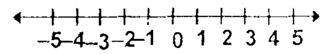
Integers: Positive integers, negative integers and zero together, form a large group of numbers called Integers. Natural numbers that start from 0 are denoted by **N**. It we represent all the integers on the number line, the representation will look like the one shown below. Integers are denoted by **Z.**



Rational Numbers any number which can be written in p/q form. Both 'p and 'q' are integers with the condition that q≠ 0. In simple words, we can say that the denominator of a rational number should not be '0'. This is so because division by 0' is not defined.

Note:

1. Every integer is a rational number as it can be written as a fraction.
2. Zero is also a rational number because zero can be written as 0/1 = 0
3. There are infinitely many rational numbers between two rational numbers.

Find rational numbers lying between two given rational numbers

Step1: Add the given two rational numbers and divide the sum by 2. The answer is a rational number between the given two numbers.

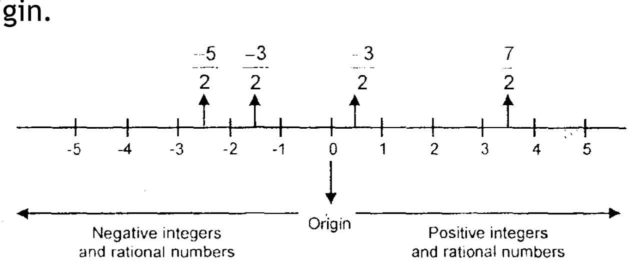
Step2: You have got one rational number in STEP I. Take that rational number and one of the given numbers and find their sum. Divide the sum by 2. You will get one more rational number. Repeat this process to get as many rational numbers as you need.

Alternate Method

1. Suppose you want to find 5 rational numbers between 3 and 4. Let these rational numbers be R1, R2, R3, R4 and R5. Now if you put these numbers between 3 and 4 you will get the following; 3, R1, R2, R3, R4, R5, 4
2. Now there are 7 numbers in this group and you have to find out R1, R2, R3, R4 and R5. For this write the given rational numbers 3 and 4 with the denominator 7 as follows
3. You know that 3 = 21/ 7 and 4 = 28/7. Now your job has become very easy. You have to just find out 5 fractions between 21/7 and 28/7. Surely your answer will be 22/7, 23/7, 24/7, 25/7, 26/7. If we have to find rational numbers between two fractions, we will first make the denominators same then we will multiply the numerator and denominator by the number of rational numbers to be found between them.

Number line: All the integers and non-integral fractions taken together form a large group called rational numbers. Rational numbers can be represented on a line called number line. 0' is placed at the centre of the line and this point is called the origin Positive numbers lie on the right side of the origin and negative numbers lie on the left side of the origin.

Exercise 1



Q.1 Find at least 5 rational numbers lying between 1/3 and 2/3. (6/15, 7/15, 8/15 and 9/15

Q.2 Represent following points on the number line.

(i) 5 (ii) -4 (iii) 3.5 (iv) - 0.5

Q.3 Find four rational numbers between 1/5 and 2/5

ABHYAS Academy, Behind Pragat Shiv Mandir, Near Govt. College, Nishat Cinema Road, Ambala Cantt.
Ph No. +91-171-2631595, 9416541198, e-Mail: anusethi1968@yahoo.com Website: www. abhyasonline.in

Q.4 Mark as true or false:
(i) All the whole numbers are natural numbers.
(ii) All the natural numbers are integers
(iii) All the integers are whole numbers.

Irrational Numbers: these are the numbers which are not rational. That means numbers which are not fractions i.e. they cannot be written as fractions.

Definition of an irrational Number: A number s is called irrational, if it cannot be written in the form of where p and 'q' are integers and q not equal to 0. Numbers like $\sqrt{2}$, $\sqrt{3}$ are the examples of irrational numbers. Decimal numbers like 0.101001000100001 are also irrational numbers.

Properties of Irrational Numbers:
(1) Negative of an irrational number is also irrational. e.g. Both and $\sqrt{2}$ and $-\sqrt{2}$ are irrationals.
(2) Sum of a rational and an irrational number is always an irrational. e.g. $2+\sqrt{2}$, $2-\sqrt{2}$ are irrationals.
(3) Product of a nonzero rational number and an irrational number is an irrational number. e.g. $2 \times \sqrt{2}$ is irrationals.
(4) Sum, difference, product and quotient of irrational numbers can be rational or irrational
(a) $\sqrt{2} + (-\sqrt{2}) = 0$: Rational number.
(b) $\sqrt{3} - \sqrt{3} = 0$: Rational number.
(c) $\sqrt{2} \times \sqrt{2} = 2$: Rational number.
(d) $\sqrt{2} / \sqrt{2} = 1$: Rational number.
(e) $\sqrt{2} + \sqrt{2} = 2\sqrt{2}$: Irrational number.
(f) $\sqrt{2} \times \sqrt{3} = \sqrt{6}$: Irrational number.

Now, we have seen that there are two types of numbers on the number line namely rational numbers and irrational numbers.

<u>Rational numbers and irrational numbers taken together will form a large group called real numbers</u>. This makes the following 2 points clear:
1. Every point on the number line represents a particular real number.
2. Every real number is represented by a particular point on the number line.

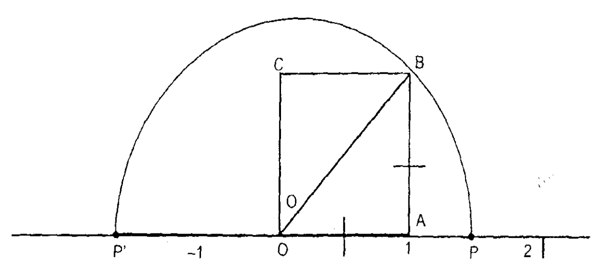
Finding irrational numbers between two number: if x and y are two rational or irrational numbers then $\sqrt{xy}$ is between x and y. for example irrational numbers between 5 and 7 is $\sqrt{35}$

Eg: Writing an irrational number between 2.3 and 2.89 can be 2.3010010001… or 2.4010010001…

Representation of real number on the number line.
To represent a real number on the number line, all you have to do is to locate the point related to that number on the number line

<u>Irrational Number On a Number Line:</u> Location of $\sqrt{2}$ on number line.

Construct a unit square OABC where O is the origin on the number line. Now it is clear that OA= AB = BC=CO = 1 unit.
By Pythagorean Theorem:
$OB^2 = OA^2 + AB^2$
$OB = \sqrt{1^2 + 1^2} = \sqrt{1+1} = \sqrt{2}$ units



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Now draw an arc with 0' as centre and 'OB' ($\surd$ 2 units) as radius intersecting the number line at P. Now OP is of length $\surd$ 2

Q. Represent $\surd$ 3 on the number line.

<u>Exercise 2</u>

Q1. Represent (($\surd$ 3 + 1) on the number line.

Q2. Represent (2 ($\surd$2 + 1) and ($\surd$ 2 - 1) on the number line

Q3. Draw ($\surd$ 5) as Spiral

Q4. Prove that $\surd$5 is irrational.

Q5. Prove that $\sqrt[3]{10}$ is irrational.

<u>Decimal Expansion of real numbers</u>

We know that real numbers include both rational and irrationals numbers. Let us take up the rational numbers (fractions) first.

Decimal representation of rational numbers can be:

(1) Terminating (2) Non -terminating and repeating

1. <u>Terminating decimal</u>: Let us convert 6/5 into decimal. For this we have to divide the numerator 6 by the denominator 5 and we get 1.2

2. <u>Non - terminating and repeating decimal</u>: Let us represent 1/6 as decimal. Now you can see that the 6 is repeating in the quotient. This will never terminate (come to an end). We can say that the decimal portion of 1/6 is non -terminating and repeating. To represent non- terminating repeating decimal, we put a bar above the digit or block of digits which is repeating. Thus we can write - 0.16.

<u>Exercise 3</u>

Q1. Convert the following numbers into decimals:

(a) 25/24 (b) 5/10 (c) 8/9 (d) 7/20 (1.04), (0.50) , (0.89), (0.35)

<u>Conversion of Decimals into Fractions</u>

Let us start with a few terminating decimal numbers.

Case 1: Terminating decimals.

Step 1: Count the number of digits to the right hand side of the decimal point.

Step 2: Ignore the decimal point in the given number and write the number as the numerator.

Step 3: Write 1 in the denominator and put as many zeroes, on the right hand side of 1, as the number of digits to the right hand side of decimal point. Now you have got the fraction.

Step 4: Reduce the fraction into the lowest terms by dividing the numerator and denominator by the common factors

Q. Convert 1.75 into rational number. (7/4)

Case 2: Non -terminating & repeating decimals

Non-terminating and repeating decimals are of two types.

(i) Pure repeating decimals:

These are the decimals in which all the digits after decimal point are repeating.

e.g. 0.3, 0.32, 0.675 etc. are pure repeating decimals.

(ii) Mixed repeating decimals

A decimal number in which at least one digit, after the decimal does not repeat and others repeated. e.g. 0.816, 0.7645, 2.1275 etc are mixed repeating decimals.

Case -2(A): Conversion of pure repeating decimals into fractions

Step 1: Put the given decimal number equal to X. Now you get an equation.

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Step 2: Remove the bar and write the repeating digits at least twice followed by dots. Name this as Equation (i)
Step 3: If one digit is repeating, multiply the equation by 10, if two digits are repeating. multiply the equation by 100 and so on. Name this as Equation (ii)
Step 4: Subtract Equation (i) from Equation (ii) Now you get a new equation. Name this as Equation (iii)
Step 5: Divide both sides of Equation (iii) by the coefficient of X. Now you have got the required fraction.
Q: Convert $0.\overline{525}$ into its rational form. (525/999)

Case 2(B): Mixed Repeating Decimal

Step 1: Put the given decimal number equal to X. Now you get an equation.
Step 2: Count the number of digits without bar after the decimal point. Let the number of digits without bar he N. Multiply both sides of equation of step 1 by 10^N. Split the resulting number into an integer and a pure repeating decimal.
Step 3: Convert the pure repeating decimal into its rational form by the process given in case 2(A).
Step 4: Add the resulting rational number and the integer obtained in Step 4 to get the required rational number.
Step 5: Divide the equation at Step 6 by 10^N to get the final result.
Q: Convert $2\ 3\overline{26}$ in rational form. (21113/990)
Q: Convert the following rational numbers into decimal form:
(a)25/11 (b)66/25 (c)91/52 ($2.\overline{27}$), (2.64), (1.75)
Q: Convert the following decimals into rational numbers:
(a) 1.22 (b) 0.568 (c) 7.264 (61/50) , (71/125), (908/125)
Q: Convert - 17.555 into rational number. (-3511/200)
Q: Convert the following decimal numbers into the form p/q.
(a) $0.\overline{6}$ (b) $0.\overline{525}$ (c) $6.\overline{7}$ (d) $21.\overline{26}$ (2/3), (525/999), (61/9), (2105/99)

Exercise 4

Q.1 Convert the following decimals in the form p/q.
(a) $2.\overline{8}$ (b) $0.\overline{837}$ (c) $5.\overline{89}$ (26/9), (31/37), (59/10)
Q.2 Convert the following decimals in the form p/q.
(a) $8.\overline{2257}$ (b) $5.3\overline{78}$ (c) $0.\overline{8}$ (d) $1.3\overline{29}$
(82249/9999), (4841/900), (8/9), (658/495)

Worksheet 1

1 Give two irrational numbers whose quotient is:
(i) rational
(ii) irrational.
2 Construct a square root spiral starting from √2 up to √5.
3. Write two numbers whose decimal expansion is non terminating and nonrepeating.
4. Convert the following decimal numbers into rational number in the form p/q.

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(i) 0.08 (ii) 1.205 (iii) 0.001 (iv) 3.2125

(2/25), (241/200), (1/1000), (257/80)

5. If a= $3\sqrt{12} + 2\sqrt{18}$ and b= $\sqrt{2} + \sqrt{3}$. Find the value of:

(i) a + b (ii) a - b (iii) 2a + 3b (iv) 5a - 4b

($7\sqrt{3} + 7\sqrt{2}$), ($5\sqrt{3} + 5\sqrt{2}$), ($15\sqrt{3} + 15\sqrt{2}$), ($26\sqrt{3} + 26\sqrt{2}$)

6. Insert 3 rational numbers between 4 and 5.

7. Express 3 and - 2 in the form of p/q where p and q are integers and q is not equal to 0.

(6/2 and -4/2)

8 Give two irrational numbers whose sum is rational. ($3 - \sqrt{5}$, $4 + \sqrt{5}$)

9. Give two irrational numbers whose product is: ($2\sqrt{5}$, $\sqrt{5}$), ($2\sqrt{3}$, $\sqrt{2}$)

(i) rational (ii) irrational

10. Locate $\sqrt{2}$ and $\sqrt{3}$ on the number line.

11. Locate the points representing $\sqrt{2} + 1$ and $\sqrt{2} - 1$ on the number line.

<u>Worksheet 2</u>

1. Write the decimal representation of 3/24 and 3/35. (0.125, 0.0857143)

2. Convert the following decimal numbers in p/q form:

(a) $0.\overline{312}$ (b) $0.\overline{092}$ (c) $0.\overline{12345}$ (d) 0.4 (e) 2 .21347

(104/333), (92/999), (4115/33333), (2/5), (221126/99900)

3. Classify the following numbers as rational or irrational.

(i) $\sqrt{2}$ (ii) $\sqrt{324}$ (iii) 0.125 (iv) 0.934984.. (v) 4.02121121112....

(Irrational, Rational, Rational, Irrational, Irrational)

4. Insert 4 rational numbers between 2/5 and 3/5.

5. State which of the following fractions are convertible into terminating decimals.

(a) 33/18 (b) 4/25 (c) 5/15 (d)5/13

(4/25)

7. Write two numbers whose decimal expansions are non-terminating and non-repeating.

8. Convert the following decimal numbers in p/q form:

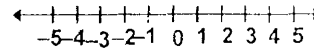
(i) 0.08 (ii) 1.205 (iii) 0.001 (iv) 3.2125

(2/25), (241/200), (1/1000), (257,80)

9. Find four irrational numbers between 1/3 and 2/3.

10 Find four irrational numbers between 5 and 6.

Integers: Positive integers, negative integers and zero together, form a large group of numbers called Integers. Natural numbers that start from 0 are denoted by **N**. It we represent all the integers on the number line, the representation will look like the one shown below. Integers are denoted by **Z.**



Rational Numbers any number which can be written in p/q form. Both 'p and 'q' are integers with the condition that q≠ 0. In simple words, we can say that the denominator of a rational number should not be '0'. This is so because division by 0' is not defined.

Note:

1. Every integer is a rational number as it can be written as a fraction.
2. Zero is also a rational number because zero can be written as 0/1 = 0
3. There are infinitely many rational numbers between two rational numbers.

Find rational numbers lying between two given rational numbers

Step1: Add the given two rational numbers and divide the sum by 2. The answer is a rational number between the given two numbers.

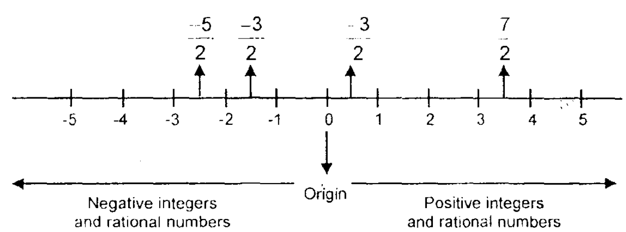
Step2: You have got one rational number in STEP I. Take that rational number and one of the given numbers and find their sum. Divide the sum by 2. You will get one more rational number. Repeat this process to get as many rational numbers as you need.

Alternate Method

1. Suppose you want to find 5 rational numbers between 3 and 4. Let these rational numbers be R1, R2, R3, R4 and R5. Now if you put these numbers between 3 and 4 you will get the following; 3, R1, R2, R3, R4, R5, 4
2. Now there are 7 numbers in this group and you have to find out R1, R2, R3, R4 and R5. For this write the given rational numbers 3 and 4 with the denominator 7 as follows
3. You know that 3 = 21/ 7 and 4 = 28/7. Now your job has become very easy. You have to just find out 5 fractions between 21/7 and 28/7. Surely your answer will be 22/7, 23/7, 24/7, 25/7, 26/7. If we have to find rational numbers between two fractions, we will first make the denominators same then we will multiply the numerator and denominator by the number of rational numbers to be found between them.

Number line: All the integers and non-integral fractions taken together form a large group called rational numbers. Rational numbers can be represented on a line called number line. 0' is placed at the centre of the line and this point is called the origin Positive numbers lie on the right side of the origin and negative numbers lie on the left side of the origin.

Exercise 1



Q.1 Find at least 5 rational numbers lying between 1/3 and 2/3. (6/15, 7/15, 8/15 and 9/15

Q.2 Represent following points on the number line.

(i) 5 (ii) -4 (iii) 3.5 (iv) - 0.5

Q.3 Find four rational numbers between 1/5 and 2/5

Q.4 Mark as true or false:
(i) All the whole numbers are natural numbers.
(ii) All the natural numbers are integers
(iii) All the integers are whole numbers.

Irrational Numbers: these are the numbers which are not rational. That means numbers which are not fractions i.e. they cannot be written as fractions.

Definition of an irrational Number: A number s is called irrational, if it cannot be written in the form of where p and 'q' are integers and q not equal to 0. Numbers like $\sqrt{2}$, $\sqrt{3}$ are the examples of irrational numbers. Decimal numbers like 0.101001000100001 are also irrational numbers.

Properties of Irrational Numbers:
(1) Negative of an irrational number is also irrational. e.g. Both and $\sqrt{2}$ and $-\sqrt{2}$ are irrationals.
(2) Sum of a rational and an irrational number is always an irrational. e.g. $2+\sqrt{2}$, $2-\sqrt{2}$ are irrationals.
(3) Product of a nonzero rational number and an irrational number is an irrational number. e.g. $2 \times \sqrt{2}$ is irrationals.
(4) Sum, difference, product and quotient of irrational numbers can be rational or irrational
(a) $\sqrt{2} + (-\sqrt{2}) = 0$: Rational number.
(b) $\sqrt{3} - \sqrt{3} = 0$: Rational number.
(c) $\sqrt{2} \times \sqrt{2} = 2$: Rational number.
(d) $\sqrt{2} / \sqrt{2} = 1$: Rational number.
(e) $\sqrt{2} + \sqrt{2} = 2\sqrt{2}$: Irrational number.
(f) $\sqrt{2} \times \sqrt{3} = \sqrt{6}$: Irrational number.

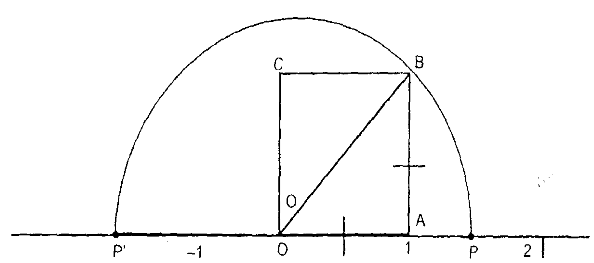
Now, we have seen that there are two types of numbers on the number line namely rational numbers and irrational numbers.
Rational numbers and irrational numbers taken together will form a large group called real numbers. This makes the following 2 points clear:
1. Every point on the number line represents a particular real number.
2. Every real number is represented by a particular point on the number line.

Finding irrational numbers between two number: if x and y are two rational or irrational numbers then $\sqrt{xy}$ is between x and y. for example irrational numbers between 5 and 7 is $\sqrt{35}$

Eg: Writing an irrational number between 2.3 and 2.89 can be 2.3010010001… or 2.4010010001…

Representation of real number on the number line.
To represent a real number on the number line, all you have to do is to locate the point related to that number on the number line

Irrational Number On a Number Line: Location of $\sqrt{2}$ on number line.
Construct a unit square OABC where O is the origin on the number line. Now it is clear that OA= AB = BC=CO = 1 unit.
By Pythagorean Theorem:
$OB^2 = OA^2 + AB^2$
$OB = \sqrt{1^2 + 1^2} = \sqrt{1+1} = \sqrt{2}$ units



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Now draw an arc with 0' as centre and 'OB' ($\sqrt{2}$ units) as radius intersecting the number line at P. Now OP is of length $\sqrt{2}$

Q. Represent $\sqrt{3}$ on the number line.

Exercise 2

Q1. Represent (($\sqrt{3}$ + 1) on the number line.
Q2. Represent (2 ($\sqrt{2}$ + 1) and ($\sqrt{2}$ - 1) on the number line
Q3. Draw ($\sqrt{5}$) as Spiral
Q4. Prove that $\sqrt{5}$ is irrational.
Q5. Prove that $\sqrt[3]{10}$ is irrational.

Decimal Expansion of real numbers

We know that real numbers include both rational and irrationals numbers. Let us take up the rational numbers (fractions) first.
Decimal representation of rational numbers can be:
(1) Terminating   (2) Non -terminating and repeating
1. Terminating decimal: Let us convert 6/5 into decimal. For this we have to divide the numerator 6 by the denominator 5 and we get 1.2
2. Non - terminating and repeating decimal: Let us represent 1/6 as decimal. Now you can see that the 6 is repeating in the quotient. This will never terminate (come to an end). We can say that the decimal portion of 1/6 is non -terminating and repeating. To represent non- terminating repeating decimal, we put a bar above the digit or block of digits which is repeating. Thus we can write - $0.1\overline{6}$.

Exercise 3

Q1. Convert the following numbers into decimals:
(a) 25/24   (b) 5/10   (c) 8/9   (d) 7/20   (1.04), (0.50) , (0.89), (0.35)

Conversion of Decimals into Fractions

Let us start with a few terminating decimal numbers.
Case 1: Terminating decimals.
Step 1: Count the number of digits to the right hand side of the decimal point.
Step 2: Ignore the decimal point in the given number and write the number as the numerator.
Step 3: Write 1 in the denominator and put as many zeroes, on the right hand side of 1, as the number of digits to the right hand side of decimal point. Now you have got the fraction.
Step 4: Reduce the fraction into the lowest terms by dividing the numerator and denominator by the common factors
Q. Convert 1.75 into rational number. (7/4)
Case 2: Non -terminating & repeating decimals
Non-terminating and repeating decimals are of two types.
(i) Pure repeating decimals:
These are the decimals in which all the digits after decimal point are repeating.
e.g. $0.\overline{3}$, 0.32, 0.675 etc. are pure repeating decimals.
(ii) Mixed repeating decimals
A decimal number in which at least one digit, after the decimal does not repeat and others repeated. e.g. $0.8\overline{16}$, 0.7645, 2.1275 etc are mixed repeating decimals.
Case -2(A): Conversion of pure repeating decimals into fractions
Step 1: Put the given decimal number equal to X. Now you get an equation.

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Step 2: Remove the bar and write the repeating digits at least twice followed by dots. Name this as Equation (i)
Step 3: If one digit is repeating, multiply the equation by 10, if two digits are repeating. multiply the equation by 100 and so on. Name this as Equation (ii)
Step 4: Subtract Equation (i) from Equation (ii) Now you get a new equation. Name this as Equation (iii)
Step 5: Divide both sides of Equation (iii) by the coefficient of X. Now you have got the required fraction.
Q: Convert $0.\overline{525}$ into its rational form. (525/999)
Case 2(B): Mixed Repeating Decimal
Step 1: Put the given decimal number equal to X. Now you get an equation.
Step 2: Count the number of digits without bar after the decimal point. Let the number of digits without bar he N. Multiply both sides of equation of step 1 by 10^N. Split the resulting number into an integer and a pure repeating decimal.
Step 3: Convert the pure repeating decimal into its rational form by the process given in case 2(A).
Step 4: Add the resulting rational number and the integer obtained in Step 4 to get the required rational number.
Step 5: Divide the equation at Step 6 by 10^N to get the final result.
Q: Convert $2\ 3\overline{26}$ in rational form.
(21113/990)
Q: Convert the following rational numbers into decimal form:
(a)25/11 (b)66/25 (c)91/52 ($2.\overline{27}$), (2.64), (1.75)
Q: Convert the following decimals into rational numbers:
(a) 1.22 (b) 0.568 (c) 7.264 (61/50) , (71/125), (908/125)
Q: Convert - 17.555 into rational number. (-3511/200)
Q: Convert the following decimal numbers into the form p/q.
(a) $0.\overline{6}$ (b) $0.\overline{525}$ (c) $6.\overline{7}$ (d) $21.\overline{26}$ (2/3), (525/999), (61/9), (2105/99)

Exercise 4

Q.1 Convert the following decimals in the form p/q.
(a) $2.\overline{8}$ (b) $0.\overline{837}$ (c) $5.\overline{89}$ (26/9), (31/37), (59/10)
Q.2 Convert the following decimals in the form p/q.
(a) $8.\overline{2257}$ (b) $5.3\overline{78}$ (c) $0.\overline{8}$ (d) $1.3\overline{29}$
(82249/9999), (4841/900), (8/9), (658/495)

Worksheet 1

1 Give two irrational numbers whose quotient is:
(i) rational
(ii) irrational.
2 Construct a square root spiral starting from $\sqrt{2}$ up to $\sqrt{5}$.
3. Write two numbers whose decimal expansion is non terminating and nonrepeating.
4. Convert the following decimal numbers into rational number in the form p/q.

(i) 0.08 (ii) 1.205 (iii) 0.001 (iv) 3.2125
(2/25), (241/200), (1/1000), (257/80)

5. If a= 3√12 + 2√18 and b= √2 + √3. Find the value of:
(i) a + b (ii) a - b (iii) 2a + 3b (iv) 5a - 4b
(7√3 + 7√2), (5√3 + 5√2), (15√3 + 15√2), (26√3 + 26√2)

6. Insert 3 rational numbers between 4 and 5.

7. Express 3 and - 2 in the form of p/q where p and q are integers and q is not equal to 0.
(6/2 and -4/2)

8 Give two irrational numbers whose sum is rational. (3 - √5, 4 + √5)

9. Give two irrational numbers whose product is: (2√5, √5), (2√3, √2)
(i) rational (ii) irrational

10. Locate √2 and √3 on the number line.

11. Locate the points representing √2 + 1 and √2 - 1 on the number line.

Worksheet 2

1. Write the decimal representation of 3/24 and 3/35. (0.125, $0.0\overline{857143}$)

2. Convert the following decimal numbers in p/q form:
(a) $0.\overline{312}$ (b) $0.\overline{092}$ (c) $0.\overline{12345}$ (d) 0.4 (e) 2 .21347
(104/333), (92/999), (4115/33333), (2/5), (221126/99900)

3. Classify the following numbers as rational or irrational.
(i) √2 (ii) √324 (iii) 0.125 (iv) 0.934984.. (v) 4.02121121112....
(Irrational, Rational, Rational, Irrational, Irrational)

4. Insert 4 rational numbers between 2/5 and 3/5.

5. State which of the following fractions are convertible into terminating decimals.
(a) 33/18 (b) 4/25 (c) 5/15 (d)5/13
(4/25)

7. Write two numbers whose decimal expansions are non-terminating and non-repeating.

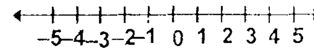
8. Convert the following decimal numbers in p/q form:
(i) 0.08 (ii) 1.205 (iii) 0.001 (iv) 3.2125
(2/25), (241/200), (1/1000), (257,80)

9. Find four irrational numbers between 1/3 and 2/3.

10 Find four irrational numbers between 5 and 6.

ABHYAS Academy, Behind Pragat Shiv Mandir, Near Govt. College, Nishat Cinema Road, Ambala Cantt.
Ph No. +91-171-2631595, 9416541198, e-Mail: anusethi1968@yahoo.com Website: www. abhyasonline.in

<u>**Integers**</u>: Positive integers, negative integers and zero together, form a large group of numbers called Integers. Natural numbers that start from 0 are denoted by **N**. It we represent all the integers on the number line, the representation will look like the one shown below. Integers are denoted by **Z**.



<u>**Rational Numbers**</u> any number which can be written in p/q form. Both 'p and 'q' are integers with the condition that q≠ 0. In simple words, we can say that the denominator of a rational number should not be '0'. This is so because division by 0' is not defined.

<u>**Note**</u>:

1. Every integer is a rational number as it can be written as a fraction.
2. Zero is also a rational number because zero can be written as 0/1 = 0
3. There are infinitely many rational numbers between two rational numbers.

<u>**Find rational numbers lying between two given rational numbers**</u>

Step1: Add the given two rational numbers and divide the sum by 2. The answer is a rational number between the given two numbers.

Step2: You have got one rational number in STEP I. Take that rational number and one of the given numbers and find their sum. Divide the sum by 2. You will get one more rational number. Repeat this process to get as many rational numbers as you need.

Alternate Method

1. Suppose you want to find 5 rational numbers between 3 and 4. Let these rational numbers be R1, R2, R3, R4 and R5. Now if you put these numbers between 3 and 4 you will get the following; 3, R1, R2, R3, R4, R5, 4
2. Now there are 7 numbers in this group and you have to find out R1, R2, R3, R4 and R5. For this write the given rational numbers 3 and 4 with the denominator 7 as follows
3. You know that 3 = 21/ 7 and 4 = 28/7. Now your job has become very easy. You have to just find out 5 fractions between 21/7 and 28/7. Surely your answer will be 22/7, 23/7, 24/7, 25/7, 26/7. If we have to find rational numbers between two fractions, we will first make the denominators same then we will multiply the numerator and denominator by the number of rational numbers to be found between them.

Number line: All the integers and non-integral fractions taken together form a large group called rational numbers. Rational numbers can be represented on a line called number line. 0' is placed at the centre of the line and this point is called the origin Positive numbers lie on the right side of the origin and negative numbers lie on the left side of the origin.

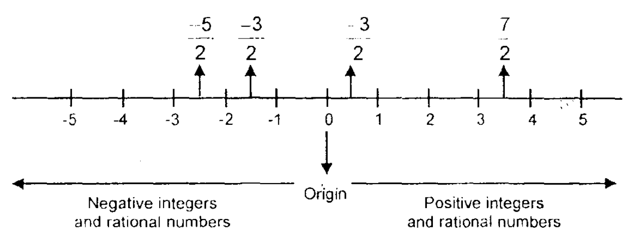
<u>**Exercise 1**</u>

Q.1 Find at least 5 rational numbers lying between 1/3 and 2/3. (6/15, 7/15, 8/15 and 9/15

Q.2 Represent following points on the number line.

(i) 5 (ii) -4 (iii) 3.5 (iv) - 0.5

Q.3 Find four rational numbers between 1/5 and 2/5



Q.4 Mark as true or false:
(i) All the whole numbers are natural numbers.
(ii) All the natural numbers are integers
(iii) All the integers are whole numbers.

Irrational Numbers: these are the numbers which are not rational. That means numbers which are not fractions i.e. they cannot be written as fractions.

Definition of an irrational Number: A number s is called irrational, if it cannot be written in the form of where p and 'q' are integers and q not equal to 0. Numbers like $\sqrt{2}$, $\sqrt{3}$ are the examples of irrational numbers. Decimal numbers like 0.101001000100001 are also irrational numbers.

Properties of Irrational Numbers:
(1) Negative of an irrational number is also irrational. e.g. Both and $\sqrt{2}$ and $-\sqrt{2}$ are irrationals.
(2) Sum of a rational and an irrational number is always an irrational. e.g. $2+\sqrt{2}$, $2-\sqrt{2}$ are irrationals.
(3) Product of a nonzero rational number and an irrational number is an irrational number. e.g. $2 \times \sqrt{2}$ is irrationals.
(4) Sum, difference, product and quotient of irrational numbers can be rational or irrational
(a) $\sqrt{2} + (-\sqrt{2}) = 0$: Rational number.
(b) $\sqrt{3} - \sqrt{3} = 0$: Rational number.
(c) $\sqrt{2} \times \sqrt{2} = 2$: Rational number.
(d) $\sqrt{2} / \sqrt{2} = 1$: Rational number.
(e) $\sqrt{2} + \sqrt{2} = 2\sqrt{2}$: Irrational number.
(f) $\sqrt{2} \times \sqrt{3} = \sqrt{6}$: Irrational number.

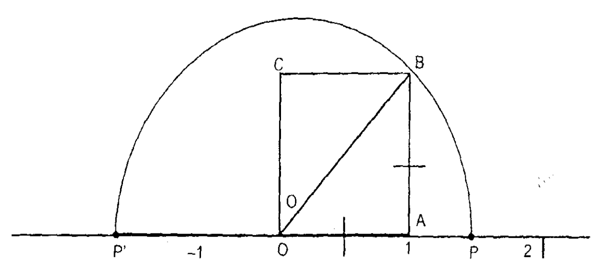
Now, we have seen that there are two types of numbers on the number line namely rational numbers and irrational numbers.
Rational numbers and irrational numbers taken together will form a large group called real numbers. This makes the following 2 points clear:
1. Every point on the number line represents a particular real number.
2. Every real number is represented by a particular point on the number line.

Finding irrational numbers between two number: if x and y are two rational or irrational numbers then $\sqrt{xy}$ is between x and y. for example irrational numbers between 5 and 7 is $\sqrt{35}$

Eg: Writing an irrational number between 2.3 and 2.89 can be 2.3010010001… or 2.4010010001…

Representation of real number on the number line.
To represent a real number on the number line, all you have to do is to locate the point related to that number on the number line

Irrational Number On a Number Line: Location of $\sqrt{2}$ on number line.
Construct a unit square OABC where O is the origin on the number line. Now it is clear that OA= AB = BC=CO = 1 unit.
By Pythagorean Theorem:
$OB^2 = OA^2 + AB^2$
$OB = \sqrt{1^2 + 1^2} = \sqrt{1+1} = \sqrt{2}$ units



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Now draw an arc with 0' as centre and 'OB' (√ 2 units) as radius intersecting the number line at P. Now OP is of length √ 2

Q. Represent √ 3 on the number line.

Exercise 2

Q1. Represent ((√ 3 + 1) on the number line.
Q2. Represent (2 (√2 + 1) and (√ 2 - 1) on the number line
Q3. Draw (√ 5) as Spiral
Q4. Prove that √5 is irrational.
Q5. Prove that $\sqrt[3]{10}$ is irrational.

Decimal Expansion of real numbers

We know that real numbers include both rational and irrationals numbers. Let us take up the rational numbers (fractions) first.

Decimal representation of rational numbers can be:
(1) Terminating (2) Non -terminating and repeating

1. Terminating decimal: Let us convert 6/5 into decimal. For this we have to divide the numerator 6 by the denominator 5 and we get 1.2

2. Non - terminating and repeating decimal: Let us represent 1/6 as decimal. Now you can see that the 6 is repeating in the quotient. This will never terminate (come to an end). We can say that the decimal portion of 1/6 is non -terminating and repeating. To represent non- terminating repeating decimal, we put a bar above the digit or block of digits which is repeating. Thus we can write - 0.16.

Exercise 3

Q1. Convert the following numbers into decimals:
(a) 25/24 (b) 5/10 (c) 8/9 (d) 7/20 (1.04), (0.50) , (0.89), (0.35)

Conversion of Decimals into Fractions

Let us start with a few terminating decimal numbers.

Case 1: Terminating decimals.

Step 1: Count the number of digits to the right hand side of the decimal point.
Step 2: Ignore the decimal point in the given number and write the number as the numerator.
Step 3: Write 1 in the denominator and put as many zeroes, on the right hand side of 1, as the number of digits to the right hand side of decimal point. Now you have got the fraction.
Step 4: Reduce the fraction into the lowest terms by dividing the numerator and denominator by the common factors

Q. Convert 1.75 into rational number. (7/4)

Case 2: Non -terminating & repeating decimals

Non-terminating and repeating decimals are of two types.

(i) Pure repeating decimals:

These are the decimals in which all the digits after decimal point are repeating.
e.g. 0.3, 0.32, 0.675 etc. are pure repeating decimals.

(ii) Mixed repeating decimals

A decimal number in which at least one digit, after the decimal does not repeat and others repeated. e.g. 0.816, 0.7645, 2.1275 etc are mixed repeating decimals.

Case -2(A): Conversion of pure repeating decimals into fractions

Step 1: Put the given decimal number equal to X. Now you get an equation.

Step 2: Remove the bar and write the repeating digits at least twice followed by dots. Name this as Equation (i)
Step 3: If one digit is repeating, multiply the equation by 10, if two digits are repeating. multiply the equation by 100 and so on. Name this as Equation (ii)
Step 4: Subtract Equation (i) from Equation (ii) Now you get a new equation. Name this as Equation (iii)
Step 5: Divide both sides of Equation (iii) by the coefficient of X. Now you have got the required fraction.
Q: Convert $0.\overline{525}$ into its rational form. (525/999)
Case 2(B): Mixed Repeating Decimal
Step 1: Put the given decimal number equal to X. Now you get an equation.
Step 2: Count the number of digits without bar after the decimal point. Let the number of digits without bar he N. Multiply both sides of equation of step 1 by 10^N. Split the resulting number into an integer and a pure repeating decimal.
Step 3: Convert the pure repeating decimal into its rational form by the process given in case 2(A).
Step 4: Add the resulting rational number and the integer obtained in Step 4 to get the required rational number.
Step 5: Divide the equation at Step 6 by 10^N to get the final result.
Q: Convert $2\ \overline{32}6$ in rational form.
(21113/990)
Q: Convert the following rational numbers into decimal form:
(a)25/11 (b)66/25 (c)91/52 ($2.\overline{27}$), (2.64), (1.75)
Q: Convert the following decimals into rational numbers:
(a) 1.22 (b) 0.568 (c) 7.264 (61/50) , (71/125), (908/125)
Q: Convert - 17.555 into rational number. (-3511/200)
Q: Convert the following decimal numbers into the form p/q.
(a) $0.\overline{6}$ (b) $0.\overline{525}$ (c) $6.\overline{7}$ (d) $21.\overline{26}$ (2/3), (525/999), (61/9), (2105/99)

<u>Exercise 4</u>

Q.1 Convert the following decimals in the form p/q.
(a) $2.\overline{8}$ (b) $0.\overline{837}$ (c) $5.\overline{89}$ (26/9), (31/37), (59/10)
Q.2 Convert the following decimals in the form p/q.
(a) $8.\overline{2257}$ (b) $5.3\overline{7}8$ (c) $0.\overline{8}$ (d) $1.\overline{32}9$
(82249/9999), (4841/900), (8/9), (658/495)

<u>Worksheet 1</u>

1 Give two irrational numbers whose quotient is:
(i) rational
(ii) irrational.
2 Construct a square root spiral starting from √2 up to √5.
3. Write two numbers whose decimal expansion is non terminating and nonrepeating.
4. Convert the following decimal numbers into rational number in the form p/q.

ABHYAS Academy, Behind Pragat Shiv Mandir, Near Govt. College, Nishat Cinema Road, Ambala Cantt.
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(i) 0.08 (ii) 1.205 (iii) 0.001 (iv) 3.2125
(2/25), (241/200), (1/1000), (257/80)

5. If a= 3√12 + 2√18 and b= √2 + √3. Find the value of:
(i) a + b (ii) a - b (iii) 2a + 3b (iv) 5a - 4b
(7√3 + 7√2), (5√3 + 5√2), (15√3 + 15√2), (26√3 + 26√2)

6. Insert 3 rational numbers between 4 and 5.

7. Express 3 and - 2 in the form of p/q where p and q are integers and q is not equal to 0.
(6/2 and -4/2)

8 Give two irrational numbers whose sum is rational. (3 - √5, 4 + √5)

9. Give two irrational numbers whose product is: (2√5, √5), (2√3, √2)
(i) rational (ii) irrational

10. Locate √2 and √3 on the number line.

11. Locate the points representing √2 + 1 and √2 - 1 on the number line.

Worksheet 2

1. Write the decimal representation of 3/24 and 3/35. (0.125, 0.0857143)

2. Convert the following decimal numbers in p/q form:
(a) $0.\overline{312}$ (b) $0.\overline{092}$ (c) $0.\overline{12345}$ (d) 0.4 (e) $2.213\overline{47}$
(104/333), (92/999), (4115/33333), (2/5), (221126/99900)

3. Classify the following numbers as rational or irrational.
(i) √2 (ii) √324 (iii) 0.125 (iv) 0.934984.. (v) 4.02121121112....
(Irrational, Rational, Rational, Irrational, Irrational)

4. Insert 4 rational numbers between 2/5 and 3/5.

5. State which of the following fractions are convertible into terminating decimals.
(a) 33/18 (b) 4/25 (c) 5/15 (d)5/13
(4/25)

7. Write two numbers whose decimal expansions are non-terminating and non-repeating.

8. Convert the following decimal numbers in p/q form:
(i) 0.08 (ii) 1.205 (iii) 0.001 (iv) 3.2125
(2/25), (241/200), (1/1000), (257,80)

9. Find four irrational numbers between 1/3 and 2/3.

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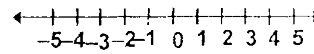

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Note:

1. Every integer is a rational number as it can be written as a fraction.
2. Zero is also a rational number because zero can be written as 0/1 = 0
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Find rational numbers lying between two given rational numbers

Step1: Add the given two rational numbers and divide the sum by 2. The answer is a rational number between the given two numbers.

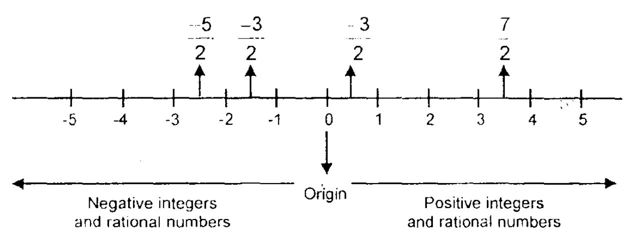
Step2: You have got one rational number in STEP I. Take that rational number and one of the given numbers and find their sum. Divide the sum by 2. You will get one more rational number. Repeat this process to get as many rational numbers as you need.

Alternate Method

1. Suppose you want to find 5 rational numbers between 3 and 4. Let these rational numbers be R1, R2, R3, R4 and R5. Now if you put these numbers between 3 and 4 you will get the following; 3, R1, R2, R3, R4, R5, 4
2. Now there are 7 numbers in this group and you have to find out R1, R2, R3, R4 and R5. For this write the given rational numbers 3 and 4 with the denominator 7 as follows
3. You know that 3 = 21/ 7 and 4 = 28/7. Now your job has become very easy. You have to just find out 5 fractions between 21/7 and 28/7. Surely your answer will be 22/7, 23/7, 24/7, 25/7, 26/7. If we have to find rational numbers between two fractions, we will first make the denominators same then we will multiply the numerator and denominator by the number of rational numbers to be found between them.

Number line: All the integers and non-integral fractions taken together form a large group called rational numbers. Rational numbers can be represented on a line called number line. 0' is placed at the centre of the line and this point is called the origin Positive numbers lie on the right side of the origin and negative numbers lie on the left side of the origin.

Exercise 1



Q.1 Find at least 5 rational numbers lying between 1/3 and 2/3. (6/15, 7/15, 8/15 and 9/15

Q.2 Represent following points on the number line.

(i) 5 (ii) -4 (iii) 3.5 (iv) - 0.5

Q.3 Find four rational numbers between 1/5 and 2/5

Q.4 Mark as true or false:
(i) All the whole numbers are natural numbers.
(ii) All the natural numbers are integers
(iii) All the integers are whole numbers.

Irrational Numbers: these are the numbers which are not rational. That means numbers which are not fractions i.e. they cannot be written as fractions.

Definition of an irrational Number: A number s is called irrational, if it cannot be written in the form of where p and 'q' are integers and q not equal to 0. Numbers like $\sqrt{2}$, $\sqrt{3}$ are the examples of irrational numbers. Decimal numbers like 0.101001000100001 are also irrational numbers.

Properties of Irrational Numbers:

(1) Negative of an irrational number is also irrational. e.g. Both and $\sqrt{2}$ and $-\sqrt{2}$ are irrationals.
(2) Sum of a rational and an irrational number is always an irrational. e.g. $2+\sqrt{2}$, $2-\sqrt{2}$ are irrationals.
(3) Product of a nonzero rational number and an irrational number is an irrational number. e.g. $2\times\sqrt{2}$ is irrationals.
(4) Sum, difference, product and quotient of irrational numbers can be rational or irrational
(a) $\sqrt{2} + (-\sqrt{2}) = 0$: Rational number.
(b) $\sqrt{3} - \sqrt{3} = 0$: Rational number.
(c) $\sqrt{2} \times \sqrt{2} = 2$: Rational number.
(d) $\sqrt{2} / \sqrt{2} = 1$: Rational number.
(e) $\sqrt{2} + \sqrt{2} = 2\sqrt{2}$: Irrational number.
(f) $\sqrt{2} \times \sqrt{3} = \sqrt{6}$: Irrational number.

Now, we have seen that there are two types of numbers on the number line namely rational numbers and irrational numbers.
<u>Rational numbers and irrational numbers taken together will form a large group called real numbers</u>. This makes the following 2 points clear:
1. Every point on the number line represents a particular real number.
2. Every real number is represented by a particular point on the number line.

Finding irrational numbers between two number: if x and y are two rational or irrational numbers then $\sqrt{xy}$ is between x and y. for example irrational numbers between 5 and 7 is $\sqrt{35}$

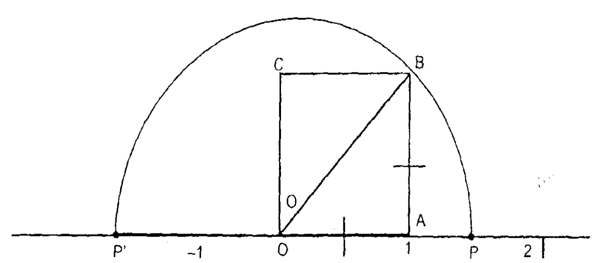
Eg: Writing an irrational number between 2.3 and 2.89 can be 2.3010010001… or 2.4010010001…

Representation of real number on the number line.

To represent a real number on the number line, all you have to do is to locate the point related to that number on the number line

<u>Irrational Number On a Number Line:</u> Location of $\sqrt{2}$ on number line.

Construct a unit square OABC where O is the origin on the number line. Now it is clear that OA= AB = BC=CO = 1 unit.
By Pythagorean Theorem:
$OB^2 = OA^2 + AB^2$
$OB = \sqrt{1^2 + 1^2} = \sqrt{1+1} = \sqrt{2}$ units



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Now draw an arc with 0' as centre and 'OB' (√ 2 units) as radius intersecting the number line at P. Now OP is of length √ 2

Q. Represent √ 3 on the number line.

<u>Exercise 2</u>

Q1. Represent ((√ 3 + 1) on the number line.

Q2. Represent (2 (√2 + 1) and (√ 2 - 1) on the number line

Q3. Draw (√ 5) as Spiral

Q4. Prove that √5 is irrational.

Q5. Prove that $\sqrt[3]{10}$ is irrational.

<u>Decimal Expansion of real numbers</u>

We know that real numbers include both rational and irrationals numbers. Let us take up the rational numbers (fractions) first.

Decimal representation of rational numbers can be:

(1) Terminating (2) Non -terminating and repeating

1. <u>Terminating decimal</u>: Let us convert 6/5 into decimal. For this we have to divide the numerator 6 by the denominator 5 and we get 1.2

2. <u>Non - terminating and repeating decimal</u>: Let us represent 1/6 as decimal. Now you can see that the 6 is repeating in the quotient. This will never terminate (come to an end). We can say that the decimal portion of 1/6 is non -terminating and repeating. To represent non- terminating repeating decimal, we put a bar above the digit or block of digits which is repeating. Thus we can write - 0.16.

<u>Exercise 3</u>

Q1. Convert the following numbers into decimals:

(a) 25/24 (b) 5/10 (c) 8/9 (d) 7/20 (1.04), (0.50) , (0.89), (0.35)

<u>Conversion of Decimals into Fractions</u>

Let us start with a few terminating decimal numbers.

Case 1: Terminating decimals.

Step 1: Count the number of digits to the right hand side of the decimal point.

Step 2: Ignore the decimal point in the given number and write the number as the numerator.

Step 3: Write 1 in the denominator and put as many zeroes, on the right hand side of 1, as the number of digits to the right hand side of decimal point. Now you have got the fraction.

Step 4: Reduce the fraction into the lowest terms by dividing the numerator and denominator by the common factors

Q. Convert 1.75 into rational number. (7/4)

Case 2: Non -terminating & repeating decimals

Non-terminating and repeating decimals are of two types.

(i) Pure repeating decimals:

These are the decimals in which all the digits after decimal point are repeating.

e.g. $0.\overline{3}$, 0.32, 0.675 etc. are pure repeating decimals.

(ii) Mixed repeating decimals

A decimal number in which at least one digit, after the decimal does not repeat and others repeated. e.g. 0.816, 0.7645, 2.1275 etc are mixed repeating decimals.

Case -2(A): Conversion of pure repeating decimals into fractions

Step 1: Put the given decimal number equal to X. Now you get an equation.

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Step 2: Remove the bar and write the repeating digits at least twice followed by dots. Name this as Equation (i)
Step 3: If one digit is repeating, multiply the equation by 10, if two digits are repeating. multiply the equation by 100 and so on. Name this as Equation (ii)
Step 4: Subtract Equation (i) from Equation (ii) Now you get a new equation. Name this as Equation (iii)
Step 5: Divide both sides of Equation (iii) by the coefficient of X. Now you have got the required fraction.
Q: Convert $0.\overline{525}$ into its rational form. (525/999)

Case 2(B): Mixed Repeating Decimal

Step 1: Put the given decimal number equal to X. Now you get an equation.
Step 2: Count the number of digits without bar after the decimal point. Let the number of digits without bar he N. Multiply both sides of equation of step 1 by 10^N. Split the resulting number into an integer and a pure repeating decimal.
Step 3: Convert the pure repeating decimal into its rational form by the process given in case 2(A).
Step 4: Add the resulting rational number and the integer obtained in Step 4 to get the required rational number.
Step 5: Divide the equation at Step 6 by 10^N to get the final result.
Q: Convert 2 $3\overline{26}$ in rational form. (21113/990)
Q: Convert the following rational numbers into decimal form:
(a)25/11 (b)66/25 (c)91/52 ($2.\overline{27}$), (2.64), (1.75)
Q: Convert the following decimals into rational numbers:
(a) 1.22 (b) 0.568 (c) 7.264 (61/50) , (71/125), (908/125)
Q: Convert - 17.555 into rational number. (-3511/200)
Q: Convert the following decimal numbers into the form p/q.
(a) $0.\overline{6}$ (b) $0.\overline{525}$ (c) $6.\overline{7}$ (d) $21.\overline{26}$ (2/3), (525/999), (61/9), (2105/99)

Exercise 4

Q.1 Convert the following decimals in the form p/q.
(a) $2.\overline{8}$ (b) $0.\overline{837}$ (c) $5.\overline{89}$ (26/9), (31/37), (59/10)
Q.2 Convert the following decimals in the form p/q.
(a) $8.\overline{2257}$ (b) $5.3\overline{7}8$ (c) $0.\overline{8}$ (d) $1.3\overline{29}$
(82249/9999), (4841/900), (8/9), (658/495)

Worksheet 1

1 Give two irrational numbers whose quotient is:
(i) rational
(ii) irrational.
2 Construct a square root spiral starting from $\sqrt{2}$ up to $\sqrt{5}$.
3. Write two numbers whose decimal expansion is non terminating and nonrepeating.
4. Convert the following decimal numbers into rational number in the form p/q.

(i) 0.08 (ii) 1.205 (iii) 0.001 (iv) 3.2125

(2/25), (241/200), (1/1000), (257/80)

5. If a= 3√12 + 2√18 and b= √2 + √3. Find the value of:

(i) a + b (ii) a - b (iii) 2a + 3b (iv) 5a - 4b

(7√3 + 7√2), (5√3 + 5√2), (15√3 + 15√2), (26√3 + 26√2)

6. Insert 3 rational numbers between 4 and 5.

7. Express 3 and - 2 in the form of p/q where p and q are integers and q is not equal to 0.

(6/2 and -4/2)

8 Give two irrational numbers whose sum is rational. (3 - √5, 4 + √5)

9. Give two irrational numbers whose product is: (2√5, √5), (2√3, √2)

(i) rational (ii) irrational

10. Locate √2 and √3 on the number line.

11. Locate the points representing √2 + 1 and √2 - 1 on the number line.

Worksheet 2

1. Write the decimal representation of 3/24 and 3/35. (0.125, 0.0857143)

2. Convert the following decimal numbers in p/q form:

(a) $0.\overline{312}$ (b) $0.\overline{092}$ (c) $0.\overline{12345}$ (d) 0.4 (e) 2 .21347

(104/333), (92/999), (4115/33333), (2/5), (221126/99900)

3. Classify the following numbers as rational or irrational.

(i) √2 (ii) √324 (iii) 0.125 (iv) 0.934984.. (v) 4.02121121112....

(Irrational, Rational, Rational, Irrational, Irrational)

4. Insert 4 rational numbers between 2/5 and 3/5.

5. State which of the following fractions are convertible into terminating decimals.

(a) 33/18 (b) 4/25 (c) 5/15 (d)5/13

(4/25)

7. Write two numbers whose decimal expansions are non-terminating and non-repeating.

8. Convert the following decimal numbers in p/q form:

(i) 0.08 (ii) 1.205 (iii) 0.001 (iv) 3.2125

(2/25), (241/200), (1/1000), (257,80)

9. Find four irrational numbers between 1/3 and 2/3.

10 Find four irrational numbers between 5 and 6.