

Department of Physics, IIT Tirupati  
Written Exam: Junior Technician, 2023

Max. Marks: 50

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Instructions:

1. Write your "Name and Application number" on the first page of the answer sheet.
  2. Clearly mention the answer number.
  3. Each question carries 1 mark.
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1. Which one of the following vectors is perpendicular to the vector (1,-2,0).  
(a) (2,0,1) (b) (-1,1,0) (c) (2,1,1) (d) (3,1,2)
2. Let  $f(x,y) = 2x^3 - y^3$ . The curve along which  $\nabla^2 f(x,y) = 0$  is  
(a)  $2x = -y$  (b)  $2x = y$  (c)  $3x = y$  (d)  $6x = -y$
3. If  $\det(A) = 0$  where  $A = \begin{bmatrix} 4 & x \\ 6 & 9 \end{bmatrix}$  then which of the following statements is correct?  
(a) A is non-symmetric (b) A is non-singular (c) A is orthogonal (d) A is symmetric.
4. Consider two eigenvectors corresponding to two non-equal eigenvalues of a symmetric matrix. Which of the following statements is correct?  
(a) Two eigenvectors are orthogonal.  
(b) Two eigenvectors are non-orthogonal.  
(c) One eigenvector is constant multiple of the other eigenvector.  
(d) The difference between the two eigenvectors is also an eigenvector of the symmetric matrix.
5. If A and B are two different unitary matrices of the same order, then the value of  $\det(AB)$  is  
(a) 1 (b) -1 (c) 1 or -1 (d) any real number.

6. Which of the following does not obey the superposition principle?

- (a) Electrostatic force      (b) Electric field      (c) Electrostatic potential  
(d) Electrostatic energy

7. When an electric field goes through a surface with a finite surface charge density, then the normal/perpendicular component of the electric field is

- (a) Discontinuous      (b) Continuous  
(c) Discontinuous with some particular condition      (d) None of the above

8. Electromagnetic waves ( $E$  and  $B$ ) are transverse.

- (a) True    (b) False    (c) Cannot say exactly    (d) None of these choices

9. Electromagnetic waves ( $E$  and  $B$ ) have the same direction of polarization.

- (a) True    (b) False    (c) Cannot say exactly    (d) None of these choices

10. Continuity equation magnetostatics refers to

- (a) Energy conservation      (b) Charge conservation  
(c) Momentum conservation      (d) None of these choices

11. The conservative force is

- (a) Path dependent       (b) Path independent  
(c) Dissipative      (d) Velocity dependent

12. A thermally insulated ideal gas of volume  $V_1$  and temperature  $T$  expands to another enclosure of volume  $V_2$  through a porous plug. What is the change in the temperature of the gas?

- (a) 0
- (b)  $T \ln(V_1/V_2)$
- (c)  $T \ln(V_2/V_1)$
- (d)  $T \ln(V_2 - V_1/V_2)$

13. The induced electro-motive force is due to

- (a) the constant electric field
- (b) the time-varying electric field
- (c) the constant magnetic field
- (d) the time-varying magnetic field

14. Consider a particle with three possible spin states:  $s = 0, \pm 1$ . There is a magnetic field  $H$  present and the energy for a spin state  $s$  is  $-Hs$ . The system is at a temperature  $T$ . Which of the following statements is true about the entropy  $S(T)$  ?

- (a)  $S(T) = \ln 3$  at  $T=0$ , and 3 at high  $T$
- (b)  $S(T) = 0$  at  $T=0$ , and  $\ln 3$  at high  $T$
- (c)  $S(T) = 0$  at  $T=0$ , and 3 at high  $T$
- (d)  $S(T) = \ln 3$  at  $T=0$ , and 0 at high  $T$

15. An ideal gas has a specific heat ratio  $C_p/C_v = 2$ . Starting at a temperature,  $T_1$  the gas undergoes an isothermal compression to increase its density by a factor of two. After this, adiabatic compression increases its pressure by a factor of two. The temperature of the gas at the end of the second process would be

- (a)  $T_1/2$
- (b)  $\sqrt{2} T_1$
- (c)  $2T_1$
- (d)  $T_1/\sqrt{2}$

16. Consider a point particle of mass 10 g hung from the roof with a massless inextensible rod of length 50 cm. If the particle is displaced horizontally by a distance of 1 cm and left free to move, it will undergo an oscillation. What is the time period of the oscillation? The approximate acceleration due to gravity is  $10 \text{ m/s}^2$ .

- (a) 1.4 s      (b) 14 s      (c) 2.8 s      (d) 28 s

17. The dispersion relation for a medium is given as  $\omega^2 = Ak$ , where  $A$  is some constant. What is the phase velocity of the wave propagating through the medium?

- (a)  $A/\sqrt{k}$       (b)  $\sqrt{A/k}$   
(c)  $A / (2\sqrt{k})$       (d)  $\sqrt{A/(2k)}$

18. Which of the following statements is true about an elliptically polarized light in the  $xy$  plane?

- (a)  $x$  and  $y$  components have equal amplitudes and in phase  
(b)  $x$  and  $y$  components have unequal amplitudes and in phase  
(c)  $x$  and  $y$  components have equal amplitudes and have  $\pi/2$  phase differences.  
(d)  $x$  and  $y$  components have unequal amplitudes and have  $\pi/2$  phase differences.

19. A person running at 3 m/s approaches a car moving at 15 m/s. If the car produces a horn at 500Hz, what frequency does the runner hear?

- (a) 500 Hz      (b) 527 Hz      (c) 483 Hz      (d) 518 Hz

20) Consider a single slit (far field) diffraction experiment in which an incident radiation at wavelength 550 nm produces its second diffraction minima at 45 degrees with respect to the incident direction. What is its slit width?

- (a) 1.56 micrometer    (b) 0.73 micrometer    (c) 4.68 micrometer    (d) None of the above

21. The time period of rotation of Foucault's pendulum's plane of oscillation on Earth's equator is

- (a) 24 hr      (b) 12 hr      (c) 0      (d) infinite

22. Can a mass in a circular orbit under a central potential have infinite speed at any instant?

- (a) No      (b) Yes      (c) Insufficient information      (d) None of the above

23. Which one of the following will *not* lead to a closed orbit when the central potential is of the type  $V(r) = kr^n$  ?

- (a)  $n = 2$       (b)  $n = -1$       (c)  $n = 4$       (d) None of these options

24. A point particle of mass  $m$  is moving on the surface of a 3-dimensional sphere of radius  $R$ . How many degrees of freedom does the particle have?

- (a) 3      (b) 2      (c) 1      (d) 0

25. "The gradient of a scalar function is a scalar." Is this statement

- (a) False      (b) True      (c) Insufficient information      (d) None of the above

26. Which of the following is *not* an example of a systematic error?

- a. Instrumental errors
- b. Personal errors
- c. Errors due to imperfection in experimental technique or procedure
- d. Random errors

27. The SI unit of energy is  $J = \text{kg m}^2 \text{s}^{-2}$ ; that of speed  $v$  is  $\text{ms}^{-1}$ , and of acceleration  $a$  is  $\text{ms}^{-2}$ . Which of the formulae for kinetic energy (K) given below can you rule out on the basis of dimensional arguments (m stands for the mass of the body) :

(a)  $K = m^2 v^3$

✓ (b)  $K = (1/2) m v^2$

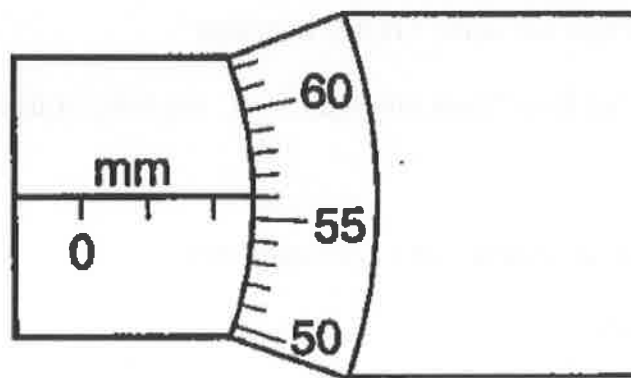
(c)  $K = m a$

(d)  $K = (3/16) m v^2$

28. Two slits are made one millimeter (1mm) apart and the screen is placed one meter (1m) away. What is the fringe separation when blue-green light of wavelength 500 nm is used?

- a. 0.1 mm
- b. 0.2 mm
- c. 0.3 mm
- d. 0.5 mm

29. While measuring the diameter of a wire, a screw gauge with a pitch of 0.1 cm and a least count of 0.001 cm records the following reading as shown in the figure below:



Choose the correct option for the diameter of the wire as measured by the screw gauge. Assume that the screw gauge is free from zero error.

- (a) 0.256 cm      (b) 0.216 mm      (c) 0.206 mm      (d) 0.266 mm

30. Which color has the maximum deviation in the dispersion of white light through a glass prism?

- (a) Green      (b) Red      (c) Violet      (d) Orange

31 The frequency  $\omega$  of magnon dispersion in a three-dimensional magnetic system at a long wavelength limit is proportional to  $k^2$ . The magnetic component of heat capacity divided by temperature  $C_m(T)/T$  is proportional to  $T^\alpha$ . The value of  $\alpha$  is

- (a) zero      (b) 1/2      (c) 1      (d) 2

32 The radius of the Fermi sphere of a simple cubic lattice with free electrons is proportional to

- (a) The lattice constant of the unit cell  
(b) The volume of the unit cell  
(c) The inverse of the lattice constant  
(d) The inverse of carrier concentration

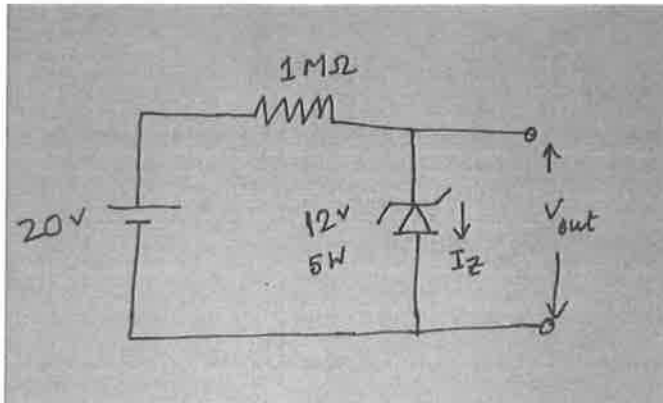
33 If the magnitude of the wavelength of the x-ray is equal to the lattice constant ' $a$ ' of a simple cubic system, the Bragg angle ' $\theta$ ' (in degrees) for the diffracted x-ray beam from the (1 1 1) plane is

- (a) 15      (b) 45      (c) 60      (d) 90

34 The magnetic susceptibility of pure metal is proportional to

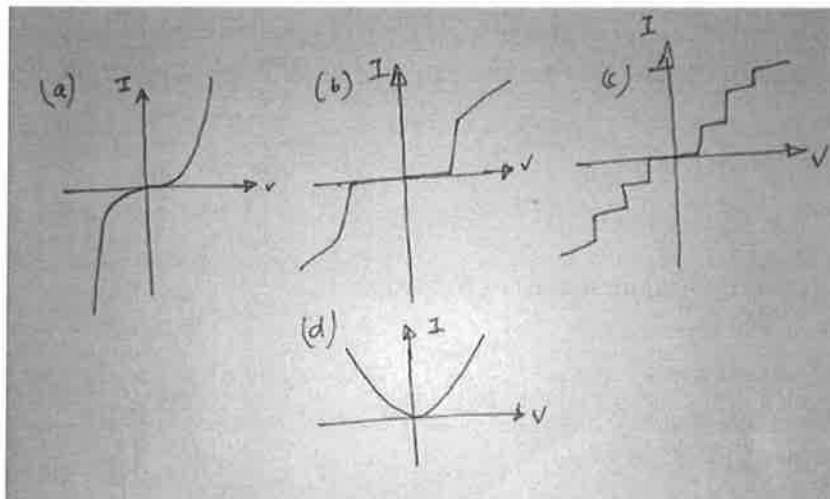
- (a) Independent of temperature  
(b) +1 and temperature dependent  
(c) -1 and temperature-independent  
(d) Zero

35. Calculate  $V_{out}$  and  $I_z$  in the given circuit below:



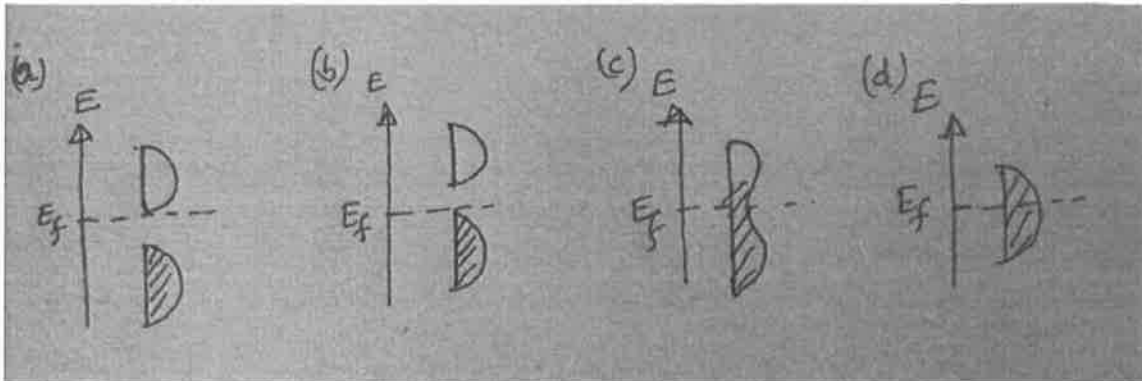
- (a) 20 V and 12 mA
- (b) 12 V and  $8\ \mu\text{A}$
- (c) 15.2 V and 10 mA
- (d) 8.2 V and  $15\ \mu\text{A}$

36 Which of the following describes the IV characteristics of a p-n Junction diode?

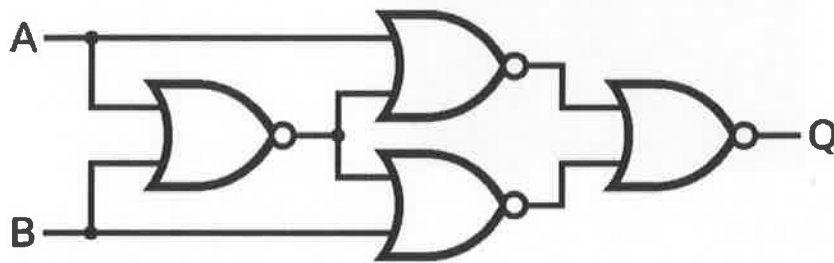




37. Which of the following is the correct band diagram of a *n*-type semiconductor?

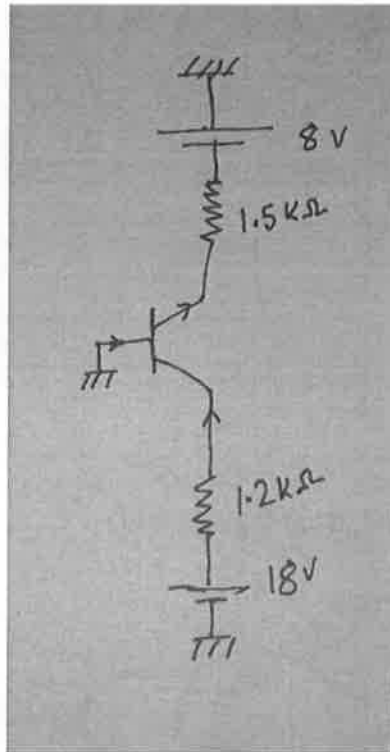


38. What is the output Q of the following logic circuit?



- (a)  $A+B$
- (b)  $(A\oplus B)$
- (c)  $A\odot B$
- (d)  $\bar{A}\cdot\bar{B}$

39. Calculate the  $I_C$  and  $V_{CB}$  of the following circuit.



- (a) 10.2 mA and 15.16 V
- (b) 4.9 mA and 12.2 V
- (c) 3.5 mA and 11.5 V
- (d) 14.2 mA and 8.2 V

40. The binding energy for a Cooper pair for a superconductor is

- a.  $10^{-1}$  eV
- b.  $10^{-4}$  eV
- c.  $10^{-7}$  eV
- d.  $10^{-9}$  eV

41. Which of the following is not a fundamental force of nature

- (a) Electromagnetic force
- (b) Friction Force
- (c) Gravitational Force
- (d) Strong interaction force

42. The photoelectric effect can be explained by assuming the following nature of light

- (a) Particle Nature
- (b) Wave Nature
- (c) Standing wave-like nature
- (d) None of the above

43. The normal Zeeman effect is observed in the presence of external

- (a) Electric field
- (b) Polarization light
- (c) Magnetic field
- (d) Ultraviolet light

44. Which of the color components of sunlight scatter the highest by the earth's atmosphere

- (a) Blue
- (b) Red
- (c) Violet
- (d) Green

45. The divergence of an electric field is a

- (a) Vector quantity
- (b) Scalar quantity
- (c) Always zero
- (d) None of the above

46. The two-dimensional quantum isotropic harmonic oscillator's first excited state is

- (a) Non-degenerate
- (b) Degenerate
- (c) Continuous energy levels
- (d) None of the above

47. In inelastic collisions between two non-similar masses, the following quantity remains conserved

- (a) Energy
- (b) Momentum
- (c) Both Energy and Momentum
- (d) Velocity

48. In an adiabatic process, which of the following quantities remains conserved

- (a) Entropy
- (b) Internal energy
- (c) Both Entropy and internal energy
- (d) None of the above

49. For a classical ideal gas, which of the following speeds will be highest

- (a) Root mean square speed
- (b) Average speed
- (c) Most probable speed
- (d) None of the above

50. According to the special theory of relativity, the speed of a massive particle

- (a) will always be lower than the speed of a Photon
- (b) will always be greater than the speed of a Photon
- (c) will be equal to the speed of a photon
- (d) None of the above