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Automorphism : Let G be a group, then the mapping $f : G \to G$ is called automorphism if

(i) f is one-one
(ii) f is onto
(iii) f is homomorphism

i.e. A mapping $f : G \to G$ is called automorphism if it is isomorphism

Note : Let Z = group of integer under addition then $f : Z \to Z$ s.t. $f(x) = mx;\ m \neq \{1, -1\}$

Then it will not be onto mapping.

So, it will not be automorphism.

$\Rightarrow$ Z have only two automorphism.

Automorphism Group :

Let G be a group, then the set of all automorphism of G form a group under the composition of mapping and this is denoted by Aut G.

Q1. For any group G, Aut(G) denote the group of automorphism of G. Which of the following are true?

(a) If G is finite, then Aut(G) is finite

(b) If G is cyclic, then Aut(G) is cyclic

(c) If G is infinite, then Aut(G) is infinite

(d) If Aut (G) is isomorphic to Aut(H) then G is isomorphic to H.

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Q2. Let $G = Z_3 \times Z_3$ be a group then order of $\mathrm{Aut}(Z_3 \times Z_3)$ is

(a) 48 (b) 168

(c) 50 (d) 150

Q3. The order of $Aut(Aut(Aut(K_4)))$ is

(a) 4 (b) 5

(c) 6 (d) 8

Group Homomorphism

Counting of homomorphism :

Procedure for Counting of homomorphism :

Let $f : G \to G'$ be a homomorphism

(i) Find Normal subgroup of G namely H_1, H_2, etc.

(ii) Using FTH

$$\frac{G}{H_i} = f(G) \text{ which is subgroup of } G'$$

(iii) Find Aut(f(G))

(iv) During all the above steps, we have collected three numbers, n_1 the number of normal subgroup (H_i) in G , n_2 number of subgroup(f(G)) in G' , n_3 order of Aut(f(G)) then product of $n_1n_2n_3$

(v) Do each step for other H_i and sum all of them

(1) Counting of group homomorphism from finite cyclic group to finite cyclic group.

Result : Let $f : Z_m \to Z_n$ be a mapping then number of homomorphism are $\gcd(m, n)$

2. Number of one-one homomorphism from finite cyclic group to finite cyclic group.

Result : Let f : $Z_m \to Z_n$ be a homomorphism then number of one-one homomorphism are $\begin{cases} \phi(m) & if \quad m \mid n \\ 0 & if \quad m \nmid n \end{cases}$.

(3) Number of onto homomorphism from Z_m to Z_n.

Result : Let $f : Z_m \to Z_n$ be a homomorphism then number of onto homomorphism are $\begin{cases} \phi(n) & \text{if } n \mid m \\ 0 & \text{if } n \nmid m \end{cases}$.

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(4) Counting of group homomorphism from S_4 to K_4.

(5) Counting of one – one group homomorphism from S_4 to K_4.

(6) Counting of onto group homomorphism from S_4 to K_4.

Homomorphism

1. Counting of homomorphism from $S_n \to Z_m$, $(n \geq 3)$

   1. Number of homomorphism $\begin{cases} 1, & m \text{ is odd} \\ 2, & m \text{ is even} \end{cases}$

   2. Number of onto homomorphism $\begin{cases} 1, & m = 1,2 \\ 0, & \text{otherwise} \end{cases}$.

   3. Number of one-one homomorphism does not exist.

2. Counting of homomorphism from $A_4 \to Z_m$

1. Number of homomorphism are $\begin{cases} 3 & if \quad 3 \mid m \\ 1 & if \quad 3 \nmid m \end{cases}$

2. Number of onto homomorphisms are $\begin{cases} 1 & if \quad m = 1 \\ 2 & if \quad m = 3 \\ 0 & otherwise \end{cases}$

3. Number of one-one homomorphism does not exist.

3. Counting of homomorphism from $A_n \to Z_m$, $(n \geq 5)$

1. Number of homomorphism only trivial.
2. Number of onto homomorphisms are $\begin{cases} 1 & if \quad m=1 \\ 0 & if \quad otherwise \end{cases}$
3. Number of one-one homomorphism does not exist.

4. Counting of homomorphism from $K_4 \to Z_n$.

1. Number of homomorphism are $\begin{cases} 4, & m \text{ is even} \\ 1, & m \text{ is odd} \end{cases}$.
2. Number of onto homomorphisms are $\begin{cases} 1, & m=1 \\ 3, & m=2 \\ 0, & otherwise \end{cases}$.
3. Number of one-one homomorphism does not exists.

5. Counting of homomorphism from $Q_8 \to Z_m$

1. Number of homomorphisms are $\begin{cases} 4, & m \text{ is even} \\ 1, & m \text{ is odd} \end{cases}$.

2. Number of onto homomorphisms are $\begin{cases} 1, & m = 1 \\ 3, & m = 2 \\ 0, & \text{otherwise} \end{cases}$.

3. Number of one-one homomorphism does not exists.

6. Counting of homomorphism from $S_n \to K_4$, $(n \geq 3)$

1. Number of homomorphism are 4.

2. Number of onto homomorphism does not exist.

3. Number of one-one homomorphism does not exist.

7. Counting of homomorphism from $S_n \to Q_8$, $n \geq 3$.

1. Number of homomorphism are 2.
2. Number of onto homomorphism does not exist.
3. Number of one-one homomorphism does not exist

Q.1. The number of group homomorphism from the cyclic group Z_4 to the cyclic group Z_7 is

(a) homomorphism (b) isomorphism

(c) unique homomorphism (d) None of these

Q.2. The number of homomorphism from Z_4 to Z_{12} is

(a) 4 (b) 3

(c) 48 (d) 12

Q.3. Let G be the cyclic group of order 8 and $H = S_3$ be the permutation group of 3 elements.

Which of the following statements are necessarily true?

(a) There exists no non-trivial group homomorphism from G to H

(b) There exists no injective group homomorphism from G to H

(c) There exists no surjective group homomorphism from G to H

(d) There are more than 20 different group homomorphism from G to H

Q.4. The number of homomorphism from S_5 to Z_5

(a) 1 (b) 2

(c) 3 (d) 4

Q.5. The number of onto homomorphism from Z_8 to Z_4

(a) 1 (b) 2

(c) 3 (d) 4

Q.6. The number of onto homomorphism from Q_8 to Z_2

(a) 1 (b) 2

(c) 3 (d) 4

Q.7. The number of onto homomorphism from Z_{200} to Z_{100}

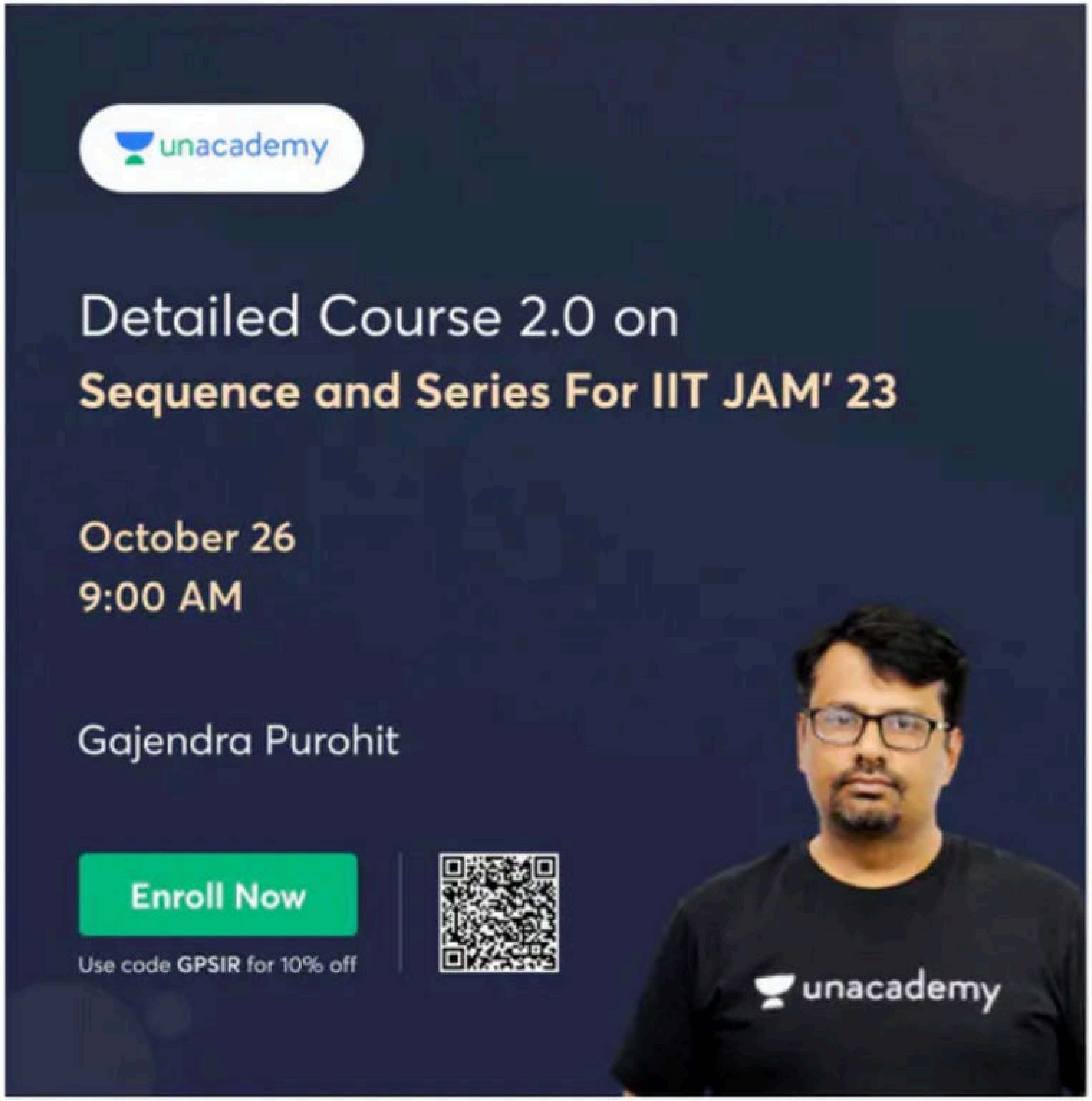
(a) 46 (b) 42

(c) 40 (d) 38

Q.8. The number of group homomorphisms from to Z_{10} is Z_{20}

(a) zero (b) one

(c) five (d) ten



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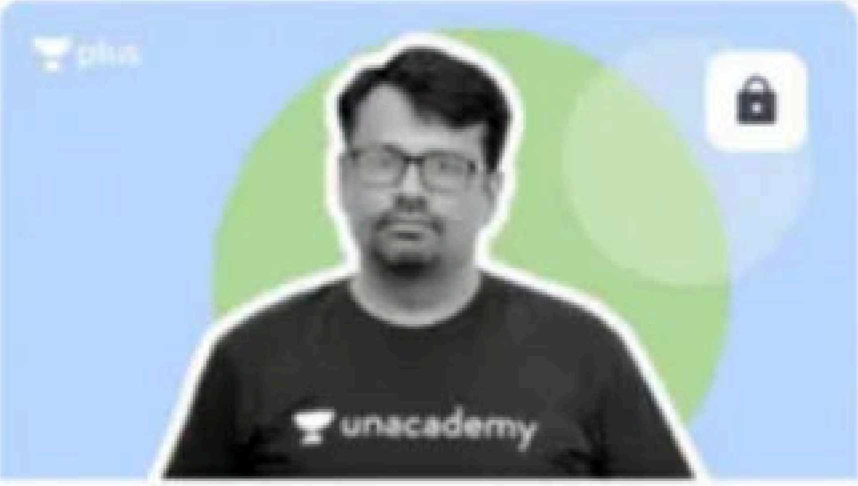

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Educator highlights

- 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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