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Partial Fraction

An expression of the form $f(x)=a_0x^n+a_1x^{n-1}+a_2x^{n-2}+......+a_n$ where n is a positive integer and $a_0,a_1,a_2,....a_n$ are real numbers is called a polynomial of degree n in the variable x.

Rational Functions

If $f(x)$ and $g(x)$ are two polynomials in x and $g(x)\neq 0$ then $\frac{f(x)}{g(x)}$ is called Rational function

If degree of $f(x)$ is less than the degree of $g(x)$ then the rational function is known as proper fraction.

If degree of $f(x)$ is greater than or equal to the degree of $g(x)$, then the rational function is known as Improper fraction. Ex: $\frac{3x-7}{x^3-x}$ is a proper fraction, $\frac{x^2+9x+19}{x^2+7x+12},\frac{3-4x-5x^2-x^3}{(x+3)(x+2)}$ are improper fractions.

Rules to resolve a rational function into partial fraction

Rule (i) : To each non-repeated linear factor $ax+b$ of $g(x)$, there corresponds a partial fraction of the form $\frac{A}{ax+b}$, where A is a constant $\neq 0$.

Rule (ii) : To each repeated linear factor $(ax+b)^r$ of $g(x)$, there corresponds r partial fractions of the form $\frac{A_1}{ax+b}+\frac{A_2}{(ax+b)^2}+.....+\frac{A}{(ax+b)^r}$, where $A_1,A_2,....A_r$ are constants, $A_r\neq 0$.

Rule (iii) : To each non-repeated irreducible quadratic factor ax^2+bx+c of $g(x)$ there corresponds a partial fraction of the form $\frac{Ax+B}{ax^2+bx+c}$ where A and B are constants not both zero.

Time saving results (Short cut methods)

- If $\frac{f(x)}{(x-a)(x-b)}$ is a proper rational function and $\frac{f(x)}{(x-a)(x-b)}=\frac{A}{x-a}+\frac{B}{x-b}$ then $A=\frac{f(a)}{a-b},\ B=\frac{f(b)}{b-a}$.
- $\frac{1}{(x-a)(x-b)}=\frac{1}{a-b}\left[\frac{1}{x-a}-\frac{1}{x-b}\right]$
- If $\frac{Px+Q}{(x-a)(x-b)^2}=\frac{A}{x-a}+\frac{B}{x-b}+\frac{C}{(x-b)^2}$ then $A=\frac{Pa^2+Qa+R}{(a-b)^2},\ B=P-A,\ C=\frac{Pb^2+Qb+R}{b-a}$.
- If $\frac{Px+Q}{x(x^2+a^2)}=\frac{A}{x}+\frac{Bx+C}{x^2+a^2}$ then $A=\frac{Q}{a^2},\ B=-A,\ C=P$.= coefficient of x in the numerator.
- If $\frac{Px+Q}{(x-a)(x^2+b^2)}=\frac{A}{x-a}+\frac{Bx+C}{x^2+b^2}$ then $A=\frac{Pa+Q}{a^2+b^2},\ B=-A,\ C=P-aA$.

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- $\dfrac{1}{(x^2+a^2)(x^2+b^2)}=\dfrac{1}{b^2-a^2}\left[\dfrac{1}{x^2+a^2}-\dfrac{1}{x^2+b^2}\right]$
- In a improper fraction if degree of numerator is equal to degree of denominator then $f(x)=\dfrac{\text{coefficient of highest degree of } x \text{ in numerator}}{\text{coefficient of highest degree of } x \text{ in denominator}}$.
- To get number of partial fractions if the repeated factor present in denominator then put $x-a=t$ and solve for t

  Eg.: $\dfrac{x^2-ax+b}{(x-c)^3}$, put $x-c=t\Rightarrow x=t+c$ then $\dfrac{x^2-ax+b}{(x-c)^3}=\dfrac{(t+c)^2-a(t+c)b}{t^3}$ and solve to get partial fractions.
- Every where but not there method

  Eg.: $\dfrac{2x-1}{(x-1)(x-2)(x-3)}=\dfrac{2.1-1}{(x-1)(1-2)(1-3)}+\dfrac{2.2-1}{(x-2)(2-1)(2-3)}+\dfrac{2.3-1}{(x-3)(3-1)(3-2)}$

  $=\dfrac{1}{2(x-1)}+\dfrac{-3}{x-2}+\dfrac{7}{2(x-3)}$

Class Work Problems

1. If $\dfrac{3x}{(x-6)(x+a)}=\dfrac{2}{x-6}+\dfrac{1}{x+a}$, then $a=$

   (a) 1 (b) 2 (c) 3 (d) 4

2. If $\dfrac{3x+a}{x^2-3x+2}=\dfrac{A}{x-2}-\dfrac{10}{x-1}$, then

   (a) $a=7, A=13$ (b) $a=-13, A=-7$

   (c) $A=-13, a=-7$ (d) $A=-13, a=7$

3. $\dfrac{x+1}{(x-1)(x-2)(x-3)}=$

   (a) $\dfrac{1}{x-1}+\dfrac{3}{x-2}+\dfrac{1}{x-3}$ (b) $-\dfrac{3}{x-1}+\dfrac{1}{x-2}+\dfrac{2}{x-3}$

   (c) $\dfrac{1}{x-1}-\dfrac{3}{x-2}+\dfrac{2}{x-3}$ (d) none of these

4. $\dfrac{9}{(x-1)(x+2)^2}$ is

   (a) $\dfrac{1}{x-1}-\dfrac{1}{x+2}-\dfrac{3}{(x+2)^2}$ (b) $\dfrac{1}{x-1}+\dfrac{1}{x+2}-\dfrac{3}{(x+2)^2}$

   (c) $\dfrac{1}{x-1}+\dfrac{1}{x+2}+\dfrac{3}{(x+2)^2}$ (d) none of these

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5. If $\frac{1}{(1-ax)(1-bx)}=\frac{A}{1-ax}+\frac{B}{1-bx}$, then $\frac{A}{(1-ax)^2(1-bx)}=$

(a) $\frac{A}{1-ax}+\frac{B}{(1-bx)^2}+\frac{AB}{(1-ax)(1-bx)}$ (b) $\frac{A}{(1-ax)^2}+\frac{AB}{1-ax}+\frac{B^2}{1-bx}$

(c) $\frac{A}{1-ax}+\frac{AB}{(1-ax)(1-bx)}$ (d) $\frac{A}{(1-ax)^2}+\frac{B}{1-bx}$

6. If $\frac{3x+4}{(x+1)^2(x-1)}=\frac{A}{x-1}+\frac{B}{x+1}+\frac{C}{(x+1)^2}$, then $A=$

(a) $-\frac{1}{2}$ (b) $\frac{15}{4}$ (c) $\frac{7}{4}$ (d) $-\frac{1}{4}$

7. If $\frac{1-x+6x^2}{x-x^3}=\frac{A}{x}+\frac{B}{1-x}+\frac{C}{1+x}$, then $A=$

(a) 1 (b) 2 (c) 3 (d) 4

8. Let a,b,c such that $\frac{1}{(1-x)(1-2x)(1-3x)}=\frac{a}{1-x}+\frac{b}{1-2x}+\frac{c}{1-3x}$, then $\frac{a}{1}+\frac{b}{3}+\frac{c}{5}=$

(a) $\frac{1}{15}$ (b) $\frac{1}{6}$ (c) $\frac{1}{5}$ (d) $\frac{1}{3}$

9. If $\frac{(1+x)(1+2x)(1+3x)}{(1-2x)(1-3x)(1-4x)}=Q+\frac{A}{1-2x}+\frac{B}{1-3x}+\frac{C}{1-4x}$, where $Q,A,B,C\in R$, then $Q=$

(a) $\frac{1}{4}$ (b) 4 (c) $-\frac{1}{4}$ (d) –4

10. $\frac{2x^2+3x+4}{(x-1)(x^2+2)}=$

(a) $\frac{3}{x-1}-\frac{x-2}{x^2+2}$ (b) $\frac{4}{x-1}-\frac{x-2}{x^2+2}$ (c) $\frac{1}{x-1}+\frac{x-2}{x^2+2}$ (d) none of these

11. If $\frac{x^2}{(x^2+a^2)(x^2+b^2)}=K\left(\frac{a^2}{x^2+a^2}-\frac{a^2}{x^2+b^2},\right)$ then $K=$

(a) a^2-b^2 (b) $\frac{1}{a+b}$ (c) $\frac{1}{a-b}$ (d) $\frac{1}{a^2-b^2}$

12. Remainder of $x^{64}+x^{27}+1$ divided by $x+1$ is

(a) 0 (b) 1 (c) 2 (d) 3

13. If $\frac{(x+1)^2}{x^3+x}=\frac{A}{x}+\frac{Bx+C}{x^2+1}$ then $A+B+C=$

(a) –4 (b) 2 (c) 4 (d) none of these

14. When resolved into partial fractions, $\frac{x^2+1}{x^4+x^2+1}=$

(a) $\frac{Ax+B}{x^2+x+1}+\frac{Cx+D}{x^2-x+1}$ (b) $\frac{Ax+B}{x^2+\sqrt{x}+1}+\frac{Cx+D}{x^2-\sqrt{x}+1}$

(c) $\frac{Ax+B}{x^2+\sqrt{x}+2}+\frac{Cx+D}{x^2-\sqrt{x}+2}$ (d) none of these

15. While resolving $\frac{3x^2-4x+5}{\left(x^2-x+1\right)^3}$, the number of partial fractions are

(a) 2 (b) 3 (c) 4 (d) none of these

16. If $\frac{x^3}{(x+1)^2(x+2)^2}=\frac{A_1}{x+1}+\frac{A_2}{(x+1)^2}+\frac{A_3}{x+2}+\frac{A_4}{(x+2)^2}$, then

(a) $A_2=-1, A_4=-8$ (b) $A_1+A_3=4$ (c) $A_2=1, A_4=8$ (d) none of these

Partial fractions (Class work answer)

1. c	2. a	3. c	4. a	5. b	6. c	7. a	8. a	9. c	10. a
11. d	12. b	13. d	14. a	15. b	16. a				

Logarithms

If a is a positive real number $\neq 1$ and $y=a^x$ then x is called the logarithm of y to the base a and is denoted by $x=\log_a y$.

Laws of logarithm

1. $\log_a uv=\log_a u+\log_a v$
2. $\log_a\left(\frac{u}{v}\right)=\log_a u-\log_a v$
3. $\log_a u^p = p\log_a u$
4. $\log_b u=\frac{\log_a u}{\log_a b}$ [change of base rule]
5. $\log_{a^p} u=\frac{1}{p}\log_a u$
6. $a^{\log_a u}=u$
7. The base of a logarithm must always be positive.
8. $\log_a 0$ is not defined and we take $\log_a 0=-\infty$ $\left(\because a^{-\infty}=0\right)$

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Since $a^0 = 1$, for all real numbers $a \neq 0$, $\log_a 1 = 0$. Thus logarithm of 1 to any base is zero.

Since $a^1 = a$, $\log_a a = 1$, i.e. logarithm of any number to the same base is equal to 1

Time saving results (Short cut methods)

- $\log_a b.\log_c a = \log_c b$
- $\log_b a = \dfrac{1}{\log_a b}$, $\log_a a^2 = 2$, $\log_{a^2} a = \dfrac{1}{2}$
- $\log_{b^p} a = \dfrac{1}{p}\log_b a$, $\log_{a^2}\left(a^p\right) = \dfrac{p}{2}$, $\log_{b^q} a^p = \dfrac{p}{q}\log_b a$
- If $\log y = m.(.............)$ then the number of digits is $(m+1)$.
- If $\log y = \bar{m}.(.............)$ then the number of zeros before the decimal in y is $(m+1)$.

Class Work Problems

1. If $\log_4 5 = a$ and $\log_5 6 = b$, then $\log_3 2$ is

   (a) $\dfrac{1}{2a+1}$ (b) $\dfrac{1}{2b+1}$ (c) $2ab+1$ (d) $\dfrac{1}{2ab-1}$

2. The value of $\log_3 4 \log_4 5 \log_5 6 \log_6 7 \log_7 8 \log_8 9$ is

   (a) 1 (b) 2 (c) 3 (d) 4

3. If $\log_e\left(\dfrac{a+b}{2}\right) = \dfrac{1}{2}\left(\log_e a + \log_e b\right)$, then relation between a and b will be

   (a) $a = b$ (b) $a = \dfrac{b}{2}$ (c) $2a = b$ (d) $a = \dfrac{b}{3}$

4. If $x = \log_a(bc)$, $y = \log_b(ca)$, $z = \log_c(ab)$, then which of the following is equal to 1?

   (a) $x+y+z$ (b) $(1+x)^{-1} + (1+y)^{-1} + (1+z)^{-1}$

   (c) xyz (d) none of these

5. The value of $3\log\dfrac{81}{80} + 5\log\dfrac{25}{24} + 7\log\dfrac{16}{15}$ is

   (a) $\log 2$ (b) $\log 3$ (c) 1 (d) 0

6. If $\dfrac{\log 3}{x-y} = \dfrac{\log 5}{y-z} = \dfrac{\log 7}{z-x}$, then $3^{x+y} \cdot 5^{y+z} \cdot 7^{z+x} =$

   (a) 0 (b) 2 (c) 1 (d) none of these

7. If x, y, z are three consecutive positive integers, then $\log(1+zx) =$

   (a) $\log y$ (b) $\log\dfrac{y}{2}$ (c) $\log(2y)$ (d) $2\log y$

8. **If** $4^{\log_9 3} + 9^{\log_2 4} = 10^{\log_x 83}$, then $x =$

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(a) 5 (b) $\frac{1}{10}$ (c) 10 (d) 25

9. If $\log_7\left(\log_5\left(\sqrt{x+5}+\sqrt{x}\right)\right)=0$, then the value of x is

(a) 3 (b) 5 (c) 1 (d) 4

10. The value of $\frac{1}{\log_2 10}+\frac{1}{\log_3 10}+\frac{1}{\log_5 10}+\frac{1}{\log_7 10}+\frac{1}{\log_{11} 10}$ is

(a) $\log_{10}(420)$ (b) $\log_{10}(2310)$ (c) $\log_{10}(11)$ (d) none of these

11. If $x\log 2 = y\log 4 = z\log 8$, then

(a) $x=6(y+z)$ (b) $6x=y+z$ (c) $5x=6(y+z)$ (d) $5(x+y)=6z$

12. If $\log 7 = 0\cdot 8451$, then number of digits in 7^{20} is

(a) 16 (b) 17 (c) 18 (d) 20

13. If $n=(1944)!$ then the sum $\frac{1}{\log_2 n}+\frac{1}{\log_3 n}+\frac{1}{\log_4 n}+\cdots+\frac{1}{\log_{1944} n}=$

(a) 0 (b) 1 (c) $\frac{1}{2}$ (d) 2

14. $81^{\left(\frac{1}{\log_5 3}\right)}+27^{(\log_9 36)}+3^{\left(\frac{4}{\log_7 9}\right)}=$

(a) 49 (b) 625 (c) 216 (d) 890

15. $(0\cdot 05)^{\log_{\sqrt{20}}(0\cdot1+0\cdot01+0\cdot001+\cdots)}=$

(a) 81 (b) $\frac{1}{81}$ (c) 20 (d) $\frac{1}{20}$

16. If $\log_{10}\log_2\log_3\left(\sqrt{x}+1\right)=0$, then $x=$

(a) 16 (b) 9 (c) 49 (d) 64

17. If $x=\log_{0\cdot1}(0\cdot 001), y=\log_9 81$, then $\sqrt{x-2\sqrt{y}}=$

(a) $3-2\sqrt{2}$ (b) $\sqrt{3}-2$ (c) $\sqrt{2}-1$ (d) $\sqrt{2}-2$

18. If $\log 2=a, \log 3=b, \log 7=c$ and $6^x=7^{x+4}$, then $x=$

(a) $\frac{4b}{b+a-c}$ (b) $\frac{4c}{a+b-c}$ (c) $\frac{4b}{c-a-b}$ (d) $\frac{4a}{a+b-c}$

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Logarithm Class work Answers

1. d	2. b	3. a	4. b	5. a	6. c	7. d	8. c	9. d	10. b
11. c	12. b	13. b	14. d	15. a	16. d	17. c	18. b		

Homework problems

1. If $\frac{3x+4}{x^2-3x+2}=\frac{A}{x-2}-\frac{B}{x-1},$ then (A,B)

   (a) $(7,10)$ (b) $(10,7)$ (c) $(10,-7)$ (d) $(-10,7)$

2. If $\frac{1}{(1-2x)(1+3x)}=\frac{A}{1-2x}+\frac{B}{1+3x},$ then $2B=$

   (a) A (b) $2A$ (c) $3A$ (d) $-3A$

3. If $\frac{x^2-4x-15}{(x+2)^3}=\frac{A}{x+2}+\frac{B}{(x+2)^2}+\frac{C}{(x+2)^3},$ then

   (a) $B=2(C-A)$ (b) $A-B+C=0$ (c) $A=B=2C$ (d) none of these

4. If $\frac{2x+3}{(x+2)^2(x+1)}=\frac{A}{x+1}+\frac{B}{x+2}+\frac{C}{(x+2)^2}$ then $A=$

   (a) -1 (b) 1 (c) 5 (d) -5

5. If $\frac{1}{x^2(x-1)}=\frac{A}{x}+\frac{B}{x^2}+\frac{C}{x-1},$ then

   (a) $A=-1$ (b) $B=1$ (c) $C=-1$ (d) none of these

6. If $\frac{1}{(1-ax)(1+x)}=\frac{A}{1-ax}+\frac{B}{1+x},$ then

   (a) $\frac{1}{(1-ax)^2(1+x)}=\frac{A^2}{(1-ax)^2}+\frac{AB}{(1-ax)}+\frac{B}{1+x}$

   (b) $\frac{1}{(1-ax)^2(1+x)}=\frac{A}{(1-ax)^2}+\frac{AB}{1-ax}+\frac{B^2}{1+x}$

   (c) $\frac{1}{(1-ax)^2(1+x)}=\frac{A^2}{(1-ax)^2}+\frac{A}{1-ax}+\frac{B^2}{1+x}$

   (d) none of these

7. If $\frac{x^2}{(x-a)(x-b)(x-c)}=\frac{P}{x-a}+\frac{Q}{x-b}+\frac{R}{x-c}$

   (a) $P=\frac{a^2}{(a-b)(a-c)}$ (b) $Q=\frac{b^2}{(b+a)(b+c)}$ (c) $R=\frac{c^2}{(c+a)(c+b)}$ (d) none of these

8. If $\dfrac{x}{(x^2+1)^2(x-1)}=\dfrac{Ax+B}{x^2+1}+\dfrac{Cx+D}{(x^2+1)^2}+\dfrac{E}{x-1}$, then $A=$

(a) $\frac{1}{4}$ (b) $-\frac{1}{3}$ (c) $-\frac{1}{4}$ (d) $-\frac{1}{5}$

9. If $\dfrac{2x+3}{(x^2+1)(x+1)}=\dfrac{Ax+B}{x^2+1}+\dfrac{C}{x+1}$, then $C=$

(a) $\frac{1}{2}$ (b) $-\frac{1}{2}$ (c) $\frac{1}{3}$ (d) $-\frac{1}{3}$

10. If $\dfrac{x^2+5}{(x^2+2)^2}=\dfrac{1}{x^2+2}+\dfrac{K}{(x^2+2)^2}$, then $K=$

(a) 1 (b) 2 (c) 3 (d) 4

11. If $\dfrac{1}{(x+a)(x^2+b^2)}=\dfrac{A}{x+a}+\dfrac{Bx+C}{x^2+b^2}$, then $\dfrac{1}{(x+a)(x^2+b^2)^2}=$

(a) $\dfrac{A^2}{x+a}+\dfrac{ABx+AC}{x^2+b^2}+\dfrac{Bx+C}{(x^2+b^2)^2}$ (b) $\dfrac{A^2}{x+a}+\dfrac{ABx}{x^2+b^2}+\dfrac{Bx+C}{(x^2+b^2)^2}$

(c) $\dfrac{A^2}{x+a}+\dfrac{AC}{x^2+b^2}+\dfrac{Bx+C}{(x^2+b^2)^2}$ (d) none of these

12. If $\dfrac{x^2}{(x^2+a^2)(x^2+b^2)}=\dfrac{Ax+B}{x^2+a^2}+\dfrac{Cx+D}{x^2+b^2}$ then (A,B) are

(a) $\left(\dfrac{a^2}{a^2-b^2},0\right)$ (b) $\left(\dfrac{b^2}{a^2-b^2},0\right)$ (c) $\left(\dfrac{a^2}{a^2+b^2},0\right)$ (d) $\left(\dfrac{b^2}{a^2+b^2},0\right)$

13. If $\dfrac{x^2+3}{(x^2+5)(x^2-7)(x^2+9)}=\dfrac{A}{x^2+5}+\dfrac{B}{x^2-7}+\dfrac{C}{x^2+9}$, then

(a) $A=\frac{1}{24}$ (b) $B=-\frac{5}{96}$ (c) $C=\frac{3}{32}$ (d) none of these

14. If $\dfrac{2x}{x^4+x^2+1}=\dfrac{A}{x^2-x+1}+\dfrac{B}{x^2+x+1}$ then $AB=$

(a) -1 (b) $\frac{1}{2}$ (c) 1 (d) 2

15. If $a=\log_{24}12$, $b=\log_{36}24$ and $c=\log_{48}36$, then $1+abc$ is equal to

(a) $2ab$ (b) $2ac$ (c) $2bc$ (d) 0

16. If $\log_7 2=m$, then $\log_{49}28$ is equal to

(a) $2(1+2m)$ (b) $\dfrac{1+2m}{2}$ (c) $\dfrac{2}{1+2m}$ (d) $1+m$

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17. If $\log_5 a \cdot \log_a x = 2$, then x is equal to

(a) 125 (b) a^2 (c) 25 (d) none of these

18. If $\frac{\log x}{a^2+ab+b^2} = \frac{\log y}{b^2+bc+c^2} = \frac{\log z}{c^2+ac+a^2}$ then $x^{a-b} \cdot y^{b-c} \cdot z^{c-a} =$

(a) 0 (b) -1 (c) 1 (d) 2

19. If $\log 2 + \frac{1}{2}\log a + \frac{1}{2}\log b = \log(a+b)$, then

(a) $a = b$ (b) $a = -b$ (c) $a = 2, b = 0$ (d) $a = 10, b = 1$

20. If $\log_4 2 + \log_4 4 + \log_4 16 + \log_4 x = 6$, then $x =$

(a) 4 (b) 64 (c) 32 (d) 8

21. If $\frac{1}{\log_a x} + \frac{1}{\log_b x} + \frac{1}{\log_c x} = 0$, then $abc =$

(a) -1 (b) 1 (c) 2 (d) none of these

22. The value of $\log_y x^2 \cdot \log_z y^3 \cdot \log_x z^4$ is

(a) 1 (b) 12 (c) 24 (d) none of these

23. $\log\left(\frac{x}{x+1}\right) + \log\left(\frac{x+1}{x+2}\right) + \log\left(\frac{x+2}{x+3}\right) \cdots$ to n terms=

(a) $\log(x+n)$ (b) $\log\left(\frac{x}{x+n}\right)$ (c) $\log\left(\frac{x+n}{x}\right)$ (d) none of these

24. If $\log_{30} 3 = a, \log_{30} 5 = b$, then $\log_{30} 8 =$

(a) $3(1-a-b)$ (b) $3(1+a+b)$ (c) $3(-a+b)$ (d) $a+b$

25. $\frac{\log_a x \times \log_b x}{\log_a x + \log_b x} =$

(a) $\log_b a$ (b) $\log_a x$ (c) $\log_{ab} x$ (d) $\log_x(ab)$

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26. $\log 5 = 0\cdot 6990$, the number of zeros between the decimal point and the first significant figure in $(0\cdot 5)^{50}$ is

(a) 14 (b) 15 (c) 16 (d) 17

27. $\log_3 5 \cdot \log_{25} 27 =$

(a) $\frac{2}{3}$ (b) $\frac{3}{2}$ (c) $-\frac{3}{2}$ (d) $-\frac{2}{3}$

28. $\sqrt{(\log_{0\cdot 5} 4)^2} =$

(a) -2 (b) $\sqrt{-4}$ (c) 2 (d) none of these

29. If $\log_4(\log_3 x) = \frac{1}{2}$ then $x =$

(a) 9 (b) 6 (c) 4 (d) 2

30. If $\log_9 x + \log_3 x = 6$ then $x =$

(a) 81 (b) 9 (c) 3 (d) 27

Home Work Answer keys

1. b	2. c	3. a	4. b	5. a	6. b	7. a	8. c	9. a	10. c
11. a	12. a	13. a	14. a	15. c	16. b	17. c	18. c	19. a	20. c
21. b	22. c	23. b	24. a	25. c	26. b	27. b	28. a	29. a	30. a