



## **Global Mental Math Olympiad 2023**

### **Referral Notes**

#### **Grand Master (12 years and Above)**

- Mental Addition
- Mental Subtraction
- Exponents
- Prime Factorization
- Profit & Loss
- Mental Multiplication
- Mental Division
- Simple Ratios

- Average/ Mean
- HCF
- LCM
- Squaring Numbers
- Cubing Numbers
- Cube Roots
- Square Roots
- Percentage

#### **To prepare for Global Mental Math Olympiad 2023:**

- **Grandmaster Category:** Practice Rounds 1 to 8 on the App.

**Good luck with your training!**

**To gain a better understanding of the types of problems topic wise and their difficulty levels, please refer to the Sample Question Bank provided. They offer a comprehensive overview of the various types of problems and the degree of complexity involved.**

**NOTE - Please note that the referral material provided is intended only as a reference. If your child is currently following a specific method, we recommend that you continue with that approach.**

**These resources are intended to support children who may be unfamiliar with certain mental math topics and are seeking additional assistance.**



## Mental Additions Methods

Sometimes, we find it difficult to add numbers which end in 6, 7, 8 and 9. For example, if we have  $16+9$ , that's a difficult problem to do mentally.

But we can make it easy. We can use a method called by addition and by subtraction'.

### Method 1

Let us try  $16 + 9$ .

Since adding 9 directly is difficult for most of us, we add 10 which is easy to do mentally. So, since 9 is 1 less than 10, we can add 10 and then subtract 1 from our answer. Our sum looks like this:

We do:

- 1)  $16 + 10 = 26$
- 2)  $26 - 1 = 25$  is our answer.

Here, we would like to draw your attention to the method which is called 'by addition and by subtraction'. So, we add first and then subtract.

Let's take another example. Say, we have:

$$68 + 9$$

We do

$$68 + 10 = 78.$$

$$78 - 1 = 77 \text{ our answer.}$$

Now, let's try another example on our own.

$$59 + 8$$

$$\text{We do: } 59 + 10 = 69$$

Since 8 is 2 less than 10, we do:

$$69 - 2 = 67.$$

The answer is 67.

Now can you tell us what happens if one of the numbers Method being added was closer to 20?



Say, we have  $116 + 18$

So, to add 18, we add 20 and then subtract the 2.

So, we do:

$$116 + 20 = 136$$

$$136 - 2 = 134. \text{ This is our answer.}$$

### **Now let's try addition with a larger number $139 + 69$**

Here, to add 69, we add 70 and then subtract 1 from the total

$$139 + 70 = 209$$

$$209 - 1 = 208 \text{ our answer.}$$

Let's try another problem.

$$166 + 88$$

To add 88, we added 90 and then subtract 2.

$$166 + 90 = 256$$

$$256 - 2 = 254 \text{ was the answer.}$$

### **ACTIVITY 1**

Find the Sum									
1	27	2	59	3	29	4	57	5	19
	+5		+6		+9		+7		+7
Ans		Ans		Ans		Ans		Ans	
6	229	7	964	8	315	9	428	10	886
	+88		+96		+99		+89		+85
Ans		Ans		Ans		Ans		Ans	



## Method 2

### Left to Right Mental Addition

This method is called Left to Right Mental Addition Method. So far traditionally in Maths, we have been doing additions and other operations from Right to Left.

However, we can also do mental addition effectively from Left to Right.

Say for example we have

$$\begin{array}{r} 88 \\ + 34 \\ \hline \end{array}$$

**Step 1,** we first add the figures in the left column.

So  $8 + 3 = 11$  (We keep this figure in our head)

$$\begin{array}{r} 88 \\ + 34 \\ \hline 11, \end{array}$$

**Step 2,** we now add the figures in the Right Hand Column

$8 + 4 = 12$  (we keep this in our head too)

The sum now looks like this:

$$\begin{array}{r} 88 \\ + 34 \\ \hline 11, 12 \end{array}$$

**Step 3,** in the final step we add the middle digits

$$\begin{array}{r} 88 \\ + 34 \\ \hline 11, 12 \\ \hline 122 \end{array}$$

So, the answer is 122



**In our next example let's try adding two 3 digit numbers**

Add  $482 + 859$

$$\begin{array}{r} 482 \\ +859 \\ \hline \end{array}$$

**Step 1:**

Start by adding the column left to right.

The first column is  $4 + 8 = 12$

The Middle Column is  $8 + 5 = 13$

$$\begin{array}{r} 482 \\ +859 \\ \hline 12,13 \end{array}$$

**Step 2:**

We add the middle digit of the first 2 columns.

So we have 133 in our head.

Then we add the last column on the right

So we have  $2 + 9 = 11$

$$\begin{array}{r} 482 \\ +859 \\ \hline 133,11 \end{array}$$

**Step 3:**

So, in our mind we have 133,11

We then add the digits on either side of the comma.

In this case, we add 3 and 1 and we get 4.

So our final answer is 1341

$$\begin{array}{r} 482 \\ +859 \\ \hline 1341 \end{array}$$

Find the Sum									
1	47	2	85	3	47	4	64	5	245
	+88		+16		+29		+47		+257
Ans		Ans		Ans		Ans		Ans	
6	239	7	864	8	818	9	2,428	10	5,886
	+188		+596		+399		+1,899		+2,285
Ans		Ans		Ans		Ans		Ans	



## Mental Subtractions

Sometimes it becomes difficult to subtract numbers like 6, 7, 8, 9 from numbers ending in 1, 2, 3, 4, 5. This new method provides us with a different view and simpler approach, just like we saw in addition.

Say, we have  $42 - 9$

We subtract 10 first (as it is easy to take away 10) and then add back 1 (since 9 is 1 less than 10).

$$42 - 10 = 32$$

So,  $32 + 1 = 33$ . This is the answer.

Let us take another example:

$$81 - 8$$

So, we subtract 10 first (as it is easy to add back 2 (since 8 is 2 less than 10).

$$81 - 10 = 71$$

So,  $71 + 2 = 73$  is the answer

Now let's try one with a slight variation!

$$43 - 17$$

So, we subtract 20 first (as it is easy to take away 20) and then add back 3 (since 17 is 3 less than 20).

$$43 - 20 = 23$$

So,  $23 + 3 = 26$  is the answer.

Let's try another variation  $272 - 28$

Here, we will first subtract 30 and then add 2.

$$272 - 30 = 242$$

So,  $242 + 2 = 244$  is the answer.

Find the Difference									
1	77	2	56	3	28	4	54	5	17
	-9		-7		-9		-7		-9
Ans		Ans		Ans		Ans		Ans	
6	122	7	464	8	315	9	826	10	886
	-69		-96		-49		-87		-88
Ans		Ans		Ans		Ans		Ans	



## Introduction to Exponents

The exponent of a number says how many times to use that number in a multiplication.

It is written as a small number to the right and above the base number.

Exponential expression has two components i.e. Base and Exponent.

Other names for exponent are index or power

$8^2$  → Exponent (Power/Index)

↓  
Base

Here's another example: the base is 4, and the exponent is 3

$$4^3$$

An exponent tells us to multiply the base by itself that number of times. In our example, we will multiply the base of 4 by itself 3 times:

$$4^3 = 4 \times 4 \times 4$$

Once we write out the multiplication problem, we can easily evaluate the expression. Let's do this for the example we've been working with

$$4^3 = 4 \times 4 \times 4$$

$$= 16 \times 4$$

$$= 64$$

Another example:  $9^2 = 9 \times 9 = 81$

(The exponent "2" says to use the 9 two times in a multiplication.)

Another example:  $5^3 = 5 \times 5 \times 5 = 125$

(The exponent "3" says to use the 5 three times in a multiplication.)



## Prime Factorization

Some numbers *only have two divisors*: 1 and the number itself. Such numbers are called **prime numbers**. 11 is one of them.

factor	factor	product
1	× 11	= 11

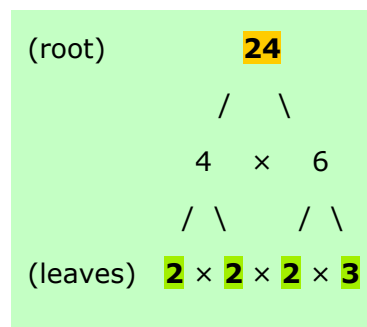
The prime numbers less than 30 are **2, 3, 5, 7, 11, 13, 17, 19, 23, and 29**. One is usually not counted as a prime number.

### Prime factorization using a factor tree

A *factor tree* is a handy way to factor numbers to their prime factors. The factor tree starts at the root and grows upside down!

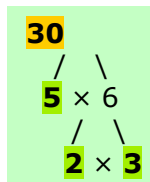
We want to factor 24 so we write 24 on top. First, 24 is factored into  $4 \times 6$ . However, 4 and 6 are not primes, so we can *continue* factoring. Four is factored into  $2 \times 2$  and six is factored into  $2 \times 3$ .

We will not factor 2 or 3 any further because they are prime numbers.

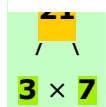


Once you get to the primes in your "tree", they are the "leaves", and you stop factoring in that "branch". So  $24 = 2 \times 2 \times 2 \times 3$ . This is the **prime factorization of 24**.

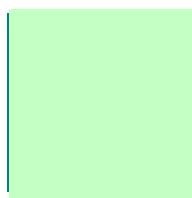
Examples:



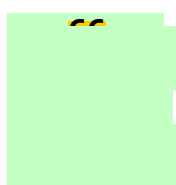
5 is a prime number—it is a "leaf". Once done, "pick the leaves"—you can even circle them to see them better! So,  $30 = 2 \times 3 \times 5$ .



Both 3 and 7 are prime numbers, so we cannot factor them any further. So  $21 = 3 \times 7$ .



OR

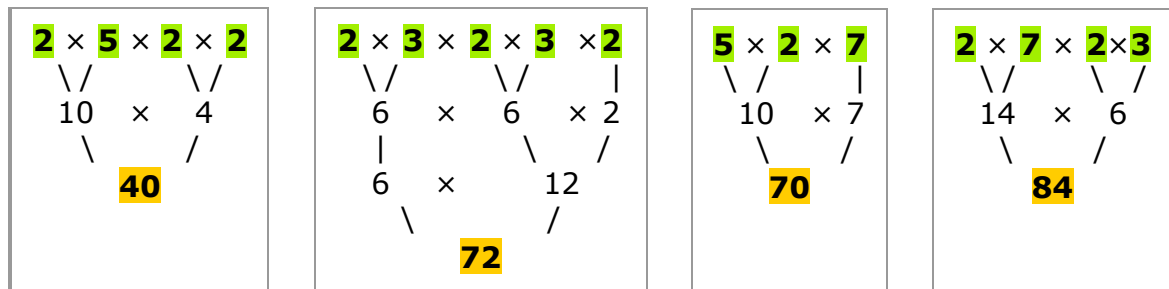


You can start the factoring process any way you want. The end result is the same:  $66 = 2 \times 3 \times 11$ .



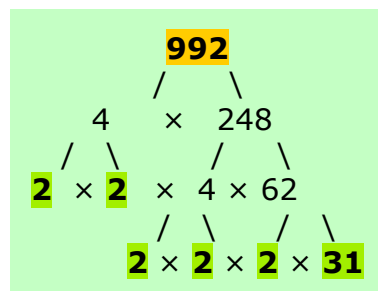


Prime numbers are like building blocks of all numbers. They are the first and foremost, and other numbers are "built" from them. "Building numbers" is like factoring backwards. We start with the building blocks—the primes—and see what number we get:



By using the process above (building numbers starting from primes) you can build ANY whole number there is! Can you believe that?

We can say this in another way: **ALL numbers** can be factored so the factors are prime numbers. That is sort of amazing! This fact is known as the *fundamental theorem of arithmetic*. Indeed, it is fundamental.



So, no matter what the number is—992 or 83,283 or 150,282—it can be written as a product of primes.

See 992 factored on the right.  $992 = 2 \times 2 \times 2 \times 2 \times 2 \times 31$ . For 83,283 we get  $3 \times 17 \times 23 \times 71$ , and  $151,282 = 2 \times 3 \times 3 \times 3 \times 11 \times 11 \times 23$ .

To find these factorizations, you need to test-divide the numbers by various primes so it is a bit tedious. Of course, computers can do the divisions very quickly



## Profit and Loss

**Cost Price:** The amount paid to purchase an article or the price at which an article is made, is known as its cost price. The cost price is abbreviated as C. P.

**Selling Price:** The price at which article is sold, is known as its selling price. The selling price is abbreviated as S. P

**Profit:** If the selling price (S.P.) of an article is greater than the cost price (C.P.), then the difference between the selling price and cost price is called profit.

Thus, If  $S. P. > C.P.$ , then

$$\text{Profit} = S. P. - C. P.$$

$$\Rightarrow S. P. = C. P. + \text{Profit}$$

$$\Rightarrow C. P. = S. P. - \text{Profit}.$$

Example:

An article was brought for Rs 75 and sold for Rs 95 Find the gain or loss.

Solution:

CP of the article = 75

SP of the article = 95

Since  $SP > CP$ , so there is a profit

$$\text{Profit} = SP - CP$$

$$\text{Profit} = 95 - 75 = 20$$

So Profit is Rs 20

**Loss:** If the selling price (S.P.) of an article is less than the cost price (C.P.), then the difference between the cost price (C.P.) and the selling price (S.P.) is called loss.

Thus if  $S.P. < C.P.$ , then

$$\text{Loss} = C.P. - S.P.$$

$$\Rightarrow C. P. = S. P. + \text{Loss}$$

$$\Rightarrow S. P. = C. P. - \text{Loss}$$

Example:

An article was brought for Rs 50 and sold for Rs 40 Find the gain or loss.

Solution:

CP of the article = 50

SP of the article = 40

Since  $SP < CP$ , so there is a Loss

$$\text{Loss} = CP - SP$$

$$\text{Loss} = 50 - 40 = 10$$

So Loss is Rs 10



## Multiplication (2 – Digit Number by a 1 – Digit Number)

To do Mental Multiplications of 2 digit numbers and higher, one needs to know tables of 2-9 by heart

Any multiplication has two parts **multiplicand** and **multiplier**. The multiplicand is the number to which we multiply and multiplier is the numbers by which we multiply.

There are several mental math techniques to multiply a 2-digit number by a 1-digit number. We suggest the best one here

### The Split and Multiply Technique:

Step 1: Split the 2-digit number into its tens and units digits.

Step 2: Multiply the 1-digit number by both the tens and units digits separately.

Step 3: Combine the results to get the final answer.

### Let's take a couple of examples to illustrate:

#### Example 1: $68 \times 5$

Step 1: Split 68 into 60 (tens) and 8 (units).

Step 2: Multiply 5 by both the tens and units digits separately.

$$5 \times 60 = 300$$

$$5 \times 8 = 40$$

Step 3: Add the results:  $300 + 40 = 340$

So,  $68 \times 5 = 340$ .

#### Example 2: $89 \times 4$

Step 1: Split 89 into 80 (tens) and 9 (units).

Step 2: Multiply 4 by both the tens and units digits separately.

$$4 \times 80 = 320$$

$$4 \times 9 = 36$$

Step 3: Add the results:  $320 + 36 = 356$

So,  $89 \times 4 = 356$ .



**LIVE**  
**MATH**  
**COMPETITIONS**  
**AND**  
**LEAGUE**

1	77	2	56	3	28	4	54	5	17
	x5		x7		x9		x4		x6
	70 x 5 = 350								
	7 x 5 = 35								
	350 + 35								
Ans	385	Ans		Ans		Ans		Ans	



## Multiplication (3 – Digit Number by a 1 – Digit Number)

There are several mental math techniques to multiply a 3-digit number by a 1-digit number. We suggest the best one here

### The Split and Multiply Technique:

Step 1: Split the 3-digit number into its Hundreds, tens and units digits.

Step 2: Multiply the 1-digit number by each of the digits(hundreds, tens, and units digits) separately.

Step 3: Combine the results to get the final answer.

### Let's take a couple of examples to illustrate:

#### Example 1: $680 \times 5$

Step 1: Split 680 into 600 (hundreds), 80 (tens) and 0 (units)

Step 2: Multiply 5 by each of the components (600,80 and 0)

$$5 \times 600 = 3000$$

$$5 \times 80 = 400$$

$$5 \times 0 = 0$$

Step 3: Add the results:  $3000 + 400 + 0 = 3400$

So,  $680 \times 5 = 3400$ .

#### Example: $456 \times 7$

Step 1: Split 456 into 400 (hundreds), 50 (tens), and 6 (units).

Step 2: Multiply 7 by each of the components (400, 50, and 6).

Step 3:

$$7 \times 400 = 2800,$$

$$7 \times 50 = 350,$$

$$7 \times 6 = 42,$$

Step 31: Add the results:  $2800 + 350 + 42 = 3192$ .

So,  $456 \times 7 = 3192$ .

Find the Product									
1	770	2	262	3	281	4	355	5	127
	$\times 5$		$\times 4$		$\times 9$		$\times 2$		$\times 6$
	$700 \times 5 = 3500$								
	$70 \times 5 = 350$								
	$0 \times 5 = 0$								
	$3500 + 350$								
Ans	3850	Ans		Ans		Ans		Ans	



### **Multiplication of Two Digit Multiplicand by Two Digit Multiplier**

Step 1: The right hand digit of multiplicand is multiplied by right hand digit of multiplier.

Step 2: Apply inside-outside principle (plus carry).

Step 3: The left hand digit of multiplicand is multiplied by left hand digit of multiplier (plus carry).

Example: Multiply 46 by 27.

$$\underline{46 \times 27}$$

**Step 1: Right hand digit 6 of multiplicand 46 is multiplied by right hand digit 7 of multiplier 27**

$6 \times 7 = 42$ ; write 2. Carry over 4

$$\begin{array}{r} 46 \times 27 \\ 2 \end{array}$$

**Step 2: Apply inside-out principle**  
 **$[(6 \times 2) + (4 \times 7) = 12 + 28 = 40$  Plus carry over. (4)**

$40 + 4 = 44$ ; write 4 and carry over 4

$$\begin{array}{r} 46 \times 27 \\ 42 \end{array}$$

**Step 3: Left hand digit 4 of multiplicand 46 is multiplied by left hand digit 2 of multiplier 27**

$4 \times 2 = 8$

Plus carry of the previous step. (4)

$8 + 4 = 12$ ; write 12

$$\begin{array}{r} 46 \times 27 \\ 1242 \end{array}$$

**The answer is 1242**

### **Exercise**

1. Multiply 43 by 36.
2. Multiply 78 by 31.
3. Multiply 98 by 77.



## Division

Dealing with multiplication of fairly considerable length, we now move to division in comparison to multiplication is considered tough, yet the truth is that division is as simple as multiplication and faster

### Naming the Parts of a Division

A division has four parts which are called **divisor, dividend, quotient and remainder**. The following rhyme will help you to remember the parts of division

"The divisor is the number that divides the dividend, the answer is the quotient, the remainders at the end."

Example : Divide 2862 by 4.

$$2862 \div 4 = 715 + 2$$

In the example the divisor is 4. because it divides the dividend 2862. The quotient is 715 (which is the result of division) and the remainder is 2 (because it is that which remains)

Consider this also

The divisor is the number that divides.

The dividend is the number that is being divided.

The quotient is the result of division

The remainder is that remains after division

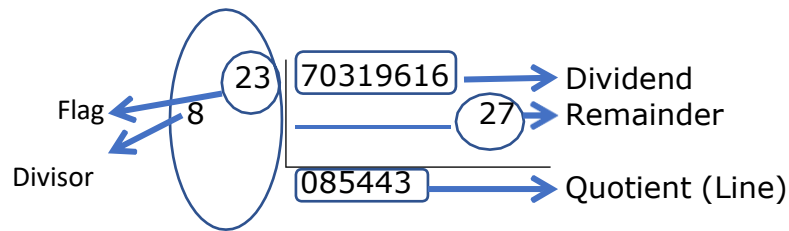
and also the remainder is always less than the divisor.

Example: Divide 70319616 by 823. Here 70319616 is dividend and 823 is divisor. On dividing

70319616 (dividend) by 823 (divisor) one gets 85443 as quotient and 27 as remainder. This can be written as

$$70319616 \div 823 = 85443 \text{ remainder } 27$$





Above we have written divisor 823 as 823 where 23 is called a flag. Note here 23 is not the power of 8. We will see later in this chapter the use of flag.

**In respective of multiplication in division we make computations dividend from left to right.**

In division we make computation with dividend from left to right

e.g., in dividing 123 by 6.

Here 123 is dividend and 6 is divisor.

In dividend we consider 1 first, then 2 and afterward 3 (from left to right digit 3).



## Division by Single Digit Divisor

### Divide remainder and successive digit (from left or right) divisor

**Example:** Divide 8396 by 6.

Divide remainder and successive digit (from left to right) by divisor.

- Since there is no remainder, divide 8 by divisor 6;  
 $8 \div 6 = 1$  remainder 2.

$$\begin{array}{r} 6 \overline{) 8396} \end{array}$$

- Divide 23 (remainder 2, successive digit 3) by divisor 6;  
 $23 \div 6 = 3$  remainder 5.

$$\begin{array}{r} 6 \overline{) 8396} \\ \underline{2} \phantom{00} \\ 1 \phantom{00} \end{array}$$

- Divide 59 (remainder 5, successive digit 9) by divisor 6
- $59 \div 6 = 9$  remainder 5.

$$\begin{array}{r} 6 \overline{) 8396} \\ \underline{25} \phantom{00} \\ 13 \phantom{00} \end{array}$$

- Divide 56 (remainder 5. Successive digit 6) by divisor 6;
- $56 \div 6 = 9$  remainder 2

$$\begin{array}{r} 6 \overline{) 8396} \\ \underline{255} \phantom{00} \\ 139 \phantom{00} \end{array}$$

$$\begin{array}{r} 6 \overline{) 8396} \\ \underline{2552} \phantom{00} \\ 1399 \phantom{00} \end{array}$$

**The answer is 1399 remainder 2.**

### Exercise

Divide, leaving whole number remainders

- |                     |                  |
|---------------------|------------------|
| 1. Divide 454 by 3  | Ans. 151 rem. 1  |
| 2. Divide 4112 by 3 | Ans: 1370 rem. 2 |
| 3. Divide 6599 by 6 | Ans. 1099 rem. 5 |
| 4. Divide 7455 by 6 | Ans. 1242 rem. 3 |



## Division by Two Digit Divisor

**Step 1:** Divide first digit of dividend by first digit of divisor Check: (Remainder and successive digit of dividend - (Flag x Quotient)

= Negative numbers choose quotient that make this positive

**Step 2:** Divide it by first digit of divisor.

Check: (Remainder and successive digit of dividend) - (Flag x Quotient)

= Negative numbers choose quotient that make this positive

**Step 3:** (Remainder and last digit of dividend) - (Flag x Quotient) = Remainder of division

**Example:** Divide 9137 by 43

$$\begin{array}{r} 3 \overline{) 9137} \\ 4 \phantom{00} \\ \hline 3 \phantom{00} 9137 \\ 4 \phantom{00} 1 \phantom{00} \\ \hline 2 \phantom{00} \end{array}$$

**Step 1:**  $9 \div 4 = 2$  remainder 1.

Check:  $11 - (3 \times 2) = 11 - 6$

= 5

**Step 2:**

- $11 - (3 \times 2) = 11 - 6 = 5$ ;
- 

$5 \div 4 = 1$  remainder 1.

**Check:**  $13 - (3 \times 1) = 13 - 3 = 10$

- $13 - (3 \times 1) = 13 - 3 = 10$ ;
- $10 \div 4 = 2$  remainder 2.

**Check:**  $27 - (3 \times 2) = 27 - 6 = 21$

$$\begin{array}{r} 3 \overline{) 9137} \\ 4 \phantom{00} \\ \hline 3 \phantom{00} 9137 \\ 4 \phantom{00} 11 \phantom{00} \\ \hline 2 \phantom{00} \end{array}$$

$$\begin{array}{r} 3 \overline{) 9137} \\ 4 \phantom{00} \\ \hline 3 \phantom{00} 9137 \\ 4 \phantom{00} 112 \phantom{00} \\ \hline 212 \phantom{00} \end{array}$$

**Step 3:**  $27 - (3 \times 2) = 27 - 6 = 21$ .

$$\begin{array}{r} 3 \overline{) 9137} \\ 4 \phantom{00} \\ \hline 3 \phantom{00} 9137 \\ 4 \phantom{00} 112 \phantom{00} \\ \hline 212 \phantom{00} 21 \end{array}$$

**The answer is 212 remainder 21.**



**Example:** Divide 38982 by 73

**Step 1:**  $3 \div 7 = 0$  remainder 3.

Check:  $38 - (3 \times 0) = 38 - 0$   
 $= 38$

**Step 2:**

- $38 - (3 \times 0) = 38 - 6 = 38$ ;  
 $38 \div 7 = 5$  remainder 3.  
**Check :**  $39 - (3 \times 5) = 39 - 15 = 24$
- $39 - (3 \times 5) = 39 - 15 = 24$ ;  
 $24 \div 7 = 3$  remainder 3.  
**Check:**  $38 - (3 \times 3) = 38 - 9 = 29$
- $38 - (3 \times 3) = 38 - 9 = 29$ ;  
 $29 \div 7 = 4$  remainder 1.  
**Check:**  $12 - (3 \times 4) = 12 - 12 = 0$

**Step 3:**  $12 - (3 \times 4) = 12 - 12 = 0$ .

**The answer is 534 remainder 0.**

$$\begin{array}{r} 3 \\ 7 \overline{) 38982} \\ \hline 38 \\ \underline{0} \phantom{00} \\ 38 \\ \underline{0} \phantom{00} \\ 98 \\ \underline{0} \phantom{00} \\ 98 \\ \underline{0} \phantom{00} \\ 2 \end{array}$$

$$\begin{array}{r} 3 \\ 7 \overline{) 38982} \\ \hline 38 \\ \underline{0} \phantom{00} \\ 38 \\ \underline{0} \phantom{00} \\ 98 \\ \underline{0} \phantom{00} \\ 98 \\ \underline{0} \phantom{00} \\ 2 \end{array}$$

$$\begin{array}{r} 3 \\ 7 \overline{) 38982} \\ \hline 38 \\ \underline{0} \phantom{00} \\ 38 \\ \underline{0} \phantom{00} \\ 98 \\ \underline{0} \phantom{00} \\ 98 \\ \underline{0} \phantom{00} \\ 2 \end{array}$$

$$\begin{array}{r} 3 \\ 7 \overline{) 38982} \\ \hline 38 \\ \underline{0} \phantom{00} \\ 38 \\ \underline{0} \phantom{00} \\ 98 \\ \underline{0} \phantom{00} \\ 98 \\ \underline{0} \phantom{00} \\ 2 \end{array}$$

$$\begin{array}{r} 3 \\ 7 \overline{) 38982} \\ \hline 38 \\ \underline{0} \phantom{00} \\ 38 \\ \underline{0} \phantom{00} \\ 98 \\ \underline{0} \phantom{00} \\ 98 \\ \underline{0} \phantom{00} \\ 2 \end{array}$$



**Exercise (Find Quotient and Remainder)**

1. Divide 7543 by 43
2. Divide 5534 by 86
3. Divide 8188 by 94
4. Divide 4524 by 51
5. Divide 8786 by 86



## Simplifying Ratios

Many ratios can be written with smaller numbers. This is called writing ratios in their simplest form, or simplifying ratios.

Simplifying ratios makes them easier to work with.

Note: To simplify ratios you can use the same technique that is used to simplify fractions.

As the two examples below show, you simplify ratios by dividing the number on each side by their greatest common factor.

### Simplify 15 : 9

Ratio	15 : 9
Factors of 15	1 , 3 , 5 , 15
Factors of 9	1 , 3 , 9
Greatest Common Factor (G.C.F)	3
Divide both by G.C.F	$15 \div 3 = 5$ $9 \div 3 = 3$
Ratio in simplest form	5 : 3

### Simplify 6 : 30

Ratio	6 : 30
Factors of 6	1,2,3,6
Factors of 30	1,2,3,5,6,10,15
Greatest Common Factor (G.C.F)	6
Divide both by G.C.F	$6 \div 6 = 1$ $30 \div 6 = 5$
Ratio in simplest form	1 : 5



## Average & Mean

The formula for calculating Average and mean are the same,

The most widely used method of calculating an average is the 'mean'.

Mean is a point in a data set which is the average of all the data point we have in a set. It is basically arithmetic average of the data set and can be calculated by taking a sum of all the data points and then dividing it by the number of data points we have in data set.

$$\text{Mean} = \frac{\text{Sum of all Data Points}}{\text{Number of Data Points}}$$

### Example

1) Find Mean of 25,20,15,10

#### Step1

Add all the numbers up. i.e.  $25+20+15+12=70$

#### Step 2

Count the number of data points. Here there are 4 numbers given i.e. 25,20,15,12

#### Step 3

We divide the sum of the numbers with the number of data points. So,  $72/4=18$ .  
18 is the Mean of 25,20,15,12

### Practice Example's

1. Find the Mean of 15,12,3,10
2. Find the Mean of 8,12,5,7
3. Find the Average of 25,35,20,12
4. Find the Average of 18,22,17,13



## HCF & LCM

**Factors and Multiples:** All the numbers that divide a number completely, i.e., without leaving any remainder, are called factors of that number.

For example,

24 is completely divisible by 1, 2, 3, 4, 6, 8, 12, 24. Each of these numbers is called a factor of 24 and 24 is called a multiple of each of these numbers.

### How to find HCF orally:

HCF stands for Highest Common Factor, which is also known as GCD or Greatest Common Divisor. It is the highest number that divides two or more numbers exactly without leaving a remainder. HCF is an important concept in mathematics, and it is used in various applications like simplification of fractions, finding the smallest common denominator, etc.

There are three methods for finding HCF: Prime Factorization Method, Subtraction Method, and Division Method. Each of these methods is useful in different situations.

### Prime Factorization Method:

This method involves finding the prime factors of the given numbers and then identifying the common prime factors. The product of these common prime factors gives us the HCF of the given numbers.

Example: Find the HCF of 24 and 36 using Prime Factorization Method.

Step 1: Find the prime factors of 24 and 36.

$$24 = 2 \times 2 \times 2 \times 3$$

$$36 = 2 \times 2 \times 3 \times 3$$

Step 2: Identify the common prime factors of 24 and 36.

$$2 \times 2 \times 3 = 12$$

Step 3: The product of common prime factors, 12, is the HCF of 24 and 36.





### **Subtraction Method:**

This method involves repeatedly subtracting the smaller number from the larger number until both the numbers become equal. The last number obtained before the numbers become equal is the HCF of the given numbers.

Example: Find the HCF of 48 and 60 using Subtraction Method.

Step 1: Start by subtracting the smaller number from the larger number.

$$60 - 48 = 12$$

Step 2: Repeat the process by subtracting the smaller number (12) from the larger number (48).

$$48 - 12 = 36$$

Step 3: Again, subtract the smaller number (12) from the larger number (36).

$$36 - 12 = 24$$

Step 4: Continue the process until both numbers become equal.

$$24 - 12 = 12$$

$$12 - 12 = 0$$

Step 5: The last non-zero number obtained, 12, is the HCF of 48 and 60.

### **Division Method:**

This method involves dividing the larger number by the smaller number and finding the remainder. Then divide the smaller number by the remainder and find the new remainder. Continue the process until the remainder is zero. The last non-zero remainder obtained is the HCF of the given numbers.

Example: Find the HCF of 72 and 90 using Division Method.

Step 1: Divide the larger number (90) by the smaller number (72) and find the remainder.

$$90 \div 72 = 1 \text{ with remainder } 18$$

Step 2: Divide the smaller number (72) by the remainder (18) and find the new remainder.

$$72 \div 18 = 4 \text{ with remainder } 0$$

Step 3: The last non-zero remainder obtained, 18, is the HCF of 72 and 90.



### **When to use each method:**

**Prime Factorization Method:** This method is best used when the numbers are small and have small prime factors. It is also useful when we need to find the HCF of more than two numbers.

**Subtraction Method:** This method is best used when the difference between the given numbers is small. It is also useful when we need to find the HCF of two numbers.

**Division Method:** This method is best used when the numbers are large and have no common prime factors. It is also useful when we need to find the HCF of two numbers.

**By using all three methods, we can verify our answers and get a better understanding of the concepts involved.**

### **Exercise:**

1. Find the HCF of 30 and 45 using prime factorization method.
2. Find the HCF of 18 and 24 using the subtraction method.
3. Find the HCF of 36 and 48 using the division method.
4. Find the HCF of 72, 90 and 126 using the prime factorization method.
5. Find the HCF of 120 and 150 using the subtraction method.

### **How to find LCM orally**

LCM stands for Least Common Multiple, which is the smallest number that is a multiple of two or more given numbers. It is an important concept in mathematics and is used in various fields such as arithmetic, algebra, and number theory.

**Methods of Identifying LCM:**

There are two main methods to identify the LCM of given numbers: the prime factorization method and the addition method.



### **Prime Factorization Method:**

In the prime factorization method, we find the prime factors of each given number and then multiply them together. To do this, we follow the steps below:

Step 1: Write the given numbers as a product of their prime factors. Step 2: Identify the common prime factors. Step 3: Multiply the common prime factors together. Step 4: Multiply any remaining prime factors together. Step 5: The product obtained in step 3 and step 4 is the LCM of the given numbers.

Example: Find the LCM of 12 and 18 using the prime factorization method.

#### **Step 1: Find the prime factorization of each number.**

$$12 = 2 \times 2 \times 3$$

$$18 = 2 \times 3 \times 3$$

**Step 2: Write down the factors that appear in either of the two factorizations, using the highest exponent for each factor.**

$$\text{LCM} = 2^2 \times 3^2 = 12 \times 9 = 36$$

**Therefore, the LCM of 12 and 18 is 36.**

### **Addition Method:**

In the addition method, we find the LCM by adding the larger number repeatedly until we get a number that is divisible by all the given numbers. To do this, we follow the steps below:

Step 1: Write the given numbers horizontally. Step 2: Identify the largest number. Step 3: Check if the largest number is divisible by the other numbers. If it is, then it is the LCM. Step 4: If it is not divisible by the other numbers, add the largest number to itself. Step 5: Repeat step 4 until you get a number that is divisible by all the given numbers. Step 6: The final number obtained is the LCM of the given numbers.

Example: Find the LCM of 15 and 25 using the addition method.

**Step 1:** Write the numbers horizontally: 15, 25

**Step 2:** The largest number is 25.

**Step 3:** 25 is not divisible by 15.

**Step 4:** Add 25 to itself to get 50.

**Step 5:** 50 is not divisible by 15.



**Step 6:** Add 25 to 50 to get 75.

**Step 7:** 75 is divisible by both 15 and 25.

Therefore, the LCM of 15 and 25 is 75.

**When to use each method:**

The prime factorization method is best suited for finding the LCM of larger numbers as it is less time-consuming than the addition method. It is also useful when finding the LCM of more than two numbers.

On the other hand, the addition method is useful for finding the LCM of smaller numbers as it involves simple addition. It is also useful when only two numbers are given.

In general, it is a good practice to use both methods to check your answer and ensure its accuracy.

**Practice**

1. Find the LCM of 18 and 24 using the addition method.
2. Find the LCM of 15 and 25 using the addition method.
3. Find the LCM of 12 and 20 Using the Prime Factorisation Method
4. Find the LCM of 24 and 36 Using the Prime Factorisation Method
5. Find the LCM of 36 and 48 using prime factorization method.



## Squaring Numbers

Squaring can be defined as 'multiplying a number by itself.'

There are many different ways of squaring numbers. Many of these techniques have their roots in multiplication as squaring is simply a process of multiplication.


Examples:  $3^2$  is 3 multiplied by 3 which equals 9


The technique that we will study are: -


### (A) SQUARING OF NUMBERS USING CRISSCROSS SYSTEM

The Urdhva-Tiryak Sutra (the Criss-Cross system) is by far the most popular system of squaring numbers amongst practitioners of Vedic Mathematics. The reason for its popularity is that it can be used for any type of numbers.

Ex: Find the square of

Ans: (a) 

(b) 

(c) 

$$\begin{array}{r} 23 \\ \times 23 \\ \hline \end{array}$$

(a) First, we multiply 3 by 3 and get the answer as 9. (Answer at this stage is \_\_\_\_\_9)

(b) Next, we cross multiply ( $2 \times 3$ ) and add it with ( $3 \times 2$ ). The final answer is 12. We write down 2 and carry over 1. (Answer at this stage is \_29)

(c) Thirdly, we multiply ( $2 \times 2$ ) and add the 1 to it. The answer is 5.  
**The final answer is 529**



## Cubing Numbers

We know that squaring is multiplying a number by itself. Cubing can be defined as multiplying a number by itself and again by itself. Thus  $3 \times 3 \times 3$  is 27 and thus 27 is the cube of 3. When we cube a number we are said to have raised it to the power of 3. The cube of a number is expressed by putting a small three on the top right part of the number. For example,

$$10^3 = 1000$$

$$11^3 = 1331$$

Cubing is important while dealing with some algebraic equations and also while dealing with three-dimensional figures in geometry.

$$2^3 = 2 \times 2 \times 2 = 8$$

$$3^3 = 3 \times 3 \times 3 = 27$$

$$4^3 = 4 \times 4 \times 4 = 64$$

$$5^3 = 5 \times 5 \times 5 = 125$$

$$6^3 = 6 \times 6 \times 6 = 216$$

$$7^3 = 7 \times 7 \times 7 = 343$$

$$8^3 = 8 \times 8 \times 8 = 512$$

$$9^3 = 9 \times 9 \times 9 = 729$$

$$10^3 = 10 \times 10 \times 10 = 1000$$



## Cube Roots of Perfect Cubes

The cube root is **often used to solve cubic equations**. In particular, it can be used to solve for the dimensions of a three-dimensional object of a certain volume

Unlike the schools methods of calculating Cube Roots, the technique used in Vedic Mathematics is very simple and fast!

By following the right steps, students can mentally calculate cube root of even big number such as 35937, 85184 and 493039 in no time at all.

Before we move ahead lets first see what is a square and cube of number

Lets take the example of the number 5

### **When we "square" the Number 5:**

We Multiply the Number 5 by itself:

$$5^2 = 5 \times 5 = 25$$

### **When we "cube" the number 5:**

We Multiply the 5 by itself 2 times:

$$5^3 = 5 \times 5 \times 5 = 125$$

Similarly, when we square the number 4, we do the following:

$$4^2 = 4 \times 4 = 16$$

And, when we cube the number 4, we

$$4^3 = 4 \times 4 \times 4 = 64$$

### **Let's now go ahead and see what is Cube-root of a number:**

Cube-root is essentially the reverse of calculating the Cube of a Number

So, if 27 is the cube of 3, then 3 is the cube root of 27

Hence, finding Cube-root of a numbers is a technique to identify the number which has been multiplied by itself twice to obtain the cube.

Thus, if 8 is the cube of 2, then 2 is the cube-root of 8.

If 27 is the cube of 3 then 3 is the cube root of 27 and so on.





What's unique about vedic mathematics is that by following its techniques and steps we will be able to easily find the cube-roots of higher numbers such as 636056, 493039 and so on.

However, do note that this technique can only be used to find the cube root of Perfect cubes

**Before we start calculating the Perfect cube-root of a Cube, we need to learn 3 Rules**

**1. Rule 1: Memorize the cubes of numbers 1-15**

**Key**

Number/Cuberoot	Cube
<u>1</u>	<u>1</u>
<u>2</u>	<u>8</u>
<u>3</u>	<u>27</u>
<u>4</u>	<u>64</u>
<u>5</u>	<u>125</u>
<u>6</u>	<u>216</u>
<u>7</u>	<u>343</u>
<u>8</u>	<u>512</u>
<u>9</u>	<u>729</u>
<u>10</u>	<u>1000</u>
11	1331
12	1728
13	2197
14	2744
15	3375





**2. Rule 2: Identify and Memorise the relationship between digits of Cube-root and Cubes,** for example

- a. if the cube of a number ends with 1, then its cuberoot also ends with 1  
So if the cube of a number is 1331, its cube root which is 11 also end with 1
- b. If the cube of a number ends with 8, then its cube root will end with 2  
So if the cube of a number is 1728, its cube root which is 12 will end with 2

The above relationship is constant for all Perfect cubes of Cube-roots

The below table is in live with the above principle

The last Digit of the Cube	The last digit of the Cube-root
1	1
2	8
3	7
4	4
5	5
6	6
7	3
8	2
9	9
0	0

- c. As shown above cube roots ending with 1,4,5,6,9,0 correspond to their cubes, except for Cube-roots ending with 8 whose cube is 2(and vice versa) and Cube-roots ending with 3 whose cube is 7 (and vice versa)



**3. Rule 3: Whenever you are solving a cube to find out its cube-root, you must put a slash before the last 3 digits**

a. For example

i. To find the Cube-root of 12167, represent the same as follows:

<div style="border: 1px solid black; padding: 2px; display: inline-block;">Left hand Side</div>	$\xrightarrow{\hspace{1cm}}$	$\underline{\text{LHS}}$	$\xleftarrow{\hspace{1cm}}$	$\underline{\text{RHS}}$	<div style="border: 1px solid black; padding: 2px; display: inline-block;">Right hand Side</div>
		12		167	

ii. To find the Cube-root of 830584, represent the same as follows:

$\underline{\text{LHS}}$	$\underline{\text{RHS}}$
830	584

iii. Although it's not a rule, generally we prefer to solve RHS first



Now that we have learnt the 3 Rules, let's start solving

Example 1: 175616

**1. Step 1: We will be solving the cube-root in 2 parts**

	<u><b>LHS</b></u>	<u><b>RHS</b></u>
Answer	175	616

**2. Step 2: As per the Relationship Rule of Cube and Cuberoot:**

- a. Find RHS: We see that the cube 175616 end with 6, so the cube root of this number will also be 6, so RHS of our answer is 6

	<u><b>LHS</b></u>	<u><b>RHS</b></u>
Answer	175	61 <u>6</u>
		6

**3. Step 3: Using the Rule no 1 of Memorization of numbers from 1-10**

	<u><b>LHS</b></u>	<u><b>RHS</b></u>
Answer	<u>175</u>	616
		6

- | <u><b>Key</b></u> |     |
|-------------------|-----|
| Number/Cuberoot   | Cub |
| <u>1</u>          |     |
| <u>2</u>          |     |
| <u>3</u>          |     |
| <u>4</u>          |     |
| <u>5</u>          |     |
| <u>6</u>          |     |
- a. Find LHS: To find Answer on LHS, we take the number on LHS which is 175
- b. Now, we need to find two perfect cubes between which the number 175 lies in the number line.
- From the key, we find that 175 lies between the perfect cubes
- 125(the cube of 5) and
- 216(the cube of 6).
- c. Now, between the 2 cubes we take the cuberoot of the lower cube, which is 5

	<u><b>LHS</b></u>	<u><b>RHS</b></u>
Answer	<u>175</u>	616
	<u>5</u>	6

So, the Cube-root of 175616 is 56



Example 2: 830584

**1. Step 1: We will be solving the cube-root in 2 parts**

	<b><u>LHS</u></b>	<b><u>RHS</u></b>
Answer	830	584

**2. Step 2: As per the Relationship Rule of Cube and Cuberoot:**

- a. Find RHS: We see that the cube 830584 end with 4, so the cube root of this number will also be 4, so RHS of our answer is 4

	<b><u>LHS</u></b>	<b><u>RHS</u></b>
Answer	830	584 4

**3. Step 3: Using the Rule no 1 of Memorization of numbers from 1-10**

	<b><u>LHS</u></b>	<b><u>RHS</u></b>
Answer	830 9	584 4

<b><u>Key</u></b>	
Number/Cuberoot	Cub
1	
2	
3	
4	
5	
6	

- a. Find LHS: To find Answer on LHS, we take the number on LHS which is 830

- b. Now, we need to find two perfect cubes between which the number 830 lies in the number line.

From the key, we find that 830 lies between the perfect cubes

- 729 (the cube of 9) and  
→ 1000 (the cube of 10).

- c. Now, between the 2 cubes we take the cuberoot of the lower cube, which is 9

	<b><u>LHS</u></b>	<b><u>RHS</u></b>
Answer	830 9	584 4

So, the Cube-root of 830584 is 94



Example 3: 1601613

**1. Step 1: We will be solving the cube-root in 2 parts**

	<b><u>LHS</u></b>	<b><u>RHS</u></b>
Answer	1601	613

**2. Step 2: As per the Relationship Rule of Cube and Cuberoot:**

- a. Find RHS: We see that the cube 1601613 ends with 3, so the cube root of this number will end with 7, so RHS of our answer is 7

	<b><u>LHS</u></b>	<b><u>RHS</u></b>
Answer	1601	61 <u>3</u> 7

**3. Step 3: Using the Rule no 1 of Memorization of numbers from 1-15**

<b><u>Key</u></b>			<b><u>LHS</u></b>	<b><u>RHS</u></b>
Number/Cuberoot	Cube	Answer	<b><u>1601</u></b>	613 7
<u>1</u>	<u>1</u>			
<u>2</u>	<u>8</u>			
<u>3</u>	<u>27</u>	a. Find LHS: To find Answer on LHS, we take the		
<u>4</u>	<u>64</u>	number on LHS which is 1601		
<u>5</u>	<u>125</u>	b. Now, we need to find two perfect cubes		
<u>6</u>	<u>216</u>	between which the number 1601 lies in the		
<u>7</u>	<u>343</u>	number line.		
<u>8</u>	<u>512</u>	From the key, we find that 1601 lies between the perfect cubes		
<u>9</u>	<u>729</u>	1331(the cube of 11) and		
<u>10</u>	<u>1000</u>	1728(the cube of 12).		
<u>11</u>	<u>1331</u>	c. Now, between the 2 cubes we take the cube-		
<u>12</u>	<u>1728</u>	root of the lower cube, which is 11		
<u>13</u>	<u>2197</u>			
<u>14</u>	<u>2744</u>			
<u>15</u>	<u>3375</u>			

	<b><u>LHS</u></b>	<b><u>RHS</u></b>
Answer	<b><u>1601</u></b> <b><u>11</u></b>	613 7

So, the Cube-root of 1601613 is 117



### Practice Sheet (Part A)

**Find the Cube-root of the Following:**

Exercise 1: 13824

**1. Step 1: We will be solving the cube-root in 2 parts**

	<u>LHS</u>	<u>RHS</u>
Answer		__

**2. Step 2: As per the Relationship Rule of Cube and Cuberoot:**

- a. Find RHS: We see that the cube 13824 ends with \_\_, so the cube root of this number will end with \_\_, so RHS of our answer is \_\_

	<u>LHS</u>	<u>RHS</u>
Answer		__

**3. Step 3: Using the Rule no 1 of Memorization of numbers from 1-15**

<u>Key</u>			<u>LHS</u>	<u>RHS</u>
Number/Cuberoot	Cube		Answer	
<u>1</u>	<u>1</u>			__
<u>2</u>	<u>8</u>	a. Find LHS: To find Answer on LHS, we take the		
<u>3</u>	<u>27</u>	number on LHS which is __		
<u>4</u>	<u>64</u>	b. Now, we need to find two perfect cubes		
<u>5</u>	<u>125</u>	between which the number __ lies in the number		
<u>6</u>	<u>216</u>	line.		
<u>7</u>	<u>343</u>	From the key, we find that __ lies between the perfect cubes		
<u>8</u>	<u>512</u>	__(the cube of __) and		
<u>9</u>	<u>729</u>	__(the cube of __).		
<u>10</u>	<u>1000</u>	c. Now, between the 2 cubes we take the cube-		
<u>11</u>	<u>1331</u>	root of the lower cube, which is __		
<u>12</u>	<u>1728</u>			
<u>13</u>	<u>2197</u>			
<u>14</u>	<u>2744</u>			
<u>15</u>	<u>3375</u>			

	<u>LHS</u>	<u>RHS</u>
Answer	__	__

So, the Cube-root of 13824 is \_\_



## Exercise 2: 97336

### 1. Step 1: We will be solving the cube-root in 2 parts

	<u>LHS</u>	<u>RHS</u>
Answer	—	—

### 2. Step 2: As per the Relationship Rule of Cube and Cuberoot:

- a. Find RHS: We see that the cube 97336 ends with \_\_\_, so the cube root of this number will end with \_\_\_, so RHS of our answer is \_\_\_

	<u>LHS</u>	<u>RHS</u>
Answer	—	—

### 3. Step 3: Using the Rule no 1 of Memorization of numbers from 1-15

<u>Key</u>		<u>LHS</u>	<u>RHS</u>
Number/Cuberoot	Cube	Answer	—
<u>1</u>	<u>1</u>		
<u>2</u>	<u>8</u>		
<u>3</u>	<u>27</u>	a. Find LHS: To find Answer on LHS, we take the	
<u>4</u>	<u>64</u>	number on LHS which is ___	
<u>5</u>	<u>125</u>	b. Now, we need to find two perfect cubes	
<u>6</u>	<u>216</u>	between which the number ___ lies in the number	
<u>7</u>	<u>343</u>	line.	
<u>8</u>	<u>512</u>	From the key, we find that ___ lies between the perfect cubes	
<u>9</u>	<u>729</u>	___(the cube of _) and	
<u>10</u>	<u>1000</u>	___(the cube of _).	
<u>11</u>	<u>1331</u>	c. Now, between the 2 cubes we take the cube-	
<u>12</u>	<u>1728</u>	root of the lower cube, which is _	
<u>13</u>	<u>2197</u>		
<u>14</u>	<u>2744</u>		
<u>15</u>	<u>3375</u>		

	<u>LHS</u>	<u>RHS</u>
Answer	—	—

So, the Cube-root of 97336 is \_\_\_



Exercise 3: 2299968

**1. Step 1: We will be solving the cube-root in 2 parts**

	<u>LHS</u>	<u>RHS</u>
Answer	—	—

**2. Step 2: As per the Relationship Rule of Cube and Cuberoot:**

- a. Find RHS: We see that the cube 2299968 ends with \_\_, so the cube root of this number will end with \_\_, so RHS of our answer is \_\_

	<u>LHS</u>	<u>RHS</u>
Answer	—	—

**3. Step 3: Using the Rule no 1 of Memorization of numbers from 1-15**

<u>Key</u>	
Number/Cuberoot	Cube
1	1
2	8
3	27
4	64
5	125
6	216
7	343
8	512
9	729
10	1000
11	1331
12	1728
13	2197
14	2744
15	3375

	<u>LHS</u>	<u>RHS</u>
Answer	—	—

- a. Find LHS: To find Answer on LHS, we take the number on LHS which is \_\_\_\_

- b. Now, we need to find two perfect cubes between which the number \_\_\_\_ lies in the number line.

From the key, we find that \_\_\_\_ lies between the perfect cubes \_\_\_\_ (the cube of \_\_) and \_\_\_\_ (the cube of \_\_).

- c. Now, between the 2 cubes we take the cube-root of the lower cube, which is \_

	<u>LHS</u>	<u>RHS</u>
Answer	—	—

So, the Cube-root of 2299968 is \_\_\_\_





**Practice Sheet (Part B)**

**Find the Cube Root Mentally**

1. **12167 = \_\_\_\_\_**
2. **29791 = \_\_\_\_\_**
3. **74088 = \_\_\_\_\_**
4. **262144 = \_\_\_\_\_**
5. **438976 = \_\_\_\_\_**
6. **970299 = \_\_\_\_\_**
7. **117649 = \_\_\_\_\_**
8. **704969 = \_\_\_\_\_**
9. **175616 = \_\_\_\_\_**
10. **1520875 = \_\_\_\_\_**



## Perfect Square Roots

Square root of a number is a value, which on multiplication by itself gives the original number. The square root of a number is the inverse of squaring a number. Hence, squares and square roots are related concepts.

Unlike the school's methods of calculating Square Roots, the technique used in Vedic Mathematics is very simple and fast!

By following the right steps, students can mentally calculate square root of even big numbers such as 4761, 4624 in no time at all!

Before we move ahead let's first see what is a square of number.

Let's take the example of the number 5.

### **When we "square" the Number 5:**

We Multiply the Number 5 by itself:

$$5^2 = 5 \times 5 = 25$$

Similarly, when we square the number 4, we do the following:

$$4^2 = 4 \times 4 = 16$$

Let's now go ahead and see what is Square-root of a number:

Square-root is essentially the reverse of calculating the Square of a Number

So, if 9 is the Square of 3, then 3 is the square root of 9.

Hence, finding Square-root of a number is a technique to identify the number which has been multiplied by itself to obtain the Square.

Thus, if 16 is the square of 4, then 4 is the square-root of 16.

If 25 is the square of 5 then 5 is the square root of 25 and so on.

But what's unique about Vedic mathematics is that by following its techniques and steps we will be able to easily find the square-roots of higher numbers such as 3136 and 9801 and so on.

**However, do note that this technique can only be used to find the square root of Perfect squares**



Before we start to calculate Perfect Square-root of a Square, we need to learn 3 Rules

**1. Rule 1: Memorize the Squares of numbers 1-10**

Number	Squares
<b>1</b>	1
<b>2</b>	4
<b>3</b>	9
<b>4</b>	16
<b>5</b>	25
<b>6</b>	36
<b>7</b>	49
<b>8</b>	64
<b>9</b>	81
<b>10</b>	100



## 2. **Rule 2: Identify and Memorise the relationship between last digits of Square-root and Squares.** for example

Referring the Table **Key**, we will need to observe and memorise the relationship between the last digit of the Squares and the last digit of their square root.

- a. if the square of a number ends with 1, then its Square-Root will end with either 1 or 9 (because  $1 \times 1 = 1$  and  $9 \times 9$  is 81)
  - So, if the square of a number is 2601, we can immediately assume that its square root will either end with 1 or 9.  
In the case of 2601 the square root is 51.
  - Likewise, if the given square is 4761, its square root will either end with 1 or 9.  
In this case for 4761, its square root is 69
- b. Similar to the 1 and 9 relationship, if a number ends in 4 the square root ends in 2 or 8(because  $2 \times 2$  is 4 and  $8 \times 8$  is 64 )
- c. If a number ends in 9, the square root ends in 3 or 7(because  $3 \times 3$  is 9 and  $7 \times 7$  is 49 )
- d. If a number ends in 6, the square root ends in 4 or 6(because  $4 \times 4$  is 16 and  $6 \times 6$  is 36)
- e. If the number ends in 5, the square root ends in 5(because  $5 \times 5$  is 25 )
- f. If the number ends in 0, the square root also ends in 0(because  $10 \times 10$  is 100)

The above relationship is constant for all Perfect Squares of Square -roots

The below table is in line with the above principle

The last Digit of the Square	The last digit of the Square-root
1	1 or 9
4	2 or 8
9	3 or 7
6	4 or 6
5	5
0	0



Now, I want you to look at the column on the left. It reads 'Last digit of the square' and the numbers contained in the column are 1, 4, 9, 6, 5 and 0. Note that the numbers 2, 3, 7 and 8 are absent in the column. That means there is no perfect square which ends with the numbers 2, 3, 7 or 8. Thus we can say:

**'A perfect square will never end with the digits 2, 3, 7 or 8'**

Now we know how to find the last digit of a Square-Root based on the last digit of the Square, although most of the times there are 2 possibilities out of which only 1 is correct.

Secondly, we still need to find out the digits of the square root. So now let's proceed with examples so that we learn how to arrive at the Final Last Digit and the other digits of the square root.

**3. Rule 3: Before we proceed there is one final table that needs to be memorised, as this will help easily determine the Square roots.**

Number	Squares
<b>10</b>	100
<b>20</b>	400
<b>30</b>	900
<b>40</b>	1600
<b>50</b>	2500
<b>60</b>	3600
<b>70</b>	4900
<b>80</b>	6400
<b>90</b>	8100
<b>100</b>	10000

Now that we have learnt the **3** Rules, let's start solving



Example 1: 4624

1. Based on the Rule Number 2 relationship between last digits of Squares and Square roots:

- a. The number 4624 ends with 4. Hence, the square root ends with 2 or 8. The answer at this stage is **2** or **8**.

Number	Squares
10	100
20	400
30	900
40	1600
50	2500
60	3600
70	4900
80	6400
90	8100
100	10000

2. Next we take in the complete number 4624, and using Table in Rule no 3, we can see that 4624 lies between 3600(which is the square of 60) and 4900(which is the square of 70).

a. Hence the Square root also lies between 60 and 70

b. Of all numbers between 60 and 70 (61,62,63,64,65,66,67,68,69), the only numbers ending with **2** and **8** are **62** and **68**. However only one of them is correct, lets find the right one.

c. Observe the squares 3600 and 4900

60 – 3600

4624

70 – 4900

d. Is 4624 closer to the smaller number 3600 or closer to the bigger number 4900?

- i. If the number 4624 is close to 3600, then take smaller 62 as the square root
- ii. If the number 4624 is close to 4900, then take smaller 68 as the square root
- iii. However, in this case we can see 4624 is closer to 4900, the right answer is **68**



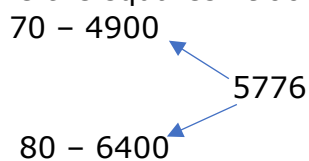
### Example 2: 5776

1. Based on the Rule Number 2 relationship between last digits of Squares and Square roots:
  - a. The number 5776 ends with 6. Hence, the square root ends with 4 or 6. The answer at this stage ends with **4** or **6**.

Number	Squares
10	100
20	400
30	900
40	1600
50	2500
60	3600
70	4900
80	6400
90	8100
100	10000

2. Next we take in the complete number 5776, and using Table in Rule no 3, we can see that 5776 lies between 4900(which is the square of 70) and 6400(which is the square of 80).

- a. Hence the Square root also lies between 70 and 80
- b. Of all the numbers between 70 and 80 (71,72,73,74,75,76,77,78,79), the only numbers ending with **4** and **6** are **74** and **76**. However only one of them is correct, lets find the right one.
- c. Observe the squares 4900 and 6400



- d. Is 5776 closer to the smaller number 4900 or closer to the bigger number 6400?
  - i. If the number 5776 is close to 4900, then take smaller 74 as the square root
  - ii. If the number 5776 is close to 6400, then take smaller 76 as the square root
  - iii. However, in this case we can see 5776 is closer to 6400, the right answer is **76**



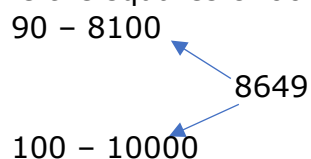
### Example 3: 8649

1. Based on the Rule Number 2 relationship between last digits of Squares and Square roots:
  - a. The number 8649 ends with 9. Hence, the square root ends with 3 or 7. The answer at this stage ends with **3** or **9**.

Number	Squares
10	100
20	400
30	900
40	1600
50	2500
60	3600
70	4900
80	6400
90	8100
100	10000

2. Next we take in the complete number 8649, and using Table in Rule no 3, we can see that 8649 lies between 8100(which is the square of 90) and 10000(which is the square of 100).

- a. Hence the Square root also lies between 90 and 100
- b. Of all the numbers between 90 and 100 (91,92,93,94,95,96,97,98,99), the only numbers ending with **3** and **7** are **93** and **97**. However only one of them is correct, lets find the right one.
- c. Observe the squares 8100 and 10000



- d. Is 8649 closer to the smaller number 8100 or closer to the bigger number 10000?
  - i. If the number 8649 is close to 8100, then take smaller 93 as the square root
  - ii. If the number 8649 is close to 10000, then take smaller 97 as the square root
  - iii. However, in this case we can see 8649 is closer to 8100, the right answer is **93**





### Practice Sheet (Part A)

#### **Find the Square-root of the Following:**

Example 1: 729

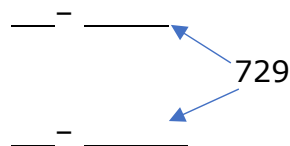
- Based on the Rule Number 2 relationship between last digits of Squares and Square roots:

- The number 729 ends with 9. Hence, the square root ends with 3 or 7. The answer at this stage ends with 3 or 7.

Number	Squares
10	100
20	400
30	900
40	1600
50	2500
60	3600
70	4900
80	6400
90	8100
100	10000

- Next we take in the complete number 729, and using Table in Rule no 3, we can see that 729 lies between \_\_\_\_\_ (which is the square of \_\_\_\_\_) and \_\_\_\_\_ (which is the square of \_\_\_\_\_).

- Hence the Square root also lies between \_\_\_\_\_ and \_\_\_\_\_
- Of all the numbers between \_\_\_\_\_ and \_\_\_\_\_ (\_\_\_\_\_, \_\_\_\_\_, \_\_\_\_\_, \_\_\_\_\_, \_\_\_\_\_), the only numbers ending with \_\_\_\_\_ and \_\_\_\_\_ are \_\_\_\_\_ and \_\_\_\_\_. However only one of them is correct, let's find the right one.
- Observe the squares \_\_\_\_\_ and \_\_\_\_\_



- Is \_\_\_\_\_ closer to the smaller number \_\_\_\_\_ or closer to the bigger number \_\_\_\_\_?
  - If the number \_\_\_\_\_ is close to \_\_\_\_\_, then take smaller \_\_\_\_\_ as the square root
  - If the number \_\_\_\_\_ is close to \_\_\_\_\_, then take smaller \_\_\_\_\_ as the square root
  - However, in this case we can see 729 is closer to \_\_\_\_\_, the right answer is \_\_\_\_\_



### Find the Square-root of the Following:

Example 2: 1849

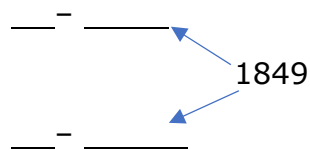
- Based on the Rule Number 2 relationship between last digits of Squares and Square roots:

- The number 1849 ends with 9. Hence, the square root ends with 3 or 7. The answer at this stage ends with 3 or 7.

Number	Squares
10	100
20	400
30	900
40	1600
50	2500
60	3600
70	4900
80	6400
90	8100
100	10000

- Next we take in the complete number 1849, and using Table in Rule no 3, we can see that 1849 lies between \_\_\_\_\_ (which is the square of \_\_\_\_\_) and \_\_\_\_\_ (which is the square of \_\_\_\_\_).

- Hence the Square root also lies between \_\_\_\_\_ and \_\_\_\_\_
- Of all the numbers between \_\_\_\_\_ and \_\_\_\_\_ (\_\_\_\_\_, \_\_\_\_\_, \_\_\_\_\_, \_\_\_\_\_, \_\_\_\_\_), the only numbers ending with \_\_\_\_\_ and \_\_\_\_\_ are \_\_\_\_\_ and \_\_\_\_\_. However only one of them is correct, let's find the right one.
- Observe the squares \_\_\_\_\_ and \_\_\_\_\_



- Is \_\_\_\_\_ closer to the smaller number \_\_\_\_\_ or closer to the bigger number \_\_\_\_\_?
  - If the number \_\_\_\_\_ is close to \_\_\_\_\_, then take smaller \_\_\_\_\_ as the square root
  - If the number \_\_\_\_\_ is close to \_\_\_\_\_, then take smaller \_\_\_\_\_ as the square root
  - However, in this case we can see 1849 is closer to \_\_\_\_\_, the right answer is \_\_\_\_\_



### Find the Square-root of the Following:

Example 2: 6084

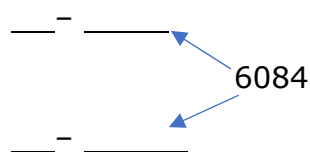
1. Based on the Rule Number 2 relationship between last digits of Squares and Square roots:

- a. The number 6084 ends with   4  . Hence, the square root ends with   2   or   8  . The answer at this stage ends with   2   or   8  .

Number	Squares
10	100
20	400
30	900
40	1600
50	2500
60	3600
70	4900
80	6400
90	8100
100	10000

2. Next we take in the complete number 6084, and using Table in Rule no 3, we can see that 6084 lies between          (which is the square of       ) and          (which is the square of       ).

- a. Hence the Square root also lies between        and
- b. Of all the numbers between        and        (      ,       ,       ,       ,       ,       ,       ,       ), the only numbers ending with        and        are        and       . However only one of them is correct, let's find the right one.
- c. Observe the squares          and



- d. Is        closer to the smaller number        or closer to the bigger number       ?
  - i. If the number        is close to       , then take smaller        as the square root
  - ii. If the number        is close to       , then take smaller        as the square root
  - iii. However, in this case we can see 6084 is closer to       , the right answer is



### **Practice Sheet (Part B)**

#### **Find the Square Root Mentally**

1. **6375 = \_\_\_\_\_**

2. **6400 = \_\_\_\_\_**

3. **7396 = \_\_\_\_\_**

4. **8281 = \_\_\_\_\_**

5. **6724 = \_\_\_\_\_**

6. **2809 = \_\_\_\_\_**

7. **1936 = \_\_\_\_\_**

8. **3721 = \_\_\_\_\_**

9. **784 = \_\_\_\_\_**

10. **3136 = \_\_\_\_\_**



## References

### **Maharaja Jagadguru Swami Sri Bharati Krishna Tirthaji.**

- Vedic Mathematics: Sixteen Simple Mathematical Formulae from the vedas. Motilal Bansridas Publishers, 1965.

### **Bill Hanley**

- Speed Mathematics

### **Ann Cutler and Rudolph Mc Shane**

- The Trachtenberg Speed System of Basic Arithmetic

### **James Glover**

- Vedic mathematics for schools (Part 1,2 and 3)

### **Arthur Benjamin and Michael Shermer**

- Secrets of Mental Math

### **Robert Fountain and Jan van Koningsveld**

- The Mental Calculators Handbook

### **Mr.Gaurav Tekriwal**

- Maths Sutras- The Art of Vedic Speed Calculation. Penguin Random House India,2015
- Maths Sutras- From around the World.

### **Mr Dhaval Bhatia**

- Vedic Mathematics Made Easy