SECTION - A

1. This question consists of 35 THIRTY-FIVE multiple questions of ONE mark each. For each question, four possible alternatives (A, B, C and D) are given, out of which ONLY ONE is correct. Indicate the correct answer in the boxes corresponding to the questions only on the FIRST sheet of the answer book.

1.1 A die is rolled three times. The probability that exactly one odd number turns up among the three outcomes is

(a) $\frac{1}{6}$ (b) $\frac{3}{8}$ (c) $\frac{1}{8}$ (d) $\frac{1}{2}$

1.2 Consider the following set of equations:

$$x + 2y = 5$$
$$4x + 8y = 12$$
$$3x + 6y + 3z = 15$$

This set

(a) has unique solution
(b) has no solutions
(c) has finite number of solutions
(d) has infinite number of solutions

1.3 Which of the following statements applies to the bisection method used for finding roots of functions:

(a) converges within a few iterations
(b) guaranteed to work for all continuous functions
(c) is faster than the Newton-Raphson method
(d) requires that there be no error in determining the sign of the function.

1.4 Consider the function $y = |x|$ in the interval [-1,1]. In this interval, the function is

(a) continuous and differentiable
(b) continuous but not differentiable
(c) differentiable but not continuous
(d) neither continuous nor differentiable

1.5 What is the converse of the following assertion?

I stay only if you go

(a) I stay if you go
(b) If I stay then you go
(c) If you do not go then I do not stay
(d) If I do not stay then you go

1.6 Suppose A is a finite set with n elements. The number of elements in the largest equivalence relation of A is

(a) n (b) n^2 (c) 1 (d) n + 1

1.7 Let R_1 and R_2 be two equivalence relations on a set. Consider the following assertions:

(i) $R_1 \cup R_2$ is an equivalence relation

(ii) $R_1 \cap R_2$ is an equivalence relation

Which of the following is correct?

(a) Both assertions are true

(b) Assertion (i) is true but assertion (ii) is not true

(c) Assertion (ii) is true but assertion (i) is not true

(d) Neither (i) nor (ii) is true

1.8 The number of functions from an m element set to an n element set is

(a) m + n (b) m^n (c) n^m (d) m*n

1.9 If the regular set A is represented by A = (01 + 1)* and the regular set 'B' is represented by B = ((01)*1*)*, which of the following is true?

(a) A ⊂ B (b) B ⊂ A

(c) A and B are incomparable (d) A = B

1.10 Which of the following set can be recognized by a Deterministic Finite state Automaton?

(a) The numbers 1, 2, 4, 8, ……. 2^n, …… written in binary

(b) The numbers 1, 2, 4, ……..,2^n, ……..written in unary

(c) The set of binary string in which the number of zeros is the same as the number of ones.

(d) The set {1, 101, 11011, 1110111, ……..}

1.11 Regarding the power of recognition of languages, which of the following statements is false?

(a) The non-deterministic finite-state automata are equivalent to deterministic finite-state automata.

(b) Non-deterministic Push-down automata are equivalent to deterministic Push-down automata.

(c) Non-deterministic Turing machines are equivalent to deterministic Push-down automata.

(d) Non-deterministic Turing machines are equivalent to deterministic Turing machines.

(e) Multi-tape Turing machines are equivalent to Single-tape Turing machines.

1.12 The string 1101 does not belong to the set represented by

(a) 110*(0 + 1) (b) 1 (0 + 1)* 101

(c) (10)* (01)* (00 + 11)* (d) (00 + (11)*0)*

1.13 What happens when a bit-string is XORed with itself n-times as shown:

$\left[B \oplus \left(B \oplus \left(B \oplus (B \ldots n \text{ times}\right]\right.\right.\right.$

(a) complements when *n* is even (b) complements when *n* is odd

(c) divides by 2^n always

(d) remains unchanged when *n* is even

1.14 A multiplexor with a 4 bit data select input is a

(a) 4:1 multiplexor (b) 2:1 multiplexor

(c) 16:1 multiplexor (d) 8:1 multiplexor

1.15 The threshold level for logic 1 in the TTL family is

(a) any voltage above 2.5 V

(b) any voltage between 0.8 V and 5.0 V

(c) any voltage below 5.0 V

(d) any voltage below V_{cc} but above 2.8 V

1.16 In serial communication employing 8 data bits, a parity bit and 2 stop bits, the minimum band rate required to sustain a transfer rate of 300 characters per second is

(a) 2400 band (b) 19200 band

(c) 4800 band (d) 1200 band

1.17 The octal representation of an integer is 3428. If this were to be treated as an eight-bit integer is an 8085 based computer, its decimal equivalent is

(a) 226 (b) -98 (c) 76 (d) -30

1.18 Which of the following devices should get higher priority in assigning interrupts?

(a) Hard disk (b) Printer

(c) Keyboard (d) Floppy disk

1.19 Which of the following addressing modes permits relocation without any change whatsoever in the code?

(a) Indirect addressing (b) Indexed addressing

(c) Base register addressing (d) PC relative addressing

1.20 Which of the following is true?

(a) Unless enabled, a CPU will not be able to process interrupts.

(b) Loop instructions cannot be interrupted till they complete.

(c) A processor checks for interrupts before executing a new instruction.

(d) Only level triggered interrupts are possible on microprocessors

1.21 Which one of the following algorithm design techniques is used in finding all pairs of shortest distances in a graph?

(a) Dynamic programming (b) Backtracking

(c) Greedy (d) Divide and Conquer

1.22 Give the correct matching for the following pairs:

(A) O (log n)	(P) Selection
(B) O (n)	(Q) Insertion sort
(C) O (n log n)	(R) Binary search
(D) O $\left(n^2\right)$	(S) Merge sort

(a) A – R B – P C – Q D - S (b) A – R B – P C – S D - Q

(c) A – P B – R C – S D - Q (d) A – P B – S C – R D - Q

1.23 How many sub strings of different lengths (non-zero) can be found formed from a character string of length n?

(a) n (b) n^2 (c) 2^n (d) $\frac{n(n+1)}{2}$

1.24 Which of the following statements is false?

(a) A tree with a n nodes has (n – 1) edges

(b) A labeled rooted binary tree can be uniquely constructed given its postorder and preorder traversal results.

(c) A complete binary tree with n internal nodes has (n + 1) leaves.

(d) The maximum number of nodes in a binary tree of height h is $\left(2^{h+1}-1\right)$

1.25 In a resident – OS computer, which of the following systems must reside in the main memory under all situations?

(a) Assembler (b) Linker

(c) Loader (d) Compiler

1.26 Which of the following statements is true?
(a) SLR parser is more powerful than LALR
(b) LALR parser is more powerful than Canonical LR parser
(c) Canonical LR parser is more powerful than LALR parser.
(d) The parsers SLR, Canonical CR, and LALR have the same power

1.27 Type checking is normally done during
(a) lexical analysis (b) syntax analysis
(c) syntax directed translation (d) code optimization

1.28 A linker reads four modules whose lengths are 200, 800, 600 and 500 words, respectively. If they are loaded in that order, what are the relocation constants?
(a) 0, 200, 500, 600 (b) 0, 200, 1000, 1600
(c) 200, 500, 600, 800 (d) 200, 700, 1300, 2100

1.29 Which of the following is an example of a spooled device?
(a) The terminal used to enter the input data for the C program being executed
(b) An output device used to print the output of a number of jobs.
(c) The secondary memory device in a virtual storage system
(d) The swapping area on a disk used by the swapper.

1.30 When the result of a computation depends on the speed of the processes involved there is said to be
(a) cycle steating (b) rare condition
(c) a time lock (d) a deadlock

1.31 A counting semaphore was initialized to 10. Then 6 P (wait) operations and 4V (signal) operations were completed on this semaphore. The resulting value of the semaphore is
(a) 0 (b) 8 (c) 10 (d) 12

1.32 A computer has six tape drives, with n processes competing for them. Each process may need two drives. What is the maximum value of n for the system to be deadlock free?
(a) 6 (b) 5 (c) 4 (d) 3

1.33 Given two union compatible relations $R_1(A,B)$ and $R_2(C,D)$, what is the result of the operation $R_1A = CAB = DR_2$?
(a) $R_1 \cup R_2$ (b) $R_1 \times R_2$ (c) $R_1 - R_2$ (d) $R_1 \cap R_2$

1.34 Which normal form is considered adequate for normal relational database design?

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

1.35 There are five records in a database.

Name	Age	Occupation	Category
Rama	27	CON	A
Abdul	22	ENG	A
Jeniffer	28	DOC	B
Maya	32	SER	D
Dev	24	MUS	C

There is an index file associated with this and it contains the values 1,3,2,5 and 4.Which one of the fields is the index built from?

(a) Age (b) Name (c) Occupation (d) Category

2. This question consists of 20 (TWENTY) multiple-choice questions (2.1 – 2.20) of TWO marks each. The answers to the multiple choice questions of this section MUST be written only in the boxes corresponding to the questions, in the second page of the answer book.

2.1 The rank of the matrix given below is:

$$\begin{matrix} 1 & 4 & 8 & 7 \\ 0 & 0 & 3 & 0 \\ 4 & 2 & 3 & 1 \\ 3 & 12 & 24 & 2 \end{matrix}$$

(a) 3 (b) 1 (c) 2 (d) 4

2.2. Consider the following determinant $\Delta = \begin{vmatrix} 1 & a & bc \\ 1 & b & ca \\ 1 & C & ab \end{vmatrix}$.

Which of the following is a factor of Δ?

(a) a+b (b) a-b (c) a+b+c (d) abc

2.3. The binary relation $R = \{(1,1)\},(2,1),(2,2),(2,3),(2,4),(3,1),(3,2),(3,3),(3,4)$ on the set A = {1,2,3,4} is

(a) reflexive, symmetric and transitive

(b) neither reflexive, nor irreflexive but transitive

(c) irreflexive, symmetric and transitive

(d) irreflexive and antisymmetric

2.4. In a room containing 28 people, there are 18 people who speak English, 15 people who speak Hindi and 22 people who speak Kannada. 9 persons speak both English and Hindi, 11 persons speak both Hindi and Kannada whereas 13 persons speak both Kannada and English. How many people speak all three languages?

(a) 9 (b) 8 (c) 7 (d) 6

2.5. Let L be the set of all binary strings whose last two symbols are the same. The number of states in the minimum state deterministic finite 0 state automaton accepting L is

(a) 2 (b) 5 (c) 8 (d) 3

2.6. Which of the following statements is false?

(a) Every finite subset of a non-regular set is regular

(b) Every subset of a regular set is regular

(c) Every finite subset of a regular set is regular

(d) The intersection of two regular sets is regular

2.7. The function represented by the Karnaugh map given below is

A \ BC	00	01	10	11
0	1	1	0	1
1	1	0	0	1

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

2.8. Which of the following operations is commutative but not associative?

(a) AND (b) OR (c) NAND (d) EXOR

2.9. Formatting for a floppy disk refers to

(a) arranging the data on the disk in contiguous fashion

(b) writing the directory

(c) erasing the system area

(d) writing identification information on all tracks and sectors

2.10. The address space of 8086 CPU is

(a) one Megabyte (b) 256 Kilobytes
(c) 1 K Megabytes (d) 64 Kilobytes

2.11. A complete n-ary tree is one in which every node has O or n sons. If x is the number of internal nodes of a complete n-ary tree, the number of leaves in it is given by

(a) x(n – 1) +1 (b) xn - 1 (c) xn + 1 (d) x(n+1)

2.12. What value would the following function return for the input x = 95?

```
Function fun (x:integer):integer;
Begin
If x > 100 then fun : x – 10
    Else fun : fun(fun (x + 11))
End;
```

(a) 89 (b) 90 (c) 91 (d) 92

2.13. What is the result of the following program?

```
program side-effect (input, output);
var x, result: integer:
fucntion f (var x:integer):integer;
begin
        x:x+1;f:=x;
end
begin
        x:=5
        result:=f(x)*f(x)
        writeln(result)
        end
```

(a) 5 (b) 25 (c) 36 (d) 42

2.14. Let A be a two-dimensional array declared as follows:

A: array [1 …. 10] [1 …… 15] of integer;

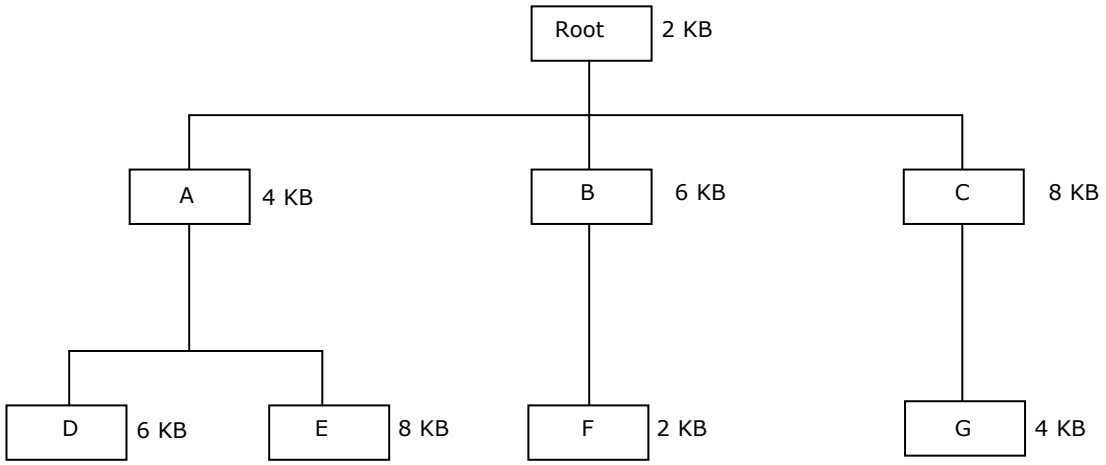
Assuming that each integer takes one memory locations the array is stored in row-major order and the first element of the array is stored at location 100, what is the address of the element A[i][j]?

(a) 15i + j + 84 (b) 15j + i + 84
(c) 10i + j + 89 (d) 10j + i + 89

2.15. Faster access to non-local variables is achieved using an array of pointers to activation records called a

(a) stack (b) heap
(c) display (d) activation tree

2.16. The overlay tree for a program is as shown below:



What will be the size of the partition (in physical memory) required to load (and run) this program?

(a) 12 KB (b) 14 KB (c) 10 KB (d) 8 KB

2.17. Consider n processes sharing the CPU in a round-robin fashion. Assuming that each process switch takes s seconds, what must be the quantum size q such that the overhead resulting from process switching is minimized but at the same time each process is guaranteed to get its turn at the CPU at least every t seconds?

(a) $q \le \frac{t-ns}{n-1}$ (b) $q \ge \frac{t-ns}{n-1}$ (c) $q \le \frac{t-ns}{n+1}$ (d) $q \ge \frac{t-ns}{n+1}$

2.18. If an instruction takes i microseconds and a page fault takes an additional j microseconds, the effective instruction time if on the average a page fault occurs every k instruction is:

(a) $i + \frac{j}{k}$ (b) $i + j * k$ (c) $\frac{i+j}{k}$ (d) $(i+j) * k$

2.19. Which of the following query transformations (i.e. replacing the l.h.s. expression by the r.h.s. expression) is incorrect? R_1 and R_2 are relations, C_1, C_2 are selection conditions and A_1, A_2 are attributes of R_1?

(a) $\sigma_{c1}(\sigma_{c1}(R_1)) \rightarrow \sigma_{c2}(\sigma_{c2}(R_1))$ (b) $\sigma_{c1}(\pi_{A1}(R_1)) \rightarrow \pi_{A1}(\sigma_{c1}(R_1))$

(c) $\sigma_{c1}(R_1 \cup R_2) \rightarrow \sigma_{c1}(R_1) \cup \sigma_{c1}(R_2)$ (d) $\pi_{A1}(\sigma_{c1}(R_1)) \rightarrow \sigma_{c1}(\pi_{A1}(R_1))$

2.20. Suppose the domain set of an attribute consists of signed four digit numbers. What is the percentage of reduction in storage space of this attribute if it is stored as an integer rather than in character form?

(a) 80% (b) 20% (c) 60% (d) 40%

3. (a) Two friends agree to meet at a park with the following conditions. Each will reach the park between 4.0 p.m. and 5.00 p.m. and will see if the other has already arrived. If not, they will wait for 10 minutes or the end of the hour whichever is earlier and leave. What is the probability that the two will not meet?

(b) Give a regular expression for the set of binary strings where 0 every is immediately followed by exactly k 1's and preceded by at least k 1's (k is a fixed integer)

4. Design a deterministic finite state automaton (using minimum number of states) that recognizes the following language:

L = {w ∈ {0, 1}*|w interpreted as binary number (ignoring the leading zeros) is divisible by five.

5. (a) The implication gate, shown below has two inputs (x and y); the output is 1 except when x = 1 and y = 0, realize f = $\bar{x}y + x\bar{y}$ using only four implication gates.

(b) show that the implication gate is functionally complete.

6. (a) Solve the following recurrence relation

$x_n = 2x_{n-1} - 1, n > 1$

$x_1 = 2$

(b) Consider the grammar

S → Aa|b

A → Ac|Sd|∈

Construct an equivalent grammar with no left recursion and with minimum number of production sales.

7. (a) Suppose we have a database consisting of the following three relations.

FREQUENTS (student, parlor) giving the parlors each student visits.

SERVES (parlor, ice-cream) indicating what kind of ice-creams each parlor serves.

LIKES (student, ice-cream) indicating what ice-creams each student likes.

(Assume that each student likes at least one ice-cream and frequents at least one parlor)

Express the following in SQL:

Print the students that frequent at least one parlor that serves some ice-cream that they like.

(b) In a computer system where the 'best-fit' algorithm is used for allocating 'jobs' to 'memory partitions', the following situation was encountered:

Partitions sizes in KB	4K 8K 20K 2K
Jobs sizes in KB	2K 14K 3K 6K 6K 10K 20K 2K
Time for execution	4 10 2 1 4 1 8 6

When will the 20K job complete?

SECTION – B

This section consists of TWENTY questions numbered 8 to 27 of FIVE marks each. Attempt ANY TEN questions. Answers must be given in the answer book provided. Answer for each question must start on a fresh page and must appear at one place only. (Answers to all parts of a question must appear together).

8. (a) Find the points of local maxima and minima, if any, of the following function defined in $0 \le x \le 6$.

$x^3 - 6x^2 + 9x + 15$

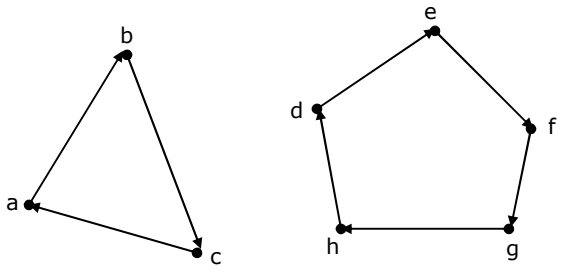
(b) Integrate

$$\int_{-\pi}^{\pi} x \cos x dx$$

9. Derive the expression for the number of operations required to solve a system of linear equations in n unknowns using the Gaussian Elimination Method. Assume that one operation refers to a multiplication followed by an addition.

10. (a) Prove by induction that the expression for the number of diagonals in a polygon of n sides is $\frac{n(n-3)}{2}$

(b) Let R be a binary relation on A = {a, b, c, d, e, f, g, h} represented by the following two component digraph. Find the smallest integers m and n such that m < n and $R^m = R^n$.



11. Suppose A = {a,b,c,d} and Π_1 is the following partition of A

Π_1 ={{a,b,c}{d}}

(a) List the ordered pairs of the equivalence relations induced by Π_1.

(b) Draw the graph of the above equivalence relation.

(c) Let $\Pi_2 = \{\{a\},\{b\},\{C\},\{d\}\}$

$\Pi_3 = \{\{a,b,c,d\}\}$

and $\Pi_4 = \{\{a,b\}\{c,d\}\}$

Draw a Poset diagram of the poset,

$\langle\{\Pi_1,\Pi_2,\Pi_3,\Pi_4\},$ refines$\rangle$

12. Let (A, *) be a semigroup, Furthermore, for every a and b in A, if a ≠ b, then a*b, b ≠ b*a.

(a) Show that for every a in A

a*a =a

(b) Show that for every a, b in A

a*b*a =a

(c) Show that for every a, b, c in A

a*b*c = a*c

13. Let $M = (\{q_0,q_1\},\{0,1\},\{z_0,X\},\delta,q_0,z_0,\phi)$ be a Pushdown automation where δ is given by

$$\delta(q_0,1,z_0) = \{(q_0,xz_0)\}$$
$$\delta(q_0,\in,z_0) = \{(q_0,\in)\}$$
$$\delta(q_0,1,X) = \{(q_0,XX)\}$$
$$\delta(q_1,1,X) = \{(q_1,\in)\}$$
$$\delta(q_0,0,X) = \{(q_1,X)\}$$
$$\delta(q_0,0,z_0) = \{(q_0,z_0)\}$$

(a) What is the language accepted by this PDA by empty store?

(b) Describe informally the working of the PDA.

14. (a) Let G_1 = (N, T, P, S_1) be a CFG where,

N = {S_1, A, B} T = {a, b} and

P is given by

$S_1 \rightarrow a, S_1 b$ $S_1 \rightarrow a B b$

$S_1 \rightarrow a A b$ $B \rightarrow Bb$

$A \rightarrow a A$ $B \rightarrow b$

$A \rightarrow a$

What is $L(G_1)$?

(b) Use the grammar in Part (a) to give a CFG for $L_2 = \left(a^i b^j a^k b^1 \,|\, i, j, k.1 \geq 1, i = j \text{ or } k = 1\right)$ by adding not more than 5 production rules.

(c) Is L_2 inherently ambiguous?

15. (a) Draw the schematic of 8085 based system that can be used to measure the width of a pulse. Assume that the pulse is given as a TTL compatible signal by the source, which generates it.

(b) Write the 8085 Assembly Language program to measure the width of the pulse. State all your assumptions clearly.

16. Design a synchronous counter to go through the following states:

1, 4, 2, 3, 1, 4, 2, 3, 1, 4 ……

17. Calculate the total time required to read 35 sectors on a 2-sided floppy disk. Assume that each track has 8 sectors and the track-to-track step time is 8 milliseconds. The first sector to be read is sector 3 on track 10. Assume that the diskette is soft sectored and the controller has a 1-sector buffer. The diskette spins at 300 RPM and initially; the head is on track 10.

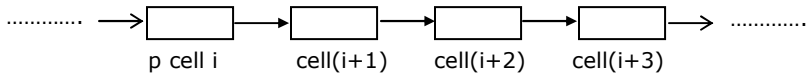
18. For a set-associative Cache Organization, the parameters are as follows:

t_c	--	Cache access time
t_m	--	Main memory access time
l	--	number of sets
b	--	block size
k * b	--	set size

Calculate the hit ratio for a loop executed 100 times where the size of the loop is n * b, and n = k*m is a non-zero integer and $1 < m \leq 1$.

Give the value of the hit ratio for 1 = 1

19. (a) Let p be a pointer as shown in the figure in a single linked list.



What do the following assignment statements achieve?

q: = p → next

p → next:=q → next

p → next:=(q → next) → next

(p → next) → next:=q

(b) Compute the post fix equivalent of the following expression.

$3 * \log(x+1) - \frac{a}{2}$

20. Draw the binary tree with node labels a, b, c, d, e, f and g for which the inorder and postorder traversals result in the following sequences.

Inorder	a f b c d g e
Postorder	a f c g e d b

21. (a) Derive a recurrence relation for the size of the smallest AVL tree with height h.

(b) What is the size of the smallest AVL tree with height 8?

(c)

22. (a) An identifier in a programming language consists of up to six letters and digits of which the first character must be a letter. Derive a regular expression for the identifier.

(b) Build an LL (1) parsing table for the language defined by the LL(1) grammar with productions

Program → begin d semi X end

X → d semi X | sY

Y → semi s Y | ∈

23. Let the attribute 'val' give the value of a binary number generated by S in the following grammar:

S → L.L | L

L → LB | B

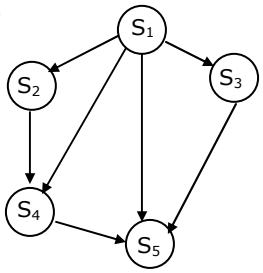
B → 0 | 1

For example, an input 101.101 give S.val = 5.625

Construct a syntax directed translation scheme using only synthesized attributes, to determine S.val.

24. (a) Four jobs are waiting to be run. Their expected run times are 6, 3, 5 and x. in what order should they be run to minimize the average response time?

(b) Write a concurrent program using par begin-par end to represent the procedure graph shown below.



25. (a) Free disk space can be kept track of using a free list or a bit map. Disk addresses require d bits. For a disk with B blocks, F of which are free, state the condition under which the free list uses less space than the bit map.

(b) Consider a disk with C cylinders, t tracks per cylinder, s sectors per track and a sector length sl. A logical file dl with fixed record length rl is stored continuously on this disk starting at location (c_L,t_L,s_L), when C_L, t_L and S_L are the cylinder, track and sector numbers, respectively. Derive the formula to calculate the disk address (i.e. cylinder, track and sector) of a logical record n assuming that rl = sl.

26. Consider the following database relations containing the attributes

Book – id

Subject – Category – of – book

Name – of – Author

Nationality – of – Author

With book – id as the primary key.

(a) What is the highest normal form satisfied by this relation?

(b) Suppose the attributes Book – title and Author – address are added to the relation, and the primary key is changed to {Name – of – Author, Book – title}, what will be the highest normal form satisfied by the relation?

27. Consider the following relational database schemes:

COURSES (Cno.name)

PRE-REQ(Cno, pre-Cno)

COMPLETED (student – no, Cno)

COURSES gives the number and name of all the available courses.

PRE-REQ gives the information about which courses are pre-requisites for a given course.

COMPLETED indicates what courses have been completed by students.

Express the following using relational algebra:

List all the courses for which a student with student-no 2310 has completed all the pre-requisites.