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ALGORITHM
BY-RAVI SIR**

- Theory
- Explanation
- Derivation
- Example
- Shortcuts
- Previous Years Question With Solution

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ALGORITHM

- 1. Notations
- 2. TC/SC of loops & Recursive Algo
- 3. Methods to solve Rec. Relations (Substitution, Rec. Tree, Master Methods)
- 4. Algo design techniques
 - divide & conquer
 - Greedy
 - DP
- 5. Binary Heaps
- 6. Graph Traversal
- 7. Sorting algo

INTRODUCTION

Algorithm: step by step rep of computer program.

Finite Number of steps to perform some task.

Criteria of Algorithm

① finiteness - algo must terminate in finite amt of time.

② Definiteness - each step of algo must be unambiguous (have a unique solⁿ)
(Such algo are also called Deterministic Algo) Analogy: DFA

Non Deterministic Algo: for each step of algo, there exists finite no. of solutions. Analogy: NFA

→ Algo should choose correct solⁿ in one attempt
→ Not possible to run in computers.

eg $a[1...n]$ searching

Det Algo

```
#comp = n
for (i=1; i<=n; i++)
{
    if (n==a[i])
        return i;
    else
        return -1;
}
```

feasible

Non Det Algo

```
i = choose(1, n);
if (x == a[i])
    return i;
else
    return -1;
#comp = 1
```

Not feasible



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Compiler Design.

- Basis of a compiler.
- Lexical Analysis
- Syntax Analysis
- Syntax Directed Translation.
- Intermediate code generation.
- code Organisation.
- Run time Environment.

* Basis of a Compiler.

- Language Translator
- Language Processing System.
- Types of Compiler
- Phases of Compiler.
- Single Pass & Multipass Compiler.

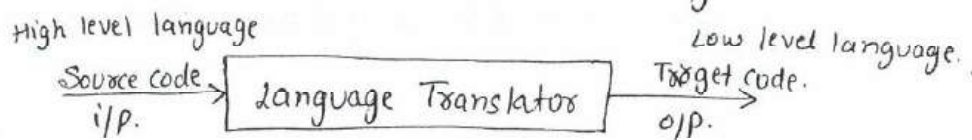
* Lexical Analysis:

- Divides into tokens
- Recognition of tokens
- Create Symbol Table
- Error Recovery Methods.
- Interacts with Syntax Analyzer.
- Lex Tool.

BASICS OF COMPILER.

LANGUAGE TRANSLATOR.

Language Translator takes one language as input and produces other languages as output. Generally the i/p is Source code and output is Target code.



Types of language Translator:-

- Compiler
- Interpreter.
- Assembler.

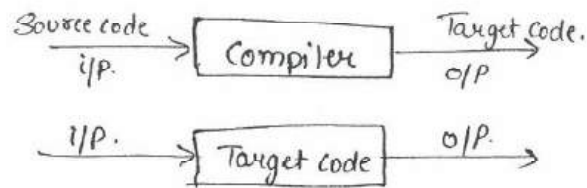
Compiler.

Compiler takes the Source code as input and produces the target code as output. If that target code is an executable code then it will be called by the user to process the inputs for producing the output.

- Compiler executes the entire code at a time, if any error occurs at any line all of them will be given at a time.
- Error diagnosis is not easy in compiler than compare to interpreter but output generation by compiler is faster than interpreter.
- Compiler is an offline process.
- Compiler requires more memory than the interpreter.

- The end user cannot make the modifications easily to the compiled program.

Eg:- C, C++, Pascal etc.



Interpreter.

- Interpreter takes the source code as input and produces the direct output. It will not produce any intermediate language as in the case of compiler.
- Interpreter executes the code line by line, if any error occurs at any line then immediately it will produce that error to the user.
- Until we resolve that error the interpreter will not move to the next line.
- Interpreter executes every statement of the program and simultaneously it processes the inputs also, thus interpreter is an online process. After completing the execution of the last line of the program, immediately it will produce the output.
- If we change the input then interpreter again executes the total program from top to bottom. Therefore output generation by interpreter is slower than the compiler.



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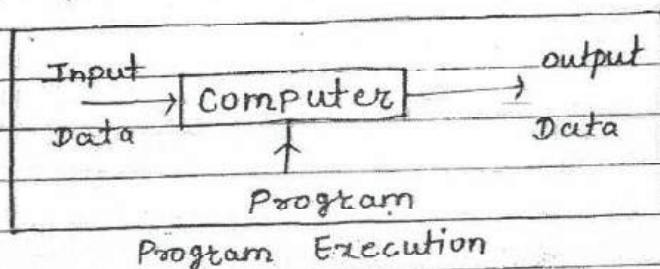
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Data Representation

1.

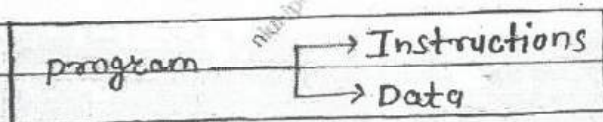
Computer →

It is a computational device used to process the data under the control of a application program which is initiated by the user. So computer system functionality is program execution.



Program →

It is a sequence of instructions along with a data used to perform some task.



Instructions →

It is a binary code which is predefined in the processor to perform some operation

Binary Code	Bind with	operation
-------------	-----------	-----------

eg → If CPU-X supports "8"

diff. operation then

$$\text{Binary code [opcode] size} = \log_2^8 \text{ bit}$$

$$= \log_2^2^3 = 3 \text{ bit}$$

Binary operation
Code

000	→	+	Decided by designer	Prepare the	Submitted
001	→	-	ROM	⇒ instruction ⇒	to the
010	→	*		Manual	user
111	→	AND	control unit (Brain of CPU)		

Q. → 1. Consider a system with 200 instructions (operation) opcode size is ?

Q. → 2. Consider a system with 9 bit opcode. Instruction set size (# instruction) is ?

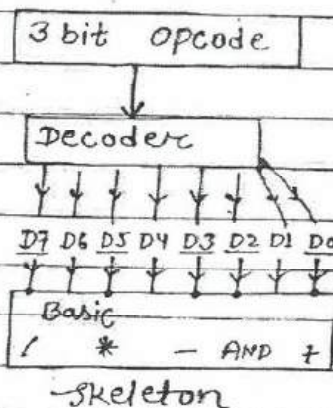
Q. → 3. Consider a system with 1020 instructions, 40 registers and 8K cells of a memory -

(i) opcode size is ?

(ii) Register Address is ?

(iii) Memory Address is ?

Q. → 4. Consider the following design -



(i) What is the opcode of a 'multiplication'?

(ii) What is the opcode of a 'AND' operation?

(iii) What is the opcode of a 'division' operation?

(iv) What is the size of 'Instruction set'?

Ans. 1 opcode = $\log_2^{200}$ bit

= $\log_2^{2^8}$ bit = 8 bit

Ans. 2 Instructions = $2^9 = 512$

Ans. 3 (i) $\log_2^{1020}$ bit

= $\log_2^{2^{10}}$ bit = 10 bit opcode size

(ii) $\log_2^{40}$ bit

= $\log_2^{2^6}$ bit = 6 bit Reg. add.

(iii) $\log_2^{8K}$ bit

= $\log_2^{2^3 \times 2^{10}}$ bit = $\log_2^{2^{13}}$ = 13 bit Memory add.

Ans. 4 (i) 101

* $\rightarrow D_5$

(ii) 010

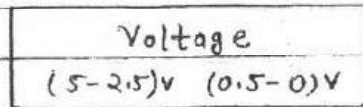
AND $\rightarrow D_2$

(iii) 111

/ $\rightarrow D_7$

(iv) # instruction = 5

Designer View →



Logic '1' Logic '0'

H/w chip

Assume

S₃₉₉₉ S₂ S₁ S₀

4000 Signals

Encoder

N: $\log_2^N$ bit

12 bit Binary code

Hexa Decimal Code

Low Level Language

Assembly code

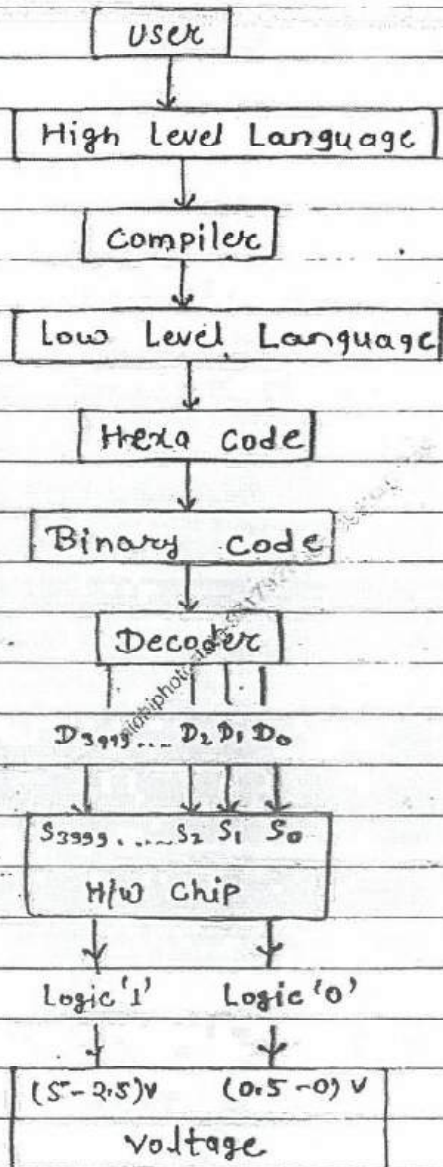
Compiler

system software

High level language

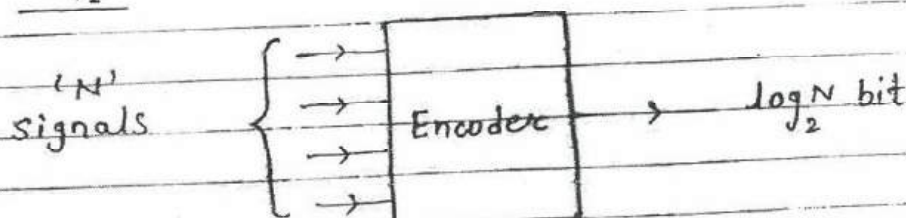
C-Code

User

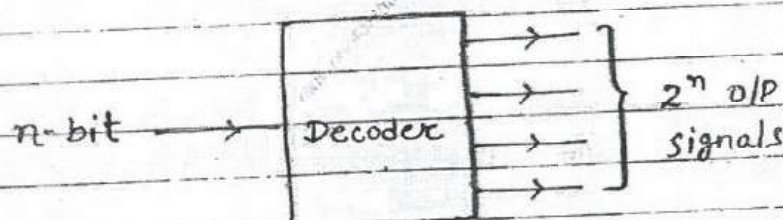
User view →

Encoding →

In this process, N signals are representing with $\log_2 N$ bit format.

# Decoding →

In this process, n -bit decoder produces 2^n o/p signals.

# Data →

It is a binary code which is associated with a value base on the data format.

Binary	Bind	value.
Code	with	

eg → (101)₂

$$\textcircled{1} \quad \begin{array}{ccc} 2 & 1 & 0 \\ 1 & 0 & 1 \end{array} = 5$$

$$(1 \times 2^2) + (0 \times 2^1) + (1 \times 2^0)$$

$$\underbrace{4 + 0 + 1}_{5}$$

unsigned format

$$\textcircled{2} \quad \begin{array}{ccc} 1 & 0 & 1 \\ \hline 1 & 0 & 1 \end{array} = -1$$

signed format

$$\textcircled{3} \quad \begin{array}{ccc} 1 & 0 & 1 \\ \hline 1 & 0 & 1 \end{array} = -2$$

$$101 \rightarrow 010 (2)$$

1's complement

$$\textcircled{4} \quad \begin{array}{ccc} 1 & 0 & 1 \\ \hline 1 & 0 & 1 \end{array} = -3$$

$$101 \rightarrow 010$$

$$\begin{array}{ccc} & 1 & \\ 0 & 1 & 1 \end{array} (3)$$

2's complement

⑤ fraction = floating point

Data Representation →

Data formats

Fixed Point Data

Floating Point Data

Single Precision
(32 bit) format

Double Precision
(64 bit) format

Magnitude format

Complement format

(Take complement to
report the value when
sign is -ve)

Unsigned format
(only +ve data)

Signed-magnitude
format
(+ve & -ve)

n -bit $[0 \text{ to } (2^n - 1)]$
range

MSB				LSB
↓ sign	value			

$[-(2^{n-1} - 1) \text{ to } +(2^{n-1} - 1)]$

1's complement
(+ve & -ve)

2's complement
(+ve & -ve)

$\{-(2^{n-1} - 1) \text{ to } +(2^{n-1} - 1)\}$

$\{-(2^{n-1}) \text{ to } +(2^n - 1)\}$



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Computer Networking

NIC card

09

Physical address

09

Ethernet address

09

Implicit address

09

MAC address

48 bit address

Hexadecimal notation: 14:1A:12:13:12:16

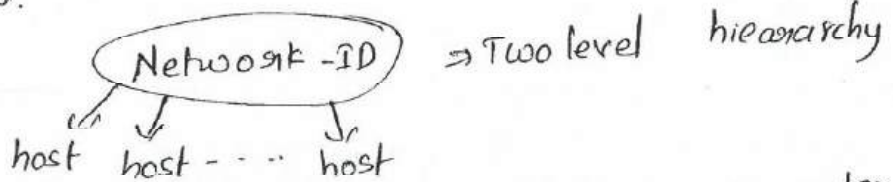
IANA → Internet Assign Number Authority.

Classful Addressing (Class) → A, B, C, D, E

A B C D Supports unicasting

D Supports multicasting

E is reserved.



Host → whenever an IP address is assign. to computer it is known as host.

classful addressing:

i) Binary notation:

0100 0000 . 10101010 . 10001101 . 11100010

2) Dotted decimal Notation.

41-89-99-121

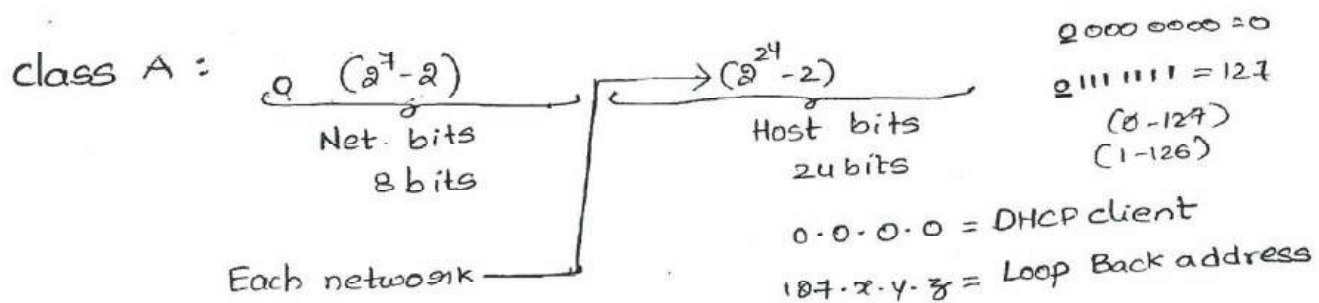
41 → 0110 0011

89 → 10111110

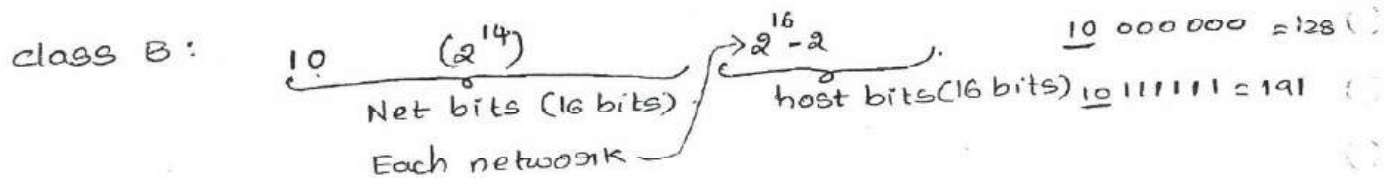
121 → 01111001

In Binary notation starting few bits will decide the type of class

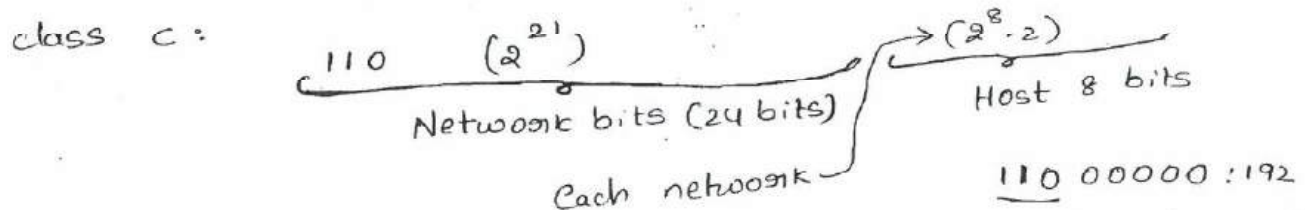
In the dotted decimal notation first octet will decide the type of class.



Eg: 40.50.60.70
 $\rightarrow$ class A.



Eg: 136.41.93.89
 $\rightarrow$ class B



Eg: 194.89.99.112
 $\rightarrow$ class C

class D: 1110

multicasting

225 . 14 . 16 . 17
↳ class D

1110 0000 : 224

1110 1111 : 239

class E: 1111

1111 0000 = 240

1111 1111 = 255

i) Network mask (or) Default mask { N bits = 1's
Host bits = 0's }

Allowing Something & Stopping Something

Class A: 1111 1111 0000 0000 0000 0000 0000 0000

255.0.0.0

Class B: 1111 1111 1111 1111 0000 0000 0000 0000

255.255.0.0

Class C: 255.255.255.0

1) IP₁ = 201.44.89.99

Net ID: ?

Direct Broadcast address of Network: ?

IP: 201.44.89.99

mask: 255.255.255.0

& Bitwise AND

201.44.89.0

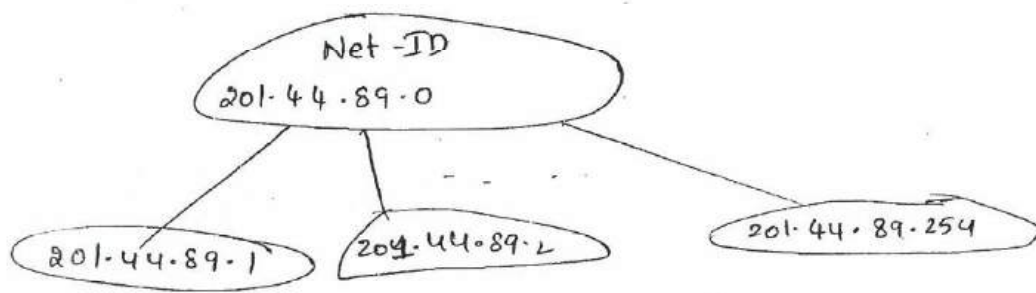
201: 11001001
255: 11111111
201: 11001001

Net - ID = 201.44.89.0

By performing Bitwise AND b/w IP address & Network

mask will get Network ID.

2)



the Direct Broadcast address = 201.44.89.255 → to send data to all hosts in the n/w Id.

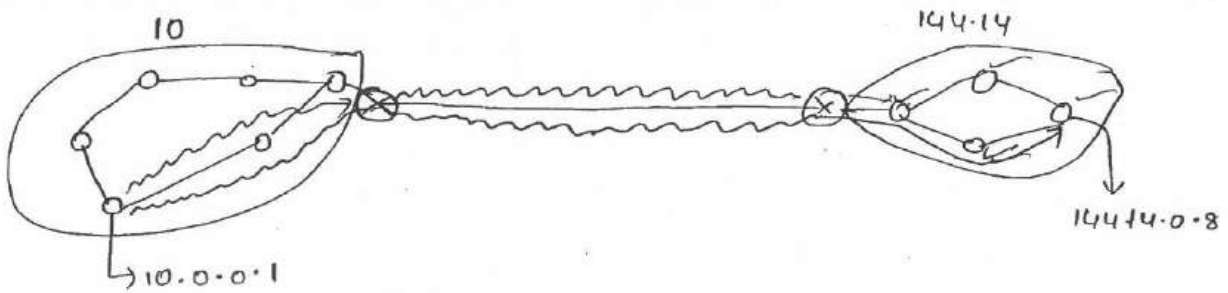
we are subtracting two addresses in the number of hosts in each network because one is used for Net-ID and other one is used for DBA of the network.

2) IP₁: 144.89.99.142

Net-ID: 144.89.0.0

DBA: 144.89.255.255

Pseudo approach of N/w:



①

	S-IP	D-IP
D	10.0.0.1	144.14.0.8

⇒ unicasting packet b/w Networks

②

	S-IP	D-IP
D	10.0.0.1	144.14.255.255

⇒ Broadcasting on the other Network

↓
Direct Broadcast address

ⓑ D.B.A is always used as destination IP.

③

	S-IP	D-IP
D	10.0.0.1	10.0.0.6

⇒ unicasting is same network

4) Special case

	S-IP	D-IP
D	10.0.0.1	255.255.255.255

⇒ Broadcasting within network.

↓
LBA
Limited Broadcast address
(Scope is local)

	S-IP	D-IP
D	255.255.255.255	10.0.0.1

which of the following is used as destination IP only.

a) 10.255.255.255

b) 172.16.0.1

c) 192.168.8.3

d) 255.255.255.255

Drawbacks of classful addressing:

Class A: $(2^7 - 2)$ Networks $\Rightarrow$ each network $(2^{24} - 2)$ hosts 90,00,000

Class B: $(2^{14} - 2)$ Networks $\Rightarrow$ each network $(2^{16} - 2)$ hosts 65,534

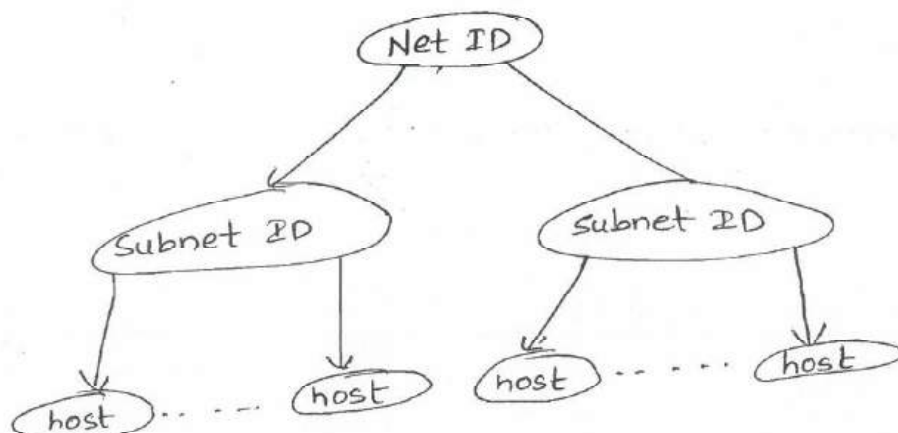
Class C: 2^{21} Networks $\Rightarrow$ each network $(2^8 - 2)$ hosts 254

Subnetting

Supernetting

Subnetting

Dividing a Network into small parts for effective utilisation of IP addresses. is known as what Subnetting.



In class C:

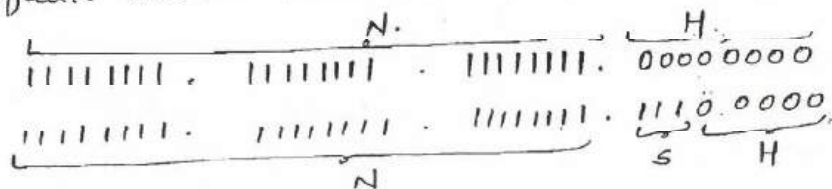
if subnet mask: 255.255.255.224

No. of subnets: $2^3 - 2 = 6$

No. of hosts in each subnet: $2^5 - 2 = 30$

Sol:

default subnet mask of C:



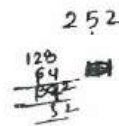
During subnetting Subnet bits are borrowed from Host bits.

2) In class B

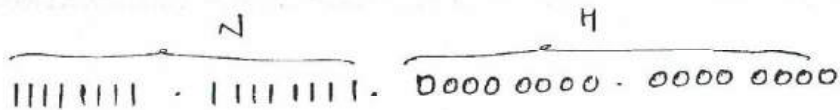
if subnet mask = 255.255.252.0

No. of subnets = ? $2^6 - 2 = 62$

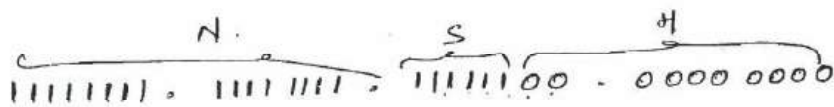
No. of hosts in each subject = ? $2^{10} - 2 = 1022$



Subnet mask of class B:



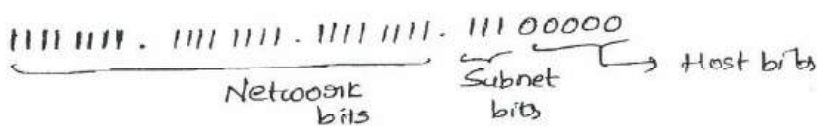
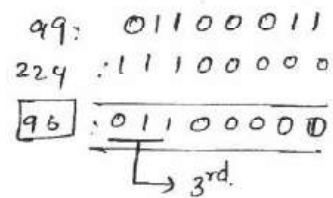
Given



3) IP: 201.44.89.99 ^{→ class C}

Subnet mask: 255.255.255.224

(1) subnet ID: 201.44.89.96



2) Subnet no: 3rd subnet.

For a Subnet ID host bits will always be zero's

∴ Subnet mask will give the information how many are the

subnet bits and host bits.



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**Computer Science Engineering / IT
Toppers Handwritten Notes
Database Management System
By-Ravi sir**

- Theory
- Explanation
- Derivation
- Example
- Shortcuts
- Previous Years Question With Solution

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Database Management System :

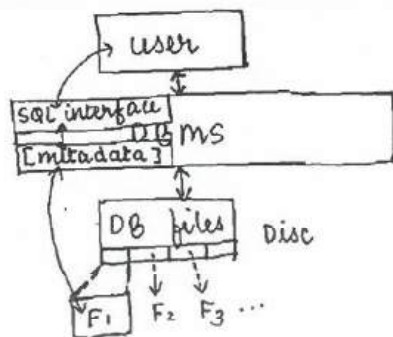
1. Integrity constraints and ER Model 1-2 marks
2. Normalization 2-4 marks
3. Queries (relational algebra, SQL, relational calculus) 4 marks
4. File organization and Indexing (B / B+ Tree) 2-4 marks
5. Transactions and concurrency control. 2-4 marks

Reference Books -

- 1) DBMS - Raghuramkrishnan
- 2) DBMS - Navathe

→ Introduction :

- Database - structured collection of related data which is stored in computer system to access data when it is required.
- University DB students info [collection of
 faculty info files]
 course info etc.
- Database management system - application software to define, manipulate and access data from database.



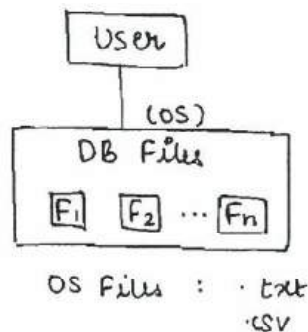
} Interface b/w user and DB files

- metadata - data about data
- also called data dictionary
- Format of file
- Format of row and column
- All storage info related to DB files

- Flat file system [OS files] - user manage database files without using DBMS.

- Small database is managed.

Flat file system fails to manage huge DB.



Limitations of Flat File System

Adv. of DBMS File System

- i) Too complex to manage app^h programs. Complete info of the program should be managed by user.
(DBA
• DB developer
• end user)
- ii) more I/O cost (and access cost) to access required data from db files
- iii) less degree of concurrency
- iv) Too complex to maintain non-redundant data
- v) Too complex to maintain different levels of access control.

- i) Easy to develop app^h programs because of data independency.
(Changes of file structure is not affected for user app^h, user can use db files without knowing storage info)
- ii) less I/O to access required data from db files from using indexing.
- iii) more degree of concurrency
- iv) easy to maintain non-redundant data by using normalization.
- v) By using views (virtual tables) can maintain different levels of access control.

→ Integrity constraints : based on RDBMS model
 ↳ correctness of data

• Data model - logical structure of DB files

- ↳ RDBMS (in syllabus) : - is widely used
 - ↳ ODBMS
 - ↳ NWDBMS
 - ↳ Hierarchical DBMS
- Codd's data model (By E.F. Codd)
 - Codd proposed 12 rules to design RDBMS software. (RDBMS guidelines)

• RDBMS Guidelines -

- i) data in db files must be in tabular format. (set of rows & cols)
- ii) no two rows of the table should be same.
- iii) Every RDBMS table must have atleast one candidate key.
- iv) Every attribute of RDBMS table must be single valued (atomic)

Eg:

Sid	Sname	Cid
S ₁	A	{C ₁ , C ₂ }
S ₂	B	{C ₂ , C ₃ }

 ← multivalued attribute not allowed in RDBMS

- v) Number of columns for each row and no. of rows for each col. must be same.
- vi) Name of one column is called attribute (or field)
- vii) Name of one row is called record or Tuple
- viii) Set of all records of the table is called relational instance (or snapshot)

Stud

Sid	Sname	DOB
S ₁	A	2000
S ₂	B	2000
S ₃	C	2002
S ₄	D	2004

relational instance

Attribute field

Tuple

: set of all records of DB Table

cardinality : 4

arity : 3

• Relational schema - definition of table

Eg: Stud (sid, sname, DOB)

• Arity - number of attributes of the table

• cardinality - number of records of the table

• domain of attribute - set of possible values accepted by the attribute.

• data type -

- char (10)

- varchar (20)

- Integer (10)

- text (for long text/para)

- Boolean

- Date (excluding time) DD/MM/YYYY

- Timestamp (including time)

• Candidate key - minimal set of attributes to differentiate records of the relation uniquely.

E.g.) [sid] : CK ✓

[sid, sname] : not CK as it is not minimal

• Let [A B] be a candidate key

- Then A B is unique for all records

- no proper subset attributes of {A, B} can differentiate records uniquely.

• "student can enroll many courses"

"course can be enrolled by many students"

sid	cid	fee
S1	C1	-
S1	C2	-
S2	C2	-
S4	C2	-

cand Key
[sid, cid]

NOTE:

NULL - unknown value
on unexisting value

Emp

eid	ename	DOB	panid	IFSC	A.No	Acc
e1	A	2000	X5	SBIC01		101
e2	B	NULL	NULL	SBIC01		102
e3	C	2005	NULL	ICIC101		101
e4	D	NULL	X2	ICIC01		102

- prime attribute - attribute which belongs to some candidate key of the relation.
- Emp { eid, ename, DOB, panID, adharID, IFSC, Acc }
- cand key { eid, panID, adharID, IFSC, Acc }
- Thus { eid, ename, panID, adharID, IFSC, Acc } are prime attributes
- prime attribute set - { eid, panID, adhar, IFSC, Acc }
- non-prime attributes - attributes which does not belong to any key of the relation.
- non-prime attribute set - { ename, DOB }

* Atleast one candidate key whose field values must be NOT NULL (in RDBMS)

create table R
(A integer(3) NOT NULL UNIQUE,
B integer(3) UNIQUE,
C integer(3)
);

create table R
(A integer(3) primary key,
B integer(3) UNIQUE,
C integer(3)
);

* UNIQUE NOT NULL $\neq$ Primary Key
default index
default ordering

• Superkey - attribute set which can differentiate the records of relation uniquely (but may not be minimal attribute set)

stud	Sid	sname	DOB
S1	A	2000	
S2	A	2000	
S3	B	2005	
S4	B	2005	

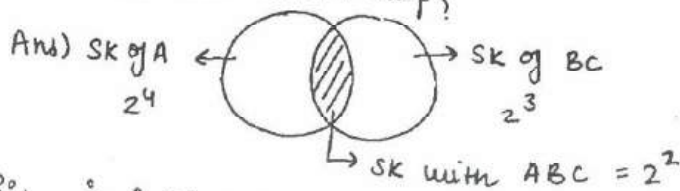
cand key { Sid } : minimal superkey
superkeys { Sid,
Sid sname,
Sid DOB,
Sid sname DOB

Ques) $R(A B C D)$ How many superkeys in R with cand key $\{A\}$?

Ans) $A \cdot \{ \text{any subset of } BCD \} \Rightarrow A \cdot \{ \text{Sub of } BCD \}$
 $\Rightarrow A \cdot 2^3$

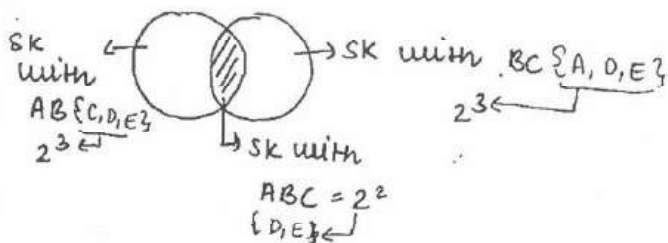
Thus, 8 superkeys are there with cand key $\{A\}$

Ques) $R(A B C D E)$ How many SK's in R (i) if $\{A, BC\}$ are the cand key?



$$\begin{aligned} \text{Total superkeys } n(X \cup Y) &= n(X) + n(Y) - n(X \cap Y) \\ &= 2^4 + 2^3 - 2^2 \\ &= 16 + 8 - 4 \\ &= 20 \text{ superkeys} \end{aligned}$$

ii) if $\{AB, BC\}$ are the cand key?



$$\begin{aligned} \text{Total superkeys} &= \\ &= 2^3 + 2^3 - 2^2 \\ &= 8 + 8 - 4 \\ &= 12 \text{ superkeys} \end{aligned}$$

Method 2 :

$$\# \text{ of superkeys of } R = \left\{ \# \text{ of superkeys among prime attr of } R \right\} * 2^{\# \text{ of non prime attributes}}$$

i) $\{A, BC\}$

$$\# \text{ of superkeys} = \left\{ \begin{matrix} A, ABC \\ AB, BC \\ AC \end{matrix} \right\} * 2^{\{D, E\}} = 5 * 2^2 = 20 \text{ superkeys}$$

here prime attributes = A, B, C

& non prime attributes = D, E

ii) $\{AB, BC\}$

$$\begin{aligned} \# \text{ of superkeys} &= \left\{ \begin{matrix} ABC, BC \\ AB \end{matrix} \right\} * 2^{\{D, E\}} \\ &= 3 * 2^2 \\ &= 12 \text{ superkeys} \end{aligned}$$

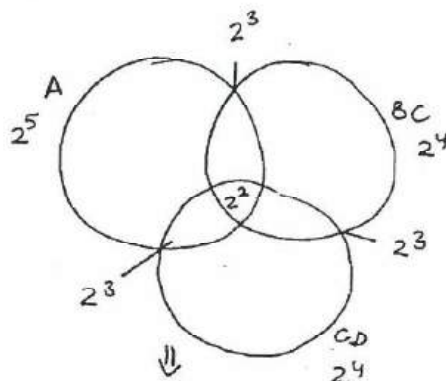
Ques) if cand key are $\{A, B, C\}$

(i) Then how many SK's in relation $R(A, B, C, D, E, F)$

$$\begin{aligned} \# \text{ of SK's} &= \left\{ \begin{array}{l} A \quad B \quad C \\ AB \quad BC \\ AC \quad ABC \end{array} \right\} * 2^{\{D, E, F\}} \\ &= 7 * 2^3 = 56 \text{ Superkeys} \end{aligned}$$

ii) $\{A, BC, CD\}$ are the cand key?

$$\begin{aligned} \# \text{ of SK's} &= \left\{ \begin{array}{l} A \quad BC \\ AB \quad BCD \\ AC \quad CD \\ AD \\ ABC \quad ABD \\ ACD \\ ABCD \end{array} \right\} * 2^{\{E, F\}} \\ &= 11 * 4 \\ &= 44 \text{ Superkeys} \end{aligned}$$



$$\begin{aligned} &= 2^5 + 2^4 + 2^4 - \{2^3 + 2^3 + 2^3\} + 2^2 \\ &= 32 + 16 + 16 - 8 - 8 - 8 + 4 \\ &= 44 \text{ superkeys} \end{aligned}$$

$$\begin{aligned} &\Leftarrow n(A) + n(BC) + n(CD) \\ &\quad - \{n(ABC) + n(BCD) + n(ACD)\} \\ &\quad + n(ABCD) \end{aligned}$$

Ques) $R(A_1, A_2, \dots, A_n)$ How many superkeys in relation R if
Assume total attributes are ≥ 6

i) $\{A_1, A_2 A_3, A_3 A_4\}$ cand key

ii) $\{A_1, A_2, A_2 A_3 A_4, A_3 A_4 A_5 A_6\}$ cand key

iii) $\{A_1, A_2 A_3, A_3 A_4\}$

Prime att : A_1, A_2, A_3, A_4

$$\# \text{ of SK} = 11 * 2^{n-4}$$

$$\{A_1\} * 2^3$$

$$+ \{A_2 A_3\} * 2^1$$

$$+ \{A_3 A_4\} * 2^0$$

$$= 8 + 2 + 1 = 11$$



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Discrete Mathematics (12-13 marks)

srinivascheekati681@gmail.com

- 1) Set Theory
- 2) Graph Theory
- 3) Combinations
- 4) Mathematical Logic.

1) Set Theory

- 1) Set — powerset
Venn Diagram
multiset.

3) Lattice

- Partial order Relⁿ
↳ poset.
- Total order Relⁿ
↳ Totset.
- Lattice
→ Distributive Lattice
Complemented Lattice
Boolean Algebra

5) Groups

- 1) Finite Groups.
- 2) Infinite Groups.
- 3) Addition modulo
- 4) Multiplication modulo.
- 5) order of an element.
- 6) Subgroups
→ Lagrange's Theorem
→ properties.
- 7) Cyclic groups
→ Generators
→ Properties

2) Relations — Cartesian Product Type of Relations —

- (Reflexive, Irreflexive, Symmetric,
Anti symmetric, Asymmetric, Transitive
Equivalence → equivalence classes.
Partition set.

4) Functions

- 1) one-one (Injective)
- 2) onto (Surjective)
- 3) Bijective
- 4) Composition of functions
↳ properties.

Set: well defined collection of ~~unlike~~ unordered distinct object is called set.

Ex: The collection of all tall boys in the class is not a set ~~because~~, we don't know that which height we treat as tall. So it is not well defined.

The collection of all tall boys in the class whose height greater than or equal to 165 cm is a set.

which of the following sets are equal?

- 1. $A =$ collection of all letters of the word "follow". $A = \{f, o, l, l, o, w\}$
2. $B =$ collection of all letter of the word "flow". $B = \{f, l, o, w\}$
3. $C =$ collection of all letters of the word "wolf". $C = \{w, o, l, f\}$

Empty set: The set which does not contain any element is called empty set.

→ It is denoted by ϕ or $\{\}$

→ $A =$ set of all -ve numbers which are $\geq 5 = \{\}$

Subset: Let, A, B are two sets. If every element of A is also an element of B . then we say that A is subset of B .

It is denoted by $A \subseteq B$.

$$A = \{1, 2, 3\} \quad B = \{1, 2, 3, 4\} \quad C = \{1, 2, 3\}$$

$$\begin{array}{l} A \subseteq B \quad A \subseteq C \\ C \subseteq B \end{array} \quad \left| \quad A \subset B \quad [A \text{ is proper subset of } B] \right.$$

NOTE: If every element of 'A' is in 'B' and if we know in advance that B contain more no of elements than 'A'. then A is proper subset of B. It is denoted by $A \subset B$

$$\text{Let, } A = \{a, b, c\} \quad B = \{a, b, c, d\} \quad C = \{a, b, c\} \quad D = \{a, b\}$$

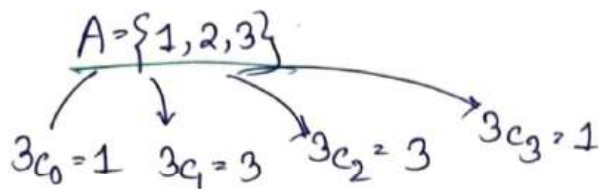
which of the following is/are TRUE?

- ~~i~~ $A \subseteq B$ ~~ii~~ $A \subseteq D$
→ ~~iii~~ $A \subset B$ ~~vi~~ $A \subset D$
→ ~~iv~~ $A \subset C$ ~~vii~~ $A \supset D$ ($D \subset A$) (A is superset of D)
→ ~~v~~ $A \subseteq C$

① Empty set is subset of every set

② Every set is itself a subset $A \subseteq A$

Powerset:- The collection of all possible subsets of a set 'A' is called powerset of 'A' denoted by $P(A)$.



$$P(A) = \{ \emptyset, \{1\}, \{2\}, \{3\}, \{1, 2\}, \{1, 3\}, \{2, 3\}, \{1, 2, 3\} \}$$

$$|P(A)| = {}^3C_0 + {}^3C_1 + {}^3C_2 + {}^3C_3$$

If $|A| = n$, then $|P(A)| = {}^nC_0 + {}^nC_1 + {}^nC_2 + {}^nC_3 + \dots + {}^nC_n$

$$= 2^n \quad (\because \text{By using Binomial Theorem})$$

NOTE:- If $|A| = n$, then every element of 'A' will appear in subset of 'A' in two ways, either the element present in the subset or absent in the subset.

$$\therefore |P(A)| = 2^n$$

Q) The cardinality of the powerset of the set $\{0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10\}$ is

$$\Rightarrow 2^{11}$$

Q) Let, $P(S)$ denote powerset of 'S'. Then which of the following is TRUE?

A) $P(P(S)) = P(S)$

C) $P(S) \cap P(S) = P(S)$

~~B) $P(P(S)) \cap P(S) = \{\emptyset\}$~~

D) $S \notin P(S)$

$\Rightarrow$ Let, $|S| = n$

$$|P(S)| = 2^n$$

$$|P(P(S))| = 2^{2^n}$$

$$\Rightarrow 2^n \cap n =$$

A) $S = \{a\}$, $S = \{a\}$

B) 2^{2^n} $P(S) = \{\emptyset, \{a\}\}$

$$P(P(S)) = \left\{ \begin{array}{l} {}^2C_0 = 1, {}^2C_1 = 2, {}^2C_2 = 1 \\ \emptyset, \{\emptyset\}, \{a\}, \{\emptyset, \{a\}\} \end{array} \right\}$$

$$P(S) \cap P(P(S)) = \{\emptyset\}$$

Q. Let C is collection of subsets of 'A' such that, for all S_1, S_2 belongs to C either $S_1 \subset S_2$ or, $S_2 \subset S_1$ then what is the max cardinality of C ?

→ a) 2^n b) n^2 c) n ✓ d) $n+1$

$$A = \{1, 2, 3\}$$

$$C = \{ \emptyset, \{1\}, \{2\}, \{3\}, \{1, 2\}, \{1, 3\}, \{2, 3\}, \{1, 2, 3\} \}$$

$$C = \{ \emptyset, \{1\}, \{1, 2\}, \{1, 2, 3\} \} \text{ or,}$$

$$C = \{ \emptyset, \{1\}, \{1, 3\}, \{1, 2, 3\} \} \text{ or,}$$

$$C = \{ \emptyset, \{2\}, \{1, 2\}, \{1, 2, 3\} \} \text{ --- and so on.}$$

$$A = \{1, 2, 3\}$$

$$\hookrightarrow \text{set of elements} \quad \begin{array}{l} 1 \in A \\ 2 \in A \\ 3 \in A \end{array}$$

$$P(A) = \{ \emptyset, \underbrace{\{1\}}_{S_1}, \underbrace{\{2\}}_{S_2}, \underbrace{\{3\}}_{S_3}, \{1, 2\}, \{1, 3\}, \{2, 3\}, \{1, 2, 3\} \}$$

$$\hookrightarrow (\text{set of set})$$

$$S_1 \in P(A)$$

$$S_2 \in P(A)$$

$$R = \{ (a, b), (b, c), (c, d) \} \quad (a, b) \in R$$

$$\hookrightarrow (\text{set of ordered pair}) \quad (c, d) \in R$$

4) Let $A = \{5, \{6\}, \{7\}\}$ and 2^A denote the powerset of A .
Consider the following statements —

a) $\emptyset \in 2^A$

which of the above statements are true?
 $\Rightarrow \emptyset \subseteq 2^A \Rightarrow \{5, \{6\}\} \in 2^A \Rightarrow \{5, \{6\}\} \subseteq 2^A$ ~~false~~

~~II) a, b, & c~~

II) a, b & d

III) only b, c & d

IV) a, b, c, d.

{Empty set is subset of every set}

$\Rightarrow P(A) = \{\emptyset, 5, \{\{6\}\}, \{\{7\}\}, \{5, \{6\}\}, \{5, \{7\}\}, \{\{6\}, \{7\}\}, \{5, \{6\}, \{7\}\} = 2^A$

$A = \{1, \{2, 3\}, 2, 3, 4, \{4, 5\}, \{6, 7, 8\}, 6, 7\}$

i) $\{1\} \in A$ x (F)

ii) $\{1, 2\} \in A$ x (F)

iii) $\{2, 3\} \in A$ ✓ (T)

iv) $\{6, 7, 8\} \in A$ True

v) $\{6\} \in A$ True

vi) $\{\{2, 3\}\} \in A$ False.

1) $\{2, 3\} \subseteq A$ (T)

2) $\{\{2, 3\}\} \subseteq A$ (T)

3) $\{6, 7, 8\} \subseteq A$ (F)

4) $\{\{6, 7, 8\}\} \subseteq A$ (T)

5) $\{6, 7\} \subseteq A$ (True)

6) $\{3, 4, 6, 7\} \subseteq A$ (True)

eliminate outermost curly braces verify those elements are present or not

5) Let, $S = \{1, 2, 3, 4, \dots, n\}$ and $A = \{(x, X) / x \in X \text{ and } X \subseteq S\}$
what is the max cardinality of A is —

$S = \{1, 2\} \Rightarrow n = 2$

$X = \{2, 3, 4\}$

$2 = 2, 3$

$P(S) = \{\emptyset, \{1\}, \{2\}, \{1, 2\}\}$

$A = \{(1, \{1\}), (2, \{2\}), (1, \{1, 2\}), (2, \{1, 2\})\}$

$|A| = 4$

$S = \{1\} \Rightarrow n = 1$

$P(S) = \{\emptyset, \{1\}\}$

$A = \{(1, \{1\})\} \therefore |A| = 1$

(A) $n * 2^n$

(B) 2^{n-1}

(C) 2^n

(D) $n * 2^{n-1}$

$$S = \{1, 2, 3, 4, 5, \dots, n\}$$

i) No of subset of 'S' with 1 element = nC_1

no of ordered pairs in 'A' with one selected element = $1 * nC_1$

$$S = \{1, 2, 3, \dots, n\}$$

$$A = \{(1, \{1\}), (2, \{2\}), \dots, (n, \{n\})\}$$

ii) No of subset of S with two elements = nC_2

$$\text{No of ordered pairs in } A = 2 * nC_2$$

⋮

No of subsets of S with 'n' elements = nC_n

$$\text{No of ordered pairs in } A = n * nC_n$$

$$\therefore |A| = 1 * nC_1 + 2 * nC_2 + \dots + n * nC_n$$

$$|A| = \sum_{k=1}^n k * nC_k = n * 2^{n-1}$$

Prove that $\sum_{k=1}^n k * nC_k = n * 2^{n-1}$

$$(x+y)^n = \sum_{k=0}^n nC_k * x^k * y^{n-k}$$

$$(x+1)^n = \sum_{k=0}^n nC_k x^k \quad [\text{put } y=1]$$

diff w.r.t x on both sides.

$$n * (x+1)^{n-1} = \sum_{k=0}^n nC_k k * x^{k-1}$$

let $x=1$

$$n(2)^{n-1} = \sum_{k=0}^n nC_k * k$$

Let 'x' is a set which has 'n' subsets.
 Let, $y = x \cup \{a, b\}$ where $a, b \notin x$. Then total no of subsets of 'y'
cardinality of power set

a) 2^n b) 4^n c) $4 * n$ d) 2^n

$\Rightarrow |P(y)| = 2^{\text{no of elements of 'y'}} = 2^{n+2} = 2^2 * 2^n$

$y = |x| \cup \{a, b\}$

$|y| = |x| + |\{a, b\}| = n+2$

Let, cardinality of $x = n$

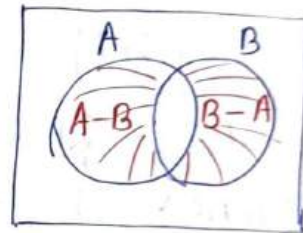
$|P(x)| = n \Rightarrow 2^n = n$

NOTE: Let A, B are two set,

$A \Delta B = (A-B) \cup (B-A)$ is called symmetric difference of A, B.

or,

$A \Delta B = (A \cup B) - (A \cap B)$



Let $x = \{1, 2, 3, 4, \dots, 2n\}$.

Let $A \subseteq x$ & $B \subseteq x$. How many ways we can choose A, B such that, $A \Delta B = \{2, 4, 6, 8, \dots, 2n-2, 2n\}$

- (A) 2^n (B) 2^{2n} (C) $4n$ (D) n .

$\Rightarrow \forall x \in x$

If x is even then
 either $x \in (A-B)$ or
 $x \in (B-A)$

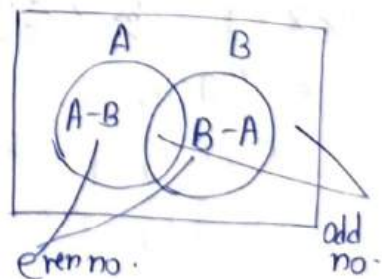
2^n

$\therefore 2^n * 2^n = 2^{2n}$

If x is odd then.

$x \in (A \cap B)$ or $x \in (\overline{A \cup B})$

$\therefore 2^n$



Venn Diagram

$$U = \{1, 2, 3, 4\}$$

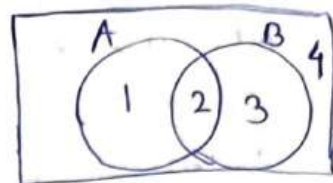
$$A = \{1, 2\} \quad B = \{2, 3\}$$

$$\bar{A} = A^c = U - A = \{1, 2, 3, 4\} - \{1, 2\} = \{3, 4\}$$

$$\bar{B} = B^c = U - B = \{1, 2, 3, 4\} - \{2, 3\} = \{1, 4\}$$

$$A - B = \{1\} \quad B - A = \{3\}$$

$$A \Delta B = (A - B) \cup (B - A) = \{1\} \cup \{3\} = \{1, 3\}$$



$$1) A - B = \{1, 4\}$$

$$2) B - A = \{3, 6\}$$

$$3) A - C = \{1, 2\}$$

$$4) C - A = \{6, 7\}$$

$$5) A - (B \cap C) = \{1, 2, 4\}$$

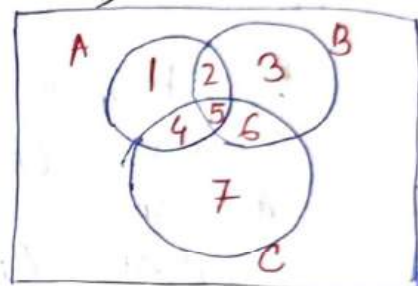
$$6) B - (A \cap C) = \{2, 3, 5, 6\} - \{4, 5\} = \{2, 3, 6\}$$

$$7) (A - B) - (A - (B \cap C))$$

$$= \{1, 4\} - (\{1, 2, 4, 5\} - \{5, 6\})$$

$$= \{1, 4\} - \{1, 2, 4\}$$

$$= \{\} = \phi$$



Q35) $X = (A - B) - C$ & $Y = (A - C) - (B - C)$ which is TRUE?

a) $X = Y$ b) $X \subset Y$ c) $Y \subset X$ d) none.

$$\rightarrow X = (A - B) - C$$

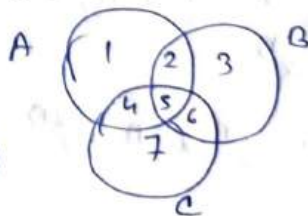
$$= \{1, 4\} - \{4, 5, 6, 7\}$$

$$= \{1\}$$

$$Y = (A - C) - (B - C)$$

$$= \{1, 2\} - \{2, 3\}$$

$$= \{1\}$$





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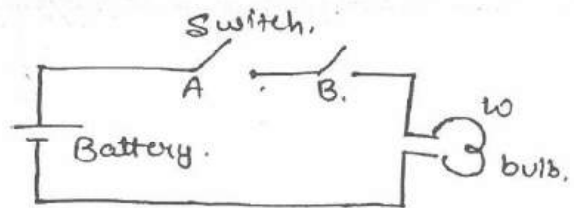
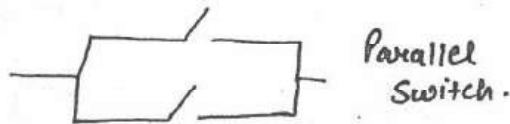
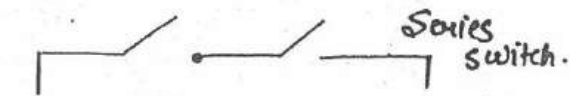
Boolean Algebra.

All variables $\rightarrow 5V$.
 $1 \rightarrow \text{high / True.}$
 $0 \rightarrow \text{low / False.}$
 $\rightarrow 0V / \text{Ground}$

Operators.

AND GATE

AB	W
0 0	0
0 1	0
1 0	0
1 1	1



("AND gate is Series Switch")

Truth table $\rightarrow$ Input/output Relationship.

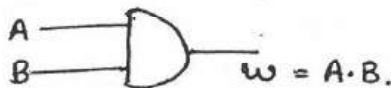
Ex: AND from Set Theory.

$X: \{2, 3, 4\}$

$Y: \{3, 5, 6\}$

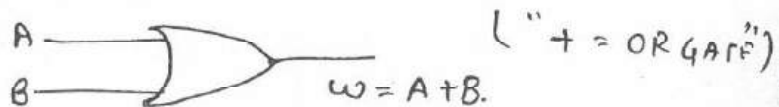
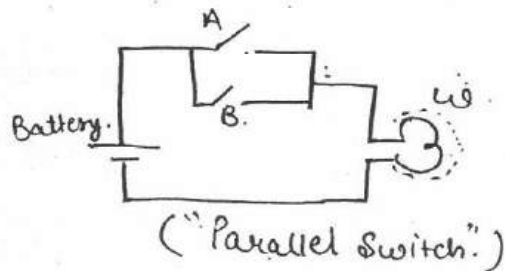
$(X \cap Y) = \{3\}$. [" $\cap$ " $\rightarrow$ AND].

And is generally
 $\cap$ intersection



OR GATE

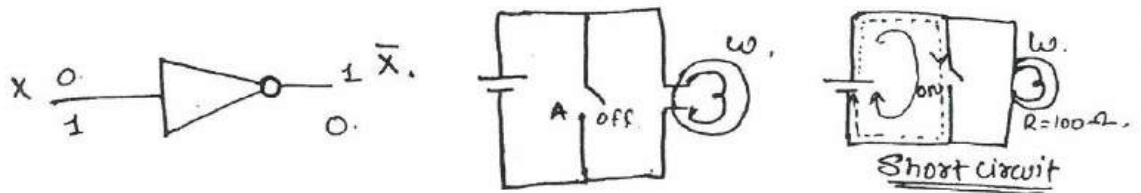
AB	W.
0 0	0
0 1	1
1 0	1
1 1	1



From Set Theory.

$X \cup Y \rightarrow$ OR gate.

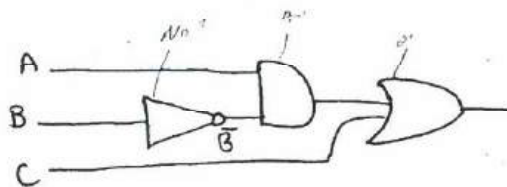
NOT Gate / Inverter.



["Current $\rightarrow 0$, Resistance $= \infty$ "]
 Current always flows from least resistance path.
 [$V = IR$].

- $\rightarrow$ AND, OR, NOT gate are called Basic gates.
 $\rightarrow$ Precedence of operators () > NOT > AND > OR

Example :- $Y = A \cdot \bar{B} + C$



1 $\rightarrow$ OR
 & $\rightarrow$ AND.

() NOT
 AND
 OR

AND properties.

- 1.) $X \cdot 0 = 0$ 3.) $X \cdot X = X$
 2.) $X \cdot 1 = X$ 4.) $X \cdot \bar{X} = 0$

OR properties.

- 1.) $X + 0 = X$ 3.) $X + X = X$
 2.) $X + 1 = 1$ 4.) $X + \bar{X} = 1$

Distributive Property :-

$$A \cdot (B + C) = A \cdot B + A \cdot C.$$

Ques Prove $(A+B) \cdot (A+C) = A + B \cdot C.$

Solⁿ $A \cdot (A+C) + B \cdot (A+C).$

$$\textcircled{A \cdot A} + A \cdot C + B \cdot A + B \cdot C.$$

$$\Rightarrow A \cdot 1 + A \cdot C + B \cdot A + B \cdot C$$

$$\Rightarrow A(1 + \underbrace{C+B}_x) + B \cdot C.$$

$$\Rightarrow A + B \cdot C. = \text{R.H.S} \quad \text{+ hence Proved.}$$

Ques Prove $A + \bar{A}B = A + B.$

Solⁿ L.H.S = $A + \bar{A}B.$

$$= A + \bar{A} \cdot B.$$

Sol, $(A + \bar{A})(B + B). (A+B)(A+\bar{A}).$

$$\Rightarrow A + B = \text{R.H.S}$$

$$\bar{A} + AB$$

$$AB$$

$$A + \bar{A}B$$

$$A + B$$

$$A \cdot BC + A \cdot \bar{B}C \cdot D.$$

$$A(BC + \bar{B}C \cdot D)$$

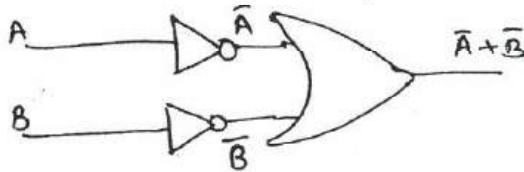
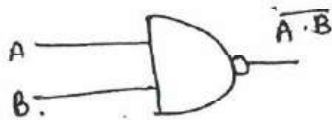
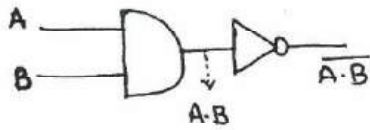
$$A \cdot (B(C + D)).$$

De Morgan's Law.

$$\overline{A+B} = \bar{A} \cdot \bar{B}$$

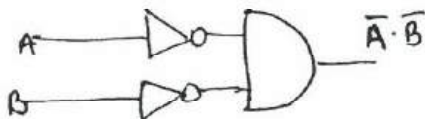
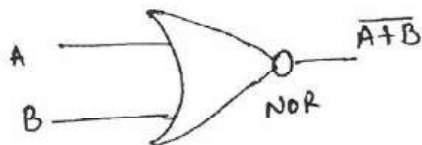
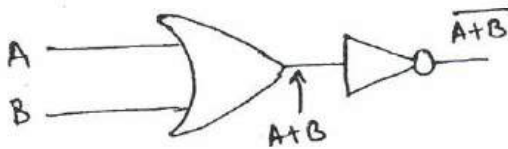
$$\overline{A \cdot B} = \bar{A} + \bar{B}$$

NAND GATE. (NOT of AND)



AB	$A \cdot B$	$\overline{A \cdot B}$
0 0	0	1
0 1	0	1
1 0	0	1
1 1	1	0

NOR GATE (NOT of OR).



AB	$A+B$	$\overline{A+B}$
0 0	0	1
0 1	1	0
1 0	1	0
1 1	1	0



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They

Engg. math.

Wate

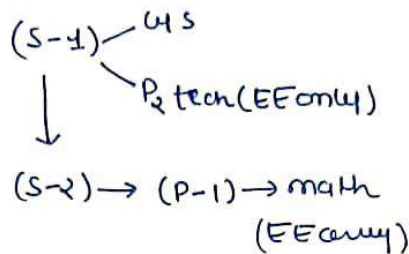
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Syllabus

- ① Linear Algebra. — 3
- ② Diff. calculus. — 3
- ③ Vector calculus — 3
- ④ Diff. calculus — 1
- ⑤ Complex variable (NOT for CE-Wate)
- ⑥ Fourier series
- ⑦ Prob & statics. — 3
- ⑧ L.T.
- ⑨ Numerical method (NOT for EC, EE, WATE).

key.

bit.ly/2024key

bit.ly/2024key

Soln

bit.ly/2024wbsoln

Probability

bit.ly/ENGGMATHNOTES

bit.ly/Correct caps.

bit.ly/msqwb msg.

bit.ly/msqkey

extra question.

bit.ly/extraquest

⑨ SRIKAR GUPTA MATHS

P.D.E ⇒ bit.ly/Pdecivil

LINEAR ALGEBRA.

→

- Linear algebra deals with Linear system and Linear transformation
- Every Linear system and Linear transformation can be expressed in term of matrices.

Transformation matrix $\leftarrow A_{n \times n} X = Y \rightarrow \text{o/p.}$
 $\downarrow$
 i/p

$x = \text{cost of Pen}$

$y = \text{cost of pencil.}$

	Pen	Pencil	cost
I day	2	3	50
II day	2	1	30

Linear system. $AX = B.$

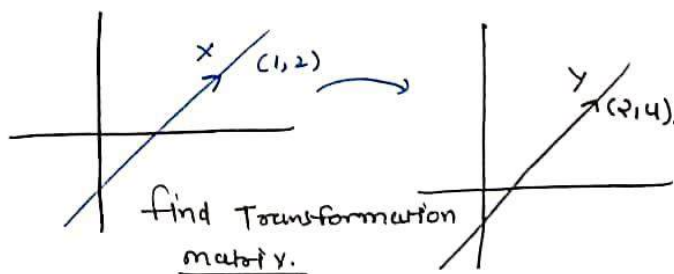
$$\begin{cases} 2x + 3y = 50 \\ 2x + y = 30 \end{cases} \quad \begin{bmatrix} 2 & 3 \\ 2 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix} = \begin{bmatrix} 50 \\ 30 \end{bmatrix}$$

$A \quad X \quad B.$

$\begin{bmatrix} \cos \theta & \sin \theta \\ -\sin \theta & \cos \theta \end{bmatrix} = A \rightarrow \text{Rotational. Orthogonal Transformation matrix of } 2 \times 2$

$\theta = 90^\circ$

$A = \begin{bmatrix} 0 & 1 \\ -1 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} = \begin{bmatrix} y_1 \\ y_2 \end{bmatrix}$



$\begin{bmatrix} 0 & 1 \\ 2 & 1 \end{bmatrix} \begin{bmatrix} 1 \\ 2 \end{bmatrix} = \begin{bmatrix} 2 \\ 4 \end{bmatrix}$
 any many combination.

MATRIX

$$A = [a_{ij}]_{m \times n}$$

m = No. of rows

n = No. of col's.

$m=n \rightarrow$ square matrix

$m \neq n \rightarrow$ rectangular matrix

a_{ij} = element in i th row and j th column's.

Operation of matrix

① Addition or Subtraction

$A \pm B$ is possible if order of A = order of B .
 $O(A) = O(B)$.

② Product of matrix

Let $A_{m \times n}$, $B_{p \times q}$

then (AB) is possible only if $n=p$.

1. $AB \neq BA$ (commutative)

2. $A(BC) = (AB)C$ (associative)

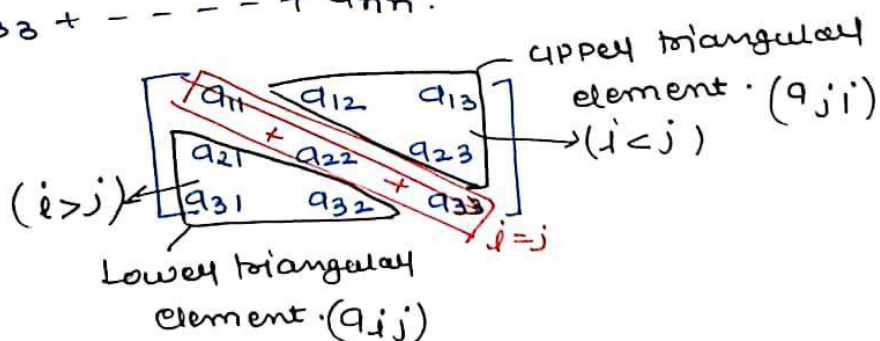
③ Trace of square matrix

= Trace ($A_{n \times n}$)

= Sum of all principle diagonal element.

= $a_{11} + a_{22} + a_{33} + \dots + a_{nn}$.

$$= \sum_{i=1}^n a_{ii}$$



④ Transpose of matrix

If $A = [a_{ij}]_{m \times n}$ then

$$A^T = A^T = [a_{ji}]_{n \times m}$$

eg: $A = \begin{bmatrix} 1 & 2 & 3 \\ 2 & 4 & 6 \end{bmatrix}_{2 \times 3}$

$$A^T = \begin{bmatrix} 1 & 2 \\ 2 & 4 \\ 3 & 6 \end{bmatrix}_{3 \times 2}$$

Properties

(1) $(A^T)^T = A$

(2) $(AB)^T = B^T A^T$

(3) $(A+B)^T = A^T + B^T$

(4) $(A^T)^n = (A^n)^T$

(5) $\text{Trace}(A) = \text{Trace}(A^T)$

(6) $\text{Trace}(kA) = k \text{Trace}(A)$

(7) $\text{Trace}(A \pm B) = \text{Trace}(A) \pm \text{Trace}(B)$

$$(A^T)^T = \begin{bmatrix} 1 & 2 & 3 \\ 2 & 4 & 6 \end{bmatrix}_{2 \times 3} = [A]$$

During transpose principle diagonal
Remains unchanged $i, j = j, i$
changes.

Symmetric matrix

$A_{n \times n}$ is a symmetric matrix if an

$$\begin{bmatrix} 1 & 2 & 3 \\ 2 & 4 & 5 \\ 3 & 5 & 6 \end{bmatrix} = \text{symmetric}$$

$$A^T = A$$

Upper diagonal element = lower diagonal element.

Corresponding Row's and Column's are
Same.

$$a_{ij} = a_{ji}$$

Let A, B are symmetric matrices ($A^T = A, B^T = B$).

then

→ A^n is symmetric matrix.

$$(A^n)^T = (A^T)^n = \underline{A^n}$$

→ AB is not a symmetric matrix

$$(AB)^T = B^T A^T$$

$$= BA$$

$$\neq AB$$

→ $AB + BA$ is symmetric

$$= (AB)^T + (BA)^T$$

$$= A^T B^T + B^T A^T$$

$$= BA + AB.$$

→ AB is symmetric if $A=B$.

$$(A^2)^T = (A^T)^2 \\ = A^2$$

Skew symmetric matrix

$A_{n \times n}$ is skew symmetric matrix

If $A^T = -A$ or $(a_{ij} = -a_{ji})$
 $\nexists a_{ii} = 0$

$$\begin{cases} i=j \\ a_{ii} = -a_{ii} \\ 2a_{ii} = 0 \cdot a_{ii} = 0 \end{cases}$$

Diagonal element = 0.

Upper triangular = - Lower triangular.

$$\begin{bmatrix} 0 & 2 & 3 \\ -2 & 0 & 5 \\ -3 & -5 & 0 \end{bmatrix}$$

Let A, B are skew symm. matrix $(A^T = -A)$
 $B^T = -B$.

① A^n is symmetric if n is even

A^n is skew symmetric when n is odd

$$(A^n)^T = (A^T)^n$$

$$= (-A)^n = (-1)^n A$$

② AB is neither symmetric ~~nor~~ nor skew symmetric.

$$(AB)^T = B^T A^T$$

$$= -B(-A)$$

$$= BA \neq AB$$

③ $AB + BA$ is symmetric. Not skew symmetric.

$$(AB + BA)^T$$

$$= -A(B) + (A)(-B)$$

$$= AB + BA$$

④ $AB - BA$ is skew symmetric matrix.

$$(AB - BA)^T = (-B)(-A) - (-A)(-B)$$

$$(AB)^T - (BA)^T = +BA - AB.$$

$$B^T A^T - A^T B^T = -[AB - BA].$$

⑤ AB is a skew symmetric matrix when $AB = -BA$

Complex matrix

$$A = [a_{ij}]_{m \times n}$$

$$\downarrow z = x + iy, \quad \bar{z} = x - iy$$

Conjugate of matrix. $A = [a_{ij}]_{m \times n}$

then $\bar{A} = [\bar{a}_{ij}]_{m \times n}$ $i = -i$ (replace i in each element).

eg: $A = \begin{bmatrix} i & 1+i \\ 2 & 2i \end{bmatrix} \Rightarrow \bar{A} = \begin{bmatrix} -i & 1-i \\ 2 & -2i \end{bmatrix}$

Hermitian matrix

$A_{n \times n} = [a_{ij}]_{n \times n}$ is H.M

$$\boxed{\bar{A} = A^T}$$

$$\boxed{\begin{matrix} a_{ji} = \text{actual} \\ a_{ij} = \overline{a_{ji}} \end{matrix}}$$

$$\begin{bmatrix} \bar{0} & \\ & i \end{bmatrix} = \begin{bmatrix} & l \\ 0 & \end{bmatrix}$$

$l = \bar{0} \quad 0 = \bar{i}$

$$\boxed{a_{ij} = \overline{a_{ji}}}$$

$$Eg = \begin{bmatrix} 1 & 1-j & 2j \\ 1+j & 2 & 1 \\ 2j & 1 & 3 \end{bmatrix}$$

$$\bar{A} = A^T$$

transpose on both side.

$$(\bar{A})^T = (A^T)^T$$

$$A^{\theta} = A$$

Skew Hermitian matrix

$A_{n \times n} = [a_{ij}]_{n \times n}$ is skew-H-matrix.

$$If \quad \boxed{\bar{A} = -A^T}$$

$$\begin{bmatrix} \bar{u} \\ \bar{v} \end{bmatrix} = \begin{bmatrix} -u \\ -v \end{bmatrix}$$

$$\left\{ \begin{array}{l} a_{ji} = \text{zero (or)} \\ a_{ij} = -\bar{a}_{ji} \end{array} \right\} \text{ purely imaginary.}$$

$$u = -\bar{v}$$

$$-v = \bar{u}$$

$$\boxed{a_{ij} = -\bar{a}_{ji}}$$

Transpose on both side

$$(\bar{A})^T = (-A^T)^T$$

$$\boxed{A^{\theta} = -A}$$

$$-(\overline{a+ib}) = -(a-ib) = -a+ib$$

$$A = \begin{bmatrix} i & -1+j & 2j \\ 1+j & 2j & -1 \\ 2j & 1 & 0 \end{bmatrix}_{3 \times 3} \quad \begin{bmatrix} i & -1+2j \\ 1+j & 2j \end{bmatrix}$$

Note

If 'A' is Hermitian then 'iA' is a skew Hermitian and vice versa.

ORTHOGONAL MATRIX

$A_{n \times n}$ is orthogonal matrix If

$$AA^T = A^T A = I \Rightarrow A^{-1} = A^T$$

$$A^T A = I$$

Multiply by A^{-1} on both side

$$(A^T A) A^{-1} = I A^{-1}$$

$$A^T (A A^{-1}) = A^{-1}$$

$$A^T I = A^{-1}$$

$$A^T = A^{-1}$$

Ex

$$A = \begin{bmatrix} x_1 & x_2 \\ \cos \theta & \sin \theta \\ -\sin \theta & \cos \theta \end{bmatrix}$$

If all the vectors in a square matrix are orthonormal vectors then that matrix is called orthogonal matrix.

$$\vec{x}_1 \cdot \vec{x}_2 = \vec{x}_1^T \vec{x}_2 = [\cos \theta \quad -\sin \theta] \begin{bmatrix} \sin \theta \\ \cos \theta \end{bmatrix}$$

Dot Product or inner product.

$$= 0$$

$$|\vec{x}_1| = ||x_1|| = \sqrt{\vec{x}_1^T \vec{x}_1}$$

Norm of x_1

$$= \sqrt{\cos^2 \theta + (-\sin^2 \theta)} = 1$$

$$||x_2|| = \sqrt{\vec{x}_2^T \vec{x}_2} = \sqrt{\cos^2 \theta + \sin^2 \theta} = 1$$

Q.5

$$A = \begin{bmatrix} x_1 & x_2 & x_3 \\ \frac{1}{9} & -\frac{4}{9} & \frac{8}{9} \\ \frac{8}{9} & \frac{4}{9} & \frac{1}{9} \\ \frac{4}{9} & -\frac{1}{9} & \frac{8}{9} \end{bmatrix}$$

$$AA^T = I = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

$\therefore A$ is orthogonal then x_1, x_2, x_3 are orthonormal vectors

x_1, x_2, x_3 are orthogonal & having length 1

$$\vec{x}_1 \cdot \vec{x}_2 = 0 \quad \vec{x}_1 \cdot \vec{x}_3 = 0 \quad \vec{x}_2 \cdot \vec{x}_3 = 0$$

Consider

$$\vec{x}_1^T \vec{x}_2 = 0$$

$$\begin{bmatrix} \frac{1}{9} & \frac{8}{9} & \frac{\alpha}{9} \end{bmatrix} \begin{bmatrix} -4 \\ 4 \\ -7 \end{bmatrix} = 0 \quad \left| \quad \bar{x}_2 \cdot \bar{x}_3 = x_2^T x_3 = 0 \right.$$

$$\frac{1}{9} \times \frac{-4}{9} + \frac{8}{9} \times \frac{4}{9} + \frac{\alpha}{9} \times \frac{-7}{9} = 0$$

$$-4 + 32 - 7\alpha = 0$$

$$\boxed{\alpha = 4}$$

$$\boxed{\beta = -4}$$

$$(ab) \in \mathbb{R}^2 = a\hat{i} + b\hat{j}$$

$$(abc) \in \mathbb{R}^3 = a\hat{i} + b\hat{j} + c\hat{k}$$

↳ 3-Tuple

Unitary matrix

$A_{n \times n}$ is unitary matrix

$$\boxed{A^\theta = A^\theta A = I} \Rightarrow \boxed{A^{-1} = A^\theta}$$

Real unitary matrix is orthogonal matrix

If A, B are orthogonal/unitary matrices then
 $AB, BA, A^{-1}, B^{-1}, A^T, B^T$ are orthogonal/unitary.

Idempotent matrix:

$A_{n \times n}$ is idempotent matrix iff $\boxed{A^2 = A}$

Note

(1) If $A^2 = A$ then $A^n = A$

(2) If $AB = B$ $BA = A$ then $A^2 = A$ $B^2 = B$.

(3) If $AB = A$, $BA = B$ then $A^2 = A$, $B^2 = B$

① $A^2 = A$

Multiplying by A

$$A^3 = A^2$$

$$A^3 = A$$

$$A^4 = A$$

$$A^n = A$$

② $A^2 = A \cdot A$

$$= A(BA)$$

$$= (AB)A$$

$$= BA$$

$$= A$$

③ $B^2 = B \cdot B$

$$= B \cdot (AB) = \cancel{A} (AB) \quad (AB) B$$

$$= BAB = \cancel{A^2} B \quad \cancel{A} (B^2)$$

$$= AB = \cancel{A} B \quad \cancel{A} B$$

$$= B = \cancel{A} B$$

Q A, B are of same size such that $AB = 0$ / $BA = 0$.
then $(A+B)^{10} = \underline{\hspace{2cm}}$

$$AB = 0 \quad BA = 0 \quad \text{then} \quad A^2 = A, \quad B^2 = B.$$

$$(A+B)^2 = A^2 + B^2 + AB + BA = 2^1 (A+B)$$

$$= A + B + 0 + 0$$

$$= 2(A+B).$$

Squaring both side.

$$(A+B)^4 = 2^2 [A+B]^2$$

$$= 2^3 [A+B].$$

⋮

$$\boxed{[A+B]^n = 2^{n-1} (A+B).}$$

INVOLUTARY MATRIX

$A_{n \times n}$ is involutory if and only if $\boxed{A^2 = I}$.

$$A \cdot A = I$$

$$\boxed{A = A^{-1}}$$

NILPOTENT MATRIX

$A_{n \times n}$ is nilpotent matrix of degree 'k' or Index 'k'

If

$$\boxed{A_n^k = 0_{n \times n}.}$$

→ Every square matrix can be expressed as sum of symmetric and skew symmetric matrix.

$$A_{n \times n} = \frac{1}{2} [2A] = A \quad \begin{array}{l} \text{Symmetric part of } A \text{ matrix} \\ = \frac{1}{2} (A + A^T) \end{array}$$

$$= \frac{1}{2} [A + A^T]$$

$$= \frac{1}{2} [A + A^T + A - A^T]$$

Skew Symm. part of A matrix

$$= \frac{1}{2} (A - A^T)$$

$$A_{n \times n} = \underbrace{\left[\frac{1}{2} [A + A^T] \right]}_{\text{Symmetric } P} + \underbrace{\left[\frac{1}{2} [A - A^T] \right]}_{\substack{Q \\ \downarrow \\ \text{Skew symmetric}}}$$

$$P^T = \frac{1}{2} [A + A^T]^T = \frac{1}{2} [A^T + (A^T)^T] = \frac{1}{2} [A^T + A] = P$$

$$Q^T = \frac{1}{2} [A - A^T]^T = \frac{1}{2} [A^T - A^{TT}] = \frac{1}{2} (A^T - A) = -Q$$

→ every square matrix can be represented as Hermitian and skew Hermitian matrix.

$$A_{n \times n} = \frac{1}{2} [2A]$$

$$= \frac{1}{2} [A + A] = \frac{1}{2} [A + A^\theta + A - A^\theta]$$

$$A_{n \times n} = \underbrace{\frac{1}{2} [A + A^\theta]}_{\substack{\downarrow \\ \text{H.M} \\ P}} + \underbrace{\frac{1}{2} [A - A^\theta]}_{\substack{\downarrow \\ \text{SK.HM} \\ Q}}$$

$$P^\theta = \frac{1}{2} [A + A^\theta]^\theta = \frac{1}{2} [A^\theta + (A^\theta)^\theta] = \frac{1}{2} [A^\theta + A] = P$$

$$Q^\theta = \frac{1}{2} [A - A^\theta]^\theta = \frac{1}{2} [A^\theta - (A^\theta)^\theta] = \frac{1}{2} [A^\theta - A] = -Q$$

LU-Decomposition

Every square matrix can be expressed as the product of lower triangular matrix and upper triangular matrix.

$$A_{n \times n} = L_{n \times n} \cdot U_{n \times n}$$

where $l_{ii} = 1, \forall i$, (OR) $u_{ii} = 1, \forall i$

Q By LU-Decomposition find L & U.

$$\text{for } \begin{bmatrix} 2 & 1 \\ 1 & 2 \end{bmatrix} = ?$$

By LU-Decomposition

$$\begin{bmatrix} 2 & 1 \\ 1 & 2 \end{bmatrix} = \begin{bmatrix} L_{11} & 0 \\ L_{21} & L_{22} \end{bmatrix} \begin{bmatrix} u_{11} & u_{12} \\ 0 & u_{22} \end{bmatrix}$$

$$\text{If } l_{11} = l_{22} = 1$$

$$\Rightarrow \begin{bmatrix} 2 & 1 \\ 1 & 2 \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ L_{21} & 1 \end{bmatrix} \begin{bmatrix} u_{11} & u_{12} \\ 0 & u_{22} \end{bmatrix}$$

$$\Rightarrow \begin{matrix} u_{11} = 2 & u_{12} = 1 & L_{21} u_{11} = 1 & L_{21} u_{12} + u_{22} = 2 \\ & & L_{21} = \frac{1}{2} & u_{22} = \frac{3}{2} \end{matrix}$$

$$L = \begin{bmatrix} 1 & 0 \\ \frac{1}{2} & 1 \end{bmatrix} \quad U = \begin{bmatrix} 2 & 1 \\ 0 & \frac{3}{2} \end{bmatrix}$$

CHOLESKY - Decomposition

Every square matrix can be expressed as LL^T

$$A_{n \times n} = L_{n \times n} L_{n \times n}^T$$

DETERMINANT

$$m_1 = -\frac{a_1}{b_1}$$

$$m_2 = -\frac{a_2}{b_2}$$

$$\begin{cases} a_1x + b_1y = c_1 \\ a_2x + b_2y = c_2 \end{cases}$$

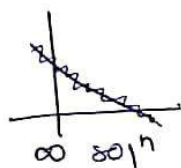
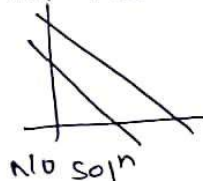
→ Determinant are calculated for square matrix.

$$m_1 = m_2$$

$$\frac{a_1}{b_1} = \frac{a_2}{b_2}$$

$$a_1b_2 - a_2b_1 = 0$$

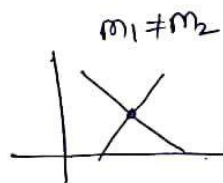
$$m_1 = m_2$$



$$m_1 \neq m_2$$

$$\frac{a_1}{b_1} \neq \frac{a_2}{b_2}$$

$$a_1b_2 - a_2b_1 \neq 0$$



unique soln

The factor which determine whether the linear system will have unique solution or not is called determinant.

$$\begin{vmatrix} a_1 & b_1 \\ a_2 & b_2 \end{vmatrix} \Rightarrow a_1b_2 - a_2b_1$$

fix $i=1$

$$|A_{n \times n}| = \sum_{j=1}^n (-1)^{1+j} a_{1j} \delta_{1j}$$

where δ_{ij} = minor of an element a_{ij}

fix $i=1$

$$\begin{vmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{vmatrix} = (-1)^{1+1} a_{11} \delta_{11} + (-1)^{1+2} a_{12} \delta_{12} + (-1)^{1+3} a_{13} \delta_{13}$$

$$= a_{11} \begin{vmatrix} a_{22} & a_{23} \\ a_{32} & a_{33} \end{vmatrix} - a_{12} \begin{vmatrix} a_{21} & a_{23} \\ a_{31} & a_{33} \end{vmatrix} + a_{13} \begin{vmatrix} a_{21} & a_{22} \\ a_{31} & a_{32} \end{vmatrix}$$

→ The No. of term in the determinant expansion of $n \times n$ matrix = $n!$ = "maximum No. of terms"

Important Properties

$$(1) |A| = |A^T| \Rightarrow \det(A) = \det(A^T) \Rightarrow \det\left(\frac{1}{A^{-1}}\right)$$

$$(2) |AB| = |A||B| = |BA|$$

"determinant of each singular matrix is zero. and we can't calculate inverse of singular matrix"

$$(3) |A^n| = |A|^n$$

$$(4) |A^{-1}| = |A|^{-1}$$

$$(5) \begin{vmatrix} ka & kb \\ c & d \end{vmatrix} = k \begin{vmatrix} a & b \\ c & d \end{vmatrix} = \begin{vmatrix} ka & b \\ kb & d \end{vmatrix}$$

$$(6) |k A_{n \times n}| = k^n |A|$$

$$(7) |\text{adj } A_n| = |A|^{n-1}$$

$$\star (8) \text{adj}(\text{adj } A_n) = |A|^{n-2} A$$

$$(9) |\text{adj}(\text{adj } A_n)| = |A|^{(n-1)^2}$$

$$(10) |\text{adj}(k A_n)| = k^{n-1} |\text{adj } A|$$

$$\rightarrow A^{-1} = \frac{\text{adj}(A)}{|A|}, |A| \neq 0$$

$$\text{adj}(A_n) = |A| A_n^{-1}$$

$$|\text{adj}(A_n)| = |(A) A_n^{-1}|$$

$$= |A|^{n-1}$$

$$= k^n |A^{-1}|$$

$$= |A|^n |A|^{-1}$$



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Operating Systems

Thapli Singh..

Teaching Schedule

I. Introduction and Background.

II. Process Management

- process concept
- CPU scheduling ✓
- Synchronization ✓
- Concurrent Programming.
- Deadlocks
- Threads.

III. Memory Management.

- RAM Chip Implementation
- Loading, Linking & Address Binding
- Techniques
 - paging
 - Multilevel paging.
 - Inverted paging
 - Segmentation
 - Segmented Paging.
- Virtual Memory.

IV. File Systems.

Textbooks

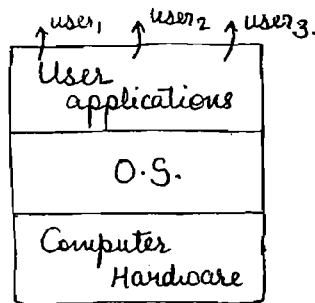
1. OS by Galvin.
2. Modern OS by A.S. Tenenbaum.
3. OS by William Stallings.

Chapter 1

Introduction and Background

Q. What is an OS?

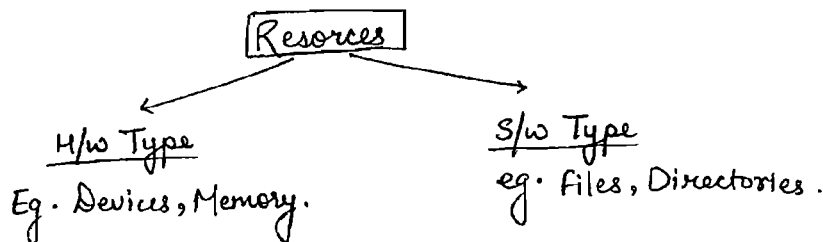
OS is an interface between user and computer hardware.



```
main()
{
    int x;
    printf("Hello");
}
```

internally calls `write()` System Call
in order to communicate with the monitor.

- System Call: System call is the request made by the user program to the OS in order to get any kind of service.
- Operating System is also called as Resource Allocator because it is responsible for allocating resources of a computer.



Goals of O.S.

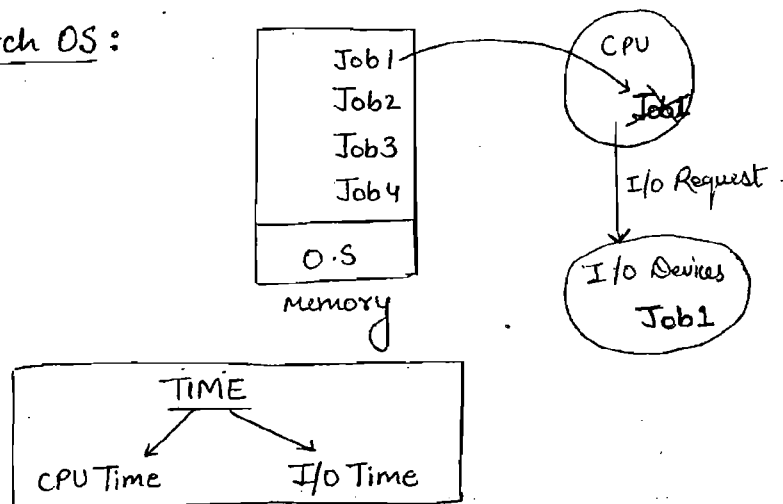
1. The primary goal is convenience. (easy to use)
2. The secondary goal is efficiency. (Stability).

Types of OS.

1).

Types of OS

(1). The Batch OS:

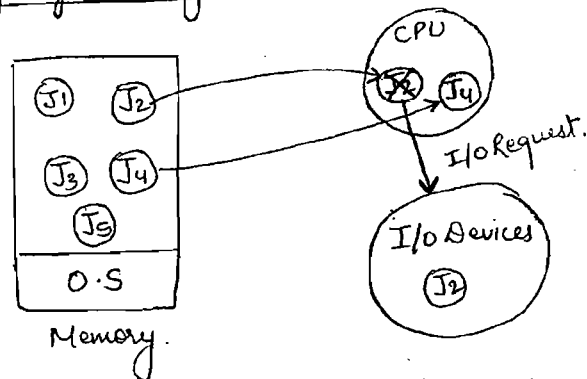


- If the Job is completed completely then only another Job will be scheduled onto CPU.
- Increased CPU idleness.
- Decreased throughput of the system.

Throughput: No. of jobs completed per unit time. is called throughput of the system.

Exp: IBM OS/2

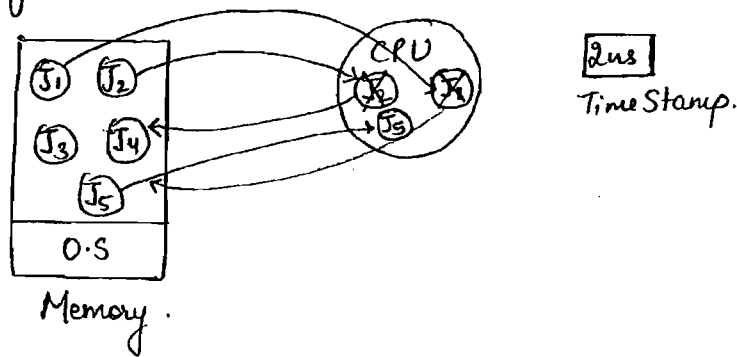
(2). Multiprogramming O.S.:



- If the job is leaving the CPU to perform IO operation, then another job which is ready for execution will be scheduled onto CPU.
- Advantage
 - Increased CPU Utilization.
 - Increased throughput of the system.

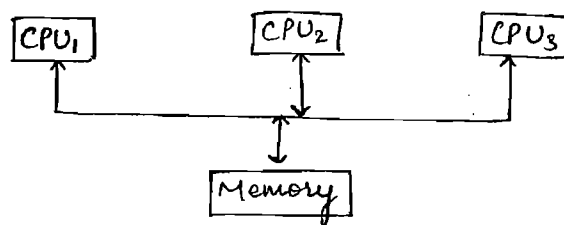
Exp: Windows, UNIX.

(3). Multitasking OS :



- Multitasking is an extension of multiprogramming OS.
 - The jobs will be executed in the time sharing mode.
- Exp: Windows, Unix

(4). Multiprocessor Systems :

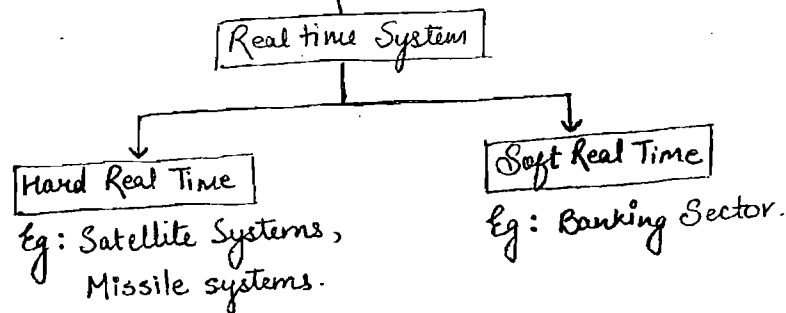


- Advantage
 - Increase the throughput of the system
 - Reliability
 - ↳ Fault Tolerant Systems.
 - Economical.

Exp: UNIX.

(5). Real Time Systems :

- The systems which are strict deadly time bound are called as real time systems.



Exp: S_x works, V_x works, RTO's.



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Programming and Data Structure

Programming

M-M 12-14

- Basic of 'C' programming
(Operators, loops, function, Switch)
- Storage Classes, Scope
- Pointers, Strings.
- Recursion, Arrays.
- Structures, unions.
- Dynamic Memory Allocation (Malloc, Calloc).

Data Structures.

- Linked Lists
- Stack
- Queue
- Tree's (BST, AVL).
- Hashing.

25/July/25

Basics of C Programming.

Operators.

Operators	Precedence	Precedance	Associativity (Right to Left)
() ,		1 (High)	L → R
↑		2	R → L
* / %		3	L → R
+ -		4	L → R
=		5 (low)	R → L

Associativity:

If two or more operator are having same Precedance the Expression will evaluated By using Associativity.

Expression	Result.
5/2	2
5.0/2	2.5
2/5	0
2.0/5	0.4
5.0/2.0	2.5
2.0/5.0	0.4

Note:-
If both are integers then output is integer, &
if any one is float the output is float.

Expression	Assigned to int	Assigned to float.
5	5	5.0
5.0	5	5.0
5/2	2	2.0
5.0/2	2	2.5
2/5	0	0.0
2.0/5	0	0.4
2.0/5.0	0	0.4
5.0/2.0	2	2.50

(First solve the expression the assign to given).

Relational & logical operators.

→ $<, <=, >, >=$ → $!=, ||$.

- 1) All the logical and Relational operators returns, 1 or 0.
- 2) If the expression is true then it returns (1). else it returns (0).
- 3) All non-zero is considered as True and zero is considered as False.

True	False.
10	0
-10	0
8.7	0
0.3	NULL.
-3.5	

Example:-

1. $a = 5 > 7;$
False (0).
2. $a = (5 > 3) + (7 > 4);$
True (1) + True (1) = 2.
3. $a = 7 > 5 > 3;$
~~True (1)~~ (Left to Right).
 $1 > 3$
 $a = (0)$ False.

Modulus operator (%)

- 1) $15 \% 7 = 1$ [∵ Modulus always gives Numerator Signs].

2) $-15 \% 7 = -1$

3) $+15 \% -7 = 1$

4) $-15 \% -7 = -1$

5) $-15.5 \% 7 = \text{error}$ [∵ Modulus doesn't work on float value. It works only on int].

6) $15.5 \% -7 = \text{error}$

7) $-10 \% +20 = -10$

8) $+10 \% -20 = 10$

- 1) Modulus always gives Numerator Sign.
- 2) Modulus doesn't work on float values, it works only on integers.
- 3) If the value is smaller without sign it gives the same value as a output.

Ques int a = 2 * 3/4 + 2.0/5 + 8/5; (Associativity)
 pf ("%d", a); [Left to Right]

Soln
 a = 1 + 0.4 + 1
 a = 2.

Ques a = 15.0/2 * 2.1/7; (Associativity).

Soln a = 7.5 * 0.3
 a = 15.0/7 (Float value).
 a = Error.

Ques void main() {

int a = 5;

if (a = 8) [Assigned Again].
 { pf ("Raj"); Not compare ==;

}

else {

pf ("Kumar"); }

pf ("%d", a);

}

Soln Output:-
 Kumar 5 Raj 8

Note:-

Assignment operator assigns the value and returns assigned value.

Ques void main() {

int x;

x = printf ("Hello"); //5. Output:- Hello 5.

printf ("%d", x); Assigned to x.

}

printf always returns integer that is no. of Symbol displayed on the screen by that particular printf.

Format Specifiers.

int	%d
float	%f
char	%c
String	%s
address	%u / %d.

Question asked

firstly check % or ? is
equal if not then
error.

 ? :
 ↑ ↑ ↑
 condition if condition if condition
 is True is False.

Condⁿ :-

- 1.) In the ternary operator there should be equal number of : and ? , otherwise it will throw error.
- 2.) ~~There should~~ Every colon [:] should match with the just before [?].
- 3.) Every [?] is followed by the [:] not immediately but following.

Example:-

$\textcircled{1} \quad a = 3 > 4 ?$ check $a = 20.$	$10 : 8 > 7 ? \quad 20 : 30 ;$ T check F True False
--	---

② $a = \frac{5 > 4 ?}{\text{check.}} \quad \frac{6 > 7 ?}{\text{True}} \quad \frac{10 : 40 : 50 ;}{\text{False.}}$
 $a = 40$

Ques:- $a = 2 > 3 ?$ $5 > 4 ?$ $10 > 30 ?$ $8 > 7 ?$ $30 > 40 ?$

 $a = 30$

Ques: $a = 6 > 7 ? 2 > 3 ? 10 : 6 > 8 ? -2 : 3 : 0 ? -1 : 6 > 8 ? 10 : 3 > 4 ? 70 : 80 ?$

$a = 80$

GATE
Ques

Which combination of the integer variables x, y, z makes variable 'a' get the value '4' in the following expression?

$$a = x \overset{3}{>} y \overset{14}{?} x \overset{17}{>} z \overset{11}{?} x \overset{4}{:} z \overset{6}{:} y \overset{4}{>} z \overset{4}{?} y \overset{2}{:} z \overset{2}{:}$$

- a) $x=6$ $y=5$ $z=3$

- b) $x=6$ $y=3$ $z=5$

- c) $x=5$ $y=4$ $z=5$

- ✓d) $x=3$ $y=4$ $z=2$.

Soln
 $a = 3 > 4 ? 3 > 2 ? 3 : 2 : 4 > 2 ? 4 : 2$
 then,
 $a = 4$

Ques Write a Program to find a Max^m of 3 no.s using ternary operator?

Soln int a, b, c, max;

max = a > b && b > c ? a : b > a ? b : c;

Solution

Max = a > b && a > c ? a : b > c ? b : c;

Ques Program Minimum of 4 numbers?

int a, b, c, d, min;

Min = a < b && b < c && c < d ?
a : b < c && c < d ? b : c < d ? c : d

min = a < b && b < c && c < d ? a : b < c && c < d ? b : c < d ? c : d.

OR

Min =

Homework :-

Solve the above two question without using 'and' 's' operator.

Pre/Post increment/Decrement

a = 10;	a = 10;	a = 10;	a = 10;	a = 10;	a = 10;
b = ++a;	b = a++;	b = a--;	b = --a;	a++;	++a;
<u>Output</u>				pf(a);	pf(a);
a b	a b	a b	a b	10	11.
11 11	11 10	9 10	9 9		

a = 10;	a = 10;	a = 10;	a = 10;
pf("%d", a++);	pf("%d", ++a);	return a--;	return a++;
<u>Output</u>			
10	11	10	10

GATE 2 Marks question

```
void main() {
    int m = 10;
    int n, n1;
    n = m ++m;
    n1 = m++;
    n--;
```

```
--n1;
n = n1;
pf("%d", n);
}
```

Output :- 0
[∵ n = n1
n = n - n1
n1 = 10
n = 10]

Ques int a=5
 Pf(++a, ++a, ++a);
 $\begin{array}{ccc} \underline{6} & \underline{7} & \underline{9} \\ \underline{8} & \underline{7} & \underline{6} \end{array}$ (Right to Left)
 (Left to Right)

Bad program.

② int a=5;
 Pf(a+1, a+2, a+3).
 $\begin{array}{ccc} \underline{6} & \underline{7} & \underline{8} \\ \underline{6} & \underline{7} & \underline{8} \end{array}$ (Right to Left)
 (Left to Right)

Good Program.

Ques a=5
 Pf(++a * a++ * ++a);
 → o/p depends on compiler
 → bad program.

→ Program should work based on logic not based on compiler.

→ Incrementing same variables in single line is bad program.

Ques void main() {
 int a=5;
 Pf("%d", (a⁵++)++); //error
 Pf("%d", (a+1)⁶++); //error
 }.

Ques a=5 | a=5 | a=5
 f(++a); | f(a++); | f(a+1);
 P.V = 6 | P.V = 5 | P.V = 6
 a.V = 6 | a.V = 6 | a.V = 5.
 [∴ Passing value
 a. value.]

Note:- Pre Increment / Post Increment works only on variables but not on constants and not on Expression.

Loops :

- 1.) For loop
- 2.) while loop
- 3.) do while loop.

WAP to print 1 to 10 using following loop.

1.) For loop.

```
int n;  
void main() {  
    for (int i = 1; i ≤ 10; i++) {  
        printf ("%d", i);  
    }  
}
```



```
void main() {  
    int i;  
    for (i = 1; i ≤ 10; (printf ("%d", i)));  
}
```

2.) while loop.

```
void main() {  
    while (i ≤ 10); {  
        printf ("%d", i);  
    }  
}
```

3.) Do while loop.

```
[void main() {  
    do { i++ }  
    while (i ≤ 10);  
    printf ("%d", i);  
}]
```



```
void main() {  
    int i = 1;  
    do { printf ("%d", i);  
        i++;  
    } while (i ≤ 10);  
}
```

Question

```
void main() {  
    int x = 5;  
    while (x++ ≤ 7);  
    printf ("%d", x);  
}
```

Output 6, 7, 8, 9.

Verification $5 \leq 7$, $x++$, $x = 6$.

$6 \leq 7$

$x++$, $x = 7$

$7 \leq 7$

$x++$, $x = 8$.

$8 \leq 7$ (condition fails)

$x++$, $x = 9$. (But x is incremented).



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Operations on String :-

Length: It is the no. of Symbol in a string.

$$\text{Let } w = abb \Rightarrow |w| = |abb| = 3.$$

$$w = baba \Rightarrow |w| = |baba| = 4.$$

$$w = \epsilon \Rightarrow |w| = |\epsilon| = 0.$$

$$w = a \Rightarrow |w| = |a| = 1.$$

' ϵ ' is the only String of length 'zero'.

Concatenation :-

$$\text{Let } u = abb \text{ \& } v = ab$$

$$\Rightarrow u \cdot v = abbab$$

$$v \cdot u = ababb$$

$$uv \neq vu$$

$$ababb \neq abbab$$

$$ab = ba \checkmark$$

$$ab \neq ba \times.$$

Concatenation is not closed under commutative but closed associative.

$$\text{i.e. } (u \cdot v) \cdot w = u \cdot (v \cdot w)$$

Reverse of a String :-

$$\text{g/ } w = abab \Rightarrow w^T / w^R = baba$$

$$|w| = |w^R|$$

$$\text{Let } u = ab \text{ \& } v = abb.$$

$$u^T = ba \text{ \& } v^T = bba.$$

$$u \cdot v = ababb.$$

$$(uv)^T = bbaba.$$

$$(uv)^T \neq u^T \cdot v^T$$

$$bbaba \neq babba.$$

$$(uv)^T$$

$$v^T \cdot u^T$$

$$(uv)^T$$

$$= w^T \cdot v^T \cdot u^T.$$

Power of a String:-

w^n where $n \geq 0$

$$w^0 = \epsilon, w^1 = w, w^2 = w \cdot w$$

$$w^3 = w \cdot w \cdot w \text{ or } w \cdot w^2 \text{ or } w^2 \cdot w$$

$$w^{m+n} = w^m \cdot w^n = w^n \cdot w^m$$

Let $w = ab$.

$$(ab)^2 = abab$$

$$(ab)^2 \neq (ba)^2$$

$$(ab)^0 = \epsilon, (ab)^1 = ab.$$

$$(ab)^2 \neq a^2 b^2$$

Kleen's closure:-

$$\text{Let } \Sigma = \{a, b\} \Rightarrow |\Sigma| = 2.$$

$$\Sigma^* = \Sigma^0 \cup \Sigma^1 \cup \Sigma^2 \cup \Sigma^3 \cup \dots \infty$$

Σ^0 is the strings of length zero i.e. ϵ

The no. of strings of length zero $|\Sigma|^0$ i.e. $2^0 = 1$.

Σ^1 is the strings of length 1 i.e. $\{a, b\}$

The no. of strings of length 1, $|\Sigma|^1$ i.e. $2^1 = 2$.

Σ^2 is the strings of length 2, i.e. $\{aa, ab, ba, bb\}$

The no. of strings of length 2, $|\Sigma|^2$ i.e. $2^2 = 4$.

Similarly, The no. of strings of length n is $|\Sigma|^n$ i.e. 2^n .

$$\Sigma^* = \Sigma^0 \cup \Sigma^1 \cup \Sigma^2 \cup \dots$$

$$= \{ \epsilon, a, b, aa, ab, ba, bb, aaa, \dots \infty \}.$$

Positive closure:-

$$\Sigma^+ = \Sigma^1 \cup \Sigma^2 \cup \Sigma^3 \cup \dots \cup \infty$$
$$= \{a, b, aa, ab, ba, bb, aaa, \dots\}.$$

$$\boxed{\Sigma^+ = \Sigma^* - \{\epsilon\}}$$

Prefix of a String:- It is taking zero or more symbols from left to right

$$\text{Let } w = \underline{a}bb \Rightarrow |w| = 3.$$

$$\text{prefix}(w) = \{\epsilon, a, ab, abb\}.$$

$$\text{The proper prefix}(w) = \{\epsilon, a, ab\}.$$

$$\text{If } |w| = n \Rightarrow |\text{Prefix}(w)| = n + 1.$$

$$\text{And } |\text{Proper prefix}(w)| = n.$$

Suffix of String:-

It is taking zero or more symbols from the end in the forward direction only.

$$\text{Let } w = a\underline{bb} \Rightarrow |w| = 3.$$

$$\text{Suffix}(w) = \{\epsilon, b, bb, abb\}$$

$$\text{proper Suffix}(w) = \{\epsilon, b, bb\}.$$

$$\text{If } |w| = n \Rightarrow |\text{Suffix}(w)| = n + 1.$$

$$\boxed{\text{Prefix}(w) \cap \text{Suffix}(w) \geq \{\epsilon, w\}}$$

Ques Let $w = abba$.

Soln

$$\text{Prefix} = \{\epsilon, a, ab, abb, abba\}.$$

$$\text{Suffix} = \{\epsilon, a, ba, aba, abba\}.$$

$$\text{Prefix}(w) \cap \text{Suffix}(w) = \{\epsilon, a, abba\}.$$

Sub String of a String :-

It is any Sequence of zero or more consecutive, Symbols of a String.

Let $w = abba$.

Substring(w) :- $\{ \epsilon, a, b, ab, bb, ba, abb, bba, abba \}$.

$$\text{Prefix}(w) \cup \text{suffix}(w) \subseteq \text{Substring}(w)$$

Ques Find the no. of Substring "DELHI".

Substring: $\{ \epsilon, D, E, L, H, I, DE, EL, LH, HI, DEL, ELH, LHI, DELH, ELHI, DELHI \}$

= 16.

Note:- The no. of Substrings of a word of length 'n' having all the letters are Different is

$$\frac{n(n+1)}{2} + 1$$

GATE-2025

Ques Let S be set of all ternary strings over $\{a, b, c\}$. Consider all strings in S that contain at least one occurrence of two consecutive Symbols;

ie aa, bb or cc . Then the no. of Such String of length 5 is?

Solⁿ: The no. of all Strings of length 5 is

$$\begin{array}{c} a/b/c \\ \downarrow \\ 3 \text{ ways} \times 3 \times 3 \times 3 \times 3 = 3^5 \text{ ways. Total.} \end{array}$$

The no. of Strings not containing aa, bb or cc is

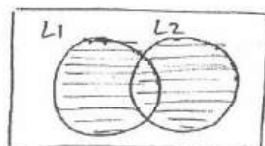
$$\begin{array}{c} a \quad b, c \\ \frac{3}{\text{ways}} \quad \frac{2}{\text{ways}} \quad \frac{2}{\text{ways}} \quad \frac{2}{\text{ways}} \\ = 48 \text{ ways} \end{array}$$

$$\begin{array}{l} \text{The required no. of} \\ \text{Strings is} \\ \therefore 243 - 48 \\ = 195 \end{array}$$

Operations on languages :-

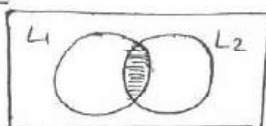
Union, Intersection, Concatenation, Reversal, complement
Kleen's closure, Positive closure, Set Difference,
Symmetric Difference / Exclusive OR, Implication,
Exclusive NOR / Bi-implication, XOR, NAND.

1.) Union :-



$$|L_1 \cup L_2| = |L_1| + |L_2| - |L_1 \cap L_2|$$

2.) Intersection :-



3.) Concatenation :-

Let $L_1 = \{a, b\}$ & $L_2 = \{aa, ba, bb\}$

$$L_1 \cdot L_2 = \{a, b\} \cdot \{aa, ba, bb\}$$

$$= \{aaa, aba, abb, baa, bba, bbb\}$$

$$|L_1 \cdot L_2| \leq |L_1| \times |L_2|$$

Example

Let $L_1 = \{a, ab\}$ & $L_2 = \{ba, a, bb\}$

$$L_1 \cdot L_2 = \{a, ab\} \cdot \{ba, a, bb\}$$

$$\{aba, aa, abb, abba, abbb\}$$

$$|L_1 \cdot L_2| = 5 < |L_1| \times |L_2|$$

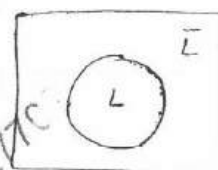
4.) Reversal

Let $L = \{ab, bab, abab\}$

$$L^R = \{ba, bab, baba\}$$

$$|L| = |L^R|$$

5.) complement



$$\Sigma = \{a, b\}$$

$$\bar{L} = \Sigma^* - L$$

$$L \cup \bar{L} = \Sigma^*$$

6.) Kleen's closure

$$L^* = L^0 \cup L^1 \cup L^2 \cup L^3 \cup \dots$$

7.) Positive closure

$$L^+ = L^1 \cup L^2 \cup L^3 \cup \dots$$

Example

Let $L = \{a\}$.

$$L^0 = \{\epsilon\}, L^1 = L = \{a\}$$

$$L^2 = L \cdot L = a \cdot a = \{a^2\}$$

$$L^3 = L \cdot L \cdot L = \{a^2\} \cdot \{a\} = \{a^3\}$$

$$L^* = L^0 \cup L^1 \cup L^2 \cup L^3 \dots \infty$$

$$= \{\epsilon, a, a^2, a^3, a^4, \dots, \infty\}$$

$$L^+ = L^1 \cup L^2 \cup L^3 \cup \dots, \infty$$

$$= \{a, a^2, a^3, a^4, \dots, \infty\}$$

$$\therefore L^+ = L^* - \{\epsilon\}$$

Let $L = \{\epsilon, a\}$.

$$L^0 = \{\epsilon\} \quad L^1 = \{\epsilon, a\}$$

$$L^2 = L \cdot L = \{\epsilon, a\} \cdot \{\epsilon, a\} = \{\epsilon, a, a^2\}$$

$$L^3 = L \cdot L \cdot L = \{\epsilon, a\} \cdot \{\epsilon, a, a^2\} = \{\epsilon, a, a^2, a^3\}$$

$$L^* = L^0 \cup L^1 \cup L^2 \cup L^3 \dots \infty$$

$$= \{\epsilon, a, a^2, a^3, a^4, \dots, \infty\}$$

$$L^+ = L^1 \cup L^2 \cup L^3 \cup L^4 \dots \infty$$

$$= \{\epsilon, a, a^2, a^3, a^4, \dots, \infty\}$$

$$\therefore L^+ = L^*$$

Note:-

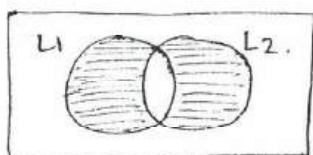
$$L^+ = L^* - \{\epsilon\} \text{ if } L \text{ doesn't contain } \epsilon$$

$$= L^* \text{ if } L \text{ contains } \epsilon$$

8) Symmetric Difference

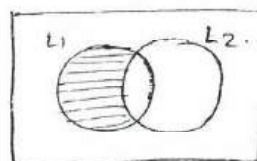
Exclusive OR:-

$$L_1 \oplus L_2 = (L_1 - L_2) \cup (L_2 - L_1)$$



$$|L_1 \oplus L_2| = |L_1| + |L_2| - 2|L_1 \cap L_2|$$

9) Set Difference



$$L_1 - L_2 =$$

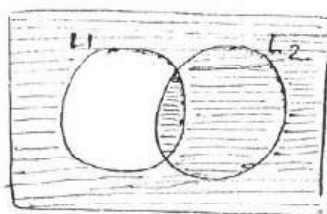
$$L_1 - \{L_1 \cap L_2\}$$

$$\Rightarrow L_1 \cap \bar{L}_2$$

$L_1 - L_2$ is the Set of all strings those are in L_1 but not in L_2 .

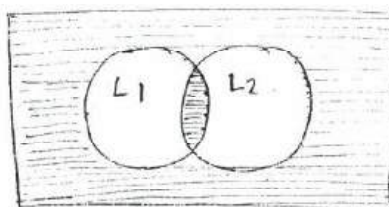
9) Implication:-

$$L_1 \Rightarrow L_2 = \bar{L}_1 \cup L_2$$



10) Exclusive NOR / Bi-Implication:-

$$L_1 \oplus L_2 = (\bar{L}_1 \cap \bar{L}_2) \cup (L_1 \cap L_2)$$



11) NOR:-

$$\overline{L_1 \cup L_2} = \overline{L_1} \cap \overline{L_2}$$

12) NAND

$$\overline{L_1 \cap L_2} = \overline{L_1} \cup \overline{L_2}$$

⇒ The language having only null (ϵ) string is

$$L = \{\epsilon\}$$

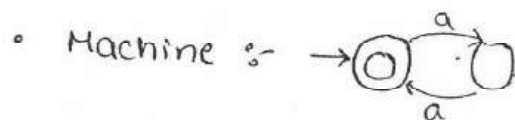
$$|L| = 1$$

$$|\epsilon| = 0.$$

⇒ The empty language is $L = \{\} = \phi$

$$|L| = 0.$$

- Listing = $L = \{\epsilon, a^2, a^4, a^6, a^8, a^{10}, a^{12}, a^{14}, a^{16}, \dots\}$
 - Statement:- $L = \{\text{The set of all even no. of } a\text{'s}\}$
 - Set Builder form:- $L = \{a^{2n} \mid n \geq 0\}$
- } Informal way of representation of a language.



• Grammar:- $\{S \rightarrow aa \mid S \in \epsilon\}$

• Regular Expression:- $RR = (aa)^*$

} Formal ways of representation of a language.

Finite Automata

It is a 5-tuple, $\{Q, \Sigma, \delta, q_0, F\}$

$M = (Q, \Sigma, \delta, q_0, F)$

- Q : Finite non empty set of states.
- Σ : finite set of input.
- δ : Transition function. It describes the change in state.
- q_0 : Initial state.
- F : Set of final states. (May be 0 or more)

Finite non empty set of states.

Transition function.

It describes the change in state

$$\delta: Q \times \Sigma \rightarrow Q.$$

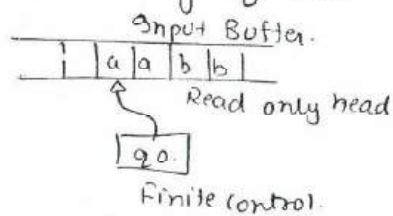
Note:-

→ At any instance of the time the Automata will be in only '1' State.

→ The next State of the automata depends on the present State and present input.

→ The transition function Describes the change of the State During a transaction.

$$\delta: Q \times \Sigma \rightarrow Q.$$

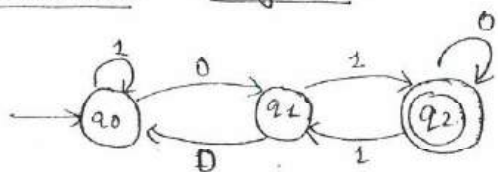


$$\delta: Q \times \Sigma \rightarrow Q.$$

Representation of a Finite Automata.

- By Transition Diagram
- By Transition Table
- By 5-tuple.

• By Transition Diagram:-



• By Transition Table:-

Present	Next State	
	0	1
→ q ₀	q ₁	q ₀
q ₁	q ₀	q ₂
⊙ q ₂	q ₂	q ₁

• By 5 tuples.

$$M = (\{q_0, q_1, q_2\}, \{0, 1\}, \delta, q_0, \{q_2\}).$$

$$\delta(q_0, 0) = q_1$$

$$\delta(q_0, 1) = q_0$$

$$\delta(q_1, 0) = q_0$$

$$\delta(q_1, 1) = q_2$$

$$\delta(q_2, 0) = q_2$$

$$\delta(q_2, 1) = q_1$$



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ENGLISH

- 1] Correction Of Sentences
- 2] Vocabulary
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- 4] Analogy.

01. CORRECTION OF SENTENCES

Subcontents

1. Question Tags

2. Usage of

a) As soon as

b) No-Sooner - Than

c) Hardly - When

d) Scarcely - When/Before

3. Degree of Comparison

4. Articles

5. Tenses + If clauses

6. Reported speech

7. prepositions

8. parts of speech

9. Concord

and
Connections

Sentences: 4 kinds

1. Assertive
 - a) positive
 - b) Negative.
2. Interrogative
3. Imperative
4. Exclamatory.

Special Verbs: (24)

am, is, are, was, were, have, has, had, do, does, did, will, would, shall, should, can, could, may, might, must, need, dare, used to, ought to.

Negative:-

To make a negative sentence, put NOT after the special verb.

Interrogative:-

To make an Interrogative sentence, put the special verb at the starting of the sentence.

Ex:- Dhoni is a perfect Gentleman (positive)
Dhoni is not a perfect Gentleman (Negative)
Is Dhoni a perfect Gentleman? (Interrogative)

* Non-Special Verbs :

borrow :- do/does/did
do = present sentence without 's'
does = present sentence with 's'
did = past tense

Note: When we borrow do, does, did, put the root verb in negative and interrogation.

Ex:-

He goes to Temple (positive)

He does not go to Temple (Negative)

Does he go to temple? (Interrogative)

Ex:-

He went to Temple (+ve)

He did not go to Temple (-ve)

Did he go to Temple? (Interrogative)

• Do, Does, Did

These 3 - always take root verb.

01. QUESTION TAGS

After giving a statement - We sometimes confirm IF the Listener is accepting (or) Not with our statement. This confirmation is called Question Tag.

Note: Question Tags are of mainly 2 kinds -

Model 1:

To a positive statement, Negative tag is added.

Rules: 1) only short forms are used

2) In the place of nouns, use pronouns.

Note: Question Tag should be ended with ~~special verb~~ Pronouns.

Ex:- Dhoni is a perfect Gentleman, isn't he?

Ex:- The clock is running past, isn't it?

Ex:- I am a teacher of English, aren't?

Ex:- We are the ~~ilk~~ of Made Easy, aren't we?
family

Ex:- My neighbour comes tomorrow, doesn't he?

Ex:- All the students went to picnic, didn't they?

Model 2:

If the statement is negative, the Question Tag is positive.

eg: → I am not a teacher of English, am I?

eg: → My friend does not know address, Does He?

or model 3

Formula: Special verb + Pronoun

Q2. USAGE OF

Hardly, rarely, seldom, scarcely, barely, never

Note: These words always give negative sense. In the case of these words the Question Tag is positive.

eg: → He hardly comes to my house, does he?

eg: → Barking dogs seldom bite, do they?

eg: → They never came to my house, did they?

Usage of Have, has, had -

Note: These three act as two kinds.

1. Main verb - (gives the meaning of possessing)

2. Special verb - (does not give any meaning)

eg: → He ^(main verb) has a car, doesn't he?

eg: → He has purchased a car, hasn't he?
_(special verb)

He had solved the problem before I went, hadn't he?

He had a problem calling, didn't he?

Usage of Everyone, Everybody, Someone, Somebody, Noone, Nobody

Note: These six words take singular verb at the time of Statements but in question Tags these words take plural verb.

→ In the place of all these words we have to write 'they'

Singular Verbs		plural verbs
----------------	--	--------------

Is	→	are
----	---	-----

was	→	were
-----	---	------

has	→	have
-----	---	------

does	→	do
------	---	----

eg: → Everyone is coming, ~~isn't everyone?~~
aren't they?

eg: → Everyone Likes Music, don't they?

eg: → Everyone has given mobile, haven't they?

eg: → Everyone has mobile, don't they?

eg: → None is coming, are they?

eg: → No one supports corruption, do they?

• Usage of a few = positive
few = Negative

a little = positive
little = Negative.

eg. He asked me a few books, didn't he?
(+ve) (-ve)

He asked me few books, did he?
(-ve) (+ve)

He wants a little, ~~doesn't~~ does he?

He wants little, does he?

• Usage of making Imperatives in a Question Tag.

Imperative:-

Rules:

- ① Subject you in absent (But the meaning is implied in it)
- ② Sentence begin with V₁
- ③ Expresses command (or) request.

Note: Imperatives generally take "will you?" in Question Tags.

A sentence i.e. satisfied with these three rules is called Imperative

eg: ① Come here, will you?

② Go there, will you?

③ Don't come here, will you?

④ Shup up, Can't you?

⑤ Get Lost, Can't you?

⑥ Keep Silence, Can't you?

- If the statement begins with Let's or Let us
The question Tag is always shall we?

eg: 1) Let's start the work, shall we?

2) Let's not start the work, shall we?

3) Let him go, will you?

Not Let's or Let us.

- If the statement begins with 'So'

a) To a positive statement, Question Tag is also +ve

b) To a negative statement, Question Tag is also -ve.

eg: So you are coming, are you?

So you are not coming, aren't you?

NO → Numerical
order

• Usage of

a) as soon as

b) No-sooner-than

c) Hardly-When

d) Scarcely - when/Before

i.e → i-deste

French word

silent → silence
singular → plural

Note: These four words are called 'Idiomatic Expressions'.

These four words give the same meaning, i.e. Immediately.

Note:

Usage of No-sooner-than

~~No sooner than~~

Rules: ① put No-sooner in the place of as soon as

② change the as soon as sentence into interrogative form.

③ put than before the second sentence.

eg: 1) As soon as I went home, I had rest.

→ No sooner did I go home than I had rest.

2) As soon as the baby sees the doctor, she will cry

→ No sooner does the baby see the doctor than she will cry.

• Usage of Hardly when:

Rules: ① put Hardly in the place of as soon as

② Change the as soon as sentence had + V₃ form and then

Change into interrogative form,

③ put when before the second sentence

eg: 1) As soon as I went home, I had rest.

→ Hardly had I gone home when I had rest.

Usage of scarcely when
before

Note: & The same rules of hardly when are applicable

eg: 1) As soon as the principal entered the classroom, all the students stood up.

→ Scarcely had the principal entered the classroom when
before
all the students stood up.

2) As soon as he had explained the topic, students felt happy.

→ No sooner had he explained the topic than students felt happy.

→ Scarcely had he explained the topic when students felt
before happy.

→ Hardly had he explained the topic when students felt happy.

03. DEGREES OF COMPARISON

Three forms of the adjective and adverbs are called degrees of comparison.

1. Positive degree.

a) ~~as soon as~~ as-as (accepting sense)

b) so-as [Negative sense].

2. Comparative degree [Takes than]

3. Superlative degree [Takes the]



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NUMBER SYSTEM

FACTORS / DIVISOR

Factors are the set of nos that will divide a given number completely.

Example :-

$$\textcircled{1} 72 = 2^3 \times 3^2 = 4 \times 3 = 12$$

$$2^0 \begin{cases} 2^1 = 2 \\ 2^2 = 4 \end{cases} \quad 3^0 \begin{cases} 3^1 = 3 \\ 3^2 = 9 \end{cases}$$

$$2^2 \begin{cases} 2^3 = 8 \\ 2^4 = 16 \end{cases} \quad 3^1 \begin{cases} 3^2 = 9 \\ 3^3 = 27 \end{cases}$$

$$1, 2, 3, 4, 6, 8, 9, 12, 18, 24, 36, 72$$

$$\textcircled{11} 120 = 2^3 \times 3^1 \times 5^1 = 4 \times 2 \times 2 = 16 - \text{TF}$$

↓
Total Factor

$$1, 2, 3, 4, 5, 6, 8, 10, 12, 15, 20, 24, 30, 40, 60, 120.$$

$$* N = a^p \times b^q \times c^r \dots$$

$$\text{Total Factor} = (p+1)(q+1)(r+1)$$

where,

a, b, c are distinct Prime No's.

p, q, r are Natural Numbers.

$$\textcircled{11} 10,800 = 2^4 \times 5^2 \times 3^2 = 5 \times 3 \times 4 = 60 - \text{TF}$$

$$\text{2nd Mtd :- } 10800$$

$$\begin{aligned} & 108 \times 100 \\ & \downarrow \\ & (12 \times 9) \times (5^2 \times 2^2) \\ & (2^2 \times 3^1)(3^2) \times (5^2 \times 2^2) \\ & = 2^4 \times 3^3 \times 5^2 = 5 \times 4 \times 3 = 60 \end{aligned}$$

$$\text{Odd Factor} = 3 \times 4 = 12$$

$$\text{Even Factor} = (60 - 12) = 48$$

$$\textcircled{14} 9000 = 2^3 \times 3^2 \times 5^3 = 4 \times 3 \times 4 = 48 - \text{TF}$$

$$\text{Odd Factors} = 3 \times 4 = 12$$

$$\text{Even Factors} = (48 - 12) = 36$$

Q1:- How many factors of number 72 are multiple of 6.

Q2:- How many factors of number 120 are multiple of 30.

Q3:- How many factors of number 9000 are multiple of 30.

$$\begin{aligned} \textcircled{1} 72 &= 2^3 \times 3^2 \\ 72 &= (2 \times 3) (2^2 \times 3) \\ & \quad \downarrow \\ & \text{T.F} = 3 \times 2 = 6 \end{aligned}$$

$$\begin{aligned} \textcircled{2} 120 &= 2^3 \times 3^1 \times 5^1 \\ &= (2^2 \times 3^1) (2^1 \times 5^1) \\ & \quad \downarrow \\ & \text{T.F} = 2 \times 2 = 4 \end{aligned}$$

$$\begin{aligned} \textcircled{3} 9000 &= 2^3 \times 3^2 \times 5^3 \\ &= (2^1 \times 3^1 \times 5^1) (2^2 \times 3^1 \times 5^2) \\ & \quad \downarrow \\ & \text{T.F} = 3 \times 2 \times 3 = 18 \end{aligned}$$

Prime and Composite Factors

1 is neither prime nor composite.

Total factors = Prime factors + composite factors + 1

$$\text{Example :- } 72 = 2^3 \times 3^2$$

$$\text{PF} = 2 \text{ for } (2, 3)$$

$$\text{CF} = ?$$

$$\text{NPNC} = 1$$

$$\text{TF} = 12$$

$$12 = 2 + \text{CF} + 1$$

$$\text{CF} = 9$$

NPNC = Neither prime nor composite.

$$120 = 2^3 \times 3^1 \times 5^1$$

$$PF = (2, 3, 5) = 3$$

$$CF = ?$$

$$NPNC = 1$$

$$16 = 3 + CF + 1$$

$$\therefore CF = 12$$

$$10800 = 2^4 \times 3^3 \times 5^2$$

$$PF = 3$$

$$CF = ? \quad NPNC = 1$$

$$60 = 3 + CF + 1$$

$$\therefore CF = 56$$

$$9000 = 48 = 3 + CF + 1$$

$$CF = 44$$

Not Important

$$N = a^p \times b^q \dots$$

$$\text{Sum of all factors} = \frac{(a^{p+1} - 1)}{(a - 1)} \times \frac{(b^{q+1} - 1)}{(b - 1)} \dots$$

$$\text{Example :- } 2^3 \times 3^2 = 72$$

$$N = \left(\frac{2^4 - 1}{2 - 1} \right) \times \left(\frac{3^3 - 1}{3 - 1} \right) = 15 \times 13 = 195$$

$$\text{Product of all } N = [N]^{\frac{TF}{2}}$$

Example :-

$$\textcircled{1} [72]^{\frac{12}{2}} = 72^6$$

$$\textcircled{2} [120]^{\frac{16}{2}} = [120]^8$$

$$\text{Ex :- } 36 = 2^2 \times 3^2 = 3 \times 3 = 9 = TF$$

$$36^4 \times 6 = 36^4 \times 36^{\frac{1}{2}} = 36^{4.5} = (36)^{\frac{1}{2}} = N^{\frac{TF}{2}}$$



Base System

$$10^1 10^0$$

$$a \cdot b = 10a + b$$

$$10^2 \cdot 10^1 10^0$$

$$abc = 100a + 10b + c$$

Th. 4 Ten Units

$$3476$$

$$10^3 10^2 10^1 10^0$$

$$(25)_{10} = (11001)_2$$

2	25	Rem.
2	12	1
2	6	0
2	3	0
1	1	

$$(25)_{10} = (121)_4$$

4	25	Rem.
4	6	1
1	2	

$$(25)_{10} = (11001)_2 = (16 + 8 + 0 + 0 + 1)_2 = (25)_{10}$$

$$(25)_{10} = (121)_4 = (16 + 8 + 1)_4 = (25)_{10}$$

$$\text{Q2/WB } 137 + 276 = 435$$

$$731 + 672 = ?$$

$$\begin{bmatrix} 137 \\ + 276 \\ \hline 435 \end{bmatrix}_{b=8} \quad \begin{bmatrix} 731 \\ + 672 \\ \hline 1623 \end{bmatrix}_{b=8} \quad \begin{bmatrix} 6731 \\ - 672 \\ \hline 037 \end{bmatrix}_{b=8}$$

$$7 + 6 = b + 5 \Rightarrow b = 8$$

$$\text{Q:- If } \begin{bmatrix} 4226 \\ - 2442 \\ \hline 10001 \end{bmatrix}_{b=7} \text{ then } \begin{bmatrix} 2342 \\ - 1656 \\ \hline 0353 \end{bmatrix}_{b=7}$$

$$6 + 2 = b + 1$$

$$b = 7$$

$$(7526)_8 - (y)_8 = (4364)_8$$

$$a - y = b$$

$$y = a - b$$

$$\begin{bmatrix} 7 & 5 & 2 & 6 \\ -4 & 3 & 6 & 4 \\ \hline 3 & 1 & 4 & 2 \end{bmatrix} b=8$$

Example : 44

$$\begin{array}{r} \times 11 \\ 1034 \end{array}$$

$$b^1 b^0 \quad b^1 b^0 \quad b^3 b^2 b^1 b^0$$

$$44 \times 11 = 1034$$

$$(4b+4) \times (b+1) = b^3 + 3b + 4$$

$$4(b+1)^2 = b^3 + 3b + 4$$

$$b=5$$

$$4(6)^2 = 125 + 15 + 4$$

$$144 = 144$$

$$\begin{array}{r} 44 \\ 11 \\ \hline 44 \\ 44 \times \\ \hline 1034 \end{array}$$

$$b=5$$

CYCLICITY

Power divided by 4 (4 operations)

$$4n+1 \xrightarrow{\text{Rem1}} 2 \quad 3 \quad 7 \quad 8$$

$$4n+2 \xrightarrow{\text{Rem2}} 4 \quad 9 \quad 9 \quad 4$$

$$4n+3 \xrightarrow{\text{Rem3}} 8 \quad 7 \quad 3 \quad 2$$

$$4n \xrightarrow{\text{Rem0}} 6 \quad 1 \quad 1 \quad 6$$

Operations - 2

$$4 \leftarrow \text{odd power} \quad 9 \leftarrow \text{odd power}$$

$$6 \leftarrow \text{Even power} \quad 1 \leftarrow \text{even}$$

Operation-1 Numbers $\rightarrow 0, 1, 5, 6$

Example :-

$$\textcircled{i} (432)^{2(27)} = u = 8 \quad (\text{Rem. } 3)$$

$$\textcircled{ii} (453)^{2(22)} = u = 9 \quad (\text{Rem } 2)$$

$$\textcircled{iii} 74^{91} = u = 4$$

$$\textcircled{iv} 79^{91} = u = 9$$

$$\textcircled{v} 74^{92} = u = 6$$

$$\textcircled{vi} 79^{92} = u = 1$$

$$\textcircled{vii} (76)^{937} \times (34)^{71} \times (273)^{993} \\ = 6 \times 4 + 3 = 7$$

$$\textcircled{Q97} | \text{Pg } 103 | \text{WB}$$

$$211^{870} + 146^{127} \times 3^{424} = 1 + 6 \times 1 = 7$$

$$\textcircled{Q103} | \text{Pg } 107 | \text{WB}$$

$$(2171)^7 + (2172)^9 + (2173)^{11} + (2174)^{13} \\ = 1 + 2 + 7 + 4 = 14$$

$$\textcircled{Q148} | \text{WB}$$

$$26591749^{110016} = 1$$

$$\textcircled{Q4} | \text{WB}$$

$$[3^{999} \times 7^{1000}] = 7 \times 1 = 7$$

$$\textcircled{Mtd-2}$$

$$(8 \times 7)^{999} \times 7^1 = (21)^{999} \times 7 = 1 \times 7 = 7$$

$$\textcircled{Q} : (4739)^{2373} \times (228)^{4532} \times (7357)^{9913} \times$$

$$(325)^{719} \times (293)^{3213}$$

multiple of 5

$$= 9 \times 6 \times 7 \times 5 \times 3$$

$$= 5670$$

Even no. & multiple of 5 will result in zero.

$$\underline{\text{Ex:}} \quad 1! + 2! + 3! + 4! + 5! + \dots + 99! = n \cdot 1$$

$$5! = 5 \times 4 \times 3 \times 2 \times 1 = 120$$

$$6! = 6 \times 5! = 720$$

$$7! = 7 \times 6 \times 5! = 5040$$

$$1 + 2 + 6 + 24 + 120 + \dots = 33$$

Q:- No. of zeroes = ? (means power of 10)

$$100! = 1 \times 2 \times 3 \times 4 \times 5 \times \dots \times 99 \times 100$$

$$\frac{100}{5} = 20 \quad [5, 10, 15, 20, \dots, 100] \approx 5^1$$

$$\frac{20}{5} = 4 \quad [25, 50, 75, 100] \approx 5^2$$

$$\underline{\underline{24}}$$

$$\underline{\text{Q:-}} \quad 100! = 1 \times 2 \times 3 \times 4 \times 5 \times 6 \times \dots \times 99 \times \dots$$

$$3^n = ?$$

$$\frac{100}{3} = 33 \quad [3, 6, 9, 12, \dots, 99] \approx 3^1$$

$$\frac{33}{3} = 11 \quad [9, 18, 27, \dots, 99] \approx 3^2$$

$$\frac{11}{3} = 3 \quad [27, 54, 81] \approx 3^3$$

$$\frac{3}{3} = 1 \quad [81] \approx 3^4$$

$$\frac{1}{3} = 0$$

$$3^{48} \rightarrow n = 48$$

$$\underline{\text{Q:-}} \quad 100! = 7^n = 7^{16}$$

$$\frac{100}{7} = 14 \quad [7, 14, 21, \dots, 98] \approx 7^1$$

$$\frac{14}{7} = 2 \quad [49, 98] \approx 7^2$$

$$\frac{2}{7} = 0$$

$$\underline{\text{Q:-}} \quad 100! = 15^n$$

$$(3 \times 5)^n$$

$$100! = 1 \times 2 \times 3 \times 4 \times 5 \times \dots \times 100$$

$$100! = 3^{48} \times 5^{24}$$

$$= (3 \times 5)^{24} \times 3^{24}$$

$$= (15)^{24} \times 3^{24} \rightarrow 2.4 \times 10^{44}$$

Q:- If first 9 multiples of 5 are multiplied.

$$p = (5 \times 10 \times 15 \times 20 \times \dots \times 45)$$

No. of zeroes in p.

$$\textcircled{a} 4 \quad \textcircled{b} 9 \quad \textcircled{c} 10 \quad \textcircled{d} \text{NOTA}$$

$$\underline{\text{Q2:-}} \quad \frac{100!}{(77)^n}, \frac{100!}{(85)^n}, \frac{100!}{(91)^n}, \frac{100!}{(65)^n}$$

$$\textcircled{1} \quad \begin{array}{ccccccc} & 1 & 4 & 2 & 1 & 3 & \\ & \uparrow & \uparrow & \uparrow & \uparrow & \uparrow & \\ 5 & \times & 10 & \times & 15 & \times & 20 & \times & 30 & \times & \dots & \times & 40 & \times & \dots & \times & 45 \\ (5 \times 1) & (5 \times 2) & (5 \times 3) & \dots & \dots & \dots & \dots & \dots & \dots & \dots & \dots & \dots & \dots & \dots & \dots & \dots & \dots & \times (5 \times 9) \end{array}$$

$$1 + 2 + 1 + 3 = 7$$

$$\underline{\text{Mtd:2}} \quad 5^9 \times 9!$$

$$5^{10} \times 2^7$$

$$10^7 \times 5^3$$

$$\textcircled{2} \quad 100! = 2^{97} \times 3^{48} \times 5^{24} \times 7^{16} \times 11^7 \times 13^7 \times 17^5 \times 19^5$$

$$\frac{100!}{(77)^n} = \frac{100!}{(7 \times 11)^n} = 9$$

$$\frac{100!}{(91)^n} = \frac{100!}{(13 \times 7)^n} = 7$$

$$\frac{100!}{(85)^n} = \frac{100!}{(17 \times 5)^n} = 5$$

$$\frac{100!}{(65)^n} = \frac{100!}{13 \times 5} = 7$$

$$\left\{ \begin{array}{l} 100! \\ \frac{100}{2} = 50 \\ 25 \\ 12 \\ 6 \\ 3 \\ 1 \\ \hline 97 \end{array} \right.$$

02/09/2024

Series

$$Q:- 5 \times 10 \times 15 \times \dots \times 120$$

$\downarrow \quad \downarrow$
 $(5 \times 1) \quad (5 \times 2)$

24! = No. of 2's

$$\frac{24}{2} = 12 \quad \frac{12}{2} = 6 \quad \frac{6}{2} = 3 \quad \frac{3}{2} = 1$$

$$12 + 6 + 3 + 1 = 22$$

Q:- No. of trailing zeros

$$Q) 1! \times 2! \times 3! \times 5! \times 10! \times 15! \times 20! \times 100!$$

$$[5 + 10 + 15 + \dots + 25 + 100]$$

$$5(1 + 2 + 3 + \dots + 20)$$

$$5 \times \left[\frac{20 \times 21}{2} \right] = 1050 + 25 + 50 + 75 + 100 = 1300$$

$$\left\{ \sum n = \frac{n(n+1)}{2} \right.$$

$$25^{25} = (5^2)^{25} = 5^{50}$$

$$(50)^{50} = (5^2 \times 2)^{50} = 5^{100}$$

$$(75)^{75} = (5^2 \times 3)^{75} = 5^{150}$$

$$100^{100} = (5^2 \times 2)^{100} = 5^{200}$$

$$Q) 1! \times 2! \times 3! \times 4! \times \dots \times 100!$$

Q124, Pg 107, WB

$$a_n = \frac{1}{n} - \frac{1}{n+2} \quad n > 0$$

$$a_1 + a_2 + a_3 + \dots + a_{48}$$

$$\left[\left(\frac{1}{1} - \frac{1}{3} \right) + \left(\frac{1}{2} - \frac{1}{4} \right) + \left(\frac{1}{3} - \frac{1}{5} \right) + \dots + \left(\frac{1}{48} - \frac{1}{50} \right) \right]$$

$$+ \left(\frac{1}{49} - \frac{1}{51} \right) + \left(\frac{1}{50} - \frac{1}{52} \right)$$

$$= \left(1 + \frac{1}{2} \right) - \left(\frac{1}{51} + \frac{1}{52} \right)$$

$$Q:- S = \frac{1}{3} + \frac{1}{15} + \frac{1}{35} + \dots + \frac{1}{399}$$

Then $S = ?$

$$A) \frac{20}{21} \quad B) \frac{19}{21} \quad C) \frac{11}{21} \quad D) \frac{10}{21}$$

$$S = \frac{1}{1 \times 3} + \frac{1}{3 \times 5} + \frac{1}{5 \times 7} + \dots + \frac{1}{19 \times 21}$$

$$S = \frac{1}{2} \left[\left(\frac{1}{1} - \frac{1}{3} \right) + \left(\frac{1}{3} - \frac{1}{5} \right) + \left(\frac{1}{5} - \frac{1}{7} \right) + \dots + \left(\frac{1}{19} - \frac{1}{21} \right) \right]$$

$$S = \frac{1}{2} \left[\frac{1}{1} - \frac{1}{21} \right] = \frac{1}{2} \left[\frac{20}{21} \right] = \frac{10}{21}$$

Mtd: 2

$$\frac{1}{(2^2 - 1^2)} + \frac{1}{(4^2 - 1^2)} + \frac{1}{(6^2 - 1^2)} + \dots + \frac{1}{(20^2 - 1^2)}$$

$$= \frac{1}{(4 - 1)} + \frac{1}{(16 - 1)} + \frac{1}{(36 - 1)} + \dots + \frac{1}{(400 - 1)}$$

$$[a^2 - b^2 = (a-b)(a+b)]$$

$$Q:- \frac{1}{1 \times 2} + \frac{1}{2 \times 3} + \dots + \frac{1}{80 \times 81}$$

$$= \frac{1}{1} \left[\frac{1}{1} - \frac{1}{81} \right] = \frac{80}{81}$$

Subtracting
(2-1), (3-2)
all 1.

1st term
Last Term

Q25, Pg-95, WB 2025

$$\frac{1}{\sqrt{1} + \sqrt{2}} + \frac{1}{\sqrt{2} + \sqrt{3}} + \frac{1}{\sqrt{3} + \sqrt{4}} + \dots + \frac{1}{\sqrt{80} + \sqrt{81}}$$

$$= \left(\frac{1}{\sqrt{2} + \sqrt{1}} \right) \left(\frac{\sqrt{2} - 1}{\sqrt{2} - 1} \right) + \left(\frac{1}{\sqrt{3} + \sqrt{2}} \right) \left(\frac{\sqrt{3} - \sqrt{2}}{\sqrt{3} - \sqrt{2}} \right) + \dots$$

$$\left(\frac{1}{\sqrt{4} + \sqrt{3}} \right) \left(\frac{\sqrt{4} - \sqrt{3}}{\sqrt{4} - \sqrt{3}} \right) + \dots + \left(\frac{1}{\sqrt{81} + \sqrt{80}} \right) \left(\frac{\sqrt{81} - \sqrt{80}}{\sqrt{81} - \sqrt{80}} \right)$$

$$= (\sqrt{2} - 1) + (\sqrt{3} - \sqrt{2}) + (\sqrt{4} - \sqrt{3}) + \dots + (\sqrt{81} - \sqrt{80})$$

$$= \sqrt{81} - \sqrt{1}$$

$$= 9 - 1 = 8$$

Q:- If Red light flashes every 3 sec. and Green light flashes every 4 sec. at what time both flashes together?

R $\xrightarrow{3\text{sec}}$ 3, 6, 9, 12, ..., 24, ..., 36, ...

G $\xrightarrow{4\text{sec}}$ 4, 8, 12, ..., 24, ..., 36, ...

K LCM [t_R, t_G]

K LCM [3, 4] = 12 K sec.

LCM Indicates

- Things happen for the first time
- Least value
- Smallest Natural Number.

In one minute time how many times will they be flashing.

⇒ 1 min = 60 Secs.

$$\frac{60}{12} = 5 \text{ times } [12, 24, 36, 48, 60]$$

Q:- R [3 times → 2 min] → 120 Secs.

G [5 times → 3 min] → 180 Secs.

(LCM [t_R, t_G]) × K

$$\text{LCM} [40, 36] = 360 \text{ Secs.} \approx 6 \text{ mins}$$

$$1 \text{ hr} = \frac{60 \times 60}{360} = 10 \text{ times.}$$

$$\star \text{LCM} \left[\frac{a}{b}, \frac{c}{d}, \frac{e}{f} \right] = \frac{\text{LCM}(a, c, e)}{\text{HCF}(b, d, f)}$$

→ 2nd Mtd:-

$$K \text{ LCM} \left[\frac{t_R}{3}, \frac{t_G}{5} \right] = K \frac{G}{1} \text{ min}$$

$$1 \text{ hr} = \frac{60 \text{ min}}{6} = 10 \text{ mins.}$$

* If question was both light started flashing in the beginning then first flash will be at $t=0$ sec. then Add 1.

$$\star \text{HCF} \left[\frac{a}{b}, \frac{c}{d}, \frac{e}{f} \right] = \frac{\text{HCF}(a, c, e)}{\text{LCM}(b, d, f)}$$

Q:- In a school ^{how many times} bell rings bell rings at the same time if classes are of duration :-

$$\text{LCM} \left[\frac{\text{VIII}}{24}, \frac{\text{IX}}{30}, \frac{\text{X}}{40}, \frac{\text{XII}}{60} \right] \text{ min}$$

School runs from 8:00 AM → 2:30 PM

→ 120 mins → 2 hrs.

[10 AM, 12 Noon, 2 PM]

Q:- HCF of two NO's = 24

Sum of these two NO's = 144.

What are the Numbers?

$$\begin{aligned} \rightarrow N_1 &= 24x \\ N_2 &= 24y \end{aligned}$$

$\left. \begin{aligned} x \text{ \& } y \text{ should be } \\ \text{co-prime no.s} \end{aligned} \right\}$

$$N_1 + N_2 = 144$$

$$24(x + y) = 144$$

$$x + y = 6$$

$$1, 5 \rightarrow \begin{aligned} N_1 &= 24 \times 1 = 24 \\ N_2 &= 24 \times 5 = 120 \end{aligned} \left[\begin{array}{l} \text{HCF} \\ 24 \end{array} \right]$$

$$\begin{aligned} \times 2, 4 & \rightarrow \begin{aligned} N_1 &= 24 \times 2 = 48 \\ N_2 &= 24 \times 4 = 96 \end{aligned} \left[\begin{array}{l} \text{HCF} \\ 48 \end{array} \right] \times \\ \times 3, 3 & \rightarrow \begin{aligned} N_1 &= 24 \times 3 = 72 \\ N_2 &= 24 \times 3 = 72 \end{aligned} \left[\begin{array}{l} \text{HCF} \\ 72 \end{array} \right] \times \end{aligned}$$

* If HCF of NO's are same then the difference of numbers will have same HCF.

Q29 | Pg-89 | WB

$$78, 104, 117, 169$$

$$l = \text{HCF} [78, 104, 117, 169] = 13$$

$$\begin{array}{cccc} \downarrow & \downarrow & \downarrow & \downarrow \\ n_1 l & n_2 l & n_3 l & n_4 l \end{array}$$

$$6 + 8 + 9 + 13 = 36.$$

Q:- Three pieces of cake of weight $4\frac{1}{2}$, $6\frac{3}{4}$, $7\frac{1}{5}$ are to be divided into parts of equal weight further each part must be as heavy as possible. If one such part is to be given to one guest. How many guests can be served.

$$\rightarrow 4\frac{1}{2}, 6\frac{3}{4}, 7\frac{1}{5}$$

$$\begin{array}{ccc} \downarrow & \downarrow & \downarrow \\ n_1 w & n_2 w & n_3 w \end{array}$$

$$W = \frac{\text{HCF}}{\text{LCM}} = \left[\frac{9}{2}, \frac{27}{4}, \frac{36}{5} \right] = \frac{9}{20}$$

$$10 + 15 + 16 = 41.$$

* Use of LCM & HCF is phenomenal

Remainder

$$N = \text{Remainder Mod (Divisor)}$$

If $x = y \text{ Mod } M$ then definitely $x - y = 0 \text{ Mod } M$.

Example:-

$$\textcircled{1} 80 = 8 \text{ Mod } (9) \quad \textcircled{2} 80 = -1 \text{ Mod } (9)$$

$$72 = 0 \text{ Mod } (9) \quad \textcircled{3} 81 = 0 \text{ Mod } (9)$$

$$\textcircled{11} 24 = 3 \text{ Mod } (7) \quad \textcircled{12} 24 = -4 \text{ Mod } (7)$$

$$21 = 0 \text{ Mod } (7) \quad \textcircled{13} 28 = 0 \text{ Mod } (7)$$

Rule 1 (applicable for +, x, -)

$$\left[\begin{array}{l} a = b \text{ Mod } (c) \\ d = e \text{ Mod } (c) \\ g = f \text{ Mod } (c) \end{array} \right] \quad [M = \text{Mod}]$$

$$a \times d \times g = b \times e \times f \text{ Mod } (c)$$

$$b \times e \times f < c$$

Example:

$$\textcircled{1} \frac{5 \times 7 \times 9}{12} = 315$$

$\therefore$ Remainder of Divisor.

$\therefore$ Divide again.

$$\frac{315}{12} = 3$$

$$\bullet a + d + g = b + e + f \text{ Mod } (c)$$

$$= b + e + f < c$$

$$\bullet a + d - g = b + e - f \text{ Mod } (c)$$

$$= b + e - f < c$$

Example -

$$\textcircled{2} \frac{5 + 7 + 9}{12} = 21, \frac{21}{12} = 9$$

$$\textcircled{3} \frac{5 + 7 - 9}{12} = 3$$

Rule-2

$$a = b \text{ Mod } (c)$$

$$a^n = b^n \text{ Mod } (c)$$

$$b^n < c$$

n = Natural Numbers

Example :-

① $2^{600} \div 15 = \text{Remainder} = ?$

$$2^4 = 1 \text{ M}(15)$$

$$(2^4)^{150} = 1^{150} \text{ M}(15)$$

$$2^{600} = 1 \text{ M}(15)$$

Re = 1

② $\frac{10^{1071} + 10^{1001} + 10^{1000} + 10^{10000}}{3} = \frac{4}{3} \text{ Re} = ?$

$$10 = 1 \text{ M}(3)$$

$$(10)^{10} = (1)^{10} \text{ M}(3)$$

$$10^{10} = 1 \text{ M}(3)$$

$$(10)^{100} = (1)^{100} \text{ M}(3) = 1 \text{ M}(3)$$

$$(10)^{1000} = (1)^{1000} \text{ M}(3) = 1 \text{ M}(3)$$

$$(10)^{10000} = (1)^{10000} \text{ M}(3) = 1 \text{ M}(3)$$

$$\text{Remainder} = \frac{1+1+1+1}{3} = \frac{4}{3} = 1$$

Q: What is the remainder?

$$\frac{2^{192}}{6}$$

- Ⓐ 0 Ⓑ 1 Ⓒ 2 Ⓓ 4

$$\frac{2^{192}}{6} \rightarrow \text{even}$$

$$\Rightarrow 2^1 = 2 \text{ M}(6)$$

$$2^7 = 2 \text{ M}(6)$$

$$2^2 = 4 \text{ M}(6)$$

$$2^8 = 4 \text{ M}(6)$$

$$2^3 = 2 \text{ M}(6)$$

$$2^4 = 4 \text{ M}(6)$$

$$2^5 = 2 \text{ M}(6)$$

$$2^6 = 4 \text{ M}(6)$$

$$\frac{2^{192}}{6} = \frac{2^x \cdot 2^{191}}{2^x \cdot 3}$$

$$2 = (-1) \text{ M}(3)$$

$$2^{191} = (-1)^{191} \text{ M}(3)$$

$$2^{191} = -1 \text{ M}(3)$$

$$2^{191} = 2 \text{ M}(3)$$

Ⓔ = -1 Mod 3
Ⓔ = +2 Mod 3

$$\frac{2^{191}}{3} = \text{Re } 2 \cdot \frac{2}{3} = \text{Re } \frac{4}{3}$$

(2 cancelled out)

Q: $5^{625} \div 7 \text{ Re} = ?$

$$5^3 = 6 \text{ M}(7)$$

$$5^3 = -1 \text{ M}(7)$$

$$(5^3)^{208} = (-1)^{208} \text{ M}(7)$$

$$5^{624} = 1 \text{ M}(7)$$

$$5^1 = 5 \text{ M}(7)$$

$$5^{625} = 5 \text{ M}(7)$$

Mtd-2

$$5^2 = 4 \text{ M}(7)$$

$$(5^2)^3 = (4)^3 \text{ M}(7)$$

$$5^6 = 64 \text{ M}(7)$$

$$5^6 = 1 \text{ M}(7)$$

$$(5^6)^{104} = (1)^{104} \text{ M}(7)$$

$$5^{624} = 1 \text{ M}(7)$$

Mtd-3

$$5 = -2 \text{ M}(7)$$

$$(5)^3 = (-2)^3 \text{ M}(7)$$

$$5^3 = -8 \text{ M}(7)$$

$$5^3 = -1 \text{ M}(7)$$

PERCENTAGE

Q1 A's salary is 20% more than that of B. By how much percentage is B's salary less than that of A.

$$\frac{x}{100+x} \longleftrightarrow \frac{x}{100-x}$$

$$\uparrow 10 \longleftrightarrow 9.09 \downarrow$$

$$\uparrow 20 \longleftrightarrow 16.6 \downarrow$$

$$\uparrow 25 \longleftrightarrow 20 \downarrow$$

$$\uparrow 33.3 \longleftrightarrow 25 \downarrow$$

$$\uparrow 50 \longleftrightarrow 33.3 \downarrow$$

* For increment $\rightarrow$ Red one $\uparrow$
 For decrement $\rightarrow$ Green one $\downarrow$

In this question, increment

So, Answer = $x = 20$

$$\frac{20}{100+20} = \frac{20}{120} = \frac{1}{6} = 16.6\%$$

Q2 A's salary is 20% less than that of B. By how much % is B's salary more than that of A.

In this question, decrement,

$$\text{So, } \frac{20}{100-20} = \frac{20}{80} = \frac{1}{4} = 25\%$$

Method 2

$$\textcircled{1} B=100 \quad A=120 \quad 20\% \uparrow$$

$$\frac{-20}{120} = -\frac{1}{6} = \downarrow 16.6\%$$

$$\textcircled{2} B=100 \quad A=80 \quad 20\% \downarrow$$

$$\frac{+20}{80} = \frac{1}{4} = 25\%$$

$$* R = \underset{\substack{\downarrow \\ x\%}}{a} \times \underset{\substack{\downarrow \\ y\%}}{b}$$

$$\Delta R\% = x + y + \frac{xy}{100}$$

$$\Delta R'\% = x + y + z + \frac{xy + yz + zx}{100} + \frac{3xyz}{100^2}$$

$$\begin{array}{l|l} x + \frac{10}{100}x & x - \frac{10}{100}x \\ x[1+.1] & x[1-.1] \end{array}$$

$$\begin{array}{ll} 1.10x & .90x \\ 1.20x & .80x \\ 1.23x & .77x \end{array}$$

$$A = l \times b$$

$$D = s \times t$$

$$R = p \times N$$

Example:-

$$\textcircled{1} l = 20\% \uparrow, b = 10\% \uparrow$$

$$A = 1.1b$$

$$A' = 1.21 \times 1.1b$$

$$A' = 1.321b = 32\% \uparrow$$

$$\text{2nd Mtd :- } 20 + 10 + \frac{20 \times 10}{100}$$

$$= 32\%$$

$$\text{3rd Mtd } 1.2 \times 1.1 = 1.32 = 32\% \uparrow$$

$$\textcircled{2} l = 20\% \uparrow \quad b = 10\% \downarrow$$

$$A = 1.1b$$

$$A' = 1.21 \times 0.9b$$

$$A' = 1.081b = 8\% \uparrow$$

$$\text{2nd Mtd :- } 20 + (-10) + \frac{20 \times (-10)}{100}$$

$$= 8\% \uparrow$$

$$\text{3rd Mtd :- } 1.2 \times 0.9 = 1.08 = 8\% \uparrow$$



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ECONOMICS

12/03/2024

- ① Types of Economy & Nature of Economy.
- ② National Income.
- ③ Banking & Finance
- ④ Poverty & Unemployment & Population/Demography.
- ⑤ Miscellaneous.
- ⑥ Economic planning



Types of Economy & Nature of Economy.

Types of Economy :- There are 3-types of economy.

- (i) Capitalist Economy.
- (ii) Socialist Economy.
- (iii) Mixed Economy.

Adam Smith :- Father of Economy.

(i) Capitalist Economy.

Laissez Faire.

Less Interference.

Adam Smith gave the concept of Capitalist Economy in his book Wealth of Nations. It focused on competition on the market forces. It introduced a word 'Laissez Faire' which means there should be less interference or no interference by the government in the factors of production & factor of production should depend upon Market Forces of Demand & Supply.

- U.S.A adopted the concept of Capitalist Economy after it's Independence & therefore U.S.A became a Capitalist Nation.
- Capitalist Economy is based on Free Market Economy in which factor of production are in the hands of private Enterprises & decision of what to produce & how much to produce depends upon the Market.

(ii) Socialist Economy

(CZHK-)

- It is also called state Economy.
- The concept of Socialist or state Economy is based on Karl Marx. Karl Marx was from Germany & he was Economist Also. He wrote two books ① 'The Communist Manifesto' ② 'Das Kapital'.
- In these books Karl Marx highlighted the problem associated with capitalism & he said that the Capitalist Economy based on exploitation of labour from which only a handful of people can get benefit while majority are exploited.
- Therefore based on the ideas of Karl Marx in Russia Bolshevik Revolution took place. In this revolution of 1917 Socialist Economy was adopted.
- Socialist Economy focuses on collective ownership of the means of production & in this state plays the main role in running the Economy.
- China adopted 'Communist Economy' (Communism).
- In Communist Economy all the properties of the state or belong to the state.

3 (iii) Mixed Economy

- The concept of Mixed Economy was given by John Maynard Keynes.
- In his book "The General theory of Employment, Interest & Money".
- In this book J.M. Keynes stated that both the theory of Economy Capitalist & Socialist Economy model are not complete. Therefore we must follow mixed model of mixed Economy.

9646369236 - 1803E
Current

Drawbacks of Capitalism:-

- In Capitalism the rich become richer & poor become the poorer.
- Capitalism then work on the cycle of peak & Recession. therefore in 1929 U.S.A experienced the worst recession of history due to which many people lost their jobs & many of them also experienced extreme poverty. Therefore this lead to distrust in capitalism.

Drawbacks of "Socialism":-

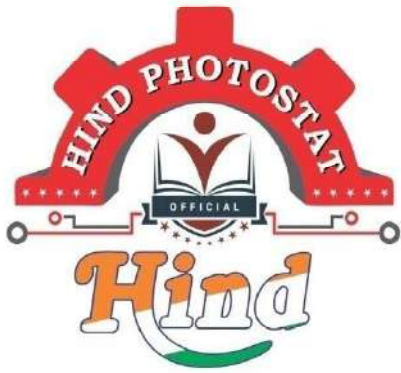
- Lack of Competitiveness.
- Corruption.
- Inefficiency.

Capitalism & Socialism both are not complete therefore mixed economy Concept was given by J.M. Keynes.

Notes:- China in 1985 adopted 'Open Door policy'.

Under 'Mao Tse Tung'.

- Under open door policy China allowed foreign investors to invest in China.
 - Russia Also adopted 'Glasnost' & 'Perestroika' which is type of open door policy. Glasnost means openness & Perestroika mean Restructuring.
 - The concept of Glasnost & Perestroika was given by Russian President "Mikhail Gorbachev".
 - Under Mikhail Gorbachev:
 - Russian Economy improved by adopting the policy of Glasnost & Perestroika.
 - He also adopted the policy of ending the nuclear race along with the American president "Ronald Reagan".
 - This disintegration of USSR to place during this time (1991)
 - Mikhail Gorbachev died on 30th Aug. 2022.
- U.S.S.R → Union Soviet Socialist Republic.



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GEOGRAPHY

(By Vinay Tripathi Sir)

Syllabus -

(1) Basics of Geography

~~2~~ Indian geography

† Physical Geographical features of India - conceptual

‡ Economic Geographical features of India - Factual

(3) Physical Geography

† Climatology

‡ Geomorphology

‡ Oceanography

(4) World Regional Geography - Mapping

Sources of Study Material -

(i) Class Notes

(ii) PYQ

(iii) Oxford Student Atlas Map

(iv) Made easy printed Material

Basics of Geography

Geography $\rightarrow$ Geo + Graphy

$\downarrow$
earth

$\downarrow$
To study

} To Study about Earth

- The term Geography was 1st coined by Greek Scholar Eratosthenes
- Age of earth is 4.5 Billion Years / 4500 Million Years
- Surface area of earth is 510 Million km^2

362 M- km^2

(Oceans)

70.8%

148 M- km^2

(Continents)

29.2%

Major Oceans in descending Order -

- PAISA

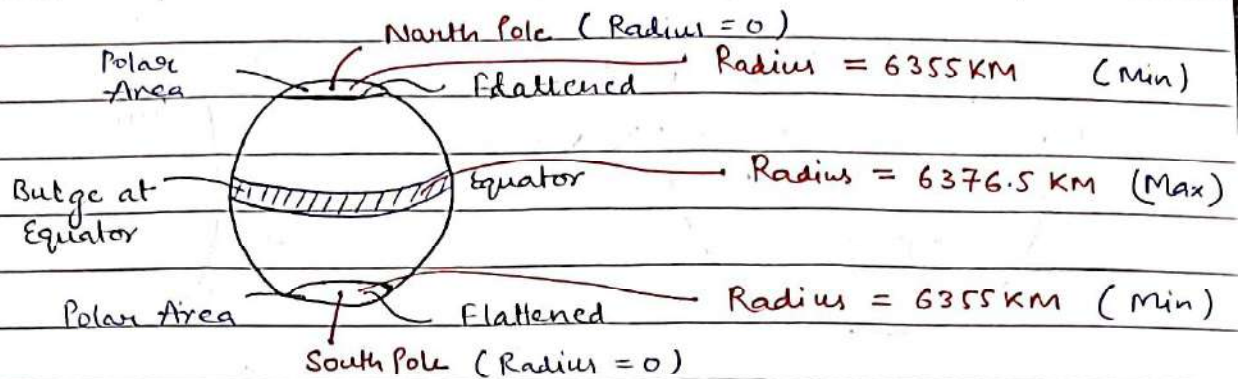
- (1) Pacific
- (2) Atlantic
- (3) Indian
- (4) South
- (5) Arctic

Major Continents in descending Order -

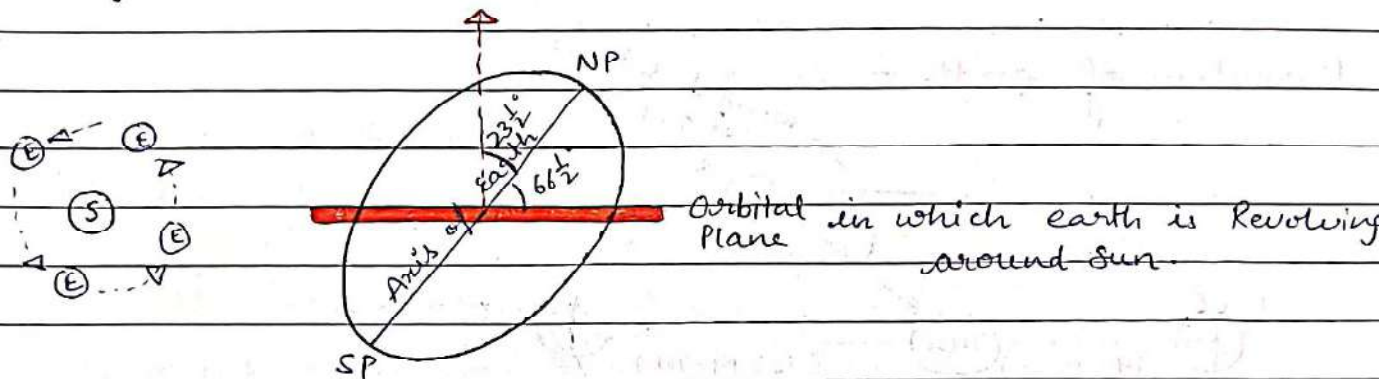
- (1) Asia
- (2) Africa
- (3) North America
- (4) South America
- (5) Antarctica
- (6) Europe
- (7) Australia + Surrounding Island - Oceania

- Shape of earth is Geoid (special type of sphere)

(or) Oblate Spheroid

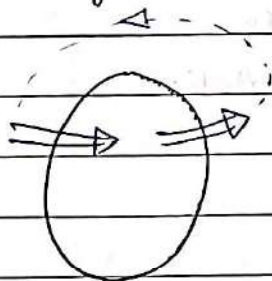


Axis of Earth -

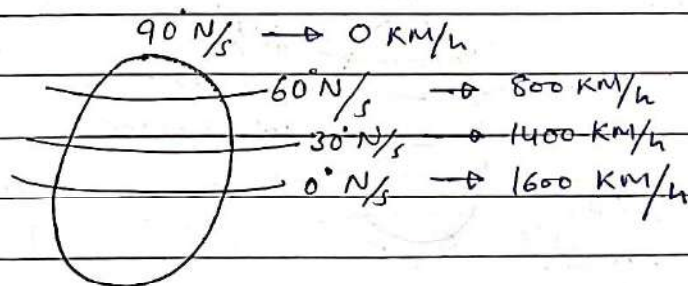


Axis is an imaginary line which joins both poles

Rotation of Earth & its Rotational Speed -



Earth is rotating from west to east in Anticlockwise dirⁿ.



$$v = r\omega$$



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POLITY

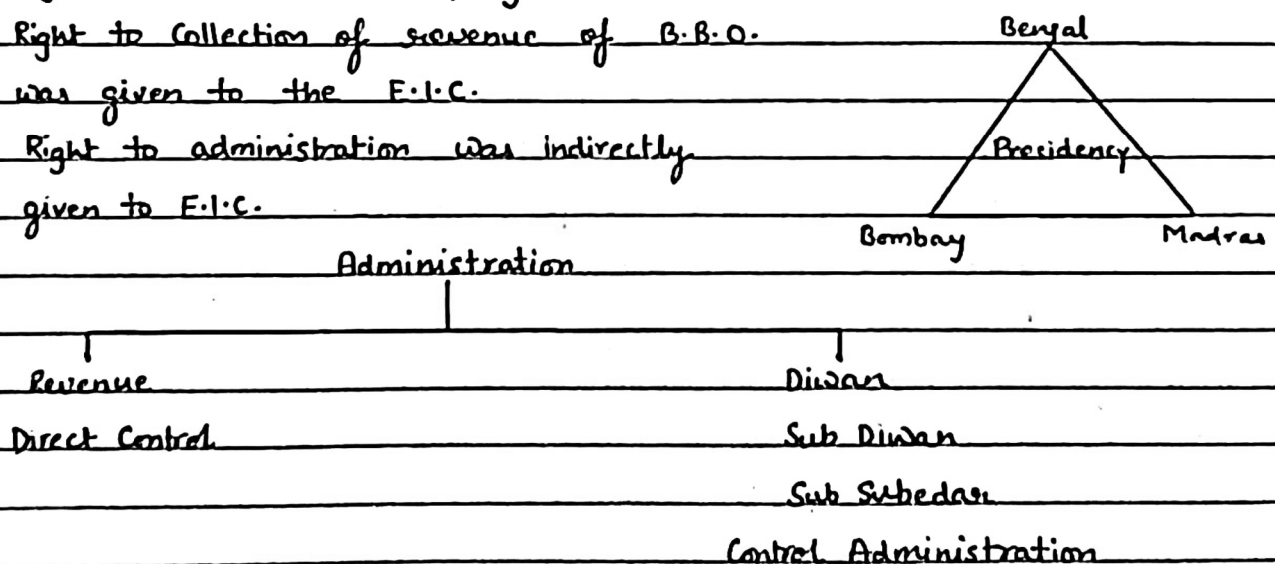
(By PN Pandey Sir)

- Polity is derived from Politeia (Greek word)
- Politeia refers to right of citizens to form government
- "Aristotle" in his book "politics" →
Political science is a study of an ideal government, rights of citizens & theory of constitution.
- Aristotle is k/w as father of political science
- Constitution is a set of rules & regulation which guide us to control and administer the State & nation.

Development of Constitution in India from 1773 - 1947 CE -

→ In 1765, Dual govt. was introduced in Bihar Bengal Orissa (BBO) by the East India Company (E.I.C.)

- (i) Right to Collection of revenue of B.B.O. was given to the E.I.C.
- (ii) Right to administration was indirectly given to E.I.C.



① Regulating Act of 1773 -

- It laid the foundation of modern constitution in India

- ① Under this act Code of Directors was setup and total members of code of directors (C.D.) were 24

② New post Governor General was created

This G.G. now looked after administration of B.B.O and war & peace matters of Bombay presidency & Madras Presidency.

③ 4 member Council was setup to support G.G. in the administration of the British India.

④ Supreme court was established at Calcutta in 1774.

Under this court judiciary of Europeans matters, business of Europeans and citizens of Calcutta.

First Chief justice of Supreme court was Sir Elijah Impey.

② Pitt's India Act 1784 -

- Under this act board of Control was setup with 6 members to oversee activities of the E.I.C. & court of Directors.

- Members of council of G.G. was reduced from 4 to 3.

③ Charter act 1793

Charter act 1813

Charter act 1833

Charter act 1853

→ Under Charter act 1813, Monopoly of the E.I.C. over trade & Commerce of India was ended except tea and opium with China.

→ Under Charter act 1833, New post Governor general of India was created in place of G.G. of Bengal.

- Member of council was again increased from 3 to 4. New members was included in the council as law member.

- Law Commission was setup to frame laws under chairmanship of Macaulay under 1833.

- Monopoly of the E.I.C. over tea & opium was also abolished.

→ Under Charter act 1853, functions of council of G.G. of India was divided into

(i) Legislative function

(ii) Executive function

- First time mini parliament was setup under Charter act 1853.

④ Govt. of India Act - 1858

- Powers of India were transferred from the E.I.C. to the British Crown.

- 2 new posts were created -

(i) Viceroy

(ii) Secretary of State for India

- A council of 15 members to support the Secretary of States for India.

- First Viceroy - Lord Canning

First Secretary - Lord Stanley

⑤ Indian Council Act - 1861

- Under this act Portfolio system was introduced in this. Home, Law, Revenue, Defence, Finance and Public works were assigned to members of the executive council.

- Under this act, Members of executive council of viceroy was increased from 6 to 12. Half of members of Executive council were non officials.

- They were responsible to their works / department & Affairs

- First time provincial legislative council was setup

→ Indian Council Act - 1892 -

- Under this act Indirect Election was started in India to elect members of central legislative council & provincial councils.

→ Indian Council Act - 1909 -

- Direct Elections was started in India under this act

- Right to separate electorate was given to Muslim communities

- Seed of Communalism was sown in this act

⑥ Government of India Act - 1919

- The genesis of responsible govt. was started / Setup
- Council of viceroy was divided into upper house (Rajya Sabha) and lower house (Lok Sabha)
- Total members of Lok Sabha was 145
- Tenure of lower house members was 3 Years
- Total members of Rajya Sabha was 60
- Tenure of members of Rajya Sabha was 5 Years
- First time Public Service Commission was setup in India
- Dyarchy System was introduced in India under this act
- In 1934 Communist leader M.N. Roy first time demanded to setup Constituent Assembly for formation of Indian constitution

Government of India Act - 1935

- Under this act autonomy was given to provinces
 - Federal Structures were Setup
 - Governors were appointed
 - Bureaucracy was Strengthened
 - Federal bank was setup in 1935 — RBI later
 - Federal court was setup in 1935 at Delhi — SC later
 - Instrument of Accession document
 - INC rejected this act & demanded to form constituent assembly for formation of Indian constitution in the Lucknow session of 1936
- The British govt finally accepted to form constituent assembly after 2nd world war in 1940

⑦ Cripps Mission - 1942

- Main Objective of Cripps mission was to bulkanize India.
- This mission was apposed
- Gandhiji called it as Post dated Cheque

① Cabinet Mission 1946 -

- Under Patrick Lawrence, Stafford Cripps & A.V. Alexander.
- Cabinet Mission recommended set up constituent assembly on 6 Dec 1946.
- First meeting of constituent assembly was held on 9 Dec 1946
- First acting president of constituent assembly was Dr Sachchidanand Sinha.
- The president of Constituent assembly was Dr. Rajendra Prasad
- First meeting of constituent assembly after independence of India was held on 31 Dec 1947
- On 29 Aug 1947 Drafting Committee was setup under Chairmanship of Dr. B.R. Ambedkar with 7 members including Chairman for formation of Indian constitution
- Drafting committee submitted constitution to the constituent assembly on 26 Nov 1949 and constituent assembly adopted Indian Constitution & implemented on 26 Jan 1950 signed with 284 members of constituent assembly out of 299 members
- Total members of C.A. (Constituent Assembly) before partition of India was 389
After independence - 299
Female members - 15
- Members of C.A. were elected by provincial legislative assemblies
- Total expenditure for formation of constitution = 64 lakh Rs
- Time = 2 Years 11 Month 18 days for formation of constitution of India
- Originally our constitution have 395 articles, 8 Schedule, 22 parts.
- Presently our constitution has more than 440 Articles, 12 Schedules and 25 parts

* Important Features from different constitutions of different countries of the world -

- 75% Features of Indian Constitution is taken from Govt of India act - 1935

(i) Autonomy of provinces

(ii) Federal Structure

(iii) Governor

(iv) Bureaucracy

(v) Administration

(I) England -

(i) Parliamentary system

(ii) Bicameralism (Lok Sabha & Rajya Sabha)

(iii) Cabinet System

(iv) Single Citizenship

(v) Speaker

(vi) P.M.

(vii) President as Nominal head

(viii) Rule of law

(II) America -

(i) Preamble

(ii) Fundamental Rights

(iii) Electoral College

(iv) Impeachment of president

(v) Removal of Judge of SC & HC

(vi) Independent Judiciary

(vii) Functions of president and Vice president, SC & HC

(III) Ireland -

(i) Directive principles of State policy

(ii) Nomination of Members of Rajya Sabha

(iii) Method of election of president

(IV) France -

- (i) Republic & ideas of liberty, equality & fraternity

(V) Canada -

- (i) Quasi federal structure with strong central govt.
- (ii) Power distribution b/w Centre & State
- (iii) Residuary power

(VI) Russia -

- (i) Justice (socio economic justice)
- (ii) Socialist
- (iii) Fundamental duties

(VII) Australia -

- (i) Concurrent list
- (ii) Free trade and Commerce
- (iii) Joint Sitting of both houses of parliament

(VIII) South Africa -

- (i) Procedure of Amendment
- (ii) Election of members of Rajya Sabha

(IX) Germany -

- (i) Emergency
- (ii) Suspension of fundamental rights during emergency

12 Schedules in the Indian Constitution -

- First Schedule describes States & Union of States
- Second Schedule describes emoluments, allowances and salary of presidents, V. President, judges, Speakers, Governors etc
- Third Schedule describes Oaths & Affirmations of President, V. Presid, PM, Ministers, Parliamentarians etc
- Fourth Schedule describes allocation of seats of Rajya Sabha
- Fifth Schedule describes provisions related to administration of S.C. and S.T.

- Sixth Schedule describes provision related to control administration of Scheduled Tribes & their areas
- Seventh Schedule describes 3 lists of Subjects of India
 - (i) Central list - 100
 - (ii) Concurrent list - 52
 - (iii) State list - 61
- Eighth Schedule contains 22 Constitutional language
- 9th Schedule describes validation of laws and regulations namely abolition of Zamindari System & land Reform
- 10th Schedule describes anti-defection act
- 11th Schedule describes Panchayati Raj System at village level
- 12th Schedule describes municipality and Municipal corporation, local self govt. at city & town level

Unification of India

State Reorganisation Commission -

(7th Amendment Act 1956)

- (i) 11 States were given to Independent India [6 to Pakistan]
- (ii) 562 princely States existing independently
- (iii) Portuguese enclave - Goa, Daman and Diu
- (iv) French enclave - Pondicherry, Yanam, Mahe, Chandranagar

Princely States - 562

- Most of the princely States signed Instrument of Accession document
- Their king became Rajpramukha (Governor) after signing later on this system was abolished
- They were paid by privy purses (1947)
- Their foreign affairs, Defence, Communication are now under the central govt. of India
- There are the following imp leaders who carried out this -
 - @ V.P. Menon - Secretary of ministry of States



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Ancient History

Bronze age / Age of civilizations
 (Indus - Saraswati rivers civilization)
 (Indus Valley Civilization)
 (Harappa Civilization)
 (Meluhha Civilization)

2600 BCE to 1900 BCE (By NCERT)

Bronze → Copper + tin

Brass → Copper + Zinc

→ Indus Valley Civilization word is given by Sir John Marshall

→ Harappa was the first site excavated in IVC in 1921 by Dayanand Sahani

→ The oldest civilization of Bronze age is Mesopotamia civilization of Iraq

→ The most developed civilization of the world is Indus Saraswati rivers civilization (India)

Note - Chalcolithic Age - 4000 BCE to 3000 BCE

Stone Age - Before 4000 BCE

Salient Features of I.V.C. -

These are following features -

(i) Town planning of IVC based on grid system -

(ii) First civilization where burnt bricks were used in the construction of houses.

(iii) Drainage system was highly developed

(iv) Water management of IVC was unique

(v) Cotton & Spices (Ginger & Turmeric) were produced.

↓ Mehargarh
(Baluchistan)

↓ Farmana, Rohtak (Haryana)

(vi) Cosmopolitan city in nature

(vii) Society was highly literate

(viii) Matriarchal society

(ix) Oligarchy system (Polity & administration was controlled by a group of Businessman)

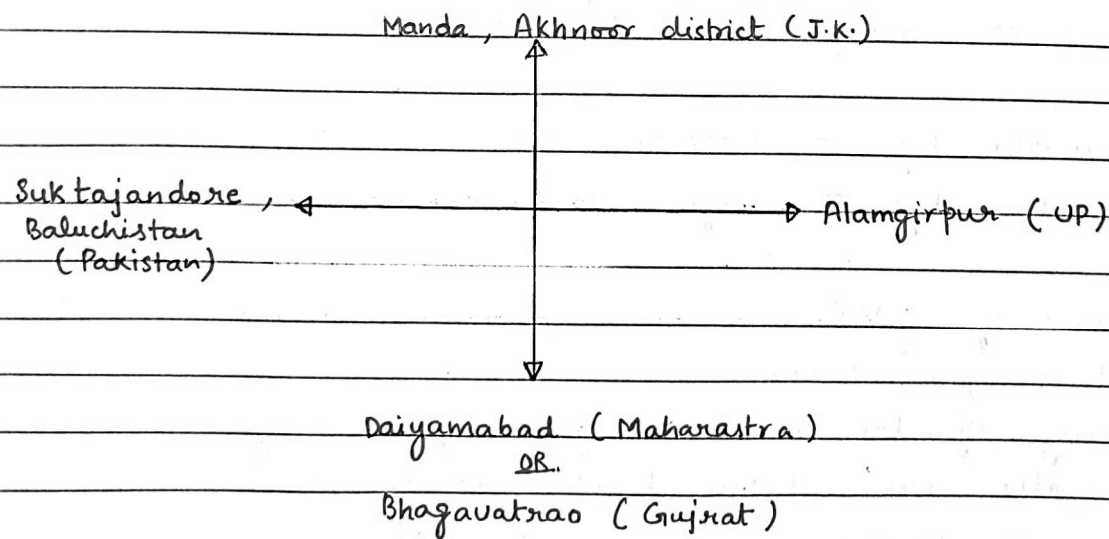
→ The Credit of excavation of IVC goes to Sir Alexander Cunningham

→ He established archaeological survey of India in 1861
Headquarter ASI in Delhi

→ Main functions of ASI are to excavate, preserve & to protect monuments of India

→ Sir Alexander Cunningham is k/o as father of Indian Archaeology.

→ Total area of IVC is more than 12,99,600 KM^2
Shape - Triangular



→ Total sites - More than 2000 sites have been excavated upto now



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physics

राशि
Quantity: Any measurable thing which expressed in number is called quantity.

Quantities (राशियाँ):

① Scalar quantities (अदिश राशियाँ): Those quantities which have magnitude only for their expression are called scalar quantities.

Ex: Mass, Volume, distance, Speed, Density, Temperature, Work, Energy, Electric current, Time, Power etc.

② Vector quantities (सदिश राशियाँ): Those quantities which have magnitude & direction both for their expression are called vector quantities.

Ex: Force, weight, acceleration, velocity, momentum, impulse, Displacement, Magnetic field, Torque, etc.

Systems of units (मात्रकों की प्रणालियाँ):

① CGS (Centimeter Gram Second system):

It is also called 'French or metric system of units.'

② FPS (Foot Pound Second system):

It is also called 'British systems of units.'

③ MKS (meter Kilogram Second system):

④ S.I (system International system)

→ Indeed, it is the improved & expanded form of MKS System which adopted in 1960 at Geneva (Switzerland)

→ There are 7 fundamental & 2 supplementary units in S.I system.

S.N	Quantity	S.I unit	Symbol
1.	Length	meter	m
2.	Mass	Kilogram	kg
3.	Time	Second	s
4.	Temperature	Kelvin	K or °
5.	Electric current	Ampere	A
6.	Luminous Intensity	Candela	cd
7.	Amount of substance	Mole	mol



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Environment & Energy / Geography / Economics

Environment & Energy

Overall

(SES + SSC)

Syllabus → 1) Geography

2) Environment & Energy

3) History

4) Polity

5) Economics

6) Current affairs

7) General Science

8) GK

Decode the syllabus

Approach / Strategy : → PYQ + Syllabus

→ Correlate the topics with PYQ

Study Materials

→ class notes

→ printed materials

→ PYQ

→ Current affairs

Subject → Environment & Energy

Syllabus → (1) Basics of environment } conventional

(2) Biodiversity } → conventional

(3) Environmental Pollution & Environmental Degradation } current

(4) Climate change & global warming } → current

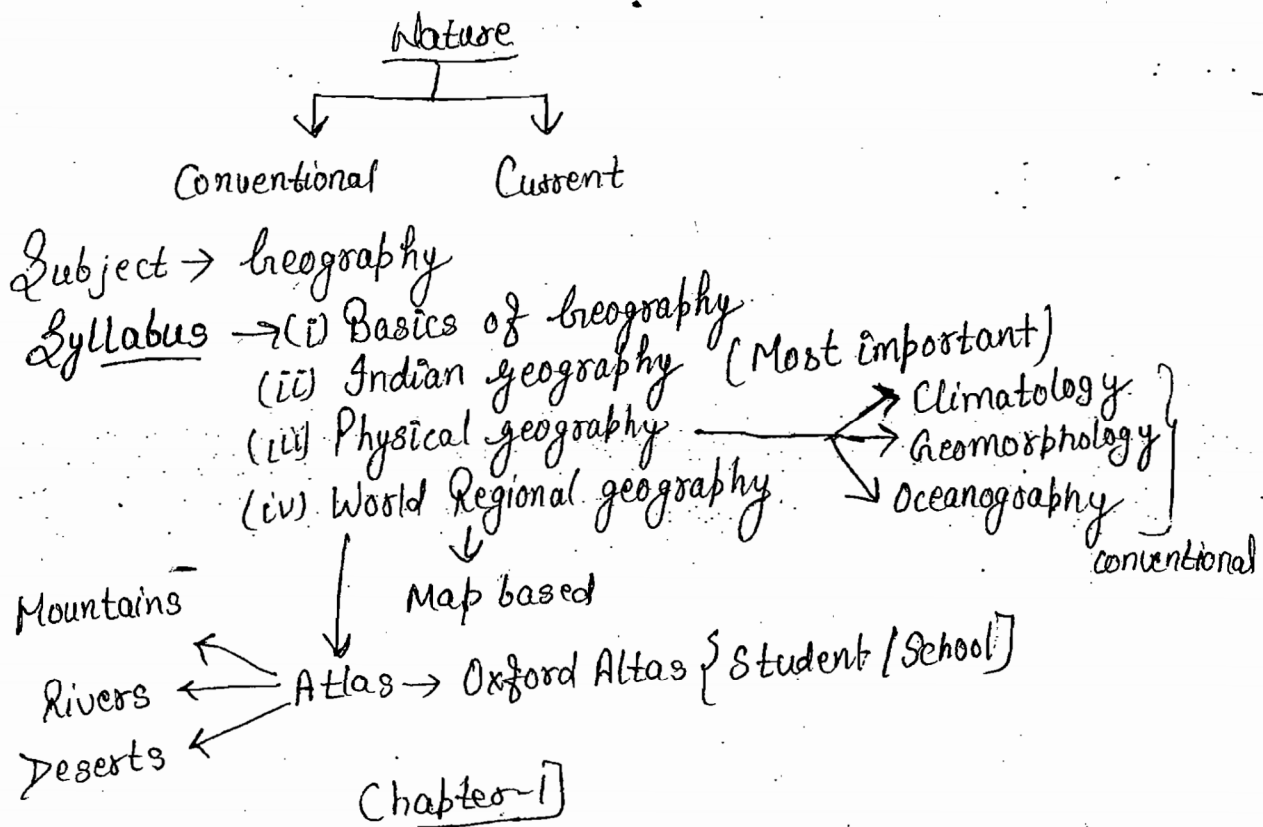
(5) Environmental treaty, convention & protocols } → current

(6) International Environmental Conferences } → conventional

(7) Ozone & Ozone holes & related aspects } → current

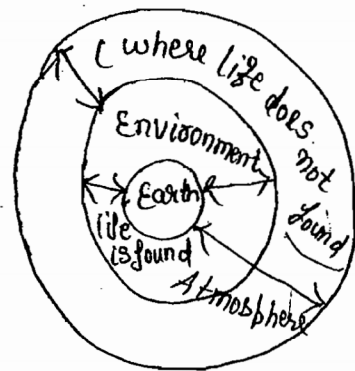
(8) Environmental Impact Assessment (EIA) → conventional

(9) Energy → conventional

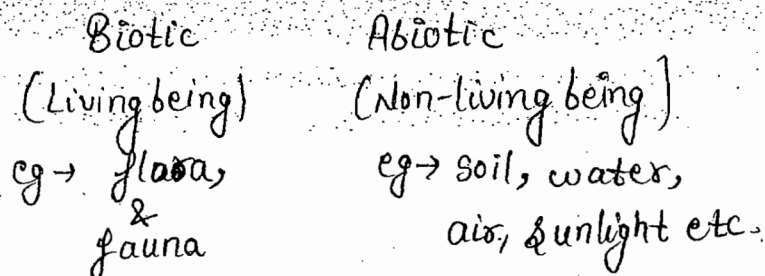


Basics of Environment

1] ⇒ Environment :→ It is derived from french word Environer/Environ which means Surrounding the Earth where life is found.

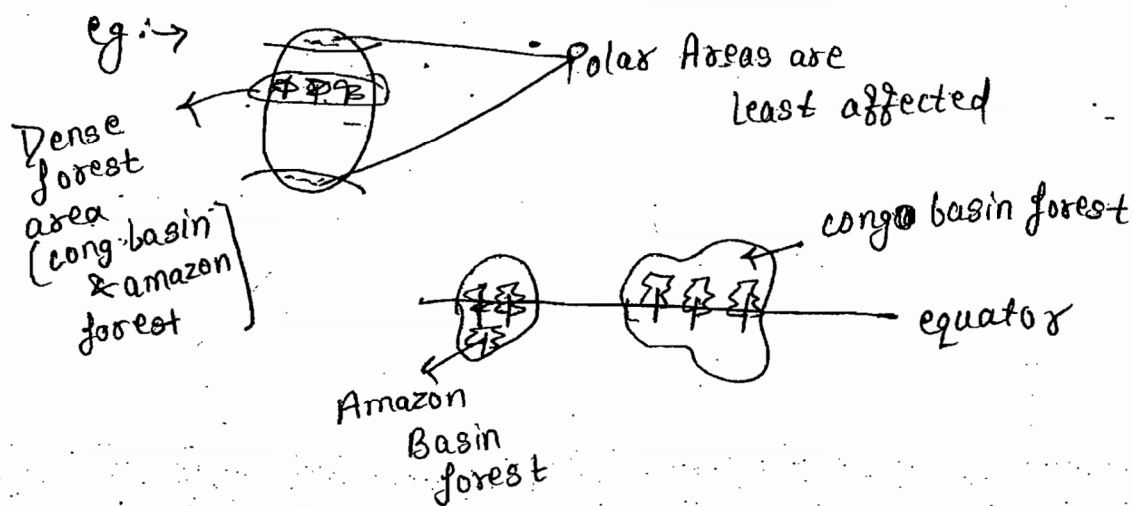


2] ⇒ Component of Environment

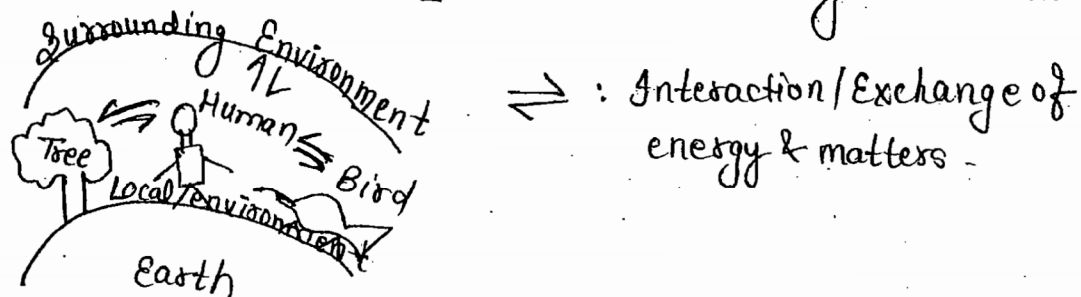


3] ⇒ What is Nature?

Ans → Nature is that part of earth which is unaffected by human being or least affected by human being.



4] Ecology → Ecology is a branch of science under which we use to study interaction of flora & fauna among themselves & their combined interaction with surrounding environment.



Ques → Who give the concept of Ecology?

Ans → Ernst Haeckel in 1869 A.D. German Scholar

⇒ Ecology is made from two words →

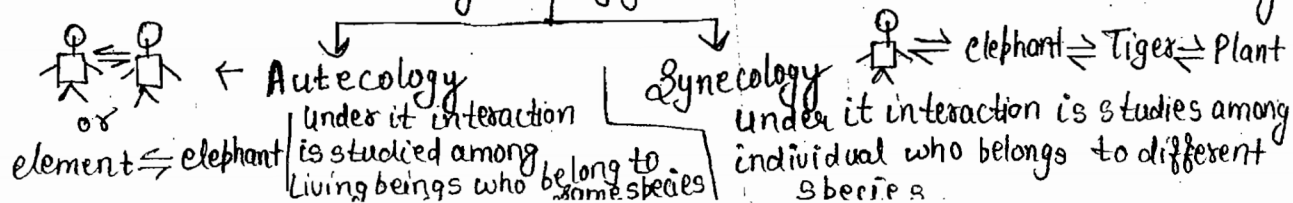
Oikos + Logos

↓ ↓
habitat (आवास) to study

to study about Habitat of Living flora & fauna

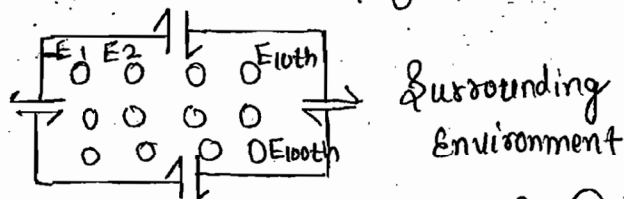
⇒ Ecology is Greek Word.

5] Approach to study Ecology: There are two approaches to study



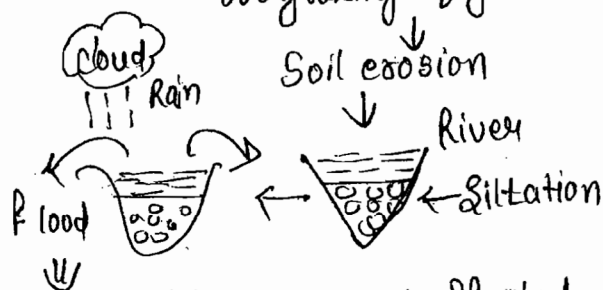
[6] Ecosystem → Concept given by A.G. Tansley in 1935
 & It is was elaborated by E.P. Odum → that's why he is
 called as Father of Ecosystem, Ecology

Eco + System ↓
 Environment is a entity which is made from more
 than one element & all elements are
 interconnected with each other in such a way that they
 function as one entity.



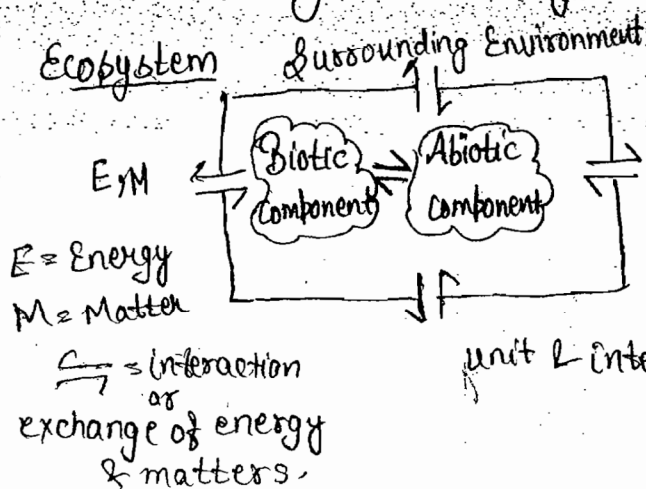
Eg → ① E_1 = Human being
 E_{10th} = Tiger (if extinct)

Outcome → Herbivores overgrow
 ↓
 Overgrazing of grasses



↓
 Food grain production get affected
 ↓
 Food Insecurity in Human Being

Eg → ② E_1 = Human being
 E_{10th} = Earthworm (if extinct)
 Then soil will be infertile
 ↓
 Less/No. production of food grains
 ↓
 Food insecurity in human being



Ecosystem is a entity/system
 which is mainly made from
Biotic & Abiotic components & they
 two are interconnected in such a
 way that they function as one
 unit & interact with surrounding environment.

7] Difference b/w Ecology & Ecosystem

Ecology → Interaction among different living beings ^(or Non-living) is studied.

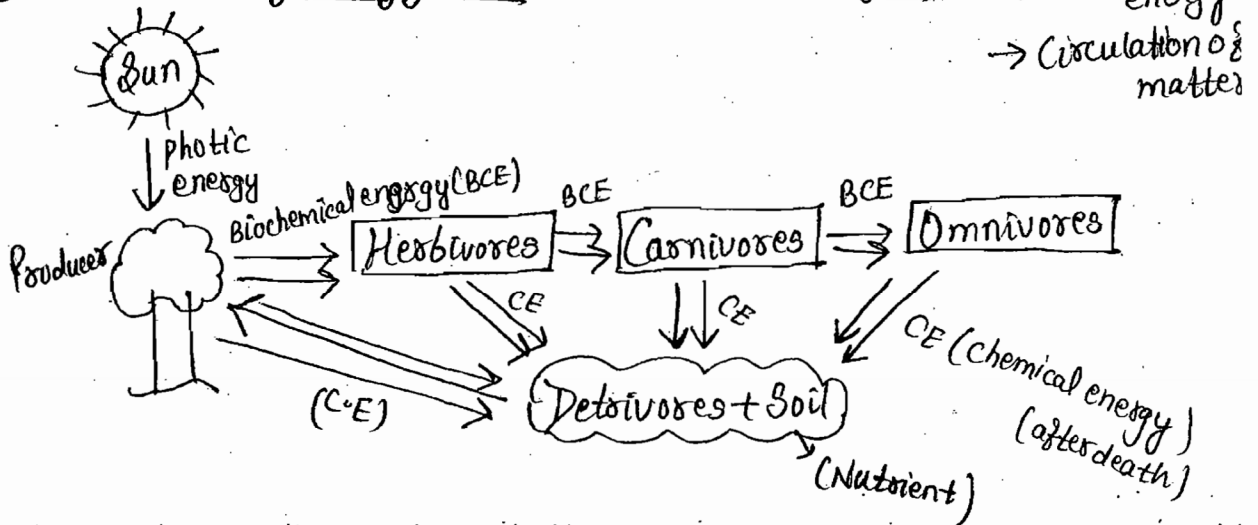
Ecosystem → {Interaction + Result of interaction} ^(Living + non-living) is studied.
(All elements function as one unit)

Note → Types of System →

	Circulation of	Exist where
Open System	✓ E, M	in nature
Close System	✓ E, ✗ M	in lab [ex-bio-weapon]
Isolated System	✗ E, ✗ M	in mental map or in imagination

* Ecosystem is open system

8] Circulation of energy and matters in Ecosystem

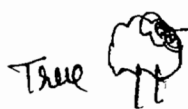


Circulation of matter → Cyclic

Circulation of energy → Non-cyclic

9] Principles on which functioning of Ecosystem is based →

(1) Homeostasis / Homeobasis → { In a computer science same is known as Cybernetic }



Damaged part (by disaster)

Heal over a period of time by itself



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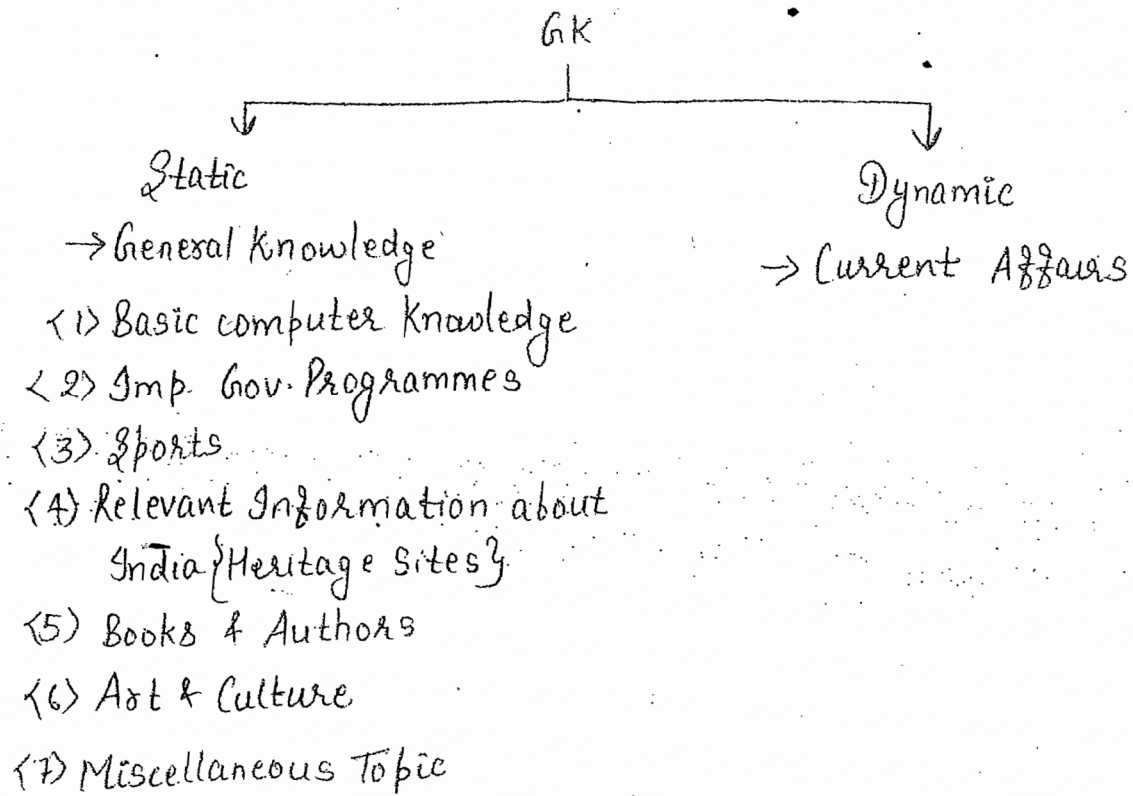
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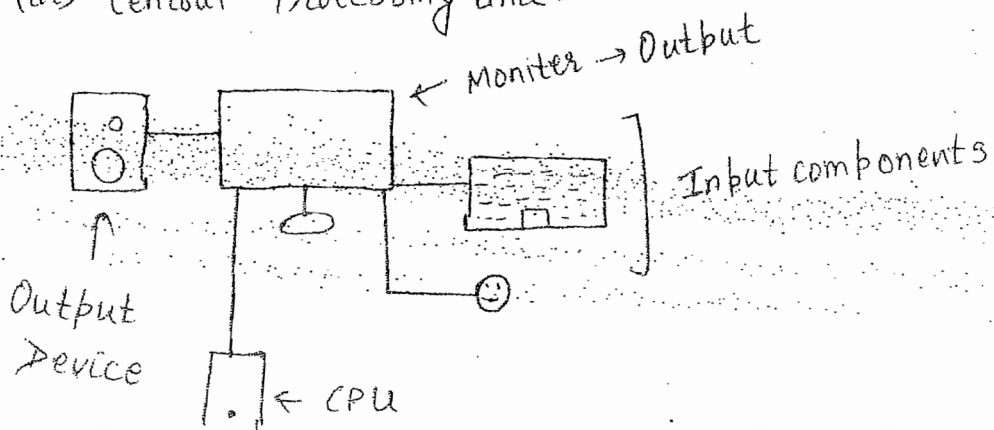


BASIC Information.

- <1> Father of Computer : Charles Babbage ✓
- <2> Current computer Architecture was given by: Van Newman & Str.

He said that computer has 3 components

- (i) Input Components
- (ii) Output
- (iii) Central Processing unit.



MacBook by Steve Jobs (Apple Company) became the first person to break Van Newman & Str.