

2014

BOOKLET NO.

TEST CODE : UGA

**Forenoon**

<b>Questions : 30</b>	<b>Time : 2 hours</b>
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*Write your Name, Registration Number, Test Centre, Test Code and the Number of this Booklet in the appropriate places on the Answersheet.*

This test contains 30 questions in all. For each of the 30 questions, there are four suggested answers. Only one of the suggested answers is correct. You will have to identify the correct answer in order to get full credit for that question. Indicate your choice of the correct answer by darkening the appropriate oval ●, completely on the answersheet.

You will get  
4 marks for each correctly answered question,  
0 marks for each incorrectly answered question and  
1 mark for each unattempted question.

ALL ROUGH WORK MUST BE DONE ON THIS BOOKLET ONLY.

YOU ARE NOT ALLOWED TO USE CALCULATOR.

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**WAIT FOR THE SIGNAL TO START.**

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UGA<sub>o</sub>-1



1. Using only the digits 2, 3 and 9, how many six digit numbers can be formed which are divisible by 6?

- (A) 41                      (B) 80                      (C) 81                      (D) 161

2. The system of inequalities

$$a - b^2 \geq \frac{1}{4}, b - c^2 \geq \frac{1}{4}, c - d^2 \geq \frac{1}{4}, d - a^2 \geq \frac{1}{4} \quad \text{has}$$

- (A) no solutions                      (B) exactly one solution  
(C) exactly two solutions                      (D) infinitely many solutions.

3. The number of solutions of the equation  $\tan x + \sec x = 2 \cos x$ , where  $0 \leq x \leq \pi$ , is

- (A) 0                      (B) 1                      (C) 2                      (D) 3.

4. Let  $\log_{12} 18 = a$ . Then  $\log_{24} 16$  is equal to

- (A)  $\frac{8-4a}{5-a}$                       (B)  $\frac{1}{3+a}$                       (C)  $\frac{4a-1}{2+3a}$                       (D)  $\frac{8-4a}{5+a}$ .

5. A light ray travelling along the line  $y = 1$ , is reflected by a mirror placed along the line  $x = 2y$ . The reflected ray travels along the line

- (A)  $4x - 3y = 5$     (B)  $3x - 4y = 2$     (C)  $x - y = 1$     (D)  $2x - 3y = 1$ .

6. What is the ratio of the areas of the regular pentagons inscribed inside and circumscribed around a given circle?

- (A)  $\cos 36^\circ$                       (B)  $\cos^2 36^\circ$                       (C)  $\cos^2 54^\circ$                       (D)  $\cos^2 72^\circ$

7. For a real number  $x$ , let  $[x]$  denote the greatest integer less than or equal to  $x$ . Then the number of real solutions of  $|2x - [x]| = 4$  is

- (A) 1                      (B) 2                      (C) 3                      (D) 4.

8. What is the value of the following integral?

$$\int_{\frac{1}{2014}}^{2014} \frac{\tan^{-1} x}{x} dx$$

- (A)  $\frac{\pi}{4} \log 2014$     (B)  $\frac{\pi}{2} \log 2014$     (C)  $\pi \log 2014$     (D)  $\frac{1}{2} \log 2014$

9. In how many ways can 20 identical chocolates be distributed among 8 students so that each student gets at least one chocolate and exactly two students get at least two chocolates each?
- (A) 308                      (B) 364                      (C) 616                      (D)  $\binom{8}{2}\binom{17}{7}$
10. Two vertices of a square lie on a circle of radius  $r$ , and the other two vertices lie on a tangent to this circle. Then, each side of the square is
- (A)  $\frac{3r}{2}$                       (B)  $\frac{4r}{3}$                       (C)  $\frac{6r}{5}$                       (D)  $\frac{8r}{5}$ .
11. Let  $z_1, z_2$  be nonzero complex numbers satisfying  $|z_1 + z_2| = |z_1 - z_2|$ . The circumcentre of the triangle with the points  $z_1, z_2$ , and the origin as its vertices is given by
- (A)  $\frac{1}{2}(z_1 - z_2)$       (B)  $\frac{1}{3}(z_1 + z_2)$       (C)  $\frac{1}{2}(z_1 + z_2)$       (D)  $\frac{1}{3}(z_1 - z_2)$ .
12. Let  $P$  be the set of all numbers obtained by multiplying five distinct integers between 1 and 100. What is the largest integer  $n$  such that  $2^n$  divides at least one element of  $P$ ?
- (A) 8                      (B) 20                      (C) 24                      (D) 25
13. Let  $A$  be the set of all points  $(h, k)$  such that the area of the triangle formed by  $(h, k), (5, 6)$  and  $(3, 2)$  is 12 square units. What is the least possible length of a line segment joining  $(0, 0)$  to a point in  $A$ ?
- (A)  $\frac{4}{\sqrt{5}}$                       (B)  $\frac{8}{\sqrt{5}}$                       (C)  $\frac{12}{\sqrt{5}}$                       (D)  $\frac{16}{\sqrt{5}}$
14. Let  $P = \{abc : a, b, c \text{ positive integers, } a^2 + b^2 = c^2, \text{ and } 3 \text{ divides } c\}$ . What is the largest integer  $n$  such that  $3^n$  divides every element of  $P$ ?
- (A) 1                      (B) 2                      (C) 3                      (D) 4
15. Consider the function  $f(x) = ax^3 + bx^2 + cx + d$ , where  $a, b, c$  and  $d$  are real numbers with  $a > 0$ . If  $f$  is strictly increasing, then the function  $g(x) = f'(x) - f''(x) + f'''(x)$  is
- (A) zero for some  $x \in \mathbb{R}$                       (B) positive for all  $x \in \mathbb{R}$   
(C) negative for all  $x \in \mathbb{R}$                       (D) strictly increasing.

16. Let  $A_1, A_2, \dots, A_{18}$  be the vertices of a regular polygon with 18 sides. How many of the triangles  $\triangle A_i A_j A_k$ ,  $1 \leq i < j < k \leq 18$ , are isosceles but not equilateral?
- (A) 63                      (B) 70                      (C) 126                      (D) 144
17. Let  $N$  be a number such that whenever you take  $N$  consecutive positive integers, at least one of them is coprime to 374. What is the smallest possible value of  $N$ ?
- (A) 4                      (B) 5                      (C) 6                      (D) 7
18. Let  $f(x) = \frac{1}{x-2}$ . The graphs of the functions  $f$  and  $f^{-1}$  intersect at
- (A)  $(1 + \sqrt{2}, 1 + \sqrt{2})$  and  $(1 - \sqrt{2}, 1 - \sqrt{2})$   
 (B)  $(1 + \sqrt{2}, 1 + \sqrt{2})$  and  $(\sqrt{2}, -1 - \frac{1}{\sqrt{2}})$   
 (C)  $(1 - \sqrt{2}, 1 - \sqrt{2})$  and  $(-\sqrt{2}, -1 + \frac{1}{\sqrt{2}})$   
 (D)  $(\sqrt{2}, -1 - \frac{1}{\sqrt{2}})$  and  $(-\sqrt{2}, -1 + \frac{1}{\sqrt{2}})$
19. Let  $A_0 = \emptyset$  (the empty set). For each  $i = 1, 2, 3, \dots$ , define the set  $A_i = A_{i-1} \cup \{A_{i-1}\}$ . The set  $A_3$  is
- (A)  $\emptyset$                       (B)  $\{\emptyset\}$                       (C)  $\{\emptyset, \{\emptyset\}\}$                       (D)  $\{\emptyset, \{\emptyset\}, \{\emptyset, \{\emptyset\}\}\}$
20. Consider the region  $R = \{(x, y) : x^2 + y^2 \leq 100, \sin(x+y) > 0\}$ . What is the area of  $R$ ?
- (A)  $25\pi$                       (B)  $50\pi$                       (C) 50                      (D)  $100\pi - 50$
21. The limit  $\lim_{x \rightarrow 0} \frac{\sin^\alpha x}{x}$  exists *only when*
- (A)  $\alpha \geq 1$                       (B)  $\alpha = 1$   
 (C)  $|\alpha| \leq 1$                       (D)  $\alpha$  is a positive integer.
22. Consider a cyclic trapezium whose circumcentre is on one of the sides. If the ratio of the two parallel sides is 1 : 4, what is the ratio of the sum of the two oblique sides to the longer parallel side?
- (A)  $\sqrt{3} : \sqrt{2}$                       (B) 3 : 2                      (C)  $\sqrt{2} : 1$                       (D)  $\sqrt{5} : \sqrt{3}$

23. Let  $f : (0, \infty) \rightarrow (0, \infty)$  be a function differentiable at 3, and satisfying  $f(3) = 3f'(3) > 0$ . Then the limit

$$\lim_{x \rightarrow \infty} \left( \frac{f\left(3 + \frac{3}{x}\right)}{f(3)} \right)^x$$

- (A) exists and is equal to 3                      (B) exists and is equal to  $e$   
 (C) exists and is always equal to  $f(3)$     (D) need not always exist.

24. What is the number of ordered triplets  $(a, b, c)$ , where  $a, b, c$  are positive integers (not necessarily distinct), such that  $abc = 1000$ ?

- (A) 64                      (B) 100                      (C) 200                      (D) 560

25. Let  $z$  be a non-zero complex number such that  $\left|z - \frac{1}{z}\right| = 2$ . What is the maximum value of  $|z|$ ?

- (A) 1                      (B)  $\sqrt{2}$                       (C) 2                      (D)  $1 + \sqrt{2}$ .

26. Consider the function  $f(x) = \left\{ \log_e \left( \frac{4 + \sqrt{2x}}{x} \right) \right\}^2$  for  $x > 0$ . Then,

- (A)  $f$  decreases upto some point and increases after that  
 (B)  $f$  increases upto some point and decreases after that  
 (C)  $f$  increases initially, then decreases and then again increases  
 (D)  $f$  decreases initially, then increases and then again decreases.

27. Let  $f$  be a function such that  $f''(x)$  exists, and  $f''(x) > 0$  for all  $x \in [a, b]$ . For any point  $c \in [a, b]$ , let  $A(c)$  denote the area of the region bounded by  $y = f(x)$ , the tangent to the graph of  $f$  at  $x = c$  and the lines  $x = a$  and  $x = b$ . Then

- (A)  $A(c)$  attains its minimum at  $c = \frac{1}{2}(a + b)$  for any such  $f$   
 (B)  $A(c)$  attains its maximum at  $c = \frac{1}{2}(a + b)$  for any such  $f$   
 (C)  $A(c)$  attains its minimum at both  $c = a$  and  $c = b$  for any such  $f$   
 (D) the points  $c$  where  $A(c)$  attains its minimum depend on  $f$ .

28. The minimum value of

$$|\sin x + \cos x + \tan x + \operatorname{cosec} x + \sec x + \cot x| \text{ is}$$

- (A) 0                      (B)  $2\sqrt{2} - 1$                       (C)  $2\sqrt{2} + 1$                       (D) 6

29. For any function  $f : X \rightarrow Y$  and any subset  $A$  of  $Y$ , define

$$f^{-1}(A) = \{x \in X : f(x) \in A\}.$$

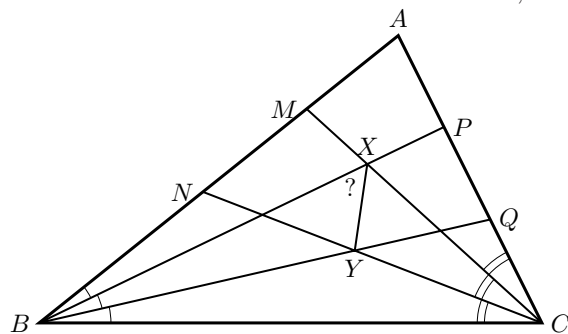
Let  $A^c$  denote the complement of  $A$  in  $Y$ . For subsets  $A_1, A_2$  of  $Y$ , consider the following statements:

- (i)  $f^{-1}(A_1^c \cap A_2^c) = (f^{-1}(A_1))^c \cup (f^{-1}(A_2))^c$   
 (ii) If  $f^{-1}(A_1) = f^{-1}(A_2)$  then  $A_1 = A_2$ .

Then,

- (A) both (i) and (ii) are always true  
 (B) (i) is always true, but (ii) may not always be true  
 (C) (ii) is always true, but (i) may not always be true  
 (D) neither (i) nor (ii) is always true.

30. In  $\triangle ABC$ , the lines  $BP, BQ$  trisect  $\angle ABC$  and the lines  $CM, CN$  trisect  $\angle ACB$ . Let  $BP$  and  $CM$  intersect at  $X$  and  $BQ$  and  $CN$  intersect at  $Y$ . If  $\angle ABC = 45^\circ$  and  $\angle ACB = 75^\circ$ , then  $\angle BXY$  is



- (A)  $45^\circ$                       (B)  $47\frac{1}{2}^\circ$                       (C)  $50^\circ$                       (D)  $55^\circ$