

**THINGS TO REMEMBER :**

**1. LOGARITHM OF A NUMBER :**

The logarithm of the number  $N$  to the base ' $a$ ' is the exponent indicating the power to which the base ' $a$ ' must be raised to obtain the number  $N$ . This number is designated as  $\log_a N$ .

Hence:  $\log_a N = x \Leftrightarrow a^x = N, a > 0, a \neq 1 \& N > 0$

If  $a = 10$ , then we write  $\log b$  rather than  $\log_{10} b$ .

If  $a = e$ , we write  $\ln b$  rather than  $\log_e b$ .

The existence and uniqueness of the number  $\log_a N$  follows from the properties of an exponential functions.

From the definition of the logarithm of the number  $N$  to the base ' $a$ ', we have an identity :  $a^{\log_a N} = N, a > 0, a \neq 1 \& N > 0$

This is known as the **Fundamental Logarithmic Identity**.

**Note :**

$$\log_a 1 = 0 \quad (a > 0, a \neq 1)$$

$$\log_a a = 1 \quad (a > 0, a \neq 1) \text{ and}$$

$$\log_{1/a} a = -1 \quad (a > 0, a \neq 1)$$

**2. THE PRINCIPAL PROPERTIES OF LOGARITHMS :**

Let  $M$  &  $N$  are arbitrary positive numbers,  $a > 0, a \neq 1, b > 0, b \neq 1$  and  $\alpha$  is any real number then ;

$$(i) \log_a (M \cdot N) = \log_a M + \log_a N \quad (ii) \log_a (M/N) = \log_a M - \log_a N$$

$$(iii) \log_a M^\alpha = \alpha \cdot \log_a M \quad (iv) \log_b M = \frac{\log_a M}{\log_a b}$$

$$\text{Note: } \log_b a \cdot \log_a b = 1 \Leftrightarrow \log_b a = 1/\log_a b. \quad \log_b a \cdot \log_c b \cdot \log_a c = 1$$

$$\log_y x \cdot \log_z y \cdot \log_a z = \log_a x. \quad e^{\ln a^x} = a^x$$

**3. PROPERTIES OF MONOTONOCITY OF LOGARITHM :**

- (i) For  $a > 1$  the inequality  $0 < x < y$  &  $\log_a x < \log_a y$  are equivalent.
- (ii) For  $0 < a < 1$  the inequality  $0 < x < y$  &  $\log_a x > \log_a y$  are equivalent.
- (iii) If  $a > 1$  then  $\log_a x < p \Rightarrow 0 < x < a^p$
- (iv) If  $a > 1$  then  $\log_a x > p \Rightarrow x > a^p$
- (v) If  $0 < a < 1$  then  $\log_a x < p \Rightarrow x > a^p$
- (vi) If  $0 < a < 1$  then  $\log_a x > p \Rightarrow 0 < x < a^p$

➤ **NOTE THAT :**

If the number & the base are on one side of the unity, then the logarithm is positive ; If the number & the base are on different sides of unity, then the logarithm is negative.

➤ The base of the logarithm ' a ' must not equal unity otherwise numbers not equal to unity will not have a logarithm & any number will be the logarithm of unity.

➤ For a non negative number ' a ' &  $n \geq 2$ ,  $n \in \mathbb{N}$   $\sqrt[n]{a} = a^{1/n}$ .

➤ **Will be covered in detail in quadratic equation**



(MATHEMATICS)

LOGARITHM

PROFICIENCY TEST-01

1. If  $x = \log_5 (1000)$  and  $y = \log_7 (2058)$  then which is greater ?
2. If  $4^{\log_9 3} + 9^{\log_2 4} = 10^{\log_x 83}$  then x is equal to:
3. If  $\ell n \left( \frac{a+b}{3} \right) = \frac{\ell na + \ell nb}{2}$  then  $\frac{a}{b} + \frac{b}{a}$  is equal to:
4. The solution set of  $\log_{11} \log_7 (\sqrt{x+5} + \sqrt{x}) = 0$  is
5. Solve for 'x' in the equation :  $\ln (x-3) + \ln (x-2) = \ln (2x+24)$
6. Value of  $3\log \frac{81}{80} + 5\log \frac{25}{24} + 7\log \frac{16}{15}$  is
7. Which is the correct order for a given number d,  $d > 1$   
 (A)  $\log_2 d < \log_3 d < \log_e d < \log_8 d$       (B)  $\log_8 d < \log_3 d < \log_e d < \log_2 d$   
 (C)  $\log_8 d < \log_e d < \log_2 d < \log_3 d$       (D)  $\log_3 d < \log_e d < \log_2 d < \log_8 d$
8. If  $\log 27 = 1.431$  then the value of  $\log 9$  is
9. If  $x = \log_{2a} a$ ,  $y = \log_{3a} 2a$ ,  $z = \log_{4a} 3a$ , then the value of  $xyz + 1$  is  
 (A)  $yz$                       (B)  $2yz$                       (C)  $y + z$                       (D)  $y - z$
10. Let  $3^a = 4$ ,  $4^b = 5$ ,  $5^c = 6$ ,  $6^d = 7$ ,  $7^e = 8$  and  $8^f = 9$ , then find the value of the product abcdef :

1. If  $\log_5 a \cdot \log_a x = 2$ , then  $x$  is equal to:
2.  $f(x) = \sqrt{\log_{10} x^2}$ . The set of all values of  $x$  for which  $f(x)$  is real is :
3. Value of  $x^{\log_x a \cdot \log_a y \cdot \log_y z}$  :
4. If  $\log_2 x + \log_2 y \geq 6$ , then the least value of  $x + y$  is :
5. A rational number which is 50 times its own logarithm to the base 10 is :
6. If  $\log 2 = 0.30103$  the no. of digits in  $2^{64}$  is :
7. The number of zeroes coming immediately after the decimal point in the value of  $(0.2)^{25}$  is :  
(Given  $\log_{10} 2 = 0.30103$ )
8. Value of  $6^{\frac{a^{\log_e b} (\log_{a^2} b) (\log_b^2 a)}{e^{\log_e a \cdot \log_e b}}}$
9. The solution set of  $\log_2 |4 - 5x| > 2$  is :
10. If  $\frac{1}{2} \leq \log_{0.1} x \leq 2$  then 'x' belongs to

(MATHEMATICS)

# LOGARITHM

## EXERCISE-I

- Let A denotes the value of  $\log_{10} \left( \frac{ab + \sqrt{(ab)^2 - 4(a+b)}}{2} \right) + \log_{10} \left( \frac{ab - \sqrt{(ab)^2 - 4(a+b)}}{2} \right)$  when  $a = 43$  and  $b = 57$   
and B denotes the value of the expression  $(2^{\log_6 18}) \cdot (3^{\log_6 3})$ .  
Find the value of  $(A \cdot B)$ .
- (a) If  $x = \log_3 4$  and  $y = \log_5 3$ , find the value of  $\log_3 10$  and  $\log_3 (1.2)$  in terms of  $x$  and  $y$ .  
(b) If  $k^{\log_2 5} = 16$ , find the value of  $k^{(\log_2 5)^2}$ .  
**Solve for x(Q. 3 to Q.5):**
- (a) If  $\log_{10} (x^2 - 12x + 36) = 2$   
(b)  $9^{1+\log x} - 3^{1+\log x} - 210 = 0$ ; where base of log is 3.
- Simplify: (a)  $\log_{1/3} \sqrt[4]{729 \cdot \sqrt[3]{9^{-1} \cdot 27^{-4/3}}}$ ; (b)  $a^{\frac{\log_b (\log_b N)}{\log_b a}}$
- (a) If  $\log_4 \log_3 \log_2 x = 0$ ;  
(b) If  $\log_e \log_5 [\sqrt{2x - 2} + 3] = 0$
- (a) Which is smaller? 2 or  $(\log_\pi 2 + \log_2 \pi)$ .  
(b) Prove that  $\log_3 5$  and  $\log_2 7$  are both irrational.
- Let  $a$  and  $b$  be real numbers greater than 1 for which there exists a positive real number  $c$ , different from 1, such that  
 $2(\log_a c + \log_b c) = 9 \log_{ab} c$ . Find the largest possible value of  $\log_a b$ .
- Find the square of the sum of the roots of the equation  
 $\log_3 x \cdot \log_4 x \cdot \log_5 x = \log_3 x \cdot \log_4 x + \log_4 x \cdot \log_5 x + \log_5 x \cdot \log_3 x$
- Find the value of the expression  $\frac{2}{\log_4 (2000)^6} + \frac{3}{\log_5 (2000)^6}$ .
- Calculate :  $4^{5 \log_{4\sqrt{2}} (3 - \sqrt{6}) - 6 \log_8 (\sqrt{3} - \sqrt{2})}$
- Simplify :  $\frac{81^{\frac{1}{\log_5 9} + 3^{\frac{3}{\log_{\sqrt{6}} 3}}}}{409} \cdot \left( (\sqrt{7})^{\frac{2}{\log_{25} 7}} - (125)^{\log_{25} 6} \right)$
- Simplify:  $5^{\log_{1/5} (\frac{1}{2})} + \log_{\sqrt{2}} \frac{4}{\sqrt{7} + \sqrt{3}} + \log_{1/2} \frac{1}{10 + 2\sqrt{21}}$ .
- Find 'x' satisfying the equation  $4^{\log_{10} x + 1} - 6^{\log_{10} x} - 2 \cdot 3^{\log_{10} x^2 + 2} = 0$ .
- Given that  $\log_2 a = s$ ,  $\log_4 b = s^2$  and  $\log_{c^2} (8) = \frac{2}{s^3 + 1}$ . Write  $\log_2 \frac{a^2 b^5}{c^4}$  as a function of 's'  
( $a, b, c > 0, c \neq 1$ )
- Find the value of  $49^{(1 - \log_7 2)} + 5^{-\log_5 4}$ .
- Given that  $\log_2 3 = a$ ,  $\log_3 5 = b$ ,  $\log_7 2 = c$ , express the logarithm of the number 63 to the base 140 in terms of  $a, b$  &

(MATHEMATICS)

LOGARITHM

17. Prove that  $\frac{\log_2 24}{\log_6 2} - \frac{\log_2 192}{\log_{12} 2} = 3$ .
18. Prove that  $a^x - b^y = 0$  where  $x = \sqrt{\log_a b}$  &  $y = \sqrt{\log_b a}$ ,  $a > 0, b > 0$  &  $a, b \neq 1$ .
19. Prove the identity :  $\log_a N \cdot \log_b N + \log_b N \cdot \log_c N + \log_c N \cdot \log_a N = \frac{\log_a N \cdot \log_b N \cdot \log_c N}{\log_{abc} N}$
20. (a) Solve for  $x$ ,  $\frac{\log_{10}(x-3)}{\log_{10}(x^2-21)} = \frac{1}{2}$   
 (b)  $\log(\log x) + \log(\log x^3 - 2) = 0$ ; where base of log is 10 everywhere.  
 (c)  $\log_x 2 \cdot \log_{2x} 2 = \log_{4x} 2$   
 (d)  $5^{\log x} + 5^{x \log 5} = 3$  ( $a > 0$ ); where base of log is  $a$ .
21. If  $x, y > 0$ ,  $\log_y x + \log_x y = \frac{10}{3}$  and  $xy = 144$ , then  $\frac{x+y}{2} = \sqrt{N}$  where  $N$  is a natural number, find the value of  $N$ .
22. Solve the system of equations:  
 $\log_a x \quad \log_a (xyz) = 48$   
 $\log_a y \quad \log_a (xyz) = 12, a > 0, a \neq 1$   
 $\log_a z \quad \log_a (xyz) = 84$
23. (a) Given:  $\log_{10} 34.56 = 1.5386$ , find  $\log_{10} 3.456$ ;  $\log_{10} 0.3456$  &  $\log_{10} 0.003456$ .  
 (b) Find the number of positive integers which have the characteristic 3, when the base of the logarithm is 7.  
 (c) If  $\log_{10} 2 = 0.3010$  &  $\log_{10} 3 = 0.4771$ , find the value of  $\log_{10} (2.25)$ .  
 (d) Find the antilogarithm of 0.75, if the base of the logarithm is 2401.
24. If  $\log_{10} 2 = 0.3010$ ,  $\log_{10} 3 = 0.4771$ . Find the number of integers in :  
 (a)  $5^{200}$                       (b)  $6^{15}$                       &                      (c) the number of zeros after the decimal in  $3^{-100}$ .
25. Let 'L' denotes the antilog of 0.4 to the base 1024.  
 and 'M' denotes the number of digits in  $6^{10}$  (Given  $\log_{10} 2 = 0.3010$ ,  $\log_{10} 3 = 0.4771$ )  
 and 'N' denotes the number of positive integers which have the characteristic 2, when base of the logarithm is 6.  
 Find the value of LMN.

EXERCISE-II

**Note :** From Q. 1 to Q. 8 , solve the equation for x :

1.  $\log_a(x) = x$  where  $a = x^{\log_4 x}$ .
2.  $x^{\log x + 4} = 32$ , where base of logarithm is 2.
3.  $\log_{x+1}(x^2 + x - 6)^2 = 4$
4.  $x + \log_{10}(1 + 2^x) = x \cdot \log_{10} 5 + \log_{10} 6$ .
5.  $5^{\log x} - 3^{\log x - 1} = 3^{\log x + 1} - 5^{\log x - 1}$ , where the base of logarithm is 10.
6.  $\frac{1 + \log_2(x-4)}{\log_{\sqrt{2}}(\sqrt{x+3} - \sqrt{x-3})} = 1$
7.  $\log_5 120 + (x-3) - 2 \cdot \log_5(1 - 5^{x-3}) = -\log_5(0.2 - 5^{x-4})$
8.  $\log 4 + \left(1 + \frac{1}{2x}\right) \log 3 = \log(\sqrt[3]{3} + 27)$ .
9. The real x and y satisfy  $\log_8 x + \log_4 y^2 = 5$  and  $\log_8 y + \log_4 x^2 = 7$ , find xy.
10. Find the real solutions to the system of equations  
 $\log_{10}(2000xy) - \log_{10} x \cdot \log_{10} y = 4$   
 and  $\log_{10}(2yz) - \log_{10} y \cdot \log_{10} z = 1$   
 $\log_{10}(zx) - \log_{10} z \cdot \log_{10} x = 0$
11. If  $x = 1 + \log_a bc$ ,  $y = 1 + \log_b ca$ ,  $z = 1 + \log_c ab$ , then prove that  $xyz = xy + yz + zx$ .
12. If  $p = \log_a bc$ ,  $q = \log_b ca$ ,  $r = \log_c ab$ , then prove that  $pqr = p + q + r + 2$ .
13. If  $\log_b a \cdot \log_c a + \log_a b \cdot \log_c b + \log_a c \cdot \log_b c = 3$  (Where a, b, c are different positive real numbers  $\neq 1$ ), then find the value of abc.
14. Let  $y = \sqrt{\log_2 3 \cdot \log_2 12 \cdot \log_2 48 \cdot \log_2 192 + 16} - \log_2 12 \cdot \log_2 48 + 10$ . Find  $y \in \mathbb{N}$ .
15. If  $\frac{\log_a N}{\log_c N} = \frac{\log_a N - \log_b N}{\log_b N - \log_c N}$  where  $N > 0$  &  $N \neq 1$ ,  $a, b, c > 0$  & not equal to 1, then prove that  $b^2 = ac$ .
16. Solve the equation  $\frac{3}{2} \log_4 (x+2)^2 + 3 = \log_4 (4-x)^3 + \log_4 (6+x)^3$ .
17. If  $(x_1, y_1)$  and  $(x_2, y_2)$  are the solution of the system of equation  
 $\log_{225}(x) + \log_{64}(y) = 4$   
 $\log_x(225) - \log_y(64) = 1$   
 then show that the value of  $\log_{30}(x_1 y_1 x_2 y_2) = 12$ .
18. Find x satisfying the equation  $\log^2 \left(1 + \frac{4}{x}\right) + \log^2 \left(1 - \frac{4}{x+4}\right) = 2 \log^2 \left(\frac{2}{x-1} - 1\right)$ .
19. Solve for x :  $\log^2(4-x) + \log(4-x) \cdot \log\left(x + \frac{1}{2}\right) - 2 \log^2\left(x + \frac{1}{2}\right) = 0$
20. If  $\log_{3x} 45 = \log_{4x} 40\sqrt{3}$  then find the characteristic of  $x^3$  to the base 7.

(MATHEMATICS)

LOGARITHM

EXERCISE-III

- Number of positive integers which have characteristic 2 when base is 5, is equal to  
(A) 25 (B) 32 (C) 100 (D) 101
- Number of values of  $x$  in the interval  $(0,5)$  satisfying the equation :  
$$\frac{\ell n(\sqrt{x^2+1}+x) + \ell n(\sqrt{x^2+1}-x)}{\ell nx} = x$$
, is  
(A) 1 (B) 2 (C) 3 (D) 0
- The number of value(s) of  $x$  satisfying the equation  
 $4^{\log 2(\ell nx)} - 1 + \ell n^3 x - 3\ell n^2 x - 5\ell nx + 7 = 0$   
(A) 0 (B) 1 (C) 2 (D) 3
- If  $\log_{105} 7 = a$ ,  $\log_7 5 = b$  then  $\log_{35} 105$  is equal to :  
(A)  $ab$  (B)  $(b+1)a$  (C)  $\frac{1}{ab}$  (D)  $\frac{1}{a(b+1)}$
- The number of zeroes after decimal before the start of any significant digit in the number  $N = (0.18)^{20}$  are :  
(A) 15 (B) 14 (C) 13 (D) 12
- If  $\log_3 5 = x$  and  $\log_{25} 11 = y$  then the value of  $\log_3 \left(\frac{11}{3}\right)$  in terms of  $x$  and  $y$  is :  
(A)  $2xy + 1$  (B)  $2xy - 1$  (C)  $\frac{2y-x}{x}$  (D)  $x^2 y + 1$
- If  $60^a = 3$  and  $60^b = 5$ , then  $12^{\frac{(1-a-b)}{2(1-b)}}$  is equal to:  
(A)  $\frac{1}{2}$  (B) 2 (C) 15 (D)  $\frac{1}{15}$
- If 'x' and 'y' are real numbers such that,  $2\log(2y - 3x) = \log x + \log y$ , find  $\frac{x}{y}$ .  
(A)  $2/3$  (B)  $3/2$  (C)  $9/4$  (D)  $4/9$
- If  $a = \log_{12} 18$  &  $b = \log_{24} 54$  then find the value of  $ab + 5(a - b)$ .  
(A) 0 (B) 1 (C) 4 (D) 9
- If  $x_1$  and  $x_2$  are the roots of the equation  $\sqrt{2010} x^{\log_{2010} x} = x^2$ , then find the cyphers at the end of the product  $(x_1 x_2)$   
(A) 0 (B) 1 (C) 2 (D) 3
- Positive numbers  $x, y$  and  $z$  satisfy  $xyz = 10^{81}$  and  $(\log_{10} x)(\log_{10} yz) + (\log_{10} y)(\log_{10} z) = 468$ . Find the value of  $(\log_{10} x)^2 + (\log_{10} y)^2 + (\log_{10} z)^2$   
(A) 1225 (B) 1728 (C) 2506 (D) 5625
- Find the sum of all value(s) of  $x$  satisfying the equations  $\log^2 x^3 - 20\log(\sqrt{x}) + 1 = 0$  and  $\log(x(x-9)) + \log\left(\frac{x-9}{x}\right) = 0$  (Base of the logarithm is 10)  
(A) 8 (B) 10 (C) 12 (D) 16

(MATHEMATICS)

LOGARITHM

EXERCISE-IV

1. Solve the following equations for  $x$  &  $y$  :  $\log_{100} |x + y| = \frac{1}{2}$  ,  $\log_{10} y - \log_{10} |x| = \log_{100} 4$   
[REE '96, 6]
2. Find all real numbers  $x$  which satisfy the equation,  
 $2\log_2(\log_2 x) + \log_{1/2}\log_2(2\sqrt{2}x) = 1$   
[REE '99, 6]
3.  $\log_{3/4}\log_8(x^2 + 7) + \log_{1/2}\log_{1/4}(x^2 + 7)^{-1} = -2$ .  
[REE 2000, 5 out of 100]
4. Number of solutions of  $\log_4(x - 1) = \log_2(x - 3)$  is  
(A) 3 (B) 1 (C) 2 (D) 0  
[JEE 2001 (Screening)]
5. Let  $(x_0, y_0)$  be solution of the following equations  
 $(2x)^{\ln 2} = (3y)^{\ln 3}$   
 $3^{\ln x} = 2^{\ln y}$   
Then  $x_0$  is :  
(A)  $\frac{1}{6}$  (B)  $\frac{1}{3}$  (C)  $\frac{1}{2}$  (D) 6  
[JEE 2011]
6. The value of  $6 + \log_{\frac{3}{2}} \left( \frac{1}{3\sqrt{2}} \sqrt{4 - \frac{1}{3\sqrt{2}}} \sqrt{4 - \frac{1}{3\sqrt{2}}} \sqrt{4 - \frac{1}{3\sqrt{2}}} \dots \right)$  is  
[JEE 2012]
7. Let  $m$  be the minimum possible value of  $\log_3(3^{y_1} + 3^{y_2} + 3^{y_3})$ , where  $y_1, y_2, y_3$  are real numbers for which  $y_1 + y_2 + y_3 = 9$ . Let  $M$  be the maximum possible value of  $(\log_3 x_1 + \log_3 x_2 + \log_3 x_3)$ , where  $x_1, x_2, x_3$  are positive real numbers for which  $x_1 + x_2 + x_3 = 9$ . Then the value of  $\log_2(m^3) + \log_3(M^2)$  is  
[JEE Advanced 2020]
8. For  $x \in \mathbb{R}$ , the number of real roots of the equation  
 $3x^2 - 4|x^2 - 1| + x - 1 = 0$  is \_\_\_\_\_.  
[JEE Advanced 2021]

(MATHEMATICS)

LOGARITHM

ANSWER KEY

PROFICIENCY TEST-01

1.  $x > y$  2. 10 3. 7 4.  $x = \frac{484}{49}$  5.  $x = 9$  6.  $\log 2$   
7. B 8. 0.954 9. B 10. 2

PROFICIENCY TEST-02

1.  $x = 25$  2.  $(-\infty, -1] \cup [1, \infty)$  3.  $z$  4. 16 5. 100  
6. 20 7. 17 8.  $\frac{3}{2}$   
9.  $(-\infty, 0) \cup (8/5, \infty)$  10.  $\left[\frac{1}{100}, \frac{1}{\sqrt{10}}\right]$

EXERCISE-I

1. 12 2. (a)  $\frac{xy+2}{2y}, \frac{xy+2y-2}{2y}$ ; (b) 625 3. (a)  $x = 16$  or  $x = -4$  (b)  $x = 5$   
4. (a) -1 (b)  $\log_b N$  5. (a) 8 (b)  $x = 3$  6. (a) 2 7. 2  
8. 3721 9.  $1/6$  10. 9 11. 1  
12. 6 13.  $x = \frac{1}{100}$  14.  $2s + 10s^2 - 3(s^3 + 1)$   
15.  $\frac{25}{2}$  16.  $\frac{1+2ac}{2c+abc+1}$   
20. (a)  $x = 5$  (b)  $x = 10$  (c)  $x = 2^{\sqrt{2}}$  or  $2^{-\sqrt{2}}$  (d)  $x = 2^{-\log_a}$  where base of log is 5. 21. 507  
22.  $(a^4, a, a^7)$  or  $\left(\frac{1}{a^4}, \frac{1}{a}, \frac{1}{a^7}\right)$  23. (a) 0.5386;  $\bar{1}.5386$ ;  $\bar{3}.5386$  (b) 2058 (c) 0.3522 (d) 343  
24. (a) 140 (b) 12 (c) 47 25. 23040

EXERCISE-II

1.  $x = 2$  2.  $x = 2$  or  $\frac{1}{32}$  3.  $x = 1$  4.  $x = 1$   
5.  $x = 100$  6.  $x = 5$  7.  $x = 1$  8.  $x \in \phi$   
9.  $xy = 2^9$  10.  $x = 1, y = 5, z = 1$  or  $x = 100, y = 20, z = 100$   
13.  $abc = 1$  14.  $y = 6$  16.  $x = 2$  or  $1 - \sqrt{33}$   
18.  $x = \sqrt{2}$  or  $\sqrt{6}$  19.  $\left\{0, \frac{7}{4}, \frac{3+\sqrt{24}}{2}\right\}$  20. 2

EXERCISE-III

1. C 2. D 3. C 4. D 5. B 6. B 7. B  
8. D 9. B 10. C 11. D 12. B

EXERCISE-IV

1.  $\{-10, 20\}, \{10/3, 20/3\}$  2.  $x = 8$  3.  $x = 3$  or  $-3$  4. B 5. C  
6. 4 7. 8.00 8. 4.00