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## IMPORTANT INFORMATION

UPSC and other organisations have now started conducting objective type papers. In objective type of questions, the candidate is not required to write detailed answers. The questions are designed to measure not only knowledge but also understanding and powers of analytical and critical thinking, ability to apply knowledge to new situations and capacity to make judgements. For each question several possible answers are given and candidate has to choose one most suitable answer.

The question paper is given in the form of a test booklet bearing number 1, 2, 3 ... etc. and a separate answer sheet is also provided to the candidate. The number of the booklet should be transferred to answer-sheet. The test booklet contains several questions, (about 200 questions to be answered in 2 hours) each given some number, and below each question, suggested answers marked (a), (b), (c) ... etc. are given. The candidate has to choose one correct answer. In case he feels there are more than one correct answers, he has to choose one best out of these, as in case of selection of more than one answers, his answer will be considered wrong. Answers are to be marked in the answer sheet only and nowhere else. In the answer sheet, the number of questions and the answers No. (a), (b), (c) ...etc. are printed against each question number. After the candidate has read a question in the test booklet and decided which of the given answers is correct or is the best, he has to mark the rectangle containing the better of the selected answer by blackening it nearly and completely with pencil to indicate the choice of his answer. For example, if he has chosen (c) as the correct answer to a question, the rectangle on which (c) is printed should be blackened against that question number. It is important to note that ink should not be used for blackening the rectangles on answer sheet as these are checked by an optical scoring machine which is insensitive to improper marking and may not be able to read blue marking. Accordingly it is essential that candidate uses only good quality HB pencil. If a wrong mark is made, it should be completely erased by a good quality eraser which does not blacken the paper further, and correct answer re-marked. The answer sheet should be properly handled so as not to fold or wrinkle, or spoil it.

As the evaluation is done mechanically, all the instructions given in test booklet need to be read carefully and followed meticulously.

Although such a test stresses accuracy more than speed, it is important for candidates that they use their time as efficiently as possible. They should work steadily and as rapidly, as they can, without becoming careless. If any question is difficult, same must be slipped over without wasting much time on it, and pass on to the other questions and come back to difficult ones later, if time permits. It is also important to note that all questions have to be answered, there being no choice and each question carries equal marks. Marks are given only for correct answers, there being no negative marking for wrong answers.

## UPSC Syllabus for Engineering Services Examination

A combined competitive examination for recruitment to the Services/posts mentioned below is held by the Union Public Service Commission at Agartala, Ahmedabad, Aizwal, Allahabad, Bangalore, Breilly, Bhopal, Bombay, Calcutta, Chandigarh, Cochin, Cuttack, Delhi, Dharwar, Dispur (Guwahati), Gangtok, Hyderabad, Imphal, Itanagar, Jaipur, Jammu, Jorhat, Kohima, Lucknow, Madras, Madurai, Nagpur, Panaji (Goa), Patna, Portblair, Raipur, Sambalpur, Shillong, Shimla, Srinagar, Tirupati, Trivandrum, Udaipur and Vishakhapatnam.

The candidates should note that no request for change of centre will normally be granted. However when a candidate desires a change in center from the one he had indicated in his Application Form for the Examination, he must send a letter addressed to the Secretary, Union Public Service Commission by Registered Post, giving full justification as to why he desires a change in centre. Such requests will be considered on merits but requests received in the Commission's Office after 14th June, will not be entertained under any circumstances nor will such communications be replied to.

Recruitment on the results of this examination will be made to following Services/posts.

### Category II—Mechanical Engineering

#### Group A Services/Posts

- (i) Indian Railway of Mechanical Engineers;
- (ii) Indian Railway Stores Service (Mechanical Engineering Posts);
- (iii) Central Water Engineering Service (Mechanical Engineering Service) (Mechanical Engineering Posts);
- (iv) Central Power Engineering Service (Mechanical Engineering Posts);
- (v) Indian Ordinance Factories Service (Engineering Branch) (Mechanical Engineering Posts);
- (vi) Indian Naval Armament Service (Mechanical Engineering Posts);
- (vii) Military Engineer Service (IDSE Electrical and Mechanical Cadre) (Mechanical Engineering Posts);
- (viii) Central Electrical & Mechanical Engineering Service (Mechanical Engineering Posts);
- (ix) Assistant Executive Engineer (Elect. & Mech.) (Mechanical Engineering Posts). Border Roads Engineering Service, Group-A.
- (x) Indian Inspection Service, Group 'A' (Mechanical Engg. Posts);
- (xi) Drilling Engineer (Junior) in G.S.I.
- (xii) Mechanical Engineer (Junior) Group-A in G.S.I.
- (xiii) Assistant Manager (Factories) Department of Telecom (Telecom Factories Organisation)
- (xiv) Central Engineering Service (Roads) Group 'A' (Mechanical Engineering Posts)
- (xv) Workshop Officer — Group 'A' (Mechanical Engg. Posts) in the Corps of E.M.E., Ministry of Defence.
- (xvi) Indian Supply Service Group 'A' (Mechanical Engg. Posts)

#### Group 'B' Services/Posts

- (xvii) Workshop Officer Group 'B' (Mechanical Engineering Posts) in the Corps of E.M.E., Ministry of Defence.

**Eligibility Conditions :** (I) **Nationality :** A candidate must be either : (a) a citizen of India, or (b) a subject of Nepal, or (c) a subject of Bhutan, or (d) a Tibetan refugee who came over to India before the 1st January, 1962 with the intention of permanently settling in India, or (e) a person of Indian origin who has migrated from Pakistan, Burma, Sri Lanka or East African Countries of Kenya, Uganda, the United Republic of Tanzania, Zambia, Malawi, Zaire and Ethiopia or from Vietnam with the intention of permanently settling in India.

(II) **Age Limits :** A candidate for this examination must have attained the age of 20 years and must not have attained the age of 28 years (S.C./S.T. Five years relaxable) on the 1st August of the year of examination.

(III) **Minimum Educational Qualifications :** For admission to the examination, a candidate must have—

- (a) obtained a degree in Engineering from a University
- (b) passed Section A and B of the Institution Examinations of the Institution of Engineers (India); or

- (c) obtained a degree/diploma in Engineering from such foreign University/College/Institution and under such conditions as may be recognised by the Government for the purpose from time to time, or
- (d) passed Graduate Membership Examination of the Institution of Electronics and Telecommunication Engineers (India); or
- (e) passed Associate Membership Examination Parts II and III/Sections A and B of the Aeronautical Society of India; or
- (f) passed Associate Membership Examinations (Sections A and B) of the Institution of Mechanical Engineers (India); or
- (g) passed Graduate Membership Examination of the Institution of Electronics and Radio Engineers, London held after November, 1959.

(IV) **FEE** : A candidate seeking admission to the Examination must pay to the Commission a fee of Rs. 100.00 (Rupees One hundred only). Payment must be made through Central Recruitment Fee Stamps or crossed Bank Draft from any branch of the State Bank of India payable to the Secretary, Union Public Service Commission at New Delhi or through crossed Indian Postal Orders payable to the Secretary, Union Public Service Commission at the New Delhi General Post Office.

CANDIDATES BELONGING TO SCHEDULED CASTES/SCHEDULED TRIBES ARE NOT REQUIRED TO PAY ANY FEE.

### Plan of Examination

1. The examination shall be conducted according to the following plan :—

**Part I** — The written examination will comprise two sections — Section I consisting only of objective type of questions and Section II of conventional papers. Both Sections will cover the entire syllabus of the relevant engineering disciplines. The standard and syllabi prescribed for these papers are given below. The details of the written examination i.e. subject, duration and maximum marks allotted to each subject are given below.

**Part II** — Personality test carrying a maximum of 200 marks of such of the candidates who qualify on the basis of the written examination.

2. The following will be the subjects for the written examination :—

### Category II — Mechanical Engineering

Subject	Code	Duration	Maximum Marks
<b>Section I—Objective Papers</b>			
General Ability Test	01	2 hrs.	200
(Part A : General English)		(Part B : General Studies)	
Mechanical Engg. Paper I	21	2 hrs.	200
Mechanical Engg. Paper II	22	2 hrs.	200
<b>Section II—Conventional Papers</b>			
Mechanical Engg. Paper I	23	3 hrs.	200
Mechanical Engg. Paper II	24	3 hrs.	200
<b>Total</b>			1000

3. In the Personality Test special attention will be paid to assessing the candidate's capacity for leadership, initiative and intellectual curiosity tact and other social qualities, mental and physical energy, powers of practical application and integrity of character.

4. Conventional papers must be answered in English. Question papers will be set in English only.

5. Candidates must write the papers in their own hand. In no circumstances will they be allowed the help of a scribe to write the answers for them.

6. The Commission have discretion to fix qualifying marks in any or all the subjects of the examination.

7. Marks will not be allotted for mere superficial knowledge.

8. Deduction up to 5 per cent of the maximum marks for the written papers will be made for illegible handwriting.

9. Credit will be given for orderly, effective and exact expression combined with due economy of words in the conventional papers of the examination.

10. In the question papers, wherever necessary, questions involving the Metric System of weights and measures only will be set.

**NOTE :** Candidates will be supplied with tables in metric units compiled and published by the Indian Standards Institution in the Examination hall for reference purpose, wherever considered necessary.

11. Candidates are permitted to bring and use battery operated pocket calculators for conventional (essay) type papers only. Loaning or inter-changing of calculators in the Examination hall is not permitted.

It is also important to note that candidate are not permitted to use calculators for answering objective type papers (Test booklets). They should not, therefore, bring the same inside the Examination Hall.

12. Candidates should use only International form of Indian numerals (e.g. 1, 2, 3, 4, 5, 6 etc.) while answering question papers.

The standard of paper in General Ability Test will be such as may be expected of an Engineering/Science Graduate. The standard of papers in other subjects will approximately be that of an Engineering Degree Examination of an Indian University. There will be no practical examination in any of the subjects.

### GENERAL ABILITY TEST

(Code No. 01)

**Part A : General English :** The question paper in General English will be designed to test the candidate's understanding of English and workman like use of words.

**Part B : General Studies :** The paper in General Studies will include knowledge of current events and of such matters as of everyday observation and experience in their scientific aspects as may be expected of an educated person. The paper will also include questions on History of India and Geography of a nature which candidates should be able to answer without special study.

### MECHANICAL ENGINEERING

(For both Objective and Conventional Type Papers)

**Paper I (Code No. 21 for Objective Type and 23 for Conventional Paper)**

1. Thermodynamics. Laws, Properties of ideal gases and vapours, Power, Cycles, Gas Powder Cycles, Gas Turbine Cycles, Fuels and Combustion.
2. I.C. Engines. C.I. and S.I. Engines, Detonation, Fuel injection and carburation. Performance and Testing. Turbo Jet and Turbo-prop. Engines, Rocket Engines, Elementary knowledge of Nuclear Power Plants and Nuclear Fuels.
3. Steam Boilers, Engines, Nozzles and Steam Turbines, Modern boilers, Steam Turbine Types, Flow of Steam through nozzles. Velocity diagrams for impulse and Reaction Turbines. Efficiencies and Governing.
4. Compressors Gas, Dynamics and Gas Turbines, Reciprocating, Centrifugal and axial flow compressors. Velocity diagrams. Efficiency and Performance, effect of mech. Number of flow, isentropic flow, Normal Shocks and flow through nozzles, Gas Turbine Cycle with Multistage Compression. Reheating and Regeneration.
5. Heat Transfer, Refrigeration and Air Conditioning. Conduction, Convection and Radiation, Heat exchangers, types, Combined Heat Transfer, Overall Heat Transfer Co-efficient. Refrigeration and heat pump cycles. Refrigeration systems. Coefficient of performance, Psychrometric and psychrometric chart. Comfort indices. Cooling and dehumidification methods. Industrial Air-conditioning Processes. Cooling and heating loads calculations.
6. Properties and classification of fluids. Fluid statics, kinematics and dynamics; principals and applications. Manometry and Buoyancy Flow of ideal fluids. Laminar and turbulent flows. Boundary layer theory. Flow over immersed bodies. Flow through pipes and Open Channels. Dimensional analysis and similitude technique.

**Note :** dimensional specific speed and classification of fluid machines in general. Energy transfer relation performance and operation of pumps and of impulse and reaction water turbines. Hydronomic power transmission.

**Paper II (Code No. 22 for Objective Type paper and 24 for conventional paper)**

7. Theory of Machines. Velocity and acceleration (i) moving bodies ; (ii) in machines. Klein's construction. Inertia forces in machines. Cames ; Gears and Gearing, Flywheels and Governors. Balancing of Rotating and Reciprocating Masses. Free and Forced vibrations of systems. Critical speeds and whirling of shafts.

8. Machine Design. Design of Joints—Threaded fasteners and Power Screws—Keys, Kotters, Couplings—Welded Joints. Transmission system : Belt and chain drives—wire ropes—shafts. Gear—Sliding and Rolling bearings.
9. Strength of Materials. Stress and strain in two dimensions ; Mohr's circles ; Relations between Elastic Constants.  
Beams : Bending moments, Shearing forces and reflection.  
Shafts : Combined bending, Direct and torsional stresses. Thick Walled cylinders and spheres under pressure, Springs, Struts and Columns. Theories of failure.
10. Engineering Materials. Alloys and Alloying Materials, Heat treatment ; Composition ; Properties and uses. Plastics and other newer engineering materials.
11. Production Engineering. Metal Machinery : Cutting tools ; Tool Materials. Wear and Machinability. Measurement of cutting forces.  
Process : Machining — Grinding, Boring, Gear, Manufacturing, Metal Casting and Joining. Basic Special Purpose Programme and Numerically controlled machine Tools, Jigs and Fixtures (locating elements).
12. Industrial Engineering. Work study and work measurement. Wage incentive. Design of Production System Product Cost. Principles of Plant Layout. Production Planning and Control. Material Handling. Operations Research. Linear Programming Queuing Theory. Value Engineering. Network Analysis, CPM and PERT. Use of Computers.

## UPSC Syllabus for IAS Exams. in Mechanical Engineering

**Statics** : Simple applications of equilibrium equations.

**Dynamics** : Simple applications of equations of motion. Simple harmonic motion. Work, energy, power.

**Theory of Machines** : Simple examples of links and mechanisms. Classification of gears, standard gear, tooth profiles. Classification of bearings. Function of flywheel. Types of governors, Static and dynamic balancing. Simple examples of vibration of bars. Whirling and shafts.

**Mechanics of Solids** : Stress, strain, Hooke's Law, Elastic moduli. Bending moment and shearing force diagrams for beams. Simple bending and torsion of beams. Springs, thin-walled cylinders. Mechanical properties and material testing.

**Manufacturing Science** : Mechanics of metal cutting, tool-life, economics of machining, cutting tool materials. Basic machining processes, types of machine tools, transfer lines, shearing, drawing, spinning, rolling, forging, extrusion. Different types of casting and welding methods.

**Production Management** : Method and time study, motion economy and work space design, operation and flow process charts. Product design and cost selection manufacturing process. Break-even analysis, Site selection. Plant layout. Materials handling, Selection of equipment for job shop and mass production; Scheduling, despatching, routing.

**Thermodynamics** : Heat, work and temperature. First and second laws of thermodynamics. Carnot, Rankine, Otto and Diesel cycles.

**Fluid Mechanics** : Hydrostatics, Continuity equation, Bernoulli's theorem. Flow through pipes, Discharge measurement. Laminar and turbulent flow. Concept of boundary layer.

**Heat Transfer** : One dimensional steady state conduction through walls and cylinders, Fins, Concept of thermal boundary layer. Heat transfer coefficient. Combined heat transfer coefficient. Heat exchangers.

**Energy Conversion** : Compression and spark ignition engines. Compressors, fans and blowers, Hydraulic pumps and turbines, Thermal turbomachines, Boilers. Flow of steam through nozzles. Layout of power plants.

**Environmental Control** : Refrigeration cycles, refrigeration equipment—Its operation and maintenance, important refrigerants, Psychrometrics comfort, cooling and dehumidification.

## Syllabus for GATE Exams.

**Engineering Materials :** Structure and mechanical properties of common engineering/metals, alloys, plastics and ceramics. Heat treatment of steels.

**Foundry :** Patterns, pattern allowances, moulding and core making, gating and risering calculations. Casting processes ; sand, die, centrifugal, investment and shell mould casting. Defects in castings.

**Welding :** Gas, arc and resistance welding. Tungsten inert gas (TIG), metal inert gas (MIG) and atomic hydrogen welding ; Power sources for welding. Brazing, Soldering and adhesive bonding.

**Metal Working :** Basic plasticity for metal forming. Hot and Cold working. Forming processes ; blanking, piercing and deep drawing. Technology of wire drawing, rolling and forging processes. Force and power calculations. Elements of power metallurgy.

**Machine Tools :** Construction, operation, kinematics and applications. Automatic and semiautomatic machine tools, indexing attachments. Jigs and fixtures. Elements of N/C machine tools.

**Metal Cutting :** Tool materials, tool geometry and surface finish. Chip formation, mechanics of machining ; force, temperature, tool wear, tool life, machinability and economics of machining.

**Machining Processes :** Turning, drilling, shaping, planing, boring, reaming, milling, grinding and finishing processes. Production of screw threads. Gear manufacturing processes ; hobbing and shaping. Introduction to unconventional machining processes like EDM, ECM, USM, Laser machining etc.

**Limits, Fits and Tolerances :** Geometric tolerancing ; straightness, flatness, roundness, parallelism, cylindricity and location. Instruments and methods for linear and angular measurements. Limit gauging and comparators. Surface finish.

**Industrial Engineering :** Plant layout and material handling. Work study. Economic analysis ; break-even analysis, present value criterion. Forecasting. Elements of production planning and control ; machine loading, sequencing and inventory control. Statistical quality control. Elements of linear programming and PERT/CPM in production system.

**Compression Ignition and Spark Ignition Engines :** Analysis of thermodynamic cycles. Fuels and mixture requirements. Alternate fuels. Fuel injection. Carburetion. Combustion ; detonation, knock, fuel rating and combustion chambers. Performance characteristics ; Volumetric efficiency, mean effective pressure, thermal efficiency and exhaust gas composition. Engine emissions.

**Power Plant Cycles :** Rankine and modified Rankine cycles, reheat and regenerative cycles. Brayton cycle with intercooling, regeneration and reheating. Binary vapour cycle.

**Power Plant Technology :** Types of fuels used, basis of fuel combustion. Types of steam generators and condensers. Boiler heat balance and efficiency. Basis of superheaters, reheaters, economizer, preheaters and feed water heaters. Nuclear power plants. Alternate energy sources.

**Reciprocating Pumps and Compressors :** Use of air vessels in pumps, indicator diagram. Compression with and without cooling, simple calculations of main dimensions.

**Flow through Nozzles :** Isentropic flow of ideal gases, stagnation properties. Sonic velocity, mass flow rate, flow areas, choking, effect of friction, effect of variation of back pressure and normal shock. Flow of steam.

**Turbomachinery :** Classification, and principles of operation ; axial, mixed and radial flow-pumps, turbines and compressors. Specific work or head, losses and efficiencies, velocity triangles, Euler energy transfer equation, degree of reaction. Laws of similarity, specific speed, model testing and dimensionless parameters. Calculation of blade angles.

**Hydraulic Turbines and pumps :** Pelton, Francis, Kaplan and propeller turbines. Draft tubes. Performance and regulation. Cavitation in pumps and turbines, its effect on performance, cavitation parameters and measures to avoid cavitation. Axial thrust in pumps and its balancing.

**Steam and Gas Turbines :** Impulse and reaction types. Pressure and velocity compounding of stages. Calculation of blade angles, work done and power. Performance and speed regulation.

**Jet Propulsion :** Principles, types of jet propulsion, components of jet propulsion system. Calculation of propulsive force, work and efficiencies for various propulsion systems.

**Heat Transfer :** Modes of heat transfer. One dimensional steady and unsteady conduction, heat transfer with fins. Steady state conduction in two dimensions. Finite difference technique. Principles of convective heat transfer, forced convection over flat plates and through tubes ; free convection from cylinders and flat plates. Basics of heat transfer is condensation and boiling. Basic laws and concepts of radiative heat transfer, radiative shape factors, heat exchange between black and grey surfaces. Heat exchanger design and performance, effectiveness-NTU method.

**Refrigeration :** Standard and actual vapor compression cycle analysis, influence of various parameters on cycle performance. Types of multipressure systems. Refrigerant compressors and expansion devices. Vapor absorption refrigeration cycle analysis, enthalpy-composition diagram.

**Air conditioning :** Properties of moist air, psychrometric chart, basic psychrometric processes. Cooling load and air conditioning calculations- concepts of RSHF, GSHF, ESHF. Basics of air conditioning equipment.

**Strength of Materials :** Stress, Strain, Biaxial and triaxial stresses. Stress-strain relationship for elastic bodies. Mohr's circle. Theories of failure. Thermal stresses. Shear force and bending moment diagrams for beams. Calculations of stresses, slope and deflection. Torsion of cylindrical shafts. Energy methods. Thin and thick cylinders. Stability of columns.

**Theory of Machines :** Constrained motion. Plane mechanisms ; Velocity and acceleration diagrams. Coriolis component of acceleration. Instantaneous centre. Flywheels and their applications. Balancing of reciprocating and rotating masses. Planar cams and followers. Involute tooth geometry. Types of gears. Gear trains with fixed axes and planetary configuration, differential. Natural and forced vibration with and without damping for systems with single degree of freedom. Transmissibility and isolation of vibration. Transverse vibrations of beams and shafts. Critical speed. Multirotor torsional vibratory systems. Principle of gyroscope.

**Machine Design :** Material and manufacturing considerations. Design of elements subjected to static and variable stresses. Factor of safety. Stress concentration. Design of flanged joints and seals, shafts and keys, helical springs, rigid and flexible couplings, universal (Hooke's) joints, Oldham coupling, Clutches and brakes belt, chain and rope drives. Hydrodynamic lubrication. Rolling element bearings. Power screws. Design calculations of spur and helical gears. Indian Standards and specifications.

**Mechanical Measurements :** Measurement of displacement, velocity, acceleration, force, torque, strain, speed, temperature, pressure, flow, shock, vibration and sound.

**PART—I**  
**CONVENTIONAL PAPER**

(For Quick Review of the Subject)

