

Signature of Invigilators

Roll No.

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(In figures as in Admit Card)

1. ....

## PHYSICAL SCIENCES

2. ....

### Paper III

Roll No. ....

(In words)

**J—0202**

Name of Areas/Section (if any) .....

Time Allowed : 2½ Hours]

[Maximum Marks : 200

#### Instructions for the Candidates

#### FOR OFFICE USE ONLY Marks Obtained

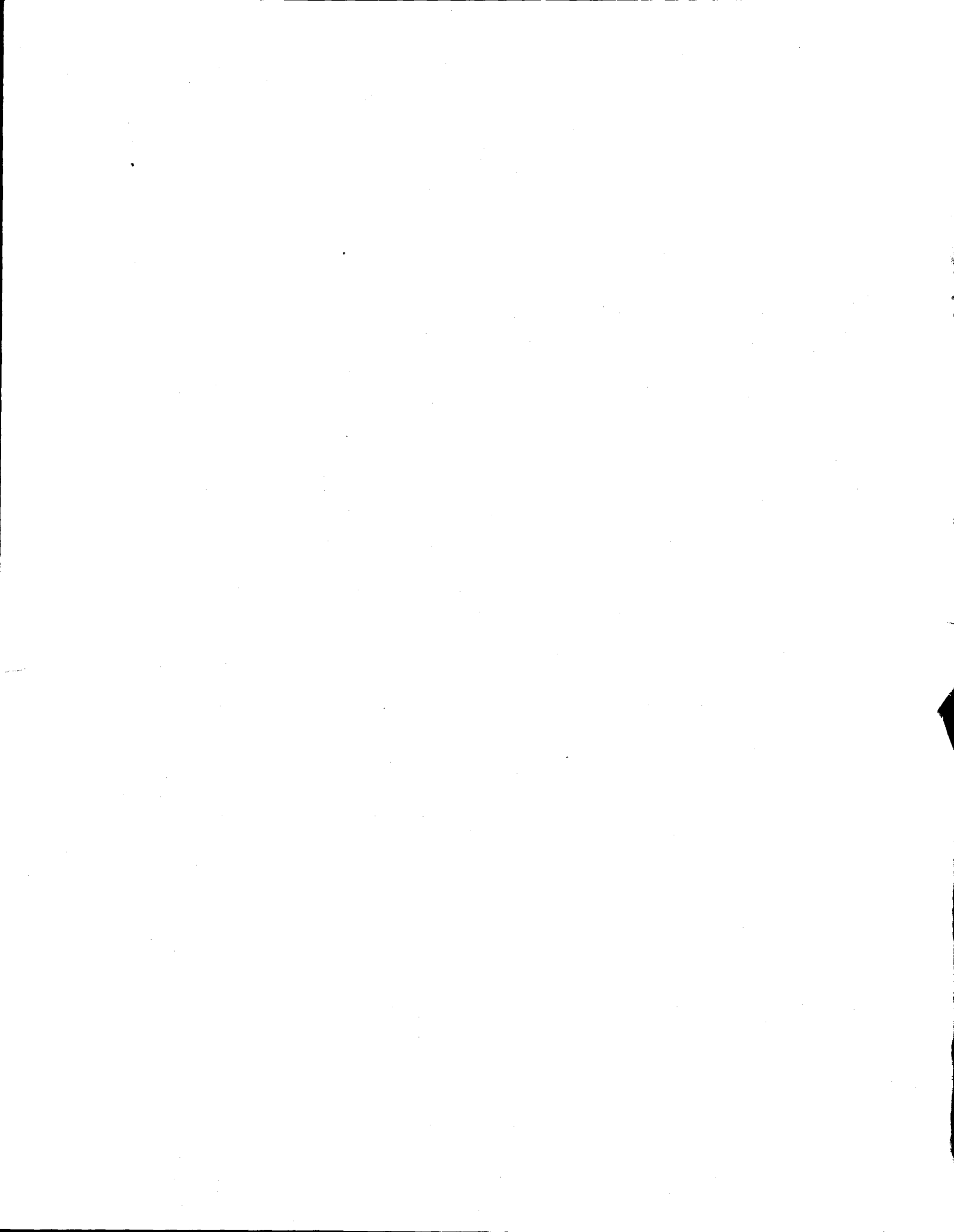
1. Write your Roll number in the space provided on the top of this page.
2. Write name of your Elective/Section if any.
3. Answer to short answer/essay type questions are to be written in the space provided below each question or after the questions in test booklet itself. No additional sheets are to be used.
4. Read instructions given inside carefully.
5. Last page is attached at the end of the test booklet for rough work.
6. If you write your name or put any special mark on any part of the test booklet which may disclose in any way your identity, you will render yourself liable to disqualification.
7. Use of any calculator is prohibited.
8. There is no negative marking.
9. You should return the test booklet to the invigilator at the end of the examination and should not carry any paper outside the examination hall.

પરીક્ષાર્થીઓ માટેની સૂચનાઓ :

૧. આ પાનાની ટોચમાં દર્શાવેલી જગ્યામાં તમારો રોલ નંબર લખો.
૨. જો કોઈ વિકલ્પ/વિભાગ પસંદ કર્યા હોય તો તે યોગ્ય જગ્યાએ દર્શાવો.
૩. ટુંકા પ્રશ્નો/નિબંધ વિષેના જવાબો એ પ્રશ્નની નીચે અગર બાજુમાં આપેલી જગ્યામાં લખો. વધારાના કોઈ પાનાનો ઉપયોગ કરશો નહીં.
૪. અંદર આપેલી સૂચનાઓ કાળજીપૂર્વક વાંચો .
૫. બુક્લેટની પાછળ આપેલું છેલ્લું પાનું રફ કામ માટે છે.
૬. બુક્લેટ કોઈપણ ઠેકાણે તમારું નામ કે કોઈ ચોક્કસ સંજ્ઞા કરવી નહીં કે જે તમારી ઓળખ પૂરી પાડે. આ તમને પરીક્ષા માટે ગેરલાયક ઠેરવશે.
૭. કેલ્ક્યુલેટર નો ઉપયોગ કરાશે નહીં.
૮. નકારાત્મક માર્કીંગ નથી.
૯. પરીક્ષા સમય પૂરો થઈ ગયા પછી આ બુક્લેટ જે તે નીરીક્ષકને સોંપી દેવી. કોઈપણ પેપર પરીક્ષા રૂમની બહાર લઈ જવું નહીં.

Question Number	Marks Obtained	Question Number	Marks Obtained	Question Number	Marks Obtained
1		26			
2					
3					
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Total Marks Obtained.....  
Signature of the co-ordinator.....  
(Evaluation)



## PHYSICAL SCIENCES

### PAPER III

Note :—(i) Part A consists of 10 questions of 10 marks each. Attempt each question in about 200 words (2 pages). All questions are compulsory.

(ii) Part B consists of 16 questions of 25 marks each. Attempt any four questions from Part B. Each question is to be answered in about 500 words (5 pages).

(iii) Log tables be allowed, but not a calculator.

### PART A

1.  $f(x) = x^2$  over  $-\pi < x < \pi$ .

Expand  $f(x)$  in the form of Fourier Series, and using it show that :

$$\sum_{n=1}^{\infty} \frac{(-1)^{n+1}}{n^2} = \frac{\pi^2}{12}.$$

2. Evaluate the following, using contour integration

$$\int_0^{\infty} \frac{x^{1/2}}{1+x^2} dx$$

3. The kinetic and potential energies of a conservative system are :

$$T = \frac{1}{2} M \dot{x}^2 + \frac{m(\dot{x}^2 + l^2 \dot{\theta}^2 + 2l \dot{x} \dot{\theta} \cos \theta)}{2}$$

$$V = -mgl \cos \theta.$$

Obtain the Lagrange's equations of the system.

4. A particle of mass 2 kg moving with a speed of 3 m/s hits another particle of mass 4 kg headon. The collision is perfectly elastic. Find the final speeds of the two particles.

5. A charged particle moving with a uniform velocity  $4\hat{i}$  m/s in the region where  $\vec{E} = 20\hat{j}$  V/m and  $\vec{B} = B_0\hat{k}$  tesla. Determine  $B_0$  such that the velocity of the particle remains constant.

6. A large number of particles  $N$  are distributed in two levels with energy

$$E_1 = - \epsilon/2$$

$$E_2 = + \epsilon/2.$$

Obtain the expression for entropy of such a system as a function of total energy of the system. At what energy is the entropy maximum ?

7. Using the Uncertainty Principle, show that a particle in an infinite square well potential will have finite kinetic energy.
8. Describe Laue's, rotating crystal, and powder methods of X-ray diffraction. What additional information, if any, one can obtain if one carries out neutron diffraction experiment ?
9. Obtain the expression for reflection coefficient for a beam of particles coming from  $-\infty$  and incident on a potential step given by :

$$V(x) = 0 \quad \text{for } x < 0$$

$$V(x) = V_0 \quad \text{for } x > 0$$

[Kinetic energy of particles is larger than  $V_0$  for  $x < 0$ ].

10. Discuss briefly the measurement of energy and time using electronic signals.

### PART B

11. (a) Explain energy band diagram of an open-circuit PN junction. Show that the contact difference of potential of the PN junction is given by

$$kT \ln \frac{N_D N_A}{n_i^2},$$

where  $N_D$ ,  $N_A$  and  $n_i$  are donor, acceptor and intrinsic carrier concentrations respectively.

- (b) What are the four possible topologies of a feedback amplifier ? Identify the output signal and the feedback signal for each topology.
12. (a) What is a comparator circuit ? How does it differ from a clipping circuit ? Draw the circuit of a diode comparator and its output waveform.
- (b) Explain how to modify a ripple counter so that it divides by  $N$ , where  $N$  is not a power of 2.

13. (a) Using OPAMs, develop a suitable block diagram of an electronic analog computer to program the differential equation

$$\frac{d^2V}{dt^2} + k_1 \frac{dV}{dt} + k_2 V - v_1 = 0$$

where  $v_1$  is a function of time,  $k_1$  and  $k_2$  are real positive constants.

- (b) Prove the Boolean identity

$$A + BC = (A + B)(A + C).$$

- (c) Why do we use, at times, D/A converter for realizing A/D converter ?

14. (a) Explain the function of a master-slave J-K flip-flop. How is race around condition eliminated in it ?
- (b) Explain briefly the function of a four stage ring counter.
- (c) Explain the function of a full adder. How many half adders are required to implement it ?

15. Elaborate the difference between spontaneous and stimulated emissions. Why is stimulated emission used for lasing action ? Explain why population inversion is necessary but not sufficient for a laser ?

16. Discuss the basic principle of NMR. For a magnetic field of 1.5 Tesla, what will be the resonance frequency ? Distinguish between spin-spin and spin-lattice relaxation. Give a block diagram of NMR spectrometer, giving description of each block. [Given :  $\mu = 1.41 \times 10^{-30}$  J/gauss]

17. What is London interaction ? Prove that the total potential energy of two atoms at separation  $R$  in a weakly bonded solid is

$$U(R) = 4 \epsilon \left[ (\sigma/R)^{12} - (\sigma/R)^6 \right].$$

18. Describe Stern-Gerlach experiment for silver atoms. If we use a beam of carbon atoms, how many different beams will emerge ?
19. Describe the Hall effect experiment for a metal having one type of charge carriers. Obtain an expression for the Hall coefficient in terms of charge carrier concentration.

A rectangular block of monoatomic metal of dimensions  $2 \text{ cm} \times 3 \text{ cm} \times 4 \text{ cm}$  is used for the Hall effect experiment. Constant current of 25 amp. is

- allowed to flow normal to one face of the block, and a magnetic field of 1 Tesla is applied normal to another face. Which faces should be chosen for obtaining maximum Hall voltage ?
20. Distinguish between metals, semiconductors, insulators and superconductors. Describe how Brillouin zone helps to understand diffraction phenomena in crystal lattices. Show that for a square two-dimensional lattice, the kinetic energy of free electron at a corner of the first Brillouin zone is higher than that of electron at the midpoint of side-face of the zone by a factor 2.
  21. What are different sources of polarizability of a solid ? Prove that the electric field at the site of an atom in the solid is greater than the external field by a factor proportional to the polarization density.
  22. Describe the tight binding method for calculation of band structure. Obtain an expression of the energy band in a simple cubic solid using this particular method. Assume nearest neighbour interactions only.
  23. Explain the terms :
    - (i) secular equilibrium;
    - (ii) transient equilibrium.Obtain relevant equations and discuss the necessary conditions.
  24. Give the evidence for nuclear shell structure, and explain the detailed structure of nucleus using single particle shell model. What are its limitations ?
  25. What do you understand by Q-value of nuclear reaction ? Discuss the compound nucleus theory of nuclear reactions. Give the experimental evidence in support of the theory.
  26. Discuss the classification of elementary particles in various families. Why is it necessary to introduce strangeness quantum number ?



