

ENGINEERING APTITUDE

(QUANTITATIVE APTITUDE & ANALYTICAL ABILITY)

ESE | GATE | PSUs

2020



- ▶ MORE THAN 170 TOPICS COVERED
- ▶ 380+ CHAPTERWISE PRACTICE QUESTIONS WITH DETAILED SOLUTIONS
- ▶ 530+ THEORETICAL EXAMPLES FOR IN-DEPTH UNDERSTANDING
- ▶ 630+ PREVIOUS YEARS QUESTIONS WITH DETAILED SOLUTIONS UPSC (39 YRS), GATE (10 YRS) & ESE (3 YRS)

ENGINEERING APTITUDE

(QUANTITATIVE APTITUDE AND ANALYTICAL ABILITY)

(For ESE GATE & PSUs Exam)

(CE, ME, PI, CH, EC, EE, IN, CS, IT)

Salient Features :

- More than 170 topics covered
- 530+ theoretical examples for in-depth understanding
- 380+ chapterwise practice questions with detailed solutions
- 630+ previous years questions with detailed solutions
UPSC (39 yrs), GATE (10 yrs) & ESE (3 yrs)



Office : F-126, (Lower Basement), Katwaria Sarai, New Delhi-110016 • **Phone :** 011-26522064
Mobile : 8130909220, 9711853908 • **E-mail:** info.publications@iesmaster.org, info@iesmaster.org
Web : iesmasterpublications.com, iesmaster.org



IES MASTER PUBLICATION

F-126, (Lower Basement), Katwaria Sarai, New Delhi-110016

Phone : 011-26522064, **Mobile** : 8130909220, 9711853908

E-mail : info.publications@iesmaster.org

Web : iesmasterpublications.com

All rights reserved.

Copyright © 2019, by IES MASTER Publication. No part of this booklet may be reproduced, or distributed in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise or stored in a database or retrieval system without the prior permission of IES MASTER Publication, New Delhi. Violates are liable to be legally prosecuted.

First Edition : 2017

Second Edition : 2018

Third Edition : 2019

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 quantitative and analytical abilities of candidates. The profession itself calls for putting candidates in situations, both human and technical, where things are tied into hundred knots. As an engineer one is 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 the common paper of ESE in 2016. With an objective to develop these abilities, IES Master has come up with the revised and updated **third edition** of the book Engineering Aptitude that acquaints an ESE aspirant to 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 they might come across during their professional career. Covering more than **170 topics under 25 chapters in 5 units**, this book is an effort by IES Master to offer the complete theory of ESE syllabus along with previous years questions from **UPSC (last 39 years), GATE (last 10 years), and ESE (last 3 years) to the ESE aspirants.**

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.

Having gone through the clarity and conciseness offered in this revised edition, we hope that as your fingers follow your command, the brain will engineer solutions no matter how difficult the challenge is.

IES Master Publication

New Delhi

CONTENTS

UNIT 1 : QUANTITATIVE APTITUDE

1.1	Number System	01–41
	(i) Number Line	01
	(ii) Definition of Various Types of Numbers	01
	(iii) Various forms of Number	02
	(iv) Concept of Prime and Composite Numbers	04
	(v) Factorization	06
	(vi) Factorial	06
	(vii) Factorization of Factorial	07
	(viii) Last Digit Problems	09
	(ix) Number of Zeros at the End of any Product	10
	(x) Divisibility Rules	11
	(xi) Relations between Dividend, Divisor and Quotient.....	14
	(xii) Successive Division	14
	(xiii) Remainder Theorem	15
	(xiv) LCM and HCF	18
	(xv) Indices or Powers	25
	(xvi) Surds	26
	(xvii) Simplification	28
	<i>Solved Examples</i>	31
	<i>Previous Years Questions UPSC/GATE/ESE</i>	34
1.2	Ratio and Proportion	42–55
	(i) Ratio	42
	(ii) Proportion	44
	(iii) Partnership.....	47
	<i>Solved Examples</i>	48
	<i>Previous Years Questions UPSC/GATE/ESE</i>	49

1.3	Percentage	56–71
	(i) Percentage	56
	(ii) Concept of Multiplying Factors	57
	(iii) Successive Percentage Change	58
	<i>Solved Examples</i>	61
	<i>Previous Years Questions UPSC/GATE/ESE</i>	62
1.4	Profit and Loss	72–85
	(i) Gain	72
	(ii) Loss	72
	(iii) Concept of Multiplying Factor Related to Profit and Loss	72
	(iv) Discount	76
	(v) Three Special Cases of Gain and Loss	77
	<i>Solved Examples</i>	79
	<i>Previous Years Questions UPSC/GATE/ESE</i>	82
1.5	Simple Interest and Compound Interest	86–93
	(i) Simple Interest	86
	(ii) Compound Interest	86
	(iii) Difference between CI and SI for First Two Years	88
	<i>Solved Examples</i>	90
	<i>Previous Years Questions UPSC/GATE/ESE</i>	93
1.6	Average and Alligation	94–119
	(i) Average	94
	(ii) Problems based on Ages	96
	(iii) Weighted Average	98
	(iv) Alligation	99
	(v) Problems based on Mixture of Two Liquids	104
	(vi) Addition of Pure Solution in a Mixture	105
	(vii) Removal and Replacement	106
	<i>Solved Examples</i>	110
	<i>Previous Years Questions UPSC/GATE/ESE</i>	114

1.7	Time and Work	120–139
(i)	Concept of Variation	120
(ii)	Work-Time	121
(iii)	Men Days	122
(iv)	Types of Questions	123
	<i>Solved Examples</i>	128
	<i>Previous Years Questions UPSC/GATE/ESE</i>	132
1.8	Speed, Distance and Time	140–167
(i)	Speed	140
(ii)	Analysis of Speed, Distance and Time Relationship	141
(iii)	Average Speed	143
(iv)	Relative Speed	145
(v)	Boats and Streams	146
(vi)	Linear and Circular Races	147
	<i>Solved Examples</i>	152
	<i>Previous Years Questions UPSC/GATE/ESE</i>	157
1.9	Geometry and Mensuration	168–224
(i)	Basic Concepts	168
(ii)	Polygon	172
(iii)	Triangle	175
(iv)	Triangle Classification	176
(v)	Similar Triangles	182
(vi)	Quadrilaterals	187
(vii)	Perimeter and Areas of Quadrilaterals	189
(viii)	Hexagon	191
(ix)	Circle	191
(x)	Properties of Circle	192
(xi)	Mensuration	198
	<i>Solved Examples</i>	203
	<i>Previous Years Questions UPSC/GATE/ESE</i>	211

UNIT 2 : ANALYTICAL REASONING

2.1	Ranking Test	225–230
	(i) Introduction	225
	<i>Solved Examples</i>	227
	<i>Previous Years Questions UPSC/GATE/ESE</i>	229
2.2	Dices and Cubes	231–248
	(i) Cubes	231
	(ii) Types of Problems	231
	(iii) Type 1 : Counting of Cubes	231
	(iv) Type 2 : Concept of Dice/Cube with Numbers	232
	(v) Type 3 : (Unfolded Cube/Dice)	234
	(vi) Type 4 : (Maximum Number of Pieces with 'x' Cuts)	235
	(vii) Type 5 : (Minimum Number of Cuts with 'n' Pieces)	236
	(viii) Type 6 : (Colouring of Cubes)	237
	<i>Solved Examples</i>	241
	<i>Previous Years Questions UPSC/GATE/ESE</i>	245
2.3	Direction Sense	249–268
	(i) Introduction	249
	(ii) Reference Compass	249
	(iii) Problem Solving Technique	249
	(iv) Types of Problems	250
	(v) Type I : Shortest Distance Based Questions	250
	(vi) Type II : Direction Based Questions	252
	(vii) Type III : Shadow Based Questions	254
	(viii) Type IV : Clocks Based Questions	255
	(ix) Type V : Faulty Compass Based Questions	256
	(x) Type VI : Rotation Based Questions	256
	<i>Solved Examples</i>	260
	<i>Previous Years Questions UPSC/GATE/ESE</i>	264



IES MASTER

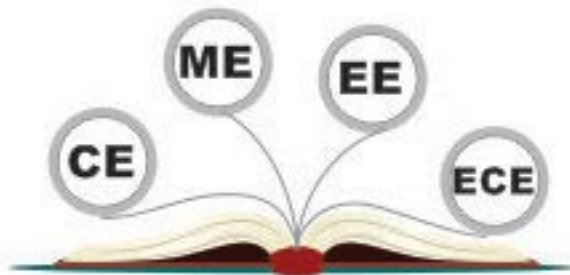
Institute for Engineers (IES/GATE/PSUs)

ESE 2020

Prelims Online Test Series

GS & Engineering Aptitude (Paper-I)

Engineering Discipline Technical (Paper-II)



- Thoroughly researched test papers
- Adheres to real exam layout
- Matches level of UPSC exam
- In-depth clarity to entire syllabus
- Track & monitor your performance
- Comprehensive analytical feedback

Call 97118 53908, 80100 09955



60 Tests

Register Now

2.4	Blood Relationship	269–282
	(i) Introduction	269
	(ii) Symbols Used in Family Diagram	269
	(iii) Types of Questions	270
	(iv) Blood Relation Based on Conversation	270
	(v) Blood Relation Based on Puzzle	273
	(vi) Coded Blood Relationship	274
	<i>Solved Examples</i>	277
	<i>Previous Years Questions UPSC/GATE/ESE</i>	280
2.5	Seating Arrangement	283–299
	(i) Introduction	283
	(ii) Linear Seating Arrangements	283
	(iii) Circular Arrangement	287
	(iv) Two Row Sitting Arrangements	289
	(v) Complex Arrangements	291
	<i>Solved Examples</i>	292
	<i>Previous Years Questions UPSC/GATE/ESE</i>	297
2.6	Coding Decoding	300–310
	(i) Introduction	300
	(ii) Type I : Change in Relative Position of Letters	300
	(iii) Type II : Shifting of Letters to Form New Word	300
	(iv) Type III : Coding Letter to Numbers	302
	(v) Type IV : Substitution Based Coding	303
	(vi) Type V : Mixed Number Coding	303
	(vii) Type VI : Mixed Letter Coding	304
	(viii) Type VII : Direct Letter Coding	305
	(ix) Type VIII : Mixed Type Coding	305
	<i>Solved Examples</i>	307
	<i>Previous Years Questions UPSC/GATE/ESE</i>	309
2.7	Puzzles	311–332
	(i) Introduction	311
	<i>Solved Examples</i>	317
	<i>Previous Years Questions UPSC/GATE/ESE</i>	320

2.8	Clocks	333–343
	(i) Clocks	333
	(ii) Types of Problems	334
	(iii) Type 1: Angle Between Two Hands (when time is given).....	334
	(iv) Type 2 : Time (when angle between two hands is given).....	334
	(v) Type 3 : Slow and Fast Clocks	336
	(vi) Type 4 : Overall Gain or Loss of Time	336
	(vii) Type 5 : Mirror Based Problems	337
	<i>Solved Examples</i>	338
	<i>Previous Years Questions UPSC/GATE/ESE</i>	340
2.9	Calendars	344–350
	(i) Concepts of Extra Days (or) Odd Days	344
	(ii) Important Points	344
	(iii) Types of Problems	345
	<i>Solved Examples</i>	348
	<i>Previous Years Questions UPSC/GATE/ESE</i>	350
UNIT 3 : CRITICAL REASONING		
3.1	Basic Concepts of Syllogism.....	351–375
	(i) Introduction	351
	(ii) Basic Terminology	351
	(iii) Classification of Propositions	353
	(iv) Elimination Techniques of Venn Diagrams	356
	(v) Adjectives in Syllogism	357
	(vi) Conclusions from Multiple Statements	357
	(vii) Types of Conclusions	358
	(viii) Special Case (The Case of “EITHER ... OR ...”)	359
	<i>Solved Examples</i>	361
	<i>Previous Years Questions UPSC/GATE/ESE</i>	374
3.2	Critical Reasoning	376–395
	(i) Introduction	376
	(ii) Basic Terminology	376
	(iii) Steps Followed in Critical Reasoning	376
	(iv) Types of Questions	377
	<i>Solved Examples</i>	383
	<i>Previous Years Questions UPSC/GATE/ESE</i>	392

UNIT 4 : MODERN MATHS

4.1	Sequences and Series	396–425
	(i) Sequence	396
	(ii) Series	396
	(iii) Arithmetic Progression (AP)	396
	(iv) Geometric Progression (GP)	397
	(v) Arithmetico–Geometric Progression (AGP)	403
	(vi) Harmonic Progression (HP)	404
	(vii) Sum of General Series	405
	(viii) Hidden Sequences	408
	<i>Solved Examples</i>	409
	<i>Previous Years Questions UPSC/GATE/ESE</i>	416
4.2	Polynomials	426–461
	(i) Introduction	426
	(ii) Algebraic Expression and Various Terms	426
	(iii) Graph of Elementary Functions	428
	(iv) Linear Equation	429
	(v) Quadratic Equations	431
	(vi) Roots of a Polynomial of Higher Degree	435
	(vii) Maximum and Minimum Values of a Polynomial	437
	(viii) Inequalities	438
	(ix) Quadratic Inequalities	440
	(x) Modulus	442
	(xi) Logarithms	443
	(xii) Logarithmic Inequalities	446
	<i>Solved Examples</i>	448
	<i>Previous Years Questions UPSC/GATE/ESE</i>	453
4.3	Set Theory	462–481
	(i) Set	462
	(ii) Types of Set	462
	(iii) Venn Diagrams of Different Sets	464
	(iv) Standard Results Based on Venn Diagrams	465
	(v) Algebraic Laws of Sets	466
	(vi) Concept of maximizing or Minimizing the Intersection and Union	468
	<i>Solved Examples</i>	470
	<i>Previous Years Questions UPSC/GATE/ESE</i>	473

4.4	Permutation and Combination	482–521
(i)	Fundamental Principle of Counting	482
(ii)	Permutation	483
(iii)	Combination	485
(iv)	Total Number of Combinations	487
(v)	Difference between Permutation and Combination	488
(vi)	Permutation of Alike Items	490
(vii)	Division of Items into Groups of Different Sizes	492
(viii)	Division of Different Items into Groups of Equal Size	492
(ix)	Distribution of Different Items	494
(x)	Distribution of Identical Items into Groups	495
(xi)	Circular Permutation	497
(xii)	Sum of all Numbers formed from given Digits	498
(xiii)	Rank of a Word	499
(xiv)	Number of Dearrangements	501
(xv)	If Only Selections or Rejections is to be Considered	502
(xvi)	Formation of Words / Formation of Numbers	503
	<i>Solved Examples</i>	505
	<i>Previous Years Questions UPSC/GATE/ESE</i>	511

UNIT 5 : DATA INTERPRETATION

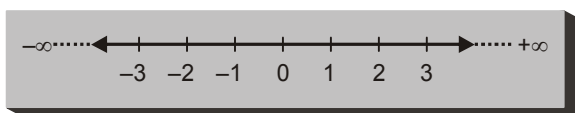
5.1	Data Interpretation	522–568
(i)	Introduction	522
(ii)	Some Theoretical Concepts	522
(iii)	Tables	523
(iv)	Line Graph	527
(v)	Bar Graph	530
(vi)	Pie Charts	539
(vii)	Double pie charts	546
(viii)	Combination of Graphs	549
	<i>Solved Examples</i>	554
	<i>Previous Years Questions UPSC/GATE/ESE</i>	558

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.,
 $N = \{1, 2, 3, 4, 5, \dots\}$.

Whole Numbers

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

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 $\frac{2}{3}, -\frac{3}{7}, \dots$ 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.

$\pi = 3.14159265358979\dots$ and $e = 2.71828182859045\dots$ 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

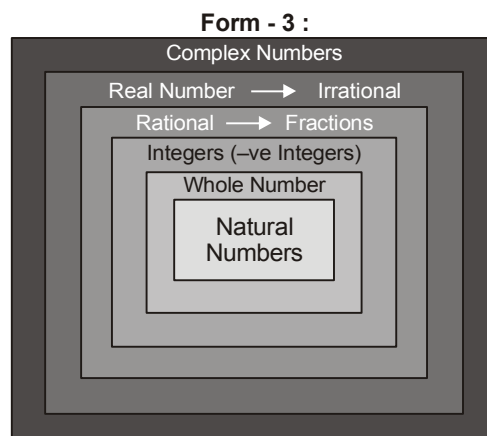
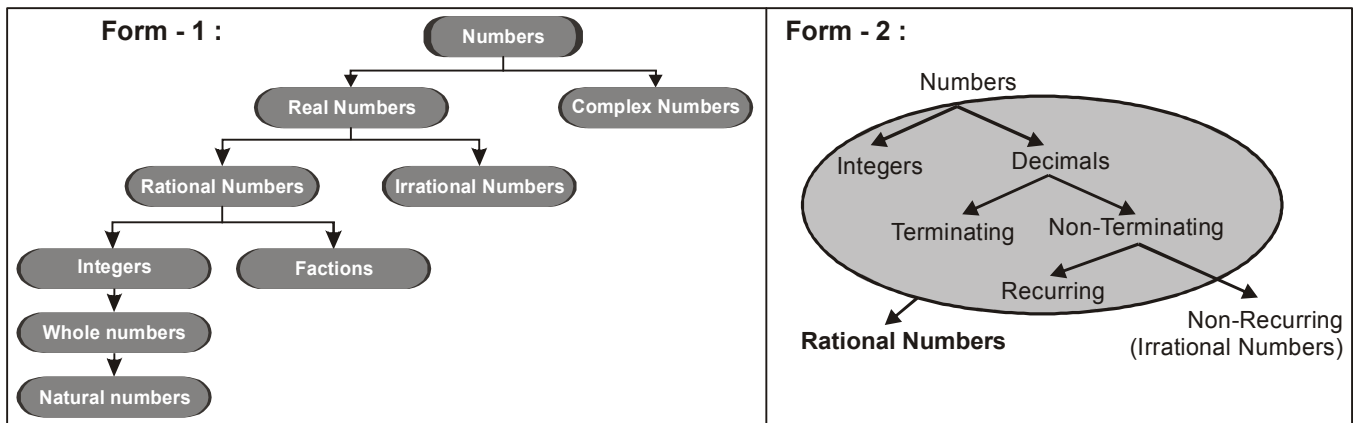
The real numbers include all the measuring numbers. The symbol for the real number is R. **All the numbers which can be represented on the number line are called real numbers.**

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.

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

VARIOUS FORMS OF NUMBER TREE



SOLVED EXAMPLES

1. For what value of k is $(x + 1)$ a factor of $x^3 + kx^2 - x + 2$?

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

Sol. (d)

As $(x + 1)$ is a factor of $f(x) = x^3 + kx^2 - x + 2$ so, $f(-1)$ will result of zero remainder.

$$\therefore f(-1) = 0 = (-3)^3 + k(-1)^2 - (-1) + 2$$

$$\text{or } -1 + k + 1 + 2 = 0$$

$$\text{or } k = -2$$

2. The largest natural number which divides every natural number of the form $(n^3 - n)(n - 2)$, where n is a natural number greater than 2, is

- (a) 6 (b) 12
(c) 24 (d) 48

Sol. (c)

Let $f(n) = (n^3 - n)(n - 2)$ for $n > 2$; where n is natural number.

$$f(3) = (3^3 - 3)(3 - 2) = 24 = 1 \times 24$$

$$f(4) = (4^3 - 4)(4 - 2) = 120 = 5 \times 24$$

$$f(5) = (5^3 - 5)(5 - 2) = 360 = 15 \times 24$$

As we see the pattern above, all the natural numbers are divisible by 24 (largest).

3. What is the sum of digits of the least multiple of 13, which when divided by 6, 8 and 12 leaves 5, 7 and 11, respectively, as the remainders?

- (a) 5 (b) 6
(c) 7 (d) 8

Sol. (a)

This is a LCM based type-3 problem.

$$\text{Here, } (6 - 5) = (8 - 7) = (12 - 11) = 1$$

The required number

$$= \text{LCM of } (6, 8 \text{ and } 12) - 1 = 24 - 1 = 23$$

$$\therefore \text{The sum of digits of } 23 = 2 + 3 = 5.$$

4. The number of pairs (x, y) , where x, y are integers satisfying the equation $21x + 48y = 5$, is

- (a) Zero (b) One
(c) Two (d) Infinity

Sol. (a)

The given equation can be written as

$$3(7x + 16y) = 5$$

As LHS is multiple of 3 and RHS is 5 so there will no integral values of x and y for which the given equation have solution.

5. A number when divided by 7 leaves a remainder 3 and the resulting quotient, when divided by 11 leaves a remainder 6. If the same number when divided by 11 leaves a remainder m and the resulting quotient when divided by 7 leaves a remainder n . What are the values of m and n , respectively?

- (a) 1 and 4 (b) 4 and 1
(c) 3 and 6 (d) 6 and 3

Sol. (a)

Let the number, $a = 7p + 3$

$$\text{then, } p = 11q + 6$$

$$\therefore a = 7(11q + 6) + 3 = 77q + 45 \\ = 11(7q + 4) + 1$$

If the number, a is divided by 11 then remainder is 1.

$$\therefore m = 1$$

When the quotient $(7q + 4)$ is divided by 7 then the remainder will be 4

$$\therefore n = 4$$

6. Let x and y be positive integers such that x is prime and y is composite. Which of the following statements are correct?

- I. $(y - x)$ can be an even integer.
II. xy can be an even integer.
III. $0.5(x + y)$ can be an even integer.

Select the correct answer using the code given below.

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

Sol. (d)

7. Let a two-digit number be k times the sum of its digits. If the number formed by interchanging the digits is m times the sum of the digits, then the value of m is

- (a) $9 - k$ (b) $10 - k$
(c) $11 - k$ (d) $k - 1$



Scan to Download IES Master App



Features

- ✓ Daily updates
- ✓ Timely notifications
- ✓ On the fly bookmark of important notes and questions
- ✓ Practice questions on all topics
- ✓ Study materials - in the form of notes, quizzes and videos

Pocket the Knowledge

As a maverick ESE/GATE platform, we embark upon being your learning partner, in your pursuit of excellence.

True to the likings of engineering students, here, information comes crisp, compact and exact, accompanied by myriad of illustrations that one's eyes can feast upon, and brain to exercise and hone its capabilities. We believe that illustrations speak louder than words; and figures communicate faster than complex wordy pages.

As your eyeballs roll through the app, concepts on all topics - from Material Science to Currents, right from the ESE and GATE toppers - shall come alive before you.

In the swarm of devices based on touch-based, smart technology, IES Master App literally manifests its belief that a right 'touch' can change one's world.



Also visit @

iesmaster.org | iesmasterpublications.com



Like us on facebook
/iesmaster1



Follow us on twitter
/es_master



Watch us on youtube
/iesmaster1



amazon.com

Flipkart



https://iesmasterpublications.com



IES MASTER PUBLICATION

F-126 (Lower Basement), Katwaria Sarai, New Delhi-110016

Phone : 011 26522064, Mobile : 97 1185 3908

E-mail : info_publications@iesmaster.org, info@iesmaster.org

Web : iesmasterpublications.com

₹ 550.00

ISBN 978-93-88000-47-7



9 789388 000477