

How to use this worksheet. Thirty questions, about 35 minutes. Count relations with 2^{n^2} , not 2^n . Test reflexive, symmetric and transitive **separately** — the usual exam answer is a relation with one property but not the other two.

Formula sheet

$n(A) = p, n(B) = q \Rightarrow n(A \times B) = pq$ | relations from A to B = 2^{pq} | functions from A to B = q^p

Relations on a set of n elements = 2^{n^2}

Reflexive: $(a, a) \in R$ for all a | Symmetric: $(a, b) \in R \Rightarrow (b, a) \in R$ | Transitive: $(a, b), (b, c) \Rightarrow (a, c)$

One-one: distinct inputs give distinct outputs | Onto: range = codomain

Section A · Level 1 — Cartesian products, relations and definitions

Ten questions. None should take more than twenty seconds.

1. If $n(A) = 3$ and $n(B) = 4$, then the number of elements in $A \times B$ is:

- (1) 7 (2) 12 (3) 16 (4) 81

2. A relation from A to B is defined as a subset of:

- (1) A (2) B (3) $A \times B$ (4) $B \times A$

3. A relation R on a set A is reflexive if:

- (1) $(a, b) \in R$ for all a, b (2) $(a, a) \in R$ for every a in A (3) $(a, b) \in R \Rightarrow (b, a) \in R$ (4) R is empty

4. A relation R is symmetric if:

- (1) $(a, a) \in R$ for all a (2) $(a, b) \in R \Rightarrow (b, a) \in R$ (3) (a, b) and $(b, c) \in R \Rightarrow (a, c) \in R$ (4) R has exactly two elements

5. A function $f: A \rightarrow B$ is called one-one if:

- (1) Every element of B has a preimage (2) Distinct elements of A have distinct images (3) Some element of A has two images (4) A and B have the same size

6. A function $f: A \rightarrow B$ is called onto if:

- (1) Every element of A has an image (2) Every element of B has at least one preimage (3) f is one-one (4) The domain equals the codomain

7. The number of relations that can be defined from a set with p elements to a set with q elements is:

- (1) pq (2) 2^{pq} (3) p^q (4) q^p

8. The domain of the function $f(x) = 1/x$ is:

- (1) All real numbers (2) All real numbers except 0 (3) All positive real numbers (4) All integers

9. The range of the identity function $f(x) = x$ on the real numbers is:

- (1) {0} (2) All real numbers (3) $[0, \infty)$ (4) $[-1, 1]$

10. An empty relation on a non-empty set A is:

- (1) Reflexive (2) Symmetric and transitive but not reflexive (3) Reflexive and symmetric (4) None of the three properties

Working space — Questions 1 to 10

Write the formula before you substitute.

Section B · Level 2 — Counting, domains and ranges

Ten questions. Check the codomain before deciding whether a function is onto.

- 11.** If $A = \{1, 2\}$ and $B = \{3, 4\}$, the number of relations from A to B is:
 (1) 4 (2) 8 (3) 16 (4) 32
- 12.** The number of functions from a set with 3 elements to a set with 2 elements is:
 (1) 6 (2) 8 (3) 9 (4) 5
- 13.** The domain of $f(x) = \sqrt{x - 2}$ is:
 (1) $x > 2$ (2) $x \geq 2$ (3) $x \leq 2$ (4) All real numbers
- 14.** The range of $f(x) = x^2$ on the real numbers is:
 (1) All real numbers (2) $[0, \infty)$ (3) $(0, \infty)$ (4) $[-1, 1]$
- 15.** The function $f: \mathbb{R} \rightarrow \mathbb{R}$ defined by $f(x) = 2x + 3$ is:
 (1) One-one but not onto (2) Onto but not one-one (3) Both one-one and onto (4) Neither one-one nor onto
- 16.** The function $f: \mathbb{R} \rightarrow \mathbb{R}$ defined by $f(x) = x^2$ is:
 (1) One-one and onto (2) One-one but not onto (3) Onto but not one-one (4) Neither one-one nor onto
- 17.** The relation R on the set of integers defined by aRb if $a = b$ is:
 (1) Reflexive only (2) Symmetric only (3) Reflexive, symmetric and transitive (4) Transitive only
- 18.** The relation “is less than” on the set of real numbers is:
 (1) Reflexive and symmetric (2) Transitive but neither reflexive nor symmetric (3) An equivalence relation (4) Symmetric only
- 19.** If $A = \{1, 2, 3\}$, the number of relations that can be defined on A is:
 (1) 2^9 (2) 2^3 (3) 3^2 (4) 3^3
- 20.** The domain of the function $f(x) = 1 / (x^2 - 4)$ is:
 (1) All reals (2) All reals except 2 (3) All reals except ± 2 (4) All reals except 0

Working space — Questions 11 to 20 Write the formula before you substitute.

Section C · Level 3 — Equivalence relations and types of function

Six questions. Test all three properties separately, never together.

- 21.** A relation that is reflexive, symmetric and transitive is called:
 (1) A function (2) An equivalence relation (3) A bijection (4) An empty relation
- 22.** The relation “is parallel to” on the set of lines in a plane is:
 (1) Reflexive and symmetric but not transitive (2) An equivalence relation (3) Symmetric only (4) Transitive only
- 23.** The relation “is perpendicular to” on the set of lines in a plane is:
 (1) Reflexive (2) Symmetric but neither reflexive nor transitive (3) Transitive (4) An equivalence relation
- 24.** A function $f: A \rightarrow B$ that is both one-one and onto is called:
 (1) An injection only (2) A surjection only (3) A bijection (4) An identity function
- 25.** If $f: A \rightarrow B$ is onto and $n(A) = n(B)$ is finite, then f must also be:
 (1) Constant (2) One-one (3) The identity function (4) Undefined
- 26.** The function $f: \mathbb{R} \rightarrow \mathbb{R}$ defined by $f(x) = c$, a constant, is:
 (1) One-one (2) Onto (3) Neither one-one nor onto (4) A bijection

Working space — Questions 21 to 26

Write the formula before you substitute.

Section D · Previous year questions — Straight from the AAI ATC papers

Four questions from the 2023 papers, recovered by optical character recognition of the scanned answer sheets and independently re-solved.

27. The range of the function $f(x) = \sqrt{36 - x^2}$ is: **[PYQ 2023 · Evening]**

(1) $(-6, 6)$ (2) $(0, 6)$ (3) $[0, 6]$ (4) $[1, 6]$

28. The function $f: \mathbb{R} \rightarrow \mathbb{R}$ defined by $f(x) = \sin x$ is: **[PYQ 2023 · Evening]**

(1) Injective but not surjective (2) Neither injective nor surjective (3) Not a relation (4) Bijective

29. If $A = \{5, 8, 9, 12\}$, then the total number of distinct relations that can be defined over A is: **[PYQ 2023 · Evening]**

(1) 8 (2) 4 (3) 2^8 (4) 2^{16}

30. Which of the following relations is symmetric, but neither reflexive nor transitive? **[PYQ 2023 · Morning]**

(1) $R = \{(T_1, T_2) : T_1 \text{ is congruent to } T_2, T \text{ the set of triangles in a plane}\}$ (2) $R = \{(L_1, L_2) : L_1 \text{ is perpendicular to } L_2, L \text{ the set of lines in a plane}\}$ (3) $R = \{(T_1, T_2) : T_1 \text{ is similar to } T_2, T \text{ the set of triangles in a plane}\}$ (4) $R = \{(L_1, L_2) : L_1 \text{ is parallel to } L_2, L \text{ the set of lines in a plane}\}$

Working space — Questions 27 to 30

Write the formula before you substitute.

Stuck on any of these? Bring them to a live class.

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