# UPSC Engineering Services Examination 2016 - Syllabus

## General Ability Test

**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 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.

## CIVIL ENGINEERING (for both Objective and Conventional Type Papers)

### PAPER I

### 1. Building Materials

Timber : Different types and species of structural timber, density-moisture relationship, strength in different directions, defects, influence of defects on permissible stress, preservation, dry and wet rots, codal provisions for designs. Plywood.

Bricks : Types, Indian Standards classification, absorption, saturation factor, strength in masonry, influence of mortar strength on masonry strength.

Cement : Compounds of, different types, setting times strength.

Cement Mortar : Ingredients, proportions, water demand, mortars for plastering and masonry.

Concrete : Importance of W/C Ratio, strength ingredients including admixtures, workability, testing for strength elasticity, non- destructive testing, mix design methods.

### 2. Solid Mechanics

Elastic constants, stress, plane stress, Mohr's circle of stress, strains, plane strain, Mohr's circle of strain combined stress; Elastic theories of failure; Simple bending, shear; Torsion of circular and rectangular sections and simple members.

### 3. Structural Analysis

Analysis of determinate structures—different methods including graphical methods.

Analysis of indeterminate skeletal frames—moment distribution, slope-deflection, stiffness and force methods, energy methods. Muller-Breslaie principle and application.

Plastic analysis of indeterminate beams and simple frames—shape factors.

**4. Design of Steel Structures**

Principles of working stress method/Design of connections, simple members, Built-up sections and frames. Design of Industrial roofs. Principles of ultimate load design. Design of simple members and frames.

**5. Design of Concrete and Masonry Structures**

Limit state design for bending, shear, axial compression and combined forces. Codal provisions for slabs, beams walls and footings. Working stress method of design of R.C. members. Principles of prestressed concrete design, materials, methods of prestressing, losses. Designs of simple members and determinate structures. Introduction of prestressing of indeterminate structures. Design of brick masonry as per I.S. Codes.

**6. Construction Practice, Planning and Management**

Concreting Equipment : Weight Batcher, mixer vibrator, batching plant, concrete pump.

Cranes, hoists, lifting equipment. Earthwork Equipment : Power shovel, hoe, dozer, dumper, trailers and tractor, rollers, sheep foot rollers pumps.

Construction, Planning and Management : Bar chart, linked bar chart, work-break down structures. Activity-on-arrow diagrams; Critical path, probabilistic activity durations. Event-based networks, PERT network; Time-cost study, crashing; resource allocation.

**PAPER II**

**1. (a) Fluid Mechanics, Open Channel, Flow, Pipe Flow**

Fluid Properties, Perssure, Thrust, Buoyancy; Flow kinematics; Integration Flow equations; Flow measurement; Relative Motion, Moment of momentum; Viscosity,

Boundary layer and control. Drag, Lift : Dimentional Analysis. Modelling Cavitation; Flow Oscillations; Momentum and Energy principles in open channel flow. Flow controls. Hydraulic jump. Flow section and properties; Normal flow. Gradually varied flow: Surges, Flow development and losses in pipe flows, Measurement, Siphons, Surges and Water hammer. Delivery of Power, Pipe networks.

**(b) Hydraulic Machines and Hydropower**

Centrifugal pumps, types, performance parameters, scaling pumps in parallel. Reciprocating pumps, air vessels, performance parameters. Hydraulic ram. Hydraulic turbines types, performance parameters/controls, choice, power houses, classification and layout, storage, pondage, control of supply.

**2. (a) Hydrology**

Hydrological cycle, precipitation and related data analysis, PMP unit and synthetic hydrographs; Evaporation and transpiration; Floods and their management, PMF; Streams and their gauging: River morphology; Routing of floods; Capacity of Reservoirs.

**(b) Water Resources Engineering**

Water resources of the globe; Multipurpose uses of Water: Soil-Plant-Water relationship, irrigation systems, water demand assessment; Storages and their yields; Ground water yield and well hydraulics; Water-logging, drainage design; Irrigation revenue; Design of rigid boundary canals, Lacey's and Tractive force concepts in canal design, lining of canals; Sediment transport in canals; Non-overflow and overflow sections of gravity dams and their design. Energy dissipators and tailwater rating; Design of headworks distribution works, falls, cross-drainage works, outlets; River raining.

**ENVIRONMENTAL ENGINEERING**

**3. (a) Water Supply Engineering**

Sources of Supply, yields, design of intakes and conductors; Estimation of demand; Water quality standards. Control of Water-borne diseases; Primary and secondary treatment detailing and maintenance of treatment units; Conveyance and distribution systems of treated water, leakages and control; Rural water supply; Institutional and industrial water supply.

**(b) Waste Water Engineering**

Urban rain water disposal : Systems of sewage collection and disposal; Design of sewers and sewerage systems; pumping. Characteristics of sewage and its treatment. Disposal of products of sewage treatment, stream flow rejuvenation; Institutional and industrial sewage management; Plumbing Systems; Rural and semi-urban sanitation.

**(c) Solid Waste Management**

Source, classification, collection and disposal; Design and Management of Landfills.

**(d) Air and Noise Pollution and Ecology**

Sources and effects of air pollution, monitoring of air pollution; Noise pollution and Standards; Ecological chain and balance. Environmental assessment.

**4. (a) Soil Mechanics**

Properties of soils, classification and inter-relationship. Compaction behaviour, methods of compaction and their choice; Permeability and seepage, flownets. Inverted filters; Compressibility and consolidation; Shearing resistance. Stresses and failure; Soil testing in laboratory and in situ; Stress path and applications; Earth pressure, theories. Stress distribution in soils; Soil exploration, samplers, load tests penetration tests.

**(b) Foundation Engineering**

Types of foundations. Selection criteria, bearing capacity, settlement, laboratory and field tests; Types of piles and their design and layout. Foundations on expansive soils, swelling and its prevention foundation on swelling soils.

**5. (a) Surveying**

Classification of surveys, scales accuracy; Measurement of distances—direct and indirect methods; optical and electronic devices; Measurement of directions, prismatic compass, local attraction; Theodolities-types; Measurement of elevations-Spirit and trigonometric levelling. Relief representation-Contours; Digital Monitoring Organisation elevation modelling concept; Establishment of control by traingulation and traversing—measurements and adjustment of observations computation of coordinates; Field astoronomy. Concept of global

positioning system; Map preparation by plane tabling and by photogrammetry. Remote sensing concepts, map substitutes.

**(b) Transportation Engineering**

Planning of highway systems, alignment and geometric design horizontal and vertical curves, grade separation; Materials and construction methods for different surfaces and maintenance; Principles of pavement design; Drainage, Traffic Surveys; Intersection, Signalling; Mass transit system, accessibility, networking.

Tunnelling, alignment, methods of construction, disposal of muck, drainage lighting and ventilation, traffic control, emergency management.

Planning of railway systems, terminology and designs relating to gauge, track, controls transits, rolling stock, tractive power and track modernisation; Maintenance, Appurtenant works, Containnerisation.

Harbours—layouts, shipping lanes, anchoring, location identification; Literal transport with erosion and deposition; Sounding methods; Dry and wet docks, components and operations; Tidal data and analysis.

Airports—layout and orientation; Runway and Taxiway; design and drainage management; Zoning laws; Visual aids and air traffic control; helipads, hangers, service equipment.

**MECHANICAL ENGINEERING (For both Objective and Conventional Type Papers)**

**PAPER I**

**1.** Thermodynamics, Cycles and IC Engines, Basic concepts. Open and Closed systems. Heat and work, Zerothe, First and Second Law, Application to non-flow and Flow processes. Entropy, Availability, Irreversibility and TDS relations. Clapeyron and real gas equations, Properties of ideal gases and vapours. Standard vapour. Gas power and Refrigeration cycles. Two stage compressor. C. I. and S. I. Engines. Pre-ignition, Detonation and Diesel-knock, Fuel injection and Carburation. Supercharging Tubro-prop and Rocket engines. Engine Cooling. Emission and Control, Fuel gas analysis. Measurement of Calorific values. Conventional and Nuclear fuels. Elements of Nuclear power production.

**2.** Heat Transfer and Refrigeration and Airconditioning Modes of heat transfer. One dimensional steady and unsteady condition. Composite slab and Equivalent Resistance. Heat dissipation from extended surfaces. Heat exchangers. Overall heat transfer coefficient. Empirical correlations for heat transfer in laminar and turbulent flows and for free and forced Convection. Thermal boundary layer over a flat plate. Fundamentals of diffusive and convective mass transfer, Block, body and basic

concepts in Radiation. Enclosure theory. Shape factor. Net work analysis. Heat pump and Refrigeration cycles and systems. Refrigerants. Condensers. Evaporators and expansion devices. Psychrometry, Charts and application to airconditioning. Sensible heating and cooling. Effective temperature, Comfort indices. Load calculations. Solar refrigeration. Controls, Duct design.

**3. Fluid Mechanics**

Properties and classification of fluids, Manometry. Forces on immersed surfaces. Center of pressure. Buoyancy, Elements of stability of floating bodies. Kinematics and Dynamics, irrotational and incompressible, inviseid flow, velocity potential, Pressure field and Forces on immersed-bodies Berroulli's equations. Fully developed flow through pipes. Pressure drop calculations. Measurement of flow rate and Pressure, drop. Elements of boundary layer theory. Integral approach. Laminar and turbulent flows. Separations, Flow over weirs and notches. Open channel flows. Hydraulic jump. Dimensionless numbers Dimensional analysis. Similitude and modelling. One-dimensional isentronic flow. Normal shock wave. Flow through convergent—divergent ducts. Oblique shock-wave, Ravleigh and Fanno lines.

**4. Fluid Machinery and Stream Generators**

Performance, Operation and control of hydraulic Pump and impulse and reaction Turbines. Specific speed Classification. Energy transfer. Coupling Power, transmission. Steam generators. Fire-tube and water-tube boilers. Flow of steam through nozzles and difusers, Wetness and condensation. Various types of steam and gas turbines Velocity diagrams. Partial admission Reciprocating, Centrifugal and axial flow Compressors, Multi-stage compression, role of Mach Number, Reheat, Regeneration, Efficiency. Governace.

**PAPER II**

**5. Theory of Machines**

Kinematic and dynamic analysis of planner mechanisms. Cams. Gears and gear trains. Flywheels, Governors, Balancing of rigid rotor and field balancing. Balancing of single and multicylinder engines. Linear vibration analysis of mechanical systems. Critical speeds and whirling of shafts. Automatic Controls.

**6. Machine Design**

Design of Joints : cotters, keys, spines, welded joints, threaded fasteners, joints formed by interference fits. Design of friction drives: couplings and clutches, belt and chain drives, power screws. Design of Power transmission systems: gears and gear drives, shaft and axle, wire ropes. Design of bearings, Hydrodynamic bearings and rolling element bearings.

**7. Strength of Materials**

Stress and strain in two dimensions. Principal stresses and strains, Mohr's construction, linear elastic materials, isotropy and anisotropy, stress-strain relations, uniaxial loading, thermal stresses. Beams: Bending moment and shear force diagram, bending stresses and deflection of beam. Shear stress distribution. Torsion of shafts, helical springs. Combined stresses, thick and thin walled pressure vessels. Struts and Columns. Strain energy concepts and theories of failure.

**8. Engineering Materials**

Basic concepts on structure of solids. Crystalline materials, Deffects in crystalline materials. Alloys and binary phase diagrams, structure and properties of common engineering materials. Heat treatment of steels. Plastics, Ceramics and composite materials. Common applications of various materials.

**9. Production Engineering**

**Metal Forming :** Basic Principles of Forming, drawing and extrusion; High energy rate forming; Powder metallurgy.

**Metal Casting :** Die casting, investment casting, Shell Moulding, Centrifugal Casting, Gating and Riser design; melting furnaces. Fabrication Processes : Principles of Gas, Arc. Shielded are Welding; Advanced. Welding Processes; weldability; Metallurgy of Welding.

**Metal Cutting :** Turning, Methods of Screw Production. Drilling, Boring. Milling, Gear Manufacturing. Production of flat surfaces Grinding and Finishing Processes.

Computer Controlled Manufacturing Systems— CNC, DNC, FMS, Automation and Robotics.

**Cutting Tool Materials :** Tool Geometry Mechanism of Tool Wear, Tool Life and Machinability; Measurement of cutting forces. Economics of Machining. Unconventional Machining. Processes, Jigs and Fixtures.

**Fits and Tolerances :** Measurement of surface texture. Comparators, Alignment tests and reconditioning of Machine Tools.

**10. Industrial Engineering**

Production, Planning and Control : Forecasting— Moving average exponential smoothing. Operations scheduling; assembly line balancing Product development. Break-even analysis, capacity planning, PERT and CPM.

Control Operations : Inventory Control—ABC analysis EOO model. Materials requirement planning Job. design. Job standards. Work measurement. Quality management— Quality analysis and control.

Operations Research : Linear programming— Graphical and Simplex methods. Transportation and assignment models. Single server queuing model.

Value Engineering : Value analysis for cost/value.

**11. Elements of Computation**

Computer Organisation, Flow charting. Features of Common Computer Languages—FORTRAN, d' Base III. Lotus 1-2-3, C and elementary programming

**ELECTRICAL ENGINEERING (for both Objective and Conventional Type Papers)**

**PAPER I**

**1. KM Theory**

Electric and magnetic fields. Gauss's Law and Awpcris Law, Fields in dielectrics, conductors and magnetic materials. Maxwell's equations. Time varying fields. Plane-Wave propagation in dielectric and conducting media. Transmission lines.

**2. Electrical Materials**

Band Theory. Conductors, Semi-conductors and Insulators. Super-Conductivity. Insulators for electrical and electronic applications. Magnetic materials. Ferro and feri-magnetism. Ceramics, properties and applications Hall effect and its applications. Special semiconductors.

**3. Electrical Circuits**

Circuit elements. Kirchoffs Laws Mesh and nodal analysis. Network theorems and applications. Natural response and forced response. Transient response and steady-stat response for arbitrary inputs. Properties of networks in terms of poles and zeros. Transfer function. Resonant circuits. Three-phase circuits Two-port network. Elements of two-element network systhesis.

**4. Measurements and Instrumentation**

Units and Standards, Error analysis. Measurement of current. Voltage Power, Power-factor and energy. Indicating instruments. Measurement of resistance inductance. Capacitance and frequency. Bridge Measurements. Electronic measuring instrument, digital voltmeter and frequency counters. Transducers and their applications to the measurement of non-electrical quantities like temperature, pressure, flow-rate displacement, acceleration, noise level etc. Data acquisition systems. A/D and D/A Converters.

**5. Control Systems**

Mathematical modelling of physical systems. Block diagrams and signal flow graphs and their reduction. Time domain and frequency domain analysis of linear dynamical system. Errors for different types of inputs and stability criteria for feedback systems. Stability analysis using Routh-Hurwitz array, Nyquist plot and Bode plot. Root locus and Nicols chart and the estimation of gain and phase margin. Basic concepts of compensator design. State variable matrix and its use in system modelling and design Sampled data system and performance of such a system with the samples in the error channel. Stability of sampled data system. Elements of nonlinear control analysis. Control system component, electromechanical hydraulic pneumatic components.

**PAPER II**

**1. Electrical Machines and power transformers**

Magnetic Circuits.— Analysis and Design of Power transformers. Construction and testing. Equivalent circuits, losses and efficiency Regulation. Auto-transformer. 3-phase transformer. Parallel operation. Basic concepts in rotating machines. EMF, torque, basic machine types. Construction and operation, leakage, losses and efficiency.

D. C. Machines Construction.—Excitation methods, Circuit models. Armature reaction and communication. Characteristics and performance analysis. Generators and motors. Starting and speed control. Testing Losses and efficiency.

Synchronous Machines.—Construction Circuit model. Operating characteristics and performance analysis. Synchronous reactance. Efficiency. Voltage regulation. Salient pole machine. Parallel operation. Hunting. Short circuit transients.

Induction Machines Construction.—Principle of operation. Rotating fields. Characteristics and performance analysis. Determination of circuit model. Circle diagram. Starting and speed control.

Fractional KW motors. — Single-phase synchronous and induction motors.

**2. Power Systems**

Types of Power Station Hydro, Thermal and Nuclear Stations. Pumped storage plants. Economics and operating factors. Power transmission lines.— Modelling and performance characteristics. Voltage control. Load flow studies. Optimal power system operation. Load frequency control. Symmetrical short circuit analysis. Z-Bus formulation Symmetrical Components. Per unit representation. Fault analysis. Transient and steady-state stability of power systems. Equal area criterion. Power system Transients. Power system Protection Circuit breakers Relays. HVDC transmission.

**3. Analog and Digital Electronics and Circuits**

Semi-conductor device physics, PN junctions and transistors, circuits Models and parameters, FET Zener tunnel, Schottky, photo diodes and their applications, rectifier circuits voltage regulators and multipliers, switching behaviour diodes and transistors. Small signal amplifiers biasing circuits, frequency response and improvement, multistage amplifiers and feed-back amplifiers, D.C. amplifiers. Oscillators, Large signal amplifiers, coupling methods, push pull amplifiers, operational amplifiers, wave, shaping circuits. Multivibrators and flip-flops and

their applications. Digital logic gate families, universal-gates- combinational circuits for arithmetic and logic operation sequential logic circuits. Counters Registers. RAM and ROMs.

**4. Microprocessors**

Microprocessor architecture.—Instruction set and simple assembly language programming. Interfacing for memory and I/O. Applications of Microprocessors in power system.

**5. Communication Systems**

Types of modulation; AM, FM and PM. Demodulators. Noise and bandwidth consideration. Digital communication systems. Pulse code modulation and demodulation. Elements of sound and vision broadcasting Carrier communication. Frequency division and time division multiplexing. Telemetry system in power engineering.

**6. Power Electronics**

Power Semi-conductor devices, Thyristor, Power transistor, GTOs and MOSFETs. Characteristics and operation. AC to DC Converters. 1-phase and 3-phase DC to DC Converters.

**AC regulators :** Thyristor controlled reactors, switched capacity networks.

**Inverters :** Single-phase and 3-phase Pulse width modulation. Sinusoidal modulation with uniform sampling. Switched mode power supply

**ELECTRONICS AND TELECOMMUNICATION ENGINEERING (For both Objective and Conventional Type Papers)**

**PAPER I**

**1. Materials and components**

Structure and properties of Electrical Engineering materials Conductors, Semi-conductors and Insulators, Magnetic, Ferroelectric, piezoelectric Ceramic, Optical and Superconducting materials. Passive components and characteristics Resistors, Capacitors and Inductors : Ferrites, Quartz crystal. Ceramic resonators, Electromagnetic and electro-mechanical components.

**2. Physical Electronics, Electron Devices and ICs**

Electrons and holes in semi-conductors. Carrier Statistics, Mechanism of current flow in a semi-conductor, Hall effect. Junction theory; Different types of diodes and their characteristics; Bipolar Junction transistor; Field effect transistors; Power switching devices like SCRs. CTOs, power MOSFETs; Basics of ICs-bipolar, MOS and CMOS types; Basics of Opto-Electronics.

**3. Signals and Systems**

Classification of signals and systems; System modelling in terms of differential and difference equations; State variable representation; Fourier series; Fourier transforms and their application to system analysis; Laplace transforms and their application to system analysis; Convolution and superposition integrals and their applications; Z-transforms and their applications to the analysis and characterisation of discrete time systems; Random signals and probability. Correlation functions; Spectral density; Response of linear system to random inputs.

**4. Network Theory**

Network analysis techniques: Network theorems, transient response steady state sipusoidal response; Network graphs and their applications in network analysis; Tellegen's theorem. Two port networks : Z, Y, h and transmission parameters. Combination of two ports analysis of common two ports. Network functions; parts of network functions; obtaining a network function from a given part. Transmission criterion : dalcy and rise time. Elmorc's and other definition effect of cascading Elements of network synthesis.

**5. Electromagnetic Theory**

Analysis of electrostatic and magnetostatic fields; Laplace's and Potson's equations; Boundary value problems and their solutions; Maxwell's equations : application to wave propagation in bounded and unbounded media; Transmission lines : basic theory, standing wave, matching applications microstrip lines; basics of waveguides and resonators; Elements of antenna theory.

**6. Electronic Measurement and Instrumentation**

Basic concepts standards and error analysis; Measurements of basic electrical quantities and parameters; Electronic measuring instruments and their principles of working, analog and digital, comparison characteristics, applications

Transducers; Electronic measurements of non-electrical quantities like temperature, pressure, humidity etc. Basics of telemetry for industrial use.

**PAPER II**

**1. Analog Electronic Circuits**

Transistor biasing and stabilization small signal analysis. Power amplifiers Frequency response. Wide banding techniques Feedback amplifiers Tuned amplifier? Oscillators, Rectifiers and power; supplies Op Amp PLL other linear integrated circuits and applications Pulse shaping circuits and waveform generator.

**2. Digital Electronic Circuits**

Transistor as a switching element; Boolean algebra simplification of Boolean functions, Karnaugh man and applications' IC

Logic gates and their characteristics : IC logic families : DTL, TTL, ECL, NMOS PMOS and CMOS gates, and their comparison Combinational logic circuits; Half adder Full adder. Digital compartor. Multiplexer. Demultiplexer; ROM and their applications, Flipflops, R-S, J. K., D and T np-nops; Different types of counters and resisters; Waveform generators. A/D and D/A conveners. Semi-conductor memories.

**3. Control Systems**

Transient and steady state response of control systems, Effect of feedback on stability and sensitivity; Root locus techniques; Frequency response analysis Concepts of gain and phase margins; constant-M and Consta. N Nichols's Chart; Approximation of transient response from Constant-N nichols Chart; Approximation of transient response from closed loop frequency response; Design of Control systems Compensators; Industrial controllers.

**4. Communication Systems**

Basic information theory. Modulation and detection in analogue and digital systems; Sampling and data reconstruction Quantization & Coding; Time division and frequency division multiplexing, Equalisation; Optical Communication in free space and fibre optic; Propagation of signals at HF, VHP, UHF and microwave frequency; Satellite Communication.

**5. Microwave Engineering**

Microwave Tubes and solid state devices, Microwave generation and amplifiers, Waveguides and other Microwave Components and Circuits Microstrip circuits, Microwave Antennas, Microwave Measurements, Masers Lasers; Microwave propagation. Microwave Communication systems-terrestrial and Satellite based.

**6. Computer Engineering**

Number Systems; Data representation; Programming; Elements of a high level programming language PASCAL/ C. Use of basic data structures; Fundamentals of computer architecture; Processor design; Control unit design; Memory organisation. I/o System Organisation, Micro-processors : Architecture and instruction set of micro-processors 8085 and 8086. Assembly language programming. Micro-processor based system design : typical examples. Personal computers and their typical uses.