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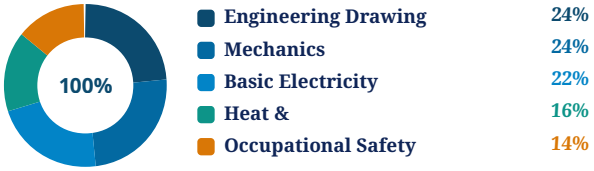
IUC ACADEMY NOTES

Complete Syllabus • Conceptual Flowcharts • Comparative Tables • Solved Practice Questions

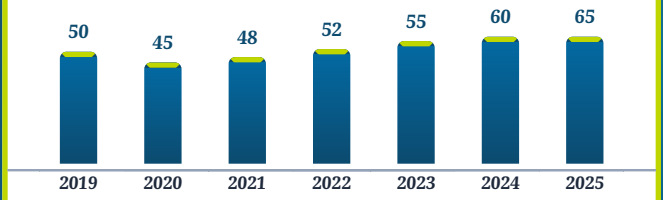
RAILWAY ALP & TECHNICIAN — BASIC SCIENCE, DRAWING & TRADE THEORY

Engineering Drawing (IS 10711 Sheet Sizes, Lines, 1st vs 3rd Angle Projection), Units & Measurements, Mass-Weight-Density, Speed & Velocity, Work-Power-Energy, Heat & Temperature, Basic Electricity, Simple Machines & Levers, Occupational Safety & ITI Trades

Topic-Wise Exam Weightage Distribution (%)



Previous Years' Question Trend Analysis



Target Competitive, Entrance & Departmental Examinations

RRB ALP CBT-1 & CBT-2 • RRB Technician Grade-I & III • RRB JE • DRDO CEPTAM • ISRO Technician • Metro Maintainer

Core Syllabus Pillars & Exam Question Weightage (%)

- Engineering Drawing (IS 10711 Sheets, Line Types, 1st/3rd Angle Projections) (24%)
- Mechanics: Units, Mass-Weight-Density, Speed-Velocity, Work-Power & Levers (24%)
- Basic Electricity: Ohm's Law, KCL/KVL, Transformers, 3-Phase Motors & Cells (22%)
- Heat & Thermodynamics: Temperature Scales, Specific/Latent Heat & Transfer (16%)
- Occupational Safety (Fire Classes A/B/C/D, PPE, 5S) & ITI Trade Theory (14%)

Complete Theory
NCERT & Official Sources

Visual Flowcharts
Comparative Matrices

Memory Tricks
Exam Trap Alerts

75+ Solved MCQs
One-Liner Capsules

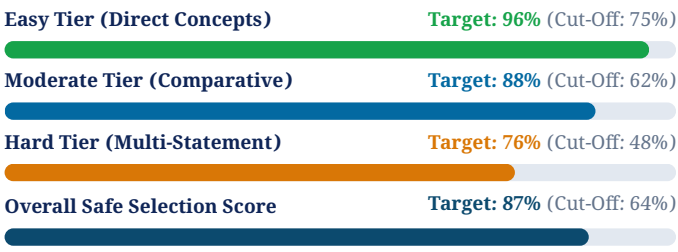
Preface, Exam Weightage Dashboard & Study Strategy — RAILWAY ALP & TECHNICIAN — BASIC SCIENCE, DRAWING & TRADE THEORY

IUC Academy (Inclusive Universal Careers Academy | www.iucacademy.com) • Official English Medium Study Notes

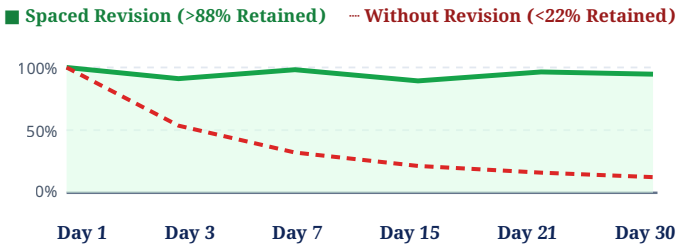
Dear Aspirants,

Modern competitive, entrance, and departmental promotion examinations demand a combination of deep conceptual clarity, statutory precision, and rapid revision tools. Prepared by **Inclusive Universal Careers Academy (IUC Academy — www.iucacademy.com)**, these comprehensive English-medium study notes integrate **structured chapter theory, 4-node conceptual process flowcharts, multi-column comparative tables, inline mathematical/scientific formulas, 'Did You Know?' boxes, 'Exam Trap Alert' callouts, 'Memory Trick' mnemonics, Chapter-End Analytical Synthesis Matrices, 75+ Step-by-Step Solved MCQs, and Rapid-Fire One-Liner Revision Capsules**.

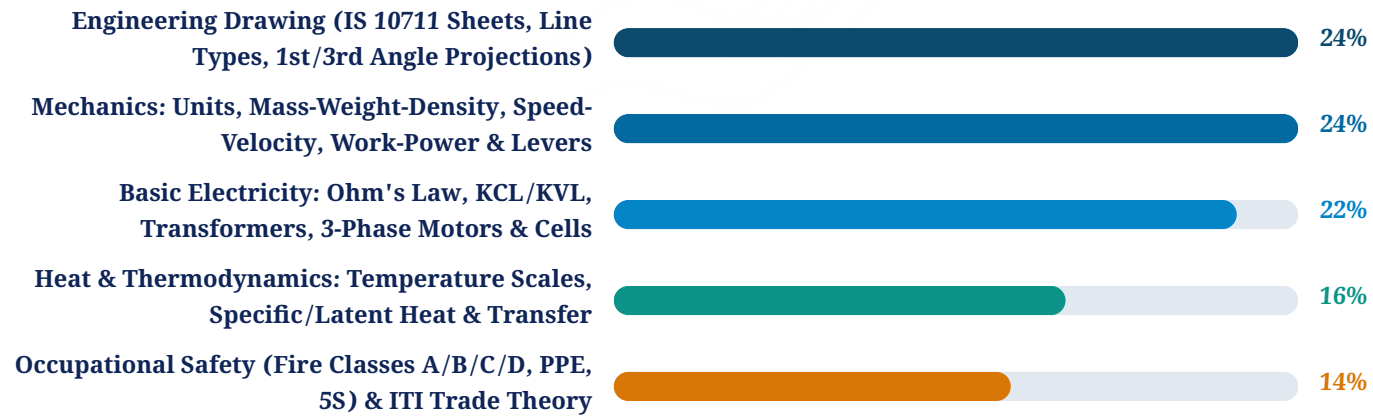
Target Accuracy vs Qualifying Cut-Off Benchmark (%)



Spaced Revision (1-3-7-21 Day Rule) & Retention Curve



Topic-Wise Exam Question Weightage Index (%)



Verified Official Curriculum & Statutory Reference Portals

- **Indian Railways Official Portal** (https://indianrailways.gov.in/)
- **Bureau of Indian Standards (BIS)** (https://www.bis.gov.in/)
- **Directorate General of Training (DGT)** (https://dgt.gov.in/)
- **NCERT Science Textbooks** (https://ncert.nic.in/)
- **IUC Academy Official Portal** (https://www.iucacademy.com)

Detailed Table of Contents & Chapter Architecture

RAILWAY ALP & TECHNICIAN — BASIC SCIENCE, DRAWING & TRADE THEORY • Complete Chapters, Comparative Matrices, Solved MCQs & Rapid Revision

1. Chapter 1: Units, Measurements, Dimensional Formulas & Precision Measuring Instruments

- 1.1 Fundamental, Supplementary, and Derived Units (SI, CGS, MKS & FPS Systems)
- 1.2 ITI Workshop Precision Measuring Instruments (Vernier Caliper, Screw Gauge & Dial Indicator)

2. Chapter 2: Mass, Weight, Density, Specific Gravity, Buoyancy & Fluid Mechanics

- 2.1 Fundamental Distinction Between Mass and Weight
- 2.2 Density, Relative Density (Specific Gravity), Archimedes' Principle & Hydrometry

3. Chapter 3: Speed, Velocity, Acceleration, Equations of Motion, Newton's Laws & Projectile Motion

- 3.1 Kinematics: Distance vs. Displacement, Speed vs. Velocity & Equations of Motion
- 3.2 Newton's Laws of Motion, Momentum, Impulse, Friction & Circular/Projectile Motion

4. Chapter 4: Work, Power, Energy, Conservation Laws & Mechanical Efficiency

- 4.1 Scientific Definition of Work: Positive, Negative, and Zero Work Conditions
- 4.2 Kinetic Energy, Potential Energy, Momentum-KE Relation & Power

5. Chapter 5: Heat, Temperature Scales, Calorimetry, Latent Heat & Thermal Expansion

- 5.1 Temperature Scales, Conversions & Thermometry
- 5.2 Specific Heat Capacity, Calorimetry, Latent Heat, Thermal Expansion & Heat Transfer

6. Chapter 6: Basic Electricity, Ohm's Law, Kirchhoff's Laws, Magnetism, Transformers & Motors

- 6.1 Electric Charge, Current, Potential, Ohm's Law, Resistance & Resistivity
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- 7.2 Principle of Levers and Complete Classification (First, Second, and Third Class Levers)

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- 8.1 Engineering Drawing Standards: Drawing Sheets (IS 10711), Pencil Grades, Scales & Lines (IS 10714)
- 8.2 Occupational Health, Safety Signs, Fire Classification (Class A, B, C, D, K) & 5S Methodology

9. Solved Exam Practice Questions (MCQs)

10. Extended Comparative & Analytical Practice Set (Questions 36–75)

11. Rapid-Fire Last-Minute One-Liner Revision Capsule

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Primary Curriculum References: https://indianrailways.gov.in/ | https://www.bis.gov.in/ | https://dgt.gov.in/ | https://ncert.nic.in/

Chapter 1: Units, Measurements, Dimensional Formulas & Precision Measuring Instruments

Chapter Key Study Pillars — Chapter 1: Units, Measurements, Dimensional Formulas & Precision Measuring Instruments

Key Study Pillar 1
Fundamental, Supplementary, and Derived Units (SI, CGS, MKS & FPS Systems)

Key Study Pillar 2
ITI Workshop Precision Measuring Instruments (Vernier Caliper, Screw Gauge & Dial Indicator)

1.1 Fundamental, Supplementary, and Derived Units (SI, CGS, MKS & FPS Systems)

• **Four Classical Systems of Units:** (1) **CGS System** (Centimetre, Gram, Second), (2) **FPS / British System** (Foot, Pound, Second), (3) **MKS System** (Metre, Kilogram, Second), and (4) **SI System (*Systeme International d'Unites*)**, adopted internationally in 1960 by the General Conference on Weights and Measures (CGPM) (https://ncert.nic.in/).

• **Seven Fundamental SI Base Quantities and Units:** Length -> **metre (m)**; Mass -> **kilogram (kg)**; Time -> **second (s)**; Electric Current -> **ampere (A)**; Thermodynamic Temperature -> **kelvin (K)**; Amount of Substance -> **mole (mol)**; and Luminous Intensity -> **candela (cd)** (https://ncert.nic.in/).

• **Two Supplementary SI Units (Dimensionless Quantities):** Plane Angle is measured in **radian (rad)** where `theta = s / r` (arc length divided by radius, `pi rad = 180 degrees`), and Solid Angle is measured in **steradian (sr)** where `SolidAngle = A / r^2` (surface area divided by radius squared, total solid angle of a sphere = `4 * pi sr`) (https://ncert.nic.in/).

• **Astronomical and Microscopic Length Units:** 1 Light Year (distance traveled by light in vacuum in one Julian year) = `9.46 10^15 m`; 1 *Astronomical Unit* (*AU, mean distance between Earth and Sun*) = `1.496` 10^11 m; 1 Parsec (Parallax Second, the largest practical unit of astronomical distance) = `3.08 * 10^16 m = 3.26 Light Years`; 1 Angstrom = `10^-10 m`; and 1 Fermi (femtometre, nuclear radius scale) = `10^-15 m` (https://ncert.nic.in/).

• **Principles of Dimensional Analysis and Homogeneity:** According to the Principle of Homogeneity of Dimensions, only physical quantities having identical dimensional formulas `[M^a L^b T^c]` can be added, subtracted, or equated across a physical equation (https://ncert.nic.in/).

1.2 ITI Workshop Precision Measuring Instruments (Vernier Caliper, Screw Gauge & Dial Indicator)

• **Vernier Caliper (Invented by Pierre Vernier):** Measures external diameter (outside jaws), internal diameter (inside nibs/jaws), and depth of blind holes/slots (depth blade). Its **Least Count (LC)** is given by the formula: `LC = 1 Main Scale Division (MSD) - 1 Vernier Scale Division (VSD)`. For a standard metric Vernier Caliper

where **50 VSD = 49 MSD** (with **1 MSD = 1 mm**), **LC = 1 mm * (1 - 49/50) = 0.02 mm** (or **0.002 cm**) (https://dgt.gov.in/).

• **Outside Micrometer / Screw Gauge:** Operates on the **principle of a screw and nut**, converting rotational motion of the thimble into precise linear travel of the spindle. Its Least Count is defined as: **LC = Pitch / Total Number of Divisions on Circular (Thimble) Scale**, where **Pitch = Linear distance moved by spindle / Number of full rotations**. For a standard metric micrometer with **Pitch = 0.5 mm** and **50 thimble divisions**, **LC = 0.5 mm / 50 = 0.01 mm** (or **0.001 cm**) (https://dgt.gov.in/).

• **Zero Error and Zero Correction in Micrometer and Vernier Caliper:** When the measuring faces are in contact, if the zero of the Vernier/Thimble scale lies ahead of (or below) the reference line, the **Zero Error is Positive (+)** and the **Zero Correction is Negative (-)** (subtracted from the observed reading). If the zero lies behind (or above) the reference line, the **Zero Error is Negative (-)** and the **Zero Correction is Positive (+)** (added to the observed reading): **True Reading = Main Scale Reading + (Coinciding Division * LC) - Zero Error** (https://dgt.gov.in/).

• **Vernier Bevel Protractor & Sine Bar:** A **Vernier Bevel Protractor** measures angles to a Least Count of **5 minutes of arc (5')** (i.e., **1/12th of a degree**), where **23 Main Scale Degrees** are divided into **12 Vernier Divisions** (**LC = 2 deg - 23/12 deg = 1/12 deg = 5'**). A **Sine Bar** is used with slip gauges and a dial test indicator to measure angles with high precision using the trigonometric principle **sin(theta) = h / L** (where **h** is slip gauge height and **L** is center distance between rollers) (https://dgt.gov.in/).

• **Feeler Gauge, Radius Gauge, Screw Pitch Gauge & Wire Gauge:** A **Feeler Gauge** checks clearance/gap between mating parts (blade thickness from **0.03 mm to 1.00 mm**); a **Screw Pitch Gauge** determines the pitch of screw threads; and a **Standard Wire Gauge (SWG)** measures sheet metal thickness and wire diameter (where a **higher SWG number indicates a thinner wire/sheet**) (https://dgt.gov.in/).

1.3 Precision Measurement Flowchart and Dimensional Formula Matrix

Step-by-Step Conceptual Process Flowchart

STEP 1
Clean Workpiece & Check Instrument Zero Error

STEP 2
Gently Seat Measuring Jaws / Ratchet Stop Without Over-Tightening

STEP 3
Read Main Scale (MSR) & Coinciding Vernier/ Thimble Division (VSR)

STEP 4
Compute Final Dimension = MSR + (VSR * LC) - Zero Error

Physical Quantity / Instrument	Formula / Working Principle	SI Unit & CGS Relation	Dimensional Formula / Least Count	Reference Source
Force (F)	**F = m *a*** (*Mass* Acceleration)	**Newton (N) = kg*m/s^2**; **1 N = 10^5 dyne**	**[M^1 L^1 T^-2]**	https://ncert.nic.in/
Work / Energy (W)	**W = F *d* cos(theta)**	**Joule (J) = N*m**; **1 J = 10^7 erg**	**[M^1 L^2 T^-2]**	https://ncert.nic.in/
Pressure / Stress (P)	**P = F / A** (Force / Area)	**Pascal (Pa) = N/m^2**; **1 Bar = 10^5 Pa**	**[M^1 L^-1 T^-2]**	https://ncert.nic.in/

Physical Quantity / Instrument	Formula / Working Principle	SI Unit & CGS Relation	Dimensional Formula / Least Count	Reference Source
Dynamic Viscosity (eta)	**F = eta *A* (dv / dx)**	**Pas** *or* **N** s/m^2; **1 Pa*s = 10 Poise**	**[M^1 L^-1 T^-1]**	https://ncert.nic.in/
Metric Vernier Caliper	Difference of two scales (**1 MSD - 1 VSD**)	Millimetre (**mm**)	**LC = 0.02 mm** (**49 MSD = 50 VSD**)	https://dgt.gov.in/
Outside Micrometer	Screw and Nut (**Pitch / Thimble Divisions**)	Millimetre (**mm**)	**LC = 0.01 mm** (**0.5 mm / 50 div**)	https://dgt.gov.in/

Did You Know?: The **Ratchet Stop** at the end of a Micrometer thimble ensures uniform measuring pressure across different operators by slipping with a clicking sound once the spindle contacts the workpiece at the calibrated force (https://dgt.gov.in/).

Exam Trap Alert: Torque (tau = r *F*) *and* Work (*W* = *F* d) have the exact same dimensional formula **[M^1 L^2 T^-2]**, and **Planck's Constant (h = E / nu)** and **Angular Momentum (L = m *v* r)** share the exact same dimensional formula **[M^1 L^2 T^-1]**, even though they represent completely different physical concepts (https://ncert.nic.in/).

★ **Memory Trick:** Remember the Least Counts of the 3 most asked ITI workshop tools with **2 - 1 - 5**: Vernier Caliper = **0.02 mm**, Micrometer = **0.01 mm**, and Vernier Bevel Protractor = **5 minutes (5')** (https://dgt.gov.in/).

Chapter *1* Comprehensive Analytical & Statutory Revision Matrix

Core Sub-Domain	Key Concept / Provision	Verified Analytical Parameters & Exam Distinctions (Indian Railways Official Portal)
Fundamental, Supplementary, and Derived Units (SI, CGS, MKS & FPS Systems)	**Four Classical Systems of Units**	(1) **CGS System** (Centimetre, Gram, Second), (2) **FPS / British System** (Foot, Pound, Second), (3) **MKS System** (Metre, Kilogram, Second), and (4) **SI System (*Systeme International d'Unites*)**, adopted internationally in 1960 by the General Conference on Weights and Measures (CGPM) (https://ncert.nic.in/).
ITI Workshop Precision Measuring Instruments (Vernier Caliper, Screw Gauge & Dial Indicator)	**Seven Fundamental SI Base Quantities and Units**	Length -> **metre (m)**; Mass -> **kilogram (kg)**; Time -> **second (s)**; Electric Current -> **ampere (A)**; Thermodynamic Temperature -> **kelvin (K)**; Amount of Substance -> **mole (mol)**; and Luminous Intensity -> **candela (cd)** (https://ncert.nic.in/).
Precision Measurement Flowchart and Dimensional Formula Matrix	**Two Supplementary SI Units (Dimensionless Quantities)**	Plane Angle is measured in **radian (rad)** where **theta = s / r** (arc length divided by radius, **pi rad = 180 degrees**), and Solid Angle is measured in **steradian (sr)** where **SolidAngle = A / r^2** (surface area divided by radius squared, total solid angle of a sphere = **4 * pi sr**) (https://ncert.nic.in/).

Core Sub-Domain	Key Concept / Provision	Verified Analytical Parameters & Exam Distinctions (Indian Railways Official Portal)
Fundamental, Supplementary, and Derived Units (SI, CGS, MKS & FPS Systems)	**Astronomical and Microscopic Length Units**	1 Light Year (distance traveled by light in vacuum in one Julian year) = **9.46 10^15 *m*** ; 1 *Astronomical Unit* (*AU*, *mean distance between Earth and Sun*) = **1.496** 10^11 m; 1 Parsec (Parallax Second, the largest practical unit of astronomical distance) = **3.08 * 10^16 m = 3.26 Light Years** ; 1 Angstrom = **10^-10 m** ; and 1 Fermi (femtometre, nuclear radius scale) = **10^-15 m** (https://ncert.nic.in/).
ITI Workshop Precision Measuring Instruments (Vernier Caliper, Screw Gauge & Dial Indicator)	**Principles of Dimensional Analysis and Homogeneity**	According to the Principle of Homogeneity of Dimensions, only physical quantities having identical dimensional formulas **[M^a L^b T^c]** can be added, subtracted, or equated across a physical equation (https://ncert.nic.in/).
Precision Measurement Flowchart and Dimensional Formula Matrix	**Vernier Caliper (Invented by Pierre Vernier)**	Measures external diameter (outside jaws), internal diameter (inside nibs/jaws), and depth of blind holes/slots (depth blade). Its **Least Count (LC)** is given by the formula: **LC = 1 Main Scale Division (MSD) - 1 Vernier Scale Division (VSD)** . For a standard metric Vernier Caliper where **50 VSD = 49 MSD** (with **1 MSD = 1 mm**), **LC = 1 mm * (1 - 49/50) = 0.02 mm** (or **0.002 cm**) (https://dgt.gov.in/).
Fundamental, Supplementary, and Derived Units (SI, CGS, MKS & FPS Systems)	**Outside Micrometer / Screw Gauge**	Operates on the **principle of a screw and nut**, converting rotational motion of the thimble into precise linear travel of the spindle. Its Least Count is defined as: **LC = Pitch / Total Number of Divisions on Circular (Thimble) Scale** , where **Pitch = Linear distance moved by spindle / Number of full rotations** . For a standard metric micrometer with **Pitch = 0.5 mm** and **50 thimble divisions** , **LC = 0.5 mm / 50 = 0.01 mm** (or **0.001 cm**) (https://dgt.gov.in/).
ITI Workshop Precision Measuring Instruments (Vernier Caliper, Screw Gauge & Dial Indicator)	**Zero Error and Zero Correction in Micrometer and Vernier Caliper**	When the measuring faces are in contact, if the zero of the Vernier/Thimble scale lies ahead of (or below) the reference line, the **Zero Error is Positive (+)** and the **Zero Correction is Negative (-)** (subtracted from the observed reading). If the zero lies behind (or above) the reference line, the **Zero Error is Negative (-)** and the **Zero Correction is Positive (+)** (added to the observed reading): **True Reading = Main Scale Reading + (Coinciding Division * LC) - Zero Error** (https://dgt.gov.in/).
Precision Measurement Flowchart and Dimensional Formula Matrix	**Vernier Bevel Protractor & Sine Bar**	A **Vernier Bevel Protractor** measures angles to a Least Count of **5 minutes of arc (5')** (i.e., **1/12th of a degree**), where **23 Main Scale Degrees** are divided into **12 Vernier Divisions** (**LC = 2 deg - 23/12 deg = 1/12 deg = 5'**). A **Sine Bar** is used with slip gauges and a dial test indicator to measure angles with high precision using the trigonometric principle **sin(theta) = h / L** (where **h** is slip gauge height and **L** is center distance between rollers) (https://dgt.gov.in/).
Fundamental, Supplementary, and Derived Units (SI, CGS, MKS & FPS Systems)	**Feeler Gauge, Radius Gauge, Screw Pitch Gauge & Wire Gauge**	A **Feeler Gauge** checks clearance/gap between mating parts (blade thickness from **0.03 mm to 1.00 mm**); a **Screw Pitch Gauge** determines the pitch of screw threads; and a **Standard Wire Gauge (SWG)** measures sheet metal thickness and wire diameter (where a **higher SWG number indicates a thinner wire/sheet**) (https://dgt.gov.in/).

Chapter 1 Multi-Statement Exam Verification Drills

Chapter 1 Statement-Verification Drill #1

Both Statements Verified Correct

Statement-I (Four Classical Systems of Units): (1) **CGS System** (Centimetre, Gram, Second), (2) **FPS / British System** (Foot, Pound, Second), (3) **MKS System** (Metre, Kilogram, Second), and (4) **SI System (*Systeme International d'Unites*)**, adopted internationally in 1960 by the General Conference on Weights and Measures (CGPM) (https://ncert.nic.in/).

Statement-II (Seven Fundamental SI Base Quantities and Units): Length -> **metre (m)**; Mass -> **kilogram (kg)**; Time -> **second (s)**; Electric Current -> **ampere (A)**; Thermodynamic Temperature -> **kelvin (K)**; Amount of Substance -> **mole (mol)**; and Luminous Intensity -> **candela (cd)** (https://ncert.nic.in/).

✓ **Exam Verification Key: Both Statement-I and Statement-II are factually accurate as per Indian Railways Official Portal & IUC Academy.**

Chapter 1 Statement-Verification Drill #2

Both Statements Verified Correct

Statement-I (Two Supplementary SI Units (Dimensionless Quantities)): Plane Angle is measured in **radian (rad)** where `theta = s / r` (arc length divided by radius, `pi rad = 180 degrees`), and Solid Angle is measured in **steradian (sr)** where `SolidAngle = A / r^2` (surface area divided by radius squared, total solid angle of a sphere = `4 * pi sr`) (https://ncert.nic.in/).

Statement-II (Astronomical and Microscopic Length Units): 1 Light Year (distance traveled by light in vacuum in one Julian year) = `9.46 10^15 m`; 1 *Astronomical Unit* (*AU*, *mean distance between Earth and Sun*) = `1.496` 10^11 m; 1 Parsec (Parallax Second, the largest practical unit of astronomical distance) = `3.08 * 10^16 m = 3.26 Light Years`; 1 Angstrom = `10^-10 m`; and 1 Fermi (femtometre, nuclear radius scale) = `10^-15 m` (https://ncert.nic.in/).

✓ **Exam Verification Key: Both Statement-I and Statement-II are factually accurate as per Indian Railways Official Portal & IUC Academy.**

Chapter 1 Statement-Verification Drill #3

Both Statements Verified Correct

Statement-I (Principles of Dimensional Analysis and Homogeneity): According to the Principle of Homogeneity of Dimensions, only physical quantities having identical dimensional formulas `[M^a L^b T^c]` can be added, subtracted, or equated across a physical equation (https://ncert.nic.in/).

Statement-II (Vernier Caliper (Invented by Pierre Vernier)): Measures external diameter (outside jaws), internal diameter (inside nibs/jaws), and depth of blind holes/slots (depth blade). Its **Least Count (LC)** is given by the formula: `LC = 1 Main Scale Division (MSD) - 1 Vernier Scale Division (VSD)`. For a standard metric Vernier Caliper where `50 VSD = 49 MSD` (with `1 MSD = 1 mm`), `LC = 1 mm * (1 - 49/50) = 0.02 mm` (or `0.002 cm`) (https://dgt.gov.in/).

✓ **Exam Verification Key: Both Statement-I and Statement-II are factually accurate as per Indian Railways Official Portal & IUC Academy.**

Chapter 1 Statement-Verification Drill #4

Both Statements Verified Correct

Statement-I (Outside Micrometer / Screw Gauge): Operates on the **principle of a screw and nut**, converting rotational motion of the thimble into precise linear travel of the spindle. Its Least Count is defined as: `LC = Pitch / Total Number of Divisions on Circular (Thimble) Scale`, where `Pitch = Linear distance moved by spindle / Number of full rotations`. For a standard metric micrometer with `Pitch = 0.5 mm` and `50 thimble divisions`, `LC = 0.5 mm / 50 = 0.01 mm` (or `0.001 cm`) (https://dgt.gov.in/).

Statement-II (Zero Error and Zero Correction in Micrometer and Vernier Caliper): When the measuring faces are in contact, if the zero of the Vernier/Thimble scale lies ahead of (or below) the reference line, the **Zero Error is Positive (+)** and the **Zero Correction is Negative (-)** (subtracted from the observed reading). If the zero lies behind (or above) the reference line, the **Zero Error is Negative (-)** and the **Zero Correction is Positive (+)** (added to the observed reading): `True Reading = Main Scale Reading + (Coinciding Division * LC) - Zero Error` (https://dgt.gov.in/).

✓ **Exam Verification Key: Both Statement-I and Statement-II are factually accurate as per Indian Railways Official Portal & IUC Academy.**

Chapter 1 Statement-Verification Drill #5 — Both Statements Verified Correct

Statement-I (Vernier Bevel Protractor & Sine Bar): A **Vernier Bevel Protractor** measures angles to a Least Count of **5 minutes of arc (5')** (i.e., **1/12th of a degree**), where **23 Main Scale Degrees** are divided into **12 Vernier Divisions** (**LC = 2 deg - 23/12 deg = 1/12 deg = 5'**). A **Sine Bar** is used with slip gauges and a dial test indicator to measure angles with high precision using the trigonometric principle **sin(theta) = h / L** (where **h** is slip gauge height and **L** is center distance between rollers) (https://dgt.gov.in/).

Statement-II (Feeler Gauge, Radius Gauge, Screw Pitch Gauge & Wire Gauge): A **Feeler Gauge** checks clearance/gap between mating parts (blade thickness from **0.03 mm to 1.00 mm**); a **Screw Pitch Gauge** determines the pitch of screw threads; and a **Standard Wire Gauge (SWG)** measures sheet metal thickness and wire diameter (where a **higher SWG number indicates a thinner wire/sheet**) (https://dgt.gov.in/).

✓ **Exam Verification Key: Both Statement-I and Statement-II are factually accurate as per Indian Railways Official Portal & IUC Academy.**

Chapter 2: Mass, Weight, Density, Specific Gravity, Buoyancy & Fluid Mechanics

Chapter Key Study Pillars — Chapter 2: Mass, Weight, Density, Specific Gravity, Buoyancy & Fluid Mechanics

Key Study Pillar 1
Fundamental Distinction Between Mass and Weight

Key Study Pillar 2
Density, Relative Density (Specific Gravity), Archimedes' Principle & Hydrometry

2.1 Fundamental Distinction Between Mass and Weight

• **Mass (m) vs. Weight (W): Mass** is the intrinsic measure of the quantity of matter and inertia contained in a body; it is a **scalar quantity**, measured in **kilograms (kg)** using a **common beam balance**, and remains **constant everywhere in the universe**. **Weight** is the gravitational pull exerted on a body (**W = m * g**); it is a **vector quantity** directed toward the center of the celestial body, measured in **Newtons (N)** or **kilogram-force (1 kgf = 9.8 N)** using a **spring balance**, and varies with local gravitational acceleration **g** (https://ncert.nic.in/).

• **Spatial Variation of Acceleration Due to Gravity (g = G *M* / *R*^2):** *Because Earth is an oblate spheroid (equatorial radius **R_e** is roughly **21 km** larger than polar radius **R_p**) and rotates about its axis (**g' = g - w_ang^2** R cos^2(lambda)):* (1) ***g** is **maximum at the Poles** (**~9.83 m/s^2**)*, (2) ***g** is **minimum at the Equator** (**~9.78 m/s^2**)*, (3) ***g** **decreases with altitude** (**g_h = g** (1 - 2h/R) for **h << R**)*, (4) **g** **decreases with depth** (**g_d = g * (1 - d/R)**), and (5) **g** is **exactly zero at the center of the Earth**, making a body's weight at the Earth's center zero while its mass remains unchanged (https://ncert.nic.in/).

• **Gravitational Weight on the Moon and in an Elevator (Lift):** On the Moon's surface, **g_moon = g_earth / 6**, so a body's weight on the Moon is **1/6th** of its weight on Earth (while mass is unchanged). In an elevator moving with upward acceleration **a**, apparent weight increases (**W_app = m (*g* + *a*)**); *in an elevator accelerating downward, apparent weight decreases* (***W_app* = *m*** (g - a)); and in **free fall (a = g)**, apparent weight becomes **zero (W_app = 0 , state of weightlessness)** (https://ncert.nic.in/).

2.2 Density, Relative Density (Specific Gravity), Archimedes' Principle & Hydrometry

• **Density (`rho`) and Relative Density (Specific Gravity): Density** is defined as mass per unit volume: `rho = m / V`, with SI unit `kg/m^3` and CGS unit `g/cm^3` (`1 g/cm^3 = 1000 kg/m^3`). **Relative Density (RD)** or **Specific Gravity (SG)** is the ratio of the density of a substance to the density of pure water at **4 degrees Celsius** (`1000 kg/m^3` or `1 g/cm^3`): `RD = Density of Substance / Density of Water at 4 deg C`. Since it is a ratio of two identical quantities, **Relative Density is completely unitless and dimensionless (`[M^0 L^0 T^0]`)** (https://ncert.nic.in/).

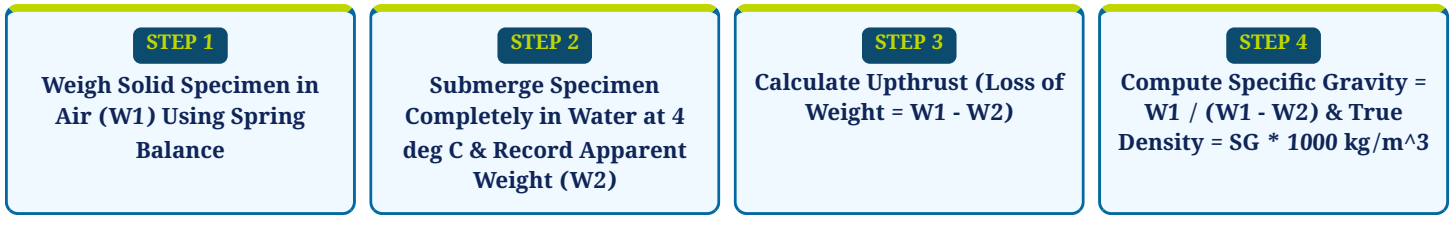
• **Anomalous Expansion of Water (0 deg C to 4 deg C):** When water is heated from `0 deg C` to `4 deg C`, instead of expanding, it **contracts in volume**, reaching its **minimum volume and maximum density (`1000 kg/m^3` or `1.00 g/cm^3`) at exactly 4 degrees Celsius**, and expands normally above `4 deg C` (https://ncert.nic.in/).

• **Archimedes' Principle and Law of Floatation:** When a body is wholly or partially immersed in a fluid at rest, it experiences an upward buoyant force (upthrust) equal to the **weight of the fluid displaced by the body** (`F_b = V_submerged *rho_fluid* g`). Using loss of weight in water, Relative Density of a solid is computed as: `RD = Weight in Air / (Weight in Air - Weight in Water)`. For a floating body (`W_body = F_b`), the fraction of volume submerged is `V_sub / V_total = rho_body / rho_fluid` (for ice of density `900 kg/m^3` floating in pure water of `1000 kg/m^3`, `9/10th` or `90%` is submerged and `1/10th` or `10%` remains above water) (https://ncert.nic.in/).

• **Hydrometer, Lactometer & Battery Hydrometer:** A **Hydrometer** measures the specific gravity of liquids directly based on the law of floatation (graduations read **smaller values at the top of the stem and larger values at the bottom** because it sinks deeper in lighter liquids). A **Lactometer** checks the purity of milk (`SG ~ 1.028 to 1.032`), and a **Battery Hydrometer** measures the state of charge of a **Lead-Acid Storage Battery**: a fully charged cell has sulfuric acid electrolyte specific gravity of **1.250 to 1.280**, whereas a discharged cell drops to **1.150 or below** (https://dgt.gov.in/).

2.3 Buoyancy & Specific Gravity Flowchart and Engineering Material Density Matrix

Step-by-Step Conceptual Process Flowchart



Substance / Engineering Material	Density in CGS (`g/cm^3`)	Density in SI (`kg/m^3`)	Specific Gravity (RD)	Workshop / Engineering Application	Reference Source
Pure Water (at 4 deg C)	`1.00 g/cm^3`	`1,000 kg/m^3`	`1.00` (Reference Standard)	Cooling systems & specific gravity baseline	https://ncert.nic.in/

Substance / Engineering Material	Density in CGS (g/cm^3)	Density in SI (kg/m^3)	Specific Gravity (RD)	Workshop / Engineering Application	Reference Source
Ice (at 0 deg C)	0.90 - 0.92 g/cm^3	900 - 920 kg/m^3	0.90 - 0.92	Floats on water with ~90% volume submerged	https://ncert.nic.in/
Aluminium (Al)	2.70 g/cm^3	2,700 kg/m^3	2.70	Lightweight coach bodies, aircraft & overhead cables	https://dgt.gov.in/
Cast Iron / Mild Steel	7.20 - 7.85 g/cm^3	7,200 - 7,850 kg/m^3	7.20 - 7.85	Machine beds (Cast Iron 7.2) & railway rails (7.85)	https://dgt.gov.in/
Copper (Cu) / Lead (Pb)	8.96 / 11.34 g/cm^3	8,960 / 11,340 kg/m^3	8.96 / 11.34	Electrical windings (Cu) & storage battery plates (Pb)	https://dgt.gov.in/
Mercury (Hg) / Gold (Au)	13.60 / 19.30 g/cm^3	13,600 / 19,300 kg/m^3	13.60 / 19.30	Barometers/manometers (Hg 13.6) & precision contacts	https://ncert.nic.in/

Did You Know?: When a block of pure ice floating in a glass of water melts completely, the **water level in the glass remains unchanged** because the melted ice occupies the exact same volume as the water it previously displaced while floating (https://ncert.nic.in/).

Exam Trap Alert: If a question gives the **mass** of an object on Earth as 60 kg and asks for its **mass** on the Moon, the answer is still 60 kg (not 10 kg!); only the **weight** becomes 1/6th on the Moon (https://ncert.nic.in/).

★ **Memory Trick:** Remember water's properties from 0 deg C to 4 deg C with **D-U / V-D** (**D**ensity goes **U**p to maximum at 4 deg C, while **V**olume goes **D**own to minimum at 4 deg C) (https://ncert.nic.in/).

Chapter 2 Comprehensive Analytical & Statutory Revision Matrix

Core Sub-Domain	Key Concept / Provision	Verified Analytical Parameters & Exam Distinctions (Indian Railways Official Portal)
Fundamental Distinction Between Mass and Weight	Mass (m) vs. Weight (W)	**Mass** is the intrinsic measure of the quantity of matter and inertia contained in a body; it is a **scalar quantity**, measured in **kilograms (kg)** using a **common beam balance**, and remains **constant everywhere in the universe**. **Weight** is the gravitational pull exerted on a body (W = m * g); it is a **vector quantity** directed toward the center of the celestial body, measured in **Newtons (N)** or **kilogram-force (1 kgf = 9.8 N)** using a **spring balance**, and varies with local gravitational acceleration g (https://ncert.nic.in/).
Density, Relative Density (Specific Gravity), Archimedes' Principle & Hydrometry	Spatial Variation of Acceleration Due to Gravity (g = G * M / R^2)	**Because Earth is an oblate spheroid (equatorial radius R_e is roughly 21 km larger than polar radius R_p) and rotates about its axis (g' = g - w_ang^2 *R* cos^2(lambda)): (1) g is maximum at the Poles (~9.83 m/s^2), (2) g is minimum at the Equator (~9.78 m/s^2), (3) g decreases with altitude (g_h = g (1 - 2*h*/*R*) *for* *h* << *R*), (4) *g* *decreases with depth* (g_d = g (1 - d/R)), and (5) g is exactly zero at the center of the Earth**, making a body's weight at the Earth's center zero while its mass remains unchanged (https://ncert.nic.in/).

Core Sub-Domain	Key Concept / Provision	Verified Analytical Parameters & Exam Distinctions (Indian Railways Official Portal)
Buoyancy & Specific Gravity Flowchart and Engineering Material Density Matrix	**Gravitational Weight on the Moon and in an Elevator (Lift)**	On the Moon's surface, **g_moon = g_earth / 6**, so a body's weight on the Moon is **1/6th** of its weight on Earth (while mass is unchanged). In an elevator moving with upward acceleration **a**, apparent weight increases (**W_app = m (*g* + *a*)**); *in an elevator accelerating downward, apparent weight decreases* (**W_app = m** (g - a)); and in **free fall (a = g)**, apparent weight becomes **zero (W_app = 0, state of weightlessness)** (https://ncert.nic.in/).
Fundamental Distinction Between Mass and Weight	**Density (rho) and Relative Density (Specific Gravity)**	**Density** is defined as mass per unit volume: **rho = m / V**, with SI unit **kg/m^3** and CGS unit **g/cm^3** (**1 g/cm^3 = 1000 kg/m^3**). **Relative Density (RD)** or **Specific Gravity (SG)** is the ratio of the density of a substance to the density of pure water at **4 degrees Celsius** (**1000 kg/m^3** or **1 g/cm^3**): **RD = Density of Substance / Density of Water at 4 deg C**. Since it is a ratio of two identical quantities, **Relative Density is completely unitless and dimensionless (*[M^0 L^0 T^0]*)** (https://ncert.nic.in/).
Density, Relative Density (Specific Gravity), Archimedes' Principle & Hydrometry	**Anomalous Expansion of Water (0 deg C to 4 deg C)**	When water is heated from **0 deg C** to **4 deg C**, instead of expanding, it **contracts in volume**, reaching its **minimum volume and maximum density (1000 kg/m^3 or 1.00 g/cm^3) at exactly 4 degrees Celsius**, and expands normally above **4 deg C** (https://ncert.nic.in/).
Buoyancy & Specific Gravity Flowchart and Engineering Material Density Matrix	**Archimedes' Principle and Law of Floatation**	When a body is wholly or partially immersed in a fluid at rest, it experiences an upward buoyant force (upthrust) equal to the **weight of the fluid displaced by the body** (**F_b = V_submerged *rho_fluid* g**). Using loss of weight in water, Relative Density of a solid is computed as: **RD = Weight in Air / (Weight in Air - Weight in Water)**. For a floating body (**W_body = F_b**), the fraction of volume submerged is **V_sub / V_total = rho_body / rho_fluid** (for ice of density **900 kg/m^3** floating in pure water of **1000 kg/m^3**, **9/10th** or **90%** is submerged and **1/10th** or **10%** remains above water) (https://ncert.nic.in/).
Fundamental Distinction Between Mass and Weight	**Hydrometer, Lactometer & Battery Hydrometer**	A **Hydrometer** measures the specific gravity of liquids directly based on the law of floatation (graduations read **smaller values at the top of the stem and larger values at the bottom** because it sinks deeper in lighter liquids). A **Lactometer** checks the purity of milk (**SG ~ 1.028 to 1.032**), and a **Battery Hydrometer** measures the state of charge of a **Lead-Acid Storage Battery**: a fully charged cell has sulfuric acid electrolyte specific gravity of **1.250 to 1.280**, whereas a discharged cell drops to **1.150 or below** (https://dgt.gov.in/).

Chapter 2 Multi-Statement Exam Verification Drills

Chapter 2 Statement-Verification Drill #1

Both Statements Verified Correct

Statement-I (Mass (m) vs. Weight (W)): **Mass** is the intrinsic measure of the quantity of matter and inertia contained in a body; it is a **scalar quantity**, measured in **kilograms (kg)** using a **common beam balance**, and remains **constant everywhere in the universe**. **Weight** is the gravitational pull exerted on a body (W = m * g); it is a **vector quantity** directed toward the center of the celestial body, measured in **Newtons (N)** or **kilogram-force (1 kgf = 9.8 N)** using a **spring balance**, and varies with local gravitational acceleration g (https://ncert.nic.in/).

Statement-II (Spatial Variation of Acceleration Due to Gravity (g = G * M / R^2)): Because Earth is an oblate spheroid (equatorial radius R_e is roughly 21 km larger than polar radius R_p) and rotates about its axis (g' = g - w_ang^2 *R* cos^2(lambda)): (1) g **is** maximum at the Poles (~9.83 m/s^2), **(2)** g **is** minimum at the Equator (~9.78 m/s^2), **(3)** g decreases with altitude (g_h = g (1 - 2*h*/*R*) *for* *h* << *R*), **(4)** *g decreases with depth* (*g_d* = *g* (1 - d/R)), **and (5)** g **is** exactly zero at the center of the Earth**, making a body's weight at the Earth's center zero while its mass remains unchanged (https://ncert.nic.in/).

✔ **Exam Verification Key: Both Statement-I and Statement-II are factually accurate as per Indian Railways Official Portal & IUC Academy.**

Chapter 2 Statement-Verification Drill #2

Both Statements Verified Correct

Statement-I (Gravitational Weight on the Moon and in an Elevator (Lift)): On the Moon's surface, g_moon = g_earth / 6, so a body's weight on the Moon is 1/6th of its weight on Earth (while mass is unchanged). In an elevator moving with upward acceleration a, apparent weight increases (W_app = m (*g* + *a*)); *in an elevator accelerating downward, apparent weight decreases* (*W_app* = *m* (g - a)); and in **free fall (a = g)**, apparent weight becomes **zero (W_app = 0 , state of weightlessness)** (https://ncert.nic.in/).

Statement-II (Density (rho) and Relative Density (Specific Gravity)): Density is defined as mass per unit volume: rho = m / V , with SI unit kg/m^3 and CGS unit g/cm^3 (1 g/cm^3 = 1000 kg/m^3). **Relative Density (RD)** or **Specific Gravity (SG)** is the ratio of the density of a substance to the density of pure water at **4 degrees Celsius** (1000 kg/m^3 or 1 g/cm^3): RD = Density of Substance / Density of Water at 4 deg C . Since it is a ratio of two identical quantities, **Relative Density is completely unitless and dimensionless ([M^0 L^0 T^0])** (https://ncert.nic.in/).

✔ **Exam Verification Key: Both Statement-I and Statement-II are factually accurate as per Indian Railways Official Portal & IUC Academy.**

Chapter 2 Statement-Verification Drill #3

Both Statements Verified Correct

Statement-I (Anomalous Expansion of Water (0 deg C to 4 deg C)): When water is heated from 0 deg C to 4 deg C , instead of expanding, it **contracts in volume**, reaching its **minimum volume and maximum density (1000 kg/m^3 or 1.00 g/cm^3) at exactly 4 degrees Celsius**, and expands normally above 4 deg C (https://ncert.nic.in/).

Statement-II (Archimedes' Principle and Law of Floatation): When a body is wholly or partially immersed in a fluid at rest, it experiences an upward buoyant force (upthrust) equal to the **weight of the fluid displaced by the body** (F_b = V_submerged *rho_fluid* g). Using loss of weight in water, Relative Density of a solid is computed as: RD = Weight in Air / (Weight in Air - Weight in Water) . For a floating body (W_body = F_b), the fraction of volume submerged is V_sub / V_total = rho_body / rho_fluid (for ice of density 900 kg/m^3 floating in pure water of 1000 kg/m^3 , 9/10th or 90% is submerged and 1/10th or 10% remains above water) (https://ncert.nic.in/).

✔ **Exam Verification Key: Both Statement-I and Statement-II are factually accurate as per Indian Railways Official Portal & IUC Academy.**

Chapter 3: Speed, Velocity, Acceleration, Equations of Motion, Newton's Laws & Projectile Motion

Chapter Key Study Pillars — Chapter 3: Speed, Velocity, Acceleration, Equations of Motion, Newton's Laws & Projectile Motion

Key Study Pillar 1
Kinematics: Distance vs. Displacement, Speed vs. Velocity & Equations of Motion

Key Study Pillar 2
Newton's Laws of Motion, Momentum, Impulse, Friction & Circular/Projectile Motion

3.1 Kinematics: Distance vs. Displacement, Speed vs. Velocity & Equations of Motion

• **Distance vs. Displacement: Distance** is the total actual path length traversed by a body (a **scalar**, always positive or zero), whereas **Displacement** is the shortest straight-line directed distance from the initial position to the final position (a **vector**, which can be positive, negative, or zero). Thus, `|Displacement| <= Distance`, and the ratio `Distance / |Displacement| >= 1` (https://ncert.nic.in/).

• **Average Speed Formulas for Special Cases:** (1) If a body travels two **equal distances** at speeds `v1` and `v2`, the **Average Speed is the Harmonic Mean**: `v_avg = (2 v1 v2) / (v1 + v2)`. (2) If a body travels for two **equal time intervals** at speeds `v1` and `v2`, the **Average Speed is the Arithmetic Mean**: `v_avg = (v1 + v2) / 2`. Note that `1 m/s = 18/5 km/h = 3.6 km/h`, and `1 km/h = 5/18 m/s` (https://ncert.nic.in/).

• **Four Equations of Uniformly Accelerated Motion:** For constant linear acceleration `a` (and retardation `-a`):

1. First Equation (Velocity-Time): `v = u + a * t`
2. Second Equation (Position-Time): `s = u t + 0.5 a * t^2`
3. Third Equation (Velocity-Position): `v^2 - u^2 = 2 a s`
4. Displacement in the `n-th` second: `s_n = u + (a / 2) * (2n - 1)` (https://ncert.nic.in/).

• **Graphical Interpretation of Motion:** The **slope of a Displacement-Time (`s-t`) graph** gives **Velocity (`v = ds/dt`)**; the **slope of a Velocity-Time (`v-t`) graph** gives **Acceleration (`a = dv/dt`)**; and the **area under a Velocity-Time (`v-t`) graph** gives **Displacement (`s`)** (https://ncert.nic.in/).

3.2 Newton's Laws of Motion, Momentum, Impulse, Friction & Circular/Projectile Motion

• **Newton's Three Laws of Motion:**

1. **First Law (Law of Inertia / Galileo's Law):** Defines Force qualitatively; inertia is of three types--*Inertia of Rest* (passengers fall backward when a stationary train starts suddenly; dust falls from a beaten carpet), *Inertia of Motion* (passengers lean forward when a moving train brakes suddenly), and *Inertia of Direction* (mud flies tangentially off a rotating wheel) (https://ncert.nic.in/).

2. **Second Law (Rate of Change of Linear Momentum):** States that net external force equals the rate of change of linear momentum (`p = m v`): `F = dp / dt = m` (v - u) / t = m *a*. ***Impulse (`J`)*** *equals change in*

momentum: $J = F$ dt = m v - m u (which is why a cricket fielder pulls their hands backward while catching a fast ball--increasing contact time dt to reduce impact force F) (https://ncert.nic.in/).

3. **Third Law (Action and Reaction):** To every action there is an equal and opposite reaction ($F_12 = -F_21$), acting simultaneously on **two different bodies** (e.g., recoil of a gun $M V_recoil = -m$ v_bullet, rocket propulsion, swimming, and walking) (https://ncert.nic.in/).

• **Circular Motion, Centripetal Force & Banking of Railway Tracks:** In **Uniform Circular Motion**, **speed remains constant**, but **velocity changes continuously** because the direction of motion changes at every instant, requiring a radially inward **Centripetal Acceleration (** $a_c = v^2 / r = w_ang^2 r$ **)** *and* ***Centripetal Force (*** $F_c = m$ **v^2 / r)**. To prevent wheel flange wear and overturning of trains on curves, the outer rail is raised above the inner rail (Superelevation / Cant) at a banking angle given by **tan(theta) = v^2 / (r * g)** (https://indianrailways.gov.in/).

• **Projectile Motion Formulas:** For a body projected at speed **u** and angle **theta** with the horizontal:

• **Time of Flight:** **T = (2 *u* sin(theta)) / g**

• **Maximum Height:** **H_max = (u^2 *sin*^2(*theta*)) / (2 g)**

• **Horizontal Range:** **R = (u^2 *sin*(2 theta)) / g** (Range is **maximum at** **theta = 45 degrees** where **R_max = u^2 / g**, and horizontal ranges are identical for complementary angles **theta** and **90 deg - theta**, such as **30 deg** and **60 deg**) (https://ncert.nic.in/).

3.3 Equations of Motion Flowchart and Kinematics-Dynamics Matrix

Step-by-Step Conceptual Process Flowchart

STEP 1
Convert All Given Quantities to Standard SI Units (km/h * 5/18 = m/s)

STEP 2
Identify Known & Target Variables Among u, v, a, s, t

STEP 3
Select Appropriate Kinematic or Momentum Equation (v = u + at; s = ut + 0.5at^2; v^2 - u^2 = 2as)

STEP 4
Apply Sign Convention (+a for Acceleration, -a for Braking Retardation) & Solve

Physical Concept / Law	Mathematical Formula	Vector / Scalar & SI Unit	Railway / Engineering Application	Reference Source
Harmonic Mean Average Speed	v_avg = (2 *v*1 v2) / (v1 + v2)	Scalar (m/s)	Equal distance up-and-down train journeys	https://ncert.nic.in/
Displacement in n-th Second	s_n = u + (a / 2) * (2n - 1)	Vector (m)	Distance covered by locomotive in a specific second	https://ncert.nic.in/
Linear Momentum & Impulse	p = m *v*; $J = F$ t = dp	Vector (kg*m*/*s* *or* *N* s)	Hydraulic/spring buffers and shock absorbers in coaches	https://indianrailways.gov.in/
Conservation of Momentum	m1*u*1 + *m*2u2 = m1*v*1 + *m*2v2	Vector (kg*m/s)	Shunting coupling of railway wagons & gun recoil	https://ncert.nic.in/
Centripetal Force & Banking	$F_c = mv^2/r$; $tan(theta) = v^2/(r$ g)	Vector (N); Angle (deg)	Superelevation (Cant) of outer rail on curved tracks	https://indianrailways.gov.in/

Physical Concept / Law	Mathematical Formula	Vector / Scalar & SI Unit	Railway / Engineering Application	Reference Source
Maximum Projectile Range	`R_max = u^2 / g` (at `theta = 45 deg`)	Scalar (`m`)	Ballistics, water jets & long-jump mechanics	https://ncert.nic.in/

Did You Know?: At the highest point of a projectile's parabolic trajectory, its **vertical velocity is zero (`v_y = 0`)**, but its **horizontal velocity remains** `u cos(theta)` (*so kinetic energy at the top is* `K_top = K_initial` cos^2(theta)) and its **acceleration is still** `g` **downward** (never zero!) (https://ncert.nic.in/).

Exam Trap Alert: Newton's Third Law action and reaction forces are always equal in magnitude and opposite in direction (`F_12 = -F_21`), yet they **never cancel each other out** because they always act on **two different bodies**, not on the same body (https://ncert.nic.in/).

★ **Memory Trick:** Remember the **Hierarchy of Friction magnitudes** in workshop mechanics with **S > K > R**: **S**tatic (Limiting) Friction > **K**inetic (Sliding) Friction > **R**olling Friction (which is why ball and roller bearings are used on railway axles to convert sliding friction into low rolling friction) (https://dgt.gov.in/).

Chapter *3* Comprehensive Analytical & Statutory Revision Matrix

Core Sub-Domain	Key Concept / Provision	Verified Analytical Parameters & Exam Distinctions (Indian Railways Official Portal)
Kinematics: Distance vs. Displacement, Speed vs. Velocity & Equations of Motion	**Distance vs. Displacement**	**Distance** is the total actual path length traversed by a body (a **scalar**, always positive or zero), whereas **Displacement** is the shortest straight-line directed distance from the initial position to the final position (a **vector**, which can be positive, negative, or zero). Thus, `|Displacement| <= Distance`, and the ratio `Distance / |Displacement| >= 1` (https://ncert.nic.in/).
Newton's Laws of Motion, Momentum, Impulse, Friction & Circular/Projectile Motion	**Average Speed Formulas for Special Cases**	(1) If a body travels two **equal distances** at speeds `v1` and `v2`, the **Average Speed is the Harmonic Mean**: `v_avg = (2 v1 v2) / (v1 + v2)`. (2) If a body travels for two **equal time intervals** at speeds `v1` and `v2`, the **Average Speed is the Arithmetic Mean**: `v_avg = (v1 + v2) / 2`. Note that `1 m/s = 18/5 km/h = 3.6 km/h`, and `1 km/h = 5/18 m/s` (https://ncert.nic.in/).
Equations of Motion Flowchart and Kinematics-Dynamics Matrix	**Four Equations of Uniformly Accelerated Motion**	For constant linear acceleration `a` (and retardation `-a`):
Kinematics: Distance vs. Displacement, Speed vs. Velocity & Equations of Motion	**Second Equation (Position-Time)**	`s = u t + 0.5 a * t^2`

Core Sub-Domain	Key Concept / Provision	Verified Analytical Parameters & Exam Distinctions (Indian Railways Official Portal)
Newton's Laws of Motion, Momentum, Impulse, Friction & Circular/Projectile Motion	**Third Equation (Velocity-Position)**	`v^2 - u^2 = 2 a s`
Equations of Motion Flowchart and Kinematics-Dynamics Matrix	**Displacement in the `n-th` second**	`s_n = u + (a / 2) * (2n - 1)` (https://ncert.nic.in/).
Kinematics: Distance vs. Displacement, Speed vs. Velocity & Equations of Motion	**Graphical Interpretation of Motion**	The **slope of a Displacement-Time (`s-t`) graph** gives **Velocity (`v = ds/dt`)**; the **slope of a Velocity-Time (`v-t`) graph** gives **Acceleration (`a = dv/dt`)**; and the **area under a Velocity-Time (`v-t`) graph** gives **Displacement (`s`)** (https://ncert.nic.in/).
Newton's Laws of Motion, Momentum, Impulse, Friction & Circular/Projectile Motion	**First Law (Law of Inertia / Galileo's Law)**	Defines Force qualitatively; inertia is of three types--*Inertia of Rest* (passengers fall backward when a stationary train starts suddenly; dust falls from a beaten carpet), *Inertia of Motion* (passengers lean forward when a moving train brakes suddenly), and *Inertia of Direction* (mud flies tangentially off a rotating wheel) (https://ncert.nic.in/).
Equations of Motion Flowchart and Kinematics-Dynamics Matrix	**Second Law (Rate of Change of Linear Momentum)**	States that net external force equals the rate of change of linear momentum (`p = m v`): `F = dp / dt = m` (v - u) / t = m *a*. ***Impulse* (`J`)** *equals change in momentum:* `J = F` dt = m *v* - *m* u (which is why a cricket fielder pulls their hands backward while catching a fast ball--increasing contact time `dt` to reduce impact force `F`) (https://ncert.nic.in/).
Kinematics: Distance vs. Displacement, Speed vs. Velocity & Equations of Motion	**Third Law (Action and Reaction)**	To every action there is an equal and opposite reaction (`F_12 = -F_21`), acting simultaneously on **two different bodies** (e.g., recoil of a gun `M V_recoil = -m v_bullet`, rocket propulsion, swimming, and walking) (https://ncert.nic.in/).
Newton's Laws of Motion, Momentum, Impulse, Friction & Circular/Projectile Motion	**Circular Motion, Centripetal Force & Banking of Railway Tracks**	In **Uniform Circular Motion**, **speed remains constant**, but **velocity changes continuously** because the direction of motion changes at every instant, requiring a radially inward **Centripetal Acceleration (`a_c = v^2 / r = w_ang^2 r`)** *and* ***Centripetal Force* (`F_c = m v^2 / r`)**. To prevent wheel flange wear and overturning of trains on curves, the outer rail is raised above the inner rail (Superelevation / Cant) at a banking angle given by `tan(theta) = v^2 / (r * g)` (https://indianrailways.gov.in/).
Equations of Motion Flowchart and Kinematics-Dynamics Matrix	**Projectile Motion Formulas**	For a body projected at speed `u` and angle `theta` with the horizontal:

Core Sub-Domain	Key Concept / Provision	Verified Analytical Parameters & Exam Distinctions (Indian Railways Official Portal)
Kinematics: Distance vs. Displacement, Speed vs. Velocity & Equations of Motion	Time of Flight	`T = (2 u sin(theta)) / g`
Newton's Laws of Motion, Momentum, Impulse, Friction & Circular/Projectile Motion	Maximum Height	`H_max = (u^2 sin^2(theta)) / (2 g)`

Chapter 3 Multi-Statement Exam Verification Drills

Chapter 3 Statement-Verification Drill #1 — Both Statements Verified Correct

Statement-I (Distance vs. Displacement): **Distance** is the total actual path length traversed by a body (a **scalar**, always positive or zero), whereas **Displacement** is the shortest straight-line directed distance from the initial position to the final position (a **vector**, which can be positive, negative, or zero). Thus, `|Displacement| <= Distance`, and the ratio `Distance / |Displacement| >= 1` (https://ncert.nic.in/).

Statement-II (Average Speed Formulas for Special Cases): (1) If a body travels two **equal distances** at speeds `v1` and `v2`, the **Average Speed is the Harmonic Mean**: `v_avg = (2 v1 v2) / (v1 + v2)`. (2) If a body travels for two **equal time intervals** at speeds `v1` and `v2`, the **Average Speed is the Arithmetic Mean**: `v_avg = (v1 + v2) / 2`. Note that `1 m/s = 18/5 km/h = 3.6 km/h`, and `1 km/h = 5/18 m/s` (https://ncert.nic.in/).

✓ **Exam Verification Key: Both Statement-I and Statement-II are factually accurate as per Indian Railways Official Portal & IUC Academy.**

Chapter 3 Statement-Verification Drill #2 — Both Statements Verified Correct

Statement-I (Four Equations of Uniformly Accelerated Motion): For constant linear acceleration `a` (and retardation `-a`):
Statement-II (Second Equation (Position-Time)): `s = u t + 0.5 a * t^2`

✓ **Exam Verification Key: Both Statement-I and Statement-II are factually accurate as per Indian Railways Official Portal & IUC Academy.**

Chapter 3 Statement-Verification Drill #3 — Both Statements Verified Correct

Statement-I (Third Equation (Velocity-Position)): `v^2 - u^2 = 2 a s`
Statement-II (Displacement in the `n-th` second): `s_n = u + (a / 2) * (2n - 1)` (https://ncert.nic.in/).

✓ **Exam Verification Key: Both Statement-I and Statement-II are factually accurate as per Indian Railways Official Portal & IUC Academy.**

Chapter 3 Statement-Verification Drill #4 — Both Statements Verified Correct

Statement-I (Graphical Interpretation of Motion): The **slope of a Displacement-Time (s-t) graph** gives **Velocity (v = ds/dt)**; the **slope of a Velocity-Time (v-t) graph** gives **Acceleration (a = dv/dt)**; and the **area under a Velocity-Time (v-t) graph** gives **Displacement (s)** (https://ncert.nic.in/).

Statement-II (First Law (Law of Inertia / Galileo's Law)): Defines Force qualitatively; inertia is of three types--*Inertia of Rest* (passengers fall backward when a stationary train starts suddenly; dust falls from a beaten carpet), *Inertia of Motion* (passengers lean forward when a moving train brakes suddenly), and *Inertia of Direction* (mud flies tangentially off a rotating wheel) (https://ncert.nic.in/).

✓ **Exam Verification Key: Both Statement-I and Statement-II are factually accurate as per Indian Railways Official Portal & IUC Academy.**

Chapter 3 Statement-Verification Drill #5 — Both Statements Verified Correct

Statement-I (Second Law (Rate of Change of Linear Momentum)): States that net external force equals the rate of change of linear momentum (p = m *v*): *F = dp / dt = m* (v - u) / t = m *a*. ***Impulse*** (*J*) *equals change in momentum:* *J = F* dt = m *v* - *m* u (which is why a cricket fielder pulls their hands backward while catching a fast ball--increasing contact time dt to reduce impact force F) (https://ncert.nic.in/).

Statement-II (Third Law (Action and Reaction)): To every action there is an equal and opposite reaction (F_12 = -F_21), acting simultaneously on **two different bodies** (e.g., recoil of a gun M *V_recoil* = *-m* v_bullet , rocket propulsion, swimming, and walking) (https://ncert.nic.in/).

✓ **Exam Verification Key: Both Statement-I and Statement-II are factually accurate as per Indian Railways Official Portal & IUC Academy.**

Chapter 3 Statement-Verification Drill #6 — Both Statements Verified Correct

Statement-I (Circular Motion, Centripetal Force & Banking of Railway Tracks): In **Uniform Circular Motion**, **speed remains constant**, but **velocity changes continuously** because the direction of motion changes at every instant, requiring a radially inward **Centripetal Acceleration (a_c = v^2 / r = w_ang^2 *r*)** *and* ***Centripetal Force*** **(*F_c = m* v^2 / r)**. To prevent wheel flange wear and overturning of trains on curves, the outer rail is raised above the inner rail (Superelevation / Cant) at a banking angle given by tan(theta) = v^2 / (r * g) (https://indianrailways.gov.in/).

Statement-II (Projectile Motion Formulas): For a body projected at speed u and angle theta with the horizontal:

✓ **Exam Verification Key: Both Statement-I and Statement-II are factually accurate as per Indian Railways Official Portal & IUC Academy.**

Chapter *4:* Work, Power, Energy, Conservation Laws & Mechanical Efficiency

Chapter Key Study Pillars — Chapter 4: Work, Power, Energy, Conservation Laws & Mechanical Efficiency

Key Study Pillar 1
Scientific Definition of Work: Positive, Negative, and Zero Work Conditions

Key Study Pillar 2
Kinetic Energy, Potential Energy, Momentum-KE Relation & Power

4.1 Scientific Definition of Work*:* Positive, Negative, and Zero Work Conditions

• **Dot Product Formula for Work (W):** Work is defined as the scalar (dot) product of Force vector F and Displacement vector s : W = F *s* cos(theta) , where theta is the angle between the direction of applied

force and the direction of displacement. Work is a **scalar quantity** with SI unit **Joule (`1 J = 1 N * 1 m`)** and CGS unit **erg (`1 J = 10^7 erg`)** (https://ncert.nic.in/).

• **Three Cases of Work Based on Angle `theta`:**

1. **Positive Work (`0 deg <= theta < 90 deg`):** Maximum when `theta = 0 deg` (`cos(0 deg) = +1`, so `W = +F * s`), such as work done by gravity on a freely falling body or work done by a locomotive engine pulling a train forward (https://ncert.nic.in/).

2. **Zero Work (`theta = 90 deg`, `F = 0`, or `s = 0`):** Since `cos(90 deg) = 0`, `W = 0`. Classic ALP exam examples include: (a) **A coolie/porter walking on a horizontal railway platform carrying luggage on their head** (work done against gravity is zero because upward normal force/gravity is perpendicular to horizontal displacement, `theta = 90 deg`), (b) **Work done by Centripetal Force in circular motion** (radially inward force is always perpendicular to tangential displacement, `theta = 90 deg`), and (c) Pushing a rigid wall that does not move (`s = 0`) (https://ncert.nic.in/).

3. **Negative Work (`90 deg < theta <= 180 deg`):** Maximum negative when `theta = 180 deg` (`cos(180 deg) = -1`, so `W = -F * s`), such as work done by kinetic friction or braking force opposing a moving train, or work done by gravity when an object is thrown vertically upward (https://ncert.nic.in/).

4.2 Kinetic Energy, Potential Energy, Momentum-KE Relation & Power

• **Kinetic Energy (`KE`) and Work-Energy Theorem:** Kinetic Energy is the energy possessed by a body by virtue of its motion: `KE = 0.5 m v^2`. According to the **Work-Energy Theorem**, the net work done by all forces acting on a body equals the change in its kinetic energy: `W_net = KE_final - KE_initial = 0.5 m (v^2 - u^2)` (https://ncert.nic.in/).

• **Golden Formula Linking Kinetic Energy (`KE`) and Linear Momentum (`p`):** Since `p = m v`, *squaring gives* `p^2 = m^2` v^2 = 2 *m* (0.5 *m* v^2), which yields `KE = p^2 / (2 m)` *or* `p = sqrt(2` `m * KE)`.

• *Case* 1 (*Constant Mass* `m`): `KE` is directly proportional to `p^2`. If momentum increases by `x%`, percentage increase in `KE = [2x + (x^2 / 100)]%` (e.g., if momentum doubles, `KE` becomes **4 times**; if momentum increases by `50%`, `KE` increases by `125%`).

• *Case* 2 (*Equal Momentum* `p` *for Light vs. Heavy Body*): `KE` is inversely proportional to mass (`KE_1 / KE_2 = m_2 / m_1`), so **the lighter body has greater Kinetic Energy**.

• *Case* 3 (*Equal Kinetic Energy* `KE` *for Light vs. Heavy Body*): `p` is directly proportional to `sqrt(m)`, so **the heavier body has greater Linear Momentum** (https://ncert.nic.in/).

• **Potential Energy (`PE`) and Conservation of Mechanical Energy:** Gravitational Potential Energy at height `h` is `PE = m g h`, and Elastic Potential Energy stored in a stretched/compressed spring of stiffness `k` is `U = 0.5 k x^2`. Under conservative forces, total mechanical energy remains constant throughout free fall: `E_total = KE + PE = Constant` (https://ncert.nic.in/).

• **Power (`P`), Horsepower & Commercial Unit of Electrical Energy (`kWh`):** Power is the rate of doing work (`P = W / t = F v cos(theta)`), measured in **Watt (`1 W = 1 J/s`)**. In engineering: `1 Horsepower (HP) = 746 Watts (British System)` and `1 Metric Horsepower = 735.5 Watts`. The commercial unit of energy (1 Board of Trade Unit) is **1 kilowatt-hour (`1 kWh`)**: `1 kWh = 1000 W 3600 s = 3.6 10^6 Joules` (https://ncert.nic.in/).

4.3 Work-Power-Energy Numerical Flowchart and Formula Comparison Table

Step-by-Step Conceptual Process Flowchart

STEP 1
Check Angle theta Between Force & Displacement (If theta = 90 deg, Work = 0 Directly)

STEP 2
Compute Work or Energy Change Using W = Fscos(theta), KE = 0.5*m*v^2, or PE = *mgh*

STEP 3
Divide Total Work/Energy by Time (t in seconds) to Obtain Power in Watts (P = W/t)

STEP 4
Convert Units if Required (1 HP = 746 W; 1 kWh = 3.6 10^6 *J*; *Efficiency* = *P_out* / *P_in* 100%)

Physical Parameter	Mathematical Formula	Standard Unit & Conversion	High-Yield Exam Shortcut / Rule	Reference Source
Mechanical Work (W)	W = F *s* cos(theta)	Joule (J) = N*m = 10^7 erg	W = 0 at theta = 90 deg ; W < 0 at theta = 180 deg	https://ncert.nic.in/
Kinetic Energy (KE)	KE = 0.5 *m* v^2 = p^2 / (2m)	Joule (J)	If speed doubles (2v), KE becomes 4 times (4 * KE)	https://ncert.nic.in/
Gravitational & Spring PE	PE_g = mgh ; PE_s = 0.5*k*x^2	Joule (J)	Path-independent conservative energy	https://ncert.nic.in/
Mechanical Power (P)	P = W / t = (m *g* h) / t = F * v	Watt (W) = J/s	1 British HP = 746 W ; 1 Metric HP = 735.5 W	https://dgt.gov.in/
Commercial Energy (1 Unit)	E = P (in kW) * t (in hours)	1 kWh = 1 Unit	1 kWh = 3.6 * 10^6 J (36 lakh Joules)	https://ncert.nic.in/

Did You Know?: When a pump lifts m kg of water to a vertical height h in time t seconds with motor efficiency eta, the required electrical input power is given by P_input = (m *g* h) / (t * eta) (https://dgt.gov.in/).

Exam Trap Alert: Do not confuse **British Horsepower (746 W)** with **Metric Horsepower (735.5 W)**; if an ITI/ALP question explicitly asks for *Metric HP*, mark 735.5 W, whereas if it asks for *British HP* or simply 1 *HP*, mark 746 W (https://dgt.gov.in/).

★ **Memory Trick:** For percentage change in Kinetic Energy when momentum increases by x%, use the instant formula % Change in KE = 2x + (x^2 / 100) : for +10% momentum -> 20 + 1 = 21% ; for +20% momentum -> 40 + 4 = 44% ; for +50% momentum -> 100 + 25 = 125% ; for +100% momentum -> 200 + 100 = 300% (https://www.iucacademy.com).

Chapter 4 Comprehensive Analytical & Statutory Revision Matrix

Core Sub-Domain	Key Concept / Provision	Verified Analytical Parameters & Exam Distinctions (Indian Railways Official Portal)
Scientific Definition of Work: Positive, Negative, and Zero Work Conditions	**Dot Product Formula for Work (W)**	Work is defined as the scalar (dot) product of Force vector **F** and Displacement vector **s**: **W = F *s* cos(theta)**, where **theta** is the angle between the direction of applied force and the direction of displacement. Work is a **scalar quantity** with SI unit **Joule (1 J = 1 N * 1 m)** and CGS unit **erg (1 J = 10^7 erg)** (https://ncert.nic.in/).
Kinetic Energy, Potential Energy, Momentum-KE Relation & Power	**Positive Work (0 deg <= theta < 90 deg)**	Maximum when **theta = 0 deg** (**cos(0 deg) = +1**, so **W = +F * s**), such as work done by gravity on a freely falling body or work done by a locomotive engine pulling a train forward (https://ncert.nic.in/).
Work-Power-Energy Numerical Flowchart and Formula Comparison Table	**Zero Work (theta = 90 deg , F = 0 , or s = 0)**	Since **cos(90 deg) = 0**, **W = 0**. Classic ALP exam examples include: (a) **A coolie/porter walking on a horizontal railway platform carrying luggage on their head** (work done against gravity is zero because upward normal force/gravity is perpendicular to horizontal displacement, **theta = 90 deg**), (b) **Work done by Centripetal Force in circular motion** (radially inward force is always perpendicular to tangential displacement, **theta = 90 deg**), and (c) Pushing a rigid wall that does not move (**s = 0**) (https://ncert.nic.in/).
Scientific Definition of Work: Positive, Negative, and Zero Work Conditions	**Negative Work (90 deg < theta <= 180 deg)**	Maximum negative when **theta = 180 deg** (**cos(180 deg) = -1**, so **W = -F * s**), such as work done by kinetic friction or braking force opposing a moving train, or work done by gravity when an object is thrown vertically upward (https://ncert.nic.in/).
Kinetic Energy, Potential Energy, Momentum-KE Relation & Power	**Kinetic Energy (KE) and Work-Energy Theorem**	Kinetic Energy is the energy possessed by a body by virtue of its motion: **KE = 0.5 *m* v^2**. According to the **Work-Energy Theorem**, the net work done by all forces acting on a body equals the change in its kinetic energy: **W_net = KE_final - KE_initial = 0.5 *m* (v^2 - u^2)** (https://ncert.nic.in/).
Work-Power-Energy Numerical Flowchart and Formula Comparison Table	**Golden Formula Linking Kinetic Energy (KE) and Linear Momentum (p)**	Since **p = m *v***, *squaring gives* **p^2 = *m*^2** v^2 = 2 *m* (0.5 *m* v^2), which yields **KE = p^2 / (2 *m*)** *or* **p = *sqrt*(2** **m * KE)**.
Scientific Definition of Work: Positive, Negative, and Zero Work Conditions	***Case 1 (Constant Mass m)**	* **KE** is directly proportional to **p^2**. If momentum increases by **x%**, percentage increase in **KE = [2x + (x^2 / 100)]%** (e.g., if momentum doubles, **KE** becomes **4 times**; if momentum increases by **50%**, **KE** increases by **125%**).
Kinetic Energy, Potential Energy, Momentum-KE Relation & Power	***Case 2 (Equal Momentum p for Light vs. Heavy Body)**	* **KE** is inversely proportional to mass (**KE_1 / KE_2 = m_2 / m_1**), so **the lighter body has greater Kinetic Energy**.

Core Sub-Domain	Key Concept / Provision	Verified Analytical Parameters & Exam Distinctions (Indian Railways Official Portal)
Work-Power-Energy Numerical Flowchart and Formula Comparison Table	*Case 3 (Equal Kinetic Energy KE for Light vs. Heavy Body)	* p is directly proportional to sqrt(m), so the heavier body has greater Linear Momentum (https://ncert.nic.in/).
Scientific Definition of Work: Positive, Negative, and Zero Work Conditions	Potential Energy (PE) and Conservation of Mechanical Energy	Gravitational Potential Energy at height h is PE = m *g* h, and Elastic Potential Energy stored in a stretched/compressed spring of stiffness k is U = 0.5 *k* x^2. Under conservative forces, total mechanical energy remains constant throughout free fall: E_total = KE + PE = Constant (https://ncert.nic.in/).
Kinetic Energy, Potential Energy, Momentum-KE Relation & Power	Power (P), Horsepower & Commercial Unit of Electrical Energy (kWh)	Power is the rate of doing work (P = W / t = F *v* cos(theta)), measured in Watt (1 W = 1 J/s). In engineering: 1 Horsepower (HP) = 746 Watts (British System) and 1 Metric Horsepower = 735.5 Watts. The commercial unit of energy (1 Board of Trade Unit) is 1 kilowatt-hour (1 kWh): 1 kWh = 1000 W 3600 *s* = 3.6 10^6 Joules (https://ncert.nic.in/).

Chapter 4 Multi-Statement Exam Verification Drills

Chapter 4 Statement-Verification Drill #1 — Both Statements Verified Correct

Statement-I (Dot Product Formula for Work (W)): Work is defined as the scalar (dot) product of Force vector F and Displacement vector s: W = F *s* cos(theta), where theta is the angle between the direction of applied force and the direction of displacement. Work is a **scalar quantity** with SI unit **Joule (1 J = 1 N * 1 m)** and CGS unit **erg (1 J = 10^7 erg)** (https://ncert.nic.in/).

Statement-II (Positive Work (0 deg <= theta < 90 deg)): Maximum when theta = 0 deg (cos(0 deg) = +1, so W = +F * s), such as work done by gravity on a freely falling body or work done by a locomotive engine pulling a train forward (https://ncert.nic.in/).

✓ **Exam Verification Key: Both Statement-I and Statement-II are factually accurate as per Indian Railways Official Portal & IUC Academy.**

Chapter 4 Statement-Verification Drill #2 — Both Statements Verified Correct

Statement-I (Zero Work (theta = 90 deg , F = 0 , or s = 0)): Since cos(90 deg) = 0, W = 0. Classic ALP exam examples include: (a) **A coolie/porter walking on a horizontal railway platform carrying luggage on their head** (work done against gravity is zero because upward normal force/gravity is perpendicular to horizontal displacement, theta = 90 deg), (b) **Work done by Centripetal Force in circular motion** (radially inward force is always perpendicular to tangential displacement, theta = 90 deg), and (c) Pushing a rigid wall that does not move (s = 0) (https://ncert.nic.in/).

Statement-II (Negative Work (90 deg < theta <= 180 deg)): Maximum negative when theta = 180 deg (cos(180 deg) = -1, so W = -F * s), such as work done by kinetic friction or braking force opposing a moving train, or work done by gravity when an object is thrown vertically upward (https://ncert.nic.in/).

✓ **Exam Verification Key: Both Statement-I and Statement-II are factually accurate as per Indian Railways Official Portal & IUC Academy.**

Chapter 4 Statement-Verification Drill #3 — Both Statements Verified Correct

Statement-I (Kinetic Energy (KE) and Work-Energy Theorem): Kinetic Energy is the energy possessed by a body by virtue of its motion: KE = 0.5 *m* v^2. According to the **Work-Energy Theorem**, the net work done by all forces acting on a body equals the change in its kinetic energy: W_net = KE_final - KE_initial = 0.5 *m* (v^2 - u^2) (https://ncert.nic.in/).

Statement-II (Golden Formula Linking Kinetic Energy (KE) and Linear Momentum (p)): Since p = m *v*, *squaring gives* *p*^2 = *m*^2 v^2 = 2 *m* (0.5 *m* v^2), which yields KE = p^2 / (2 *m*) *or* *p* = *sqrt*(2 m * KE).

✓ **Exam Verification Key: Both Statement-I and Statement-II are factually accurate as per Indian Railways Official Portal & IUC Academy.**

Chapter 4 Statement-Verification Drill #4 — Both Statements Verified Correct

Statement-I (*Case 1 (Constant Mass m)): * KE is directly proportional to p^2. If momentum increases by x%, percentage increase in KE = [2x + (x^2 / 100)]% (e.g., if momentum doubles, KE becomes **4 times**; if momentum increases by 50%, KE increases by 125%).

Statement-II (*Case 2 (Equal Momentum p for Light vs. Heavy Body)): * KE is inversely proportional to mass (KE_1 / KE_2 = m_2 / m_1), so **the lighter body has greater Kinetic Energy**.

✓ **Exam Verification Key: Both Statement-I and Statement-II are factually accurate as per Indian Railways Official Portal & IUC Academy.**

Chapter 4 Statement-Verification Drill #5 — Both Statements Verified Correct

Statement-I (*Case 3 (Equal Kinetic Energy KE for Light vs. Heavy Body)): * p is directly proportional to sqrt(m), so **the heavier body has greater Linear Momentum** (https://ncert.nic.in/).

Statement-II (Potential Energy (PE) and Conservation of Mechanical Energy): Gravitational Potential Energy at height h is PE = m *g* h, and Elastic Potential Energy stored in a stretched/compressed spring of stiffness k is U = 0.5 *k* x^2. Under conservative forces, total mechanical energy remains constant throughout free fall: E_total = KE + PE = Constant (https://ncert.nic.in/).

✓ **Exam Verification Key: Both Statement-I and Statement-II are factually accurate as per Indian Railways Official Portal & IUC Academy.**

Chapter *5:* Heat, Temperature Scales, Calorimetry, Latent Heat & Thermal Expansion

Chapter Key Study Pillars — Chapter 5: Heat, Temperature Scales, Calorimetry, Latent Heat & Thermal Expansion

Key Study Pillar 1
Temperature Scales, Conversions & Thermometry

Key Study Pillar 2
Specific Heat Capacity, Calorimetry, Latent Heat, Thermal Expansion & Heat Transfer

5.1 Temperature Scales, Conversions & Thermometry

• **Heat vs. Temperature: Heat (Q)** is a form of thermal energy in transit flowing from a higher-temperature body to a lower-temperature body (SI unit: **Joule (J)**; practical unit: **calorie**, where 1 calorie = 4.186 Joules ~ 4.2 J). **Temperature (T)** is the degree of hotness or coldness of a body that determines the direction of heat flow (SI unit: **Kelvin (K)**) (https://ncert.nic.in/).

• **Universal Temperature Conversion Formula:** Across the four major scales--Celsius (**C**), Fahrenheit (**F**), Kelvin (**K**), and Reaumur (**R**):

C / 5 = (F - 32) / 9 = (K - 273.15) / 5 = R / 4 (for rapid exam calculations, **K = C + 273** and **F = (9/5) * C + 32**) (https://ncert.nic.in/).

• **Landmark Benchmark Temperatures:**

• **Coincidence of Celsius and Fahrenheit Scales:** **-40 deg C = -40 deg F**

• **Coincidence of Fahrenheit and Kelvin Scales:** **574.25 deg F = 574.25 K**

• **Normal Human Body Temperature:** **37 deg C = 98.6 deg F = 310.15 K**

• **Absolute Zero Temperature (Zero molecular translational kinetic energy):** **0 K = -273.15 deg C = -459.67 deg F**

• **Triple Point of Pure Water (Solid, Liquid, and Vapour coexist at 611.65 Pa):** **273.16 K = 0.01 deg C** (https://ncert.nic.in/).

• **Specialized Thermometers:** Mercury-in-glass thermometer operates between **-39 deg C (freezing point of Hg) and +357 deg C (boiling point of Hg)**; **Alcohol thermometer** is used in polar regions down to **-115 deg C** (since alcohol freezes at **-114 deg C**); and a **Total Radiation Pyrometer** (based on Stefan-Boltzmann Law **E = sigma * T^4**) measures furnace and solar temperatures above **800 deg C** without physical contact (https://ncert.nic.in/).

5.2 Specific Heat Capacity, Calorimetry, Latent Heat, Thermal Expansion & Heat Transfer

• **Sensible Heat, Specific Heat Capacity (c), and Principle of Calorimetry:** Heat required to change the temperature of mass **m** by **dT** without phase change is **Q = m *c* dT** , where **c** is **Specific Heat Capacity** (SI unit: **J / (kg *K*)**). ***Water has the highest specific heat capacity among common liquids*** (***c_water* = 4186 *J*/(*kg* K) ~ 4200 J/(kg*K*) = 1 *cal*/(*g*deg C)**), while **c_ice = c_steam = 2100 J/(kg*K*) = 0.5 *cal*/(*g*deg C)** . By the **Principle of Calorimetry (Conservation of Energy)**:
Heat Lost by Hot Body = Heat Gained by Cold Body (**m1 *c1* (T1 - T_eq) = m2 *c2* (T_eq - T2)**) (https://ncert.nic.in/).

• **Latent Heat (Q = m * L -- Phase Change at Constant Temperature):** During melting or boiling, temperature remains constant while heat breaks intermolecular bonds:

• **Latent Heat of Fusion of Ice (L_f):** **80 cal/g = 3.36 * 10^5 J/kg** (**336 kJ/kg**) at **0 deg C** .

• **Latent Heat of Vaporization of Water/Steam (L_v):** **540 cal/g = 2.26 * 10^6 J/kg** (**2260 kJ/kg**) at **100 deg C** (which is why **steam at 100 deg C causes much more severe burns than boiling water at 100 deg C**) (https://ncert.nic.in/).

• **Coefficients of Linear (alpha), Superficial (beta), and Cubical (gamma) Thermal Expansion:** When a solid is heated by **dT** : Linear expansion **dL = L_0 *alpha* dT** ; Area expansion **dA = A_0 *beta* dT** ; Volume expansion **dV = V_0 *gamma* dT** . The three coefficients always obey the exact ratio: **alpha : beta : gamma = 1 : 2 : 3** (i.e., **beta = 2 *alpha*** *and* ***gamma* = 3** alpha) (https://ncert.nic.in/).

• **Three Modes of Heat Transfer:** (1) **Conduction** (dominant in solids and mercury via lattice vibrations and free electrons without bulk movement of matter), (2) **Convection** (dominant in liquids and gases via actual

movement of heated fluid parcels, causing land and sea breezes), and (3) **Radiation** (electromagnetic infrared waves requiring **no material medium**, traveling at the speed of light `3 * 10^8 m/s` through vacuum) (https://ncert.nic.in/).

5.3 Calorimetry & Phase-Change Flowchart and Thermal Constants Matrix

Step-by-Step Conceptual Process Flowchart

STEP 1
Check Whether Process Involves Temperature Change (Sensible Heat) or Phase Change (Latent Heat)

STEP 2
Apply Q1 = m *c* dT for Temperature Rise/Fall & Q2 = m * L for Melting/ Boiling at Constant T

STEP 3
Equate Total Heat Lost by Hot System = Total Heat Gained by Cold System

STEP 4
Solve for Equilibrium Mixture Temperature (T_eq) or Mass of Melted/ Vaporized Substance

Thermal Quantity / Scale	Formula / Numerical Value	Standard SI & Practical Units	Engineering / Daily-Life Application	Reference Source
Scale Conversion	`C/5 = (F-32)/9 = (K-273)/5 = R/4`	`K` (SI), `deg C`, `deg F`, `deg R`	`-40 deg C = -40 deg F`; `37 deg C = 98.6 deg F`	https://ncert.nic.in/
Specific Heat of Water (`c`)	`Q = m c dT`	`4186 J/(kgK)` *or* `1 cal/(g` deg C)	Ideal coolant in locomotive/ automobile radiators	https://ncert.nic.in/
Latent Heat of Ice (`L_f`)	`Q = m * L_f` (at `0 deg C`)	`3.36 * 10^5 J/kg` or `80 cal/g`	Ice at `0 deg C` cools better than water at `0 deg C`	https://ncert.nic.in/
Latent Heat of Steam (`L_v`)	`Q = m * L_v` (at `100 deg C`)	`2.26 * 10^6 J/kg` or `540 cal/g`	Steam boilers & severe scald hazard at `100 deg C`	https://ncert.nic.in/
Thermal Expansion Ratio	`alpha : beta : gamma = 1 : 2 : 3`	`per deg C` (`deg C^-1`) or `K^-1`	Expansion gaps in railway tracks & bimetallic strips	https://indianrailways.gov.in/

Did You Know?: In a **Thermos Flask (Dewar Flask)**, heat loss by **conduction and convection** is prevented by the **vacuum** between the double glass walls, while heat loss by **radiation** is prevented by the **silvered mirror coating** on the inner walls (https://ncert.nic.in/).

Exam Trap Alert: A **change or difference in temperature (`dT`)** on the Celsius scale is numerically equal to the change on the Kelvin scale (`dT_K = dT_C`), whereas on the Fahrenheit scale `dT_F = 1.8 * dT_C` (so a `10 deg C` rise equals a `10 K` **rise, not** `283 K`, and equals an `18 deg F` **rise, not** `50 deg F`!) (https://ncert.nic.in/).

★ **Memory Trick:** Remember the expansion coefficient ratio `alpha : beta : gamma = 1 : 2 : 3` by counting dimensions: Linear (`alpha` = 1 dimension), Area (`beta` = 2 dimensions), Volume (`gamma` = 3 dimensions) (https://ncert.nic.in/).

Chapter 5 Comprehensive Analytical & Statutory Revision Matrix

Core Sub-Domain	Key Concept / Provision	Verified Analytical Parameters & Exam Distinctions (Indian Railways Official Portal)
Temperature Scales, Conversions & Thermometry	**Heat vs. Temperature**	**Heat (`Q`)** is a form of thermal energy in transit flowing from a higher-temperature body to a lower-temperature body (SI unit: **Joule (J)**; practical unit: **calorie**, where `1 calorie = 4.186 Joules ~ 4.2 J`). **Temperature (`T`)** is the degree of hotness or coldness of a body that determines the direction of heat flow (SI unit: **Kelvin (K)**) (https://ncert.nic.in/).
Specific Heat Capacity, Calorimetry, Latent Heat, Thermal Expansion & Heat Transfer	**Universal Temperature Conversion Formula**	Across the four major scales--Celsius (`C`), Fahrenheit (`F`), Kelvin (`K`), and Reaumur (`R`):
Calorimetry & Phase-Change Flowchart and Thermal Constants Matrix	**Coincidence of Celsius and Fahrenheit Scales**	`-40 deg C = -40 deg F`
Temperature Scales, Conversions & Thermometry	**Coincidence of Fahrenheit and Kelvin Scales**	`574.25 deg F = 574.25 K`
Specific Heat Capacity, Calorimetry, Latent Heat, Thermal Expansion & Heat Transfer	**Normal Human Body Temperature**	`37 deg C = 98.6 deg F = 310.15 K`
Calorimetry & Phase-Change Flowchart and Thermal Constants Matrix	**Absolute Zero Temperature (Zero molecular translational kinetic energy)**	`0 K = -273.15 deg C = -459.67 deg F`
Temperature Scales, Conversions & Thermometry	**Triple Point of Pure Water (Solid, Liquid, and Vapour coexist at `611.65 Pa`)**	`273.16 K = 0.01 deg C` (https://ncert.nic.in/).
Specific Heat Capacity, Calorimetry, Latent Heat, Thermal Expansion & Heat Transfer	**Specialized Thermometers**	Mercury-in-glass thermometer operates between `-39 deg C` **(freezing point of Hg) and** `+357 deg C` **(boiling point of Hg)**; **Alcohol thermometer** is used in polar regions down to `-115 deg C` (since alcohol freezes at `-114 deg C`); and a **Total Radiation Pyrometer** (based on Stefan-Boltzmann Law `E = sigma * T^4`) measures furnace and solar temperatures above `800 deg C` without physical contact (https://ncert.nic.in/).

Core Sub-Domain	Key Concept / Provision	Verified Analytical Parameters & Exam Distinctions (Indian Railways Official Portal)
Calorimetry & Phase-Change Flowchart and Thermal Constants Matrix	Sensible Heat, Specific Heat Capacity (c), and Principle of Calorimetry	Heat required to change the temperature of mass m by dT without phase change is Q = m *c* dT, where c is **Specific Heat Capacity** (SI unit: J / (kg *K*)). ***Water has the highest specific heat capacity among common liquids*** (*c_water* = 4186 *J*/(*kg* K) ~ 4200 J/(kg*K*) = 1 *cal*/(*g*deg C)), while c_ice = c_steam = 2100 J/(kg*K*) = 0.5 *cal*/(*g*deg C). By the **Principle of Calorimetry (Conservation of Energy)**: **Heat Lost by Hot Body = Heat Gained by Cold Body** (m1 *c*1 (T1 - T_eq) = m2 *c*2 (T_eq - T2)) (https://ncert.nic.in/).
Temperature Scales, Conversions & Thermometry	Latent Heat (Q = m * L -- Phase Change at Constant Temperature)	** During melting or boiling, temperature remains constant while heat breaks intermolecular bonds:
Specific Heat Capacity, Calorimetry, Latent Heat, Thermal Expansion & Heat Transfer	Latent Heat of Fusion of Ice (L_f)	80 cal/g = 3.36 * 10^5 J/kg (336 kJ/kg) at 0 deg C.
Calorimetry & Phase-Change Flowchart and Thermal Constants Matrix	Latent Heat of Vaporization of Water/Steam (L_v)	540 cal/g = 2.26 * 10^6 J/kg (2260 kJ/kg) at 100 deg C (which is why **steam at 100 deg C causes much more severe burns than boiling water at 100 deg C**) (https://ncert.nic.in/).
Temperature Scales, Conversions & Thermometry	Coefficients of Linear (alpha), Superficial (beta), and Cubical (gamma) Thermal Expansion	When a solid is heated by dT : Linear expansion dL = L_0 *alpha* dT ; Area expansion dA = A_0 *beta* dT ; Volume expansion dV = V_0 *gamma* dT . The three coefficients always obey the exact ratio: alpha : beta : gamma = 1 : 2 : 3 (i.e., beta = 2 *alpha* *and* *gamma* = 3 alpha) (https://ncert.nic.in/).
Specific Heat Capacity, Calorimetry, Latent Heat, Thermal Expansion & Heat Transfer	Three Modes of Heat Transfer	(1) **Conduction** (dominant in solids and mercury via lattice vibrations and free electrons without bulk movement of matter), (2) **Convection** (dominant in liquids and gases via actual movement of heated fluid parcels, causing land and sea breezes), and (3) **Radiation** (electromagnetic infrared waves requiring **no material medium**, traveling at the speed of light 3 * 10^8 m/s through vacuum) (https://ncert.nic.in/).

Chapter 5 Multi-Statement Exam Verification Drills

Chapter 5 Statement-Verification Drill #1

Both Statements Verified Correct

Statement-I (Heat vs. Temperature): **Heat (`Q`)** is a form of thermal energy in transit flowing from a higher-temperature body to a lower-temperature body (SI unit: **Joule (J)**; practical unit: **calorie**, where `1 calorie = 4.186 Joules ~ 4.2 J`). **Temperature (`T`)** is the degree of hotness or coldness of a body that determines the direction of heat flow (SI unit: **Kelvin (K)**) (https://ncert.nic.in/).

Statement-II (Universal Temperature Conversion Formula): Across the four major scales--Celsius (`C`), Fahrenheit (`F`), Kelvin (`K`), and Reaumur (`R`):

✓ **Exam Verification Key: Both Statement-I and Statement-II are factually accurate as per Indian Railways Official Portal & IUC Academy.**

Chapter 5 Statement-Verification Drill #2

Both Statements Verified Correct

Statement-I (Coincidence of Celsius and Fahrenheit Scales): `-40 deg C = -40 deg F`

Statement-II (Coincidence of Fahrenheit and Kelvin Scales): `574.25 deg F = 574.25 K`

✓ **Exam Verification Key: Both Statement-I and Statement-II are factually accurate as per Indian Railways Official Portal & IUC Academy.**

Chapter 5 Statement-Verification Drill #3

Both Statements Verified Correct

Statement-I (Normal Human Body Temperature): `37 deg C = 98.6 deg F = 310.15 K`

Statement-II (Absolute Zero Temperature (Zero molecular translational kinetic energy)): `0 K = -273.15 deg C = -459.67 deg F`

✓ **Exam Verification Key: Both Statement-I and Statement-II are factually accurate as per Indian Railways Official Portal & IUC Academy.**

Chapter 5 Statement-Verification Drill #4

Both Statements Verified Correct

Statement-I (Triple Point of Pure Water (Solid, Liquid, and Vapour coexist at `611.65 Pa`)): `273.16 K = 0.01 deg C` (https://ncert.nic.in/).

Statement-II (Specialized Thermometers): Mercury-in-glass thermometer operates between `-39 deg C` **(freezing point of Hg) and** `+357 deg C` **(boiling point of Hg)**; **Alcohol thermometer** is used in polar regions down to `-115 deg C` (since alcohol freezes at `-114 deg C`); and a **Total Radiation Pyrometer** (based on Stefan-Boltzmann Law `E = sigma * T^4`) measures furnace and solar temperatures above `800 deg C` without physical contact (https://ncert.nic.in/).

✓ **Exam Verification Key: Both Statement-I and Statement-II are factually accurate as per Indian Railways Official Portal & IUC Academy.**

Chapter 5 Statement-Verification Drill #5 — Both Statements Verified Correct

Statement-I (Sensible Heat, Specific Heat Capacity (c), and Principle of Calorimetry): Heat required to change the temperature of mass m by dT without phase change is Q = m *c* dT, where c is **Specific Heat Capacity** (SI unit: J / (kg *K*)). ***Water has the highest specific heat capacity among common liquids*** (*c_water* = 4186 *J*/(*kg* K) ~ 4200 J/(kg*K*) = 1 *cal*/(*g*deg C)), while c_ice = c_steam = 2100 J/(kg*K*) = 0.5 *cal*/(*g*deg C). By the **Principle of Calorimetry (Conservation of Energy)**: Heat Lost by Hot Body = Heat Gained by Cold Body (m1 *c1* (T1 - T_eq) = m2 *c2* (T_eq - T2)) (https://ncert.nic.in/).

Statement-II (Latent Heat (Q = m * L -- Phase Change at Constant Temperature)): ** During melting or boiling, temperature remains constant while heat breaks intermolecular bonds:

✓ **Exam Verification Key: Both Statement-I and Statement-II are factually accurate as per Indian Railways Official Portal & IUC Academy.**

Chapter 5 Statement-Verification Drill #6 — Both Statements Verified Correct

Statement-I (Latent Heat of Fusion of Ice (L_f)): 80 cal/g = 3.36 * 10^5 J/kg (336 kJ/kg) at 0 deg C.

Statement-II (Latent Heat of Vaporization of Water/Steam (L_v)): 540 cal/g = 2.26 * 10^6 J/kg (2260 kJ/kg) at 100 deg C (which is why **steam at 100 deg C causes much more severe burns than boiling water at 100 deg C**) (https://ncert.nic.in/).

✓ **Exam Verification Key: Both Statement-I and Statement-II are factually accurate as per Indian Railways Official Portal & IUC Academy.**

Chapter *6*: Basic Electricity, Ohm's Law, Kirchhoff's Laws, Magnetism, Transformers & Motors

Chapter Key Study Pillars — Chapter 6: Basic Electricity, Ohm's Law, Kirchhoff's Laws, Magnetism, Transformers & Motors

Key Study Pillar 1
Electric Charge, Current, Potential, Ohm's Law, Resistance & Resistivity

Key Study Pillar 2
Series/Parallel Circuits, Kirchhoff's Laws, Joule's Heating, Fuse & AC Machinery

6.1 Electric Charge, Current, Potential, Ohm's Law, Resistance & Resistivity

• **Charge (Q), Current (I), and Potential Difference (V):** Electric charge is quantized (Q = n *e* , *where* *e* = 1.6 10^-19 Coulomb and 1 C = 6.25 * 10^18 electrons). Electric Current is the rate of flow of charge: I = Q / t (SI unit: **Ampere (1 A = 1 C/s)**, measured by a low-resistance **Ammeter connected in Series**). Electric Potential Difference is work done per unit charge: V = W / Q (SI unit: **Volt (1 V = 1 J/C)**, measured by a high-resistance **Voltmeter connected in Parallel**; an ideal Ammeter has **zero resistance**, and an ideal Voltmeter has **infinite resistance**) (https://ncert.nic.in/).

• **Ohm's Law and Factors Affecting Resistance:** At constant temperature and physical conditions, potential difference across a conductor is directly proportional to current: V = I *R* , *where* *R* *is Resistance* (*SI unit:* ***Ohm***). *The resistance of a uniform wire of length* *L* *and cross-sectional area* *A* *is* R = *rho* (L / A), where rho is Resistivity (Specific Resistance, SI unit: Ohm *metre*). ***Resistivity*** *rho* ***depends ONLY on the nature of the material and temperature****--it does* ***not*** *change when a wire's length or area is altered! However,*

if a wire of resistance `R` *is* ***stretched to*** `n` ***times its original length*** *(at constant volume), its new resistance becomes* `R_new = n^2` **R** (https://ncert.nic.in/).

• **Temperature Coefficient of Resistance (** `alpha` **):** (1) **Metals/Conductors** (Silver, Copper, Aluminium) have a **Positive Temperature Coefficient (PTC)**--resistance increases as temperature rises; (2) **Semiconductors** (Silicon, Germanium) and **Carbon/Electrolytes** have a **Negative Temperature Coefficient (NTC)**--resistance decreases as temperature rises; and (3) **Alloys** (Manganin, Constantan, Eureka) have a **nearly zero temperature coefficient**, making them ideal for standard resistance coils (https://dgt.gov.in/).

6.2 Series/Parallel Circuits, Kirchhoff's Laws, Joule's Heating, Fuse & AC Machinery

• **Series vs. Parallel Combinations of Resistors and Capacitors:**

• **Resistors in Series (Same Current** `I` **):** `R_eq = R1 + R2 + R3` (for `n` equal resistors, `R_s = n * R`).

• **Resistors in Parallel (Same Voltage** `V` **, used in domestic house wiring at** `230V, 50Hz` **):** `1 / R_eq = 1 / R1 + 1 / R2 + 1 / R3` (for two resistors, `R_p = (R1 * R2) / (R1 + R2)`; for `n` equal resistors, `R_p = R / n`, so `R_s / R_p = n^2`).

• **Capacitors (** `C = Q / V` **, unit: Farad):** Opposite to resistors--in **Parallel**: `C_eq = C1 + C2`; in **Series**: `1 / C_eq = 1 / C1 + 1 / C2` (https://ncert.nic.in/).

• **Kirchhoff's Two Circuit Laws:** (1) **Kirchhoff's Current Law (KCL / Junction Rule / First Law):** Sum of currents entering a node equals sum of currents leaving it (`Sum(I) = 0`), based on **Conservation of Electric Charge**; (2) **Kirchhoff's Voltage Law (KVL / Loop Rule / Second Law):** Algebraic sum of all potential differences and EMFs across any closed loop is zero (`Sum(V) = 0`), based on **Conservation of Energy** (https://ncert.nic.in/).

• **Joule's Law of Heating, Electric Power & Safety Devices:** Heat generated in a resistor is `H = I^2 R t = V I t = (V^2 / R) t`, *and Electric Power is* `P = V I = I^2 * R = V^2 / R`. An **Electric Fuse Wire** (made of an alloy of **Lead 37% + Tin 63%**) is always connected in **Series with the Live (Phase) wire** and possesses **High Resistivity and Low Melting Point**, whereas a **Heater Element (Nichrome: Nickel 80% + Chromium 20%)** and **Bulb Filament (Tungsten, melting point** `3380 deg C` **)** have **High Resistivity and High Melting Point** (https://dgt.gov.in/).

• **Fleming's Rules & Transformer Principle: Fleming's Left-Hand Rule** gives the direction of force/motion on a current-carrying conductor in a **DC Motor**, whereas **Fleming's Right-Hand Rule** gives the direction of induced current in a **Generator (Dynamo)**. A **Transformer** works strictly on **Alternating Current (AC)** by the principle of **Mutual Induction** (`V_s / V_p = N_s / N_p = I_p / I_s`), stepping voltage up or down while **keeping Frequency (** `50 Hz` **in India) constant**, with its laminated **Silicon Steel Core** minimizing eddy current and hysteresis losses (https://dgt.gov.in/).

6.3 Electrical Circuit Analysis Flowchart and Component Specification Matrix

Step-by-Step Conceptual Process Flowchart

STEP 1
Identify Series vs. Parallel Branches & Reduce Network to Equivalent Resistance (R_eq)

STEP 2
Apply Ohm's Law (I_total = V / R_eq) & KCL/KVL to Find Branch Currents & Drops

STEP 3
Compute Power Dissipation (P = I^2*R* = *V*^2/ *R*) & *Heat Generated* (*H* = *P* t)

STEP 4
Calculate Commercial Energy Units (kWh = (Watts *Hours* Days) / 1000)

Electrical Device / Law	Governing Formula / Alloy	Key Material Property / Conservation Principle	Connection / Operating Rule	Reference Source
Ohm's Law & Wire Stretching	**V = I *R***; ***R* = *rho*** L / A; **R' = n^2 * R**	**rho** depends only on material & temperature	Valid at constant temperature	https://ncert.nic.in/
Kirchhoff's Laws (KCL & KVL)	**Sum(I_node) = 0**; **Sum(V_loop) = 0**	KCL -> Charge Conservation; KVL -> Energy Conservation	DC and AC network analysis	https://ncert.nic.in/
Electric Fuse Wire	Tin (63%) + Lead (37%) Solder Alloy	**High Resistivity & Low Melting Point**	Connected in **Series** on **Live (Phase)** wire	https://dgt.gov.in/
Heating Element & Filament	Nichrome (80% Ni + 20% Cr); Tungsten (**W**)	**High Resistivity & High Melting Point** (**3380 deg C** for W)	Resists oxidation at white-hot temperatures	https://dgt.gov.in/
AC Transformer	**V_s / V_p = N_s / N_p = I_p / I_s**	Works on **Mutual Induction**; Laminated Silicon Steel core	Operates on **AC only**; **Frequency stays constant**	https://dgt.gov.in/

Did You Know?: When two bulbs rated **40 W, 220 V** and **100 W, 220 V** are connected in **Parallel** across **220 V**, the **100 W bulb glows brighter** (**P = V^2 / R**); however, when connected in **Series**, the **40 W bulb glows brighter** because it has higher resistance (**R = V^2 / P**) and both carry the same series current (**P_actual = I^2 * R**) (https://ncert.nic.in/).

Exam Trap Alert: If a **DC supply** is connected to the primary winding of a Transformer, no alternating magnetic flux is produced (**dPhi/dt = 0**), so **zero EMF is induced in the secondary winding** and the primary winding can **burn out** due to low ohmic resistance and absence of back-EMF (https://dgt.gov.in/).

★ **Memory Trick:** Remember **Fleming's Rules** with **L-M / R-G**: Left-Hand Rule = **M**otor (Force on conductor); **R**ight-Hand Rule = **G**enerator (Induced EMF/Current) (https://ncert.nic.in/).

Chapter *6* Comprehensive Analytical & Statutory Revision Matrix

Core Sub-Domain	Key Concept / Provision	Verified Analytical Parameters & Exam Distinctions (Indian Railways Official Portal)
Electric Charge, Current, Potential, Ohm's Law, Resistance & Resistivity	**Charge (`Q`), Current (`I`), and Potential Difference (`V`)**	Electric charge is quantized (`Q = n e`, *where* `e = 1.6` 10^-19 Coulomb and `1 C = 6.25 * 10^18 electrons`). Electric Current is the rate of flow of charge: `I = Q / t` (SI unit: **Ampere (`1 A = 1 C/s`)**, measured by a low-resistance **Ammeter connected in Series**). Electric Potential Difference is work done per unit charge: `V = W / Q` (SI unit: **Volt (`1 V = 1 J/C`)**, measured by a high-resistance **Voltmeter connected in Parallel**; an ideal Ammeter has **zero resistance**, and an ideal Voltmeter has **infinite resistance**) (https://ncert.nic.in/).
Series/Parallel Circuits, Kirchhoff's Laws, Joule's Heating, Fuse & AC Machinery	**Ohm's Law and Factors Affecting Resistance**	At constant temperature and physical conditions, potential difference across a conductor is directly proportional to current: `V = I R`, *where* `R` *is Resistance* (*SI unit*: ***Ohm***). *The resistance of a uniform wire of length* `L` *and cross-sectional area* `A` *is* `R = rho (L / A)`, where `rho` **is Resistivity (Specific Resistance, SI unit: `Ohm metre`)**. ***Resistivity*** `rho` ***depends ONLY on the nature of the material and temperature****--it does* ***not*** *change when a wire's length or area is altered! However, if a wire of resistance* `R` *is* ***stretched to*** `n` ***times its original length*** (*at constant volume*), *its new resistance becomes* `R_new = n^2 R` (https://ncert.nic.in/).
Electrical Circuit Analysis Flowchart and Component Specification Matrix	**Temperature Coefficient of Resistance (`alpha`)**	(1) **Metals/Conductors** (Silver, Copper, Aluminium) have a **Positive Temperature Coefficient (PTC)**--resistance increases as temperature rises; (2) **Semiconductors** (Silicon, Germanium) and **Carbon/Electrolytes** have a **Negative Temperature Coefficient (NTC)**--resistance decreases as temperature rises; and (3) **Alloys** (Manganin, Constantan, Eureka) have a **nearly zero temperature coefficient**, making them ideal for standard resistance coils (https://dgt.gov.in/).
Electric Charge, Current, Potential, Ohm's Law, Resistance & Resistivity	**Resistors in Series (Same Current `I`)**	`R_eq = R1 + R2 + R3` (for `n` equal resistors, `R_s = n * R`).
Series/Parallel Circuits, Kirchhoff's Laws, Joule's Heating, Fuse & AC Machinery	**Resistors in Parallel (Same Voltage `V`, used in domestic house wiring at `230V, 50Hz`)**	`1 / R_eq = 1 / R1 + 1 / R2 + 1 / R3` (for two resistors, `R_p = (R1 * R2) / (R1 + R2)`; for `n` equal resistors, `R_p = R / n`, so `R_s / R_p = n^2`).
Electrical Circuit Analysis Flowchart and Component Specification Matrix	**Capacitors (`C = Q / V`, unit: Farad)**	Opposite to resistors--in **Parallel**: `C_eq = C1 + C2`; in **Series**: `1 / C_eq = 1 / C1 + 1 / C2` (https://ncert.nic.in/).

Core Sub-Domain	Key Concept / Provision	Verified Analytical Parameters & Exam Distinctions (Indian Railways Official Portal)
Electric Charge, Current, Potential, Ohm's Law, Resistance & Resistivity	**Kirchhoff's Two Circuit Laws**	(1) **Kirchhoff's Current Law (KCL / Junction Rule / First Law):** Sum of currents entering a node equals sum of currents leaving it (**Sum(I) = 0**), based on **Conservation of Electric Charge**; (2) **Kirchhoff's Voltage Law (KVL / Loop Rule / Second Law):** Algebraic sum of all potential differences and EMFs across any closed loop is zero (**Sum(V) = 0**), based on **Conservation of Energy** (https://ncert.nic.in/).
Series/Parallel Circuits, Kirchhoff's Laws, Joule's Heating, Fuse & AC Machinery	**Joule's Law of Heating, Electric Power & Safety Devices**	Heat generated in a resistor is **H = I^2 *R* t = V *I* t = (V^2 / R) *t***, *and Electric Power is* **P = V I = I^2 * R = V^2 / R**. An **Electric Fuse Wire** (made of an alloy of **Lead 37% + Tin 63%**) is always connected in **Series with the Live (Phase) wire** and possesses **High Resistivity and Low Melting Point**, whereas a **Heater Element (Nichrome: Nickel 80% + Chromium 20%)** and **Bulb Filament (Tungsten, melting point 3380 deg C)** have **High Resistivity and High Melting Point** (https://dgt.gov.in/).
Electrical Circuit Analysis Flowchart and Component Specification Matrix	**Fleming's Rules & Transformer Principle**	**Fleming's Left-Hand Rule** gives the direction of force/motion on a current-carrying conductor in a **DC Motor**, whereas **Fleming's Right-Hand Rule** gives the direction of induced current in a **Generator (Dynamo)**. A **Transformer** works strictly on **Alternating Current (AC)** by the principle of **Mutual Induction** (**V_s / V_p = N_s / N_p = I_p / I_s**), stepping voltage up or down while **keeping Frequency (50 Hz in India) constant**, with its laminated **Silicon Steel Core** minimizing eddy current and hysteresis losses (https://dgt.gov.in/).

Chapter *6* Multi-Statement Exam Verification Drills

Chapter 6 Statement-Verification Drill #1 — **Both Statements Verified Correct**

Statement-I (Charge (Q), Current (I), and Potential Difference (V)): Electric charge is quantized (**Q = n *e***, *where* **e = 1.6** 10^-19 Coulomb and **1 C = 6.25 * 10^18 electrons**). Electric Current is the rate of flow of charge: **I = Q / t** (SI unit: **Ampere (1 A = 1 C/s)**, measured by a low-resistance **Ammeter connected in Series**). Electric Potential Difference is work done per unit charge: **V = W / Q** (SI unit: **Volt (1 V = 1 J/C)**, measured by a high-resistance **Voltmeter connected in Parallel**; an ideal Ammeter has **zero resistance**, and an ideal Voltmeter has **infinite resistance**) (https://ncert.nic.in/).

Statement-II (Ohm's Law and Factors Affecting Resistance): At constant temperature and physical conditions, potential difference across a conductor is directly proportional to current: **V = I *R***, *where* ***R*** *is Resistance (SI unit:* ***Ohm****). The resistance of a uniform wire of length* ***L*** *and cross-sectional area* ***A*** *is* ***R = rho*** **(L / A)**, where **rho is Resistivity (Specific Resistance, SI unit: Ohm *metre*)**. ***Resistivity rho depends ONLY on the nature of the material and temperature****--it does* ***not*** *change when a wire's length or area is altered! However, if a wire of resistance* ***R*** *is* ***stretched to n times its original length*** *(at constant volume), its new resistance becomes* **R_new = n^2 R** (https://ncert.nic.in/).

✔ **Exam Verification Key: Both Statement-I and Statement-II are factually accurate as per Indian Railways Official Portal & IUC Academy.**

Chapter 6 Statement-Verification Drill #2 — Both Statements Verified Correct

Statement-I (Temperature Coefficient of Resistance (alpha)): (1) **Metals/Conductors** (Silver, Copper, Aluminium) have a **Positive Temperature Coefficient (PTC)**--resistance increases as temperature rises; (2) **Semiconductors** (Silicon, Germanium) and **Carbon/Electrolytes** have a **Negative Temperature Coefficient (NTC)**--resistance decreases as temperature rises; and (3) **Alloys** (Manganin, Constantan, Eureka) have a **nearly zero temperature coefficient**, making them ideal for standard resistance coils (https://dgt.gov.in/).

Statement-II (Resistors in Series (Same Current I)): R_eq = R1 + R2 + R3 (for n equal resistors, R_s = n * R).

✔ **Exam Verification Key: Both Statement-I and Statement-II are factually accurate as per Indian Railways Official Portal & IUC Academy.**

Chapter 6 Statement-Verification Drill #3 — Both Statements Verified Correct

Statement-I (Resistors in Parallel (Same Voltage V , used in domestic house wiring at 230V, 50Hz)): 1 / R_eq = 1 / R1 + 1 / R2 + 1 / R3 (for two resistors, R_p = (R1 * R2) / (R1 + R2) ; for n equal resistors, R_p = R / n , so R_s / R_p = n^2).

Statement-II (Capacitors (C = Q / V , unit: Farad)): Opposite to resistors--in **Parallel**: C_eq = C1 + C2 ; in **Series**: 1 / C_eq = 1 / C1 + 1 / C2 (https://ncert.nic.in/).

✔ **Exam Verification Key: Both Statement-I and Statement-II are factually accurate as per Indian Railways Official Portal & IUC Academy.**

Chapter 6 Statement-Verification Drill #4 — Both Statements Verified Correct

Statement-I (Kirchhoff's Two Circuit Laws): (1) **Kirchhoff's Current Law (KCL / Junction Rule / First Law):** Sum of currents entering a node equals sum of currents leaving it (Sum(I) = 0), based on **Conservation of Electric Charge**; (2) **Kirchhoff's Voltage Law (KVL / Loop Rule / Second Law):** Algebraic sum of all potential differences and EMFs across any closed loop is zero (Sum(V) = 0), based on **Conservation of Energy** (https://ncert.nic.in/).

Statement-II (Joule's Law of Heating, Electric Power & Safety Devices): Heat generated in a resistor is H = I^2 *R* t = V *I* t = (V^2 / R) *t* , *and Electric Power is* P = V I = I^2 * R = V^2 / R. An **Electric Fuse Wire** (made of an alloy of **Lead 37% + Tin 63%**) is always connected in **Series with the Live (Phase) wire** and possesses **High Resistivity and Low Melting Point**, whereas a **Heater Element (Nichrome: Nickel 80% + Chromium 20%)** and **Bulb Filament (Tungsten, melting point 3380 deg C)** have **High Resistivity and High Melting Point** (https://dgt.gov.in/).

✔ **Exam Verification Key: Both Statement-I and Statement-II are factually accurate as per Indian Railways Official Portal & IUC Academy.**

Chapter 7: Simple Machines, Levers (Class 1, 2 & 3), Pulleys, Mechanical Advantage & Efficiency

Chapter Key Study Pillars — Chapter 7: Simple Machines, Levers (Class 1, 2 & 3), Pulleys, Mechanical Advantage & Efficiency

Key Study Pillar 1
Mechanical Advantage (MA), Velocity Ratio (VR) & Efficiency (eta) of Simple Machines

Key Study Pillar 2
Principle of Levers and Complete Classification (First, Second, and Third Class Levers)

7.1 Mechanical Advantage (MA), Velocity Ratio (VR) & Efficiency (eta) of Simple Machines

• **Core Definitions of Simple Machine Parameters:** Let **L** = **Load lifted** and **E** = **Effort applied**, while **d_E** = **Distance moved by Effort** and **d_L** = **Distance moved by Load**:

1. **Mechanical Advantage (MA):** **MA = Load / Effort = L / E** (unitless ratio of forces; depends on friction).

2. **Velocity Ratio (VR):** **VR = Distance moved by Effort / Distance moved by Load = d_E / d_L** (unitless geometric ratio; depends purely on machine geometry and **does not change with friction**).

3. **Mechanical Efficiency (eta):** **eta = Work Output / Work Input = (L *d_L*) / (*E* d_E) = MA / VR** (or **(MA / VR) * 100%**) (https://dgt.gov.in/).

• **Ideal Machine vs. Actual Machine & Condition for Self-Locking (Irreversibility):** For an **Ideal (Frictionless) Machine**, **Work Output = Work Input**, **eta = 1 (100%)**, and **MA = VR**. For any **Actual (Real) Machine**, due to frictional losses, **Work Output < Work Input**, **eta < 1 (< 100%)**, and **MA < VR**. Furthermore, a lifting machine (such as a screw jack or worm-and-wheel) is **Self-Locking (Non-Reversible)**--meaning the load will not fall back on its own when effort is removed--if and only if its **efficiency is less than 50% (eta < 50%)**, and **Reversible** if **eta >= 50%** (https://dgt.gov.in/).

7.2 Principle of Levers and Complete Classification (First, Second, and Third Class Levers)

• **Law of the Lever (Moment Equilibrium about the Fulcrum F):** A lever is a rigid bar capable of rotating about a fixed pivot called the **Fulcrum (F)**. In rotational equilibrium, **Clockwise Moment = Anticlockwise Moment**, giving: **Effort (E) *Effort Arm* (*d_E*) = *Load* (*L*) Load Arm (d_L)**, so **MA = L / E = Effort Arm / Load Arm** (https://ncert.nic.in/).

• **First Class Lever (Fulcrum F is in the Middle between Effort E and Load L):** Since Effort Arm can be greater than, equal to, or less than Load Arm, **MA can be > 1, = 1, or < 1**. Classic examples: **Scissors, Pliers (Cutting Pliers), Crowbar, See-Saw, Common Beam Balance (MA = 1), Claw Hammer (extracting a nail), Hand Pump handle, and Tin Snips** (https://dgt.gov.in/).

• **Second Class Lever (Load L is in the Middle between Fulcrum F and Effort E):** Since Effort lies at the far end from the Fulcrum, **Effort Arm is always longer than Load Arm (d_E > d_L)**, so **MA is ALWAYS greater than 1 (MA > 1)**, acting as a **Force Multiplier**. Classic examples: **Wheelbarrow, Nutcracker, Lemon Squeezer, Bottle Opener, Paper Sheet Cutter, and Oar of a Rowing Boat** (https://dgt.gov.in/).

• **Third Class Lever (Effort E is in the Middle between Fulcrum F and Load L):** Since Effort is applied closer to the Fulcrum than the Load, **Effort Arm is always shorter than Load Arm (d_E < d_L)**, so **MA is ALWAYS less than 1 (MA < 1)**, acting as a **Speed / Distance Multiplier** for precision and rapid movement. Classic examples: **Fire Tongs (*Chimta*), Sugar/Ice Tongs, Tweezers/Forceps, Human Forearm lifting a weight in the palm (Elbow = Fulcrum, Biceps attachment = Effort, Palm = Load), Fishing Rod, Stapler, and Shovel/Broom** (https://dgt.gov.in/).

• **Pulleys, Inclined Plane, Wheel-and-Axle & Screw Jack Velocity Ratios:**

• **Single Fixed Pulley:** **VR = 1** (**MA = 1** ideally; used only to change the direction of effort).

• **Single Movable Pulley:** **VR = 2**.

- First System of Pulleys (with `n` movable pulleys): `VR = 2^n`; Second System (Block and Tackle with `n` total pulleys): `VR = n`.
- Inclined Plane (length `L`, height `h`, inclination `theta`): `VR = L / h = 1 / sin(theta)`.
- Screw Jack (handle length `R`, screw pitch `p`): `VR = (2 pi R) / p` (https://dgt.gov.in/).

7.3 Lever & Simple Machine Analysis Flowchart and Comparative Matrix

Step-by-Step Conceptual Process Flowchart

STEP 1
Locate Which Component Lies in the Middle Between the Other Two (F, L, or E)

STEP 2
Classify Lever Using FLE Rule (F Middle = Class 1; L Middle = Class 2; E Middle = Class 3)

STEP 3
Compare Effort Arm (F to E) vs. Load Arm (F to L) to Determine MA = Effort Arm / Load Arm

STEP 4
Apply Efficiency Relation eta = (MA / VR) * 100% & Check Self-Locking Condition (eta < 50%)

Lever / Machine Type	Central Element / Geometry	Mechanical Advantage (`MA`) / `VR`	Functional Role	Standard Exam Examples	Reference Source
Class 1 Lever	**Fulcrum (`F`)** in middle	`MA > 1`, `MA = 1`, or `MA < 1`	Force multiplier, speed multiplier, or direction changer	Scissors, Pliers, See-Saw, Beam Balance, Crowbar, Claw Hammer	https://dgt.gov.in/
Class 2 Lever	**Load (`L`)** in middle	**Always** `MA > 1` (`d_E > d_L`)	Always a **Force Multiplier** (saves effort)	Wheelbarrow, Nutcracker, Lemon Squeezer, Bottle Opener	https://dgt.gov.in/
Class 3 Lever	**Effort (`E`)** in middle	**Always** `MA < 1` (`d_E < d_L`)	Always a **Speed / Distance Multiplier**	Fire Tongs (*Chimta*), Forceps/ Tweezers, Human Forearm, Fishing Rod	https://dgt.gov.in/
Block & Tackle Pulley	`n` pulleys in two blocks	`VR = n` (`MA = eta * n`)	Heavy workshop hoisting	Chain pulley block & crane tackle	https://dgt.gov.in/
Screw Jack	Lever arm `R`, thread pitch `p`	`VR = (2 pi R) / p`	Self-locking (`eta < 50%`) heavy lifting	Lifting railway bogies and heavy vehicles	https://dgt.gov.in/

Did You Know?: A **Screw Jack** has one of the highest Velocity Ratios (`VR = 2 pi R / p`) among simple workshop machines, and its deliberate high thread friction keeps its efficiency below `50%` so that it is **self-locking** and never drops a lifted locomotive or vehicle when the operator lets go of the handle (https://dgt.gov.in/).

Exam Trap Alert: Candidates often misclassify the **Human Forearm holding a load** as Class 1 or Class 2--remember that the **Elbow joint is the Fulcrum (`F`)**, the **Biceps muscle attaches just in front of the elbow (`E` in the middle)**, and the **Load (`L`) is in the hand**, making the human forearm a classic **Class 3 Lever (`MA < 1`)** (https://ncert.nic.in/).

★ **Memory Trick:** Master all Lever questions in 2 seconds with the mnemonic **F - L - E (1 - 2 - 3)**:

- Fulcrum in middle = Class **1**
- Load in middle = Class **2**
- Effort in middle = Class **3** (https://www.iucacademy.com).

Chapter 7 Comprehensive Analytical & Statutory Revision Matrix

Core Sub-Domain	Key Concept / Provision	Verified Analytical Parameters & Exam Distinctions (Indian Railways Official Portal)
Mechanical Advantage (MA), Velocity Ratio (VR) & Efficiency (eta) of Simple Machines	**Core Definitions of Simple Machine Parameters**	Let **L** = **Load lifted** and **E** = **Effort applied**, while **d_E** = **Distance moved by Effort** and **d_L** = **Distance moved by Load**:
Principle of Levers and Complete Classification (First, Second, and Third Class Levers)	**Mechanical Advantage (MA)**	**MA = Load / Effort = L / E** (unitless ratio of forces; depends on friction).
Lever & Simple Machine Analysis Flowchart and Comparative Matrix	**Velocity Ratio (VR)**	**VR = Distance moved by Effort / Distance moved by Load = d_E / d_L** (unitless geometric ratio; depends purely on machine geometry and **does not change with friction**).
Mechanical Advantage (MA), Velocity Ratio (VR) & Efficiency (eta) of Simple Machines	**Mechanical Efficiency (eta)**	**eta = Work Output / Work Input = (L *d_L*) / (*E* d_E) = MA / VR** (or **(MA / VR) * 100%**) (https://dgt.gov.in/).
Principle of Levers and Complete Classification (First, Second, and Third Class Levers)	**Ideal Machine vs. Actual Machine & Condition for Self-Locking (Irreversibility)**	For an **Ideal (Frictionless) Machine**, **Work Output = Work Input**, **eta = 1 (100%)**, and **MA = VR**. For any **Actual (Real) Machine**, due to frictional losses, **Work Output < Work Input**, **eta < 1 (< 100%)**, and **MA < VR**. Furthermore, a lifting machine (such as a screw jack or worm-and-wheel) is **Self-Locking (Non-Reversible)**--meaning the load will not fall back on its own when effort is removed--if and only if its **efficiency is less than 50% (eta < 50%)**, and **Reversible** if **eta >= 50%** (https://dgt.gov.in/).
Lever & Simple Machine Analysis Flowchart and Comparative Matrix	**Law of the Lever (Moment Equilibrium about the Fulcrum F)**	A lever is a rigid bar capable of rotating about a fixed pivot called the **Fulcrum (F)**. In rotational equilibrium, **Clockwise Moment = Anticlockwise Moment**, giving: **Effort (E) *Effort Arm* (*d_E*) = *Load* (*L*) Load Arm (d_L)**, so **MA = L / E = Effort Arm / Load Arm** (https://ncert.nic.in/).
Mechanical Advantage (MA), Velocity Ratio (VR) & Efficiency (eta) of Simple Machines	**First Class Lever (Fulcrum F is in the Middle between Effort E and Load L)**	Since Effort Arm can be greater than, equal to, or less than Load Arm, **MA can be > 1, = 1, or < 1**. Classic examples: **Scissors, Pliers (Cutting Pliers), Crowbar, See-Saw, Common Beam Balance (MA = 1), Claw Hammer (extracting a nail), Hand Pump handle, and Tin Snips** (https://dgt.gov.in/).

Core Sub-Domain	Key Concept / Provision	Verified Analytical Parameters & Exam Distinctions (Indian Railways Official Portal)
Principle of Levers and Complete Classification (First, Second, and Third Class Levers)	Second Class Lever (Load `L` is in the Middle between Fulcrum `F` and Effort `E`)	Since Effort lies at the far end from the Fulcrum, **Effort Arm is always longer than Load Arm (`d_E > d_L`)**, so `MA` **is ALWAYS greater than 1 (`MA > 1`)**, acting as a **Force Multiplier**. Classic examples: **Wheelbarrow, Nutcracker, Lemon Squeezer, Bottle Opener, Paper Sheet Cutter, and Oar of a Rowing Boat** (https://dgt.gov.in/).
Lever & Simple Machine Analysis Flowchart and Comparative Matrix	Third Class Lever (Effort `E` is in the Middle between Fulcrum `F` and Load `L`)	Since Effort is applied closer to the Fulcrum than the Load, **Effort Arm is always shorter than Load Arm (`d_E < d_L`)**, so `MA` **is ALWAYS less than 1 (`MA < 1`)**, acting as a **Speed / Distance Multiplier** for precision and rapid movement. Classic examples: **Fire Tongs (*Chimta*), Sugar/Ice Tongs, Tweezers/Forceps, Human Forearm lifting a weight in the palm (Elbow = Fulcrum, Biceps attachment = Effort, Palm = Load), Fishing Rod, Stapler, and Shovel/Broom** (https://dgt.gov.in/).
Mechanical Advantage (MA), Velocity Ratio (VR) & Efficiency (eta) of Simple Machines	Single Fixed Pulley	`VR = 1` (`MA = 1` ideally; used only to change the direction of effort).
Principle of Levers and Complete Classification (First, Second, and Third Class Levers)	First System of Pulleys (with `n` movable pulleys)	`VR = 2^n`; **Second System (Block and Tackle with** `n` **total pulleys):** `VR = n`.
Lever & Simple Machine Analysis Flowchart and Comparative Matrix	Inclined Plane (length `L`, height `h`, inclination `theta`)	`VR = L / h = 1 / sin(theta)`.
Mechanical Advantage (MA), Velocity Ratio (VR) & Efficiency (eta) of Simple Machines	Screw Jack (handle length `R`, screw pitch `p`)	`VR = (2 pi R) / p` (https://dgt.gov.in/).

Chapter 7 Multi-Statement Exam Verification Drills

Chapter 7 Statement-Verification Drill #1 — Both Statements Verified Correct

Statement-I (Core Definitions of Simple Machine Parameters): Let `L` = **Load lifted** and `E` = **Effort applied**, while `d_E` = **Distance moved by Effort** and `d_L` = **Distance moved by Load**:
Statement-II (Mechanical Advantage (MA)): `MA = Load / Effort = L / E` (unitless ratio of forces; depends on friction).

✔ **Exam Verification Key: Both Statement-I and Statement-II are factually accurate as per Indian Railways Official Portal & IUC Academy.**

Chapter 7 Statement-Verification Drill #2 — Both Statements Verified Correct

Statement-I (Velocity Ratio (VR)): `VR = Distance moved by Effort / Distance moved by Load = d_E / d_L` (unitless geometric ratio; depends purely on machine geometry and **does not change with friction**).

Statement-II (Mechanical Efficiency (`eta`)): `eta = Work Output / Work Input = (L d_L) / (E d_E) = MA / VR` (or `(MA / VR) * 100%`) (https://dgt.gov.in/).

✓ **Exam Verification Key: Both Statement-I and Statement-II are factually accurate as per Indian Railways Official Portal & IUC Academy.**

Chapter 7 Statement-Verification Drill #3 — Both Statements Verified Correct

Statement-I (Ideal Machine vs. Actual Machine & Condition for Self-Locking (Irreversibility)): For an **Ideal (Frictionless) Machine**, `Work Output = Work Input`, `eta = 1 (100%)`, and `MA = VR`. For any **Actual (Real) Machine**, due to frictional losses, `Work Output < Work Input`, `eta < 1 (< 100%)`, and `MA < VR`. Furthermore, a lifting machine (such as a screw jack or worm-and-wheel) is **Self-Locking (Non-Reversible)**--meaning the load will not fall back on its own when effort is removed--if and only if its **efficiency is less than 50%** (`eta < 50%`), and **Reversible** if `eta >= 50%` (https://dgt.gov.in/).

Statement-II (Law of the Lever (Moment Equilibrium about the Fulcrum `F`)): A lever is a rigid bar capable of rotating about a fixed pivot called the **Fulcrum** (`F`). In rotational equilibrium, `Clockwise Moment = Anticlockwise Moment`, giving: `Effort (E) Effort Arm (d_E) = Load (L) Load Arm (d_L)`, so `MA = L / E = Effort Arm / Load Arm` (https://ncert.nic.in/).

✓ **Exam Verification Key: Both Statement-I and Statement-II are factually accurate as per Indian Railways Official Portal & IUC Academy.**

Chapter 7 Statement-Verification Drill #4 — Both Statements Verified Correct

Statement-I (First Class Lever (Fulcrum `F` is in the Middle between Effort `E` and Load `L`)): Since Effort Arm can be greater than, equal to, or less than Load Arm, `MA` **can be** `> 1`, `= 1`, **or** `< 1`. Classic examples: **Scissors, Pliers (Cutting Pliers), Crowbar, See-Saw, Common Beam Balance (`MA = 1`), Claw Hammer (extracting a nail), Hand Pump handle, and Tin Snips** (https://dgt.gov.in/).

Statement-II (Second Class Lever (Load `L` is in the Middle between Fulcrum `F` and Effort `E`)): Since Effort lies at the far end from the Fulcrum, **Effort Arm is always longer than Load Arm (`d_E > d_L`)**, so `MA` **is ALWAYS greater than 1** (`MA > 1`), acting as a **Force Multiplier**. Classic examples: **Wheelbarrow, Nutcracker, Lemon Squeezer, Bottle Opener, Paper Sheet Cutter, and Oar of a Rowing Boat** (https://dgt.gov.in/).

✓ **Exam Verification Key: Both Statement-I and Statement-II are factually accurate as per Indian Railways Official Portal & IUC Academy.**

Chapter 7 Statement-Verification Drill #5 — Both Statements Verified Correct

Statement-I (Third Class Lever (Effort `E` is in the Middle between Fulcrum `F` and Load `L`)): Since Effort is applied closer to the Fulcrum than the Load, **Effort Arm is always shorter than Load Arm (`d_E < d_L`)**, so `MA` **is ALWAYS less than 1** (`MA < 1`), acting as a **Speed / Distance Multiplier** for precision and rapid movement. Classic examples: **Fire Tongs (*Chimta*), Sugar/Ice Tongs, Tweezers/Forceps, Human Forearm lifting a weight in the palm (Elbow = Fulcrum, Biceps attachment = Effort, Palm = Load), Fishing Rod, Stapler, and Shovel/Broom** (https://dgt.gov.in/).

Statement-II (Single Fixed Pulley): `VR = 1` (`MA = 1` ideally; used only to change the direction of effort).

✓ **Exam Verification Key: Both Statement-I and Statement-II are factually accurate as per Indian Railways Official Portal & IUC Academy.**

Chapter 7 Statement-Verification Drill #6 — Both Statements Verified Correct

Statement-I (First System of Pulleys (with `n` movable pulleys)): `VR = 2^n`; Second System (Block and Tackle with `n` total pulleys): `VR = n`.

Statement-II (Inclined Plane (length `L`, height `h`, inclination `theta`)): `VR = L / h = 1 / sin(theta)`.

✓ **Exam Verification Key: Both Statement-I and Statement-II are factually accurate as per Indian Railways Official Portal & IUC Academy.**

Chapter *8:* Engineering Drawing *(*BIS SP *46* / IS *10711* Standards, Projections, Lines*)* & Occupational Safety

Chapter Key Study Pillars — Chapter 8: Engineering Drawing (BIS SP 46 / IS 10711 Standards, Projections, Lines) & Occupational Safety

Key Study Pillar 1
Engineering Drawing Standards: Drawing Sheets (IS 10711), Pencil Grades, Scales & Lines (IS 10714)

Key Study Pillar 2
Occupational Health, Safety Signs, Fire Classification (Class A, B, C, D, K) & 5S Methodology

8.1 Engineering Drawing Standards*:* Drawing Sheets *(*IS *10711)*, Pencil Grades, Scales & Lines *(*IS *10714)*

• **BIS Drawing Sheet Designations and Exact Dimensions (IS 10711:2001 / SP 46):** All standard ISO-A series drawing sheets have a constant side aspect ratio of **`1 : sqrt(2)`** (**`1 : 1.414`**), and the surface area of the flagship **A0 sheet is exactly 1 square metre (`1.00 m^2`)**, with each subsequent sheet having half the area of the preceding size:

• **A0 Trimmed Size:** **`841 mm * 1189 mm`** (Area = **`1.00 m^2`**)

• **A1 Trimmed Size:** **`594 mm * 841 mm`** (Area = **`0.50 m^2`**)

• **A2 Trimmed Size:** **`420 mm * 594 mm`** (Area = **`0.25 m^2`**)

• **A3 Trimmed Size:** **`297 mm * 420 mm`** (Area = **`0.125 m^2`**)

• **A4 Trimmed Size:** **`210 mm * 297 mm`** (Area = **`0.0625 m^2`**)

• **A5 Trimmed Size:** **`148 mm * 210 mm`** (https://www.bis.gov.in/).

• **Title Block, Drawing Board, T-Square & Mini-Drafter:** According to BIS SP 46, the **Title Block** is always placed at the **bottom right-hand corner** of the drawing sheet with standard dimensions of **`185 mm * 65 mm`**. A **Mini-Drafter** combines the functions of a **T-Square, Set-Squares (`30-60 deg` and `45 deg`), Scale, and Protractor** into a single parallelogram-linkage instrument (only **Compass/Divider** is not part of a mini-drafter). A **French Curve** is used to draw smooth **irregular (non-circular) curves** (https://dgt.gov.in/).

• **18 Grades of Engineering Drawing Pencils (Clay vs. Graphite):** Pencils are graded from **9H (Hardest, highest kaolin clay content)** to **7B (Softest and darkest, highest graphite content)** with **HB** and **F** in the middle. In technical drawing: **H / 2H** is used for visible outlines, dimension lines, and lettering; **2H / 3H** is used for construction lines, projection lines, and leader lines; and **HB** is used for freehand sketching and arrowheads (https://dgt.gov.in/).

• **Standard Types of Lines (IS 10714 / SP 46) & Representative Fraction (RF):**

• **Type A (Continuous Thick):** Visible outlines and visible edges.

• **Type B (Continuous Thin Straight):** Dimension lines, extension/projection lines, leader lines, and **Hatching (Section) lines inclined at 45 degrees**.

• **Type C / D (Continuous Thin Freehand / Zigzag with Z):** Limits of partial or interrupted views.

• **Type E / F (Dashed Thick / Thin): Hidden outlines and hidden edges**.

• **Type G (Chain Thin -- alternating long dash and short dash): Center lines, lines of symmetry, and pitch circles**.

• **Representative Fraction (RF): RF = Length of Object on Drawing / Actual Length of Object** (in same units). **RF < 1** = **Reducing Scale** (for buildings, bridges, boilers); **RF = 1** = **Full Size Scale** (**1:1**); **RF > 1** = **Enlarging Scale** (for wrist-watch gears and micro-components). A **Plain Scale** reads 2 consecutive units, while a **Diagonal Scale** reads **3 consecutive units** (e.g., metres, decimetres, and centimetres) (**https://www.bis.gov.in/**).

• **First-Angle vs. Third-Angle Orthographic Projection & Isometric Projection:**

• **First-Angle Projection (Object in 1st Quadrant: Object between Observer and Plane, standard in BIS/India & ISO/Europe):** The **Top View (Plan) comes BELOW the Front View (Elevation)**, and the Left-Hand Side View is drawn on the Right of the Front View. Its symbol has the smaller end of the frustum facing the circular view.

• **Third-Angle Projection (Object in 3rd Quadrant: Transparent Projection Plane between Observer and Object, used in USA):** The **Top View comes ABOVE the Front View**, and the Left-Hand Side View is drawn on the Left.

• **Isometric Projection vs. Isometric View:** Isometric axes are inclined at **120 degrees to each other** (**30 degrees** to the horizontal). Because isometric lengths foreshorten by **sqrt(2/3) = 0.816** (**~81.6%**), an **Isometric Projection** is drawn using an **Isometric Scale** (**0.816 * True Length**) and is smaller than an **Isometric View / Drawing** drawn using True Length (**100%**) (**https://www.bis.gov.in/**).

8.2 Occupational Health, Safety Signs, Fire Classification (Class A, B, C, D, K) & *5S* Methodology

• **Four Categories of BIS / ISO Safety Signs (Shape & Colour Coding):**

1. **Prohibition Signs ("Do Not Do"): Circular shape** with **White backdrop, Red circular border and diagonal crossbar, and Black pictogram** (e.g., *No Smoking*, *No Naked Flame*).

2. **Mandatory Signs ("Must Do / Wear PPE"): Circular shape** with **Blue backdrop and White pictogram** (e.g., *Wear Safety Helmet*, *Wear Goggles*, *Wear Safety Shoes*).

3. **Warning / Caution Signs ("Risk of Danger"): Equilateral Triangular shape** with **Yellow backdrop, Black border, and Black pictogram** (e.g., *440V High Voltage Danger*, *Overhead Crane*, *Laser Beam*).

4. **Information / Emergency Safe Condition Signs: Square or Rectangular shape** with **Green backdrop and White pictogram** (or Red backdrop for fire-fighting equipment) (e.g., *First-Aid Post*, *Emergency Exit*) (**https://dgt.gov.in/**).

• **Fire Triangle & Five Classes of Fire with Matching Extinguishers:** Fire requires three elements--**Fuel + Heat (Ignition Temperature) + Oxygen**. Fires are classified into:

• **Class A Fire (Carbonaceous Solids -- Wood, Paper, Cloth, Jute):** Extinguished by cooling with **Water-jet or Soda-Acid extinguisher**.

• **Class B Fire (Flammable Liquids -- Petrol, Diesel, Kerosene, Oil, Paint):** Extinguished by smothering (cutting off oxygen) with **Foam, Dry Powder, or CO2 extinguisher** (never use water, as oil floats on water and spreads fire!).

• **Class C Fire (Flammable Gases -- LPG, CNG, Acetylene, Hydrogen):** Extinguished with **Dry Chemical Powder (DCP) or CO2**.

• **Class D Fire (Combustible Metals & Live Electrical Fires in Indian DGT standard -- Sodium, Magnesium, Potassium, Aluminium powder, and Electrical Equipment):** Metal fires require **Special Dry Powder (TEC / Graphite / Sand)**; live **Electrical Fires** are extinguished with **Carbon Dioxide (CO2), Halon / CTC (Carbon Tetrachloride / Bromochlorodifluoromethane - BCF), or Dry Powder** (never use water or foam on electrical fire due to electrocution hazard!).

• **PASS Operating Sequence for Fire Extinguishers: P**ull the safety pin -> **A**im at the base of the fire -> **S**queeze the lever -> **S**weep from side to side (https://dgt.gov.in/).

• **Japanese 5S Workshop Housekeeping System:** (1) **Seiri (Sort)** -- eliminate unnecessary items; (2) **Seiton (Set in Order / Straighten)** -- a place for everything and everything in its place; (3) **Seiso (Shine / Sweep)** -- workplace cleanliness; (4) **Seiketsu (Standardize)** -- maintain uniform rules and visual coding; and (5) **Shitsuke (Sustain / Self-Discipline)** -- habitual adherence (https://dgt.gov.in/).

8.3 Engineering Drawing & Workshop Safety Flowchart and Reference Matrix

Step-by-Step Conceptual Process Flowchart

STEP 1
Select Standard Sheet (A0-A4 per IS 10711) & Fix Title Block (185 mm * 65 mm) at Bottom-Right Corner

STEP 2
Choose Projection Method (First-Angle BIS Standard: Plan Below Elevation) & Scale RF

STEP 3
Draft Outlines (Type A Thick), Hidden Edges (Type E Dashed) & Center Lines (Type G Chain)

STEP 4
Dimension Parallel/ Aligned per SP 46 & Enforce Workshop 5S and Safety Sign Compliance

Standard / Safety Item	Specification / Geometry	Colour / Material / Dimension	Primary Engineering / Workshop Rule	Reference Source
Drawing Sheet Sizes (IS 10711)	Aspect Ratio **1 : sqrt(2)**; **A0 Area = 1 m^2**	**A0: 8411189**; **A1: 594** 841; **A2: 420594**; **A3: 297** 420; **A4: 210*297 mm**	Title block (**185 * 65 mm**) at bottom-right corner	https://www.bis.gov.in/
First-Angle Projection (BIS)	Object in 1st Quadrant (**Observer -> Object -> Plane**)	Top View (Plan) **below** Front View (Elevation)	Default orthographic projection in BIS SP 46	https://www.bis.gov.in/
Warning vs. Mandatory Signs	Warning = **Triangle**; Mandatory = **Circle**	Warning = **Yellow bg + Black symbol**; Mandatory = **Blue bg + White symbol**	Prohibition = White circle with Red border/ crossbar	https://dgt.gov.in/

Standard / Safety Item	Specification / Geometry	Colour / Material / Dimension	Primary Engineering / Workshop Rule	Reference Source
Class A, B, C & Electrical Fires	A = Solid; B = Liquid; C = Gas; D/Elec = Metal/ Electrical	A -> Water; B -> Foam; C -> Dry Powder; Electrical -> **CO2 / Halon (CTC)**	Never use water or foam on electrical or oil fires	https:// dgt.gov.in/
5S Housekeeping Pillars	Seiri, Seiton, Seiso, Seiketsu, Shitsuke	Sort -> Set in Order -> Shine -> Standardize -> Sustain	Improves workshop safety, productivity & quality	https:// dgt.gov.in/

Did You Know?: When folding any large engineering drawing sheet (**A0, A1, A2, A3**) for filing or binding into a folder according to **IS 11664**, the sheet is always folded to **A4 size (210 mm 297 *mm*)** *in such a way that the* ***Title Block*** **(** **185 *mm*** **65 mm) remains completely visible on the front top-most face** (https://www.bis.gov.in/).

Exam Trap Alert: Never confuse **First-Angle** and **Third-Angle Projection** positions: in **First-Angle Projection (used in India/BIS)**, the **Top View (Plan) is drawn BELOW the Front View** and the **Left Side View is drawn on the RIGHT**, whereas in **Third-Angle Projection**, the Top View is ABOVE the Front View and the Left Side View is on the LEFT (https://www.bis.gov.in/).

★ **Memory Trick:** Remember all **A0 to A4 Drawing Sheet dimensions (** **mm** **)** effortlessly by halving the longer side at each step and truncating down to the nearest integer:

- **A0:** **841 * 1189** (**1189 / 2 = 594.5 -> 594**)
- **A1:** **594 * 841** (**841 / 2 = 420.5 -> 420**)
- **A2:** **420 * 594** (**594 / 2 = 297**)
- **A3:** **297 * 420** (**420 / 2 = 210**)
- **A4:** **210 * 297** (https://www.bis.gov.in/).

Chapter *8* Comprehensive Analytical & Statutory Revision Matrix

Core Sub-Domain	Key Concept / Provision	Verified Analytical Parameters & Exam Distinctions (Indian Railways Official Portal)
Engineering Drawing Standards: Drawing Sheets (IS 10711), Pencil Grades, Scales & Lines (IS 10714)	**BIS Drawing Sheet Designations and Exact Dimensions (IS 10711:2001 / SP 46)**	All standard ISO-A series drawing sheets have a constant side aspect ratio of **1 : sqrt(2)** (**1 : 1.414**), and the surface area of the flagship **A0 sheet is exactly 1 square metre (** **1.00 m^2** **)**, with each subsequent sheet having half the area of the preceding size:
Occupational Health, Safety Signs, Fire Classification (Class A, B, C, D, K) & 5S Methodology	**A0 Trimmed Size**	**841 mm * 1189 mm** (Area = **1.00 m^2**)

Core Sub-Domain	Key Concept / Provision	Verified Analytical Parameters & Exam Distinctions (Indian Railways Official Portal)
Engineering Drawing & Workshop Safety Flowchart and Reference Matrix	A1 Trimmed Size	594 mm * 841 mm (Area = 0.50 m^2)
Engineering Drawing Standards: Drawing Sheets (IS 10711), Pencil Grades, Scales & Lines (IS 10714)	A2 Trimmed Size	420 mm * 594 mm (Area = 0.25 m^2)
Occupational Health, Safety Signs, Fire Classification (Class A, B, C, D, K) & 5S Methodology	A3 Trimmed Size	297 mm * 420 mm (Area = 0.125 m^2)
Engineering Drawing & Workshop Safety Flowchart and Reference Matrix	A4 Trimmed Size	210 mm * 297 mm (Area = 0.0625 m^2)
Engineering Drawing Standards: Drawing Sheets (IS 10711), Pencil Grades, Scales & Lines (IS 10714)	A5 Trimmed Size	148 mm * 210 mm (https://www.bis.gov.in/).
Occupational Health, Safety Signs, Fire Classification (Class A, B, C, D, K) & 5S Methodology	Title Block, Drawing Board, T-Square & Mini-Drafter	According to BIS SP 46, the **Title Block** is always placed at the **bottom right-hand corner** of the drawing sheet with standard dimensions of 185 mm * 65 mm. A **Mini-Drafter** combines the functions of a **T-Square, Set-Squares (30-60 deg and 45 deg), Scale, and Protractor** into a single parallelogram-linkage instrument (only **Compass/Divider** is not part of a mini-drafter). A **French Curve** is used to draw smooth **irregular (non-circular) curves** (https://dgt.gov.in/).
Engineering Drawing & Workshop Safety Flowchart and Reference Matrix	18 Grades of Engineering Drawing Pencils (Clay vs. Graphite)	Pencils are graded from **9H (Hardest, highest kaolin clay content)** to **7B (Softest and darkest, highest graphite content)** with **HB** and **F** in the middle. In technical drawing: **H / 2H** is used for visible outlines, dimension lines, and lettering; **2H / 3H** is used for construction lines, projection lines, and leader lines; and **HB** is used for freehand sketching and arrowheads (https://dgt.gov.in/).

Core Sub-Domain	Key Concept / Provision	Verified Analytical Parameters & Exam Distinctions (Indian Railways Official Portal)
Engineering Drawing Standards: Drawing Sheets (IS 10711), Pencil Grades, Scales & Lines (IS 10714)	**Type A (Continuous Thick)**	Visible outlines and visible edges.
Occupational Health, Safety Signs, Fire Classification (Class A, B, C, D, K) & 5S Methodology	**Type B (Continuous Thin Straight)**	Dimension lines, extension/projection lines, leader lines, and **Hatching (Section) lines inclined at `45 degrees`**.
Engineering Drawing & Workshop Safety Flowchart and Reference Matrix	**Type C / D (Continuous Thin Freehand / Zigzag with Z)**	Limits of partial or interrupted views.
Engineering Drawing Standards: Drawing Sheets (IS 10711), Pencil Grades, Scales & Lines (IS 10714)	**Type E / F (Dashed Thick / Thin)**	**Hidden outlines and hidden edges.**
Occupational Health, Safety Signs, Fire Classification (Class A, B, C, D, K) & 5S Methodology	**Type G (Chain Thin -- alternating long dash and short dash)**	**Center lines, lines of symmetry, and pitch circles.**

Chapter *8* Multi-Statement Exam Verification Drills

Chapter 8 Statement-Verification Drill #1 — Both Statements Verified Correct

Statement-I (BIS Drawing Sheet Designations and Exact Dimensions (IS 10711:2001 / SP 46)): All standard ISO-A series drawing sheets have a constant side aspect ratio of `1 : sqrt(2)` (`1 : 1.414`), and the surface area of the flagship **A0 sheet is exactly 1 square metre (`1.00 m^2`)**, with each subsequent sheet having half the area of the preceding size:
Statement-II (A0 Trimmed Size): `841 mm * 1189 mm` (Area = `1.00 m^2`)

✓ **Exam Verification Key: Both Statement-I and Statement-II are factually accurate as per Indian Railways Official Portal & IUC Academy.**

Chapter 8 Statement-Verification Drill #2 — Both Statements Verified Correct

Statement-I (A1 Trimmed Size): `594 mm * 841 mm` (Area = `0.50 m^2`)
Statement-II (A2 Trimmed Size): `420 mm * 594 mm` (Area = `0.25 m^2`)

✓ **Exam Verification Key: Both Statement-I and Statement-II are factually accurate as per Indian Railways Official Portal & IUC Academy.**

Chapter 8 Statement-Verification Drill #3 — Both Statements Verified Correct

Statement-I (A3 Trimmed Size): `297 mm * 420 mm` (Area = `0.125 m^2`)
Statement-II (A4 Trimmed Size): `210 mm * 297 mm` (Area = `0.0625 m^2`)

✓ **Exam Verification Key: Both Statement-I and Statement-II are factually accurate as per Indian Railways Official Portal & IUC Academy.**

Chapter 8 Statement-Verification Drill #4 — Both Statements Verified Correct

Statement-I (A5 Trimmed Size): `148 mm * 210 mm` (https://www.bis.gov.in/).

Statement-II (Title Block, Drawing Board, T-Square & Mini-Drafter): According to BIS SP 46, the **Title Block** is always placed at the **bottom right-hand corner** of the drawing sheet with standard dimensions of `185 mm * 65 mm`. A **Mini-Drafter** combines the functions of a **T-Square, Set-Squares (`30-60 deg` and `45 deg`), Scale, and Protractor** into a single parallelogram-linkage instrument (only **Compass/Divider** is not part of a mini-drafter). A **French Curve** is used to draw smooth **irregular (non-circular) curves** (https://dgt.gov.in/).

✓ **Exam Verification Key: Both Statement-I and Statement-II are factually accurate as per Indian Railways Official Portal & IUC Academy.**

Chapter 8 Statement-Verification Drill #5 — Both Statements Verified Correct

Statement-I (18 Grades of Engineering Drawing Pencils (Clay vs. Graphite)): Pencils are graded from **9H (Hardest, highest kaolin clay content)** to **7B (Softest and darkest, highest graphite content)** with **HB** and **F** in the middle. In technical drawing: **H / 2H** is used for visible outlines, dimension lines, and lettering; **2H / 3H** is used for construction lines, projection lines, and leader lines; and **HB** is used for freehand sketching and arrowheads (https://dgt.gov.in/).
Statement-II (Type A (Continuous Thick)): Visible outlines and visible edges.

✓ **Exam Verification Key: Both Statement-I and Statement-II are factually accurate as per Indian Railways Official Portal & IUC Academy.**

Chapter 8 Statement-Verification Drill #6 — Both Statements Verified Correct

Statement-I (Type B (Continuous Thin Straight)): Dimension lines, extension/projection lines, leader lines, and **Hatching (Section) lines inclined at `45 degrees`**.
Statement-II (Type C / D (Continuous Thin Freehand / Zigzag with Z)): Limits of partial or interrupted views.

✓ **Exam Verification Key: Both Statement-I and Statement-II are factually accurate as per Indian Railways Official Portal & IUC Academy.**

Solved Exam Practice Questions (MCQs)

Practice Question #1 — Solved Exam MCQ

1. **What is the Least Count of a standard metric Vernier Caliper where 50 Vernier Scale Divisions coincide with 49 Main Scale Divisions (1 MSD = 1 mm)?**
(A) 0.1 mm | (B) 0.02 mm | (C) 0.01 mm | (D) 0.05 mm
Answer: (B) 0.02 mm -- `LC = 1 MSD - 1 VSD = 1 - 49/50 = 1/50 mm = 0.02 mm` (https://dgt.gov.in/).

Practice Question #2 Solved Exam MCQ

2. **On which mechanical principle does an Outside Micrometer (Screw Gauge) work, and what is its standard metric Least Count?**
(A) Rack and pinion; 0.02 mm | (B) Screw and nut; 0.01 mm | (C) Difference of two scales; 0.01 mm | (D) Lever amplification; 0.001 mm
Answer: (B) Screw and nut; 0.01 mm (`LC = Pitch / Thimble divisions = 0.5 mm / 50 = 0.01 mm`) (https://dgt.gov.in/).

Practice Question #3 Solved Exam MCQ

3. **Which pair of physical quantities possesses the exact same dimensional formula `[M^1 L^2 T^-1]`?**
(A) Force and Impulse | (B) Work and Power | (C) Planck's Constant and Angular Momentum | (D) Stress and Strain
Answer: (C) Planck's Constant (`h = E / nu`) and Angular Momentum (`L = m v r`) both have dimensions `[M^1 L^2 T^-1]` (https://ncert.nic.in/).

Practice Question #4 Solved Exam MCQ

4. **What is the Least Count of a Workshop Vernier Bevel Protractor used for precision angle measurement?**
(A) 1 degree | (B) 5 minutes (`5'`) | (C) 1 minute (`1'`) | (D) 5 seconds (`5''`)
Answer: (B) 5 minutes (`5'` or `1/12th of a degree`) (https://dgt.gov.in/).

Practice Question #5 Solved Exam MCQ

5. **If the mass of a body on the surface of the Earth is 60 kg, what will be its mass and weight on the surface of the Moon (`g_earth = 9.8 m/s^2`)?**
(A) Mass = 10 kg, Weight = 98 N | (B) Mass = 60 kg, Weight = 98 N | (C) Mass = 60 kg, Weight = 588 N | (D) Mass = 10 kg, Weight = 10 N
Answer: (B) Mass = 60 kg (mass is constant everywhere), Weight on Moon = `(60 * 9.8) / 6 = 98 N` (https://ncert.nic.in/).

Practice Question #6 Solved Exam MCQ

6. **At what temperature does pure water possess its maximum density (`1000 kg/m^3`) and minimum volume?**
(A) 0 deg C | (B) 4 deg C | (C) 37 deg C | (D) 100 deg C
Answer: (B) 4 deg C (277.15 K) due to the anomalous expansion of water (https://ncert.nic.in/).

Practice Question #7 Solved Exam MCQ

7. **A solid metal block weighs 50 N in air and 40 N when completely immersed in water at 4 deg C. What is its Relative Density (Specific Gravity)?**
(A) 4.0 | (B) 5.0 | (C) 1.25 | (D) 10.0
Answer: (B) 5.0 -- `RD = Weight in Air / Loss of Weight in Water = 50 / (50 - 40) = 50 / 10 = 5.0` (https://ncert.nic.in/).

Practice Question #8 Solved Exam MCQ

8. **What is the specific gravity of the sulfuric acid electrolyte in a fully charged Lead-Acid storage battery as measured by a Battery Hydrometer?**
(A) 1.00 to 1.05 | (B) 1.11 to 1.15 | (C) 1.25 to 1.28 | (D) 1.84
Answer: (C) 1.25 to 1.28 (drops to ~1.15 when discharged) (https://dgt.gov.in/).

Practice Question #9 Solved Exam MCQ

9. **A train travels from Station A to Station B at a constant speed of 40 km/h and returns from B to A at 60 km/h. What is its average speed and average velocity for the entire journey?**
(A) Average speed = 50 km/h, Average velocity = 50 km/h | (B) Average speed = 48 km/h, Average velocity = 0 | (C) Average speed = 50 km/h, Average velocity = 0 | (D) Average speed = 48 km/h, Average velocity = 48 km/h
Answer: (B) Average speed = `(2 40 60) / (40 + 60) = 48 km/h`; Average velocity = `0` since net displacement is zero (https://ncert.nic.in/).

Practice Question #10 Solved Exam MCQ

10. **A locomotive starting from rest accelerates uniformly at `2 m/s^2`. What is the distance traveled by it during the 5th second (`s_5`) of its motion?**
(A) 25 m | (B) 9 m | (C) 10 m | (D) 16 m
Answer: (B) 9 m -- `s_n = u + (a/2) (2n - 1) = 0 + (2/2) (2*5 - 1) = 9 m` (25 m is total distance in 5 seconds, not the 5th second!) (https://ncert.nic.in/).

Practice Question #11 Solved Exam MCQ

11. **For a projectile launched from horizontal surface, at what angle of projection with the horizontal is the Horizontal Range (`R`) equal to 4 times the Maximum Height (`H_max`)?**
(A) 30 degrees | (B) 45 degrees | (C) 60 degrees | (D) 76 degrees
Answer: (B) 45 degrees -- Since `R / H_max = 4 / tan(theta)`, when `R = 4 * H_max`, `tan(theta) = 1 -> theta = 45 degrees` (where range is also maximum) (https://ncert.nic.in/).

Practice Question #12 Solved Exam MCQ

12. **On a curved railway track of radius `r`, the outer rail is raised above the inner rail (Superelevation/Cant) by an angle `theta` to provide safe turning at speed `v`. What is the formula for `tan(theta)`?**
(A) `v / (r g)` | (B) `v^2 / (r` g) | (C) `(r g) / v^2` | (D) `v^2` r * g
Answer: (B) `tan(theta) = v^2 / (r * g)` (https://indianrailways.gov.in/).

Practice Question #13 Solved Exam MCQ

13. **A railway porter carries a 30 kg suitcase on his head and walks 50 m horizontally along a level platform. How much work is done by him against the force of gravity?**
(A) 1500 J | (B) 14700 J | (C) Zero (0 J) | (D) -14700 J
Answer: (C) Zero (0 J) -- Angle between vertical gravitational/normal force and horizontal displacement is `theta = 90 degrees`, and `cos(90 deg) = 0` (https://ncert.nic.in/).

Practice Question #14 Solved Exam MCQ

14. **If the linear momentum (`p`) of a moving body is increased by 50% (at constant mass), by what percentage will its Kinetic Energy (`KE`) increase?**
(A) 50% | (B) 100% | (C) 125% | (D) 225%
Answer: (C) 125% -- Using `% increase in KE = 2x + (x^2 / 100) = 2(50) + (2500 / 100) = 100 + 25 = 125%` (https://ncert.nic.in/).

Practice Question #15 Solved Exam MCQ

15. **How many Joules are equal to 1 commercial unit of electrical energy (`1 kWh`)?**
(A) `3.6 10^5 J` | (B) `3.6` 10^6 J | (C) `3.6 * 10^7 J` | (D) `746 J`
Answer: (B) `3.6 10^6 J` (`1000 W` 3600 s) (https://ncert.nic.in/).

Practice Question #16 Solved Exam MCQ

16. **An electric motor lifts 300 kg of water to an overhead tank at a vertical height of 20 m in 10 seconds (g = 10 m/s^2). If the efficiency of the pump is 60%, what is the electrical input power required?**
(A) 6 kW | (B) 10 kW | (C) 3.6 kW | (D) 12 kW
Answer: (B) 10 kW -- Output power P_out = (mgh)/t = (3001020)/10 = 6000 W = 6 kW ; Input power P_in = P_out / eta = 6 / 0.60 = 10 kW (https://dgt.gov.in/).

Practice Question #17 Solved Exam MCQ

17. **At what numerical reading do the Celsius and Fahrenheit temperature scales show the exact same value?**
(A) 0 degrees | (B) -40 degrees | (C) +40 degrees | (D) -273.15 degrees
Answer: (B) -40 degrees (-40 deg C = -40 deg F) (https://ncert.nic.in/).

Practice Question #18 Solved Exam MCQ

18. **How much total heat energy (in calories) is required to convert 10 grams of ice at 0 deg C into water at 20 deg C (L_fusion = 80 cal/g , c_water = 1 cal/(g*deg C))?**
(A) 200 cal | (B) 800 cal | (C) 1000 cal | (D) 5400 cal
Answer: (C) 1000 cal -- Q = m *L_f* + *m* c *dT* = (10 80) + (10 1 20) = 800 + 200 = 1000 cal (https://ncert.nic.in/).

Practice Question #19 Solved Exam MCQ

19. **What is the numerical ratio between the Coefficient of Linear Expansion (alpha), Coefficient of Superficial Expansion (beta), and Coefficient of Cubical Expansion (gamma) of an isotropic solid?**
(A) 1 : 1 : 1 | (B) 1 : 2 : 3 | (C) 3 : 2 : 1 | (D) 1 : 4 : 9
Answer: (B) 1 : 2 : 3 (beta = 2 *alpha* *and* *gamma* = 3 alpha) (https://ncert.nic.in/).

Practice Question #20 Solved Exam MCQ

20. **A copper wire of resistance 10 Ohm is uniformly stretched so that its length becomes 3 times its original length (3L) at constant volume. What will be its new resistance and new resistivity?**
(A) Resistance = 30 Ohm , Resistivity = 3 *rho* | (B) *Resistance* = 90 *Ohm* , *Resistivity remains unchanged* (*rho*) | (C) *Resistance* = 90 *Ohm* , *Resistivity* = 9 rho | (D) Resistance = 10/3 Ohm , Resistivity remains unchanged (rho)
Answer: (B) Resistance = n^2 *R* = 3^2 10 = 90 Ohm , while Resistivity (rho) remains completely unchanged because material and temperature are unchanged (https://ncert.nic.in/).

Practice Question #21 Solved Exam MCQ

21. **Three resistors of 2 Ohm , 3 Ohm , and 6 Ohm are connected in parallel across a 12 V DC battery. What is the equivalent resistance of the circuit and the total current drawn from the battery?**
(A) 11 Ohm and 1.09 A | (B) 1 Ohm and 12 A | (C) 2 Ohm and 6 A | (D) 0.5 Ohm and 24 A
Answer: (B) 1 Ohm and 12 A -- 1/R_eq = 1/2 + 1/3 + 1/6 = (3+2+1)/6 = 1 -> R_eq = 1 Ohm , and I = V / R_eq = 12 / 1 = 12 A (https://ncert.nic.in/).

Practice Question #22 Solved Exam MCQ

22. **Kirchhoff's Current Law (First Law / Junction Rule) and Kirchhoff's Voltage Law (Second Law / Loop Rule) are based respectively on the conservation of which two fundamental quantities?**
(A) Energy and Momentum | (B) Electric Charge and Energy | (C) Energy and Electric Charge | (D) Mass and Charge
Answer: (B) KCL is based on Conservation of Electric Charge, and KVL is based on Conservation of Energy (https://ncert.nic.in/).

Practice Question #23 Solved Exam MCQ

23. **Which two essential properties must an electric safety Fuse Wire (made of Tin-Lead alloy) possess?**
(A) Low resistivity and high melting point | (B) High resistivity and low melting point | (C) High resistivity and high melting point | (D) Low resistivity and low melting point
Answer: (B) High resistivity and low melting point (so that excess current rapidly heats and melts the fuse to break the circuit) (https://dgt.gov.in/).

Practice Question #24 Solved Exam MCQ

24. **An electrical workshop runs five `100 W` lamps and two `1000 W` heaters for 4 hours every day. How many commercial units (`kWh`) of electricity are consumed in 30 days?**
(A) 100 Units | (B) 150 Units | (C) 300 Units | (D) 360 Units
Answer: (C) 300 Units -- Total Power = `(5 100) + (2 1000) = 2500 W = 2.5 kW`; Energy in 30 days = `2.5 kW 4 h/day 30 days = 300 kWh (Units)` (https://dgt.gov.in/).

Practice Question #25 Solved Exam MCQ

25. **In a Step-Up Transformer connected to a `230 V, 50 Hz` AC supply, which physical quantity remains unchanged between the primary and secondary windings?**
(A) Voltage | (B) Current | (C) Frequency (`50 Hz`) | (D) Number of turns
Answer: (C) Frequency (`50 Hz`) remains constant in a transformer (https://dgt.gov.in/).

Practice Question #26 Solved Exam MCQ

26. **A simple lifting machine has a Velocity Ratio (`VR`) of 20 and lifts a load of `1200 N` with an effort of `100 N`. What is its Mechanical Advantage (`MA`), Efficiency (`eta`), and is the machine self-locking?**
(A) `MA = 12`, `eta = 60%`, Reversible (Not self-locking) | (B) `MA = 12`, `eta = 60%`, Self-locking | (C) `MA = 20`, `eta = 100%`, Ideal | (D) `MA = 8`, `eta = 40%`, Self-locking
Answer: (A) `MA = L / E = 1200 / 100 = 12`; `eta = (MA / VR) 100 = (12 / 20) 100 = 60%`; since `eta >= 50%`, it is Reversible (not self-locking) (https://dgt.gov.in/).

Practice Question #27 Solved Exam MCQ

27. **Which of the following is an example of a Second-Class Lever (where Mechanical Advantage is ALWAYS greater than 1)?**
(A) Pair of Scissors | (B) Fire Tongs (*Chimta*) | (C) Wheelbarrow and Nutcracker | (D) Human Forearm holding a weight
Answer: (C) Wheelbarrow and Nutcracker have the Load (`L`) in the middle between Fulcrum (`F`) and Effort (`E`), so `MA > 1` always (https://dgt.gov.in/).

Practice Question #28 Solved Exam MCQ

28. **Which class of lever ALWAYS has a Mechanical Advantage less than 1 (`MA < 1`) and functions as a speed or distance multiplier?**
(A) First-Class Lever | (B) Second-Class Lever | (C) Third-Class Lever | (D) Compound Pulley
Answer: (C) Third-Class Lever (Effort `E` is in the middle, so Effort Arm < Load Arm and `MA < 1`) (https://dgt.gov.in/).

Practice Question #29 Solved Exam MCQ

29. **According to BIS SP 46 / IS 10711:2001, what are the standard trimmed dimensions (in mm) of an A2 Drawing Sheet and an A4 Drawing Sheet respectively?**
(A) **A2: 594 841 *mm*** ; **A4: 210** 297 mm | (B) **A2: 420 594 *mm*** ; **A4: 210** 297 mm | (C) **A2: 297 420 *mm*** ; **A4: 148** 210 mm | (D) **A2: 841 1189 *mm*** ; **A4: 297** 420 mm
Answer: (B) **A2 = 420 mm 594 *mm*** *and* **A4 = 210 *mm*** 297 mm (https://www.bis.gov.in/).

Practice Question #30 Solved Exam MCQ

30. **According to BIS SP 46 standards, what is the standard size of the Title Block on an engineering drawing sheet, and where is it located?**
(A) **185 mm 65 *mm*** *at the bottom right-hand corner* | (B) **170 *mm*** 65 mm at the top right-hand corner | (C) **185 mm 55 *mm*** *at the bottom left-hand corner* | (D) **210 *mm*** 65 mm at the center bottom
Answer: (A) **185 mm * 65 mm** at the bottom right-hand corner (https://www.bis.gov.in/).

Practice Question #31 Solved Exam MCQ

31. **In First-Angle Orthographic Projection (the standard adopted by the Bureau of Indian Standards), where is the Top View (Plan) drawn relative to the Front View (Elevation)?**
(A) Directly above the Front View | (B) Directly below the Front View | (C) To the left of the Front View | (D) To the right of the Front View
Answer: (B) Directly below the Front View (whereas in Third-Angle Projection, the Top View is drawn above the Front View) (https://www.bis.gov.in/).

Practice Question #32 Solved Exam MCQ

32. **According to IS 10714 (Engineering Drawing Lines), what does a 'Continuous Thin Straight Line' inclined at 45 degrees represent, and what does a 'Dashed Thin/Thick Line' represent?**
(A) Center line and Visible outline | (B) Section hatching line and Hidden edge/outline | (C) Hidden edge and Cutting plane | (D) Short break line and Long break line
Answer: (B) Continuous thin lines at **45 deg** represent Hatching (Sectioning) lines, and Dashed lines represent Hidden outlines/edges (https://www.bis.gov.in/).

Practice Question #33 Solved Exam MCQ

33. **In workshop safety signage (ISO / BIS standards), a Triangular sign with a Yellow backdrop, Black border, and Black symbol represents which category of safety sign?**
(A) Prohibition Sign | (B) Mandatory Sign | (C) Warning / Caution Sign | (D) Emergency Information Sign
Answer: (C) Warning / Caution Sign (Mandatory signs are Blue circles; Prohibition signs are White circles with Red crossbar) (https://dgt.gov.in/).

Practice Question #34 Solved Exam MCQ

34. **Which fire extinguisher must be used to extinguish a live Electrical Fire in a railway traction sub-station or ITI workshop (and which must NEVER be used)?**
(A) Use CO2 or Halon (CTC); Never use Water or Foam | (B) Use Water jet; Never use CO2 | (C) Use Soda-Acid; Never use Dry Powder | (D) Use Foam; Never use Sand
Answer: (A) Use Carbon Dioxide (CO2), Halon/CTC, or Dry Powder; NEVER use Water or Foam because they conduct electricity (https://dgt.gov.in/).

Practice Question #35 Solved Exam MCQ

35. **In the Japanese 5S Workshop Management System, what is the correct English meaning of the five sequential steps (Seiri, Seiton, Seiso, Seiketsu, Shitsuke)?**
(A) Shine, Sort, Sustain, Standardize, Set in Order | (B) Sort, Set in Order, Shine, Standardize, Sustain | (C) Sort, Shine, Set in Order, Sustain, Standardize | (D) Standardize, Sort, Set in Order, Shine, Sustain
Answer: (B) Seiri (Sort) -> Seiton (Set in Order) -> Seiso (Shine) -> Seiketsu (Standardize) -> Shitsuke (Sustain) (**https://dgt.gov.in/**).

Extended Comparative & Analytical Practice Set (Questions *36* to *75*)

Practice Question #36 High-Yield Comparative MCQ

Q36. With reference to Physical Quantity / Instrument and Formula / Working Principle, which of the following is accurately matched with "Force (F)"?

(A) **F = m *a*** (*Mass* Acceleration)
(B) **W = F *d* cos(theta)**
(C) **P = F / A** (Force / Area)
(D) **F = eta *A* (dv / dx)**

Correct Answer: (A) | **Explanation:** For **Force (F)** (Physical Quantity / Instrument), the verified Formula / Working Principle is **F = m *a*** (***Mass* Acceleration**). Furthermore, **Newton (N) = kg*m/s^2**; **1 N = 10^5 dyne**. (Source: Indian Railways Official Portal & IUC Academy).

Practice Question #37 High-Yield Comparative MCQ

Q37. With reference to Physical Quantity / Instrument and Formula / Working Principle, which of the following is accurately matched with "Work / Energy (W)"?

(A) **P = F / A** (Force / Area)
(B) **W = F *d* cos(theta)**
(C) **F = eta *A* (dv / dx)**
(D) Difference of two scales (**1 MSD - 1 VSD**)

Correct Answer: (B) | **Explanation:** For **Work / Energy (W)** (Physical Quantity / Instrument), the verified Formula / Working Principle is **W = F *d* cos(theta)**. Furthermore, **Joule (J) = N*m**; **1 J = 10^7 erg**. (Source: Indian Railways Official Portal & IUC Academy).

Practice Question #38 High-Yield Comparative MCQ

Q38. With reference to Physical Quantity / Instrument and Formula / Working Principle, which of the following is accurately matched with "Pressure / Stress (P)"?

(A) **F = eta *A* (dv / dx)**
(B) Difference of two scales (**1 MSD - 1 VSD**)
(C) **P = F / A** (Force / Area)
(D) Screw and Nut (**Pitch / Thimble Divisions**)

Correct Answer: (C) | **Explanation:** For **Pressure / Stress (P)** (Physical Quantity / Instrument), the verified Formula / Working Principle is **P = F / A** (**Force / Area**). Furthermore, **Pascal (Pa) = N/m^2**; **1 Bar = 10^5 Pa**. (Source: Indian Railways Official Portal & IUC Academy).

Practice Question #39 High-Yield Comparative MCQ

Q39. With reference to Physical Quantity / Instrument and Formula / Working Principle, which of the following is accurately matched with “Dynamic Viscosity (eta)”?

(A) Difference of two scales (**1 MSD - 1 VSD**)
(B) Screw and Nut (**Pitch / Thimble Divisions**)
(C) **1.00 g/cm^3**
(D) **F = eta *A* (dv / dx)**

Correct Answer: (D) | **Explanation:** For **Dynamic Viscosity (eta)** (Physical Quantity / Instrument), the verified Formula / Working Principle is **F = eta *A* (dv / dx)**. Furthermore, **Pas** *or* ***N*** s/m^2; **1 Pa*s = 10 Poise**. (Source: Indian Railways Official Portal & IUC Academy).

Practice Question #40 High-Yield Comparative MCQ

Q40. With reference to Physical Quantity / Instrument and Formula / Working Principle, which of the following is accurately matched with “Metric Vernier Caliper”?

(A) Difference of two scales (**1 MSD - 1 VSD**)
(B) Screw and Nut (**Pitch / Thimble Divisions**)
(C) **1.00 g/cm^3**
(D) **0.90 - 0.92 g/cm^3**

Correct Answer: (A) | **Explanation:** For **Metric Vernier Caliper** (Physical Quantity / Instrument), the verified Formula / Working Principle is **Difference of two scales (1 MSD - 1 VSD)**. Furthermore, Millimetre (**mm**). (Source: Indian Railways Official Portal & IUC Academy).

Practice Question #41 High-Yield Comparative MCQ

Q41. With reference to Physical Quantity / Instrument and Formula / Working Principle, which of the following is accurately matched with “Outside Micrometer”?

(A) **1.00 g/cm^3**
(B) Screw and Nut (**Pitch / Thimble Divisions**)
(C) **0.90 - 0.92 g/cm^3**
(D) **2.70 g/cm^3**

Correct Answer: (B) | **Explanation:** For **Outside Micrometer** (Physical Quantity / Instrument), the verified Formula / Working Principle is **Screw and Nut (Pitch / Thimble Divisions)**. Furthermore, Millimetre (**mm**). (Source: Indian Railways Official Portal & IUC Academy).

Practice Question #42 High-Yield Comparative MCQ

Q42. With reference to Substance / Engineering Material and Density in CGS (g/cm^3), which of the following is accurately matched with “Pure Water (at 4 deg C)”?

(A) **0.90 - 0.92 g/cm^3**
(B) **2.70 g/cm^3**
(C) **1.00 g/cm^3**
(D) **7.20 - 7.85 g/cm^3**

Correct Answer: (C) | **Explanation:** For **Pure Water (at 4 deg C)** (Substance / Engineering Material), the verified Density in CGS (**g/cm^3**) is **1.00 g/cm^3**. Furthermore, **1,000 kg/m^3**. (Source: Indian Railways Official Portal & IUC Academy).

Practice Question #43 High-Yield Comparative MCQ

Q43. With reference to Substance / Engineering Material and Density in CGS (`g/cm^3`), which of the following is accurately matched with "Ice (at 0 deg C)"?

(A) `2.70 g/cm^3`
(B) `7.20 - 7.85 g/cm^3`
(C) `8.96 / 11.34 g/cm^3`
(D) `0.90 - 0.92 g/cm^3`

Correct Answer: (D) | **Explanation:** For **Ice (at 0 deg C)** (Substance / Engineering Material), the verified Density in CGS (`g/cm^3`) is `0.90 - 0.92 g/cm^3`. Furthermore, `900 - 920 kg/m^3`. (Source: Indian Railways Official Portal & IUC Academy).

Practice Question #44 High-Yield Comparative MCQ

Q44. With reference to Substance / Engineering Material and Density in CGS (`g/cm^3`), which of the following is accurately matched with "Aluminium (Al)"?

(A) `2.70 g/cm^3`
(B) `7.20 - 7.85 g/cm^3`
(C) `8.96 / 11.34 g/cm^3`
(D) `13.60 / 19.30 g/cm^3`

Correct Answer: (A) | **Explanation:** For **Aluminium (Al)** (Substance / Engineering Material), the verified Density in CGS (`g/cm^3`) is `2.70 g/cm^3`. Furthermore, `2,700 kg/m^3`. (Source: Indian Railways Official Portal & IUC Academy).

Practice Question #45 High-Yield Comparative MCQ

Q45. With reference to Substance / Engineering Material and Density in CGS (`g/cm^3`), which of the following is accurately matched with "Cast Iron / Mild Steel"?

(A) `8.96 / 11.34 g/cm^3`
(B) `7.20 - 7.85 g/cm^3`
(C) `13.60 / 19.30 g/cm^3`
(D) `v_avg = (2 v1 v2) / (v1 + v2)`

Correct Answer: (B) | **Explanation:** For **Cast Iron / Mild Steel** (Substance / Engineering Material), the verified Density in CGS (`g/cm^3`) is `7.20 - 7.85 g/cm^3`. Furthermore, `7,200 - 7,850 kg/m^3`. (Source: Indian Railways Official Portal & IUC Academy).

Practice Question #46 High-Yield Comparative MCQ

Q46. With reference to Substance / Engineering Material and Density in CGS (`g/cm^3`), which of the following is accurately matched with "Copper (Cu) / Lead (Pb)"?

(A) `13.60 / 19.30 g/cm^3`
(B) `v_avg = (2 v1 v2) / (v1 + v2)`
(C) `8.96 / 11.34 g/cm^3`
(D) `s_n = u + (a / 2) * (2n - 1)`

Correct Answer: (C) | **Explanation:** For **Copper (Cu) / Lead (Pb)** (Substance / Engineering Material), the verified Density in CGS (`g/cm^3`) is `8.96 / 11.34 g/cm^3`. Furthermore, `8,960 / 11,340 kg/m^3`. (Source: Indian Railways Official Portal & IUC Academy).

Practice Question #47 High-Yield Comparative MCQ

Q47. With reference to Substance / Engineering Material and Density in CGS (`g/cm^3`), which of the following is accurately matched with “Mercury (Hg) / Gold (Au)”?

(A) `v_avg = (2 v1 v2) / (v1 + v2)`
(B) `s_n = u + (a / 2) * (2n - 1)`
(C) `p = m v`; `J = F` t = dp
(D) `13.60 / 19.30 g/cm^3`

Correct Answer: (D) | **Explanation:** For **Mercury (Hg) / Gold (Au)** (Substance / Engineering Material), the verified Density in CGS (`g/cm^3`) is `13.60 / 19.30 g/cm^3`. Furthermore, `13,600 / 19,300 kg/m^3`. (Source: Indian Railways Official Portal & IUC Academy).

Practice Question #48 High-Yield Comparative MCQ

Q48. With reference to Physical Concept / Law and Mathematical Formula, which of the following is accurately matched with “Harmonic Mean Average Speed”?

(A) `v_avg = (2 v1 v2) / (v1 + v2)`
(B) `s_n = u + (a / 2) * (2n - 1)`
(C) `p = m v`; `J = F` t = dp
(D) `m1u1 + m2u2 = m1v1 + m2v2`

Correct Answer: (A) | **Explanation:** For **Harmonic Mean Average Speed** (Physical Concept / Law), the verified Mathematical Formula is `v_avg = (2 v1 v2) / (v1 + v2)`. Furthermore, Scalar (`m/s`). (Source: Indian Railways Official Portal & IUC Academy).

Practice Question #49 High-Yield Comparative MCQ

Q49. With reference to Physical Concept / Law and Mathematical Formula, which of the following is accurately matched with “Displacement in `n-th` Second”?

(A) `p = m v`; `J = F` t = dp
(B) `s_n = u + (a / 2) * (2n - 1)`
(C) `m1u1 + m2u2 = m1v1 + m2v2`
(D) `F_c = mv^2/r`; `tan(theta) = v^2/(r` g)

Correct Answer: (B) | **Explanation:** For **Displacement in `n-th` Second** (Physical Concept / Law), the verified Mathematical Formula is `s_n = u + (a / 2) * (2n - 1)`. Furthermore, Vector (`m`). (Source: Indian Railways Official Portal & IUC Academy).

Practice Question #50 High-Yield Comparative MCQ

Q50. With reference to Physical Concept / Law and Mathematical Formula, which of the following is accurately matched with “Linear Momentum & Impulse”?

(A) `m1u1 + m2u2 = m1v1 + m2v2`
(B) `F_c = mv^2/r`; `tan(theta) = v^2/(r` g)
(C) `p = m v`; `J = F` t = dp
(D) `R_max = u^2 / g` (at `theta = 45 deg`)

Correct Answer: (C) | **Explanation:** For **Linear Momentum & Impulse** (Physical Concept / Law), the verified Mathematical Formula is `p = m v`; `J = F` **t = dp**. Furthermore, Vector (`kgm/s` *or* `N` s). (Source: Indian Railways Official Portal & IUC Academy).

Practice Question #51 High-Yield Comparative MCQ

Q51. With reference to Physical Concept / Law and Mathematical Formula, which of the following is accurately matched with "Conservation of Momentum"?

(A) F_c = mv^2/r ; tan(theta) = v^2/(r g)
(B) R_max = u^2 / g (at theta = 45 deg)
(C) W = F s cos(theta)
(D) m1u1 + m2u2 = m1v1 + m2v2

Correct Answer: (D) | **Explanation:** For **Conservation of Momentum** (Physical Concept / Law), the verified Mathematical Formula is m1u1 + m2u2 = m1v1 + m2v2. Furthermore, Vector (kg*m/s). (Source: Indian Railways Official Portal & IUC Academy).

Practice Question #52 High-Yield Comparative MCQ

Q52. With reference to Physical Concept / Law and Mathematical Formula, which of the following is accurately matched with "Centripetal Force & Banking"?

(A) F_c = mv^2/r ; tan(theta) = v^2/(r g)
(B) R_max = u^2 / g (at theta = 45 deg)
(C) W = F s cos(theta)
(D) KE = 0.5 m v^2 = p^2 / (2m)

Correct Answer: (A) | **Explanation:** For **Centripetal Force & Banking** (Physical Concept / Law), the verified Mathematical Formula is F_c = mv^2/r ; tan(theta) = v^2/(r g). Furthermore, Vector (N); Angle (deg). (Source: Indian Railways Official Portal & IUC Academy).

Practice Question #53 High-Yield Comparative MCQ

Q53. With reference to Physical Concept / Law and Mathematical Formula, which of the following is accurately matched with "Maximum Projectile Range"?

(A) W = F s cos(theta)
(B) R_max = u^2 / g (at theta = 45 deg)
(C) KE = 0.5 m v^2 = p^2 / (2m)
(D) PE_g = mgh ; PE_s = 0.5kx^2

Correct Answer: (B) | **Explanation:** For **Maximum Projectile Range** (Physical Concept / Law), the verified Mathematical Formula is R_max = u^2 / g (at theta = 45 deg). Furthermore, Scalar (m). (Source: Indian Railways Official Portal & IUC Academy).

Practice Question #54 High-Yield Comparative MCQ

Q54. With reference to Physical Parameter and Mathematical Formula, which of the following is accurately matched with "Mechanical Work (W)"?

(A) KE = 0.5 m v^2 = p^2 / (2m)
(B) PE_g = mgh ; PE_s = 0.5kx^2
(C) W = F s cos(theta)
(D) P = W / t = (m g h) / t = F * v

Correct Answer: (C) | **Explanation:** For **Mechanical Work (W)** (Physical Parameter), the verified Mathematical Formula is W = F s cos(theta). Furthermore, Joule (J) = N*m = 10^7 erg. (Source: Indian Railways Official Portal & IUC Academy).

Practice Question #55 High-Yield Comparative MCQ

Q55. With reference to Physical Parameter and Mathematical Formula, which of the following is accurately matched with "Kinetic Energy (KE)"?

(A) PE_g = mgh ; PE_s = 0.5kx^2
(B) P = W / t = (m g h) / t = F * v
(C) E = P (in kW) * t (in hours)
(D) KE = 0.5 m v^2 = p^2 / (2m)

Correct Answer: (D) | **Explanation:** For **Kinetic Energy (KE)** (Physical Parameter), the verified Mathematical Formula is KE = 0.5 m v^2 = p^2 / (2m). Furthermore, Joule (J). (Source: Indian Railways Official Portal & IUC Academy).

Practice Question #56 High-Yield Comparative MCQ

Q56. With reference to Physical Parameter and Mathematical Formula, which of the following is accurately matched with "Gravitational & Spring PE "?

(A) PE_g = mgh ; PE_s = 0.5kx^2
(B) P = W / t = (m g h) / t = F * v
(C) E = P (in kW) * t (in hours)
(D) C/5 = (F-32)/9 = (K-273)/5 = R/4

Correct Answer: (A) | **Explanation:** For **Gravitational & Spring PE** (Physical Parameter), the verified Mathematical Formula is PE_g = mgh ; PE_s = 0.5kx^2. Furthermore, Joule (J). (Source: Indian Railways Official Portal & IUC Academy).

Practice Question #57 High-Yield Comparative MCQ

Q57. With reference to Physical Parameter and Mathematical Formula, which of the following is accurately matched with "Mechanical Power (P)"?

(A) E = P (in kW) * t (in hours)
(B) P = W / t = (m g h) / t = F * v
(C) C/5 = (F-32)/9 = (K-273)/5 = R/4
(D) Q = m c dT

Correct Answer: (B) | **Explanation:** For **Mechanical Power (P)** (Physical Parameter), the verified Mathematical Formula is P = W / t = (m g h) / t = F * v. Furthermore, Watt (W) = J/s. (Source: Indian Railways Official Portal & IUC Academy).

Practice Question #58 High-Yield Comparative MCQ

Q58. With reference to Physical Parameter and Mathematical Formula, which of the following is accurately matched with "Commercial Energy (1 Unit)"?

(A) C/5 = (F-32)/9 = (K-273)/5 = R/4
(B) Q = m c dT
(C) E = P (in kW) * t (in hours)
(D) Q = m * L_f (at 0 deg C)

Correct Answer: (C) | **Explanation:** For **Commercial Energy (1 Unit)** (Physical Parameter), the verified Mathematical Formula is E = P (in kW) * t (in hours). Furthermore, 1 kWh = 1 Unit. (Source: Indian Railways Official Portal & IUC Academy).

Practice Question #59 High-Yield Comparative MCQ

Q59. With reference to Thermal Quantity / Scale and Formula / Numerical Value, which of the following is accurately matched with "Scale Conversion"?

(A) `Q = m c dT`
(B) `Q = m * L_f` (at `0 deg C`)
(C) `Q = m * L_v` (at `100 deg C`)
(D) `C/5 = (F-32)/9 = (K-273)/5 = R/4`

Correct Answer: (D) | **Explanation:** For **Scale Conversion** (Thermal Quantity / Scale), the verified Formula / Numerical Value is `C/5 = (F-32)/9 = (K-273)/5 = R/4`. Furthermore, `K` (SI), `deg C`, `deg F`, `deg R`. (Source: Indian Railways Official Portal & IUC Academy).

Practice Question #60 High-Yield Comparative MCQ

Q60. With reference to Thermal Quantity / Scale and Formula / Numerical Value, which of the following is accurately matched with "Specific Heat of Water (`c`)"?

(A) `Q = m c dT`
(B) `Q = m * L_f` (at `0 deg C`)
(C) `Q = m * L_v` (at `100 deg C`)
(D) `alpha : beta : gamma = 1 : 2 : 3`

Correct Answer: (A) | **Explanation:** For **Specific Heat of Water (`c`)** (Thermal Quantity / Scale), the verified Formula / Numerical Value is `Q = m c dT`. Furthermore, `4186 J/(kgK)` *or* `1 cal/(g` deg C). (Source: Indian Railways Official Portal & IUC Academy).

Practice Question #61 High-Yield Comparative MCQ

Q61. With reference to Thermal Quantity / Scale and Formula / Numerical Value, which of the following is accurately matched with "Latent Heat of Ice (`L_f`)"?

(A) `Q = m * L_v` (at `100 deg C`)
(B) `Q = m * L_f` (at `0 deg C`)
(C) `alpha : beta : gamma = 1 : 2 : 3`
(D) `V = I R`; `R = rho` L / A; `R' = n^2 * R`

Correct Answer: (B) | **Explanation:** For **Latent Heat of Ice (`L_f`)** (Thermal Quantity / Scale), the verified Formula / Numerical Value is `Q = m * L_f` **(at `0 deg C`)**. Furthermore, `3.36 * 10^5 J/kg` or `80 cal/g`. (Source: Indian Railways Official Portal & IUC Academy).

Practice Question #62 High-Yield Comparative MCQ

Q62. With reference to Thermal Quantity / Scale and Formula / Numerical Value, which of the following is accurately matched with "Latent Heat of Steam (`L_v`)"?

(A) `alpha : beta : gamma = 1 : 2 : 3`
(B) `V = I R`; `R = rho` L / A; `R' = n^2 * R`
(C) `Q = m * L_v` (at `100 deg C`)
(D) `Sum(I_node) = 0`; `Sum(V_loop) = 0`

Correct Answer: (C) | **Explanation:** For **Latent Heat of Steam (`L_v`)** (Thermal Quantity / Scale), the verified Formula / Numerical Value is `Q = m * L_v` **(at `100 deg C`)**. Furthermore, `2.26 * 10^6 J/kg` or `540 cal/g`. (Source: Indian Railways Official Portal & IUC Academy).

Practice Question #63 High-Yield Comparative MCQ

Q63. With reference to Thermal Quantity / Scale and Formula / Numerical Value, which of the following is accurately matched with "Thermal Expansion Ratio"?

(A) `V = I R` ; `R = rho` L / A; `R' = n^2 * R`
(B) `Sum(I_node) = 0` ; `Sum(V_loop) = 0`
(C) Tin (63%) + Lead (37%) Solder Alloy
(D) `alpha : beta : gamma = 1 : 2 : 3`

Correct Answer: (D) | **Explanation:** For **Thermal Expansion Ratio** (Thermal Quantity / Scale), the verified Formula / Numerical Value is `alpha : beta : gamma = 1 : 2 : 3`. Furthermore, `per deg C` (`deg C^-1`) or `K^-1`. (Source: Indian Railways Official Portal & IUC Academy).

Practice Question #64 High-Yield Comparative MCQ

Q64. With reference to Electrical Device / Law and Governing Formula / Alloy, which of the following is accurately matched with "Ohm's Law & Wire Stretching"?

(A) `V = I R` ; `R = rho` L / A; `R' = n^2 * R`
(B) `Sum(I_node) = 0` ; `Sum(V_loop) = 0`
(C) Tin (63%) + Lead (37%) Solder Alloy
(D) Nichrome (80% Ni + 20% Cr); Tungsten (`W`)

Correct Answer: (A) | **Explanation:** For **Ohm's Law & Wire Stretching** (Electrical Device / Law), the verified Governing Formula / Alloy is `V = I R` ; `R = rho` **L / A;** `R' = n^2 * R`. Furthermore, `rho` depends only on material & temperature. (Source: Indian Railways Official Portal & IUC Academy).

Practice Question #65 High-Yield Comparative MCQ

Q65. With reference to Electrical Device / Law and Governing Formula / Alloy, which of the following is accurately matched with "Kirchhoff's Laws (KCL & KVL)"?

(A) Tin (63%) + Lead (37%) Solder Alloy
(B) `Sum(I_node) = 0` ; `Sum(V_loop) = 0`
(C) Nichrome (80% Ni + 20% Cr); Tungsten (`W`)
(D) `V_s / V_p = N_s / N_p = I_p / I_s`

Correct Answer: (B) | **Explanation:** For **Kirchhoff's Laws (KCL & KVL)** (Electrical Device / Law), the verified Governing Formula / Alloy is `Sum(I_node) = 0` ; `Sum(V_loop) = 0`. Furthermore, KCL -> Charge Conservation; KVL -> Energy Conservation. (Source: Indian Railways Official Portal & IUC Academy).

Practice Question #66 High-Yield Comparative MCQ

Q66. With reference to Electrical Device / Law and Governing Formula / Alloy, which of the following is accurately matched with "Electric Fuse Wire"?

(A) Nichrome (80% Ni + 20% Cr); Tungsten (`W`)
(B) `V_s / V_p = N_s / N_p = I_p / I_s`
(C) Tin (63%) + Lead (37%) Solder Alloy
(D) Fulcrum (`F`) in middle

Correct Answer: (C) | **Explanation:** For **Electric Fuse Wire** (Electrical Device / Law), the verified Governing Formula / Alloy is **Tin (63%) + Lead (37%) Solder Alloy**. Furthermore, High Resistivity & Low Melting Point. (Source: Indian Railways Official Portal & IUC Academy).

Practice Question #67 High-Yield Comparative MCQ

Q67. With reference to Electrical Device / Law and Governing Formula / Alloy, which of the following is accurately matched with "Heating Element & Filament"?

(A) `V_s / V_p = N_s / N_p = I_p / I_s`
(B) Fulcrum (`F`) in middle
(C) Load (`L`) in middle
(D) Nichrome (80% Ni + 20% Cr); Tungsten (`W`)

Correct Answer: (D) | **Explanation:** For **Heating Element & Filament** (Electrical Device / Law), the verified Governing Formula / Alloy is **Nichrome (80% Ni + 20% Cr); Tungsten (`W`)**. Furthermore, High Resistivity & High Melting Point (`3380 deg C` for W). (Source: Indian Railways Official Portal & IUC Academy).

Practice Question #68 High-Yield Comparative MCQ

Q68. With reference to Electrical Device / Law and Governing Formula / Alloy, which of the following is accurately matched with "AC Transformer"?

(A) `V_s / V_p = N_s / N_p = I_p / I_s`
(B) Fulcrum (`F`) in middle
(C) Load (`L`) in middle
(D) Effort (`E`) in middle

Correct Answer: (A) | **Explanation:** For **AC Transformer** (Electrical Device / Law), the verified Governing Formula / Alloy is `V_s / V_p = N_s / N_p = I_p / I_s`. Furthermore, Works on Mutual Induction; Laminated Silicon Steel core. (Source: Indian Railways Official Portal & IUC Academy).

Practice Question #69 High-Yield Comparative MCQ

Q69. With reference to Lever / Machine Type and Central Element / Geometry, which of the following is accurately matched with "Class 1 Lever"?

(A) Load (`L`) in middle
(B) Fulcrum (`F`) in middle
(C) Effort (`E`) in middle
(D) `n` pulleys in two blocks

Correct Answer: (B) | **Explanation:** For **Class 1 Lever** (Lever / Machine Type), the verified Central Element / Geometry is **Fulcrum (`F`) in middle**. Furthermore, `MA > 1`, `MA = 1`, or `MA < 1`. (Source: Indian Railways Official Portal & IUC Academy).

Practice Question #70 High-Yield Comparative MCQ

Q70. With reference to Lever / Machine Type and Central Element / Geometry, which of the following is accurately matched with "Class 2 Lever"?

(A) Effort (`E`) in middle
(B) `n` pulleys in two blocks
(C) Load (`L`) in middle
(D) Lever arm `R`, thread pitch `p`

Correct Answer: (C) | **Explanation:** For **Class 2 Lever** (Lever / Machine Type), the verified Central Element / Geometry is **Load (`L`) in middle**. Furthermore, Always `MA > 1` (`d_E > d_L`). (Source: Indian Railways Official Portal & IUC Academy).

Practice Question #71 High-Yield Comparative MCQ

Q71. With reference to Lever / Machine Type and Central Element / Geometry, which of the following is accurately matched with "Class 3 Lever"?

(A) `n` pulleys in two blocks
(B) Lever arm `R`, thread pitch `p`
(C) Aspect Ratio `1 : sqrt(2)`; `A0 Area = 1 m^2`
(D) Effort (`E`) in middle

Correct Answer: (D) | **Explanation:** For **Class 3 Lever** (Lever / Machine Type), the verified Central Element / Geometry is **Effort (`E`) in middle**. Furthermore, Always `MA < 1` (`d_E < d_L`). (Source: Indian Railways Official Portal & IUC Academy).

Practice Question #72 High-Yield Comparative MCQ

Q72. With reference to Lever / Machine Type and Central Element / Geometry, which of the following is accurately matched with "Block & Tackle Pulley"?

(A) `n` pulleys in two blocks
(B) Lever arm `R`, thread pitch `p`
(C) Aspect Ratio `1 : sqrt(2)`; `A0 Area = 1 m^2`
(D) Object in 1st Quadrant (`Observer -> Object -> Plane`)

Correct Answer: (A) | **Explanation:** For **Block & Tackle Pulley** (Lever / Machine Type), the verified Central Element / Geometry is `n` **pulleys in two blocks**. Furthermore, `VR = n` (`MA = eta * n`). (Source: Indian Railways Official Portal & IUC Academy).

Practice Question #73 High-Yield Comparative MCQ

Q73. With reference to Lever / Machine Type and Central Element / Geometry, which of the following is accurately matched with "Screw Jack"?

(A) Aspect Ratio `1 : sqrt(2)`; `A0 Area = 1 m^2`
(B) Lever arm `R`, thread pitch `p`
(C) Object in 1st Quadrant (`Observer -> Object -> Plane`)
(D) Warning = Triangle; Mandatory = Circle

Correct Answer: (B) | **Explanation:** For **Screw Jack** (Lever / Machine Type), the verified Central Element / Geometry is **Lever arm `R`, thread pitch `p`**. Furthermore, `VR = (2 pi R) / p`. (Source: Indian Railways Official Portal & IUC Academy).

Practice Question #74 High-Yield Comparative MCQ

Q74. With reference to Standard / Safety Item and Specification / Geometry, which of the following is accurately matched with "Drawing Sheet Sizes (IS 10711)"?

(A) Object in 1st Quadrant (`Observer -> Object -> Plane`)
(B) Warning = Triangle; Mandatory = Circle
(C) Aspect Ratio `1 : sqrt(2)`; `A0 Area = 1 m^2`
(D) A = Solid; B = Liquid; C = Gas; D/Elec = Metal/Electrical

Correct Answer: (C) | **Explanation:** For **Drawing Sheet Sizes (IS 10711)** (Standard / Safety Item), the verified Specification / Geometry is **Aspect Ratio** `1 : sqrt(2)`; `A0 Area = 1 m^2`. Furthermore, `A0: 8411189`; `A1: 594` 841; `A2: 420594`; `A3: 297` 420; `A4: 210*297 mm`. (Source: Indian Railways Official Portal & IUC Academy).

Practice Question #75 High-Yield Comparative MCQ

Q75. With reference to Standard / Safety Item and Specification / Geometry, which of the following is accurately matched with "First-Angle Projection (BIS)"?

(A) Warning = Triangle; Mandatory = Circle

(B) A = Solid; B = Liquid; C = Gas; D/Elec = Metal/Electrical

(C) Seiri, Seiton, Seiso, Seiketsu, Shitsuke

(D) Object in 1st Quadrant (`Observer -> Object -> Plane`)

Correct Answer: (D) | **Explanation:** For **First-Angle Projection (BIS)** (Standard / Safety Item), the verified Specification / Geometry is **Object in 1st Quadrant (`Observer -> Object -> Plane`)**. Furthermore, Top View (Plan) below Front View (Elevation). (Source: Indian Railways Official Portal & IUC Academy).

Rapid-Fire Last-Minute One-Liner Revision Capsule

1. **Number of Fundamental Base SI Units and Supplementary Units:** 7 Base Units (`m, kg, s, A, K, mol, cd`) and 2 Supplementary Units (`radian` and `steradian`) (https://ncert.nic.in/).

2. **Largest Practical Unit of Astronomical Distance:** Parsec (`1 Parsec = 3.26 Light Years = 3.08 * 10^16 m`) (https://ncert.nic.in/).

3. **1 Light Year Value in Metres:** `9.46 * 10^15 m` (measures **distance**, not time!) (https://ncert.nic.in/).

4. **Least Count of Standard Metric Vernier Caliper:** `0.02 mm` (`0.002 cm`) (https://dgt.gov.in/).

5. **Least Count of Standard Metric Outside Micrometer:** `0.01 mm` (`0.001 cm`), working on the **Screw and Nut principle** (https://dgt.gov.in/).

6. **Least Count of Vernier Bevel Protractor:** `5 minutes of arc (5')` (`1/12th of a degree`) (https://dgt.gov.in/).

7. **Purpose of Ratchet Stop in a Micrometer:** Ensures uniform measuring pressure across all readings (https://dgt.gov.in/).

8. **Sine Bar Working Formula:** `sin(theta) = h / L` (Slip gauge height divided by roller center distance) (https://dgt.gov.in/).

9. **Standard Wire Gauge (SWG) Rule:** Larger SWG number = Smaller wire diameter / thinner sheet (https://dgt.gov.in/).

10. **Weight of a Body at the Center of the Earth: Zero (`0 N`)** because `g = 0` at the Earth's center, while Mass remains unchanged (https://ncert.nic.in/).

11. **Where is Acceleration Due to Gravity (`g`) Maximum and Minimum on Earth's Surface?:** Maximum at the **Poles** (`~9.83 m/s^2`) and Minimum at the **Equator** (`~9.78 m/s^2`) (https://ncert.nic.in/).

12. **Apparent Weight in a Freely Falling Lift (`a = g`): Zero (`W = m(g - g) = 0` , Weightlessness)** (https://ncert.nic.in/).

13. **Unit and Dimensional Formula of Relative Density (Specific Gravity): Unitless and Dimensionless (`[M^0 L^0 T^0]`)** (https://ncert.nic.in/).

14. **Temperature of Maximum Density of Water (`1000 kg/m^3`): `4 degrees Celsius` (`277.15 K`)** (https://ncert.nic.in/).

15. **Density of Mercury, Steel, and Aluminium in SI Units:** Mercury = `13,600 kg/m^3` , Mild Steel = `7,850 kg/m^3` , Aluminium = `2,700 kg/m^3` (https://dgt.gov.in/).

16. **Instrument Used to Test Purity of Milk and Battery Charge:** Milk -> **Lactometer**; Lead-Acid Battery -> **Hydrometer** (charged `SG = 1.25 to 1.28`) (https://dgt.gov.in/).

17. **Conversion Factor from `km/h` to `m/s`:** Multiply by `5/18` (`18 km/h = 5 m/s`; `36 km/h = 10 m/s`; `54 km/h = 15 m/s`; `72 km/h = 20 m/s`; `90 km/h = 25 m/s`) (https://ncert.nic.in/).

18. **Slope and Area of a Velocity-Time (`v-t`) Graph:** Slope = **Acceleration (`a`)**; Area under curve = **Displacement (`s`)** (https://ncert.nic.in/).

19. **Displacement in the `n-th` Second Formula:** `s_n = u + (a / 2) * (2n - 1)` (https://ncert.nic.in/).

20. **Newton's First Law gives the Definition of Force; Second Law gives the Magnitude/Formula of Force (`F = dp/dt = m*a`)** (https://ncert.nic.in/).

21. **Recoil Velocity of a Gun Formula (Conservation of Momentum):** `V_gun = -(m_bullet * v_bullet) / M_gun` (https://ncert.nic.in/).

22. **Angle of Projection for Maximum Horizontal Range of a Projectile:** `45 degrees` (`R_max = u^2 / g`) (https://ncert.nic.in/).

23. **Work Done by Centripetal Force in Circular Motion: Always Zero (`0 J`)** because force is perpendicular (`90 deg`) to instantaneous velocity/displacement (https://ncert.nic.in/).

24. **Work Done by Friction on a Sliding Body: Negative Work** (`theta = 180 deg`, `cos(180 deg) = -1`) (https://ncert.nic.in/).

25. **Relation Between Kinetic Energy (`KE`) and Linear Momentum (`p`):** `KE = p^2 / (2m)` and `p = sqrt(2 m KE)` (https://ncert.nic.in/).

26. **Effect of Doubling Velocity on Kinetic Energy and Stopping Distance:** Both become **4 times (`2^2 = 4`)** (https://ncert.nic.in/).

27. **1 Horsepower (HP) in Watts: British HP =** `746 Watts`; **Metric HP =** `735.5 Watts` (https://dgt.gov.in/).

28. **1 Kilowatt-Hour (`1 kWh` / 1 Unit) in Joules:** `3.6 * 10^6 Joules` (`3.6 MJ`) (https://ncert.nic.in/).

29. **Mechanical Equivalent of Heat (`1 calorie` in Joules):** `1 cal = 4.186 J ~ 4.2 J` (https://ncert.nic.in/).

30. **Temperature Where Celsius and Fahrenheit Scales Coincide:** `-40 degrees` (`-40 deg C = -40 deg F`) (https://ncert.nic.in/).

31. **Absolute Zero Temperature:** `0 K = -273.15 deg C = -459.67 deg F` (https://ncert.nic.in/).

32. **Triple Point of Pure Water:** `273.16 K = 0.01 deg C` (https://ncert.nic.in/).

33. **Specific Heat Capacity of Water:** `4186 J/(kgK) ~ 4200 J/(kgK) = 1 cal/(g*deg C)` (highest among common liquids) (https://ncert.nic.in/).

34. **Latent Heat of Fusion of Ice (`0 deg C`) and Vaporization of Steam (`100 deg C`):** Ice = **`80 cal/g`** (`336 kJ/kg`); Steam = **`540 cal/g`** (`2260 kJ/kg`) (https://ncert.nic.in/).

35. **Ratio of Thermal Expansion Coefficients (`alpha : beta : gamma`):** `1 : 2 : 3` (https://ncert.nic.in/).

36. **Fastest Mode of Heat Transfer Requiring No Medium: Radiation** (travels through vacuum at `3 * 10^8 m/s`) (https://ncert.nic.in/).

37. **Number of Electrons in 1 Coulomb of Charge:** `6.25 10^18 electrons` (`e = 1.6` 10^-19 C) (https://ncert.nic.in/).

38. **Internal Resistance of an Ideal Ammeter and Ideal Voltmeter:** Ideal Ammeter = **Zero (`0 Ohm`)**; Ideal Voltmeter = **Infinite (`infinity`)** (https://ncert.nic.in/).

39. **Best Metallic Conductor of Electricity and Heat: Silver (Ag)**, followed by Copper (Cu), Gold (Au), and Aluminium (Al) (https://ncert.nic.in/).

40. **New Resistance When a Wire is Stretched to `n` Times its Length: `R_new = n^2 * R`**, while **Resistivity (`rho`) stays unchanged** (https://ncert.nic.in/).

41. **Temperature Coefficient of Resistance of Semiconductors (Si, Ge) and Carbon: Negative (NTC)** -- resistance decreases as temperature increases (https://dgt.gov.in/).

42. **Composition of Electric Fuse Wire (Solder Alloy): 63% Tin (Sn) + 37% Lead (Pb)** -- High resistivity and Low melting point (https://dgt.gov.in/).

43. **Composition of Nichrome Heating Element and Bulb Filament:** Heater = **Nichrome (80% Nickel + 20% Chromium)**; Bulb Filament = **Tungsten (`W`, melting point `3380 deg C`)** (https://dgt.gov.in/).

44. **Domestic AC Power Supply Standard in India:** `230 V, 50 Hz` single-phase AC, with all household appliances connected in **Parallel** (https://dgt.gov.in/).

45. **Standard Colour Code of 3-Core Wiring (Phase, Neutral, Earth): Phase (Live) = Red (or Brown); Neutral = Black (or Blue); Protective Earth = Green (or Green-Yellow)** (https://dgt.gov.in/).

46. **Transformer Operating Principle and Core Material: Mutual Induction** on **AC only**; core is made of **Laminated Silicon Steel** to reduce eddy current and hysteresis losses (https://dgt.gov.in/).

47. **Efficiency Formula of a Simple Machine:** `eta = (MA / VR) * 100%`, where `MA = Load / Effort` and `VR = d_E / d_L` (https://dgt.gov.in/).

48. **Condition for a Lifting Machine (e.g., Screw Jack) to be Self-Locking: Efficiency must be less than 50% (`eta < 50%`)** (https://dgt.gov.in/).

49. **FLE Rule for Class 1, 2, and 3 Levers:** Fulcrum in middle = Class 1 (`MA` any); Load in middle = Class 2 (`MA > 1`); Effort in middle = Class 3 (`MA < 1`) (https://dgt.gov.in/).

50. **Velocity Ratio of a Screw Jack:** `VR = (2 *pi* R) / p` (`R` = handle length, `p` = thread pitch) (https://dgt.gov.in/).

51. **Aspect Ratio and Surface Area of A0 Engineering Drawing Sheet (IS 10711):** Side ratio = `1 : sqrt(2)` (`1 : 1.414`); Area of `A0 = 1.00 m^2` (`841 mm * 1189 mm`) (https://www.bis.gov.in/).

52. **Trimmed Dimensions of A1, A2, A3, and A4 Drawing Sheets:** `A1 = 594841 *mm*`; `A2 = 420` 594 mm; `A3 = 297420 *mm*`; `A4 = 210` 297 mm (https://www.bis.gov.in/).

53. **Standard Title Block Size and Location (BIS SP 46):** `185 mm * 65 mm` at the **bottom right-hand corner** (https://www.bis.gov.in/).

54. **Hardest and Softest Engineering Drawing Pencil Grades:** Hardest = `9H`; Softest = `7B` (total 18 grades) (https://dgt.gov.in/).

55. **First-Angle vs. Third-Angle Orthographic Projection:** First-Angle (BIS standard) puts **Plan below Elevation**; Third-Angle puts **Plan above Elevation** (https://www.bis.gov.in/).

56. **Angle Between Isometric Axes and Isometric Foreshortening Ratio:** Axes are `120 degrees` **apart** (`30 deg` to horizontal); Isometric Length = `sqrt(2/3) = 0.816` times True Length (https://www.bis.gov.in/).

57. **Representative Fraction (RF) for Enlarging, Full, and Reducing Scales:** Enlarging Scale -> `RF > 1`; Full Scale -> `RF = 1`; Reducing Scale -> `RF < 1` (https://www.bis.gov.in/).

58. **Four Safety Sign Shapes and Colours:** Prohibition = White circle with Red border/crossbar; Mandatory = Blue circle; Warning = Yellow triangle; Safe Condition = Green rectangle/square (https://dgt.gov.in/).

59. **Extinguishers for Class A, B, C, and Electrical Fires:** Class A (Wood/Paper) -> Water; Class B (Oil/Petrol) -> Foam; Class C (LPG/Gas) -> Dry Powder; Electrical -> **CO2 or Halon (CTC)** (https://dgt.gov.in/).

60. **Japanese 5S Sequence: Seiri (Sort) -> Seiton (Set in Order) -> Seiso (Shine) -> Seiketsu (Standardize) -> Shitsuke (Sustain)** (https://dgt.gov.in/).

IUC Academy *1-3-7-21* Day Spaced-Revision & Self-Assessment Tracker (www.iucacademy.com)

Chapter / Study Section	Day 1 (First Read)	Day 3 (Active Recall)	Day 7 (MCQ Drill)	Day 21 (Exam Ready)
1. Chapter 1: Units, Measurements, Dimensional Formulas & Precision Measuring Instruments	☐ Completed (100% Concept Clarity)	☐ Flowchart & Tables Revised	☐ 75+ MCQs Solved (>85% Accuracy)	☐ **Final Rapid Recall Ready**
2. Chapter 2: Mass, Weight, Density, Specific Gravity, Buoyancy & Fluid Mechanics	☐ Completed (100% Concept Clarity)	☐ Flowchart & Tables Revised	☐ 75+ MCQs Solved (>85% Accuracy)	☐ **Final Rapid Recall Ready**
3. Chapter 3: Speed, Velocity, Acceleration, Equations of Motion, Newton's Laws & Projectile Motion	☐ Completed (100% Concept Clarity)	☐ Flowchart & Tables Revised	☐ 75+ MCQs Solved (>85% Accuracy)	☐ **Final Rapid Recall Ready**
4. Chapter 4: Work, Power, Energy, Conservation Laws & Mechanical Efficiency	☐ Completed (100% Concept Clarity)	☐ Flowchart & Tables Revised	☐ 75+ MCQs Solved (>85% Accuracy)	☐ **Final Rapid Recall Ready**
5. Chapter 5: Heat, Temperature Scales, Calorimetry, Latent Heat & Thermal Expansion	☐ Completed (100% Concept Clarity)	☐ Flowchart & Tables Revised	☐ 75+ MCQs Solved (>85% Accuracy)	☐ **Final Rapid Recall Ready**
6. Chapter 6: Basic Electricity, Ohm's Law, Kirchhoff's Laws, Magnetism, Transformers & Motors	☐ Completed (100% Concept Clarity)	☐ Flowchart & Tables Revised	☐ 75+ MCQs Solved (>85% Accuracy)	☐ **Final Rapid Recall Ready**
7. Chapter 7: Simple Machines, Levers (Class 1, 2 & 3), Pulleys, Mechanical Advantage & Efficiency	☐ Completed (100% Concept Clarity)	☐ Flowchart & Tables Revised	☐ 75+ MCQs Solved (>85% Accuracy)	☐ **Final Rapid Recall Ready**
8. Chapter 8: Engineering Drawing (BIS SP 46 / IS 10711 Standards, Projections, Lines) & Occupational Safety	☐ Completed (100% Concept Clarity)	☐ Flowchart & Tables Revised	☐ 75+ MCQs Solved (>85% Accuracy)	☐ **Final Rapid Recall Ready**
9. Solved Exam Practice Questions (MCQs)	☐ Completed (100% Concept Clarity)	☐ Flowchart & Tables Revised	☐ 75+ MCQs Solved (>85% Accuracy)	☐ **Final Rapid Recall Ready**
10. Extended Comparative & Analytical Practice Set (Questions 36–75)	☐ Completed (100% Concept Clarity)	☐ Flowchart & Tables Revised	☐ 75+ MCQs Solved (>85% Accuracy)	☐ **Final Rapid Recall Ready**
11. Rapid-Fire Last-Minute One-Liner Revision Capsule	☐ Completed (100% Concept Clarity)	☐ Flowchart & Tables Revised	☐ 75+ MCQs Solved (>85% Accuracy)	☐ **Final Rapid Recall Ready**