భారతీయ సాంకేతిక విజ్ఞాన సంస్థ హైదరాబాద్
भारतीय प्रौद्योगिकी संस्थान हैदराबाद
Indian Institute of Technology Hyderabad

Advt. No. IITH/2023/NF/15

Question Paper Code:

Application Number of the Candidate

Name of the Post: Junior Technician – Civil Engineering (Structural Engineering)
Pay Level: 03

Date & Time of the Exam: 11.12.2023 **Duration: 02 hr. 00 min**

Scheme of the Exam:

Topic	Number of Questions	Marks
Engineering Mathematics (Common for JT in Geotechnical and Structural Engineering and will be used as a tie breaker for the selection)	10	10
Electrical and Electronics	55	55
Total	**65**	**65**

Instructions to fill the responses in the OMR answer sheet:

1. Candidate must write his/her **application number** in the designated box on the top of OMR answer sheet.
2. Candidates must write the post code and Question paper code in the designated boxes on the top of OMR answer sheet.
3. Candidates must sign in the box provided in the OMR answer sheet.
4. Each answer sheet must be signed by the invigilator in the space printed in the OMR answer sheet.
5. Only one response to be selected & marked. In case more than one response is marked for a single question or no response is marked for a question, no marks will be awarded for that question.
6. Partially filled circles shall not be considered as responses.
7. Erasing or changing of answer is not allowed.
8. No negative marking
9. Candidate must use Blue/Black ball point pen to fill his/her responses.
10. Rough work should not be done on the OMR answer sheet.
11. Candidates can use the designated page(s) of the question booklet for the purpose of rough work.

Engineering Mathematics

1. Find the determinant of the matrix: $\begin{bmatrix} 3 & 1 & 2 \\ 2 & 4 & 5 \\ 1 & 6 & 4 \end{bmatrix}$

   a. 42
   b. 36
   c. 28
   d. 14

2. Evaluate the limit: $\lim_{x \to 0} \frac{\sin(3x)}{x}$

   a. 1
   b. 2
   c. 3
   d. Does not exist

3. Let 'x' be a continuous variable defined over the interval $(-\infty, \infty)$, and $f(x) = e^{-x-e^{-x}}$.

   The integral $g(x) = \int f(x)\,dx$ is equal to

   a. $e^{e^{-x}}$
   b. $e^{-e^{-x}}$
   c. $e^{-e^{x}}$
   d. e^{-x}

4. Given the matrices J = $\begin{pmatrix} 3 & 2 & 1 \\ 2 & 4 & 2 \\ 1 & 2 & 6 \end{pmatrix}$ and K = $\begin{pmatrix} 1 \\ 2 \\ -1 \end{pmatrix}$, the product $K^T JK$ is

   a. 20
   b. 24
   c. 22
   d. 23

5. The sum of Eigen values of the matrix, [M] is…? where [M] = $\begin{pmatrix} 215 & 650 & 795 \\ 655 & 150 & 835 \\ 485 & 355 & 550 \end{pmatrix}$

   a. 915
   b. 1355
   c. 1640
   d. 2180

6. If $y = 5x^2 + 3$, then the tangent at $x = 0, y = 3$

   a. passes through $x = 0, y = 0$
   b. has a slope of +1
   c. is parallel to the x-axis
   d. has a slope of -1

7. A two-faced fair coin has its faces designated as head (H) and tail (T). This coin is tossed three times in succession to record the following outcomes: H, H, H. If the coin is tossed one more time, the probability (up to one decimal place) of obtaining H again, given the previous realizations of H, H and H, would be:
   a. 1 to 0.5
   b. 1 to 1
   c. 0.5 to 0.5
   d. 0.5 to 1

8. Solve the first-order linear ODE: $\frac{dy}{dx} + 2y = 4$
   a. $y = Ce^{2x} + 2$
   b. $y = Ce^{2x} - 2$
   c. $y = Ce^{-2x} + 2$
   d. $y = -Ce^{-2x} + 2$

9. Apply the Newton-Raphson method to find the root of $g(x) = e^{x} - 4x$ with initial guess of $x_o = 1.0$. The next iteration will yield:
   a. 1.0
   b. 1.5
   c. 2.0
   d. 2.5

10. The number of parameters in the univariate exponential and gaussian distributions, respectively are:
   a. 2 and 2
   b. 1 and 2
   c. 2 and 1
   d. 1 and 1

11. Following Boolean expression represents

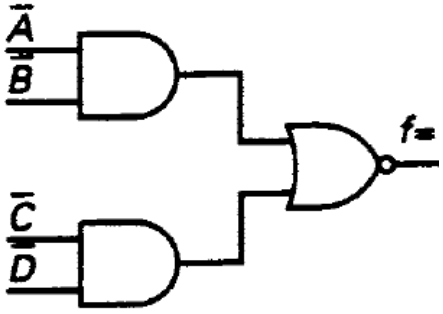
$$\boldsymbol{F = \overline{\overline{(A.B)}.A} \,.\, \overline{\overline{(A.B)}.B}}$$

(a) XNOR gate
(b) OR gate
(c) XOR gate
(d) NOR gate

12. The standard SOP format F(A,B,C,D) = ∑ m(9, 11, 13, 14, 15) into Boolean expression is
(a) A.B.D + A.C
(b) B.C.D + A.C + A.B.D
(c) A.B + B.C.D
(d) A.B.C + A.D

13. Minimize the following function F(A,B,C,D)= ∑ m(1,2,3,5,6,7,10,11)
(a) $\overline{A} + B\overline{D} +$ B$\overline{C}$
(b) $\overline{B}\,C$+$\overline{A}$C +$\overline{A}D$
(c) $\overline{B}\,C$+$\overline{A}$C +$\overline{A}B$
(d) $\overline{A}\,D$+$\overline{A}$C +$B\overline{C}$

14. Find the 'f' from the below expressions

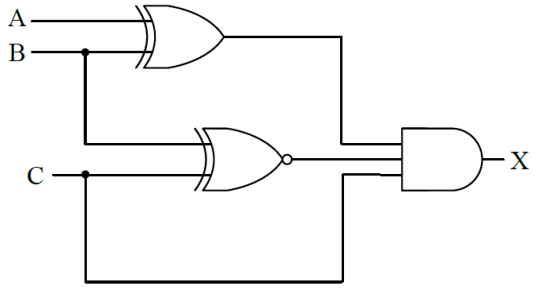


(a)(A+C)(B+D)
(b)(A+B)(C+D)
(c)(B+C)(A+D)
(d)(A+D)(C+D)

15. Boolean function Y= AB + CD is to be realized using only 2 input NAND gates. The minimum number of gates required is

(a) 2
(b) 3
(c) 4
(d) 5

16. For the logic circuit shown in the figure, the required input condition (A,B,C) to make the output X =1 is

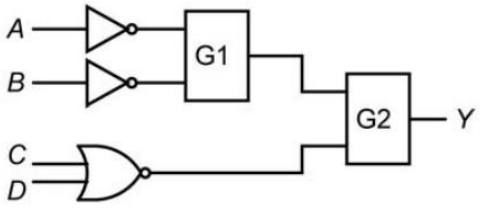


(a) 1, 0, 1
(b) 0, 0, 1
(c) 1, 1, 1
(d) 0, 1, 1

17. A 3-input majority gate is defined by the logic function M (a,b,c)= ab + bc + ca . Which one of the following gates is represented by the function M ($\overline{M(a,b,c)}$, M(a, b, $\overline{c}$),c) ?

(a) 3-input NAND gate
(b) 3-input XOR gate
(c) 3-input NOR gate
(d) 3-input XNOR gate

18. In the figure shown, the output Y is required to be Y = AB + $\overline{C}\,\overline{D}$ The gates G1 and G2 must be, respectively,

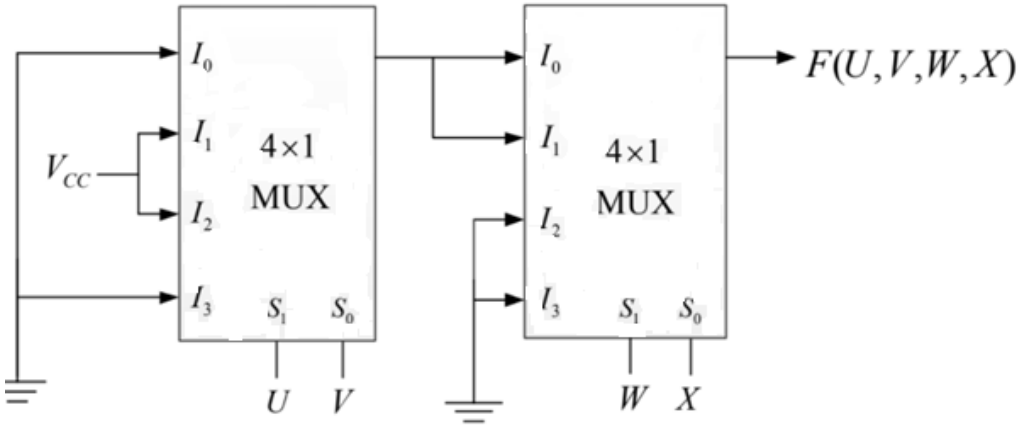


(a) NOR , OR
(b) OR, NAND
(c) NAND, OR
(d) AND, NAND

19. The product of sum expression of a Boolean function F(A, B, C) of three variables is given By
$F(A, B, C) = (A + B + \overline{C}) \cdot (A + \overline{B} + \overline{C}) \cdot (\overline{A} + B + C) \cdot (\overline{A} + \overline{B} + \overline{C})$
The canonical sum of product expression of F(A, B, C) is given by

(a) $\overline{A}\ \overline{B}\ C + \overline{A}\ B\ C + A\ \overline{B}\ \overline{C} + A\ B\ C$
(b) $\overline{A}\ \overline{B}\ \overline{C} + \overline{A}B\ \overline{C} + A\overline{B}\ C + A\ B\ \overline{C}$
(c) $A\ B\ \overline{C} + A\ \overline{B}\ \overline{C} + \overline{A}B\ C + \overline{A}\ \overline{B}\ \overline{C}$
(d) $\overline{A}\ \overline{B}\ \overline{C} + A\overline{B}\ C + A\ B\ \overline{C} + A\ B\ C$

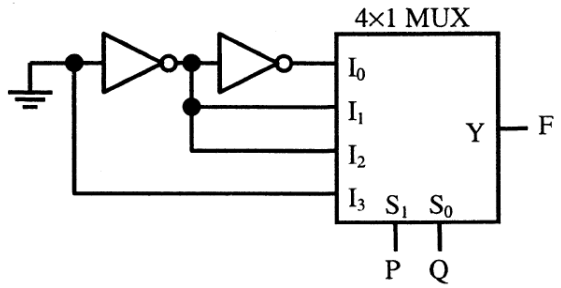
20. A four-variable Boolean function is realized using 4 :1 multiplexers as shown in the figure.



The minimized expression for F (U ,V, W, X) is

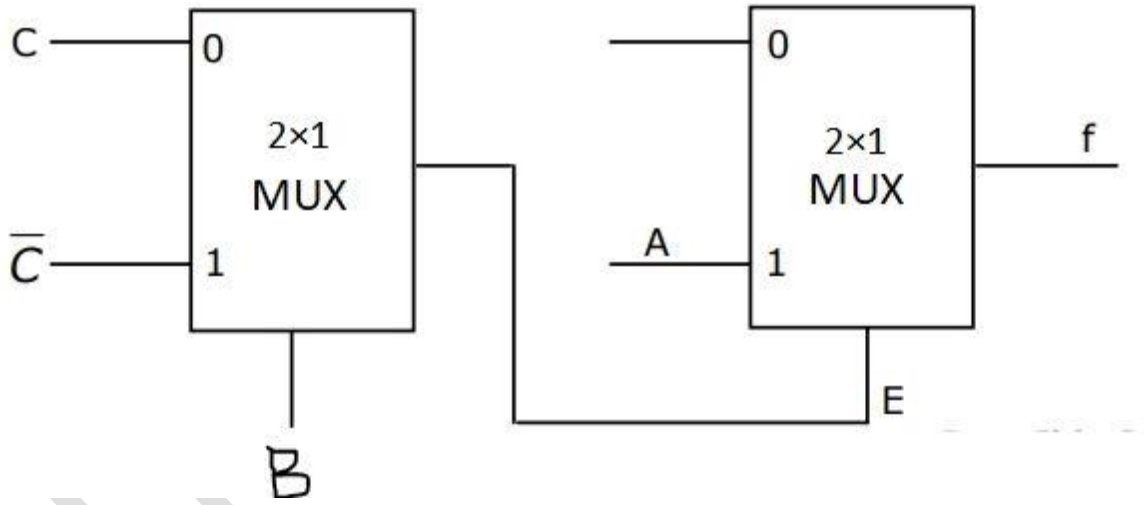
(a) (U V +$\overline{U}\ \overline{V}$) $\overline{W}$
(b) (U V +$\overline{U}\ \overline{V}$) ($\overline{W}\ \overline{X}$ +$\overline{W}$ X)
(c) (U $\overline{V}$ +$\overline{U}V$) $\overline{W}$
(d) (U $\overline{V}$ +$\overline{U}V$) ($\overline{W}\ \overline{X}$ +$\overline{W}$ X)

21. The logic function implemented by the circuit shown below is(ground implies a logic '0')



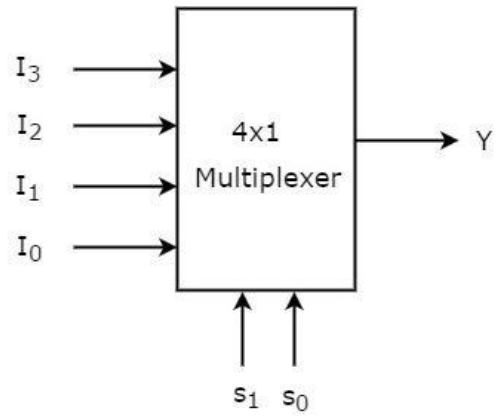
(a) AND(P,Q)
(b) XOR(P,Q)
(c) OR(P,Q)
(d) XNOR(P,Q)

22. The Boolean function f implemented in the figure using two input multiplexers is



(a)A$\overline{B}C$ +AB$\overline{C}$
(b) ABC +A$\overline{BC}$
(c)A$\overline{B}$ $\overline{C}$ +AB$\overline{C}$
(d) $\overline{ABC}$ +AB$\overline{C}$

23. A 4:1 multiplexer is to be used for generating the output carry of a full adder. S_0 and S_1 are the bits to be added while C_{in} is the input carry and Y is the output carry. $S_0$and S_1 are to be used as the select bits with S_1 being the more significant select bit.



Which one of the following statements correctly describes the choice of signals to be connected to the inputs I_0, I_1 I_2 I_3 (consider I_0 as first input) so that the output is Y?

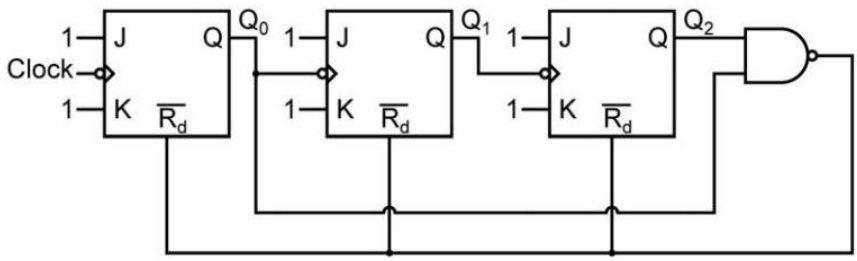
(a) I_0=0, $I_1 = C_{in}$, I_2 =C_{in}, I_3=1

(b) I_0=1, $I_1 = C_{in}$, I_2 =C_{in}, I_3=1

(c) $I_0 = C_{in}$,$I_1 = 0$, I_2 =C_{in}, I_3=1

(d) $I_0 = C_{in}$, I_1=1, I_2 =C_{in}, I_3=1

24. The circuit shown consists of J-K flip-flops, each with an active low asynchronous reset ($\overline{R_d}$ input). The counter corresponding to this circuit is



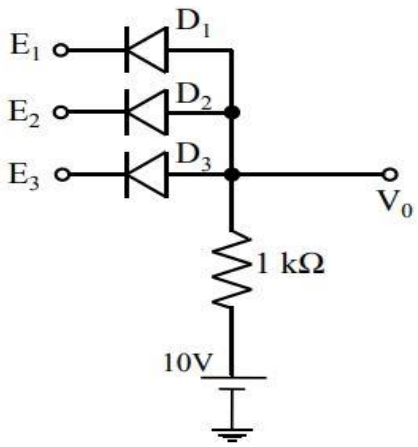
(a) a modulo-5 binary up counter

(b) a modulo-6 binary down counter

(c) a modulo-5 binary down counter

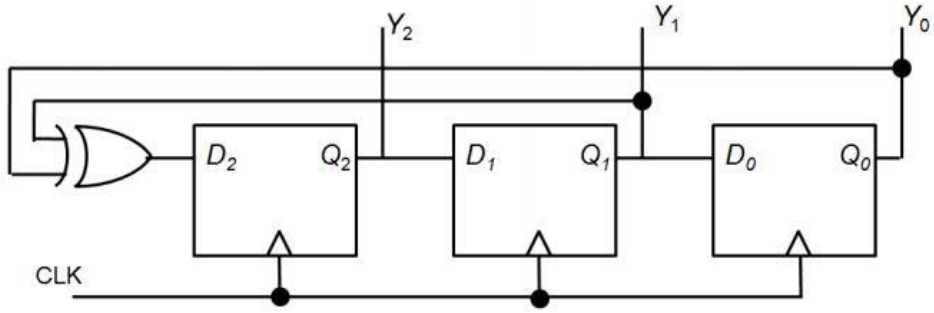
(d) a modulo-6 binary up counter

25. In the circuit shown, diodes D_1, D_2 and D_3 are ideal, and the inputs E_1, E_2 and E_3 are “0 V” for logic ‘0’ and “10 V” for logic ‘1’. What logic gate does the circuit represent?



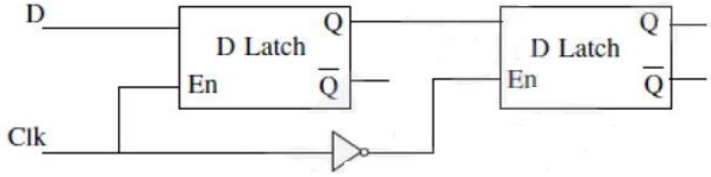
(a) 3-input OR gate
(b) 3-input NOR gate
(c) 3-input AND gate
(d) 3-input XOR gate

26. A three-bit pseudo random number generator is shown. Initially the value of output $Y \equiv Y_2\, Y_1\, Y_0$ is set to 111. The value of output Y after three clock cycles is



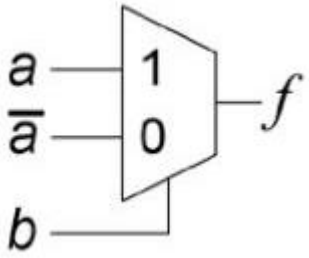
(a) 000
(b) 001
(c) 010
(d) 100

27. The circuit shown in the figure is a



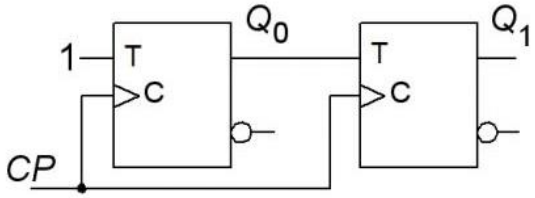
(a) Toggle Flip Flop
(b) JK Flip Flop
(c) SR Latch
(d) Master-Slave D Flip Flop

28. What logic function does this multiplexor circuit represent f(b,a)=?



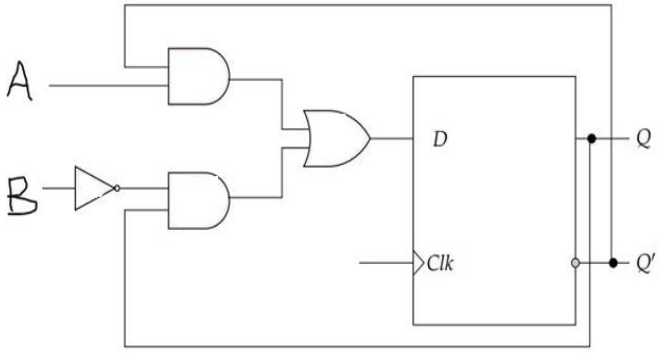
(a) NOR
(b) XNOR
(c) XOR
(d) NAND

29. A synchronous counter with T flip-flops in the figure starts in the state Q1Q0 = 00. Give its sequence of states for the following four clock pulses.



(a) $Q_1\ Q_0$: 00, 01, 10, 11, 00
(b) $Q_1\ Q_0$: 00, 01, 11, 10, 01
(c) $Q_1\ Q_0$: 00, 11, 10, 01, 00
(d) $Q_1\ Q_0$: 00, 10, 01, 11, 00

30. Below circuit represents



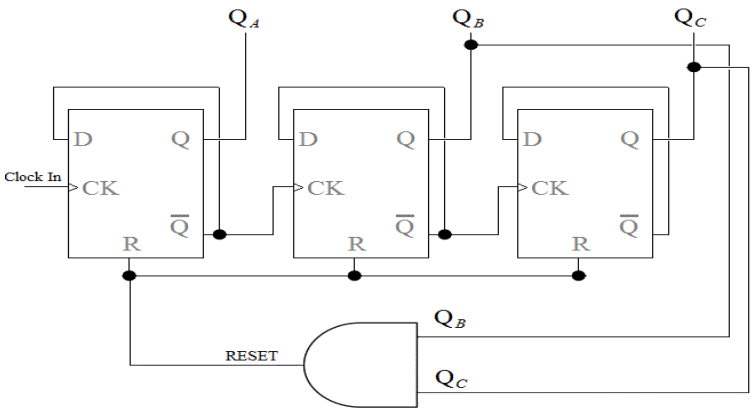
(a) T-flip flop
(b) S-R latch
(c) J-K flip flop
(d) Master slave D-flip flop

31. An N – type silicon is obtained by doping silicon with
    a) Germanium
    b) Aluminium
    c) Boron
    d) Phosphorus

32. How many natural states are there in a 6-bit ripple counter
    a) 6
    b) 16
    c) 32
    d) 64

33. Which flip flops serve to be the fundamental building blocks of counters?
    a) S-R flip flops
    b) J-K flip flops
    c) T flip flops
    d) D flip flops

34. The ripple counter shown in the figure below functions as



a) Mod-3 up counter
b) Mod-6 up counter
c) Mod-3 down counter
d) Mod-6 down counter

35. If a transistor is operating with both of its junctions forward biased, but with the collector base forward bias greater than the emitter base forward bias, then it is operating in the
    a) Forward active mode
    b) Forward saturation mode
    c) Reverse active mode
    d) Reverse saturation mode
36. The early effect in a bipolar junction transistor is caused by
    a) Large collector-base reverse bias
    b) Large emitter-base reverse bias
    c) Large collector-base forward bias
    d) Large emitter-base forward bias

37. Which of the following is correct about PN Junction:
    a) It conducts in the reverse direction only
    b) It conducts in the forward direction only
    c) It has low resistance in forward as well as reverse direction
    d) It has high resistance in forward as well as reverse direction

38. Avalanche breakdown in a diode occurs when
    a) Potential barrier becomes zero.
    b) Forward current exceeds certain threshold value.
    c) Reverse bias exceeds a certain threshold value.
    d) None of these

39. Fermi energy level for n-type extrinsic semiconductors lies
    a) At middle of the band gap
    b) Close to conduction band
    c) Close to valence band
    d) None of the above
40. Choose the correct statement
    a) MOSFET has a positive temperature co-efficient
    b) MOSFET has a high gate circuit impedance
    c) MOSFET is a voltage controlled device
    d) All of the above

41. For an electronic device, the peak single phase input sinusoidal voltage is A Volt with a frequency of 50 Hz. Then, the root mean square voltage is equal to

    a) A Volt
    b) 0.707 A Volt
    c) 2 A Volt
    d) 1.414 A Volt

42. The internal resistance of an ideal voltmeter used to measure actual potential difference across two points should be equal to

    a) Infinite
    b) Zero
    c) 1 Ohm
    d) 100 Ohm

43. For a DC machine the following loss is due to the armature being subjected to magnetic field reversal.

    a) Armature Copper Loss
    b) Shunt Field Copper Loss
    c) Series Field Copper Loss
    d) Hysteresis Loss

44. The Hall effect sensor (or simply Hall sensor) is a type of sensor which detects the presence and magnitude of

    a) Moisture
    b) Temperature
    c) Magnetic Field
    d) Pressure

45. The following device can be used to measure non-ionizing (heat) radiation

    a) Bolometer
    b) Radiation dosimeter
    c) Geiger counter
    d) Scintillators

46. The following proximity sensor sends and receive a pulse in the same device for detection

    a) Inductive
    b) Magnetic
    c) Ultrasonic
    d) Capacitive

47. The following modulation technique is more spectrally efficient

    a) QPSK
    b) Binary FSK
    c) 4 PAM
    d) 16 QAM

48. The IPv6 allows an address size of 16 byte. Given the traditional IPv4 contains an address size of 32 bits, the ratio of IP addresses supported by IPv6 to IPv4 is

    a) 2^16
    b) 2^32
    c) 2^96
    d) 2^128

49. For an M^{th} order PAM modulation scheme with maximum symbol amplitude A, the total probability of error is
    a) an increasing function with respect to both M and A
    b) a decreasing function with respect to both M and A
    c) an increasing function of M and decreasing function of A
    d) a decreasing function of M and increasing function of A

50. The Gaussian Minimum Shift Keying has been used as a modulation technique in
    a) 1G
    b) 2G
    c) 3G
    d) 4G

51. A telephone system received 60 calls per hour with an average call duration of 5 minutes. Then, the traffic volume is
    a) 5 erlang
    b) 6 erlang
    c) 60 erlang
    d) 300 erlang

52. The maximum number of bits/symbol that can be communicated by 1024 QAM are
    a) 7
    b) 8
    c) 9
    d) 10

53. The bit sequence 00 when Manchester coded becomes
    a) 0000
    b) 1100
    c) 0101
    d) 1111

54. Given Gray code symbols which of the following cannot be bit sequences mapped to neighboring symbols in a modulation scheme
    a) 11 and 10
    b) 10 and 01
    c) 00 and 10
    d) 00 and 01

55. Which of the following is a linear equalizer
    a) BCJR equalizer
    b) Turbo equalizer
    c) Viterbi equalizer
    d) ZF

56. Non-coherent detection can be used for the following modulation technique
    a) FSK
    b) PSK
    c) QAM
    d) Bi-orthogonal Signaling

57. The Nyquist condition for zero intersymbol interference of a bandlimited signal x(t) (with frequency domain representation of X(f)) with symbol duration T is
    a) X(f)=1 for f=0 and 0 for all other frequencies
    b) x(nT)=1 for n=0 and 0 otherwise
    c) X(f)=0 for f=0 and 1 for all other frequencies
    d) x(nT)=0 for n=0 and 1 otherwise

58. A complex Gaussian random process Z(t) is circular if
    a) its mean and autocorrelation function are periodic functions with the same period
    b) its mean is non zero constant
    c) it is proper and zero-mean
    e) its power spectral density is Gaussian

59. Consider a single carrier communication system that uses 64 QAM modulation with a symbol duration of 1 ms. Then the bit rate is equal to:
    (a) 1 Kbps
    (b) 6 Kbps
    (c) 64 Kbps
    (d) 128 Kbps

60. To reconstruct a one-dimensional signal from a set of samples, the minimum sampling rate for a signal with the frequency components from 10 Hz to 100 Hz
    (a) 10 Hz
    (b) 20 Hz
    (c) 100 Hz
    (d) 200 Hz

61. The Maximum hamming distance between any two codes in the code book {0000, 1010, 0101, 1001, 0110, 1111} is
    (a) 1
    (b) 2
    (c) 4
    (d) 6

62. Which of the following LINUX command is used for searching for a specific string in an output
    (a) grep
    (b) locate
    (c) mv
    (d) rmdir

63. Which of the following devices can be used to measure two or more electrical values (like voltage, current, resistance etc.)
    (a) ammeter
    (b) voltmeter
    (c) ohmmeter
    (d) multimeter

64. Which of the following is a wireless communication protocol
    (a) Ethernet
    (b) WLAN
    (c) Profibus
    (d) UART

65. Which of the following is NOT a command for package installation in LINUX
    (a) grep
    (b) yum
    (c) rpm
    (d) apt

Rough Work