SSC-JE 2021

STAFF SELECTION COMMISSION
[JUNIOR ENGINEER]
PRELIMINARY EXAMINATION

MECHANICAL ENGINEERING

PREVIOUS YEARS TOPICWISE OBJECTIVE
DETAILED SOLUTION WITH THEORY

2007-2019

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PREFACE

There is no better way to get into SSC-JE in an effortless manner than to get into the minds of the examiner/commission. And, the route to it is reverse engineering the previous year's questions while understanding the psychological requirements of learning. What if, in doing so, you not only memorise but also acquire the ability to project upon the probabilities of the type of questions of the upcoming exam.

As you dive into the first edition of the book '**IES Master Previous Years Topicwise Objective Detailed Solutions with Theory**' carrying **37** previous years question paper sets, you will start feeling the pulse of the exam whereby which in turn will help you to develop the feel of subjects. The previous year's questions decoded in a Question-Answer format not only give you ample amount of relevant theory, but an extra theory along with reasoning for other given options. This kind of concept will not only help you to cater SSC-JE exam but also will help to go through the other exams viz state PSC, RRB etc.

So, what might appear to other students as disorder, randomness, and wide coverage, becomes order for you as you work through topic-wise solutions. While delving into the knowledge base, the numbers dance to your fingers, and the weights assigned to the subjects fit in like a jigsaw puzzle. From here on, you know what to read, where to read, and how to read.

This masterpiece from IES Master's Research & Development Team ensures that your level of preparedness matches exactly to that required in the actual SSC-JE exam. Thus far, and no further, the book leaves no stone unturned in its easy-to-understand language, optimized with fonts and layout that your eyes will surely relish.

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NEW DELHI

HOW TO GET THE MOST OUT OF THIS BOOK

To get the most out of any book in the most effortless and effective manner, one needs to move ahead in a strategic manner rather than just wrestling with the content. How a book is read is the biggest determining factor in getting the most out of any book. Therefore, to help the readers of this book understand its value, we are going to present hereby a multi-step process that needs to be followed.

Before going into the details about the process, first of all let us understand the structure of this book's content. The book includes questions from previous year SSC-JE question papers. The questions are arranged in a topic-wise manner, and each question has a detailed solution followed by a crux theory related to that particular question's topic. A good amount of research has gone into preparing this crux theory as previous years' question papers of SSC-JE, State PSCs, and other engineering exams have been comprehensively analysed in a topic-wise manner. The crux theory has been prepared in such a comprehensive manner that the probability of questions coming in the forthcoming SSC-JE, State PSCs or other engineering exams from that particular topic becomes very high.

Now let's see how the worth of reading this book can be realised in an effective manner. To start with, one need to read in one go any particular topic-related question, its detailed solution, and the related crux theory. Memorise the crux theory of that topic before jumping on to the next topic question. As the questions in the book have been arranged in a topic-wise manner, memorising the theory along with detailed solution will facilitate covering any particular topic in the most efficient as well as effective manner.

Thus, by reading this book in such a selective and targeted manner, one will cover the entire exam syllabus well before time leaving no stone unturned.

Our main objective behind bringing out this book is that you as a reader benefit the most from reading it. Hope by implementing the above-discussed strategy, you achieve success in fulfilling your dream of clearing SSC-JE, State PSCs or other engineering exams.

All the best!!!

EXAM PATTERN

PAPERS	MODE OF EXAMINATION	SUBJECT	NUMBER OF QUESTIONS	MAXIMUM MARKS	DURATION & TIMINGS
Paper-I Objective Type	Computer Based Test	(i) General Intelligence & Reasoning	50	50	2 Hours
		(ii) General Awareness	50	50	Morning Shift
		(iii) General Engineering (Mechanical Engineering)	100	100	Evening Shift
Paper-II Conventional Type	Written Examination	General Engineering (Mechanical Engineering)		300	2 Hours

SYLLABUS

PAPER-I

General Awareness

Questions will be aimed at testing the candidate's general awareness of the environment around him/her and its application to society. Questions will also be designed to test knowledge of current events and of such matters of everyday observations and experience in their scientific aspect as may be expected of any educated person. The test will also include questions relating to India and its neighbouring countries especially pertaining to History, Culture, Geography, Economic Scene, General Polity and Scientific Research, etc. These questions will be such that they do not require a special study of any discipline.

General Intelligence & Reasoning

The Syllabus for General Intelligence would include questions of both verbal and non-verbal type. The test may include questions on analogies, similarities, differences, space visualization, problem solving, analysis, judgement, decision making, visual memory, discrimination, observation, relationship concepts, arithmetical reasoning, verbal and figure classification, arithmetical number series etc. The test will also include questions designed to test the candidate's abilities to deal with abstract ideas and symbols and their relationships, arithmetical computations and other analytical functions.

General Engineering

Mechanical Engineering

Fluid mechanics, Thermodynamics, Heat and Mass Transfer, Refrigeration and Air Conditioning, Power Plant Engineering, IC Engine, Theory of Machine, Strength of Materials, Engineering Mechanics, Machine Design, Production Engineering.

PAPER-II

Fluid mechanics : Properties & Classification of Fluid: ideal & real fluids, Newton's law of viscosity, Newtonian and Non-Newtonian fluids, compressible and incompressible fluids. Fluid Statics: Pressure at a point. Measurement of Fluid Pressure: Manometers, U-tube, Inclined tube. Fluid Kinematics: Stream line, laminar & turbulent flow, external and internal flow, continuity equation. Dynamics of ideal fluids: Bernoulli's equation, Total head; Velocity head; Pressure head; Application of Bernoulli's equation. Measurement of Flow rate Basic Principles: Venturimeter, Pitot tube, orifice meter. Hydraulic Turbines: Classifications, Principles. Centrifugal Pumps: Classifications, Principles, Performance.

Thermodynamics : Properties of pure substances: p-v & P-T diagrams of pure substance like H_2O, Introduction of steam table with respect to steam generation process; definition of saturation, wet & superheated status. Definition of dryness fraction of steam, degree of superheat of steam. H-s chart of steam (Mollier's Chart).

1st Law of Thermodynamics: Definition of stored energy and internal energy, 1st Law of Thermodynamics of cyclic process, Non Flow Energy Equation, Flow Energy & Definition of Enthalpy, Conditions for Steady State Steady Flow; Steady State Steady Flow Energy Equation.

2nd Law of Thermodynamics: Definition of Sink, Source Reservoir of Heat, Heat Engine, Heat Pump & Refrigerator; Thermal Efficiency of Heat Engines & co-efficient of performance of Refrigerators. Kelvin – Planck & Clausius Statements of 2nd Law of Thermodynamics, Absolute or Thermodynamics Scale of temperature, Clausius Integral, Entropy, Entropy change calculation of ideal gas processes. Carnot Cycle & Carnot Efficiency, PMM-2; definition & its impossibility.

Refrigeration and Air Conditioning : Refrigeration cycle, principle of a refrigeration plant, VCRS

Power Plant Engineering : Rankine cycle of steam: Simple Rankine cycle plot on P-V, T-S, h-s planes, rankine cycle efficiency with and without pump work. Boilers ; classification, specification; fittings and accessories: Fire tube and water Tube Boilers. Nozzle and steam turbine. Air compressor and their cycles.

IC Engine : Air standard cycles for IC engines: Otto cycle; plot on P-V, T-S planes; thermal efficiency, Diesel cycle; plot on P-V, T-S planes; thermal efficiency.

IC engine performance, IC engine combustion, IC engine cooling and lubrication.

Theory of Machine : Concept of simple machine, four bar linkage and link motion, flywheel and fluctuation of energy. Gears - Type of gears, gear profile and gear ratio calculation, governors - principle and classification.

Strength of Materials : Concepts of stress and strain, Elastic limit and elastic constants, Bending moments and shear force diagram. Stress in composite bars, Torsion of circular shafts, Buckling of columns – Euler's Rankine's theories, Thin walled pressure vessels.

Engineering Mechanics : Equilibrium of Forces, Law of motion, Friction

Machine Design : Power transmission by belt - V - belts and flat belts, clutches - plate and conical clutch, riveted Joint, Bearings, Friction in Collars and Pivots.

Production Engineering : Classification of Steels: Mild steal and alloy steel, Heat treatment of steel, Welding – Arc Welding, Gas Welding, Resistance Welding, Special Welding Techniques i.e. TIG, MIG, etc. (Brazing & Soldering), Welding Defects and Testing; NDT, Foundry & Casting – methods, defects different casting processes, Forging, Extrusion, etc, Metal cutting principles cutting tools, Basic Principles of machining with (i) Lathe (ii) Milling (iii) Drilling (iv) Shaping (v) Grinding, Machines, tools and manufacturing processes.

Analysis of Previous Years Questions											
Years	**TD**	**MD**	**EM**	**SOM**	**PPE**	**RAC**	**PROD**	**ICE**	**HMT**	**FM**	**TOM**
2007	8	2	-	4	1	-	10	3	1	8	4
2008	3	1	-	6	1	-	12	4	-	7	5
2009	3	2	-	5	3	-	13	2	-	6	4
2010	9	2	1	8	1	-	11	3	-	7	8
2011	4	3	-	9	5	-	11	3	-	8	7
2012	16	11	-	10	7	-	19	8	-	18	11
2013	12	9	1	12	8	1	19	10	-	19	8
2014 (M)	11	4	7	9	10	1	9	10	-	29	9
2014 (E)	8	6	7	6	7	1	10	13	-	31	11
2015	10	10	5	8	8	5	10	6	-	30	7
2016 (M) (01/03/2017)	10	16	-	9	1	-	9	-	20	29	6
2016 (E) (01/03/2017)	13	13	14	-	1	15	12	-	-	31	1
2016 (M) (02/03/2017)	10	3	6	8	7	6	13	6	6	29	12
2016 (E) (02/03/2017)	11	12	14	-	3	10	11	-	1	28	3
2016 (M) (03/03/2017)	12	2	1	15	8	4	18	6	-	32	2
2016 (E) (03/03/2017)	13	11	4	8	7	-	11	1	15	22	6
2016 (M) (04/03/2017)	19	6	5	8	1	-	17	4	6	30	4
2016 (E) (04/03/2017)	18	7	5	10	5	-	11	3	5	31	5
2017 (M) (22/01/2018)	15	4	1	14	5	-	10	10	-	35	12
2017 (E) (22/01/2018)	22	3	-	15	1	-	9	7	-	23	13
2017 (M) (23/01/2018)	22	4	2	12	1	2	10	3	-	31	11
2017 (E) (23/01/2018)	14	6	3	10	2	2	10	12	-	30	10
2017 (M) (24/01/2018)	23	4	2	13	2	1	8	6	-	29	12
2017 (E) (24/01/2018)	14	3	-	14	3	-	10	14	-	31	12
2017 (M) (25/01/2018)	13	4	2	13	7	2	10	8	-	28	11
2017 (E) (25/01/2018)	26	6	4	9	-	1	10	4	-	28	10
2017 (M) (27/01/2018)	13	5	4	10	5	3	8	11	-	30	11
2017 (E) (27/01/2018)	23	5	3	12	2	1	10	5	-	31	11
2017 (M) (29/01/2018)	19	4	4	11	-	2	9	8	-	30	12
2017 (E) (29/01/2018)	23	8	3	11	-	-	8	6	-	34	9
2018 (E) (25/09/2019)	12	2	1	3	25	7	5	12	-	30	1
2018 (M) (27/09/2019)	9	1	2	3	24	10	5	11	-	32	3
2018 (E) (27/09/2019)	11	3	2	2	24	9	6	11	-	31	1
2019 (M) (27/10/2020)	13	1	4	1	20	13	5	11	-	29	3
2019 (E) (27/10/2020)	8	1	1	4	24	10	6	11	-	32	3
2019 (E) (28/10/2020)	10	2	1	5	22	13	7	9	-	30	1
2019 (M) (11/12/2020)	11	-	1	4	22	8	5	13	-	32	4

* TD - Thermodynamics, MD - Machine Design, EM - Engineering Mechanics, SOM - Strength of Material, PPE - Power Plant Engineering, PROD - Production Engineering, ICE - IC Engine, HMT - Heat and Mass Transfer, FM - Fluid Mechanics, TOM - Theory of Machine

CONTENT

UNIT-1 THERMODYNAMICS

SYLLABUS

1st Law of Thermodynamics: *Definiton of stored energy and internal energy, 1st Law of Thermodynamics of cyclic process, Non Flow Energy Equation, Flow Energy & Definition of Enthalpy, Conditions for Steady State Steady Flow; Steady State Steady Flow Energy Equation.*

2nd Law of Thermodynamics: *Definition of Sink, Source Reservoir of Heat, Heat Engine, Heat Pump & Refrigerator; Thermal Efficiency of Heat Engines & co-efficient of performance of Refrigerators. Kelvin – Planck & Clausius Statements of 2nd Law of Thermodynamics, Absolute or Thermodynamic Scale of temperature, Clausius Integral, Entropy, Entropy change calculation of ideal gas processes. Carnot Cycle & Carnot Efficiency, PMM-2; definition & its impossibility.*

Properties of pure substances: *p-v & P-T diagrams of pure substance like H_2O, Introduction of steam table with respect to steam generation process; definition of saturation, wet & superheated status. Definition of dryness fraction of steam, degree of superheat of steam. H-s chart of steam (Mollier's Chart).*

CONTENTS

1 INTRODUCTION AND FIRST LAW

2007

1. The ratio of two specific heats of air is equal to

(a) 0.17 **(b) 0.24**
(c) 0.1 **(d) 1.41**

Sol–(d)

The ratio of two specific heats of air. i.e. specific heat at constant pressure (c_p) to specific heat constant volume (c_v) is

$$\gamma = \frac{c_p}{c_v} = 1.41$$

Note: γ for CO_2 = 1.28, γ for steam = 1.33

2. According to which law, all perfect gases change in volume by 1/273rd of their original volume at 0° for every 1°C change in temperature when pressure remains constant?

(a) Joule's law **(b) Boyle's law**
(c) Gay-Lussac law **(d) Charles law**

Sol–(d)

- According to Charle's law, all the perfect gases change in volume by $1/273^{rd}$ of their original volume at 0° for every 1°C change in temperature when pressure remain constant.

Boyle's law: It is a gas law which states that the pressure exerted by a gas (of a given mass, kept at a constant temperature) is inversely proportional to the volume occupied by it

i.e., $P \alpha \left(\frac{1}{V}\right)$, T = constant

Gay-Lussac's Law: It is a gas law which states that the pressure exerted by a gas (of a given mass and kept at a constant volume) varies directly with the absolute temperature of the gas.

i.e., $P \alpha T$, V = constant

Joule's law: It states that for a perfect gas the internal energy is independent of pressure and volume and depends only on the temperature of the gas.

3. Properties of substances like pressure, temperature and density in thermodynamic co-ordinates are

(a) Path function **(b) Point function**
(c) Cyclic function **(d) Real function**

Sol–(b)

Properties of substances like pressure, temperature and density are are point functions as they depend only on the end states.

Path functions are functions whose magnitudes depend on the path followed during a process as well as the end states. These are inexact differentials and is denoted by 'δ'.

e.g. heat, work etc.

4. Work done in an adiabatic process between a given pair of end state depends on

(a) The end states only
(b) Particular adiabatic process
(c) The value of index n
(d) The value of heat transferred

Sol–(a)

$$Q = \Delta E + W$$
$$W = -\Delta E$$

$(\because Q = 0 \text{ for adiabatic process})$

Since ΔE depends only on the end states, so workdone in adiabatic process will also depend on end states only.

5. For which of the following substances, the internal energy and enthalpy are the functions of temperature only?

(a) Any gas **(b)** Saturated steam
(c) Water **(d)** Perfect gas

Sol–(d)

According to Joule's law, "for a perfect i.e. ideal gas, the internal energy and enthalpy are the functions of temperature only."

6. Change in enthalpy in a closed system is equal to heat transferred if the reversible process takes place at constant

(a) Pressure **(b)** Temperature
(c) Volume **(d)** Internal energy

Sol–(a)

dQ = dU + pdV

If P is constant

dQ = dU + d(PV) = d (U + PV)

dQ = dH

Hence, change in enthalpy in a closed system is equal to the heat transferred if the reversible process takes place at constant pressure.

2008

7. Zeroth law of thermodynamics defines

(a) internal energy **(b)** enthalpy
(c) temperature **(d)** pressure

Sol–(c)

Zeroth law of thermodynamics defines temperature. It states that "if two system are in thermal equilibrium with a third system then both are in thermal equilibrium with each other". It forms the basis for temperature measurement.

2009

8. First law of thermodynamics furnishes the relationship between

(a) Heat and work
(b) Heat, work and properties of the system
(c) Various properties of the system
(d) Various thermodynamic processes

Sol–(b)

According to first law of thermodynamics for a closed system,

$$Q - W = \Delta E$$

$$\Rightarrow \quad Q = \Delta E + W$$

2010

9. Work done in a free expansion process is

(a) Positive **(b)** Negative
(c) Zero **(d)** Maximum

Sol–(c)

Expansion of a gas in vacuum is called free expansion process. No work is done during free expansion because there is no resistance.

10. An open system is one in which–

(a) Mass does not cross boundaries of the system, though energy may do so
(b) Neither mass nor energy crosses the boundaries of the system
(c) Both energy and mass crosses the boundaries of the system
(d) Mass crosses the boundary but not the energy

Sol–(c)

An **open system** is one in which both mass and energy cross the boundaries of the system. e.g. Turbine, pump

A **close system** is one in which energy crosses the boundary of system but mass does not cross. e.g. Pressure Cooker, A rubber balloon, field with air and tightly closed.

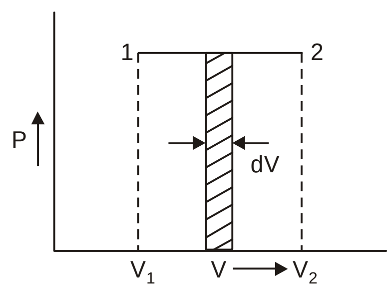
An **isolated system** is one in which neither mass nor energy crosses the boundary of system.

e.g. Thermos flask

11. The work done in the expansion of a gas from volume V_1 to V_2 under constant pressure p is equal to –

(a) zero **(b)** $p(V_2 - V_1)$
(c) $p(V_2 + V_1)$ **(d)** $p(V_2 \div V_1)$

Sol–(b)



Work done in the expansion of a gas from volume V_1 to V_2 under constant pressure 'P' is equal to the area under P – V diagram.