2021

PHYSICS (Honours)

Paper Code : VII - A & B

[New Syllabus]

Important Instructions for Multiple Choice Question (MCQ)

- Write Subject Name and Code, Registration number, Session and Roll number in the space provided on the Answer Script.

  Example : Such as for Paper III-A (MCQ) and III-B (Descriptive).

  Subject Code : | III | A | & | B |

  Subject Name : | |

- Candidates are required to attempt all questions (MCQ). Below each question, four alternatives are given [i.e. (A), (B), (C), (D)]. Only one of these alternatives is 'CORRECT' answer. The candidate has to write the Correct Alternative [i.e. (A)/(B)/(C)/(D)] against each Question No. in the Answer Script.

  Example — If alternative A of 1 is correct, then write :
  1. — A

- There is no negative marking for wrong answer.

মাল্টিপল চয়েস প্রশ্নের (MCQ) জন্য জরুরী নির্দেশাবলী

- উত্তরপত্রে নির্দেশিত স্থানে বিষয়ের (Subject) নাম এবং কোড, রেজিস্ট্রেশন নম্বর, সেশন এবং রোল নম্বর লিখতে হবে।

  উদাহরণ — যেমন Paper III-A (MCQ) এবং III-B (Descriptive)।

  Subject Code : | III | A | & | B |

  Subject Name : | |

- পরীক্ষার্থীদের সবগুলি প্রশ্নের (MCQ) উত্তর দিতে হবে। প্রতিটি প্রশ্নে চারটি করে সম্ভাব্য উত্তর, যথাক্রমে (A), (B), (C) এবং (D) করে দেওয়া আছে। পরীক্ষার্থীকে তার উত্তরের স্বপক্ষে (A) / (B) / (C) / (D) সঠিক বিকল্পটিকে প্রশ্ন নম্বর উল্লেখসহ উত্তরপত্রে লিখতে হবে।

  উদাহরণ — যদি 1 নম্বর প্রশ্নের সঠিক উত্তর **A** হয় তবে লিখতে হবে :

  1. — A

- ভুল উত্তরের জন্য কোন নেগেটিভ মার্কিং নেই।

Paper Code : VII - A

Full Marks : 20 Time : Thirty Minutes

Choose the correct answer.

Each question carries 2 marks.

1. The Lagrangian of a particle of mass m moving under the action of a central force having force constant k, is given by, in polar coordinate system —

   (A) $L = \frac{1}{2}m\left(\dot{r}^2 + r^2\dot{\theta}^2\right) - \frac{k}{r}$

   (B) $L = \frac{1}{2}\left(\dot{r}^2 + r^2\dot{\theta}^2\right) + \frac{k}{r}$

   (C) $L = \frac{1}{2}m\left(\dot{r}^2 + r^2\dot{\theta}^2\right) + \frac{k}{r}$

   (D) $L = \frac{1}{2}\left(\dot{r}^2 + r\dot{\theta}^2\right) - \frac{k}{r}$

2. The value of Poisson's bracket $[\vec{p}, r^n]$ is —

   (A) $n\, r^{n-2}\vec{r}$

   (B) $-n\, r^{n-2}\vec{r}$

   (C) $-n\, r^{n-1}\vec{r}$

   (D) $n\, r^{n-1}\vec{r}$

3. If a free particle obeys the MB statistics, what is the average thermal energy of the particle at 300 K?

   (A) 0.39 eV

   (B) 0.26 eV

   (C) 0.026 eV

   (D) 0.039 eV

4. Law of conservation of angular momentum is a consequence of —

(A) homogeneity of space

(B) isotropy of space

(C) homogeneity of space and time

(D) homogeneity of time

5. For a classical 3D-system having N indistinguishable particles, which have coordinates q_i and momenta p_i, partition function is given by —

(A) $\frac{1}{h^{3N}} \int d^{3N} p \, d^{3N} q \, e^{-\beta H(p,q)}$

(B) $\frac{1}{h^{N}} \int d^{N} p \, d^{N} q \, e^{-\beta H(p,q)}$

(C) $\frac{1}{h^{3N} N!} \int d^{3N} p \, d^{3N} q \, e^{-\beta H(p,q)}$

(D) $\frac{1}{h^{N} N!} \int d^{N} p \, d^{N} q \, e^{-\beta H(p,q)}$

6. Specific heat of two Bose particles, each of which can occupy any of the two energy levels 0 and $\in$ is —

(A) $\frac{2 \in^2}{kT^2} \left[e^{-\in\beta} + e^{-2\in\beta} \right]$

(B) $\frac{2 \in^2}{kT^2} \left[e^{-\in\beta} - e^{-2\in\beta} \right]$

(C) $\frac{2 \in^2}{kT^2} \left[e^{-\in\beta} + 2e^{-2\in\beta} \right]$

(D) $\frac{2 \in^2}{kT^2} \left[e^{-\in\beta} - 2e^{-2\in\beta} \right]$

7. At cut-off, the JFET channel is —

(A) At its widest point

(B) Completely closed by depletion region

(C) Extremely narrow

(D) Reverse biased

8. A CE amplifier has a resistor $R_F = 40k\Omega$ connected between collector and base, $R_C = 4k\Omega$. Given $h_{fe} = 50, r_\pi = 1k\Omega,$ the output resistance R_0 is given by —

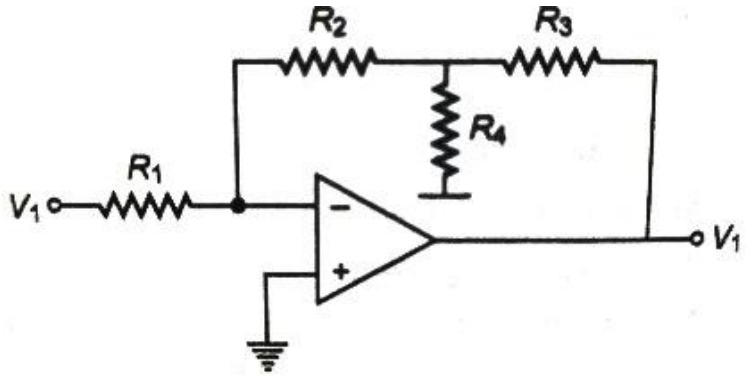
(A) $40k\Omega$

(B) $20k\Omega$

(C) $4k\Omega$

(D) $0.66k\Omega$

9. The voltage gain of the circuit shown in figure is given by —



(A) $-\left[\dfrac{R_2 + R_3 + \dfrac{R_2 R_3}{R_4}}{R_1}\right]$

(B) $-\left[\dfrac{\dfrac{R_3 R_4}{R_3 + R_4} + R_2}{R_1}\right]$

(C) $-\left[\dfrac{\dfrac{R_2 R_4}{R_2 + R_4} + R_3}{R_1}\right]$

(D) $-\left[\dfrac{R_2 + R_3}{R_1}\right]$

10. The minimum number of selectors required for a 4:1 multiplexer is —

(A) 1

(B) 3

(C) 4

(D) 2

2021

PHYSICS (Honours)

Paper Code : VII - B

[New Syllabus]

Full Marks : 70 Time : Three Hours Thirty Minutes

The figures in the margin indicate full marks.

Answer any *five* questions, taking at least *one* from each group.

Group - A

(Classical Mechanics - II and Fluid Mechanics)

1. (a) Explain the principle of virtual work. Write down the advantages of this principle to solve the equation of motion of a dynamical system. 3+1

   (b) Derive Lagrange's equation from D'Alembert's principle. 6

   (c) The Lagrangian of a system is given by $L = \frac{1}{2} e^{at} \left(\dot{x}^2 - p^2 x^2 \right)$ where a and p are constants. Find the equation of motion of the system. 4

2. (a) What are the advantages of the Lagrangian approach over Newtonian one? Of the two approaches Hamiltonian and Lagrangian, which one will you prefer and why?

   (b) Show that the generalized momentum conjugate to a cyclic coordinate is conserved.

   (c) Deduce Hamilton's canonical equations. 2+4+4+4

3. (a) State Bernoulli's theorem for the streamline flow of an incompressible non-viscous fluid. Deduce Bernoulli's equation in this case from energy consideration. From Bernoulli's theorem arrive at Torricelli's theorem. 1+5+2

(b) A particle of mass m is suspended from a fixed support by a spring and from this particle another mass m is suspended by another spring. If both the springs have spring constant k and unstretched length l_0, then determine the normal mode frequencies for vibration of masses along vertical line through the support. 6

Group - B

(Statistical Mechanics)

4. (a) Starting from Bose-Einstein distribution formula, establish Planck's law of black-body radiation. 2+5

(b) Show that for a two dimensional free electron gas, the number of electrons per unit area is given by $n = \frac{4\pi m k_B T}{h^2} \ln\left(\frac{E_F}{e^{k_B T}} + 1\right)$. 4

(c) Show that the chemical potential of the system of N quantum harmonic oscillators having frequency ω and at a temperature T will be —

$$\mu = \frac{\hbar\omega}{2} + kT \ln\left(1 - \exp(-\hbar\omega\beta)\right)$$ 3

5. (a) For thermionic emission at a low temperature, derive the Richardson-Dushman equation for current density. 6

(b) What is the difference between Einstein's and Debye's theories of specific heat of solids? Justify which theory can explain the low temperature behaviour of specific heat more accurately. 2+2

(c) If the two sub-systems 1 and 2 are in thermal equilibrium and entropy σ of the total system has a maximum value with respect to small transfer of energy from one subsystem to another, then statistical temperature τ is defined as $\frac{1}{\tau} = \left(\frac{\partial\sigma}{\partial U}\right)$. 4

Group - C

(Electronics - II)

6. (a) What is the difference between the depletion and enhancement type MOSFET? Draw the output characteristics in both cases for n-channel MOSFET and explain the shape of the curve qualitatively. 3+3

   (b) Define the pinch-off voltage and sketch the depletion region before and after the pinch-off voltage. Define transconductance (g_m) of a JFET. Draw the transconductance curve. 2+1+1

   (c) A common source FET amplifier has $R_L = 250k\Omega$. The ac drain resistance and transconductance of FET are $200k\Omega$ and $0.1mA/V$, respectively. Calculate the voltage gain of the amplifier. 4

7. (a) Draw a circuit of a 4-stage R-2R ladder D/A converter. Calculate the output voltage when input binary number is 1110 where reference voltage is 16V and $R = 10k\Omega$. What voltage resolution is possible using the above network? 2+3+1

   (b) Draw a circuit diagram of J-K flip-flop with preset (P_r) and clear (C_r) input. Hence explain the operation with the help of a truth table. 1+2

   (c) Design a 4 to 1 multiplexer using basic gates. 3

   (d) What are advantages of synchronous counter over asynchronous counter? 2

8. (a) Explain the following terms with reference to a CRO : (i) Horizontal time base (ii) Synchronization (iii) Triggering. 3

   (b) In a differential amplifier using OPAMP with two inputs the output is $2.01mV$ when the inputs are $110\mu V$ and $90\mu V$ but the output is $2mV$ when the inputs are $10\mu V$ and $-10\mu V$. Find the CMRR of the amplifier. 4

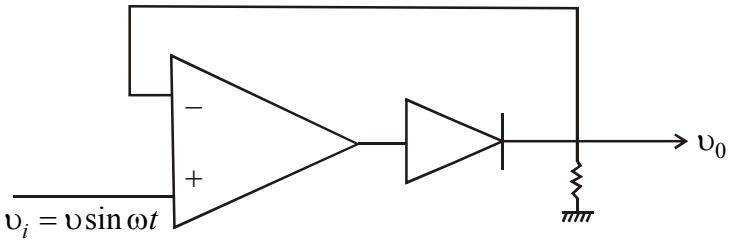
   (c) Draw an analog computer circuit using OP-AMP to solve the following simultaneous equations :

   (i) $5x + 2y = 12$, (ii) $2x + 3y = 6$. 4

(d) What is a power amplifier? How does it differ from a voltage amplifier and a current amplifier? 3

9. (a) Derive expressions for low and high frequency voltage gain of a R-C coupled amplifier in terms of mid-frequency voltage gain. 3+3

(b) Explain how the band-width of an amplifier can be increased with negative feedback. 3

(c) Voltage gain of an amplifier is 200 and its band with is 200kHz. If a negative feedback with feedback fraction 0.02 is applied, find (i) gain of the amplifier with feedback and (ii) bandwidth of the amplifier with feedback. 2+1

(d) Explain the operation of the following circuit :