Gajendra Purohit

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TOPIC -: GROUP THEORY

LECTURE NO. 01

Basic definition related to group theory

Lecture Index:-

i) Euler's function & Sum of relative Prime no.

ii) Congruent Modulo & its theorem

iii) No. of Positive Divisors

iv) Sum of positive divisors

1. **Euler's ϕ function** -:

A mapping $\phi : \mathbf{N} \to \mathbf{N}$ defined by $\phi(n) = |\{x \in \mathbb{N} ; 1 \leq x \leq n; \gcd(x,n) = 1\}|$

Example : $\phi(6) = |\{1,5\}| = 2$

$\phi(9) = |\{1,2,4,5,7,8\}| = 6$

- **Some shortcuts to find Euler's Phi Function**

➢ If p is a prime number and **a** is a positive integer then

$\phi(p^a) = (p^a - p^{a-1})$

- If $p_1, p_2, \ldots p_n$ are prime numbers and a, b, …. z are the positive integers

$$\phi(p_1^a . p_2^b \ldots p_n^z) = (p_1^a - p_1^{a-1})(p_2^b - p_2^{b-1}) \ldots . (p_n^z - p_n^{z-1})$$

- $\phi(m.n) = \phi(m).\ \phi(n)$; iff gcd(m,n) = 1
- **Sum of relative prime numbers -:** Sum of all positive integers (including unity) which are less than and co-prime to it.

or

S = {x ϵ ℕ ; 1≤ x ≤n; gcd(x,n) = 1}, Sum of all elements of set S

2. **Number of positive divisors, $\tau(n)$ -:** let $n>1$, n be a positive integer,

$n = p_1^a . p_2^b . p_3^c \ldots . p_n^z$, where p_1, p_2, p_3,.... p_n are prime number, then number of positive divisors of n is denoted by $\tau(n) = \tau(p_1^a . p_2^b . p_3^c \ldots . p_n^z) = (a + 1).(b + 1).(c + 1)\ldots (z + 1)$.

3. **Sum of positive divisors, $\sigma(n)$-:** let n>1, n be a positive integer, $n = p_1^a . p_2^b . p_3^c \ldots . p_n^z$, where $p_1, p_2, p_3, \ldots . p_n$ are prime number, then sum of positive divisors of n is denoted by $\sigma(n)$.

$$\boldsymbol{\sigma(n) = \left(\frac{p_1^{a+1}-1}{p_1-1}\right).\left(\frac{p_2^{b+1}-1}{p_2-1}\right).\left(\frac{p_3^{c+1}-1}{p_3-1}\right) \ldots . \left(\frac{p_n^{z+1}-1}{p_n-1}\right).}$$

4. **Congruent modulo** -: let n be a fixed positive integer,

two integer **a** and **b** are congruent modulo n if $n \mid (a-b)$

and it is denoted by $a \equiv b(\text{mod } n)$

i.e. $a \equiv b(\text{mod } n)$ if $n \mid (a-b)$

$\Rightarrow a - b = nk \in \mathbb{Z} \Rightarrow a = b + nk$

Note : $a \equiv b(\text{mod } n) \Leftrightarrow b \equiv a(\text{mod } n)$

Some special theorem

- **Fermat's Theorem-:** If p is a prime number, a is integer and p ∤ a [p does not divide a], then $\mathbf{a^{p-1} \equiv 1 (mod\ p)}$.

  Example : $2^{10} (\text{mod } 11) = 1 \Leftrightarrow 2^{10} \equiv 1 (\text{mod } 11)$ [∴ 11∤2]

- **Euler's theorem-:** If n≥1 and gcd(a,n) = 1, then $\mathbf{a^{\phi(n)} = 1 (mod\ n)}$.

- **Wilson's Theorem-:** If p is a prime number, then **$(p-1)! = (-1) \pmod p$.**

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Q.1 Which of the following statements involving Euler's function ϕ is/are true?

(a) $\phi(n)$ is even as many times as it is odd

(b) $\phi(n)$ is odd for only two values of n

(c) $\phi(n)$ is even when $n > 2$

(d) $\phi(n)$ is odd when $n = 2$ or n is odd

Q.2. Find the total number of divisors of number 38808 excluding 1 and the number itself.

(a) 72 (b) 71

(c) 70 (d) 74

Q.3. The remainder when $\sum_{r=1}^{100} r!$ is divided by 12 is

(a) 5 (b) 7

(c) 9 (d) 11

Q.4. Remainder when the sum $1^5+2^5+3^5+4^5+\ldots\ldots+99^5+100^5$ is divided by 4 is

(a) 0 (b) 1

(c) 2 (d) 3

Q.5. For Euler's ϕ function ($\phi : N \rightarrow N$), $\phi(n)$ is

(a) Always even number

(b) Neither one-one nor onto

(c) $\phi(1000) = 400$

(d) None of the above

Q.6. Find the Sum of positive divisors of 50 is.

(a) 31 (b) 20

(c) 06 (d) 93

Q.7. Find the number of divisors of N =2520 (excluding unity)

.....

(a) 41 (b) 42

(c) 45 (d) 47

Q.8 let S be the set of all positive integers (including unity) which are less than 3969 and co-prime to it. What is the sum of all the elements of S?

(a) 6001125 (b) 6001128

(c) 6001130 (d) 6001344

Q.9. The number of positive divisors of 50,000 is

(a) 20 (b) 30

(c) 40 (d) 50

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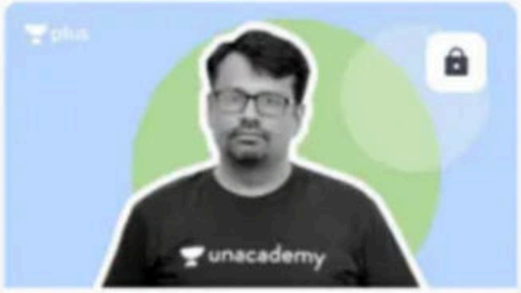

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Educator highlights

- Works at **Pacific Science College**
- Studied at **M.Sc., NET, PhD(Algebra), MBA(Finance), BEd**
- PhD, NET | Plus Educator For CSIR NET | Youtuber (260K+Subs.) | Director Pacific Science College |
- Lives in **Udaipur, Rajasthan, India**
- Unacademy Educator since

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