Relations and Functions

Standard difficulty · 20 questions · 40 marks · Time: 36 minutes

Name: _____ Date: _____ Score: ____ / 40

Show your working for Sections B and C. Answers are on the last page — try every question first!

Section A — Choose the correct answer 8 × 1 = 8 marks

1. The number of relations on a set with 1 element is:
(a) 2 **(b)** 3 **(c)** 1 **(d)** 4

2. The number of bijective functions from a set with 6 elements to itself is:
(a) 720 **(b)** 46,656 **(c)** 64 **(d)** 36

3. If $f(x) = -3x - 2$ and $g(x) = -2x + 8$, then $(g \circ f)(x)$ is:
(a) $6x + 12$ **(b)** $6x - 16$ **(c)** $6x - 26$ **(d)** $-5x + 6$

4. The inverse of $f: R \to R$, $f(x) = 8x + 9$ is $f^{-1}(x)$ =
(a) $x/8 - 9$ **(b)** $(x + 9)/8$ **(c)** $(x - 9)/8$ **(d)** $8x - 9$

5. A relation R on A is reflexive when:
(a) $(a, b) \in R$ for all a, b
(b) $(a, a) \in R$ for every $a \in A$
(c) $(a, b) \in R$ implies $(b, a) \in R$
(d) R is empty

6. The relation $R = \{(1, 1), (1, 3), (2, 2), (3, 1), (3, 3)\}$ on $A = \{1, 2, 3\}$ is:
(a) an equivalence relation
(b) reflexive and symmetric, but not transitive
(c) reflexive only
(d) symmetric and transitive, but not reflexive

7. The function $f: R \to [0, \infty)$, $f(x) = x^2$ is:
(a) neither one-one nor onto
(b) one-one but not onto
(c) onto but not one-one
(d) one-one and onto

8. Assertion (A): The relation $R = \{(a, b) : a - b > 3\}$ on Z is an equivalence relation.
Reason (R): A relation is an equivalence relation when it is reflexive, symmetric and transitive.
(a) Both A and R are true, and R is the correct explanation of A.
(b) Both A and R are true, but R is not the correct explanation of A.
(c) A is true, but R is false.
(d) A is false, but R is true.

Section B — Short answer 8 × 2 = 16 marks

9. Determine whether the relation $R = \{(1, 1), (1, 4), (2, 2), (3, 2), (3, 3)\}$ on $A = \{1, 2, 3, 4\}$ is reflexive, symmetric and transitive.

10. R = {(a, b) : a − b is divisible by 4} is an equivalence relation on A = {0, 1, 2, …, 8}. Find the equivalence class [0].

11. If f(x) = 3x + 5 and g(x) = x^2 + 7, find (f ∘ g)(x) and (g ∘ f)(x).

12. Find the inverse of f(x) = (4x − 1)/(2x − 2), x ≠ 1.

13. A has 4 elements and B has 5 elements. Find the number of (a) relations from A to B, (b) functions from A to B, (c) one-one functions from A to B.

14. f: {1, 2, 3, 4} → {a, b, c, d, e} is given by f = {(1, d), (2, d), (3, e), (4, a)}. Is f one-one? Is f onto?

15. If f(x) = x^2 − 3 and g(x) = −2x + 6, find (f ∘ g)(1) and (g ∘ f)(1).

16. A relation R on A = {1, 2, …, 7} is defined by R = {(x, y) : y = 2x}. Write R in roster form and find its domain and range.

Section C — Word problems — 4 × 4 = 16 marks

17. Show that R = {(a, b) : |a − b| is a multiple of 3} is an equivalence relation on A = {1, 2, …, 12}, and write all its equivalence classes.

18. Let f(x) = 5x − 6 and g(x) = x^2 − 4. Find (g ∘ f)(x) and (f ∘ g)(x). Is g ∘ f = f ∘ g? Find (g ∘ f)(2) and (f ∘ g)(2).

19. Show that f: R − {−7/4} → R − {1}, f(x) = (4x − 5)/(4x + 7) is one-one and onto, and find f^{-1}.

20. A = {1, 2} and B has 2 elements. Find the number of (a) reflexive relations on A, (b) symmetric relations on A, (c) onto functions from B to A, (d) bijections from A to A.

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Answer key

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Q	Answer	Working
1	**(a) 2**	$2^{(1 \times 1)} = 2^1$
2	**(a) 720**	$6! = 6 \times 5 \times 4 \times 3 \times 2 \times 1$
3	**(a) 6x + 12**	$g(f(x)) = -2(-3x - 2) + 8$
4	**(c) (x − 9)/8**	$y = 8x + 9 \Rightarrow x = (y - 9)/8$
5	**(b) (a, a) ∈ R for every a ∈ A**	—
6	**(a) an equivalence relation**	reflexive: every (a, a) is in R; symmetric; transitive
7	**(c) onto but not one-one**	f(2) = f(−2), but every non-negative value is reached
8	**(d) A is false, but R is true.**	A is false: (a, a) ∉ R because 0 > 3 is false, so R is not reflexive. R is true.
9	**transitive only**	not reflexive: (4, 4) ∉ R; not symmetric: (1, 4) ∈ R but (4, 1) ∉ R; transitive
10	**{0, 4, 8}**	the elements that leave remainder 0 on division by 4
11	**$(f \circ g)(x) = 3x^2 + 26$; $(g \circ f)(x) = 9x^2 + 30x + 32$**	$f(g(x)) = 3(x^2 + 7) + 5$; $g(f(x)) = (3x + 5)^2 + 7$
12	**$f^{-1}(x) = (2x - 1)/(2x - 4)$, $x \neq 2$**	$y(2x - 2) = 4x - 1 \Rightarrow x(2y - 4) = 2y - 1$
13	**(a) $2^{20} = 1{,}048{,}576$; (b) 625; (c) 120**	$2^{(4 \times 5)}$; 5^4; $5 \times 4 \times 3 \times 2$
14	**Not one-one; not onto**	f(1) = f(2) = d; b, c have no pre-image
15	**$(f \circ g)(1) = 13$; $(g \circ f)(1) = 10$**	g(1) = 4, f(1) = −2
16	**R = {(1, 2), (2, 4), (3, 6)}; domain {1, 2, 3}; range {2, 4, 6}**	list every pair that satisfies the rule
17	**Reflexive: |a − a| = 0 is a multiple of 3. Symmetric: |a − b| = |b − a|. Transitive: a − c = (a − b) + (b − c). Classes: {1, 4, 7, 10}, {2, 5, 8, 11}, {3, 6, 9, 12}**	group the numbers by their remainder on division by 3
18	**$(g \circ f)(x) = 25x^2 - 60x + 32$; $(f \circ g)(x) = 5x^2 - 26$; not equal; $(g \circ f)(2) = 12$, $(f \circ g)(2) = -6$**	substitute one function into the other
19	**$f(x_1) = f(x_2)$ gives $(48)(x_1 - x_2) = 0$, so $x_1 = x_2$ (one-one); every $y \neq 1$ has the pre-image $x = (7y + 5)/(-4y + 4)$ (onto). $f^{-1}(y) = (7y + 5)/(-4y + 4)$**	cross-multiply: ad − bc = 48 ≠ 0
20	**(a) 4; (b) 8; (c) 2; (d) 2**	(a) $2^{(n^2 - n)}$; (b) $2^{(n(n + 1)/2)}$; (c) 2^2 minus the maps that miss some element (inclusion–exclusion); (d) 2!

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