



GATE RA Conquest Book

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The knowledge of all things is possible.

Leonardo da Vinci

Common Section

Engineering Mathematics: (i) *Linear Algebra:* Matrices, transpose, determinant, rank, eigenvalues and eigenvectors, trace, adjoint, solutions to system of linear equations. (ii) *Calculus:* Functions of a single variable, limit, continuity, differentiability, mean value theorems, indeterminate forms, evaluation of definite and improper integrals, double and triple integrals, partial derivatives, total derivative, Taylor series (in one and two variables), maxima and minima, gradient, divergence and curl, vector identities. (iii) *Differential Equations:* First-order equations (linear and nonlinear), higher-order linear differential equations with constant coefficients, Euler-Cauchy equation, initial and boundary value problems, Laplace transforms, solutions of heat, wave, and Laplace's equations, Fourier series. (iv) *Probability and Statistics:* Axioms of probability, conditional probability, mean, median, mode, standard deviation, expectation, binomial, Poisson, normal distributions, hypothesis testing, Probability Density Function (PDF), Cumulative Distribution Function (CDF). (v) *Numerical Methods:* Solutions of linear algebraic equations, solutions of non-linear algebraic equations, integration by trapezoidal and Simpson's rules, finite differences, explicit single and multi-step methods for differential equations.

Basics of Mechatronics: (i) *Network Elements:* Ideal voltage and current sources, dependent sources, R, L, C, M elements. *Network Solution Methods:* Kirchoff's laws (KCL, KVL), Node and Mesh analysis. *Network Theorems:* Thevenin's theorem, Norton's theorem, Superposition, Maximum Power Transfer theorem. *Transient and AC Networks:* Transient response of DC and AC networks, sinusoidal steady-state analysis, resonance, two-port networks, balanced three-phase circuits, complex power, power factor in AC circuits. (ii) *Digital Circuits:* Boolean algebra. *Combinational Circuits:* multiplexers, encoders, decoders. *Sequential Circuits:* sequential circuits, flip-flops, counters. (iii) *Sensors:* Resistive sensors, capacitive sensors, inductive sensors, piezoelectric sensors, Hall effect sensors, associated signal conditioning circuits. *Transducers for Industrial Instrumentation:* displacement (linear and angular), velocity, acceleration, force, torque, pressure. (iv) *Actuators:* Principles of operation, performance, torque-speed characteristics of hydraulic actuators, pneumatic actuators, DC motors, stepper motors, servo motors. (v) *Engineering Mechanics:* Free-body diagrams, equilibrium, friction and its applications, rolling friction, belt-pulley, trusses and frames, kinematics and dynamics of rigid bodies in plane motion. (vi) *Programming:* Flowcharts and pseudo code; *Programming in Python:* data types, operators, expressions, conditional statements (if, elif, else, case), looping statements (while, for), loop control statements (break and continue), functions, arrays, dictionary, strings, recursion. (vii) *Data Structures:* Stack, queue, linked list, binary search tree, binary heap, graph.

Principles of Robotics and Automation: *Robotic Classification:* serial and parallel manipulators, geometrical configuration, Links and joints, Coordinate systems and degrees-of-freedom, Rotation matrices in 2D and 3D, homogeneous transformations, forward kinematics. *Robot Applications:* point-to-point and continuous path control, types of end-effectors, robot accuracy and repeatability. *Computer Integrated Manufacturing:* Automation in Manufacturing, Programmable Logic Controllers (PLCs) in manufacturing, Automated material handling systems, Automated storage and retrieval systems, Automated identification, detection and capture systems, computer numerical control, Basics of single and multi-axis positioning systems, Basics of concurrent design and manufacturing planning for automation.

Electrical Engineering

Analog Circuits and Embedded Systems: *Analog Filters:* low-pass, high-pass, band-pass, band-reject. *Amplifiers:* biasing, equivalent circuit and frequency response, feedback amplifiers, operational amplifiers, characteristics and applications. oscillators. Voltage Controlled Oscillators and timers. Schmitt triggers, sample and hold circuits, Analog-to-Digital (A/D) converters, Digital-to-Analog (D/A) converters, Switched Mode Power Supplies (SMPS). *Embedded Systems:* Microprocessor and microcontroller applications, components of microcontrollers, CPU, memory, I/O ports, timers, interrupt handling, memory and input-output interfacing, basics of data acquisition systems.

Signals and Systems: Representation of continuous and discrete time signals, shifting and scaling properties, linear time-invariant and causal systems, Fourier series representation of continuous and discrete time periodic signals, Shannon's sampling theorem, Definitions and properties of Fourier Transform, Laplace Transform, Z transform, R.M.S. value, average value calculation.

Control Systems: Mathematical modeling and representation of systems, feedback principle, transfer function, Block diagrams, Signal flow graphs, Transient and Steady-state analysis of linear time-invariant systems. *Stability analysis using:* Routh-Hurwitz, Nyquist criteria, Bode plots, Root Loci, Lag compensators, Lead compensators, Lead-Lag compensators, P, PI and PID controllers.

Mechanical Engineering

Mechanics of Materials: Stress and strain, elastic constants, Poisson's ratio, Mohr's circle for plane stress and plane strain, thin cylinders, shear force and bending moment diagrams, bending stresses, shear stresses, concept of shear centre, deflection of beams, torsion of circular shafts, Euler's theory of columns, Castigliano's theorems, thermal stresses, strain gauges and rosettes, testing of materials with universal testing machine, testing of hardness and impact strength.

Kinematics and Dynamics: Displacement, velocity, acceleration analysis of plane mechanisms, dynamic analysis of linkages, gears and gear trains, balancing of reciprocating and rotating masses, gyroscope. *Vibrations:* free and forced vibration of single degree of freedom systems, the effect of damping, vibration isolation, resonance, critical speeds of shafts.

Machine Design and Computer Integrated Manufacturing: Design for static and dynamic loading, failure theories, fatigue strength, the S-N diagram, principles of the design of machine elements such as, bolted, riveted and welded joints, shafts, rolling and sliding contact bearings, brakes, clutches, springs, Basic concepts of Computer Aided Design (CAD)/Computer Aided Manufacturing (CAM) and their integration tools, additive manufacturing.

PYQs: —

Bibliography: My Tastefully Curated Sources of Learning



1 Engineering Mathematics

Mathematics is the language in which God
has written the universe.

Galileo Galilei

This section develops the mathematical foundations required for Robotics and Automation.

1.1 Matrices

Placeholder content for matrices.

1.2 transpose

Placeholder content for transpose.

1.3 determinant

Placeholder content for determinant.

1.4 rank

Placeholder content for rank.

1.5 eigenvalues and eigenvectors

Placeholder content for eigenvalues and eigenvectors.

1.6 trace

Placeholder content for trace.

1.7 adjoint

Placeholder content for adjoint.

1.8 solutions to system of linear equations

Placeholder content for solutions to system of linear equations.

1.9 Functions of a single variable

Placeholder content for functions of a single variable.

1.10 limit

Placeholder content for limit.

1.11 continuity

Placeholder content for continuity.

1.12 differentiability

Placeholder content for differentiability.

1.13 mean value theorems

Placeholder content for mean value theorems.

1.14 indeterminate forms

Placeholder content for indeterminate forms.

1.15 evaluation of definite and improper integrals

Placeholder content for evaluation of definite and improper integrals.

1.16 double and triple integrals

Placeholder content for double and triple integrals.

1.17 partial derivatives

Placeholder content for partial derivatives.

1.18 total derivative

Placeholder content for total derivative.

1.19 Taylor series (in one and two variables)

Placeholder content for taylor series (in one and two variables).

1.20 maxima and minima

Placeholder content for maxima and minima.

1.21 gradient

Placeholder content for gradient.

1.22 divergence and curl

Placeholder content for divergence and curl.

1.23 vector identities

Placeholder content for vector identities.

1.24 First-order equations (linear and nonlinear)

Placeholder content for first-order equations (linear and nonlinear).

1.25 higher-order linear differential equations with constant coefficients

Placeholder content for higher-order linear differential equations with constant coefficients.

1.26 Euler-Cauchy equation

Placeholder content for euler-cauchy equation.

1.27 initial and boundary value problems

Placeholder content for initial and boundary value problems.

1.28 Laplace transforms

Placeholder content for laplace transforms.

1.29 solutions of heat, wave, and Laplace's equations

Placeholder content for solutions of heat, wave, and laplace's equations.

1.30 Fourier series

Placeholder content for fourier series.

1.31 Axioms of probability

Placeholder content for axioms of probability.

1.32 conditional probability

Placeholder content for conditional probability.

1.33 mean

Placeholder content for mean.

1.34 median

Placeholder content for median.

1.35 mode

Placeholder content for mode.

1.36 standard deviation

Placeholder content for standard deviation.

1.37 random variables

Placeholder content for random variables.

1.38 expectation

Placeholder content for expectation.

1.39 binomial

Placeholder content for binomial.

1.40 Poisson

Placeholder content for poisson.

1.41 normal distributions

Placeholder content for normal distributions.

1.42 hypothesis testing

Placeholder content for hypothesis testing.

1.43 Probability Density Function (PDF)

Placeholder content for probability density function (pdf).

1.44 Cumulative Distribution Function (CDF)

Placeholder content for cumulative distribution function (cdf).

1.45 Solutions of linear algebraic equations

Placeholder content for solutions of linear algebraic equations.

1.46 solutions of non-linear algebraic equations

Placeholder content for solutions of non-linear algebraic equations.

1.47 integration by trapezoidal and Simpson's rules

Placeholder content for integration by trapezoidal and simpson's rules.

1.48 finite differences

Placeholder content for finite differences.

1.49 explicit single and multi-step methods for differential equations

Placeholder content for explicit single and multi-step methods for differential equations.

2 Basics of Mechatronics

The interface between mechanical and electrical engineering is where the future lies.

Unknown

This section introduces the electrical, digital, sensing, actuation, mechanics, programming and data-structure foundations of mechatronics.

2.1 Ideal voltage and current sources

Placeholder content for ideal voltage and current sources.

2.2 dependent sources

Placeholder content for dependent sources.

2.3 R, L, C, M elements

Placeholder content for r, l, c, m elements.

2.4 Kirchoff's laws (KCL, KVL)

Placeholder content for kirchoff's laws (kcl, kvl).

2.5 Node and Mesh analysis

Placeholder content for node and mesh analysis.

2.6 Thevenin's theorem

Placeholder content for thevenin's theorem.

2.7 Norton's theorem

Placeholder content for norton's theorem.

2.8 Superposition

Placeholder content for superposition.

2.9 Maximum Power Transfer theorem

Placeholder content for maximum power transfer theorem.

2.10 Transient response of DC and AC networks

Placeholder content for transient response of dc and ac networks.

2.11 sinusoidal steady-state analysis

Placeholder content for sinusoidal steady-state analysis.

2.12 resonance

Placeholder content for resonance.

2.13 two-port networks

Placeholder content for two-port networks.

2.14 balanced three-phase circuits

Placeholder content for balanced three-phase circuits.

2.15 complex power

Placeholder content for complex power.

2.16 power factor in AC circuits

Placeholder content for power factor in ac circuits.

2.17 Boolean algebra

Placeholder content for boolean algebra.

2.18 multiplexers

Placeholder content for multiplexers.

2.19 encoders

Placeholder content for encoders.

2.20 decoders

Placeholder content for decoders.

2.21 sequential circuits

Placeholder content for sequential circuits.

2.22 flip-flops

Placeholder content for flip-flops.

2.23 counters

Placeholder content for counters.

2.24 Resistive sensors

Placeholder content for resistive sensors.

2.25 capacitive sensors

Placeholder content for capacitive sensors.

2.26 inductive sensors

Placeholder content for inductive sensors.

2.27 piezoelectric sensors

Placeholder content for piezoelectric sensors.

2.28 Hall effect sensors

Placeholder content for hall effect sensors.

2.29 associated signal conditioning circuits

Placeholder content for associated signal conditioning circuits.

2.30 displacement

Placeholder content for displacement.

2.31 linear

Placeholder content for linear.

2.32 angular

Placeholder content for angular.

2.33 velocity

Placeholder content for velocity.

2.34 acceleration

Placeholder content for acceleration.

2.35 force

Placeholder content for force.

2.36 torque

Placeholder content for torque.

2.37 Pressure

Placeholder content for pressure transducers.

2.38 Pressure

Placeholder content for pressure transducers.

2.39 Principles of operation

Placeholder content for principles of operation.

2.40 performance

Placeholder content for performance.

2.41 torque-speed characteristics

Placeholder content for torque-speed characteristics.

2.42 hydraulic actuators

Placeholder content for hydraulic actuators.

2.43 pneumatic actuators

Placeholder content for pneumatic actuators.

2.44 DC motors

Placeholder content for dc motors.

2.45 stepper motors

Placeholder content for stepper motors.

2.46 servo motors

Placeholder content for servo motors.

2.47 Free-body diagrams

Placeholder content for free-body diagrams.

2.48 equilibrium

Placeholder content for equilibrium.

2.49 friction and its applications

Placeholder content for friction and its applications.

2.50 rolling friction

Placeholder content for rolling friction.

2.51 belt-pulley

Placeholder content for belt-pulley.

2.52 trusses and frames

Placeholder content for trusses and frames.

2.53 kinematics and dynamics of rigid bodies in plane motion

Placeholder content for kinematics and dynamics of rigid bodies in plane motion.

2.54 Flowcharts and pseudo code

Placeholder content for flowcharts and pseudo code.

2.55 data types

Placeholder content for data types.

2.56 operators

Placeholder content for operators.

2.57 expressions

Placeholder content for expressions.

2.58 conditional statements (if, elif, else, case)

Placeholder content for conditional statements (if, elif, else, case).

2.59 looping statements (while, for)

Placeholder content for looping statements (while, for).

2.60 loop control statements (break and continue)

Placeholder content for loop control statements (break and continue).

2.61 functions

Placeholder content for functions.

2.62 arrays

Placeholder content for arrays.

2.63 dictionary

Placeholder content for dictionary.

2.64 strings

Placeholder content for strings.

2.65 recursion

Placeholder content for recursion.

2.66 Stack

Placeholder content for stack.

2.67 queue

Placeholder content for queue.

2.68 linked list

Placeholder content for linked list.

2.69 binary search tree

Placeholder content for binary search tree.

2.70 binary heap

Placeholder content for binary heap.

2.71 graph

Placeholder content for graph.

3 Principles of Robotics and Automation

The future of robotics is not about replacing humans, but about augmenting human capabilities.

Unknown

This section develops the fundamental principles of robotic systems and automated manufacturing.

3.1 serial and parallel manipulators

Placeholder content for serial and parallel manipulators.

3.2 geometrical configuration

Placeholder content for geometrical configuration.

3.3 Links and joints

Placeholder content for links and joints.

3.4 Coordinate systems and degrees-of-freedom

Placeholder content for coordinate systems and degrees-of-freedom.

3.5 Rotation matrices in 2D and 3D

Placeholder content for rotation matrices in 2d and 3d.

3.6 homogeneous transformations

Placeholder content for homogeneous transformations.

3.7 forward kinematics

Placeholder content for forward kinematics.

3.8 point-to-point and continuous path control

Placeholder content for point-to-point and continuous path control.

3.9 types of end-effectors

Placeholder content for types of end-effectors.

3.10 robot accuracy and repeatability

Placeholder content for robot accuracy and repeatability.

3.11 Automation in Manufacturing

Placeholder content for automation in manufacturing.

3.12 Programmable Logic Controllers (PLCs) in manufacturing

Placeholder content for programmable logic controllers (plcs) in manufacturing.

3.13 Automated material handling systems

Placeholder content for automated material handling systems.

3.14 Automated storage and retrieval systems

Placeholder content for automated storage and retrieval systems.

3.15 Automated identification, detection and capture systems

Placeholder content for automated identification, detection and capture systems.

3.16 computer numerical control

Placeholder content for computer numerical control.

3.17 Basics of single and multi-axis positioning systems

Placeholder content for basics of single and multi-axis positioning systems.

3.18 Basics of concurrent design and manufacturing planning for automation

Placeholder content for basics of concurrent design and manufacturing planning for automation.

4 Analog Circuits and Embedded Systems

In electronics, the circuit is the canvas and the current is the paint.

Unknown

This section covers the analog and embedded-system foundations used in robotic and automated systems.

4.1 low-pass

Placeholder content for low-pass.

4.2 high-pass

Placeholder content for high-pass.

4.3 band-pass

Placeholder content for band-pass.

4.4 band-reject

Placeholder content for band-reject.

4.5 biasing

Placeholder content for biasing.

4.6 equivalent circuit and frequency response

Placeholder content for equivalent circuit and frequency response.

4.7 feedback amplifiers

Placeholder content for feedback amplifiers.

4.8 operational amplifiers

Placeholder content for operational amplifiers.

4.9 characteristics and applications

Placeholder content for characteristics and applications.

4.10 oscillators

Placeholder content for oscillators.

4.11 Voltage Controlled Oscillators and timers

Placeholder content for voltage controlled oscillators and timers.

4.12 Schmitt triggers

Placeholder content for schmitt triggers.

4.13 sample and hold circuits

Placeholder content for sample and hold circuits.

4.14 Analog-to-Digital (A/D) converters

Placeholder content for analog-to-digital (a/d) converters.

4.15 Digital-to-Analog (D/A) converters

Placeholder content for digital-to-analog (d/a) converters.

4.16 Switched Mode Power Supplies (SMPS)

Placeholder content for switched mode power supplies (smps).

4.17 Microprocessor and microcontroller applications

Placeholder content for microprocessor and microcontroller applications.

4.18 components of microcontrollers

Placeholder content for components of microcontrollers.

4.19 CPU

Placeholder content for cpu.

4.20 memory

Placeholder content for memory.

4.21 I/O ports

Placeholder content for i/o ports.

4.22 timers

Placeholder content for timers.

4.23 interrupt handling

Placeholder content for interrupt handling.

4.24 memory and input-output interfacing

Placeholder content for memory and input-output interfacing.

4.25 basics of data acquisition systems

Placeholder content for basics of data acquisition systems.

5 Signals and Systems

Every signal carries a message; the art is in learning how to listen.

Unknown

This section develops the representation and analysis of signals and systems.

5.1 Representation of continuous and discrete time signals

Placeholder content for representation of continuous and discrete time signals.

5.2 shifting and scaling properties

Placeholder content for shifting and scaling properties.

5.3 linear time-invariant and causal systems

Placeholder content for linear time-invariant and causal systems.

5.4 Fourier series representation of continuous and discrete time periodic signals

Placeholder content for fourier series representation of continuous and discrete time periodic signals.

5.5 Shannon's sampling theorem

Placeholder content for shannon's sampling theorem.

5.6 Definitions and properties of Fourier Transform

Placeholder content for definitions and properties of fourier transform.

5.7 Laplace Transform

Placeholder content for laplace transform.

5.8 Z transform

Placeholder content for z transform.

5.9 R.M.S. value

Placeholder content for r.m.s. value.

5.10 average value calculation

Placeholder content for average value calculation.

6 Control Systems

Control engineering is the art of taming uncertainty to achieve desired behavior.

Unknown

This section introduces the modeling, analysis and control of dynamic systems.

6.1 Mathematical modeling and representation of systems

Placeholder content for mathematical modeling and representation of systems.

6.2 feedback principle

Placeholder content for feedback principle.

6.3 transfer function

Placeholder content for transfer function.

6.4 Block diagrams

Placeholder content for block diagrams.

6.5 Signal flow graphs

Placeholder content for signal flow graphs.

6.6 Transient and Steady-state analysis of linear time-invariant systems

Placeholder content for transient and steady-state analysis of linear time-invariant systems.

6.7 Routh-Hurwitz

Placeholder content for routh-hurwitz.

6.8 Nyquist criteria

Placeholder content for nyquist criteria.

6.9 Bode plots

Placeholder content for bode plots.

6.10 Root Loci

Placeholder content for root loci.

6.11 Lag compensators

Placeholder content for lag compensators.

6.12 Lead compensators

Placeholder content for lead compensators.

6.13 Lead-Lag compensators

Placeholder content for lead-lag compensators.

6.14 P, PI and PID controllers

Placeholder content for p, pi and pid controllers.

7 Mechanics of Materials

Materials are the building blocks of civilization; their mechanics govern what we can build.

Unknown

This section develops the mechanics needed to analyze stresses, strains and deformation in materials.

7.1 Stress and strain

Placeholder content for stress and strain.

7.2 elastic constants

Placeholder content for elastic constants.

7.3 Poisson's ratio

Placeholder content for poisson's ratio.

7.4 Mohr's circle for plane stress and plane strain

Placeholder content for mohr's circle for plane stress and plane strain.

7.5 thin cylinders

Placeholder content for thin cylinders.

7.6 shear force and bending moment diagrams

Placeholder content for shear force and bending moment diagrams.

7.7 bending stresses

Placeholder content for bending stresses.

7.8 shear stresses

Placeholder content for shear stresses.

7.9 concept of shear centre

Placeholder content for concept of shear centre.

7.10 deflection of beams

Placeholder content for deflection of beams.

7.11 torsion of circular shafts

Placeholder content for torsion of circular shafts.

7.12 Euler's theory of columns

Placeholder content for euler's theory of columns.

7.13 Castigliano's theorems

Placeholder content for castigliano's theorems.

7.14 thermal stresses

Placeholder content for thermal stresses.

7.15 strain gauges and rosettes

Placeholder content for strain gauges and rosettes.

7.16 testing of materials with universal testing machine

Placeholder content for testing of materials with universal testing machine.

7.17 testing of hardness and impact strength

Placeholder content for testing of hardness and impact strength.

8 Kinematics and Dynamics

Dynamics is the study of forces and motion—the heartbeat of every machine.

Unknown

This section develops the kinematic and dynamic analysis of mechanisms and machines.

8.1 Displacement

Placeholder content for displacement.

8.2 velocity

Placeholder content for velocity.

8.3 acceleration analysis of plane mechanisms

Placeholder content for acceleration analysis of plane mechanisms.

8.4 dynamic analysis of linkages

Placeholder content for dynamic analysis of linkages.

8.5 gears and gear trains

Placeholder content for gears and gear trains.

8.6 balancing of reciprocating and rotating masses

Placeholder content for balancing of reciprocating and rotating masses.

8.7 gyroscope

Placeholder content for gyroscope.

8.8 free and forced vibration of single degree of freedom systems

Placeholder content for free and forced vibration of single degree of freedom systems.

8.9 the effect of damping

Placeholder content for the effect of damping.

8.10 vibration isolation

Placeholder content for vibration isolation.

8.11 resonance

Placeholder content for resonance.

8.12 critical speeds of shafts

Placeholder content for critical speeds of shafts.

9 Machine Design and Computer Integrated Manufacturing

Design is not just what it looks like and feels like. Design is how it works.

Steve Jobs

This section covers machine design and computer-integrated manufacturing.

9.1 Design for static and dynamic loading

Placeholder content for design for static and dynamic loading.

9.2 failure theories

Placeholder content for failure theories.

9.3 fatigue strength

Placeholder content for fatigue strength.

9.4 the S-N diagram

Placeholder content for the s-n diagram.

9.5 principles of the design of machine elements

Placeholder content for principles of the design of machine elements.

9.6 bolted joints

Placeholder content for bolted joints.

9.7 riveted joints

Placeholder content for riveted joints.

9.8 welded joints

Placeholder content for welded joints.

9.9 shafts

Placeholder content for shafts.

9.10 rolling contact bearings

Placeholder content for rolling contact bearings.

9.11 sliding contact bearings

Placeholder content for sliding contact bearings.

9.12 brakes

Placeholder content for brakes.

9.13 clutches

Placeholder content for clutches.

9.14 springs

Placeholder content for springs.

9.15 Basic concepts of Computer Aided Design (CAD)/Computer Aided Manufacturing (CAM) and their integration tools

Placeholder content for basic concepts of computer aided design (cad)/computer aided manufacturing (cam) and their integration tools.

9.16 additive manufacturing

Placeholder content for additive manufacturing.

My Tastefully Curated Sources of Learning

I cannot remember the books I've read any more than the meals I have eaten; even so, they have made me.

Ralph Waldo Emerson

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