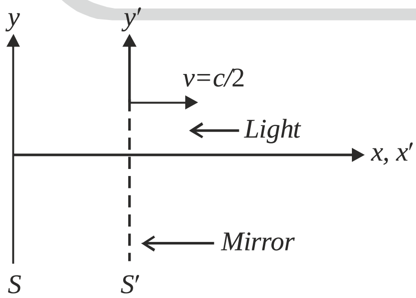
$$S = \exp\left(\frac{\gamma t}{2}\right)q$$

Which among the following is a constant of motion?

(a) $\dot{S}^2 - \left(\frac{k}{m} + \left(\frac{\gamma}{2}\right)^2\right)S^2 = 0$ (b) $\dot{S}^2 - \left(\frac{k}{m} - \left(\frac{\gamma}{2}\right)^2\right)S^2 = 0$

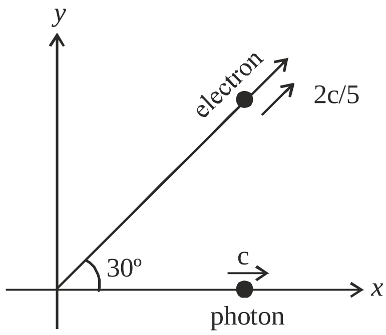
(c) $\dot{S}^2 + \left(\frac{k}{m} + \left(\frac{\gamma}{2}\right)^2\right)S^2 = 0$ (d) $\dot{S}^2 + \left(\frac{k}{m} - \left(\frac{\gamma}{2}\right)^2\right)S^2 = 0$

50. A perfectly reflecting mirror is moving through vacuum with relativistic speed $\frac{c}{2}$ in the x-direction. A beam of light with frequency v is normally incident (from $x = +\infty$) on the mirror, as shown in figure.
If the average energy flux of the incident beam is P, then the average reflected energy flux is



(a) $3P$ (b) $\frac{P}{3}$ (c) $2P$ (d) $\frac{P}{2}$

51. An electron and photon are moving as shown in figure. Velocity of electron with respect to the photon,

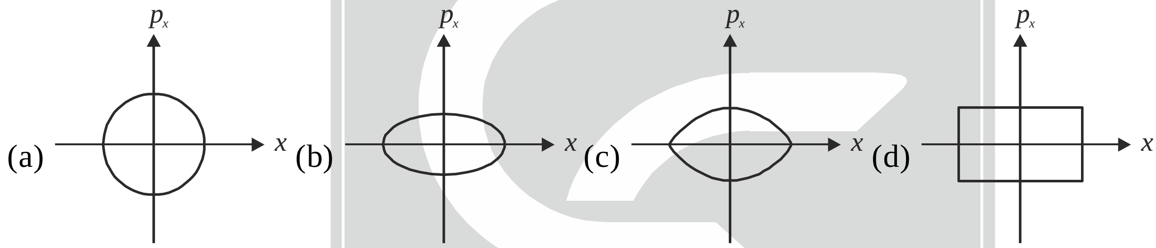


(a) $\frac{3c}{5}$ (b) $\frac{2c}{5}$ (c) c (d) $\frac{\sqrt{12}}{5}c$

52. Lagrangian of a system is $L = \dot{x}x - \sqrt{1-\dot{x}^2}$. The Hamiltonian is given by

(a) $\sqrt{(p_x - x)^2 - 1}$ (b) $\sqrt{(p_x - x)^2 + 1}$ (c) $\sqrt{(p_x + x)^2 - 1}$ (d) $\sqrt{(p_x + x)^2 + 1}$

53. A particle moves in one dimension under a potential $V(x) = \alpha(\cosh x - 1)$ with energy $E > 0$ and $a > 0$. Which one of the following plots describes the phase space trajectory of the particle?



54. Let p and q be the canonical momentum and coordinate of a dynamical system. Consider the following transformation.

$$Q = \frac{1}{\sqrt{2}}(p + \alpha q) \text{ and } P = \frac{1}{\sqrt{2}}(p + \beta q)$$

For the transformation to be canonical, the relationship between α and β will be

(a) $\alpha = \frac{1}{2}\beta$ (b) $\alpha = -\beta$ (c) $\alpha = \beta + 1$ (d) $\alpha = \beta + 2$

55. Poisson bracket $\{(\vec{r}\cdot\vec{p}), |\vec{r}|\}$ is equal to

(a) $|\vec{p}|$ (b) $-|\vec{r}|$ (c) $|\vec{r}|$ (d) $-|\vec{p}|$

Space for rough work

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PHYSICAL SCIENCES
TEST SERIES-B

Date : 26-05-2019

ANSWER KEY

PART-A

1. (a)	2. (d)	3. (a)	4. (a)	5. (d)	6. (d)	7. (b)
8. (a)	9. (c)	10. (a)				

PART-B

11. (b)	12. (d)	13. (d)	14. (b)	15. (a)	16. (c)	17. (b)
18. (a)	19. (d)	20. (a)	21. (c)	22. (d)	23. (b)	24. (d)
25. (c)	26. (c)	27. (b)	28. (b)	29. (d)	30. (c)	

PART-C

31. (a)	32. (b)	33. (b)	34. (b)	35. (d)	36. (b)	37. (d)
38. (b)	39. (b)	40. (d)	41. (b)	42. (b)	43. (a)	44. (c)
45. (c)	46. (d)	47. (c)	48. (a)	49. (d)	50. (a)	51. (c)
52. (b)	53. (b)	54. (d)	55. (b)			