

Time: 2 1/2 hrs.

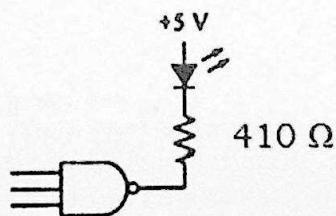
M. M.: 75

**N.B.:**

1. All questions are compulsory.
2. Figures to the right indicate full marks.
3. Draw neat diagrams wherever necessary.
4. Symbols have usual meaning unless otherwise stated.
5. Use of non-programmable calculator is allowed.

1. (a) Attempt any one: -
  - (i) Draw circuit and explain transconductance characteristics of n-channel JFET and explain the terms pinch-off voltage, transconductance, and amplification factor. 10
  - (ii) Sketch the cross section of n-channel E-MOSFET and explain its working. Draw and explain its drain and trans-conductance curves. 10
- (b) Attempt any one: -
  - (i) Explain the following terms in relation to SCR. a) Break-over voltage b) Holding current and c) Forward current rating 5
  - (ii) A JFET has a drain current of 5 mA. If  $I_{DSS} = 10$  mA and  $V_{GS(off)} = -6$  V, find the value of (i)  $V_{GS}$  and (ii)  $V_P$ . 5
2. (a) Attempt any one: -
  - (i) Describe the AC analysis for a differential amplifier with a non-inverting input - single-ended output. Draw the AC-equivalent circuit and derive the expression for the voltage gain of the same. 10
  - (ii) Draw the diagram of first order active low pass filter in non-inverting configuration. State the expression for cut-off frequency and pass band gain. Sketch the frequency response curve. 10
- (b) Attempt any one: -
  - (i) Explain the concept of a common-mode signal and state expression for common mode voltage gain. 5
  - (ii) Draw the circuit diagram of Wein bridge oscillator using Op-Amp. Calculate the output frequency if  $R_1 = R_2 = 2$  k $\Omega$  and  $C_1 = C_2 = 0.047$   $\mu$ F. 5
3. (a) Attempt any one: -
  - (i) Draw a neat circuit diagram of transistorized Monostable multivibrator. With the help of necessary waveform, explain its working derive the expression pulse width. 10
  - (ii) Draw the circuit diagram of voltage-controlled oscillator using IC555 timer. Discuss its working. Derive the expressions for output time period. 10
- (b) Attempt any one: -
  - (i) Explain in brief the following characteristics of the power supply, i) Load Regulation. ii) Line Regulation. iii) Output Resistance. 5
  - (ii) Explain the working of Bistable multivibrator with neat circuit diagram. 5

4. (a) Attempt any one: -
- (i) Explain the characteristics of CMOS in terms of Sourcing and Sinking. 10
  - (ii) Explain the advantages of digital communication systems. 10
- (b) Attempt any one: -
- (i) Draw circuit diagram and truth table of TTL NOR gate. 5
  - (ii) An information signal to be transmitted digitally is a rectangular wave with a period of  $60.0 \mu\text{s}$ . It has been found that the wave will be adequately passed if the bandwidth includes the fourth harmonic. Calculate (a) The signal frequency, (b) The fourth harmonic and (c) Minimum sampling frequency. 5
5. Attempt any Five: -
- (i) Calculate the transconductance of JFET having specified values of  $I_{DSS} = 12 \text{ mA}$  and  $V_P = -4 \text{ V}$  at bias points,  $V_{GS} = 0 \text{ V}$  and  $V_{GS} = -1.5 \text{ V}$ . 3
  - (ii) SCR has a circuit fusing rating of  $60 \text{ A}^2\text{S}$ , determine the highest surge current value that SCR can withstand for a period of  $20 \text{ ms}$ . 3
  - (iii) A differential amplifier has an open-circuit voltage gain of 200. This amplifier has a common input signal of  $3.2 \text{ V}$  to both terminals. This results in an output signal of  $26 \text{ mV}$ . Determine common-mode voltage gain and the CMRR in dB. 3
  - (iv) Op-Amp astable multivibrator has  $R = 1000 \Omega$ ,  $C = 0.22 \mu\text{F}$ ,  $R_1 = 20 \text{ k}\Omega$ ,  $R_2 = 2 \text{ k}\Omega$ . Find the frequency of output signal. 3
  - (v) Calculate the time period and frequency of oscillation of an astable multivibrator using IC 555 timer, if  $R_A = 1500 \Omega$ ,  $R_B = 10 \text{ k}\Omega$ ,  $C = 0.47 \mu\text{F}$ . 3
  - (vi) Calculate capacitance of capacitor in symmetric transistorized astable multivibrator circuit when base current  $I_B$  is  $0.2 \text{ mA}$ ,  $V_{CC}$  is  $+15 \text{ V}$  and frequency is  $500 \text{ Hz}$ . 3
  - (vii) A TTL circuit drives an LED. When the TTL output is high, the LED is dark. When the TTL output is low, the LED lights up. If the LED voltage drop is  $1.5 \text{ V}$ , Calculate LED current for a low TTL output. 3



- (viii) The input voltage of a compander with a maximum voltage range of  $1.1 \text{ V}$  and a  $\mu$  of 255 is 0.25. calculate the output voltage and gain? 3

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3. Draw neat diagrams wherever necessary.
4. Symbols have usual meaning unless otherwise stated.
5. Use of non-programmable calculator is allowed.

**Constants:** Boltzmann Constant:  $k = 1.38 \times 10^{-23} \text{ J}^\circ\text{K}$

Planck's Constant:  $h = 6.63 \times 10^{-34} \text{ J-sec}$

1. (a) Attempt any one: -
  - (i) Explain Inverse square law of force with example. Give qualitative information of the motion in an inverse square field. **10**
  - (ii) What is meant by Foucault's pendulum and obtain equation of motion for it. Show that the pendulum plane precesses slowly clockwise in the northern hemisphere. **10**
- (b) Attempt any one: -
  - (i) Explain the significance of the different terms appearing in the Coriolis theorem. **5**
  - (ii) A comet revolves around the Sun with a period of 56 years. Calculate the semi-major axis of its orbit in astronomical units (AU). **5**  
(Given: Mass of the sun =  $2.0 \times 10^{30} \text{ kg}$ ,  $G = 6.67 \times 10^{-11} \text{ Nm}^2/\text{kg}^2$ ,  $1\text{AU} = 1.5 \times 10^8 \text{ km}$ )
2. (a) Attempt any one: -
  - (i) Two equal masses  $m_1 = m_2 = m$  with co-ordinates  $x_1$  and  $x_2$  in one dimension are connected by spring of constant  $k$ . Write down the Lagrangian equation for these masses. What is the angular frequency of simple harmonic motion for the relative displacement  $x_1 - x_2$  of the two masses. **10**
  - (ii) What is virtual displacement and virtual work? State and prove D'Alembert's principle. **10**
- (b) Attempt any one: -
  - (i) Define constraints. Explain types of constraints with examples. **5**
  - (ii) For a particle moving in a plane, Write down the Lagrange's equation of motion in a polar coordinate. **5**
3. (a) Attempt any one:-
  - (i) Show that kinetic energy of a rotating body is conserved if no external torque acts on it. **10**
  - (ii) Show that for a steady flow of fluid, the total kinetic energy plus the potential energy remains constant. **10**
- (b) Attempt any one:-
  - (i) Show that the time rate of change of total linear momentum in a volume  $V$  of moving fluid is equal to the total external force acting on it. **5**
  - (ii) If the velocity of a fluid element at a point is  $\vec{v} = x^2\hat{i} + 3yz\hat{j}$ , is the flow rotational and fluid is compressible? **5**

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4. (a) Attempt any one:-
- (i) What are the various forces acting on the anharmonic oscillator? Write down the equation of motion of anharmonic oscillator and obtain the Duffing's equation. Using the suitable rescaling derive the reduced Duffing's equation and discuss the feature of this equation. 10
- (ii) What is logistic map? Using this map obtain the equation for the slope of the tangent drawn at a fixed point and hence explain the stability of the fixed points for 1)  $0 < \lambda < 1$  2)  $1 < \lambda < 3$  and 3)  $3 < \lambda < 4$ . 10
- (b) Attempt any one:-
- (i) Explain the term: Scale invariance, self-similarity and fractal dimensions in relation to chaotic systems. 5
- (ii) Two very close initial values of  $x$  on logistic map are 0.40000 and 0.40001 respectively. With  $\lambda = 4$  after 15 iterations the values are 0.13561 and 0.00180 respectively. Calculate Lyapunov exponent. 5
5. Attempt any Five:-
- (i) Halley's Comet revolves around the Sun in an elliptical orbit. If the semi-major axis of its orbit is  $a = 17.92$  AU and its minimum distance from the Sun is  $r_{\min} = 0.6$  AU, calculate (i) the maximum distance  $r_{\max}$  in AU, and (ii) the eccentricity of its orbit. 3
- (ii) A 100 kg mass is moving horizontally along the latitude  $60^\circ$  in the northern hemisphere at a speed of 50 m/s. Find the magnitude of Coriolis force acting on it. 3
- (iii) Write a short note on Generalized coordinate. 3
- (iv) Explain the cyclic coordinate with example. Find the cyclic coordinate in equation given below 3
- $$L = \frac{1}{2} m(\dot{x}^2 + \dot{y}^2) - mgx$$
- (v) Three-point masses ( $m$  each), are located at  $(0,0,0)$ ,  $(2,2,0)$  and  $(2,-2,0)$ . They are connected by massless rigid rods. Find the moment of inertia tensor of the body referred to the axes. OX, OY and OZ. 3
- (vi) Consider a fluid flow given by  $\vec{v} = by \hat{i}$  in a co-ordinate system S. Is the fluid incompressible? 3
- (vii) Find the fractal dimension of a line of length  $l$  in a plane. 3
- (viii) Write a note on Henon map. 3

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T.Y.B.A./B.Sc

Reg.

Time: 2 ½ hrs.

Sem. VI

20/4/2026

Marks: 75

N.B.:

1. All questions are compulsory.
  2. Figures to the right indicate full marks.
  3. Draw neat diagrams wherever necessary.
  4. Symbols have usual meaning unless otherwise stated.
  5. Use of non-programmable calculator is allowed.
1. (a) Attempt any one: -
    - (i) What is Lorentz Fitzgerald contraction hypothesis? How does it explain the negative result of Michelson Morley experiment? Why was it discarded? 10
    - (ii) State the postulates of special theory of relativity and derive Lorentz transformation equations for space and time. 10
  - (b) Attempt any one: -
    - (i) Explain the concept of relativity of simultaneity using examples. 5
    - (ii) Show that the equation  $x^2 + y^2 + z^2 - c^2t^2$  is invariant under Lorentz transformation of space-time coordinates. 5
  2. (a) Attempt any one: -
    - (i) Derive Lorentz transformation equations for components of acceleration. 10
    - (ii) Deduce the expression for the time order (time like), space separation (space like) and light like of events with help of space-time diagram. 10
  - (b) Attempt any one: -
    - (i) Write a short note on Minkowski's space time diagrams. 5
    - (ii) Derive Lorentz transformation equations for velocity. 5
  3. (a) Attempt any one:-
    - (i) If the body of rest mass  $m_0$  is moving with velocity  $u$ , show that its relativistic mass is given by  $m = \frac{m_0}{\sqrt{1 - \frac{u^2}{c^2}}}$  10
    - (ii) Starting from the relativistic force law, obtain the expression for the total energy of a single particle in relativistic mechanics 10
  - (b) Attempt any one:-
    - (i) Derive the relation  $E^2 = p^2c^2 + m_0^2c^4$  where E is the total energy, 'p' is the momentum 'm<sub>0</sub>' is the rest mass of the particle and 'c' the velocity of light. 5
    - (ii) Show that  $p_x^2 + p_y^2 + p_z^2 - \frac{E^2}{c^2}$  remains invariant under Lorentz transformation. 5

4. (a) Attempt any one:-
- (i) Derive the transformation equations for magnetic field  $\vec{B}$  given by 10  

$$B'_{\parallel} = B_{\parallel} \text{ \& } B'_{\perp} = \gamma \left( B_{\perp} - \frac{1}{c^2} [v \times E]_{\perp} \right)$$
  - (ii) Obtain an expression for electric field of a uniformly moving point charge. 10  
 Also show that the field is not spherically symmetric.
- (b) Attempt any one:-
- (i) Discuss experimental observations in favour of general relativity theory. 5
  - (ii) Show that if  $\vec{E}$  and  $\vec{B}$  are perpendicular to each other in one inertial frame 5  
 then they are perpendicular to each other in another inertial frame also.
5. Attempt any Five:-
- (i) Calculate the period of 'seconds pendulum' measured by an observer 3  
 moving at  $0.6c$  speed.
  - (ii) Transform the displacement vector  $10 \hat{i} + 4 \hat{j}$  cm in a system  $S$  to  $S'$ . Velocity 3  
 of  $S'$  frame relative to frame  $S$  is  $0.6 c \hat{j}$ .
  - (iii) Consider a radioactive nucleus moving with uniform velocity  $0.05c$  relative 3  
 to the laboratory. The nucleus decays by emitting an electron that is moving  
 with a speed  $0.8c$  along the direction of motion. Find the magnitude of  
 velocity of the electron in the laboratory frame in terms of  $c$ .
  - (iv) State and explain Longitudinal Doppler effect. 3
  - (v) Find the momentum of an electron whose velocity is  $0.9c$ . ( $m_0 =$  3  
 $0.511 \text{ MeV}$ ).
  - (vi) Find the velocity at which the rest mass of an electron is exactly half of its 3  
 mass at that speed.
  - (vii) State Maxwell's equations in electrodynamics and explain various terms in 3  
 it.
  - (viii) Calculate the strength of the electric field for the uniformly moving point 3  
 charge in the inertial frame for the limiting case  $\theta = 0^\circ$ , where  $\theta$  is the angle  
 made by radius vector with x-axis.

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Constants: Boltzmann Constant:  $1.380649 \times 10^{-23} \text{ m}^2 \text{ kg s}^{-2} \text{ K}^{-1}$

Planck's Constants:  $6.64 \times 10^{-34} \text{ Js}$

1. (a) Attempt any one: -

- (i) Discuss Gamow's theory of  $\alpha$ -decay. 10
- (ii) With the help of a neat labeled diagram, describe Cowan and Reines experiment to detect the neutrino. 10

(b) Attempt any one: -

- (i) Discuss the energetics of spontaneous  $\alpha$ -decay. 5
- (ii) A free neutron decays into a proton, an electron and an antineutrino. If  $M(n) = 1.00898 \text{ amu}$ ,  $M(p) = 1.00759 \text{ amu}$  and  $M(e^-) = 0.00055 \text{ amu}$ . Find the kinetic energy shared by the electron and the antineutrino. 5  
Given:  $1 \text{ amu} = 931.5 \text{ MeV}$

2. (a) Attempt any one: -

- (i) Describe the selection rules for  $\gamma$ -decay. Also explain the phenomenon of the internal conversion process. 10
- (ii) Using semi-empirical mass formula determine the charge and mass of the most stable even  $A$  and odd  $A$  isobar. Explain parabolic relationship between the masses  $M(Z, A)$  of odd  $A$  isobars. 10

(b) Attempt any one: -

- (i) Explain the nuclear isomerism of bromine and draw the decay scheme of nuclear isomer. 5
- (ii) For the isobaric family  $A = 65$ , obtain the nuclear charge  $Z_0$  of the most stable isobar. (Given:  $a_a = 23.70 \text{ MeV}$ ,  $a_c = 0.71 \text{ MeV}$ ,  $M_n = 939.57 \text{ MeV}$ ,  $M_p = 938.27 \text{ MeV}$ ). 5

3. (a) Attempt any one:-

- (i) Explain the construction and working of Betatron in detail. 10
- (ii) What is a nuclear reactor? Explain its principle, construction and working. 10

(b) Attempt any one:-

- (i) Calculate the energy released by 40 gm of  $\text{U}^{235}$  when it is completely fissioned. Take energy released per fission of  $\text{U}^{235}$  as 200 MeV and Avogadro's number =  $6.023 \times 10^{23}$  per mole. 5
- (ii) Write a note on Van de Graff generator. 5

4. (a) Attempt any one: -

- (i) Discuss the meson theory of nuclear force, and use Heisenberg's uncertainty principle to estimate the radius of the nucleus if mass of the meson associated with the nuclear interaction is  $M_{\pi} = 270 m_e$ . 10
- (ii) Explain the four fundamental interactions of elementary particles, highlighting their key characteristics, mediating particles, and relative strengths. 10

(b) Attempt any one: -

- (i) Explain properties of photons. 5
- (ii) Write down the short note on quark model. 5

5. Attempt any Five:-

- (i) The nuclide  ${}_{84}\text{Rn}^{211}$  emits three groups of  $\alpha$ -particles with kinetic energies of 5.847 MeV, 5.779 MeV and 5.163 MeV respectively. Calculate the  $\alpha$  - disintegration energies. 3  
Given:  $M({}_{82}\text{Pb}^{207}) = 207$  amu.
- (ii)  ${}_{12}\text{Mg}^{23}$  decays to  ${}_{11}\text{Na}^{23}$  by emitting positron. Represent the decay process by an equation and calculate  $Q_{\beta^+}$ . 3  
Given:  $M({}_{12}\text{Mg}^{23}) = 23.0002$  amu,  $M({}_{11}\text{Na}^{23}) = 22.99618$  amu,  $M({}_{+1}\text{e}^0) = 0.00055$  amu,  $1\text{amu} = 931.5$  MeV.
- (iii)  $\text{Bi}^{210}$  atoms, formed by  $\beta$ -decay of  $\text{Pb}^{210}$ , emit internal conversion electrons with kinetic energies 482.5, 480.6, 480.0, and 405.8 keV. Electron binding energies are  $K = 90.5$  keV,  $L_I = 16.3$  keV,  $L_{II} = 15.7$  keV, and  $L_{III} = 13.8$  keV. The highest K.E. corresponds to  $L_{III}$  electrons. Calculate the energy of the gamma ray emitted simultaneously with the decay. 3
- (iv) Write short note on shell model of nucleus. 3
- (v) If the fission process starts with the 5000 neutrons and the multiplication factor  $k = 1.05$ , calculate the number of neutrons present in the tenth generation. 3
- (vi) The radius of dees in the cyclotron is 35 cm and magnetic field is 3000 Gauss. What would be the velocity of protons? 3  
Given:  $m_p = 1.67 \times 10^{-27}$  Kg,  $q = 1.6 \times 10^{-19}$ C.
- (vii) Explain the term magnetic dipole moment of Deuteron. 3
- (viii) State any two conservation laws follow by elementary particles. 3

T.Y.B.Sc - sem - V ATKT

13/4/2022

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Constants: Boltzmann Constant:  $1.38054 \times 10^{-23}$  Joule/Kelvin

Planck's Constants:  $6.626 \times 10^{-34}$  Joule sec

1. (a) Attempt any one: -
  - (i) For simple cubic structure, derive an expression for interplanar distance for the planes having Miller indices (h k l). 10
  - (ii) Briefly discuss the crystal structure of diamond cubic and sodium chloride. 10
- (b) Attempt any one: -
  - (i) Explain the terms Unit cell and lattice parameters. 5
  - (ii) Silicon crystallizes in the diamond cubic structure. The radius of silicon atom is 0.1176 nm. The atomic weight and density of silicon are 28.09 and  $2.3 \times 10^3$  kg / m<sup>3</sup>. Give me the number of atoms present in a unit cell. 5
2. (a) Attempt any one: -
  - (i) Define Fermi energy. State the expression for density of energy states  $Z(E) dE$  in metals, and derive expression for average kinetic energy of electrons in metals at 0K. 10
  - (ii) Derive the expression for the electrical conductivity of a metal based on the classical free electron theory. Explain how does the electrical conductivity of a metal depend on temperature? Does this agree with experimental observations? 10
- (b) Attempt any one: -
  - (i) Show how the classical theory fails to explain the experimental value of the electronic specific heat capacity. 5
  - (ii) Resistivity of aluminum at room temperature is  $2.62 \times 10^{-8}$  ohm m. Valency of Aluminum is 3. Calculate (i) The drift velocity (ii) Their mobility, for an applied voltage of 1 Volt, on the basis of classical free electron theory. 5
3. (a) Attempt any one: -
  - (i) Explain how materials can be classified into conductors, insulators and semiconductors on the basis of the E - K curve for the material. 10
  - (ii) Explain electrons and holes in an intrinsic semiconductor and derive expression for the concentration of holes in an intrinsic semiconductor. 10

- (b) **Attempt any one: -**
- (i) What is Hall effect? State the applications of Hall effect. 5
- (ii) A two-dimensional square lattice has side of 0.89 nm. Calculate momentum and energy of the free electron of first Brillouin zone. 5
4. (a) **Attempt any one: -**
- (i) Draw the energy band diagram of an unbiased p - n junction. Derive the Einstein equation  $D_p/\mu_p = kT/e$ , where symbols have their usual meaning. 10
- (ii) Explain Meissner effect in superconductors. Hence discuss Type I and Type II superconductors. 10
- (b) **Attempt any one: -**
- (i) State and explain law of junction in semiconductors. 5
- (ii) A superconductor tin has a critical temperature of 1.9 K in zero magnetic field and a critical field of 0.037 Tesla at 0 K. Find the critical field at 1K. 5
5. **Attempt any Five: -**
- (i) Copper has fcc structure and its atomic radius is 0.1178 nm. Calculate its density. Take the atomic weight of copper as 63.5. 3
- (ii) The Miller Indices of a plane in a simple cubic lattice crystal are (1 2 3). Get the coordinates of the plane and sketch it. 3
- (iii) The Fermi energy of silver is 5.51 eV. Calculate the Fermi velocity ( $v_F$ ) of the electrons in silver. 3
- (iv) Calculate the probability that an allowed state occupied by an electron lies above the Fermi level by 1 eV. 3
- (v) An electric field of 50 V/m is applied to a sample of n-type semiconductor with carrier density  $5.0 \times 10^{20} /m^3$ . Determine the current density in the sample, assuming  $\mu_n = 0.40 m^2/ VS$ . 3
- (vi) If Hall coefficient of n-type semiconductor a sample is  $- 0.0125m^3 /C$ . Determine the carrier density in the sample. 3
- (vii) A superconductor tin has a critical temperature of 2.8 K in zero magnetic field and a critical field of 0.041 Tesla at 0 K. Find the critical field at 1K. 3
- (viii) A germanium p-n junction has reverse saturation current,  $I_0 = 2 \mu A$  at  $27^\circ C$ . Find its static resistance for an applied forward bias of 0.2 V at  $27^\circ C$ . 3
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