NATIONAL INSTITUTE OF WIND ENERGY

Written test for the position of Assistant Director(Technical)

ROLL No. **OMR ANSWER SHEET No.** **QUESTION BOOKLET No.**

2081

Signature of Invigilator

Signature of the Candidate

Duration: 90 minutes (One and half hours) **Maximum Marks:100**

Please read the following instructions carefully:

General Instructions:

1. Total duration of examination is 90 minutes (1½ hours).
2. The maximum marks for the paper/written test is 100.
3. You will be provided a) One Question Booklet with two blank sheets for rough work and b) OMR sheet which is THE Answer Sheet.
4. All questions are objective type only.
5. Please check whether you have marked/entered details such as Roll Number, Question Booklet No. and OMR Sheet No. correctly both in the Question Booklet and Answer Sheet/OMR Sheet.
6. Select an answer for a multiple choice type question from the separate sheet provided. Only one answer is right.
7. Both, the Question Booklet and the Answer/OMR Sheet must be handed back to the invigilator before leaving the examination hall.

SEAL

Question Booklet specific instructions:

1. There are NINE sections:

SECTION No.	SUBJECT/TOPIC
I	Engineering Mathematics andSciences
II	Renewable Energy
III	Computer Science & Information Technology
IV	Electronics, & Communications Engineering
V	Mechanical Engineering
VI	Production Engineering
VII	Civil Engineering
VIII	Aeronautical Engineering
IX	Electrical Engineering

2. ***There are a total of 63 questions carrying 100 marks.*** The question paper consists of questions of multiple choice type. Multiple choice type questions will have four choices for the answer *with only one correct choice*.
3. **Section I (Engineering Mathematics and Sciences) and Section II (Renewable Energy) are compulsory.**
4. ***Attempt any one of the Sections III through IX.***
5. There are 30 questions carrying 50 marks in Section I (Engineering Mathematics and Sciences), which is compulsory. Questions 1 to 10 carry 1 mark each, and questions 11 –30 carry 2 marks each.

6. There are 11 questions carrying 15 marks in Section II (Renewable Energy), which is compulsory. Questions 31 to 37 carry 1 mark each and questions 38 to 41 carry 2 marks each.
7. Each of the other sections (Sections III through IX) contains 22 questions carrying 35 marks. Questions 42 - 50 carry 1 mark each and questions 51 - 63 carry 2 marks each.
8. Questions not answered will carry **no** mark. Wrong answers for multiple choice type questions will result in NEGATIVE marks. For every wrong answer, one-fourth (1/4 th) mark will be deducted.
9. Charts, graph sheets or tables, log tables and other electronic devices including Calculator, mobiles/cells, are NOT allowed in the examination hall.
10. Do the rough work in the blank sheets attached at the end with the question booklet provided.

SECTION No.	SUBJECT/TOPIC	No. of Questions	MARKS
I	Engineering Mathematics andSciences (COMPULSORY)	30 (Question No. 1 to 30)	50
II	Renewable Energy (COMPULSORY)	11(Question No. 31 to 41)	15
CHOSE ANY ONE SECTION FROM BELOW			
III	Computer Science & Information Technology	22(Question No. 42 to 63)	35
IV	Electronics, Electrical & Communications Engineering		
V	Mechanical Engineering		
VI	Production Engineering		
VII	Civil Engineering		
VIII	Aeronautical Engineering		
IX	Electrical Engineering		
	TOTAL	**63**	**100**

Answer Sheet/OMR SHEET specific instructions:

1. All entries in the correct circles must be made by BALL POINT PEN (Blue or Black) only.
2. Please check whether you have marked details such as Roll Number, Question Booklet No. and OMR Sheet No. correctly both in the Question Booklet and Answer Sheet/OMR Sheet.
3. ***Before you proceed further, shade the BOX provided in the OMR/Answer Sheet to choose the optional section (any one from Section-III to Section-IX) you have attempted. SINCE THE ANSWER SHEET IS AN OMR SHEET, IF YOU DO NOT SHADE THE OPTIONAL SECTION (FROM AMONG SECTION-III TO SECTION-IX) YOU HAVE CHOSEN, THE SECTION WILL NOT BE EVALUATED EVEN IF YOU HAVE ATTEMPTED.***
4. There is only one correct answer to each question.
5. Ensure your choice before shading/darkening.
6. Darken/shade only ONE answer for each question.
7. Circle should be darkened/shaded completely, so that the alphabet inside the circle is not visible.
8. For rough work, only the blank sheet provided at the end of the Question Booklet must be used.
9. Do not make any stray mark/fold/tear/wrinkle/spread ink on Answer Sheet.
10. In case you do not follow any of the above instructions, your Answer Sheet is liable to be rejected.
11. No replacement of OMR Sheet is possible.

SECTION I: ENGINEERING MATHEMATICS & SCIENCES (COMPULSORY)

Notation used:
P - pressure, V - volume, T - temperature, S - entropy, H - enthalpy, U - internal energy, A - Helmholtz free energy, Cp - specific heat capacity at constant pressure.
Specific properties are designated by lower case symbols.

Useful data:
Universal gas constant $R = 8.314$ kJ/(kmol.K) C_p of air = 1.005 kJ/(kg.K)
Ratio of ideal gas specific heats for air: $\gamma = 1.4$ Molecular mass of hydrogen: 2 kg/kmol

Questions 1 to 10 carry one mark each.

1 A company records heights of all employees. Let X and Y denote the errors in the average height of male and female employees respectively.
Assume that $XX \sim N\ (0, 4)$ and $YY \sim (0, 9)$ and they are independent. Then the distribution of $ZZ = (XX + YY)/2$ is

(A) (0, 6.5) (B) $N(0, 3.25)$ (C) $N(0, 2)$ (D) $N(0, 1)$

2 The volume of the solid obtained by revolving the curve $yy^2 = xx$, $0 \le xx \le 1$ around yy-axis is

(A) π (B) 2 (C) $\pi/2$ (D) $\pi/5$

3. Let f be a differentiable function, so that
$f'(0) = 0$, and
when $x < 0$ it is also true that $f'(x) < 0$, and
when $x > 0$ it is also true that $f'(x) > 0$.
What can you say about the point $(0, f(0))$?

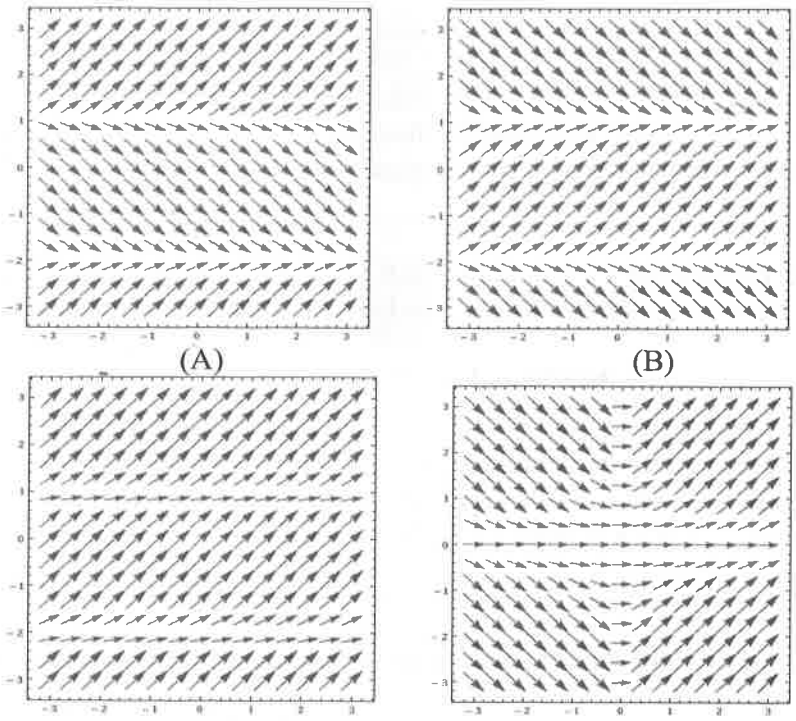
(A) Maxima (B) Asymptote (C) Minima (D) None of these

4 For a plane irrotational flow, equi-potential lines and streamlines are

(A) parallel to each other (B) at an angle of 90^0 to each other

(C) at an angle of 45^0 to each other (D) at an angle of 60^0 to each other

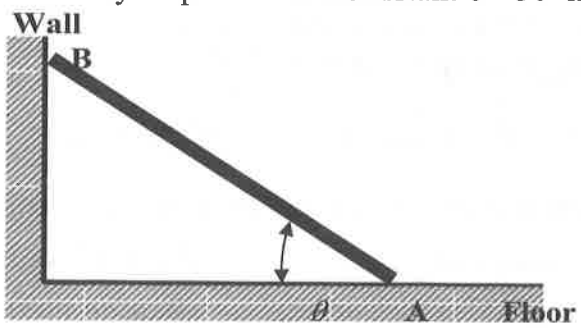
5. Which of the following could be a direction field for $\frac{dy}{dx} = (y-1)(y+2)$?



(A) (B)

(C) (D)

6. The lower end A of the rigid bar AB is moving horizontally on the floor towards right with a constant velocity of 5 m/s and the point B is sliding down the wall. The magnitude of the velocity of point B at the instant $\theta = 30°$ is



(A) zero (B) 4.34 m/s (C) 7.25 m/s (D) 8.66 m/s

7. Water vapour can be treated as an ideal gas,

(A) for all temperature and pressure
(B) for sufficiently low pressure, regardless of its temperature
(C) for very high pressure only
(D) for sufficiently low temperature, regardless of its pressure

8. Polyethylene and polypropylene form an immiscible blend mainly due to

(A) entropy factor (B) enthalpy factor
(C) crystallinity (D) solubility

9. If $\phi(x,y)$ is velocity potential and $\psi(x,y)$ is stream function for a 2-D, steady, incompressible and irrotational flow, which one of the followings is incorrect?

(A) $\left(\frac{dy}{dx}\right)_{\phi=\text{constant}} = -\frac{1}{\left(\frac{dy}{dx}\right)_{\psi=\text{constant}}}$ (B) $\frac{\partial^2\psi}{\partial x^2} + \frac{\partial^2\psi}{\partial y^2} = 0$

(C) $\left(\frac{dy}{dx}\right)_{\phi=\text{constant}} = \frac{1}{\left(\frac{dy}{dx}\right)_{\psi=\text{constant}}}$ (D) $\frac{\partial^2\phi}{\partial x^2} + \frac{\partial^2\phi}{\partial y^2} = 0$

10. A TV remote control works on the principle of

(A) pulse code modulated ultra violet light (B) pulse code modulated infrared light
(C) demodulation (D) either (A) or (B)

Questions 11 to 30 carry two marks each.

11 A diagnostic test for a certain disease is 90% accurate. That is, the probability of a person having (respectively, not having) the disease tested positive (respectively, negative) is 0.9. Fifty percent of the population has the disease. What is the probability that a randomly chosen person has the disease given that the person tested negative?

(A) 0.099: 0.101 (B) 0.09: 0.10 (C) 0.90 : 0.10 (D) 0.99: 0.10

12 Let $M = \begin{pmatrix} 1 & 1 \\ 0 & 1 \end{pmatrix}$, which of the following is correct?

(A) Rank of M is 1 and M is not diagonalizable
(B) Rank of M is 2 and M is diagonalizable
(C) 1 is the only eigenvalue and M is not diagonalizable
(D) 1 is the only eigenvalue and M is diagonalizable

13 Velocity field of a 2-D steady flow is provided as $\vec{V} = c(x^2 - y^2)\hat{i} - 2cxy\hat{j}$. The equation of the streamlines of this flow is

(A) $x^2y - y^2/3 = \text{constant}$ (B) $xy^2 - y^2/3 = \text{constant}$
(C) $xy - y/3 = \text{constant}$ (D) $x^2y = y^3/3 = \text{constant}$

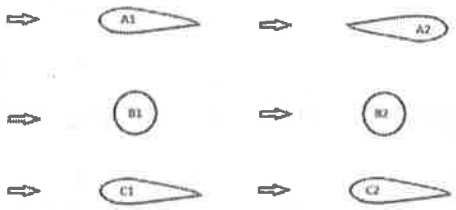
14 Prototype of a dam spillway (a structure used for controlled release of water from the dam) has characteristic length of 20m and characteristic velocity of 2m/s. A small model is constructed by keeping Froude number same for dynamic similarity between the prototype and the model. What is the minimum length-scale ratio between prototype and the model such that the minimum Reynolds' number for the model is 100? The density of water is 1000 kg/m^3 and viscosity is 10^{-3} Pa-s.

(A) 1.8×10^{-4} (B) 1×10^{-4} (C) 1.8×10^{-3} (D) 9.1×10^{-4}

15 Consider the following figures shown below. The objects are marked as A1, A2, B1, B2 and C1, C2 and the flow directions over these objects are shown by the respective arrow placed to the left of the object. Freestream velocities are same for all the cases. Amongst these objects, A1, A2, B1 and C1 are having smooth surfaces while B2 and C2 are having rough surfaces. Reynolds number is such that flow over rough surfaces become turbulent and flow over smooth surfaces

can be considered laminar. All the airfoils can be considered as thin slender airfoil. Among the statements (i) to (vi) made about the drag of these objects which is/are correct?

(i) Drag of object A1 is less than drag of object A2.
(ii) Drag of Object A1 and A2 are same.
(iii) Drag of Object B1 is more than drag of object B2.
(iv) Drag of object B2 is more than drag of object B1.
(v) Drag of Object C1 is more than drag of object C2.
(vi) Drag of object C2 is more than drag of object C1.



(A) (i),(iii) & (vi) (B) (ii),(iii) & (vi) (C) (i),(iii) & (v) (D) (i),(iv) & (vi)

16. Match the type of magnetism given in Group 1 with the material given in Group 2:

Group 1	Group 2
P: Ferromagnetic	1: Nickel oxide
Q: Ferrimagnetic	2: Sodium
R: Antiferromagnetic	3: Magnetite
S: Paramagnetic	4: Cobalt

(A) P-4, Q-3, R-1, S-2 (B) P-4, Q-1, R-3, S-2
(C) P-1, Q-2, R-4, S-3 (D) P-3, Q-2, R-1, S-4

17. Match the heat treatment process of steels given in Group 1 with the microstructural feature given in Group 2:

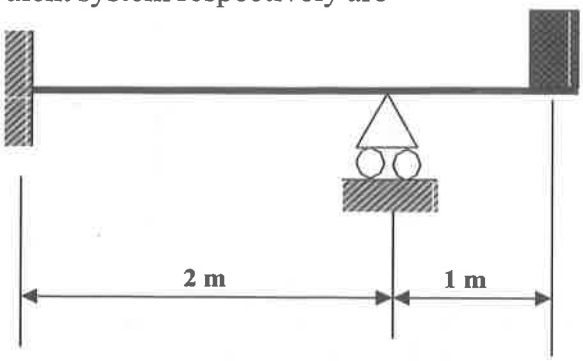
Group 1	Group 2
P: Quenching	1: Bainite
Q: Normalizing	2: Martensite
R: Tempering	3: Pearlite
S: Austempering	4: Iron carbide precipitates
	5: Intermetallic precipitates

(A) P-2, Q-3, R-4, S-1 (B) P-3, Q-4, R-5, S-1
(C) P-4, Q-1, R-5, S-3 (D) P-2, Q-5, R-4, S-3

18. In the photoelectric effect, electrons are ejected

(A) at all wavelengths, as long as the intensity of the incident radiation is above a threshold value.
(B) at all wavelengths, as long as the intensity of the incident radiation is below a threshold value.
(C) at all intensities, as long as the wavelength of the incident radiation is below a threshold value.
(D) at all intensities, as long as the wavelength of the incident radiation is above a threshold value.

19 The vibrating system shown in the figure carries a mass of 10 kg at the free end, where the static deflection is 1 mm. This system is to be replaced by an equivalent vibrating spring mass system having equivalent mass of 2kg (assume g =10 m/s^2). The natural frequency (in rad/s) and the stiffness (in kN/m) of the equivalent system respectively are

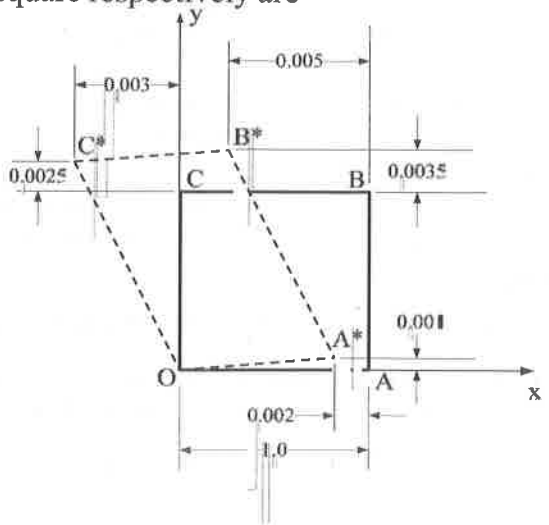


(A) 10 and 20 (B) 20 and 100 (C) 100 and 20 (D) 1000 and 20

20 A beam having flexural rigidity EI and length L is subjected to a concentrated end moment M_0 as shown in the figure. For $EI = 4\times10^3$ N-m^2, L =1m and M_0=8 kN-m, the strain energy stored (in kN-m) in the beam and the rotation (in rad) at the free end respectively are

(A) 8.00 and 0.02 (B) 8.00 and 2.00 (C) 8.00 and 0.04 (D) 0.80 and 2.00

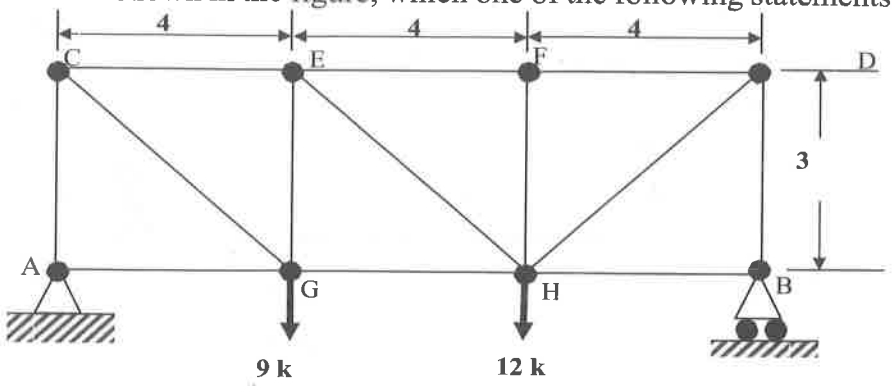
21 At a point 'O' on a metal sheet a square OABC of a unit side length is drawn. The square undergoes a small uniform elastic deformation and deforms to OA*B*C* (dashed lines) as shown in the figure. All dimensions are in mm and the figure is not to scale. The normal strains ε_x, ε_y and shear strain γ_{xy} developed in the square respectively are



(A) –0.0020,0.0025 and 0.0020 (B) 0.0020, – 0.0025 and – 0.0020

(C) 0.0025, – 0.0020 and 0.0020 (D) –0.0020, 0.0025 and – 0.0020

22. For the truss shown in the figure, which one of the following statements is true?



(A) AG is the only zero force member.
(B) AG and BH are the only two zero force members.
(C) AG, BH and HF are zero force members.
(D) AG, BH, HF and GC are zero force members.

23. Consider the following statements related to the second law of thermodynamics:

P. A cyclic heat engine cannot produce network by exchanging heat only with one reservoir.
Q. The efficiency of a reversible heat engine is dependent on the nature and amount of working substance undergoing the cycle.
R. It is impossible to have a cyclic device which will produce no effect other than the transfer of heat from a cold body to a hot body.
S. It is impossible to have heat engines operating between a heat source and sink to have a lower efficiency than that of a reversible heat engine operating between the same source and sink.

For which of the following options, BOTH the statements are inconsistent with the second law of thermodynamics:

(A) P and R (B) P and Q (C) R and S (D) Q and S

24. Consider the following statements related to air-standard Otto, Diesel, and Brayton cycles:

P. Brayton cycle has at least one isentropic and one isobaric process.
Q. Otto cycle has at least one isentropic and one isochoric process.
R. Diesel cycle has at least one isentropic and one isothermal process.
S. At least one of the cycles has an isothermal process.

For which of the following options, BOTH the statements are consistent with the operation of the above cycles:

(A) P and R (B) P and Q (C) R and S (D) P and S

25. For phase change from solid (sol) to liquid (liq) state, if the slope of the solid-liquid coexistence line in the P-T diagram is negative, then:

(A) $v_{liq} < v_{sol}$ (B) $v_{liq} > v_{sol}$ (C) $s_{liq} < s_{sol}$ (D) $h_{liq} < h_{sol}$

26. Match the processing technique to the appropriate product listed below:

Processing Technique	Product
P. Blow molding	1. Bucket
Q. Co-extrusion	2. Blister packaging
R. Injection molding	3. Bottles
S. Thermoforming	4. Multilayered sheets

(A) P-3; Q-4; R-2; S-1 (B) P-3; Q-1; R-4; S-2
(C) P-3; Q-4; R-1; S-2 (D) P-3; Q-2; R-1; S-4

27. Match the following polymer additives to their function:

Additive	Function
P. Azocarbonamide	1. Chemical plasticizer
Q. Antimony trioxide	2. Accelerator
R. Pentachlorothiophenol	3. Flame retardant
S. Mercaptobenzothiazole	4. Blowing agent

(A) P-4; Q-1; R-3; S-2 (B) P-4; Q-2; R-1; S-3
(C) P-4; Q-3; R-2; S-1 (D) P-4; Q-3; R-1; S-2

28. Dynamic mechanical analysis of polystyrene (Tg = 100 °C) measured at a frequency of 1 Hz shows the damping peak at 110 °C. If the measurement is made at 10^4 Hz, then the peak temperature (°C) will be

(A) 123.2 (B) 133.2 (C) 143.2 (D) 153.2

29. Match the elastomers listed below to the appropriate curing agent:

Elastomer	Curing Agent
P. Silicone rubber	1. Zinc oxide + ethylene thiourea
Q. Natural rubber	2. Diamine
R. Chloroprene rubber	3. Sulfur
S. Acrylate elastomer	4. Dicumyl peroxide

(A) P-4; Q-3; R-1; S-2 (B) P-3; Q-4; R-1; S-2
(C) P-4; Q-1; R-3; S-2 (D) P-2; Q-3; R-4; S-1

30. A computer program that converts assembly language to machine language is

(A) Compilers (B) Interpreter (C) Assembler (D) Comparator

END OF SECTION-I QUESTION PAPER

SECTION II: RENEWABLE ENERGY (COMPULSORY)

Questions 31 to 37 carry one mark each.

31. Which of the following countries contribute to maximum CO_2 emissions?

(A) China (B) USA (C) India (D) Brazil

32. Which of the following gases has highest Global Warming Potential?

(A) Carbon dioxide (B) Nitrogen (C) Oxygen (D) Methane

33. In India, the installed capacity of Renewable energy is:

(A) <5% (B) 5% -10% (C) 10% - 20% (D) >20%

34 Which of the following state has the highest roof-top solar installations in India:

(A) Gujarat (B) Tamilnadu (C) Andhra Pradesh (D) Rajasthan

35. The renewable energy target set by Government of India by 2022 is :

(A) 100GW (B) 50GW (C) 200GW (D) None of the above

36. Among the following renewable technologies, highest electrical efficiency is achieved in the following technology:

(A) Geothermal (B) Silicon Photovoltaics
(C) Solar Thermal (D) Concentrating Solar Thermal

37. Which of the following state has the highest solar installations in India currently:

(A) Gujarat (B) Delhi (C) Andhra Pradesh (D) Rajasthan

Questions 38 to 41 carry two marks each.

38 A horizontal solar panel generates 100 W of power when the sun is directly overhead. If the same panel is tilted 45 degrees facing the sun, the power output of the panel:

(A) reduces two times (B) reduces 0.707 times

(C) increases two times (D) does not change

39 Consider a solar thermal system operating between source temperature of 1000 K and sink temperature of 300 K. Assuming it has an electrical efficiency is 40% of Carnot efficiency, the efficiency of the system is:

(A) 28% (B) 70% (C) 50% (D) 32%

40 A cell phone consumes 1 Watt for its continuous operation. Assuming it is fitted with a 1 A-hr, Lithium-Ion battery, the cell phone can continuously run approximately for

(A) 10 hours (B) 2 hours (C) 6 hours (D) 4 hours

41 A scientist discovered a new phase change material that can store 10 MJ/Kg. The energy stored in 10 kg of phase change material can be used to run a 1 kW Air conditioning system operating at 20% system efficiency for:

(A) 3-4 hours (B) 2-3 hours (C) < 1 hour (D) 5-6 hours

END OF SECTION-II QUESTION PAPER

SECTION-III: COMPUTER SCIENCE & INFORMATION TECHNOLOGY

(PLEASE ENSURE THAT YOU HAVE SHADED THIS SELECTION IN THE OMR SHEET)

Questions 42 to 50 carry one mark each.

42. Consider the following C program.

```
void f(int, short);
void main()
{
        int i = 100;
        short s = 12;
        short *p =
        &s;
        _____;        // call to f()
}
```

Which one of the following expressions, when placed in the blank above, will **NOT** result in a type checking error?

(A) f(s,*s) (B) i = f(i,s) (C) f(i,*s) (D) f(i,*p)

43. Let a_n be the number of n-bit strings that do NOT contain two consecutive 1s. Which one of the following is the recurrence relation for a_n?

(A) $a_n = a_{n-1} + 2a_{n-2}$ (B) $a_n = a_{n-1} + a_{n-2}$

(C) $a_n = 2a_{n-1} + a_{n-2}$ (D) $a_n = 2a_{n-1} + 2a_{n-2}$

44. The worst case running times of *Insertion sort*, *Merge sort* and *Quick sort*, respectively, are:

(A) $\Theta(n \log n)$, $\Theta(n \log n)$, and $\Theta(n2)$

(B) $\Theta(n2)$, $\Theta(n2)$, and $\Theta(n \log n)$

(C) $\Theta(n2)$, $\Theta(n \log n)$, and $\Theta(n \log n)$

(D) $\Theta(n2)$, $\Theta(n \log n)$, and $\Theta(n2)$

45. Let G be a weighted connected undirected graph with distinct positive edge weights. If every edge weight is increased by the same value, then which of the following statements is/are TRUE?

P: Minimum spanning tree of G does not change
Q: Shortest path between any pair of vertices does not change

(A) P only (B) Q only (C)Neither P nor Q (D) Both P and Q

46. Which of the following languages is generated by the given grammar?

$$S \longrightarrow aS \mid bS \mid \varepsilon$$

(A) $\{a^n b^m \mid n, m \geq 0\}$ (B) $\{w \in \{a,b\}^* \mid w$ has equal number of a's and b's $\}$

(C) $\{a^n \mid n \geq 0\} \cup \{b^n \mid n \geq 0\} \cup \{a^n b^n \mid n \geq 0\}$ (D) $\{a,b\}^*$

47. Which of the following decision problems are undecidable?

I. Given NFAs $N1$ and $N2$, is $L(N1) \cap L(N2) = \Phi$?
II. Given a CFG $G = (N, \Sigma, P, S)$ and a string $x \in \Sigma*$, does $x \in L(G)$?
III. Given CFGs $G1$ and $G2$, is $L(G1) = L(G2)$?
IV. Given a TM M, is $L(M) = \Phi$?

(A) I and IV only (B) II and III only (C) III and IV only (D) II and IV only

48. Which one of the following regular expressions represents the language: *the set of all binary strings having two consecutive* 0*s and two consecutive* 1*s*?

(A) $(0+1)^*0011(0+1)^* + (0+1)^*1100(0+1)^*$

(B) $(0+1)^*(00(0+1)^*11 + 11(0+1)^*00)(0+1)^*$

(C) $(0+1)^*00(0+1)^* + (0+1)^*11(0+1)^*$

(D) $00(0+1)^*11 + 11(0+1)^*00$

49. Consider an arbitrary set of CPU-bound processes with unequal CPU burst lengths submitted at the same time to a computer system. Which one of the following process scheduling algorithms would minimize the average waiting time in the ready queue?

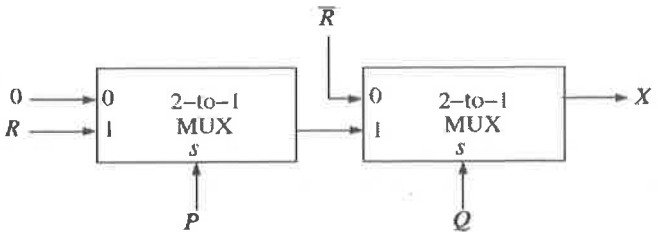
(A) Shortest remaining time first
(B) Round-robin with time quantum less than the shortest CPU burst
(C) Uniform random
(D) Highest priority first with priority proportional to CPU burst length

50. Which of the following is **NOT** a superkey in a relational schema with attributes V, W, X, Y, Z and primary key $V\ Y$?

(A) $VXYZ$ (B) $VWXZ$ (C) $VWXY$ (D) $VWXYZ$

Questions 51 to 63 carry two marks each.

51. Consider the two cascaded 2-to-1 multiplexers as shown in the figure.



The minimal sum of products form of the output X is

(A) $\bar{P}\,\bar{Q}$ +PQR (B) $\bar{P}Q$+QR (C) PQ+$\bar{P}\,\bar{Q}R$ (D) $\bar{Q}\,\bar{R}$ +PQR

52. Consider a carry lookahead adder for adding two n-bit integers, built using gates of fan-in at most two. The time to perform addition using this adder is

(A) $\Theta(1)$ (B) $\Theta(\log(n))$ (C) $\Theta(\sqrt{n})$ (D) $\Theta(n)$

53. The following function computes the maximum value contained in an integer array p[] of size n (n >= 1).

```
int max(int *p, int n) {
    int a=0, b=n-1;

    while (_____) {
        if (p[a] <= p[b]) { a = a+1; }
        else              { b = b-1; }
    }

    return p[a];
}
```

The missing loop condition is

(A) a != n (B) b != 0 (C) b > (a + 1) (D) b != a

54. What will be the output of the following C program?

```
void count(int
     n){ static
     int d=1;

     printf("%d ", n);
     printf("%d ",
     d); d++;
     if(n>1) count(n-1);
     printf("%d ", d);
}

void main(){
     count(3);
}
```

(A) 3 1 2 2 1 3 4 4 4 (B) 3 1 2 1 1 1 2 2 2 (C) 3 1 2 2 1 3 4 (D) 3 1 2 1 1 1 2

55. What will be the output of the following pseudo-code when parameters are passed by reference and dynamic scoping is assumed?

```
a=3;
void n(x) {x = x * a; print(x);}
void m(y) {a = 1; a = y - a; n(a);
print(a);} void main() {m(a);}
```

(A) 6, 2 (B) 6, 6 (C) 4, 2 (D) 4, 4

56. An operator `delete(i)` for a binary heap data structure is to be designed to delete the item in the i-th node. Assume that the heap is implemented in an array and i refers to the i-th index of the array. If the heap tree has depth d (number of edges on the path from the root to the farthest leaf), then what is the time complexity to re-fix the heap efficiently after the removal of the element?

(A) $O(1)$ (B) $O(d)$ but not $O(1)$ (C) $O(2^d)$ but not $O(d)$ (D) $O(d2^d)$ but not $O(2^d)$

57. G = (V, E) is an undirected simple graph in which each edge has a distinct weight, and e is a particular edge of G. Which of the following statements about the minimum spanning trees (MSTs) of G is/are TRUE?

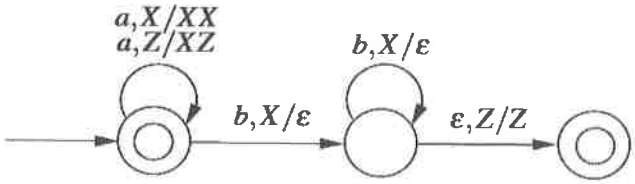
I. If e is the lightest edge of some cycle in G, then every MST of G includes e
II. If e is the heaviest edge of some cycle in G, then every MST of G excludes e

(A) I only (B) II only (C) both I and II (D) neither I nor II

58. Consider the following context-free grammars:
$G1$: $S \rightarrow aS|B,\ B \rightarrow b|bB$
$G2$: $S \rightarrow aA|bB,\ A \rightarrow aA|B|\varepsilon,\ B \rightarrow bB|\varepsilon$
Which one of the following pairs of languages is generated by $G1$ and $G2$, respectively?

(A) $\{ambn|m > 0 \text{ or } n > 0\}$ and $\{ambn|m > 0 \text{ and } n > 0\}$
(B) $\{ambn|m > 0 \text{ and } n > 0\}$ and $\{ambn|m > 0 \text{ or } n \geq 0\}$
(C) $\{ambn|m \geq 0 \text{ or } n > 0\}$ and $\{ambn|m > 0 \text{ and } n > 0\}$
(D) $\{ambn|m \geq 0 \text{ and } n > 0\}$ and $\{ambn|m > 0 \text{ or } n > 0\}$

59. Consider the transition diagram of a PDA given below with input alphabet $\Sigma = \{a, b\}$ and stack alphabet $\Gamma = \{X, Z\}$. Z is the initial stack symbol. Let L denote the language accepted by the PDA. Which one of the following is **TRUE**?



(A) $L = \{anbn|n \geq 0\}$ and is not accepted by any finite automata
(B) $L = \{an|n \geq 0\} \cup \{anbn|n \geq 0\}$ and is not accepted by any deterministic PDA
(C) L is not accepted by any Turing machine that halts on every input
(D) $L = \{an|n \geq 0\} \cup \{a^n b^n|n \geq 0\}$ and is deterministic context-free

60. Let X be a recursive language and Y be a recursively enumerable but not recursive language. Let W and Z be two languages such that Y reduces to W, and Z reduces to X (reduction means the standard many-one reduction). Which one of the following statements is TRUE?

(A) W can be recursively enumerable and Z is recursive.
(B) W can be recursive and Z is recursively enumerable.
(C) W is not recursively enumerable and Z is recursive.
(D) W is not recursively enumerable and Z is not recursive.

61. Consider the following Syntax Directed Translation Scheme (SDTS), with non-terminals {S, A} and terminals {**a**, **b**}.

S → **a**A {print 1}
S → **a** {print 2}
A → S**b** {print 3}

Using the above SDTS, the output printed by a bottom-up parser, for the input **aab** is:

(A) 1 3 2 (B) 2 2 3 (C) 2 3 1 (D) syntax error

62. Consider the following proposed solution for the critical section problem. There are n processes: $P0 \ldots Pn-1$. In the code, function `pmax` returns an integer not smaller than any of its arguments. For all i, `t[i]` is initialized to zero.

Code for P_i:

```
do {
c[i]=1; t[i] = pmax(t[0],...,t[n-1])+1; c[i]=0; for every j /= i in
{0,..,n-1} {
while (c[j]);
while (t[j] != 0 && t[j]<=t[i]);

}
Critical Section;
t[i]=0;
Remainder Section;
} while (true);
```

Which one of the following is **TRUE** about the above solution?

(A) At most one process can be in the critical section at any time
(B) The bounded wait condition is satisfied
(C) The progress condition is satisfied
(D) It cannot cause a deadlock

63. Consider the following two phase locking protocol. Suppose a transaction T accesses (for read or write operations), a certain set of objects $\{O_1, \ldots, O_k\}$. This is done in the following manner:

Step 1. T acquires exclusive locks to $O_1, \ldots, O_k$ in increasing order of their addresses.

Step 2. The required operations are performed.

Step 3. All locks are released.

This protocol will

(A) guarantee serializability and deadlock-freedom
(B) guarantee neither serializability nor deadlock-freedom
(C) guarantee serializability but not deadlock-freedom
(D) guarantee deadlock-freedom but not serializability

END OF SECTION-III QUESTION PAPER

SECTION IV ELECTRONICS AND COMMUNICATIONS ENGINEERING

(PLEASE ENSURE THAT YOU HAVE SHADED THIS SELECTION IN THE OMR SHEET)

Questions 42 to 50 Carry one mark each.

42. Which one of the following is a property of the solutions to the Laplace equation: $\nabla^2 f = 0$?

(A) The solutions have neither maxima nor minima anywhere except at the boundaries.
(B) The solutions are not separable in the coordinates.
(C) The solutions are not continuous.
(D) The solutions are not dependent on the boundary conditions.

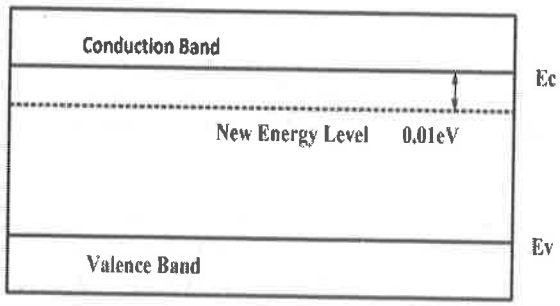
43. Which one of the following is an eigen function of the class of all continuous-time, linear, time-invariant systems ((t) denotes the unit-step function)?

(A) $e^{j\omega_0}(t)$ (B) $\cos(\omega_0 t)$
(C) $e^{j\omega_0 t}$ (D) $\sin(\omega_0 t)$

44. A continuous-time function $x(t)$ is periodic with period T. The function is sampled uniformly with a sampling period T_S. In which one of the following cases is the sampled signal periodic?

(A) $T = \sqrt{2}\, T_S$ (B) $T = 1.2\, T_S$ (C) Always (D) Never

45. A small percentage of impurity is added to an intrinsic semiconductor at 300 K. Which one of the following statements is true for the energy band diagram shown in the following figure?



(A) Intrinsic semiconductor doped with pentavalent atoms to form n-type semiconductor
(B) Intrinsic semiconductor doped with trivalent atoms to form n-type semiconductor
(C) Intrinsic semiconductor doped with pentavalent atoms to form p-type semiconductor
(D) Intrinsic semiconductor doped with trivalent atoms to form p-type semiconductor

46. Consider the following statements for a metal oxide semiconductor field effect transistor (MOSFET):

P: As channel length reduces, OFF-state current increases.
Q: As channel length reduces, output resistance increases.
R: As channel length reduces, threshold voltage remains constant.
S: As channel length reduces, ON current increases.

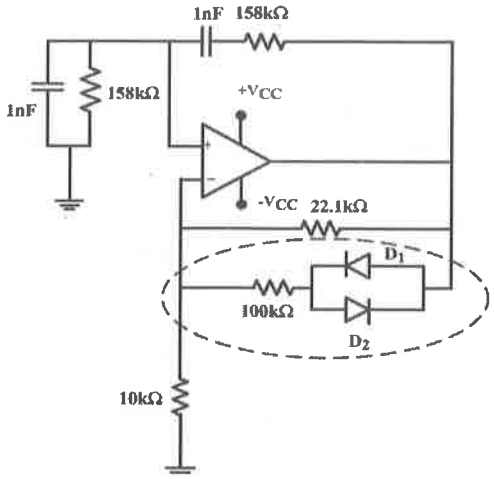
Which of the above statements are INCORRECT?

(A) P and Q (B) P and S (C) Q and R (D) R and S

47 Consider the signal $x(t) = \cos(6\pi t) + \sin(8\pi t)$, where t is in seconds. The Nyquist sampling rate (in samples/second) for the signal $y(t) = x(2t + 5)$ is

(A) 8 (B) 12 (C) 16 (D) 32

48. Consider the oscillator circuit shown in the figure. The function of the network (shown in dotted lines) consisting of the 100 kΩ resistor in series with the two diodes connected back-to-back is to:



(A) introduce amplitude stabilization by preventing the op amp from saturating and thus producing sinusoidal oscillations of fixed amplitude

(B) introduce amplitude stabilization by forcing the opamp to swing between positive and negative saturation and thus producing square wave oscillations of fixed amplitude

(C) introduce frequency stabilization by forcing the circuit to oscillate at a single frequency

(D) enable the loop gain to take on a value that produces square wave oscillations

49. In an 8085 system, a PUSH operation requires more clock cycles than a POP operation. Which one of the following options is the correct reason for this?

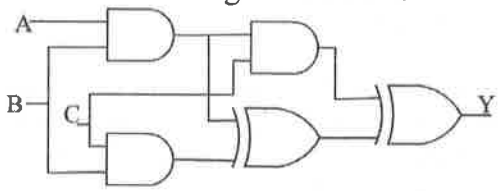
(A) For POP, the data transceivers remain in the same direction as for instruction fetch (memory to processor), whereas for PUSH their direction has to be reversed.

(B) Memory write operations are slower than memory read operations in an 8085 based system.

(C) The stack pointer needs to be pre-decremented before writing registers in a PUSH, whereas a POP operation uses the address already in the stack pointer.

(D) Order of registers has to be interchanged for a PUSH operation, whereas POP uses their natural order.

50. The output of the combinational circuit given below is



(A) A+B+C (B) A(B+C) (C) B(C+A) (D) C(A+B)

Questions 51 to 63 carry two marks each.

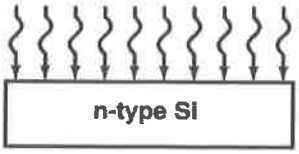
51. A first-order low-pass filter of time constant T is excited with different input signals (with zero initial conditions up to $t = 0$). Match the excitation signals X, Y, Z with the corresponding time responses for $t \geq 0$:

X: Impulse
Y: Unit step
Z: Ramp

P: $1 - e^{-t/T}$
Q: $t - T(1 - e^{-t/T})$
R: $e^{-t/T}$

(A) X→R, Y→Q, Z→P
(B) X→Q, Y→P, Z→R
(C) X→R, Y→P, Z→Q
(D) X→P, Y→R, Z→Q

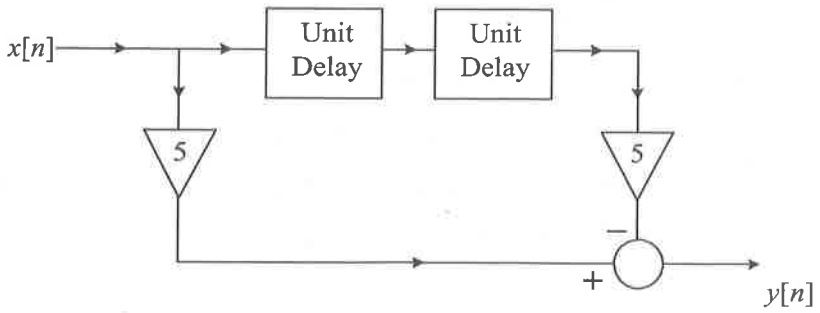
52. Consider a silicon sample at T = 300K, with a uniform donor density $N_d = 5\times10^{16}\ cm^{-3}$, illuminated uniformly such that the optical generation rate is $G_{opt} = 1.5\times10^{20}\ cm^{-3}\ s^{-1}$ throughout the sample. The incident radiation is turned off at $t = 0$. Assume low-level injection to be valid and ignore surface effects. The carrier lifetimes are $\tau_{p0} = 0.1\ \mu s$ and $\tau_{n0} = 0.5\ \mu s$.



The hole concentration at $t = 0$ and the hole concentration at $t = 0.3\ \mu s$, respectively, are

(A) $1.5 \times 10^{13}\ cm^{-3}$ and $7.47 \times 10^{11}\ cm^{-3}$
(B) $1.5 \times 10^{13}\ cm^{-3}$ and $8.23 \times 10^{11}\ cm^{-3}$
(C) $7.5 \times 10^{13}\ cm^{-3}$ and $3.73 \times 10^{11}\ cm^{-3}$
(D) $7.5 \times 10^{13}\ cm^{-3}$ and $4.12 \times 10^{11}\ cm^{-3}$

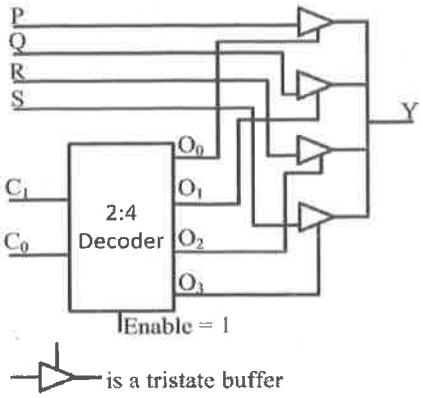
53 The direct form structure of an FIR (finite impulse response) filter is shown in the figure.



The filter can be used to approximate a

(A) low-pass filter
(B) high-pass filter
(C) band-pass filter
(D) band-stop filter

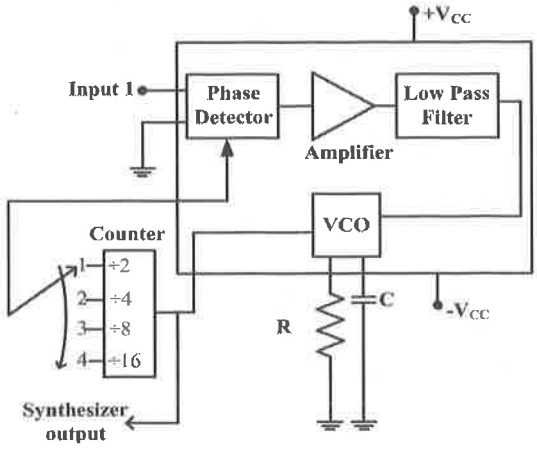
54. The functionality implemented by the circuit below is



(A) 2-to-1 multiplexer (B) 4-to-1 multiplexer

(C) 7-to-1 multiplexer (D) 6-to-1 multiplexer

55. The block diagram of a frequency synthesizer consisting of a Phase Locked Loop (PLL) and a divide-by-*N* counter (comprising ÷ 2, ÷ 4, ÷ 8, ÷ 16 outputs) is sketched below. The synthesizer is excited with a 5 kHz signal (Input 1). The free-running frequency of the PLL is set to 20 kHz. Assume that the commutator switch makes contacts repeatedly in the order 1-2-3-4.



The corresponding frequencies synthesized are:

(A) 10 kHz, 20 kHz, 40 kHz, 80 kHz

(B) 20 kHz, 40 kHz, 80 kHz, 160 kHz

(C) 80 kHz, 40 kHz, 20 kHz, 10 kHz

(D) 160 kHz, 80 kHz, 40 kHz, 20 kHz

56. The open-loop transfer function of a unity-feedback control system is

$$G(s) = K/(s^2 + 5s + 5)$$

The value of *K* at the breakaway point of the feedback control system's root-locus plot is

(A) 1.2:1.3; -1.3:-1.2 (B) 1.3:1.2; -1.3:-1.2 (C) -1.2:1.3; -1.3:1.2 (D) 1.2:1.3; -1.2:-1.3

57. The open-loop transfer function of a unity-feedback control system is given by

$$G(s) = K/\{s(s+2)\}$$

For the peak overshoot of the closed-loop system to a unit step input to be 10%, the value of K is

(A) 2.7:3.0 (B) 3.0:2.7 (C) 1.8:2.0 (D) 2.0:1.8

58. The transfer function of a linear time invariant system is given by $H(s) = 2s^4 - 5s^3 + 5s - 2$ The number of zeros in the right half of the s-plane is

(A) 3:3 (B) 2:2 (C) 3:2 (D) 4:4

59. Consider a unity feedback control system with open-loop transfer function $G(s) = \frac{K}{s(s+1)}$ The steady state error of the system due to a unity step input is:

(A) Zero (B) K (C) 1/K (D) infinite

60. Narrow band FM signal can be represented as

(A) $A \cos(2\pi f_c t) - \beta A \sin(2\pi f_c t) \sin(2\pi f_m t)$

(B) $A \cos(2\pi f_m t) - \beta A \sin(2\pi f_c t) \sin(2\pi f_m t)$

(C) $A \cos(2\pi f_c t) + \beta A \sin(2\pi f_c t) \sin(2\pi f_m t)$

(D) $A \cos(2\pi f_m t) + \beta A \sin(2\pi f_m t) \sin(2\pi f_c t)$

61. The Fourier series of a real periodic function has only

i) Cosine terms if it is even
ii) Sine terms if it is even
iii) Cosine terms if it is odd
iv) Sine terms if it is odd

Which of the above statements are correct?

(A) i) and iv) (B) i) and ii) (C) ii) and iv) (D) ii) and iii)

62. A communication channel with AWGN operating at a signal to noise ratio SNR >> 1 and bandwidth B has capacity C_1. If the SNR is doubled keeping B constant, the resulting capacity C_2 is given by

(A) $C_2 \approx 2C_1$ (B) $C_2 \approx C_1 + B$ (C) $C_2 \approx C_1 + 2B$ (D) $C_2 \approx C_1 + 0.3B$

63. The fourier transform of a double sided exponential function $e^{-\frac{1}{2}|t|}$ or $e^{-\frac{|t|}{2}}$ is

(A) $\frac{2}{1+4\omega^2}$ (B) $\frac{1+4\omega^2}{4}$ (C) $\frac{1+4\omega^2}{2}$ (D) $\frac{4}{1+4\omega^2}$

END OF SECTION-IV QUESTION PAPER

SECTION-V: MECHANICAL ENGINEERING

(PLEASE ENSURE THAT YOU HAVE SHADED THIS SELECTION IN THE OMR SHEET)

Questions 42 to 50 carry one mark each.

42. A cantilever beam having square cross-section of side a is subjected to an end load. If a is increased by 19%, the tip deflection decreases approximately by

(A) 19% (B) 29% (C) 41% (D) 50%

43 The spring constant of a helical compression spring DOES NOT depend on

(A) coil diameter (B) material strength
(C) number of active turns (D) wire diameter

44. The instantaneous stream-wise velocity of a turbulent flow is given as follows:

$$u(x,y,z,t) = \overline{u}(x,y,z) + u'(x,y,z,t)$$

The time-average of the fluctuating velocity $u'(x,y,z,t)$ is

(A) $u'/2$ (B) $-\overline{u}/2$ (C) zero (D) $\overline{u}/2$

45. For a floating body, buoyant force acts at the

(A) centroid of the floating body (B) center of gravity of the body
(C) centroid of the fluid vertically below the body
(D) centroid of the displaced fluid

46. A plastic sleeve of outer radius $r0$ = 1 mm covers a wire (radius r = 0.5 mm) carrying electric current. Thermal conductivity of the plastic is 0.15 W/m-K. The heat transfer coefficient on the outer surface of the sleeve exposed to air is 25 W/m^2-K. Due to the addition of the plastic cover, the heat transfer from the wire to the ambient will

(A)Increase (B) remain the same (C) decrease (D) be zero

47. Which of the following statements are TRUE with respect to heat and work?

(i) They are boundary phenomena
(ii) They are exact differentials
(iii) They are path functions

(A) both (i) and (ii) (B) both (i) and (iii) (C) both (ii) and (iii) (D) only (iii)

48. The INCORRECT statement about regeneration in vapor power cycle is that

(A) it increases the irreversibility by adding the liquid with higher energy content to the steam generator
(B) heat is exchanged between the expanding fluid in the turbine and the compressed fluid before heat addition
(C) the principle is similar to the principle of Stirling gas cycle
(D) it is practically implemented by providing feed water heaters

49. The "Jominy test" is used to find

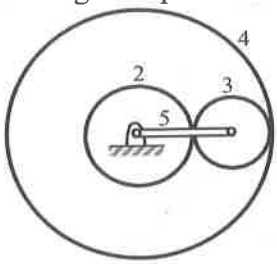
(A) Young's modulus
(B) hardenability
(C) yield strength
(D) thermal conductivity

50. Under optimal conditions of the process the temperatures experienced by a copper work piece in fusion welding, brazing and soldering are such that

(A) $T_{welding} > T_{soldering} > T_{brazing}$
(B) $T_{soldering} > T_{welding} > T_{brazing}$
(C) $T_{brazing} > T_{welding} > T_{soldering}$
(D) $T_{welding} > T_{brazing} > T_{soldering}$

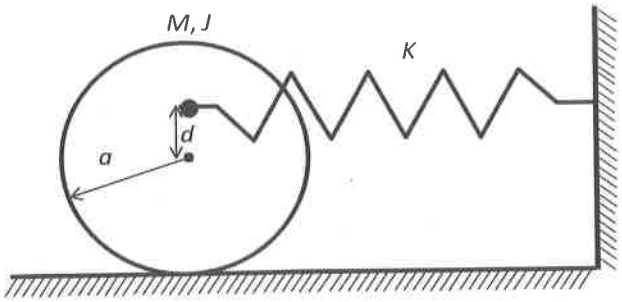
Questions 51 to 63 carry two marks each.

51. In the gear train shown, gear 3 is carried on arm 5. Gear 3 meshes with gear 2 and gear 4. The number of teeth on gear 2, 3, and 4 are 60, 20, and 100, respectively. If gear 2 is fixed and gear 4 rotates with an angular velocity of 100rpm in the counterclockwise direction, the angular speed of arm 5 (in rpm) is



(A) 166.7 counterclockwise
(B) 166.7 clockwise
(C) 62.5 counterclockwise
(D) 62.5 clockwise

52. A solid disc with radius a is connected to a spring at a point d above the center of the disc. The other end of the spring is fixed to the vertical wall. The disc is free to roll without slipping on the ground. The mass of the disc is M and the spring constant is K. The polar moment of inertia for the disc about its centre is $J = M a^2/2$



The natural frequency of this system in rad/s is given by

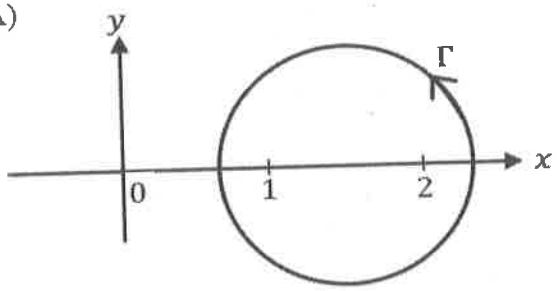
(A) $\sqrt{\frac{(2K(a+d)^2}{3Ma^2}}$ (B) $\sqrt{\frac{2K}{3M}}$ (C) $\sqrt{\frac{2K(a+d)^2}{Ma^2}}$ (D) $\sqrt{\frac{K(a+d)^2}{3Ma^2}}$

53. In a binary system or A and B, a liquid or 20% A (80% B) is coexisting with a solid of 70% A (30% B). For an overall composition having 40% A, the fraction of sol id is

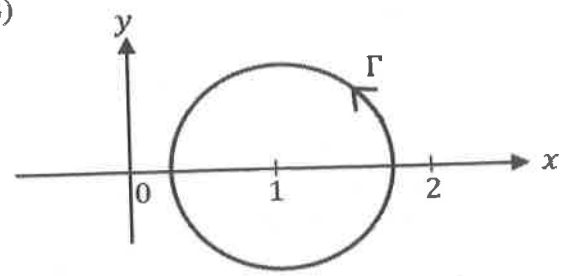
(A) 0.40 (B) 0.50 (C) 0.60 (D) 0.75

54. The value of $\oint_\Gamma \frac{3z-5}{(z-1)(z-2)} dz$ along a closed path Γ is equal to $(4\pi i)$, where $z=x+iy$ and $i=\sqrt{-1}$. The correct path Γ is

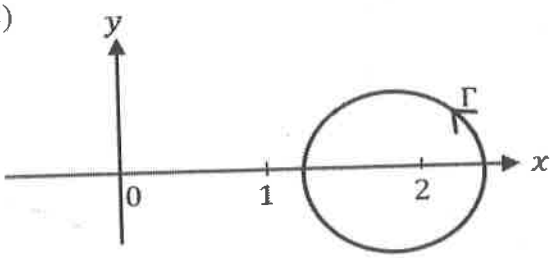
(A)



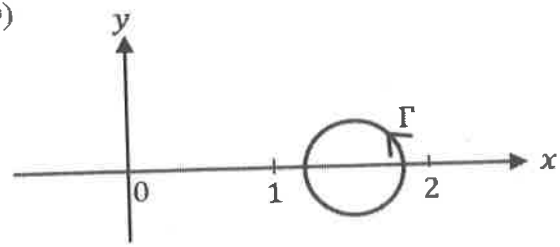
(B)



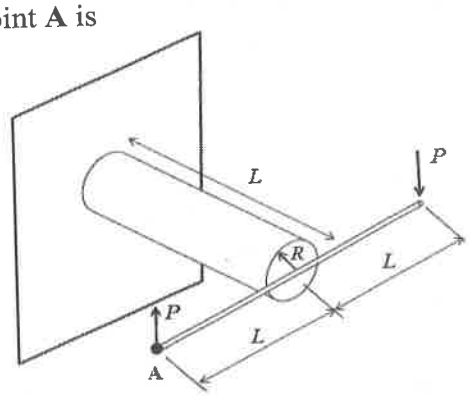
(C)



(D)



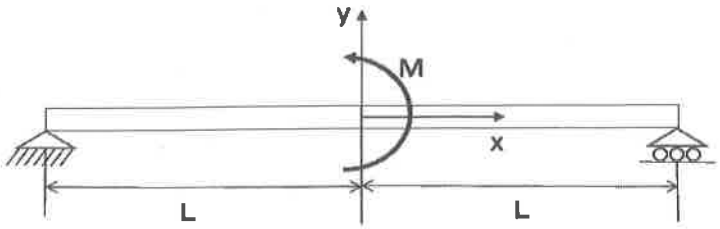
55. A rigid horizontal rod of length $2L$ is fixed to a circular cylinder of radius R as shown in the figure. Vertical forces of magnitude P are applied at the two ends as shown in the figure. The shear modulus for the cylinder is G and the Young's modulus is E. The vertical deflection at point **A** is



(A) $PL^3/(\pi R^4G)$ (B) $PL^3/(\pi R^4E)$ (C) $2PL^3/(\pi R^{4E}G)$ (D) $4PL^3/(\pi R^4G)$

56. A simply supported beam of length $2L$ is subjected to a moment M at the mid-point $x = 0$ as shown in the figure. The deflection in the domain $0 \le x \le L$ is given by

$$w = \frac{-Mx(L-x)(x+c)}{12EIL}$$



center $x = 0$ is

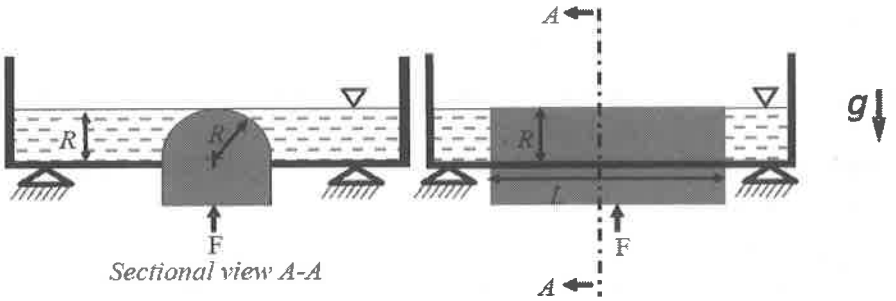
The slope at the center, $x = 0$ is

(A) ML/(2EI) (B) ML/(3EI) (C) ML/(6EI) (D) ML/(12EI)

57. In a structural member under fatigue loading, the minimum and maximum stresses developed at the critical point are 50 MPa and 150 MPa, respectively. The endurance, yield, and the ultimate strengths of the material are 200 MPa, 300 MPa and 400 MPa, respectively. The factor of safety using modified Goodman criterion is

(A) 3/2 (B) 8/5 (C) 12/7 (D) 2

58. Consider a frictionless, massless and leak-proof plug blocking a rectangular hole of dimensions $2R \times L$ at the bottom of an open tank as shown in the figure. The head of the plug has the shape of a semi-cylinder of radius R. The tank is filled with a liquid of density ρ up to the tip of the plug. The gravitational acceleration is g. Neglect the effect of the atmospheric pressure.



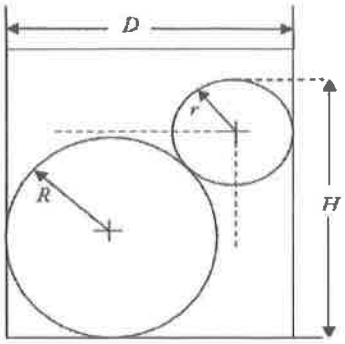
The force F required to hold the plug in its position is

(A) $2\rho R^2 gL(1 - \frac{\pi}{4})$ (B) $2\rho R^2 gL(1+\frac{\pi}{4})$ (C) $\pi\rho R^2 gL$ (D) $\frac{\pi}{2}\rho R^2 gL$

59. A cylindrical job with diameter of 200 mm and height of 100 mm is to be cast using modulus method of riser design. Assume that the bottom surface of cylindrical riser does not contribute as cooling surface. If the diameter of the riser is equal to its height, then the height of the riser (in mm) is

(A) 150 (B) 200 (C) 100 (D) 125

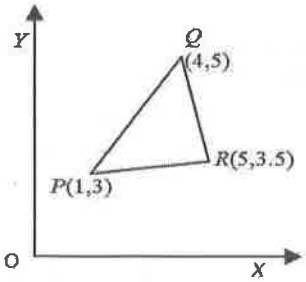
60. For the situation shown in the figure below the expression for H in terms of r, R and D is



(A) $H = D + \sqrt{r^2 + R^2}$ (B) $H = (R + r) + (D + r)$

(C) $H = (R + r) + \sqrt{D^2 - R^2}$ (D) $H = (R + r) + \sqrt{2D(R + r) - D^2}$

61. The figure below represents a triangle PQR with initial coordinates of the vertices as $P(1,3)$, $Q(4,5)$ and $R(5,3.5)$. The triangle is rotated in the X-Y plane about the vertex P by angle θ in clockwise direction. If $\sin\theta = 0.6$ and $\cos\theta = 0.8$, the new coordinates of the vertex Q are



(A) (4.6, 2.8) (B) (3.2, 4.6) (C) (7.9, 5.5) (D) (5.5, 7.9)

62. Three cards were drawn from a pack of 52 cards. The probability that they are a king, a queen, and a jack is

(A) $\frac{16}{5525}$ (B) $\frac{64}{2197}$ (C) $\frac{3}{13}$ (D) $\frac{8}{16575}$

63. Maximize $Z = 15X1 + 20X2$ subject to

$12X1 + 4X2 \geq 36$

$12X1 - 6X2 \leq 24$

$X1, X2 \geq 0$

The above linear programming problem has

(A) infeasible solution (B) unbounded solution

(C) alternative optimum solutions (D) degenerate solution

END OF SECTION-V QUESTION PAPER

SECTION-VI: PRODUCTION ENGINEERING

(PLEASE ENSURE THAT YOU HAVE SHADED THIS SELECTION IN THE OMR SHEET)

Questions 42 to 50 carry one mark each.

42. The number of solutions of the simultaneous algebraic equations y = 3x + 3 and y = 3x + 5 is

(A) zero (B) 1 (C) 2 (D) infinite

43. At $x = 0$, the function: $f(x) = \left|sin\frac{2\pi x}{L}\right|$ $(-\infty < x < \infty, L>0)$ is

(A) continuous and differentiable (B) not continuous and not differentiable.
(C) not continuous but differentiable (D) continuous but not differentiable.

44. For the two functions: a) $f(x,y) = x^3 - 3xy^2$ and b) $g(x,y) = 3x^2y - y^3$

Which one of the following options is correct?

(A) $\frac{\partial f}{\partial x} = \frac{\partial g}{\partial x}$ (B) $\frac{\partial f}{\partial x} = -\frac{\partial g}{\partial x}$ (C) $\frac{\partial f}{\partial y} = -\frac{\partial g}{\partial x}$ (D) $\frac{\partial f}{\partial y} = \frac{\partial g}{\partial x}$

45. The function $f(z) = \frac{z^2+1}{z^2+4}$ is singular at

(A) $z = \pm 2$ (B) $z = \pm 1$ (C) $z = \pm i$ (D) $z = \pm 2i$

46. A fair coin is tossed N times. The probability that head does not turn up in any of the tosses is

(A) $(\frac{1}{2})^{N-1}$ (B) $1 - (\frac{1}{2})^{N-1}$ (C) $(\frac{1}{2})^{N}$ (D) $1 - (\frac{1}{2})^{N}$

47. Consider the following statements:

P : Hardness is the resistance of a material to indentation.
Q : Elastic modulus is a measure of ductility.
R : Deflection depends on stiffness.
S : The total area under the stress-strain curve is a measure of resilience.

Among the above statements, the correct ones are

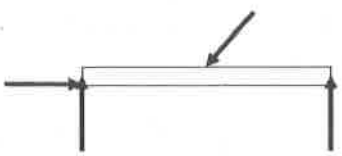
(A) P and Q only (B) Q and S only (C) P and R only (D) R and S only

48. A beam is subjected to an inclined concentrated load as shown in the figure below. Neglect the weight of the beam.

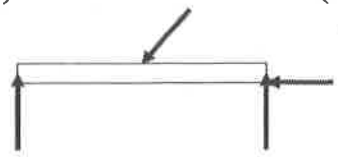
The correct Free Body Diagram is:

(A)

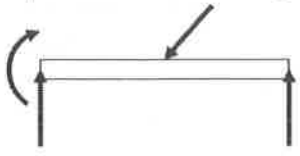
(B)



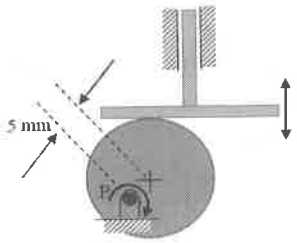
(C)



(D)



49. Consider a circular cam with a flat face follower as shown in the figure below. The cam is rotated in the plane of the paper about point P lying 5 mm away from its center. The radius of the cam is 20 mm. The distance (in mm) between the highest and the lowest positions of the flat face follower is:



(A) 5 (B) 10 (C) 40 (D) 45

50. Which one of the following is a natural polymer?

(A) Cellulose (B) Nylon (C) Polyester (D) Polyvinyl chloride

Questions 51 to 63 carry two marks each.

51. The range of values of k for which the function $f(x) = (k^2 - 4)x^2 + 6x^3 + 8x^4$ has a local maxima at point $x = 0$ is

(A) $k < -2$ or $k > 2$ (B) $k \leq -2$ or $k \geq 2$ (C) $-2 < k < 2$ (D) $-2 \leq k \leq 2$

52. To solve the equation $2 \sin x = x$ by *Newton-Raphson* method, the initial guess was chosen to be $x = 2.0$. Consider x in radian only. The value of x (in radian) obtained after one iteration will be closest to

(A) – 8.101 (B) 1.901 (C) 2.099 (D) 12.101

53. In linear gas tungsten arc welding of two plates of the same material, the peak temperature T (in K) is given as $T = C_1 q/\alpha$, where q is the heat input per unit length (in J/m) of weld, α is the thermal diffusivity (in m^2/s) of the plate materials and C_1 is a constant independent of process parameters and material types. Two welding cases are given below.

Case I: $V = 15$ V, $I = 200$ A, $v = 5$ mm/s, $k = 150$ W/mK, $\rho = 3000 kg/m^3$, $C = 900$ J/kg-K

Case II: $V = 15$ V, $I = 300$ A, $v = 10$ mm/s, $k = 50$ W/mK, $\rho = 8000$ kg/m^3, $C = 450$ J/kg-K

where, V is welding voltage, I is welding current, v is welding speed, and k, ρ and C refer to the thermal conductivity, the density and the specific heat of the plate materials, respectively. Consider that electrical energy is completely converted to thermal energy. All other conditions remain same. The ratio of the peak temperature in Case I to that in Case II is

(A) 1/3 (B) ½ (C) 1 (D) 2

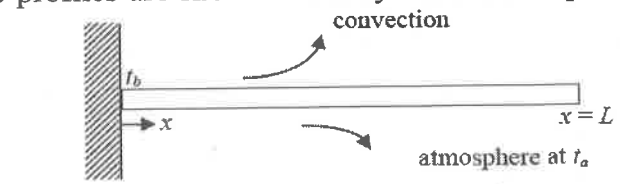
54. An ideal gas of mass m is contained in a rigid tank of volume V at a pressure p. During a reversible process its pressure reduces to p_1. Following statements are made regarding the process.

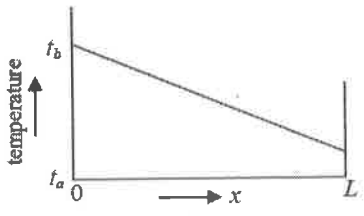
(P) Heat is transferred from the gas.
(Q) Work done by the gas is zero.
(R) Entropy of the gas remains constant.
(S) Entropy of the gas decreases.

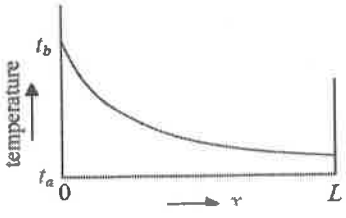
Among the above statements, the correct ones are

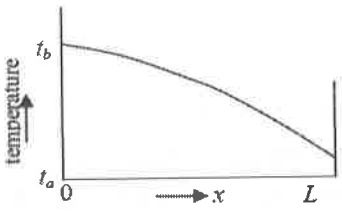
(A) P and R only (B) P, Q and R only (C) Q and R only (D) P, Q and S only.

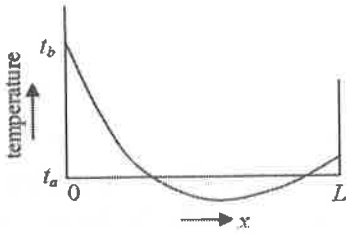
55. A long slender metallic rod of length L is used as a fin. As shown in the figure below, the left end of the fin is kept at a constant temperature t_b. The fin loses heat by convection to the atmosphere which is at a temperature t_a ($t_a < t_b$). Four options of temperature profiles are shown. Identify the correct option.



(A)


(B)


(C)


(D)


56. In a fully developed turbulent flow through a circular pipe, a head loss of hl is observed. The diameter of the pipe is increased by 10% for the same flow rate and a head loss of h2 is noted. Assume friction factor for both the cases of pipe flow is the same. The ratio of h2/h1 is closest to

(A) 0.34 (B) 0.62 (C) 0.87 (D) 1.00

57. For a process, the quality loss coefficient is 5. The target value on the dimension to be attained through the process is 50 mm. If the maximum loss permissible (in monetary terms) is INR 80, the maximum allowable deviation (in mm) from the target is

(A) ¼ (B) $\sqrt{\frac{1}{10}}$ (C) 4 (D) $\sqrt{10}$

58. Consider a network with nodes 1, 2, 3, 4, 5 and 6. The nodes are connected with directed arcs as shown in the table below. The respective costs (in INR) incurred while traversing the directed arcs are also mentioned.

Directed arcs	1→2	1→3	2→4	2→5	3→2	3→4	3→5	4→5	4→6	5→6
Cost (in INR)	3	9	3	2	2	4	8	7	2	2

The second shortest path from node 1 to node 6 (i.e. the path that has the second least total cost and does not use any part of the shortest path) has a total cost (in INR) of

(A) 7 (B) 8 (C) 15 (D) 19

59. Five jobs need to be processed on a single machine. All the are available for processing at time t = 0. Their respective processing times are given below.

Jobs	I	II	III	IV	V
Processing times (in minutes)	13	4	7	14	11

The average completion time (in minutes) of jobs as per the Shortest Processing Time rule is

(A) 9.8 (B) 24.2 (C) 49.0 (D) 121.0

60. Transportation costs (in INR/unit) from factories to respective markets are given in the table below. The market requirements and factory capacities are also given. Using the North-West Corner method, the quantity (in units) to be transported from factory R to market II is

		Factory				Requirements (in units)
		P	Q	R	S	
Market	I	3	3	2	1	50
	II	4	2	5	9	20
	III	1	2	1	4	30
	Factory Capacity (in units)	20	40	30	10	

(A) 30 (B) 20 (C) 10 (D) 0

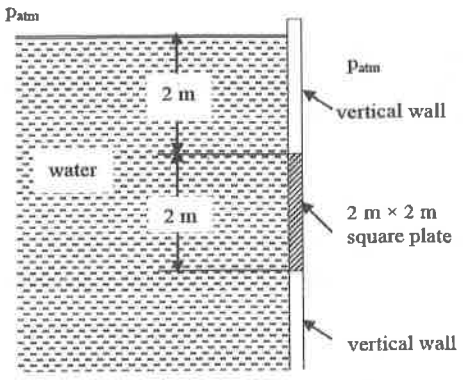
61. In a given year, a restaurant earned INR 38,500 in revenues. In that year, total expenses incurred were INR 30,000 and the depreciation amount was INR 3,200. At 40% tax rate, the net cash flow (in INR) for that year was

(A) 6380 (B) 5680 (C) 8560 (D) 3860

62. Two solid cylinders of equal diameter have different heights. They are compressed plastically by a pair of rigid dies to create the same percentage reduction in their respective heights. Consider that the die-workpiece interface friction is negligible. The ratio of the final diameter of the shorter cylinder to that of the longer cylinder is

(A) 1.0 (B) 2.0 (C) 1.5 (D) 2.5

63. A 2 m × 2 m square opening in a vertical wall is covered with a metallic plate of the same dimensions as shown in the figure below. Consider the acceleration due to gravity to be 10.0 m/s2. The force (in kN) exerted by water on the plate is



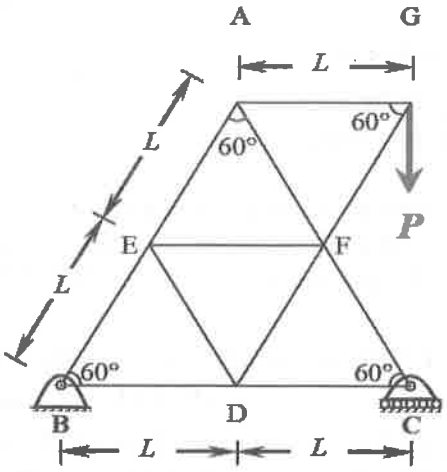
(A) 120 (B) 140 (C) 100 (D) 150

END OF SECTION-VI QUESTION PAPER

SECTION-VII: CIVIL ENGINEERING

Questions 42 to 50 carry one mark each.

42. Consider the plane truss with load P as shown in the figure. Let the horizontal and vertical reactions at the joint B be HB and VB, respectively and VC be the vertical reaction at the joint C.



Which one of the following sets gives the correct values of VB, HB and VC?

(A) VB = 0; HB = 0; VC = P
(B) VB = P/2; HB = 0; VC = P/2
(C) VB = P/2; HB = P (sin 60°); VC = P/2
(D) VB = P; HB = P (cos 60°); VC = 0

43 The compound which is largely responsible for initial setting and early strength gain of Ordinary Portland Cement is

(A) C_3A (B) C_3S (C) C_2S (D) C_4AF

44. In the consolidated undrained triaxial test on a saturated soil sample, the pore water pressure is zero

(A) during shearing stage only (B) at the end of consolidation stage only

(C) both at the end of consolidation and during shearing stages

(D) under none of the above conditions

45. A fine grained soil is found to be plastic in the water content range of 26-48%. As per Indian Standard Classification System, the soil is classified as

(A) CL (B) CH (C) CL-ML (D) CI

46. A vertical cut is to be made in a soil mass having cohesion *c*, angle of internal friction <*p*, and unit weight *y*. Considering K_a and K_P as the coefficients of active and passive earth pressures, respectively, the maximum depth of unsupported excavation is

(A) $\frac{4c}{\gamma\sqrt{K_p}}$ (B) $\frac{2c\sqrt{K_p}}{\gamma}$ (C) $\frac{4c\sqrt{K_a}}{\gamma}$ (D) $\frac{4c}{\gamma\sqrt{K_a}}$

47. The type of flood routing (Group I) and the equation(s) used for the purpose (Group II) are given below:

Group I	Group II
P Hydrologic flood routing	1 Continuity equation
Q Hydraulic flood routing	2 Momentum equation
	3 Energy equation

The correct match is:

(A) P-1; Q-1, 2&3 (B) P-1; Q-1&2 only
(C) P-1 &2; Q-1 only (D) P-1&2; Q-1&2 only

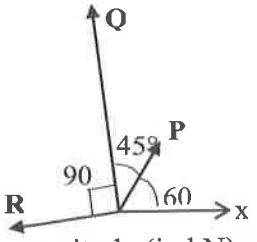
48. Pre-cursors to photochemical oxidants are:
(A) NO_X, VOCs and sunlight (B) SO_2, CO_2 and sunlight
(C) H2S, CO and sunlight (D) SO_2, NH_3 and sunlight

49. Crown corrosion in a reinforced concrete sewer is caused by:
(A) H_2S (B) CO_2 (C) CH_4 (D) NH_3

50. It was decided to construct a fabric filter, using bags of 0.45 m diameter and 7.5 m long, for removing industrial stack gas containing particulates. The expected rate of airflow into the filter is 10 m^3/s. If the filtering velocity is 2.0 m/min, the minimum number of bags (rounded to nearest higher integer) required for continuous cleaning operation is
(A) 27 (B) 29 (C) 31 (D) 32

Questions 51 to 63 carry two marks each.

51. The magnitudes of vectors **P**, **Q** and **R** are 100 kN, 250 kN and 150 kN, respectively as shown in the figure.



The respective values of the magnitude (in kN) and the direction (with respect to the x-axis) of the resultant vector are

(A) 290.9 and 96.0° (B) 368.1 and 94.7°
(C) 330.4 and 118.9° (D) 400.1 and 113.5°

52. Two beams PQ (fixed at P and with a roller support at Q, as shown in Figure I, which allows vertical movement) and XZ (with a hinge at Y) are shown in the Figures I and II respectively. The spans of PQ and XZ are L and 2L respectively. Both the beams are under the action of uniformly distributed load (W) and have the same flexural stiffness, *EI* (where, *E* and *I* respectively denote modulus of elasticity and moment of inertia about axis of bending). Let the maximum deflection and maximum rotation

be δ_{max1} and θ_{max1}, respectively, in the case of beam PQ and the corresponding quantities for the beam XZ be δ_{max2}

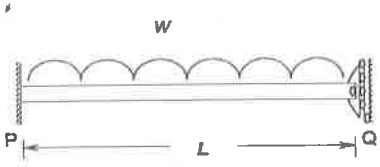


Figure I

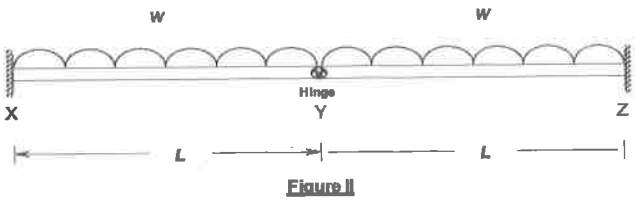


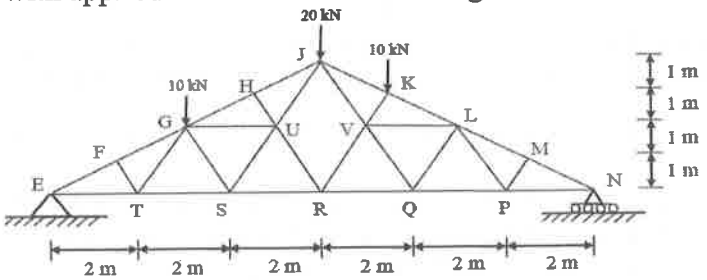
Figure II

Which one of the following relationships is true?

(A) $\delta_{max1} \neq \delta_{max2}$ and $\theta_{max1} \neq \theta_{max2}$ (B) $\delta_{max1} = \delta_{max2}$ and $\theta_{max1} \neq \theta_{max2}$

(C) $\delta_{max1} \neq \delta_{max2}$ and $\theta_{max1} = \theta_{max2}$ (D) $\delta_{max1} = \delta_{max2}$ and $\theta_{max1} = \theta_{max2}$

53. A plane truss with applied loads is shown in the figure.



The members which do not carry any force are

(A) FT, TG, HU, MP, PL (B) ET, GS, UR, VR, QL

(C) FT, GS, HU, MP, QL (D) MP, PL, HU, FT, UR

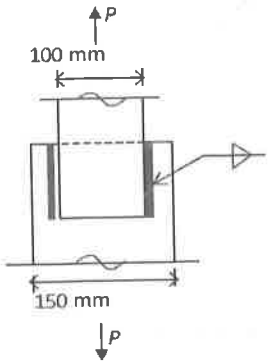
54. A reinforced concrete (RC) beam with width of 250 mm and effective depth of 400 mm is reinforced with Fe415 steel. As per the provisions of IS 456-2000, the minimum and maximum amount of tensile reinforcement (expressed in mm2) for the section are, respectively

(A) 250 and 3500 (B) 205 and 4000 (C) 270 and 2000 (D) 300 and 2500

55. A propped cantilever of span L carries a vertical concentrated load at the mid-span. If the plastic moment capacity of the section is Mp, the magnitude of the collapse load is

(A) $8M_p/L$ (B) $6M_p/L$ (C) $4M_p/L$ (D) $2M_p/L$

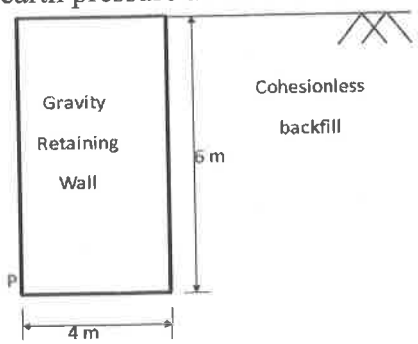
56. Two plates are connected by fillet welds of size 10 mm and subjected to tension, as shown in the figure. The thickness of each plate is 12 mm. The yield stress and the ultimate tensile stress of steel are 250 MPa and 410 MPa, respectively. The welding is done in the workshop (γ_{mw} = 1.25)



As per the Limit State Method of IS 800: 2007, the minimum length (rounded off to the nearest higher multiple of 5 mm) of each weld to transmit a force P equal to 270 kN (factored) is

(A) 90 mm (B) 105 mm (C) 110 mm (D) 115 mm

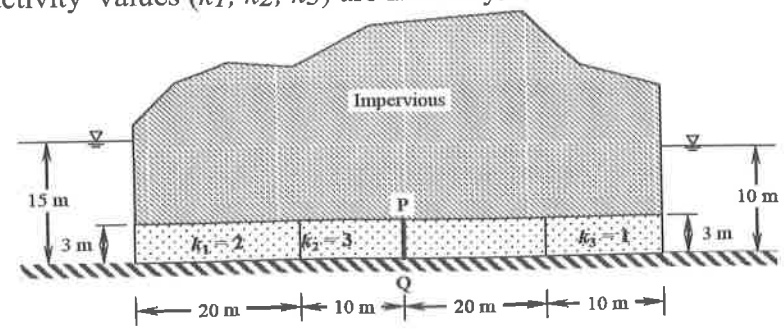
57. A homogeneous gravity retaining wall supporting a cohesionless backfill is shown in the figure. The lateral active earth pressure at the bottom of the wall is 40 kPa.



The minimum weight of the wall (expressed in kN per m length) required to prevent it from overturning about its toe (Point P) is

(A) 120 (B) 180 (C) 240 (D) 360

58. Seepage is occurring through a porous media shown in the figure. The hydraulic conductivity values ($k1$, $k2$, $k3$) are in m/day.



The seepage discharge (m^3/day per m) through the porous media at section PQ is

(A) 7/12 (B) 1/2 (C) 9/16 (D) 3/4

59. A 4 m wide rectangular channel, having bed slope of 0.001 carries a discharge of 16 m^3/s. Considering Manning's roughness coefficient = 0.012 and g = 10 m/s^2, the category of the channel slope is

(A) Horizontal (B) mild (C) critical (D) steep

60. A two lane, one-way road with radius of 50 m is predominantly carrying lorries with wheelbase of 5 m. The speed of lorries is restricted to be between 60 kmph and 80 kmph. The mechanical widening and psychological widening required at 60 kmph are designated as $w_{,60}$ and $w_{ps,60}$ respectively. The mechanical widening and psychological widening required at 80 kmph are designated as $w_{m,80}$ and $w_{ps,80}$, respectively. The correct values of $w_{me,60}$, $w_{ps,60}$, $w_{me,80}$ and $w_{ps,80}$, respectively are

(A) 0.89 m, 0.50 m, 1.19 m, and 0.50 m (B) 0.50 m, 0.89 m, 0.50 m, and 1.19 m
(C) 0.50 m, 1.19 m, 0.50 m, and 0.89 m (D) 1.19 m, 0.50 m, 0.89 m, and 0.50 m

61. Consider the following linear system.

$x + 2y - 3z = a$ $2x + 3y + 3z = b$ $5x + 9y - 6z = c$

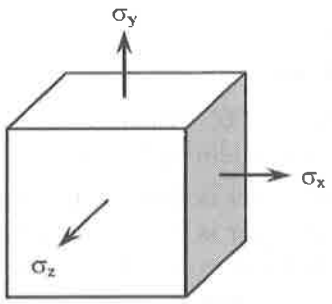
This system is consistent if a, b and c satisfy the equation

(A) $7a - b - c = 0$ (B) $3a + b - c = 0$
(C) $3a - b + c = 0$ (D) $7a - b + c = 0$

62. The angle of intersection of the curves $x^2 = 4y$ and $y^2 = 4x$ at point (0, 0) is

(A) 0° (B) 30° (C) 45° (D) 90°

63. An elastic isotropic body is in a hydrostatic state of stress as shown in the figure. For no change in the volume to occur, what should be its Poisson's ratio?



(A) 0.00 (B) 0.25 (C) 0.50 (D) 1.00

END OF SECTION-VII QUESTION PAPER

SECTION-VIII: AERONAUTICAL ENGINEERING

(PLEASE ENSURE THAT YOU HAVE SHADED THIS SELECTION IN THE OMR SHEET)

Questions 42 to 50 carry one mark each.

42. With increase in airfoil thickness, the critical Mach number for an airfoil is likely to

(A) increase (B) decrease (C) remain unchanged (D) undefined

43. Which of the following airfoil will have location of the maximum camber at half chord length from the leading edge?

(A) NACA 5212 (B) NACA 1225 NACA 2215 (D) NACA 2512

44. Which of the following statement is NOT TRUE across an oblique shock wave?

(A) Static temperature increases, total temperature remains constant.
(B) Static pressure increases, static temperature increases.
(C) Static temperature increases, total pressure decreases.
(D) Static pressure increases, total temperature decreases

45. For a completely subsonic isentropic flow through a convergent nozzle, which of the following statement is TRUE?

(A) Pressure at the nozzle exit > back pressure.
(B) Pressure at the nozzle exit < back pressure.
(C) Pressure at the nozzle exit = back pressure.
(D) Pressure at the nozzle exit = total pressure.

46. Which of the following aircraft engines has the highest propulsive efficiency at a cruising Mach number of less than 0.5?

(A) Turbofan engine (B) Turbojet engine
(C) Turboprop engine (D) Ramjet engine

47. Air, with a Prandtl number of 0.7, flows over a flat plate at a high Reynolds number. Which of the following statement is TRUE?

(A) Thermal boundary layer is thicker than the velocity boundary layer.
(B) Thermal boundary layer is thinner than the velocity boundary layer.
(C) Thermal boundary layer is as thick as the velocity boundary layer.
(D) There is no relationship between the thicknesses of thermal and velocity boundary layers.

48. Consider an eigenvalue problem given by $\mathbf{Ax} = \lambda_i \mathbf{x}$. If λ_ι represents represent the eigenvalues of the non-singular square matrix **A,** then what will be the eigenvalues of matrix $\mathbf{A}^2$?

(A) λ^4_i (B) λ^2_i (C) $\lambda_i{}^{½}$ (D) $\lambda_i{}^{¼}$

49. If **A** and **B** are both non-singular nxn matrices, then which of the following statement is NOT TRUE. Note: det represents the determinant of a matrix.

(A) det(AB) = det(A)det(B) (B) det(A+B) = det(A) + det(B)
(C) det(AA-1) = 1 (D) det(AT) = det(A)

50. Determine the correctness or otherwise of the following statements, [a] and [r]:

[a]: In a plane stress problem, the shear strains along the thickness direction of a body are zero but the normal strain along the thickness is not zero.
[r]: In a plane stress problem, Poisson effect induces the normal strain along the thickness direction of the body.

(A) Both [a] and [r] are true and [r] is the correct reason for [a].
(B) Both [a] and [r] are true but [r] is not the correct reason for [a].
(C) Both [a] and [r] are false.
(D) [a] is true but [r] is false.

Questions 51 to 63 carry two marks each.

51. A single-stage gas turbine operates with an axial absolute flow at the entry and exit from the stage. The absolute flow angle at the nozzle exit is 70^{o}. The turbine stage generates a specific work of 228 kJ/k when operating with a mean blade speed of 440 m/s. The absolute velocity at the rotor entry is

(A) 275.7 m/s (B) 551.5 m/s (C) 1103.0 m/s (D) 1654.5 m/s

52. The maximum value of coefficient of lift (C_l) for a 2D circular cylinder, provided at least one stagnation point lies on the cylinder surface, is predicted by the potential flow theory to be

(A) $\pi/2$ (B) π (C) 2π (D) 4π

53. The rate of change of moment coefficient with respect to the angle of attack, $dC_m/d\alpha$, at half chord point of a thin airfoil, as per approximations from the thin airfoil theory is

(A) $\pi/4$ radian^{-1} (B) $\pi/2$ radian^{-1} (C) π radian^{-1} (D) 2π radian^{-1}

54. An untwisted wing of elliptic planform and aspect ratio 6 consists of thin symmetric airfoil sections. The coefficient of lift (C_L) at 10^0 angle of attack assuming inviscid incompressible flow is

(A) $\pi 2/16$ (B) $\pi 2/12$ (C) $\pi 2/8$ (D) $\pi/2$

55. Consider 1-D, steady, inviscid, compressible flow through a convergent nozzle. The total temperature and total pressure are T_o, P_o respectively. The flow through the nozzle is choked with a mass flow rate of $\dot{m}_0$. If the total temperature is increased to $4T_o$, with total pressure remaining changed, then the mass flow rate through the nozzle

(A) remains unchanged (B) becomes half of $\dot{m}_0$
(C) becomes twice of $\dot{m}_0$. (D) becomes four times of $\dot{m}_0$

56. Consider a second order linear ordinary differential equation, $\frac{d^2y}{dx^2} - 4\frac{dy}{dx} + 4y = 0$, with the boundary conditions $y(0) = 1$ $\left.\frac{dy}{dx}\right|_{x=0} = 1$. The value of y at x =1 is

(A) 0 (B) 1 (C) e (D) e^2

57. Consider the following system of linear equations:

(i) $2x - y + z = 1$ (ii) $3x - 3y + 4z = 6$ (iii) $x - 2y + 3z = 4$

This system of linear equations has

(A) no solution (B) one solution (C) two solutions (D) three solutions

58. Determine the correctness or otherwise of the following statements, [a] and [r],

[a]: Ribs, used in airplane wings, increase the column buckling strength of the longitudinal stiffeners

[r]: Ribs distribute concentrated loads into the structure and redistribute stresses around discontinuities.

(A) Both [a] and [r] are true and [r] is the correct reason for [a]
(B) Both [a] and [r] are true but [r] is not the correct reason for [a]
(C) Both [a] and [r] are false
(D) [a] is true but [r] is false

59. A substance experiences an entropy change of $\Delta s > 0$ in a quasi-steady process. The rise in temperature (corresponding to the entropy change Δs) is highest for the following process:

(A) isenthalpic (B) isobaric (C) isochoric (D) isothermal

60. An aircraft weighing 10000 N is flying level at 100 m/s and it is powered by a jet engine. The thrust required for level flight is 1000 N. The maximum possible thrust produced by the jet engine is 5000 N. The minimum time required to climb 1000 m, when flight speed is 100 m/s, is

(A) 25 sec (B) 20 sec (C) 10 sec (D) 0 sec

61. The aircraft velocity (m/s) components in body axes are given as $[u, v, w] = [100, 10, 10]$. The air velocity (m/s), angle of attack (deg) and sideslip angle (deg) in that order are

(A) [120, 0.1, 0.1] (B) [100, 0.1, 0.1]
(C) [100.995, 0.1, 5.73] (D) [100.995, 5.71, 5.68]

62. The Dutch roll motion of the aircraft is described by following relationships

$$\begin{pmatrix} \Delta\dot{\beta} \\ \Delta\dot{r} \end{pmatrix} = \begin{bmatrix} -0.26 & -1 \\ 4.49 & -0.76 \end{bmatrix} \begin{pmatrix} \Delta\beta \\ \Delta r \end{pmatrix}$$

The undamped natural frequency (rad/s) and damping ratio for the Dutch roll motion in that order are:

(A) 4.68, 1.02 (B) 4.49, 1.02 (C) 2.165, 0.235 (D) 2.165, 1.02

63. A rocket, with a total lift-off mass of 10000 kg, moves vertically upward from rest under a constant gravitational acceleration of 9.81 m/s^2. The propellant mass of 8400 kg burns at a constant rate of 8400 kg burns at the constant rate of 1200 kg/s. If the specific impulse of the rocket engine is 240s, neglecting drag, the burnout city in m/s is

(A) 3933.7 (B) 4314.6 (C) 4245.9 (D) 4383.3

END OF SECTION-VIII QUESTION PAPER

SECTION IX ELECTRICAL ENGINEERING

(PLEASE ENSURE THAT YOU HAVE SHADED THIS SELECTION IN THE OMR SHEET)

Questions 42 to 50 carry one mark each.

42. The Laplace Transform of $f(t) = e^{2t}\ sin(5t)\ u(t)$ is

(A) $\frac{5}{s^2-4s+29}$ (B) $\frac{5}{s^2+5}$ (C) $\frac{s-2}{s^2-4s+29}$ (D) $\frac{s}{s+5}$

43. A function $y(t)$, such that $y(0) = 1$ and $y(1) = 3e^{-1}$, is a solution of the differential equation $\frac{d^2y}{dt^2} + 2\frac{dy}{dt} + y = 0$. Then $y(2)$ is

(A) $5e^{-1}$ (B) $5e^{-2}$ (C) $7e^{-1}$ (D) $7e^{-2}$

44. The value of the counter integral $\oint \frac{2z+5}{\left(z-\frac{1}{2}\right)(z^2-4z+5)}\,dz$ over the contour $|z| = 1$, taken in the anti-clockwise direction, would be

(A) $\frac{24\pi i}{13}$ (B) $\frac{48\pi i}{13}$ (C) $\frac{24}{13}$ (D) $\frac{12}{13}$

45. The transfer function of a system is $\frac{Y(s)}{R(s)} = \frac{s}{s+2}$. The steady state output $y(t)$ is A $\cos(2t + \psi)$ for the input $\cos(2t)$. The values of A and ψ, respectively are

(A) $\frac{1}{\sqrt{2}}$, -45^0 (B) $\frac{1}{\sqrt{2}}$, $+45^0$ (C) $\sqrt{2}$, -45^0 (D) $\sqrt{2}$, $+45^0$

46. The phase cross-over frequency of the transfer function $G(s) = \frac{100}{(s+1)^3}$ in rad/s is

(A) $\sqrt{3}$ (B) $\frac{1}{\sqrt{3}}$ (C) 3 (D) $3\sqrt{3}$

47 Consider a continuous-time system with input $x(t)$ and output $y(t)$ is given by $y(t) = x(t)cos(t)$. The system is

(A) linear and time-invariant (B) non-linear and time-invariant

(C) linear and time-varying (D) non-linear and time-varying

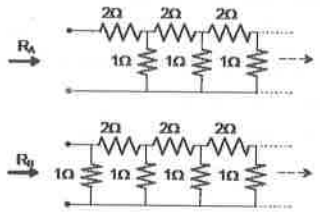
48. A temperature in the range of −40° C to 55° C is to be measured with a resolution of 0.1° C. The minimum number of ADC bits required to get a matching dynamic range of the temperature sensor is

(A) 8 (B) 10 (C) 12 (D) 14

49. In cylindrical coordinate system, the potential produced by a uniform ring charge is given by $\phi = f(r, z)$, where f is a continuous function of r and z. Let $\vec{E}$ be the resulting electric field. Then the magnitude of $\nabla \times \vec{E}$

(A) increases with r (B) is 0 (C) is 3 (D) decreases with z

50. R_A and R_B are the input resistances of circuits as shown below. The circuits extend infinitely in the direction shown. Which one of the following statements is TRUE?



(A) $R_A = R_B$ (B) $R_A = R_B = 0$ (C) $R_A < R_B$ (D) $R_B = R_A/(1+R_A)$

Questions 51 to 63 carry two marks each.

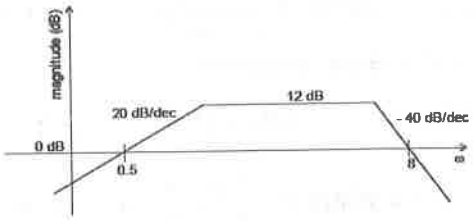
51. Let the eigenvalues of a 2 x 2 matrix A be 1, -2 with eigenvectors x_1 and x_2 respectively. Then the eigenvalues and eigenvectors of the matrix $A^2 - 3A + 4I$ would, respectively, be

(A) 2, 14; x_1, x_2 (B) 2, 14; $x_1 + x_2$, $x_1 - x_2$ (C) 2, 0; x_1, x_2 (D) 2, 0; $x_1 + x_2$, $x_1 - x_2$

52. Let A be a 4×3 real matrix with rank 2. Which one of the following statement is TRUE?

(A) Rank of A^TA is less than 2
(B) Rank of A^TA is equal to 2
(C) Rank of A^TA is greater than 2
(D) Rank of A^TA can be any number between 1 and 3

53 Consider the following asymptotic Bode magnitude plot (ω is in rad/s).



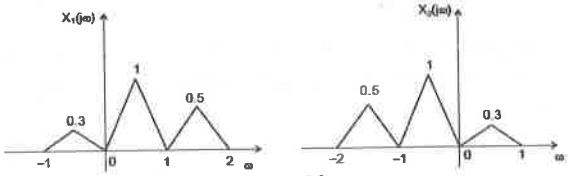
Which one of the following transfer functions is best represented by the above Bode magnitude plot?

(A) $\frac{2s}{(1+0.5s)(1+0.25s)^2}$ (B) $\frac{4(1+0.5s)}{s(1+0.25s)}$ (C) $\frac{2s}{(1+2s)(1+4s)}$ (D) $\frac{4s}{(1+2s)(1+4s)^2}$

54. Loop transfer function of a feedback system is $G(s)H(s) = \frac{s+3}{s^2(s-3)}$. Take the Nyquist contour in the clockwise direction. Then, the Nyquist plot of $G(s)H(s)$ encircles $-1+j0$

(A) once in clockwise direction
(B) twice in clockwise direction
(C) once in anticlockwise direction
(D) twice in anticlockwise direction

55. Suppose $x_1(t)$ and $x_2(t)$ have the Fourier transforms as shown below.



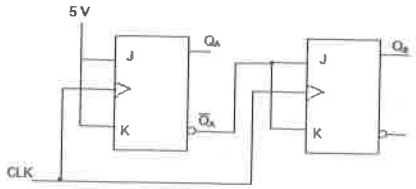
Which one of the following statements is TRUE?

(A) $x_1(t)$ and $x_2(t)$ are complex and $x_1(t)\,x_2(t)$ is also complex with nonzero imaginary part
(B) $x_1(t)$ and $x_2(t)$ are real and $x_1(t)\,x_2(t)$ is also real
(C) $x_1(t)$ and $x_2(t)$ are complex but $x_1(t)\,x_2(t)$ is real
(D) $x_1(t)$ and $x_2(t)$ are imaginary but $x_1(t)\,x_2(t)$ is real

56. The output of a continuous-time, linear time-invariant system is denoted by $\boldsymbol{T}\{x(t)\}$ where $x(t)$ is the input signal. A signal $z(t)$ is called eigen-signal of the system $\boldsymbol{T}$, when $\boldsymbol{T}\{z(t)\} = \gamma\, z(t)$, where γ is a complex number, in general, and is called an eigenvalue of $\boldsymbol{T}$. Suppose the impulse response of the system $\boldsymbol{T}$ is real and even. Which of the following statements is TRUE?

(A) $\cos(t)$ is an eigen-signal but $\sin(t)$ is not
(B) $\cos(t)$ and $\sin(t)$ are both eigen-signals but with different eigenvalues
(C) $\sin(t)$ is an eigen-signal but $\cos(t)$ is not
(D) $\cos(t)$ and $\sin(t)$ are both eigen-signals with identical eigenvalues

57. The current state Q_A Q_B of a two JK flip-flop system is 00. Assume that the clock rise-time is much smaller than the delay of the JK flip-flop. The next state of the system is

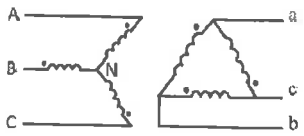


(A) 00 (B) 01 (C) 11 (D) 10

58. Two electric charges q and $-2q$ are placed at (0,0) and (6,0) on the x-y plane. The equation of the zero equipotential curve in the x-y plane is

(A) $x = -2$ (B) $y = 2$ (C) $x^2 + y^2 = 2$ (D) $(x + 2)^2 + y^2 = 16$

59. If the star side of the star-delta transformer shown in the figure is excited by a negative sequence voltage, then



(A) V_{AB} leads V_{ab} by 60°
(B) V_{AB} lags V_{ab} by 60°
(C) V_{AB} leads V_{ab} by 30°
(D) V_{AB} lags V_{ab} by 30°

60. A single-phase thyristor-bridge rectifier is fed from a 230 V, 50 Hz, single-phase AC mains. If it is delivering a constant DC current of 10 A, at firing angle of 30^0, then value of the power factor at AC mains is

(A) 0.87 (B) 0.9 (C) 0.78 (D) 0.45

61. A single-phase, 22 kVA, 2200 V/ 220 V, 50 Hz, distribution transformer is to be connected as an auto-transformer to get an output voltage of 2420 V. Its maximum kVA rating as an auto-transformer is

(A) 22 (B) 24.2 (C) 242 (D) 2420

62. A single-phase full-bridge voltage source inverter (VSI) is fed from a 300 V battery. A pulse of 120^0 duration is used to trigger the appropriate devices in each half-cycle. The rms value of the fundamental component of the output voltage, in volts, is

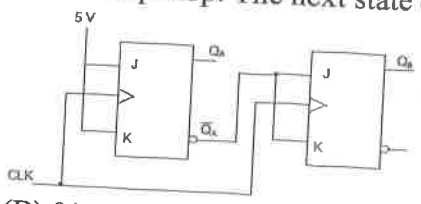
(A) 234 (B) 245 (C) 300 (D) 331

63. The gain at the breakaway point of the root locus of a unity feedback system with open loop transfer function $G(s) = \frac{Ks}{(s-1)(s-4)}$ is

(A) 1 (B) 2 (C) 5 (D) 9

END OF SECTION-IX QUESTION PAPER

57. The current state Q_A Q_B of a two JK flip-flop system is 00. Assume that the clock rise-time is much smaller than the delay of the JK flip-flop. The next state of the system is

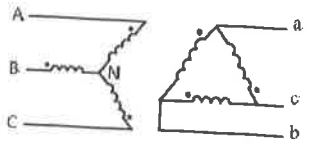


(A) 00 (B) 01 (C) 11 (D) 10

58. Two electric charges q and −2q are placed at (0,0) and (6,0) on the x-y plane. The equation of the zero equipotential curve in the x-y plane is

(A) $x = -2$ (B) $y = 2$ (C) $x^2 + y^2 = 2$ (D) $(x + 2)^2 + y^2 = 16$

59. If the star side of the star-delta transformer shown in the figure is excited by a negative sequence voltage, then



(A) V_{AB} leads V_{ab} by 60°
(B) V_{AB} lags V_{ab} by 60°
(C) V_{AB} leads V_{ab} by 30°
(D) V_{AB} lags V_{ab} by 30°

60. A single-phase thyristor-bridge rectifier is fed from a 230 V, 50 Hz, single-phase AC mains. If it is delivering a constant DC current of 10 A, at firing angle of 30^0, then value of the power factor at AC mains is

(A) 0.87 (B) 0.9 (C) 0.78 (D) 0.45

61. A single-phase, 22 kVA, 2200 V/ 220 V, 50 Hz, distribution transformer is to be connected as an auto-transformer to get an output voltage of 2420 V. Its maximum kVA rating as an auto-transformer is

(A) 22 (B) 24.2 (C) 242 (D) 2420

62. A single-phase full-bridge voltage source inverter (VSI) is fed from a 300 V battery. A pulse of 120^0 duration is used to trigger the appropriate devices in each half-cycle. The rms value of the fundamental component of the output voltage, in volts, is

(A) 234 (B) 245 (C) 300 (D) 331

63. The gain at the breakaway point of the root locus of a unity feedback system with open loop transfer function $G(s) = \frac{Ks}{(s-1)(s-4)}$ is

(A) 1 (B) 2 (C) 5 (D) 9

END OF SECTION-IX QUESTION PAPER

Duration: 90 minutes (One and half hours) **Maximum Marks: 100**

Please read the following instructions carefully:

General Instructions:

1. Total duration of examination is 90 minutes (1½ hours).
2. The maximum marks for the paper/written test is 100.
3. You will be provided a) One Question Booklet with two blank sheets for rough work and b) OMR sheet which is THE Answer Sheet.
4. All questions are objective type only.
5. Please check whether you have marked/entered details such as Roll Number, Question Booklet No. and OMR Sheet No. correctly both in the Question Booklet and Answer Sheet/OMR Sheet.
6. Select an answer for a multiple choice type question from the separate sheet provided. Only one answer is right.
7. Both, the Question Booklet and the Answer/OMR Sheet must be handed back to the invigilator before leaving the examination hall.

Question Booklet specific instructions:

1. There are NINE sections:

SECTION No.	SUBJECT/TOPIC
I	Engineering Mathematics and Sciences
II	Renewable Energy
III	Computer Science & Information Technology
IV	Electronics, & Communications Engineering
V	Mechanical Engineering
VI	Production Engineering
VII	Civil Engineering
VIII	Aeronautical Engineering
IX	Electrical Engineering

2. ***There are a total of 63 questions carrying 100 marks.*** The question paper consists of questions of multiple choice type. Multiple choice type questions will have four choices for the answer *with only one correct choice*.
3. **Section I (Engineering Mathematics and Sciences) and Section II (Renewable Energy) are compulsory.**
4. ***Attempt any one of the Sections III through IX.***
5. There are 30 questions carrying 50 marks in Section I (Engineering Mathematics and Sciences), which is compulsory. Questions 1 to 10 carry 1 mark each, and questions 11 –30 carry 2 marks each.
6. There are 11 questions carrying 15 marks in Section II (Renewable Energy), which is compulsory. Questions 31 to 37 carry 1 mark each and questions 38 to 41 carry 2 marks each.
7. Each of the other sections (Sections III through IX) contains 22 questions carrying 35 marks. Questions 42 - 50 carry 1 mark each and questions 51 - 63 carry 2 marks each.
8. Questions not answered will carry **no** mark. Wrong answers for multiple choice type questions will result in NEGATIVE marks. For every wrong answer, one-fourth (1/4th) mark will be deducted.
9. Charts, graph sheets or tables, log tables and other electronic devices including Calculator, mobiles/cells, are NOT allowed in the examination hall.

10. Do the rough work in the blank sheets attached at the end with the question booklet provided.

SECTION No.	SUBJECT/TOPIC	No. of Questions	MARKS
I	Engineering Mathematics and Sciences (COMPULSORY)	30 (Question No. 1 to 30)	50
II	Renewable Energy (COMPULSORY)	11 (Question No. 31 to 41)	15
	CHOSE ANY ONE SECTION FROM BELOW		
III	Computer Science & Information Technology	22 (Question No. 42 to 63)	35
IV	Electronics, Electrical & Communications Engineering		
V	Mechanical Engineering		
VI	Production Engineering		
VII	Civil Engineering		
VIII	Aeronautical Engineering		
IX	Electrical Engineering		
	TOTAL	**63**	**100**

Answer Sheet/OMR SHEET specific instructions:

1. All entries in the correct circles must be made by BALL POINT PEN (Blue or Black) only.
2. Please check whether you have marked details such as Roll Number, Question Booklet No. and OMR Sheet No. correctly both in the Question Booklet and Answer Sheet/OMR Sheet.
3. ***Before you proceed further, shade the BOX provided in the OMR/Answer Sheet to choose the optional section (any one from Section-III to Section-IX) you have attempted. SINCE THE ANSWER SHEET IS AN OMR SHEET, IF YOU DO NOT SHADE THE OPTIONAL SECTION (FROM AMONG SECTION-III TO SECTION-IX) YOU HAVE CHOSEN, THE SECTION WILL NOT BE EVALUATED EVEN IF YOU HAVE ATTEMPTED.***
4. There is only one correct answer to each question.
5. Ensure your choice before shading/darkening.
6. Darken/shade only ONE answer for each question.
7. Circle should be darkened/shaded completely, so that the alphabet inside the circle is not visible.
8. For rough work, only the blank sheet provided at the end of the Question Booklet must be used.
9. Do not make any stray mark/fold/tear/wrinkle/spread ink on Answer Sheet.
10. In case you do not follow any of the above instructions, your Answer Sheet is liable to be rejected.
11. No replacement of OMR Sheet is possible.

SYLLABUS OUTLINE

SECTION I: ENGINEERING MATHEMATICS & SCIENCES (COMPULSORY)

Linear Algebra; Calculus; Differential Equations; Vector Analysis; Complex Analysis; Numerical Methods; Probability and Statistics; Fluid Mechanics; Material Science; Solid Mechanics; Polymer Science & Engineering; Thermodynamics; Basic elements of Information Technology and computer applications

SECTION II: RENEWABLE ENERGY (COMPULSORY)

General concepts & knowledge on different sources of new and renewable energy

SECTION III: COMPUTER SCIENCE AND INFORMATION TECHNOLOGY

Digital Logic; Computer Organization and Architecture; Programming and Data Structures; Algorithms; Theory of Computation; Compiler Design; Operating System; Databases; Computer Networks; Network Security; Big Data Analytics

SECTION IV: ELECTRONICS AND COMMUNICATIONS ENGINEERING

Networks, Signals and Systems; Continuous-time signals: Electronic Devices; Analog Circuits; Digital Circuits; Control Systems; Communications; Electromagnetics

SECTION V: MECHANICAL ENGINEERING

Applied Mechanics and Design: Engineering Mechanics; Mechanics of Materials; Theory of Machines; Vibrations; Machine Design;
Fluid Mechanics and Thermal Sciences: Fluid Mechanics; Heat-Transfer; Thermodynamics; Applications: *Power Engineering*;
Materials, Manufacturing and Industrial Engineering: Engineering Materials; Casting, Forming and Joining Processes; Machining and Machine Tool Operations; Metrology and Inspection; Computer Integrated Manufacturing; Production Planning and Control; Inventory Control; Operations Research

SECTION VI: PRODUCTION ENGINEERING

General Engineering: Engineering Materials; Applied Mechanics; Theory of Machines and Design; Thermal and Fluids Engineering
Manufacturing Processes: Casting; Metal Forming; Joining of materials; Powder processing; Polymers and Composites; Machine Tools and Machining; Non-traditional Manufacturing; Computer Integrated Manufacturing;
Quality and Reliability: Metrology and Inspection; Quality management; Reliability and Maintenance;
Industrial Engineering: Product Design and Development; Work System Design; Facility Design
Operations research and Operations management: Operation Research; Engineering Economy and Costing; Production control; Project management

SECTION VII: CIVIL ENGINEERING

Structural Engineering: Engineering Mechanics; Solid Mechanics; Structural Analysis; Construction Materials and Management; Concrete Structures; Steel Structures
Geotechnical Engineering: Soil Mechanics; Foundation Engineering;
Water Resources Engineering: Fluid Mechanics; Hydraulics; Hydrology; Irrigation;
Environmental Engineering: Water and Waste Water; Air Pollution; Municipal Solid Wastes; Noise Pollution
Transportation Engineering: Transportation Infrastructure; Highway Pavements:
Geomatics Engineering: Principles of surveying; Photogrammetry

SECTION VIII: AERONAUTICAL ENGINEERING

Flight Mechanics: Basics; Airplane performance; Static stability
Space Dynamics: Central force motion, determination of trajectory and orbital period in simple cases; Orbit transfer, in-plane and out-of-plane
Aerodynamics: Basic Fluid Mechanics; Airfoils and wings; Compressible Flows
Structures: Strength of Materials; Flight vehicle structures; Structural Dynamics
Propulsion: Basics; Thermodynamics of aircraft engines; Axial compressors; Axial turbines; Centrifugal compressor; Rocket propulsion

SECTION IX: ELECTRICAL ENGINEERING

Networks, Signals and Systems; Continuous-time signals: Electrical and Electronic Measurements; Electric Circuits; Power Systems; Control Systems; Communications; Electromagnetics; Electrical Machines; Power Electronics

MODEL PAPER (WRITTEN Test for the position of Assistant Director (Technical)

Notation used:
P - pressure, V - volume, T - temperature, S - entropy, H - enthalpy, U - internal energy, A - Helmholtz free energy, Cp - specific heat capacity at constant pressure.
Specific properties are designated by lower case symbols.

Useful data:
Universal gas constant $R = 8.314$ kJ/(kmol.K), C_p of air = 1.005 kJ/(kg.K)
Ratio of ideal gas specific heats for air: $\gamma = 1.4$ Molecular mass of hydrogen: 2 kg/kmol

Sample One or two mark Questions

SECTION I: ENGINEERING MATHEMATICS & SCIENCES (COMPULSORY)

1 Which of the following is a quasi-linear partial differential equation?

(A) $\frac{\partial^2 u}{\partial t^2} + u^2 = 0$

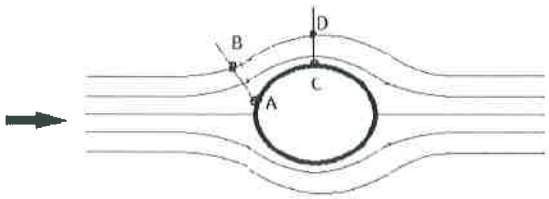
(B) $\left(\frac{\partial u}{\partial t}\right)^2 + \frac{\partial u}{\partial x} = 0$

(C) $\left(\frac{\partial u}{\partial t}\right)^2 - \left(\frac{\partial u}{\partial x}\right)^2 = 0$

(D) $\left(\frac{\partial u}{\partial t}\right)^4 - \left(\frac{\partial u}{\partial x}\right)^3 = 0$

Answer: A

2 The flow field shown over a bluff body has considerably curved streamlines. A student measures pressures at points A, B, C, and D and denotes them as PA, PB, PC, and PD respectively. State which one of the following statements is true. The arrow indicates the freestream flow direction.



(A) PA = PB and PC > PD (B) PA > PB and PC > PD
(C) PA = PB and PC < PD (D) PA > PB and PC < PD
Answer: D

3. Energy Dispersive Spectroscopy (EDS) in a typical scanning electron microscope enables elemental identification by collecting and examining which of the following:
(A) Secondary electrons from the sample
(B) Back scattered electrons from the sample
(C) Characteristic X-rays from the sample
(D) Diffraction pattern from the sample
Answer: C

4 A single degree of freedom vibrating system has mass of 5 kg, stiffness of 500 N/m and damping coefficient of 100 N-s/m. To make the system critically damped

(A) only the mass is to be increased by 1.2 times.
(B) only the stiffness is to be reduced to half.
(C) only the damping coefficient is to be doubled.
(D) no change in any of the system parameters is required.

Answer: D

5. An U-tube manometer shows a height difference of z_1 between the two columns for a known gauge pressure P_1 (both z_1 and P_1 in appropriate units). If the height difference between the two columns is $2z_1$, then the corresponding gauge pressure will be:

(A) $P_1/2$ (B) $2P_1$ (C) P_1 (D) $4P_1$

Answer: B

6. The polymer with minimum number of branches is

(A) HDPE (B) VLDPE (C) LDPE (D) LLDPE

Answer: C

7. A computer program that converts assembly language to machine language is

(A) Compilers (B) Interpreter (C) Assembler (D) Comparator

Answer: C

SECTION-II RENEWABLE ENERGY (COMPULSORY)

8. The following is not a renewable technology:

(A) Geothermal energy (B) Solar photovoltaics
(C) Nuclear energy (D) Wind energy

Answer: C

SECTION-III: COMPUTER SCIENCE & INFORMATION TECHNOLOGY

9. Consider the systems, each consisting of m linear equations in n variables.

If m < n, then all such systems have a solution
If m > n, then none of these systems has a solution
If m = n, then there exists a system which has a solution

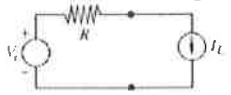
Which one of the following is CORRECT?

(B) I, II and III are true
(C) Only II and III are true
(D) Only III is true
(E) None of them is true

Answer: C

SECTION IV ELECTRONICS AND COMMUNICATIONS ENGINEERING

10. In the circuit shown below, V_S is a constant voltage source and I_L is a constant current load.



The value of I_L that maximizes the power absorbed by the constant current load is

(A) $V_S/4R$ (B) $/2R$ (C) V_S/R (D) ∞

Answer: B

SECTION-V: MECHANICAL ENGINEERING

11. The cross sections of two hollow bars made of the same material are concentric circles as shown in the figure. It is given that $r_3 > r_1$ and $r_4 > r_2$, and that the areas of the cross-sections are the same. J1 and J2 are the torsional rigidities of the bars on the left and right, respectively. The ratio J2/J1 is

(A) > 1 (B) < 0.5 (C) =1 (D) between 0.5 and 1

Answer: A

SECTION-VI: PRODUCTION ENGINEERING

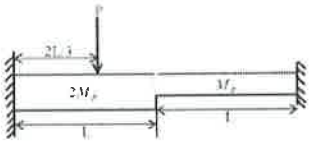
12. The elastic modulus of a rigid perfectly plastic solid is

(A) 0 (B) 1 (C) 100 (D) infinity

Answer: D

SECTION-VII: CIVIL ENGINEERING

13. A fixed-end beam is subjected to a concentrated load (P) as shown in the figure. The beam has two different segments having different plastic moment capacities $(M_p, 2M_p)$ as shown.



The minimum value of load (P)at which the beam would collapse (ultimate load) is

(A) $7.5M_p\ L$ (B) $5.0M_p\ L$ (C) $4.5M_p\ L$ (D) $2.5M_p\ L$

Answer: A

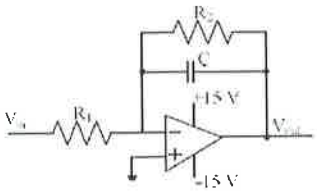
SECTION-VIII: AERONAUTICAL ENGINEERING

14 During an aircraft cruising flight, the altitude above the ground is usually measured using

(A) dynamic pressure. (B) static pressure. (C) radar (D) laser range finder

Answer: B

SECTION-IX: ELECTRICAL ENGINEERING



15 The circuit shown is an example of a

(A) low pass filter (B) band pass filter (C) high pass filter (D) notch filter

Answer: A

END OF THE MODEL PAPER

Recruitment for two posts of Assistant Director – Technical [S&C (UR) & IV (OBC)
Ref: Advertisement dt.2nd April – 8th April 2016 in the Employment News

ERRATA

TO THE GENERAL INSTRUCTIONS & SYLLABUS, SYLLABUS OUTLINE AND MODEL PAPER

Wherever "Electronics & Communications Engineering" appears

it should be read as

"Electrical, Electronics & Communications Engineering"