Relations and Functions (Advanced)

Standard difficulty · 20 questions · 40 marks · Time: 34 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. If (2x + 7, y − 9) = (15, −8), then:
(a) x = 4, y = 1 **(b)** x = 1, y = 4 **(c)** x = −4, y = 1 **(d)** x = 4, y = 3

2. If n(A) = 6 and n(B) = 5, how many relations can be defined from A to B?
(a) 2^{11} **(b)** 30^2 **(c)** 30 **(d)** 2^{30}

3. If (a, b) = (c, d), then:
(a) a + b = c + d **(b)** ab = cd
(c) a = d and b = c **(d)** a = c and b = d

4. f : {−3, −1, 0, 3} → Z is $f(x) = x^2 - 2$. The range of f is:
(a) {−2, −1, 7} **(b)** {−5, −3, −2, 1}
(c) {−3, −1, 0, 3} **(d)** {2, 3, 11}

5. [5.6] − [−3.1] + |−13| equals (where [x] is the greatest integer not more than x):
(a) −4 **(b)** 21 **(c)** 14 **(d)** 22

6. A relation from A to B is a function when:
(a) A and B have the same number of elements **(b)** every element of B has a pre-image
(c) some element of A has two images **(d)** every element of A has exactly one image

7. R = {(a, b) : a + 3b = 22; a, b ∈ N}. How many ordered pairs are in R?
(a) 7 **(b)** 9 **(c)** 22 **(d)** 8

8. The graph of $y = (x - 6)^2$ is the graph of $y = x^2$:
(a) shifted 6 units to the right **(b)** shifted 6 units down
(c) shifted 6 units to the left **(d)** shifted 6 units up

Section B — Short answer — 8 × 2 = 16 marks

9. A = {1, 4, 7} and B = {1, 7, 8}. Find (A × B) ∩ (B × A).

10. A = {4, 5, 6} and B = {5, 7, 8, 9}. R = {(a, b) : a divides b; a ∈ A, b ∈ B}. Write R in roster form, and its domain and range.

11. A = {p, q, r} and B = {7, 8}. Find (a) n(A × B) (b) the number of relations from A to B (c) the number of those relations that contain the pair (p, 7).

12. $f(x) = 2x^2 - 2$ on the domain {−2, −1, 0, 1, 2}. Find the range of f and say how many elements it has.

13. A = {2, 6, 8}, B = {c, e, f, h} and R = {(2, h), (8, h)}. Is R a function from A to B? Give the reason.

14. Evaluate [6.6] + [−7.4] − |−15| + [−3.1], where [x] is the greatest integer not more than x.

15. On A = {1, 2, …, 7}, R = {(a, b) : |a − b| = 1}. Write R in roster form and find n(R), its domain and its range.

16. f is a linear function f(x) = ax + b with f(3) = −23 and f(8) = −53. Find a and b.

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

17. A = {3, 4}, B = {3, 4, 6} and C = {4, 5, 7}. Find B ∪ C and A × (B ∪ C), and check that A × (B ∪ C) = (A × B) ∪ (A × C). How many elements does it have?

18. $f(x) = x^2 - 9$ on the domain {−4, −3, −2, −1, 0, 1, 2, 3, 4}. (a) Write the range of f. (b) Find the pre-images of −8. (c) How many ordered pairs does f contain? (d) Is f a function? Why?

19. Class XI has 29 students (set A) and Class IX has 25 students (set B). Find (a) $n(A \times B)$ (b) the number of relations from A to B, as a power of 2 (c) the number of relations from A to B that contain exactly two ordered pairs.

20. Find the domain and range of each function: (a) $y = 1/(x - 2)$ (b) $y = 7 - |x|$ (c) $y = \sqrt{(x - 2)}$.

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Answer key

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Q	Answer	Working
1	**(a) x = 4, y = 1**	2x + 7 = 15 and y − 9 = −8
2	**(d) 2^{30}**	n(A × B) = 6 × 5 = 30; a relation is any subset: 2^{30}
3	**(d) a = c and b = d**	ordered pairs are equal only when matching entries are equal
4	**(a) {−2, −1, 7}**	f(−3) = 7, f(−1) = −1, f(0) = −2, f(3) = 7
5	**(d) 22**	5 − (−4) + 13
6	**(d) every element of A has exactly one image**	no first element appears twice, and none is missing
7	**(a) 7**	b = 1, 2, …, 7 keep a = 22 − 3b ≥ 1
8	**(a) shifted 6 units to the right**	y = f(x + k) shifts left for k > 0 and right for k < 0
9	**{(1, 1), (1, 7), (7, 1), (7, 7)}**	a pair is in both only if each entry is in A ∩ B = {1, 7}; so it is (A ∩ B) × (A ∩ B)
10	**R = {(4, 8), (5, 5)}; domain {4, 5}; range {5, 8}**	check every pair of A × B against the rule
11	**(a) 6; (b) 64; (c) 32**	(b) 2^6; (c) that pair is fixed in, the other 5 pairs are free: 2^5
12	**{−2, 0, 6}; 3 elements**	f(−x) = f(x), so the 5 inputs give only 3 images
13	**No: 6 has no image**	a function needs exactly one image for every element of A
14	**−21**	6 + (−8) − 15 + (−4)
15	**R = {(1, 2), (2, 1), (2, 3), (3, 2), (3, 4), (4, 3), (4, 5), (5, 4), (5, 6), (6, 5), (6, 7), (7, 6)}; n(R) = 12; domain = range = {1, 2, 3, 4, 5, 6, 7}**	6 pairs with b = a + 1 and 6 with b = a − 1
16	**a = −6, b = −5**	a = (−53 − (−23)) ÷ (8 − 3) = −6; then b = −23 − (−6) × 3 = −5
17	**B ∪ C = {3, 4, 5, 6, 7}; A × (B ∪ C) = {(3, 3), (3, 4), (3, 5), (3, 6), (3, 7), (4, 3), (4, 4), (4, 5), (4, 6), (4, 7)}; 10 elements**	n = n(A) × n(B ∪ C) = 2 × 5; (A × B) ∪ (A × C) gives the same pairs
18	**(a) {−9, −8, −5, 0, 7}; (b) −1 and 1; (c) 9; (d) yes, every element of the domain has exactly one image**	x^2 − 9 = −8 gives x^2 = 1; one pair per element of the domain
19	**(a) 725; (b) 2^{725}; (c) 262,450**	(c) choose 2 of the 725 pairs: 725 × 724 ÷ 2
20	**(a) domain: all real x except 2; range: all real y except 0; (b) domain: all real x; range: y ≤ 7; (c) domain: x ≥ 2; range: y ≥ 0**	the reciprocal cannot divide by 0 and is never 0; |x| ≥ 0, so y is at most 7; a square root needs a non-negative number and is never negative

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