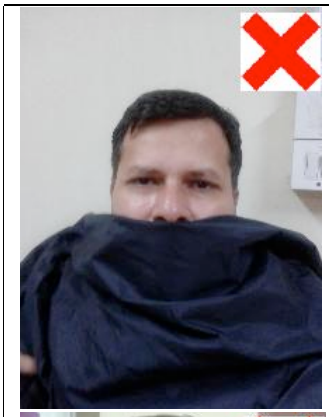
3.5.5.2 Sample Photographs

Not Acceptable Photograph	Reason for Rejection	Acceptable
	Mobile phone; Distorted face	
	Blue Background	
	Facial Area is less than 50% of total	
	Not looking straight into Camera	



Cloth Covering facial features

Shadow on face

Improper flash or Improper Lighting

Too much glare on spectacles

Dark/Tinted Spectacles or Sunglasses

Poor Digital Resolution (100×75)

3.5.5.3 Signature Specifications

1. Please put your signature with black or dark blue ink on a white paper.
2. Get the signature digitally photographed/image scanned by a professional photo studio, and get the image cropped by the studio itself.
3. Only JPEG image formats will be accepted.
4. The maximum pixel resolution for the image is 800 x 300.
5. The minimum pixel resolution for the image is 400 x 150.
6. Mobile phone photographs of signatures are not acceptable, and can result in disqualification of the application without any refund of the fee.

3.6 Admit Card

Admit card can only be downloaded from the zonal GATE websites from 5th December 2012 onwards. Sending Admit cards by post has been discontinued. Bring the downloaded admit card at the test center along with at least one original (not photocopied / scanned copy) and valid (not expired) photo identification. ONLY one of the following photo identifications is permitted: Driving license, Passport, PAN Card, Voter ID, College ID, Employee identification card, or a notarized Affidavit with Photo, Signature, Date of Birth and Residential Address. Photocopies of the original identification document are not acceptable. **Candidates will NOT be permitted to take the test, if original and valid photo identification is not presented**.

4 Examination Related Information

4.1 Structure of GATE 2013

A candidate can apply for only ONE of the 21 papers listed in Table given below. The syllabus for each of the papers is given separately. Making a choice of the appropriate paper during GATE application is the responsibility of the candidate. Some guidelines in this respect are suggested below.

The candidate is expected to appear in a paper appropriate to the discipline of his/her qualifying degree. The candidate is, however, free to choose any paper according to his/her admission plan, keeping in mind the eligibility criteria of the institutions in which he/she wishes to seek admission.

Table: List of GATE papers and corresponding codes

Sl. No.	Paper	Code	Sl. No.	Paper	Code
1	Aerospace Engineering	AE	**12**	Instrumentation Engineering	IN
2	Agricultural Engineering	AG	**13**	Mathematics	MA
3	Architecture and Planning	AR	**14**	Mechanical Engineering	ME
4	Biotechnology	BT	**15**	Mining Engineering	MN
5	Civil Engineering	CE	**16**	Metallurgical Engineering	MT
6	Chemical Engineering	CH	**17**	Physics	PH
7	Computer Science and Information Technology	CS	**18**	Production and Industrial Engineering	PI
8	Chemistry	CY	**19**	Textile Engineering and Fibre Science	TF
9	Electronics and Communication Engineering	EC	**20**	Engineering Sciences	XE*
10	Electrical Engineering	EE	**21**	Life Sciences	XL*
11	Geology and Geophysics	GG			
	XE PAPER SECTIONS	**CODE**		**XL PAPER SECTIONS**	**CODE**
	Engineering Mathematics (Compulsory)	A		Chemistry (Compulsory)	H
	Fluid Mechanics	B		Biochemistry	I
	Materials Science	C		Botany	J
	Solid Mechanics	D		Microbiology	K
	Thermodynamics	E		Zoology	L
	Polymer Science and Engineering	F		Food Technology	M
	Food Technology	G			

* XE (Engineering Sciences) and XL (Life Sciences) papers are of general nature and will comprise of the sections listed in the above table. See further explanation below.

4.1.1 General Aptitude Questions

All the papers will contain few questions that test the General Aptitude (Language and Analytical Skills), apart from the core subject of the paper.

4.1.2 XE Paper

A candidate appearing in the XE paper has to answer the following

1. Section A – Engineering Mathematics
2. GA – General Aptitude
3. Any two of XE sections B to G

The choice of two out of the sections B to G can be made at the time of appearing for the exam after viewing the questions. Only two optional sections can be answered at a time. A candidate wishing to change from one optional to another optional section during the exam must first choose to deselect one of the previously chosen optional sections (B to G).

4.1.3 XL Paper

A candidate appearing in the XL paper has to answer the following

1. Section H – Chemistry
2. GA – General Aptitude
3. Any two of XL sections I to M

The choice of two out of the sections I to M can be made at the time of appearing for the exam after viewing the questions. Only two optional sections can be answered at a time. A candidate wishing to change from one optional to another optional section during the exam must first choose to deselect one of the previously chosen optional sections (I to M).

4.2 Duration and Exam Type

The GATE examination consists of a single paper of 3 hours duration that contains 65 questions carrying a maximum of 100 marks. The question paper will consist of only objective questions. The pattern of question papers is discussed separately in detail in Section 4.3.

The examination for the papers with codes AE, AG, AR, BT, CE, CH, CY, GG, PH, MA, MN, MT, TF, XE, and XL will be carried out as ONLINE computer based test where the candidates will be shown the questions in a random sequence on a computer screen. The candidates are required to enter the answer for each question using a mouse (keyboards will be disabled). Candidates will be provided with blank paper sheets for rough work. At the end of the three hour window, the computer will automatically close the screen from further actions.

For all other papers (CS, EC, EE, IN, ME, and PI), the candidates will be given the questions printed on a paper, and they have to mark the correct choice on an Optical Response Sheet (ORS) by darkening the appropriate bubble against each question using a black ink ball point pen.

4.3 Pattern of Question Papers and Marking Scheme

4.3.1 Pattern of Question Papers

The examination for the papers with codes AE, AG, AR, BT, CE, CH, CY, GG, MA, MN, MT, PH, TF, XE and XL will be conducted ONLINE using computers where the candidates will be required to select the answer for each question using a mouse. For all other papers (CS, EC, EE, IN, ME & PI), the candidates will have to mark the correct choice on an Optical Response Sheet (ORS) by darkening the appropriate bubble against each question.

In all the papers, there will be a total of 65 questions carrying 100 marks, out of which 10 questions carrying total of 15 marks are in General Aptitude (GA). The remaining 85 % of the total marks is devoted to the syllabus of the paper (as indicated in the syllabus section).

GATE 2013 would contain questions of four different types in various papers:

(i) Multiple choice questions carrying 1 or 2 marks each; Each of the multiple choice objective questions in all papers and sections will contain four answers, of which one correct answer is to be marked.

(ii) Common data questions (which are also multiple choice questions), where two successive questions use the same set of input data;

Example

Statement for Common Data Questions, for instance, for Questions 48 and 49 in Main Paper:

Let X and Y be jointly distributed random variables such that the conditional distribution of Y, given X=x, is uniform on the interval (x-1,x+1). Suppose E(X)=1 and Var(X)=5/3.

First question using common data:

Q.48 The mean of the random variable Y is

(A) 1/2 (B) 1 (C) 3/2 (D) 2

Second question using common data:

Q.49 The variance of the random variable Y is

(A) 1/2 (B) 2/3 (C) 1 (D) 2

(iii) Linked answer questions (which are also multiple choice questions), where the answer to the first question in the pair is required to answer its successor;

Example: Statement for Linked Answer Questions, for instance, for Questions 52 and 53 in Main Paper:

An *E. coli* cell of volume 10-12 cm3 contains 60 molecules of lac-repressor. The repressor has a binding affinity (Kd) of 10-8 M and 10-9 M with and without lactose respectively, in the medium.

First question of the pair:

Q.52 The molar concentration of the repressor in the cell is

(A) 0.1 nM (B) 1 nM (C) 10 nM (D) 100 nM

Second question of the pair:

Q.53 Therefore the lac-operon is

(A) repressed and can only be induced with lactose.
(B) repressed and cannot be induced with lactose.
(C) not repressed.
(D) expressed only when glucose and lactose are present.

(iv) Numerical answer questions, where the answer is a number, to be entered by the candidate.

Design of Questions

The questions in a paper may be designed to test the following abilities:

(i) *Recall*: These are based on facts, principles, formulae or laws of the discipline of the paper. The candidate is expected to be able to obtain the answer either from his/her memory of the subject or at most from a one-line computation.

Example

Q. During machining maximum heat is produced

(A) in flank face
(B) in rake face
(C) in shear zone
(D) due to friction between chip and tool

(ii) *Comprehension*: These questions will test the candidate's understanding of the basics of his/her field, by requiring him/her to draw simple conclusions from fundamental ideas.

Example

Q. A DC motor requires a starter in order to
(A) develop a starting torque
(B) compensate for auxiliary field ampere turns
(C) limit armature current at starting
(D) provide regenerative braking

(iii) *Application*: In these questions, the candidate is expected to apply his/her knowledge either through computation or by logical reasoning.

Example

Q. The sequent depth ratio of a hydraulic jump in a rectangular channel is 16.48. The Froude number at the beginning of the jump is:

(A) 5.0 (B) 8.0 (C) 10.0 (D) 12.0

(iv) ***Analysis and Synthesis*****:** These can be linked answer questions, where the answer to the first question of the pair is required in order to answer its successor. Or these can be common data questions, in which two questions share the same data but can be solved independently of each other.

Common data based questions: Two questions are linked to a common data problem, passage and the like. Each question is independent and its solution is obtainable from the above problem data or passage directly. (Answer of the previous question is not required to solve the next question). Each question under this group will carry two marks.

Linked answer questions: These questions are of problem solving type. A problem statement is followed by two questions based on the problem statement. The two questions are designed such that the solution to the second question depends upon the answer to the first one. In other words, the first answer is an intermediate step in working out the second answer. Each question in such 'linked answer questions' will carry two marks.

Examples of each of this design is given in the types of questions above.

The questions based on the above four logics may be a mix of single stand alone statement/phrase /data type questions, combination of option codes type questions or match items type questions.

4.4 Marking Scheme

For 1mark multiple-choice questions, 1/3 mark will be deducted for a wrong answer. Likewise, for 2 marks multiple-choice questions, 2/3 mark will be deducted for a wrong answer. However, for the linked answer question pair, where each question carries 2 marks, 2/3 mark will be deducted for a wrong answer to the first question only. There is no negative marking for wrong answer to the second question of the linked answer question pair. If the first question in the linked pair is wrongly answered or is unattempted, then the answer to the second question in the pair will not be evaluated. There is no negative marking for numerical answer type questions.

4.4.1 General Aptitude (GA) Questions

In all papers, GA questions are of multiple choice type, and carry a total of 15 marks. The GA section includes 5 questions carrying 1 mark each (sub-total 5 marks) and 5 questions carrying 2 marks each (sub-total 10 marks).

4.4.2 Question papers other than GG, XE and XL

These papers would contain 25 questions carrying one mark each (sub-total 25 marks) and 30 questions carrying two marks each (sub-total 60 marks). Out of these, two pairs of questions would be common data questions, and two pairs of questions would be linked answer questions. In the ONLINE papers, the question paper will consist of questions of multiple choice type and numerical answer type. For multiple choice type questions, each question will have four choices

for the answer. For numerical answer type questions, each question will have a number as the answer and choices will not be given**.** Candidates will have to enter the answer using a virtual keypad.

4.4.3 GG (Geology and Geophysics) Paper

Apart from the General Aptitude (GA) section, the GG question paper consists of two parts: Part A and Part B. Part A is common for all candidates. Part B contains two sections: Section 1 (Geology) and Section 2 (Geo-physics). Candidates will have to attempt questions in Part A and either Section 1 or Section 2 in Part B.

Part A consists of 25 multiple-choice questions carrying 1-mark each (sub-total 25 marks & some of these may be numerical questions). Each section in Part B (Section 1 and Section 2) consists of 30 multiple-choice questions carrying 2 marks each (sub-total 60 marks and some of these may be numerical questions). Out of these, two pairs of questions would be common data questions, and two pairs of questions would be linked answer questions.

4.4.4 XE Paper (Engineering Sciences)

In XE paper, Engineering Mathematics section (Section A) is compulsory. This section contains 11 multiple-choice questions carrying a total of 15 marks: 7 questions carrying 1-mark each (sub-total 7 marks), and 4 questions carrying 2-marks each (sub-total 8 marks). Some of the multiple-choice questions may be replaced by numerical questions.

Each of the other sections of the XE paper (Sections B through G) contains 22 questions carrying a total of 35 marks: 9 questions carrying 1 mark each (sub-total 9 marks) and 13 questions carrying 2 marks each (sub-total 26 marks). Out of the 2 mark questions, 2 pairs are common data questions and 1 pair is linked answer questions. Some of the multiple choice questions may be replaced by numerical questions.

4.4.5 XL Paper (Life Sciences)

In XL paper, Chemistry section (Section H) is compulsory. This section contains 15 multiple-choice questions carrying a total of 25 marks: 5 questions carrying 1 mark each (sub-total 5 marks) and 10 questions carrying 2-marks each (sub-total 20 marks). Out of the 2-mark questions, 1 pair is common data questions, and 1 pair is linked answer questions. Some of the multiple-choice questions may be replaced by numerical questions.

Each of the other sections of the XL paper (Sections I through M) contains 20 multiple choice questions carrying a total of 30 marks: 10 questions carrying 1 mark each (sub-total 10 marks) and 10 questions carrying 2 marks each (sub-total 20 marks). Some of the multiple-choice questions may be replaced by numerical questions.

4.5 GATE Syllabi

4.5.1 General Aptitude (GA): Common to All Papers Engineering

1. **Verbal Ability:** English grammar, sentence completion, verbal analogies, word groups, instructions, critical reasoning and verbal deduction.

2. **Numerical Ability:** Numerical computation, numerical estimation, numerical reasoning and data interpretation.

Sample Questions

Verbal Ability

Q.1. Choose the appropriate answer to complete the following sentence:

After several ……. attempts to send the missile into space, the spacecraft was finally launched successfully.

(A) abortive (B) difficult (C) experimental (D) preliminary

Ans. (A)

Q.2. Choose the appropriate answer to complete the following sentence:

Medicine is to illness as law is to _____

(A) discipline (B) anarchy (C) treason (D) etiquette

Ans. (B)

Q.3. Read the following paragraph:

"The ordinary form of mercury thermometer is used for temperature ranging from -40^{o}F to 500^{o}F. For measuring temperature below -40^{o}F, thermometers filled with alcohol are used. These are, however, not satisfactory for use in high temperatures. When a mercury thermometer is used for temperature above 500^{o}F, the space above the mercury is filled with some inert gas, usually nitrogen or carbon dioxide, placed in the thermometer under pressure. As the mercury rises, the gas pressures are increased, so that it is possible to use these thermometers for temperatures as high as 1000^{o}F."

With what, besides mercury, would a thermometer be filled if it was designed to be used for measuring temperature of about 500^{o}F?

(A) Pyrometer (B) Inert gas (C) Iron and brass (D) Gas

Ans. (B)

Q.4. The cost of manufacturing tractors in Korea is twenty percent less than the cost of manufacturing tractors in Germany. Even after transportation fees and import taxes are added, it is still cheaper to import tractors from Korea to Germany than to produce tractors in Germany.

Which of the following assertions is best supported by the above information?

(A) Labour costs in Korea are twenty percent below those in Germany.

(B) Importing tractors into Germany will eliminate twenty percent of the manufacturing jobs in Germany.

(C) The costs of transporting a tractor from Korea to Germany is more than twenty percent of the cost of manufacturing the tractor in Korea.

(D) The import taxes on a tractor imported from Korea to Germany is less than twenty percent of the cost of manufacturing the tractor in Germany.

Ans. (D)

Numerical Ability

Q.5. In a survey, 3/16 of the people surveyed told that they preferred to use public transport while commuting daily to office. 5/8 of the people surveyed told that they preferred to use their own vehicles. The remaining 75respondents said that they had no clear preference. How many people preferred to use public transport?

(A) 75 (B) 100 (C) 125 (D) 133

Ans. (A)

4.5.2 Aerospace Engineering (AE)

Engineering Mathematics

Linear Algebra: Matrix algebra, systems of linear equations, eigen values and eigen vectors.

Calculus: Functions of single variable, limit, continuity and differentiability, mean value theorems, evaluation of definite and improper integrals, partial derivatives, total derivative, maxima and minima, gradient, divergence and curl, vector identities, directional derivatives, line, surface and volume integrals. Theorems of Stokes, Gauss and Green.

Differential Equations: First order linear and nonlinear equations, higher order linear ODEs with constant coefficients, Cauchy and Euler equations, initial and boundary value problems, Laplace transforms. Partial differential equations and separation of variables methods.

Numerical methods: Numerical solution of linear and nonlinear algebraic equations, integration by trapezoidal and Simpson rule, single and multi-step methods for differential equations.

Flight Mechanics

Atmosphere: Properties, standard atmosphere. Classification of aircraft.Airplane (fixed wing aircraft) configuration and various parts.

Airplane performance: Pressure altitude; equivalent, calibrated, indicated air speeds; Primary flight instruments: Altimeter, ASI, VSI, Turn-bank indicator. Drag polar; take off and landing; steady climb & descent,-absolute and service ceiling; cruise, cruise climb, endurance or loiter; load factor, turning flight, V-n diagram; Winds: head, tail & cross winds.

Static stability: Angle of attack, sideslip; roll, pitch & yaw controls; longitudinal stick fixed & free stability, horizontal tail position and size; directional stability, vertical tail position and size; dihedral stability. Wing dihedral, sweep & position; hinge moments, stick forces.

Dynamic stability: Euler angles; Equations of motion; aerodynamic forces and moments, stability & control derivatives; decoupling of longitudinal and lat-directional dynamics; longitudinal modes; lateral-directional modes.

Space Dynamics

Central force motion, determination of trajectory and orbital period in simple cases. Orbit transfer, in-plane and out-of-plane. Elements of rocket motor performance.

Aerodynamics

Basic Fluid Mechanics: Incompressible irrotational flow, Helmholtz and Kelvin theorem, singularities and superposition, viscous flows, boundary layer on a flat plate.

Airfoils and wings: Classification of airfoils, aerodynamic characteristics, high lift devices, Kutta Joukowski theorem; lift generation; thin airfoil theory; wing theory; induced drag; qualitative treatment of low aspect ratio wings.

Viscous Flows: Flow separation, introduction to turbulence, transition, structure of a turbulent boundary layer.

Compressible Flows: Dynamics and Thermodynamics of I-D flow, isentropic flow, normal shock, oblique shock, Prandtl-Meyer flow, flow in nozzles and diffusers, inviscid flow in a c-d nozzle, flow in diffusers. subsonic and supersonic airfoils, compressibility effects on lift and drag, critical and drag divergence Mach number, wave drag.

Wind Tunnel Testing: Measurement and visualisation techniques.

Structures

Stress and Strain: Equations of equilibrium, constitutive law, strain-displacement relationship, compatibility equations, plane stress and strain, Airy's stress function.

Flight Vehicle Structures: Characteristics of aircraft structures and materials, torsion, bending and flexural shear. Flexural shear flow in thin-walled sections. Buckling. Failure theories. Loads on aircraft.

Structural Dynamics: Free and forced vibration of discrete systems. Damping and resonance. Dynamics of continuous systems.

Propulsion

Thermodynamics of Aircraft Gas Turbine engines, thrust and thrust augmentation.

Turbomachinery: Axial compressors and turbines, centrifugal pumps and compressors.

Aerothermodynamics of non-rotating propulsion components: Intakes, combustor and nozzle. Thermodynamics of ramjets and scramjets. Elements of rocket propulsion.

4.5.3 Agricultural Engineering (AG)

Engineering Mathematics

Linear Algebra: Matrices and Determinants, Systems of linear equations, Eigen values and eigen vectors.

Calculus: Limit, continuity and differentiability; Partial Derivatives; Maxima and minima; Sequences and series; Test for convergence; Fourier series.

Vector Calculus: Gradient; Divergence and Curl; Line; surface and volume integrals; Stokes, Gauss and Green's theorems.

Differential Equations: Linear and non-linear first order ODEs; Higher order linear ODEs with constant coefficients; Cauchy's and Euler's equations; Laplace transforms; PDEs -Laplace, heat and wave equations.

Probability and Statistics: Mean, median, mode and standard deviation; Random variables; Poisson, normal and binomial distributions; Correlation and regression analysis.

Numerical Methods: Solutions of linear and non-linear algebraic equations; integration of trapezoidal and Simpson's rule; single and multi-step methods for differential equations.

Farm Machinery And Power

Sources of power on the farm-human, animal, mechanical, electrical, wind, solar and biomass; bio-fuels; design and selection of machine elements – gears, pulleys, chains and sprockets and belts; overload safety devices used in farm machinery; measurement of force, torque, speed, displacement and acceleration on machine elements.

Soil tillage; forces acting on a tillage tool; hitch systems and hitching of tillage implements; mechanics of animal traction; functional requirements, principles of working, construction and operation of manual, animal and power operated equipment for tillage, sowing, planting, fertilizer application, inter-cultivation, spraying, mowing, chaff cutting, harvesting, threshing and transport; testing of agricultural machinery and equipment; calculation of performance parameters -field capacity, efficiency, application rate and losses; cost analysis of implements and tractors

Thermodynamic principles of I.C. engines; I.C. engine cycles; engine components; fuels and combustion; lubricants and their properties; I.C. engine systems – fuel, cooling, lubrication, ignition, electrical, intake and exhaust; selection, operation, maintenance and repair of I.C. engines; power efficiencies and measurement; calculation of power, torque, fuel consumption, heat load and power losses.

Tractors and power tillers – type, selection, maintenance and repair; tractor clutches and brakes; power transmission systems – gear trains, differential, final drives and power take-off; mechanics of tractor chassis; traction theory; three point hitches- free link and restrained link operations; mechanical steering and hydraulic control systems used in tractors; human engineering and safety in tractor design; tractor tests and performance.

Soil And Water Conservation Engineering

Ideal and real fluids, properties of fluids; hydrostatic pressure and its measurement; hydrostatic forces on plane and curved surface; continuity equation; Bernoulli's theorem; laminar and turbulent flow in pipes, Darcy- Weisbach and Hazen-Williams equations, Moody's diagram; flow through orifices and notches; flow in open channels.

Engineering properties of soils; fundamental definitions and relationships; index properties of soils; permeability and seepage analysis; shear strength, Mohr's circle of stress, active and passive earth pressures; stability of slopes.

Hydrological cycle; meteorological parameters and their measurement, analysis of precipitation data; abstraction from precipitation; runoff; hydrograph analysis, unit hydrograph theory and application; stream flow measurement; flood routing, hydrological reservoir and channel routing.

Measurement of distance and area; chain surveying, methods of traversing; measurement of angles and bearings, plane table surveying; types of levelling; contouring; instruments for surveying and levelling; computation of earth work.

Mechanics of soil erosion, soil erosion types; wind and water erosion; factors affecting erosion; soil loss estimation; biological and engineering measures to control erosion; terraces and bunds; vegetative waterways; gully control structures, drop, drop inlet and chute spillways; earthen dams; water harvesting structures, farm ponds, watershed management.

Soil-water-plant relationship, water requirement of crops; consumptive use and evapotranspiration; irrigation scheduling; irrigation efficiencies; design of irrigation channels; measurement of soil moisture, irrigation water and infiltration; surface, sprinkler and drip methods of irrigation; design and evaluation of irrigation methods.

Drainage coefficient; planning, design and layout of surface and sub-surface drainage systems; leaching requirement and salinity control; irrigation and drainage water quality.

Groundwater occurrence confined and unconfined aquifers, evaluation of aquifer properties; well hydraulics; groundwater recharge.

Classification of pumps; pump characteristics; pump selection and installation.

Agricultural Processing And Food Engineering

Steady state heat transfer in conduction, convection and radiation; transient heat transfer in simple geometry; condensation and boiling heat transfer; working principles of heat exchangers; diffusive and convective mass transfer; simultaneous heat and mass transfer in agricultural processing operations.

Material and energy balances in food processing systems; water activity, sorption and desorption isotherms; centrifugal separation of solids, liquids and gases; kinetics of microbial death – pasteurization and sterilization of liquid foods; preservation of food by cooling and freezing; refrigeration and cold storage basics and applications; psychrometry – properties of air-vapour mixture; concentration and drying of liquid foods – evaporators, tray, drum and spray dryers.

Mechanics and energy requirement in size reduction of granular solids; particle size analysis for comminuted solids; size separation by screening; fluidization of granular solids-pneumatic, bucket, screw and belt conveying; cleaning and grading; Effectiveness of grain cleaners.

Hydrothermal treatment, drying and milling of cereals, pulses and oilseeds; Processing of seeds, spices, fruits and vegetables; By-product utilization from processing industries.

Controlled and modified atmosphere storage; Perishable food storage, godowns, bins and grain silos.

4.5.4 Architecture and Planning (AR)

City planning: Evolution of cities; principles of city planning; types of cities & new towns; planning regulations and building byelaws; eco-city concept; sustainable development.

Housing: Concept of housing; neighbourhood concept; site planning principles; housing typology; housing standards; housing infrastructure; housing policies, finance and management; housing programs in India; self help housing.

Landscape Design: Principles of landscape design and site planning; history of landscape styles; landscape elements and materials; plant characteristics & planting design; environmental considerations in landscape planning.

Computer Aided Design:Application of computers in architecture and planning; understanding elements of hardware and software; computer graphics; programming languages – C and Visual Basic and usage of packages such as AutoCAD, 3D-Studio, 3D Max.

Environmental Studies in Building Science:Components of Ecosystem; ecological principles concerning environment; climate responsive design; energy efficient building design; thermal comfort; solar architecture; principles of lighting and styles for illumination; basic principles of architectural acoustics; environment pollution, their control & abatement.

Visual and Urban Design: Principles of visual composition; proportion, scale, rhythm, symmetry, harmony, datum, balance, form, colour, texture; sense of place and space, division of space; barrier free design; focal point, vista, image ability, visual survey, figure-background relationship.

History of Architecture: *Indian* – Indus valley, Vedic, Buddhist, Indo-Aryan, Dravidian and Mughal periods; *European* – Egyptian, Greek, Roman, medieval and renaissance periods- construction and architectural styles; vernacular and traditional architecture.

Development of Contemporary Architecture: Architectural developments and impacts on society since industrial revolution; influence of modern art on architecture; works of national and international architects; art novuea, eclecticism, international styles, post modernism, deconstruction in architecture.

Building Services: Water supply, sewerage and drainage systems; sanitary fittings and fixtures; plumbing systems, principles of internal & external drainage systems, principles of electrification of buildings, intelligent buildings; elevators & escalators, their standards and uses; air-conditioning systems; fire fighting systems, building safety and security systems.

Building Construction and Management: Building construction techniques, methods and details; building systems and prefabrication of building elements; principles of modular coordination; estimation, specification, valuation, professional practice; project management techniques e.g., PERT, CPM etc;

Materials and Structural Systems: Behavioural characteristics of all types of building materials e.g. mud, timber, bamboo, brick, concrete, steel, glass, FRP, different polymers, composites; principles of strength of materials; design of structural elements in wood, steel and RCC; elastic and limit state design; complex structural systems; principles of pre-stressing; tall buildings; principles of disaster resistant structures.

Planning Theory: Regional planning; settlement system planning; history of human settlements; growth of cities & metropolises; principles of Ekistics; rural-urban migration; urban conservation; urban renewal; Five-year plan; structural and sectoral plan.

Techniques of Planning: Planning survey techniques; preparation of urban and regional structure plans, development plans, action plans; site planning principles and design; statistical methods of data analysis; application of G.I.S and remote sensing techniques in urban and regional planning; decision making models.

Traffic and Transportation Planning: Principles of traffic engineering and transportation planning; traffic survey methods; design of roads, intersections, grade separators and parking areas; hierarchy of roads and levels of services; traffic and transport management in urban areas, intelligent transportation system; mass transportation planning; para-transits and other modes of transportation, pedestrian & slow moving traffic planning.

Infrastructure, Services and Amenities: Principles of water supply and sanitation systems; water treatment; solid waste disposal systems; waste treatment, recycle & reuse; urban rainwater harvesting; power supply and communication systems — network, design & guidelines; demography related standards at various levels of the settlements for health, education, recreation, religious & public-semi public facilities.

Development Administration and Management: Planning laws; development control and zoning regulations; laws relating to land acquisition; development enforcements, urban land ceiling; land management techniques; planning and municipal administration; disaster mitigation management; 73rd& 74th Constitutional amendments; valuation & taxation; revenue resources and fiscal management; public participation and role of NGO & CBO; Institutional networking & capacity building.

4.5.5 Biotechnology (BT)

Engineering Mathematics

Linear Algebra**:** Matrices and determinants, Systems of linear equations, Eigen values and Eigen vectors.

Calculus**:** Limit, continuity and differentiability, Partial derivatives, Maxima and minima, Sequences and series, Test for convergence, Fourier Series.

Differential Equations**:** Linear and nonlinear first order ODEs, higher order ODEs with constant coefficients, Cauchy's and Euler's equations, Laplace transforms, PDE- Laplace, heat and wave equations.

Probability and Statistics**:** Mean, median, mode and standard deviation, Random variables, Poisson, normal and binomial distributions, Correlation and regression analysis.

Numerical Methods**:** Solution of linear and nonlinear algebraic equations, Integration of trapezoidal and Simpson's rule, Single and multistep methods for differential equations.

Biotechnology

Microbiology: Prokaryotic and eukaryotic cell structure; Microbial nutrition, growth and control; Microbial metabolism (aerobic and anaerobic respiration, photosynthesis); Nitrogen fixation; Chemical basis of mutations and mutagens; Microbial genetics (plasmids, transformation, transduction, conjugation); Microbial diversity and characteristic features; Viruses.

Biochemistry: Biomolecules and their conformation; Weak inter-molecular interactions in biomacromolecules; Chemical and functional nature of enzymes; Kinetics of single substrate and bi-substrate enzyme catalyzed reactions; Bioenergetics; Metabolism (Glycolysis, TCA and Oxidative phosphorylation); Membrane transport and pumps; Cell cycle and cell growth control; Cell signaling and signal transduction.

Molecular Biology and Genetics: Molecular structure of genes and chromosomes; DNA replication and control; Transcription and its control; Translational processes; Regulatory controls in prokaryotes and eukaryotes; Mendelian inheritance; Gene interaction; Complementation; Linkage, recombination and chromosome mapping; Extrachromosomal inheritance; Chromosomal variation; Population genetics; Transposable elements, Molecular basis of genetic diseases and applications.

Process Biotechnology: Bioprocess technology for the production of cell biomass and primary/secondary metabolites, such as baker's yeast, ethanol, citric acid, amino acids, exo-polysacharides, antibiotics and pigments etc.; Microbial production, purification and bioprocess application(s) of industrial enzymes; Production and purification of recombinant proteins on a large scale; Chromatographic and membrane based bioseparation methods; Immobilization of enzymes and cells and their application for bioconversion processes.

Aerobic and anaerobic biological processes for stabilization of solid / liquid wastes; Bioremediation.

Bioprocess Engineering: Kinetics of microbial growth, substrate utilization and product formation; Simple structured models; Sterilization of air and media; Batch, fed-batch and continuous processes; Aeration and agitation; Mass transfer in bioreactors; Rheology of fermentation fluids; Scale-up concepts; Design of fermentation media; Various types of microbial and enzyme reactors; Instrumentation in bioreactors.

Plant and Animal Biotechnology: Special features and organization of plant cells; Totipotency; Regeneration of plants; Plant products of industrial importance; Biochemistry of major metabolic pathways and products; Autotrophic and heterotrophic growth; Plant growth regulators and elicitors; Cell suspension culture development: methodology, kinetics of growth and production formation, nutrient

optimization; Production of secondary metabolites by plant suspension cultures; Hairy root cultures and their cultivation. Techniques in raising transgencies.

Characteristics of animal cells: Metabolism, regulation and nutritional requirements for mass cultivation of animal cell cultures; Kinetics of cell growth and product formation and effect of shear force; Product and substrate transport; Micro & macro-carrier culture; Hybridoma technology; Live stock improvement; Cloning in animals; Genetic engineering in animal cell culture; Animal cell preservation.

Immunology: The origin of immunology; Inherent immunity; Humoral and cell mediated immunity; Primary and secondary lymphoid organ; Antigen; B and T cells and Macrophages; Major histocompatibility complex (MHC); Antigen processing and presentation; Synthesis of antibody and secretion; Molecular basis of antibody diversity; Polyclonal and monoclonal antibody; Complement; Antigen-antibody reaction; Regulation of immune response; Immune tolerance; Hyper sensitivity; Autoimmunity; Graft versus host reaction.

Recombinant DNA Technology: Restriction and modification enzymes; Vectors: plasmid, bacteriophage and other viral vectors, cosmids, Ti plasmid, yeast artificial chromosome; cDNA and genomic DNA library; Gene isolation; Gene cloning; Expression of cloned gene; Transposons and gene targeting; DNA labeling; DNA sequencing; Polymerase chain reactions; DNA fingerprinting; Southern and northern blotting; In-situ hybridization; RAPD; RFLP; Site-directed mutagenesis; Gene transfer technologies; Gene therapy.

Bioinformatics: Major bioinformatics resources (NCBI, EBI, ExPASy); Sequence and structure databases; Sequence analysis (biomolecular sequence file formats, scoring matrices, sequence alignment, phylogeny); Genomics and Proteomics (Large scale genome sequencing strategies; Comparative genomics; Understanding DNA microarrays and protein arrays); Molecular modeling and simulations (basic concepts including concept of force fields).

4.5.6 Civil Engineering (CE)

Engineering Mathematics

Linear Algebra: Matrix algebra, Systems of linear equations, Eigen values and eigenvectors.

Calculus: Functions of single variable, Limit, continuity and differentiability, Mean value theorems, Evaluation of definite and improper integrals, Partial derivatives, Total derivative, Maxima and minima, Gradient, Divergence and Curl, Vector identities, Directional derivatives, Line, Surface and Volume integrals, Stokes, Gauss and Green's theorems.

Differential equations: First order equations (linear and nonlinear), Higher order linear differential equations with constant coefficients, Cauchy's and Euler's equations, Initial and boundary value problems, Laplace transforms, Solutions of one dimensional heat and wave equations and Laplace equation.

Complex variables: Analytic functions, Cauchy's integral theorem, Taylor and Laurent series.

Probability and Statistics: Definitions of probability and sampling theorems, Conditional probability, Mean, median, mode and standard deviation, Random variables, Poisson,Normal and Binomial distributions.

Numerical Methods: Numerical solutions of linear and non-linear algebraic equations Integration by trapezoidal and Simpson's rule, single and multi-step methods for differential equations.

Structural Engineering

Mechanics**:** Bending moment and shear force in statically determinate beams. Simple stress and strain relationship: Stress and strain in two dimensions, principal stresses, stress transformation, Mohr's circle. Simple bending theory, flexural and shear stresses, unsymmetrical bending, shear centre. Thin walled pressure vessels, uniform torsion, buckling of column, combined and direct bending stresses.

Structural Analysis**:** Analysis of statically determinate trusses, arches, beams, cables and frames, displacements in statically determinate structures and analysis of statically indeterminate structures by force/ energy methods, analysis by displacement methods (slope deflection and moment distribution methods), influence lines for determinate and indeterminate structures. Basic concepts of matrix methods of structural analysis.

Concrete Structures**:** Concrete Technology- properties of concrete, basics of mix design. Concrete design- basic working stress and limit state design concepts, analysis of ultimate load capacity and design of members subjected to flexure, shear, compression and torsion by limit state methods. Basic elements of prestressed concrete, analysis of beam sections at transfer and service loads.

Steel Structures**:** Analysis and design of tension and compression members, beams and beam- columns, column bases. Connections- simple and eccentric, beam–column connections, plate girders and trusses.Plastic analysis of beams and frames.

Geotechnical Engineering

Soil Mechanics**:**Origin of soils, soil classification, three-phase system, fundamental definitions, relationship and interrelationships, permeability &seepage, effective stress principle, consolidation, compaction, shear strength.

Foundation Engineering**:**Sub-surface investigations- scope, drilling bore holes, sampling, penetration tests, plate load test. Earth pressure theories, effect of water table, layered soils. Stability of slopes-infinite slopes, finite slopes. Foundation types-foundation design requirements. Shallow foundations-bearing capacity, effect of shape, water table and other factors, stress distribution, settlement analysisinsands & clays. Deep foundations–pile types, dynamic &static formulae, load capacity of piles in sands &clays, negative skin friction.

Water Resources Engineering

Fluid Mechanics and Hydraulics**:** Properties of fluids, principle of conservation of mass, momentum, energy and corresponding equations, potential flow, applications of momentum and Bernoulli's equation, laminar and turbulent flow, flow in pipes, pipe networks. Concept of boundary layer and its growth. Uniform flow, critical flow and gradually varied flow in channels, specific energy concept, hydraulic jump. Forces on immersed bodies, flow measurements in channels, tanks and pipes. Dimensional analysis and hydraulic modeling. Kinematics of flow, velocity triangles and specific speed of pumps and turbines.

Hydrology**:** Hydrologic cycle, rainfall, evaporation, infiltration, stage discharge relationships, unit hydrographs, flood estimation, reservoir capacity, reservoir and channel routing. Well hydraulics.

Irrigation**:** Duty, delta, estimation of evapo-transpiration. Crop water requirements. Design of: lined and unlined canals, waterways, head works, gravity dams and spillways. Design of weirs on permeable foundation. Types of irrigation system, irrigation methods. Water logging and drainage, sodic soils.

Environmental Engineering

Water requirements**:** Quality standards, basic unit processes and operations for water treatment. Drinking water standards, water requirements, basic unit operations and unit processes for surface water treatment, distribution of water. Sewage and sewerage treatment, quantity and characteristics of wastewater. Primary, secondary and tertiary treatment of wastewater, sludge disposal, effluent discharge standards. Domestic wastewater treatment, quantity of characteristics of domestic wastewater, primary and secondary treatment Unit operations and unit processes of domestic wastewater, sludge disposal.

Air Pollution**:** Types of pollutants, their sources and impacts, air pollution meteorology, air pollution control, air quality standards and limits.

Municipal Solid Wastes**:** Characteristics, generation, collection and transportation of solid wastes, engineered systems for solid waste management (reuse/ recycle, energy recovery, treatment and disposal).

Noise Pollution**:** Impacts of noise, permissible limits of noise pollution, measurement of noise and control of noise pollution.

Transportation Engineering

Highway Planning**:** Geometric design of highways, testing and specifications of paving materials, design of flexible and rigid pavements.

Traffic Engineering**:** Traffic characteristics, theory of traffic flow, intersection design, traffic signs and signal design, highway capacity.

Surveying

Importance of surveying, principles and classifications, mapping concepts, coordinate system, map projections, measurements of distance and directions, leveling, theodolite traversing, plane table surveying, errors and adjustments, curves.

4.5.7 Chemical Engineering (CH)

Engineering Mathematics

Linear Algebra*:* Matrix algebra, Systems of linear equations, Eigen values and eigenvectors.

Calculus*:* Functions of single variable, Limit, continuity and differentiability, Mean value theorems, Evaluation of definite and improper integrals, Partial derivatives, Total derivative, Maxima and minima, Gradient, Divergence and Curl, Vector identities, Directional derivatives, Line, Surface and Volume integrals, Stokes, Gauss and Green's theorems.

Differential equations*:* First order equations (linear and nonlinear), Higher order linear differential equations with constant coefficients, Cauchy's and Euler's equations, Initial and boundary value problems, Laplace transforms, Solutions of one dimensional heat and wave equations and Laplace equation.

Complex variables*:*Analytic functions, Cauchy's integral theorem, Taylor and Laurent series, Residue theorem.

Probability and Statistics*:* Definitions of probability and sampling theorems, Conditional probability, Mean, median, mode and standard deviation, Random variables, Poisson,Normal and Binomial distributions.

Numerical Methods*:* Numerical solutions of linear and non-linear algebraic equations Integration by trapezoidal and Simpson's rule, single and multi-step methods for differential equations.

Chemical Engineering

Process Calculations and Thermodynamics: Laws of conservation of mass and energy; use of tie components; recycle, bypass and purge calculations; degree of freedom analysis. First and Second laws of thermodynamics. First law application to close and open systems. Second law and Entropy. Thermodynamic properties of pure substances: equation of state and departure function, properties of mixtures: partial molar properties, fugacity, excess properties and activity coefficients; phase equilibria: predicting VLE of systems; chemical reaction equilibria.

Fluid Mechanics and Mechanical Operations: Fluid statics, Newtonian and non-Newtonian fluids, Bernoulli equation, Macroscopic friction factors, energy balance, dimensional analysis, shell balances, flow through pipeline systems, flow meters, pumps and compressors, packed and fluidized beds, elementary boundary layer theory, size reduction and size separation; free and hindered settling; centrifuge and cyclones; thickening and classification, filtration, mixing and agitation; conveying of solids.

Heat Transfer: Conduction, convection and radiation, heat transfer coefficients, steady and unsteady heat conduction, boiling, condensation and evaporation; types of heat exchangers and evaporators and their design.

Mass Transfer: Fick's laws, molecular diffusion in fluids, mass transfer coefficients, film, penetration and surface renewal theories; momentum, heat and mass transfer analogies; stagewise and continuous contacting and stage efficiencies; HTU & NTU concepts design and operation of equipment for distillation, absorption, leaching, liquid-liquid extraction, drying, humidification, dehumidification and adsorption.

Chemical Reaction Engineering: Theories of reaction rates; kinetics of homogeneous reactions, interpretation of kinetic data, single and multiple reactions in ideal reactors, non-ideal reactors; residence time distribution, single parameter model; non-isothermal reactors; kinetics of heterogeneous catalytic reactions; diffusion effects in catalysis.

Instrumentation and Process Control: Measurement of process variables; sensors, transducers and their dynamics, transfer functions and dynamic responses of simple systems, process reaction curve, controller modes (P, PI, and PID); control valves; analysis of closed loop systems including stability, frequency response and controller tuning, cascade, feed forward control.

Plant Design and Economics: Process design and sizing of chemical engineering equipment such as compressors, heat exchangers, multistage contactors; principles of process economics and cost estimation including total annualized cost, cost indexes, rate of return, payback period, discounted cash flow, optimization in design.

Chemical Technology: Inorganic chemical industries; sulfuric acid, NaOH, fertilizers (Ammonia, Urea, SSP and TSP); natural products industries (Pulp and Paper, Sugar, Oil, and Fats); petroleum refining and petrochemicals; polymerization industries; polyethylene, polypropylene, PVC and polyester synthetic fibers.