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ENGINEERING APTITUDE
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(QUANTATIVE APTITUDE AND ANALYTICAL ABILITY)

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PREFACE

Union Public Services Commission (UPSC) in its quest for best engineering minds looks for the very basic pride of an engineer, which it tests through your quantitative and analytical abilities. The profession itself calls for putting you in situations, both human and technical, where things are tied into hundred knots. As an engineer you are expected to think critically, detect systematic themes while analysing data, and achieve thoroughness with accuracy in deriving solutions under challenging circumstances.

To test these qualities in an ESE aspirant, in the year 2016, UPSC introduced Engineering Aptitude as a part of the syllabus for common paper of ESE in 2016. With an objective to develop these abilities, IES Master has come up with this Engineering Aptitude book that brings you face-to-face with thousands of problems under various sub-heads such as probability, polynomials, speed-time, work-time, clock and calendar, as well as geometry and measurements that you might encounter as a professional. Covering 171 topics under 25 chapters in 5 units, this book is an effort by IES Master to expose you to the complete theory of ESE syllabus along with previous years questions from UPSC (last 38 years), GATE (last 9 years), and ESE (last 2 years).

As you flip through the pages of this book, it captures your imagination with subtleness, and exposes you to more than 1,200 problems, enough to give your pen the required strength to take on any competitive exams including ESE, GATE and PSUs.

Under the expert guidance of **Mr Kanchan Kumar Thakur (Ex-IES), Mr Puneet Sharma**, who has more than 14 years of teaching, has tamed the tornado that will blow you away, with its concept clarity and conciseness. Having gone through it, we hope that as your fingers follow your command, the brain will engineer solutions no matter how difficult the challenge is.

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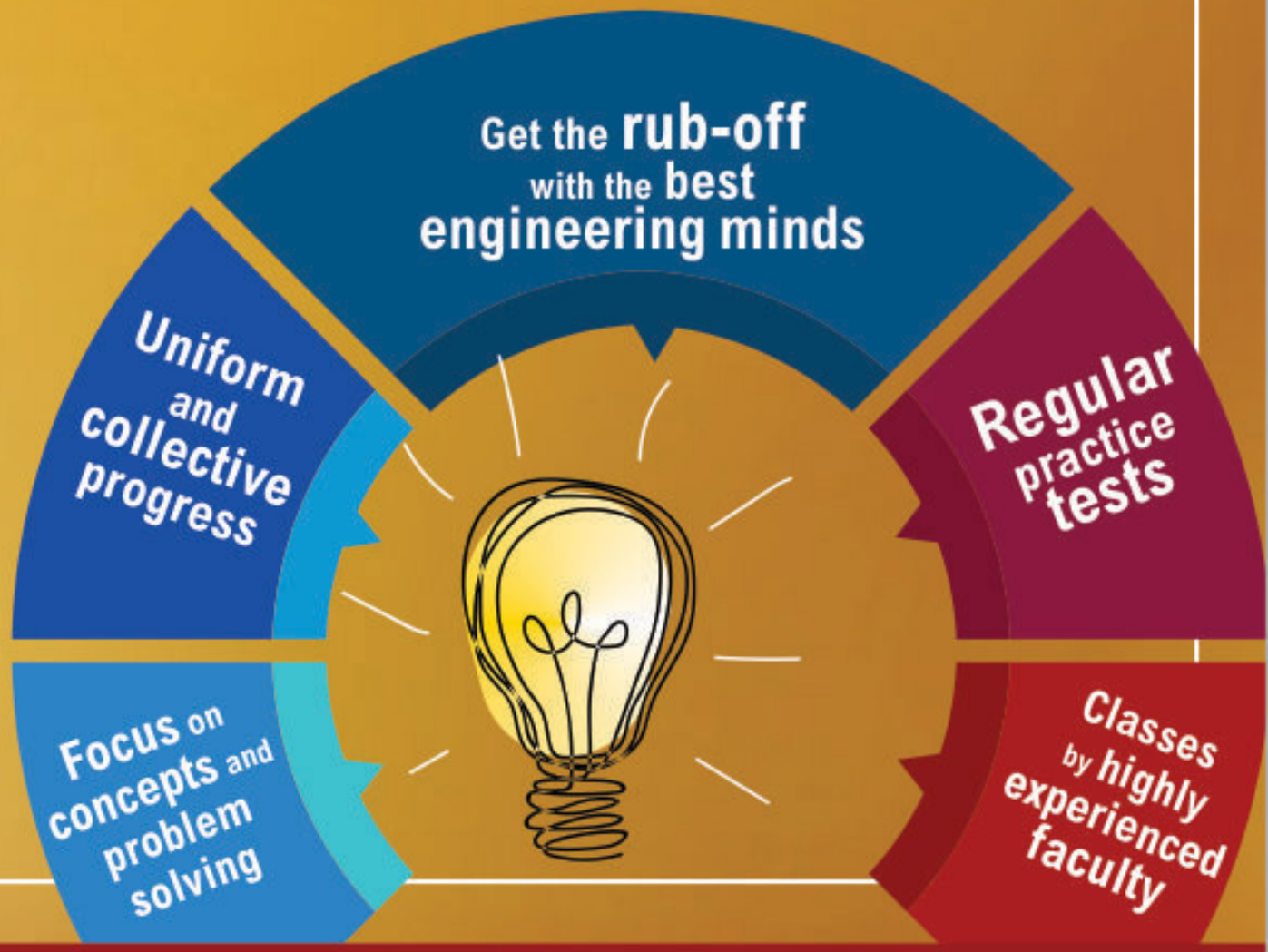

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UNIT 3 : CRITICAL REASONING

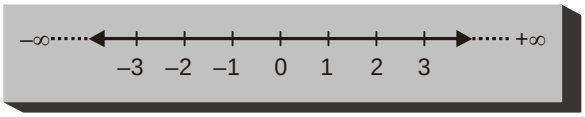
UNIT 4 : MODERN MATHS

UNIT 5 : DATA INTERPRETATION

1.1 NUMBER SYSTEM

NUMBER LINE

Number line is a line on which all the positive and negative numbers can be represent in a sequence. It stretches from negative infinity to positive infinity.



DEFINITION OF VARIOUS TYPES OF NUMBERS

Natural Numbers

Counting Numbers 1, 2, 3, 4, ... are called Natural Numbers. The symbolic representation is N, i.e.,

N = {1, 2, 3, 4, 5, ...}.

Whole Numbers

All the natural numbers together with '0' are called Whole Numbers and the symbolic representation is W, i.e., W = {0, 1, 2, 3, 4, ...}

Integers

An integer is a number that can be written without a fractional component, it is represented by 'Z'.
Integers are further classified into positive integers (2, 4, 5 etc.), zero (0) and negative integers (–2, –5 etc.).

Rational Numbers

A number which can be expressed in the form of $\frac{p}{q}$ where, p and q are integers and $q \neq 0$, is called a rational number.

For example : *Any integer number is a rational number since, it can be written as the ratio of two integer numbers, one the integer number itself and another number is 1.*

Other examples of rational number are $\frac{2}{3}, -\frac{3}{7}, \ldots$ etc.

Note : *A decimal represents a rational number if and only if it has a finite number of digits. But recurring decimals are exceptions as they are also assumed as Rational Numbers, i.e., all recurring decimals are rational numbers.*

Irrational Numbers

A real number, which is not rational, is called **irrational number**. An irrational number has non-terminating and non-recurring decimal part.

Between any two numbers, there are infinite numbers of irrational numbers.

Examples of irrational numbers are : $\sqrt{3}, \sqrt{5}, \sqrt[3]{7}, \sqrt[4]{11}$

Numbers π and e are also irrational number because both have non-terminating and non-recurring decimal part.

π = 3.14159265358979… and e = 2.71828182859045… where, e is called Euler's number.

Note : *Any terminating* ***or*** *recurring decimal is a rational number. Any non-terminating* ***and*** *non-recurring decimal is an irrational number.*

Example 1

Which one of the following is not a rational number?

(a) $\frac{3}{8}$ (b) $-\frac{111}{23}$ (c) $\sqrt{2}$ (d) None of these

Sol. (c)

The number is option (a) and (b) are rational numbers, as they are the ratio of two integers. The number $\sqrt{2}$ is non-recurring, so it is not a rational number.

Real Numbers

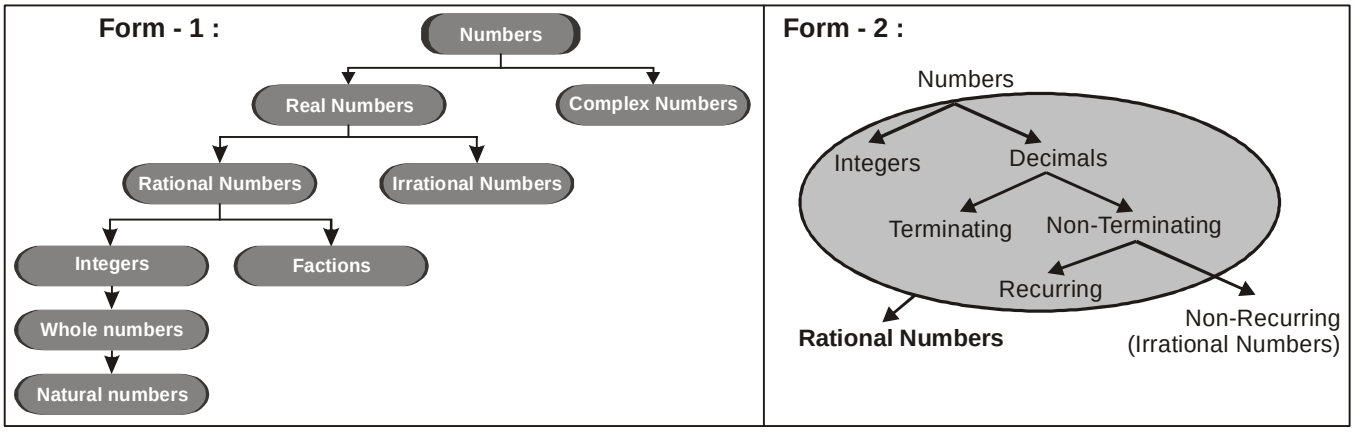
The real numbers include all the measuring numbers. The symbol for the real number is R. **All the numbers which can be represented on the number line are called real numbers.**

Complex Numbers

All the numbers that can be represented in a + ib form where a & b are real numbers and i = $\sqrt{-1}$ are called Complex Numbers.

$$C = \{a + ib; a, b \in R \ \& \ i^2 = -1\}$$

VARIOUS FORMS OF NUMBER TREE



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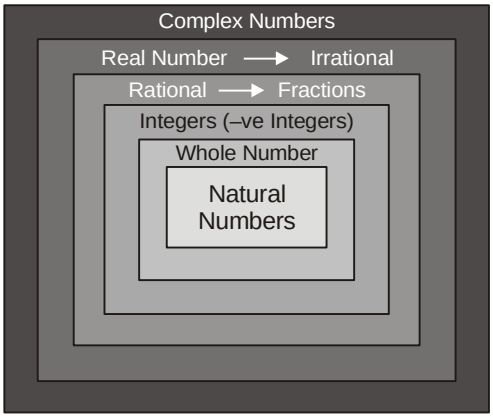

Example 2

Consider the following statements :

I. Every natural number is a real number.
II. Every real number is a rational number.
III. Every integer is a real number.
IV. Every rational number is a real number.

Which of the above statements are correct?

(a) I, II and III (b) I, III and IV (c) II and III (d) III and IV

Sol. (b)

From the number tree, given above, all natural numbers are real numbers but its converse is not true. So, statement (I) is true.

Every real number is not a rational number, some may be irrational numbers. Hence, statement (II) is wrong.

Similarly, from number tree, we can say about statement (III) and (IV) that both the statements are true.

Recurring Decimals

A decimal in which a digit or a set of digits is repeated continuously is called a recurring decimal. For representing recurring decimal, we place bar on the repeated numbers.

For example : (i) The number *0.247632476324763* … can be represented as $0.\overline{24763}$

(ii) and similarly, the number 0.1555 … can be represented as $0.1\bar{5}$

Example 3

Express the recurring decimal $0.\overline{230}$ in the form of a fraction.

Sol.

The given decimal can be written as $0.\overline{230} = 0.230230230\ldots$ …(i)

As the bar is placed on **three digits**, so, we will multiply the above equation by 10^3

$$0.\overline{230} \times 10^3 = 230.230230\ldots \quad \ldots(ii)$$

From equation (i) and (ii), we can write

$$(10^3 - 1)\, 0.\overline{230} = 230 \quad \text{or} \quad 0.\overline{230} = \frac{230}{10^3 - 1} = \frac{230}{999}$$

Example 4

The value of $1.\overline{34} + 4.1\bar{2}$ is

(a) $\frac{133}{90}$ (b) $\frac{371}{90}$ (c) $5\frac{219}{990}$ (d) $5\frac{461}{990}$

Sol. (d)

The decimal $1.\overline{34}$ can be written as $1.\overline{34} = 1.343434\ldots$ …(i)

As the bar is placed on two digits after decimal point, so, we will multiply the above equation by 10^2

$$1.\overline{34} \times 10^2 = 134.3434\ldots \quad \ldots(ii)$$

From equation (i) and (ii)

$$(10^2 - 1)\, 1.\overline{34} = 133 \qquad \therefore \quad 1.\overline{34} = \frac{133}{99}$$

In $4.1\bar{2}$, the bar is place on one digit so it can be written as $4.1\bar{2} = 4.1222\ldots$ …(i)

by multiplying 10^2 in above equation $4.1\bar{2} \times 10^2 = 412.222\ldots$ …(ii)

PREVIOUS YEARS QUESTIONS
UPSC/GATE/ESE

1. Product of 82540027 and 43253 is

(a) 3570403787831 (b) 3570403787832

(c) 3570403787833 (d) 3570403787834

[UPSC–1985]

2. In binary system, 1010 is equivalent to

(a) 8 (b) 9

(c) 10 (d) 11 **[UPSC–1986]**

3. If n is an integer between 20 and 80, then any of the following could be (n + 7) except

(a) 47 (b) 58

(c) 84 (d) 88 **[UPSC–1988]**

4. Zero was invented by

(a) Aryabhata (b) Varahamihira

(c) Bhaskara I (d) An unknown Indian

[UPSC–1995]

5. A person has to completely put each of three liquids: 403 litres of petrol, 465 litres of diesel and 496 litres of mobil oil in bottles of equal size without mixing any of the above three types of liquids such that each bottle is completely filled. What is the least possible number of bottles required?

(a) 34 (b) 44

(c) 46 (d) None of the above

[UPSC–2007]

6. Four metal rods of lengths 78 cm, 104 cm, 117cm and 169 cm are to be cut into parts of equal length. Each part must be as long as possible. What is the maximum number of pieces that can be cut?

(a) 27 (b) 36

(c) 43 (d) 480 **[UPSC–2009]**

7. Three bells toll at intervals of 9, 12 and 15 minutes respectively. All the three begin to toll at 8am. At what time will they first toll together again?

(a) 08:45 am (b) 10:30 am

(c) 11:00 am (d) 01:30 pm

[UPSC–2013]

8. There are five hobby clubs in a college viz, photography, yachting, chess, electronics and gardening. The gardening group meets every second day, the electronics group meets every third day, the chess group meets every fourth day, the yachting group meets every fifth day and the photography group meets every sixth day. How many times do all the five groups meet on the same day within 180 days?

(a) 3 (b) 5

(c) 10 (d) 18 **[UPSC–2013]**

9. A gardener has 1000 plants. He wants to plan them in such a way that the number of rows and the number of columns remains the same. What is the minimum number of plants that he needs more for this purpose?

(a) 14 (b) 24

(c) 32 (d) 34 **[UPSC–2013]**

10. Three persons start walking together and their steps measure 40 cm, 42 cm and 45 cm respectively. What is the minimum distance each should walk so that each can cover the same distance in complete steps?

(a) 25.20 m (b) 50.40 m

(c) 75.60 m (d) 100.80 m

[UPSC–2013]

11. Five persons fire bullets at a target at an interval of 6, 7, 8, 9 and 12 sec. respectively. The number of times they would fire the bullets together at the target in an hour is.

(a) 6 (b) 7

(c) 8 (d) 9 **[UPSC–2014]**

12. The question is followed by two statements I and II. Mark the answer as

(a) if the question can be answered with the help of statement I alone.

(b) if the question can be answered with the help of statement II, alone.

(c) if both statement I and statement II are needed to answer the question.

(d) if the question cannot be answered even with the help of both the statements.

If x, y and z are real numbers, is z – x even or odd?

(I) xyz is odd.

(II) xy + yz + zx is even. **[UPSC–2014]**

ANSWER KEY

1.	(a)	7.	(c)	13.	(b)	19.	(d)	25.	(d)	31.	(d)
2.	(c)	8.	(a)	14.	(c)	20.	(c)	26.	(a)	32.	(b)
3.	(d)	9.	(b)	15.	(d)	21.	(c)	27.	(d)	33.	(d)
4.	(d)	10.	(a)	16.	(b)	22.	(7)	28.	(b)	34.	(b)
5.	(b)	11.	(b)	17.	(c)	23.	(a)	29.	(b)	35.	(c)
6.	(b)	12.	(a)	18.	(d)	24.	(c)	30.	(b)		

EXPLANATIONS

1. (a)

In this problem, we will see only last digits. These are 7 and 3 respectively. Hence, last digit of the product of two numbers will be 1. Hence, option (a) is correct.

2. (c)

$(1001)_2 = 1 \times 2^3 + 0 \times 2^2 + 0 \times 2^1 + 1 \times 2^0 = 9$

3. (d)

Given, $20 < n < 80$ So, $20 + 7 < (n + 7) < 80 + 7$

or, $27 < (n + 7) < 87$.

Hence, option (d) is not possible.

4. (d)

It is not clear whether Brahm Gupta or Aryabhata was the inventor of zero.

So, **option (d).**

5. (b)

The size of bottle required to be filled

= HCF of (403, 465 and 1496 litres)

= 31 litres

The minimum possible number of bottles required

$$= \frac{403}{31} + \frac{465}{31} + \frac{496}{31} = 13 + 15 + 16 = 44$$

6. (b)

The maximum equal size of each piece = HCF of (78 cm, 104 cm, 117 cm and 169 cm)

By factorisation method, HCF can be found as below

$78 = 2 \times 3 \times 13$

$104 = 2 \times 2 \times 2 \times 13$

$117 = 3 \times 3 \times 13$

$169 = 13 \times 13$

HCF = 13 cm

$\therefore$ The required number of pieces

$$= \left(\frac{78}{13} + \frac{104}{13} + \frac{117}{13} + \frac{169}{13}\right)$$

$= (6 + 8 + 9 + 13) = 36$

7. (c)

The time direction after which each bell toll

= LCM of (9, 12 and 15 min.)

= 180 min. = 3 hrs

$\therefore$ If all the three begin to toll at 8:00 AM then the next toll together again = 8 + 3 = 11:00 AM

8. (a)

The number of days after which all the five groups meet same day

= LCM of (2, 3, 4, 5 and 6 days) = 60 days

$\therefore$ The number of times all the groups meet on the same day within 180 days $= \frac{180}{60} = 3$ times

9. (b)

As the number of columns and rows are same so, the number of plants will be a perfect square (i.e. n^2).

The perfect square just greater than 1000 is 1024 so, the number of plants needed

= 1024 – 1000

= 24 plants

10. (a)

The required distance = LCM of (40 cm, 42 cm and 45 cm).

By factorisation method, the LCM can be found as below.

$40 = 2 \times 2 \times 2 \times 5$

$42 = 2 \times 3 \times 7$

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