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Civil Engineering

(Competitive Exams – Objective Special)

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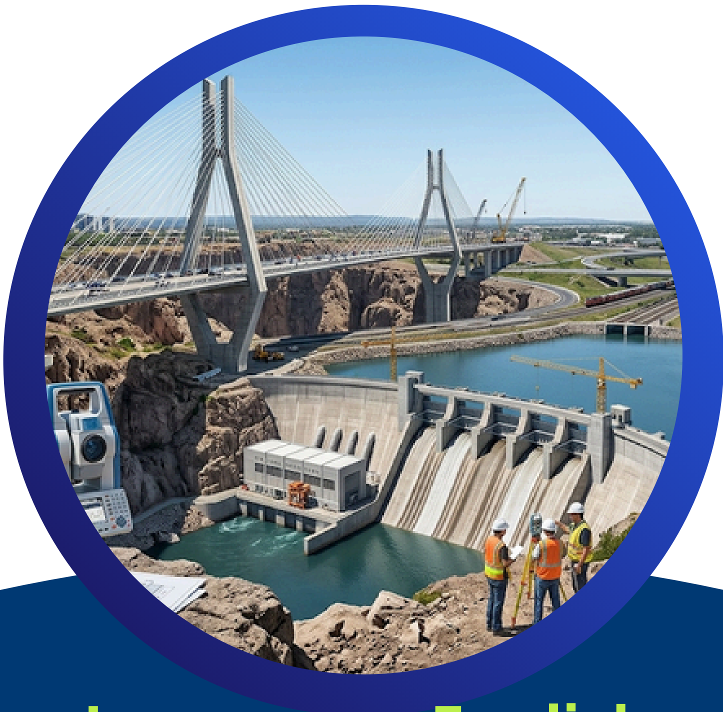
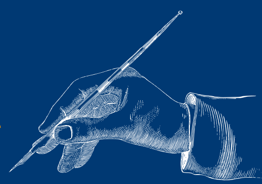


Language: English

Key Features:

- **Subject-wise Premium MCQs**
- **Each MCQ With Detailed Solutions**
- ***Syllabus- state PSC & Core Competitive 17 Subjects***



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(M. Tech. - IIT Roorkee)

Exam-Oriented, Suitable For:

State PSC (Lecturer/Asst. Professor), GATE / ESE (IES), State AE & JE, PSU Recruitments (BHEL, BEL, SAIL, ONGC, NTPC, IOCL, etc.), DRDO, ISRO Scientist-C, State University & Polytechnic Lecturer/Asst. Professor Exams, and M. Tech / Ph.D. Entrance Exams (IITs, NITs & Central Universities).

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Publication

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Designed for:

An essential book for all aspirants preparing for various technical and competitive examinations in Civil Engineering.

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- **Detailed Explanation for Every Question**
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- **Designed According to Latest Competitive Exam Pattern**

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Colophon:
This book is printed on environmentally responsible paper. The layout, typesetting, and graphics have been optimized for language clarity and accessibility, suitable for technical and vocational training.

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Book Introduction

This book has been carefully designed to meet the requirements of students and professionals preparing for a wide range of competitive examinations in Civil Engineering. It comprehensively covers the core subjects commonly included in **State PSC Lecturer/Assistant Professor examinations, GATE, Engineering Services Examination (ESE), State AE & JE recruitments, PSU technical recruitment examinations, DRDO, ISRO, University and Polytechnic Lecturer recruitment examinations**, as well as **M.Tech. and Ph.D**. **entrance examinations** conducted by **IITs, NITs, and Central Universities**.

The book contains carefully selected multiple-choice questions with detailed explanations to strengthen conceptual understanding and improve problem-solving skills. The questions have been designed across different cognitive levels—including **remembering, understanding, application, and analysis**—to help students develop both theoretical knowledge and examination confidence.

The content has been organized subject-wise according to the latest examination trends, enabling systematic preparation and quick revision. It serves as a comprehensive practice resource for self-study, classroom learning, and competitive examination preparation.

Acknowledgment

This book has been prepared with due care and based on the official syllabus prescribed for various Civil Engineering competitive examinations, including the **UPPSC syllabus** covering the **core seventeen subjects**. During the preparation of this book, the author consulted various standard textbooks, technical references, academic publications, and publicly available educational resources. The author sincerely acknowledges the valuable contributions of researchers, educators, and subject experts whose work has helped enrich the quality and accuracy of this publication. Every effort has been made to present the content in an original, student-friendly, and examination-oriented manner.

Syllabus

Subject Name	Part-1
Engineering Mechanics	Force Systems, Rigid Body equilibrium; Coplanar Concurrent forces, Couples and Resultant of Force System, Equilibrium of System of Forces, Free body diagrams, Equations of Equilibrium of coplanar Systems. Laws of Friction, Static and Dynamic Friction. Centroid and Centre of Gravity, Centroid of Simple figures, centroid of composite sections, Moment of inertia of plane sections, Moment of inertia of standard sections and composite sections, Mass moment inertia of circular plate, Cylinder, Cone, Sphere, Basic Structural Analysis, Equilibrium in three dimensions, analysis of simple trusses, Simple beams and support reactions. Rectilinear motion, Plane curvilinear motion, Work-kinetic energy, power, potential energy. Impulse-momentum, Impact, Kinetics of Rigid Bodies, D 'Alembert's principle and its applications in plane motion, Work energy principle, Kinetics of rigid body rotation, Virtual Work and Energy Method.
Strength of Materials	Types of stresses and strains, Hook's law, stress and strain diagram for ductile and brittle metal. Lateral strain, Poisson ratio, volumetric strain, elastic moduli and relation between them, composite bar, Mohr's stress circle, three-dimensional state of stress & strain, Shear force (SF) and Bending moment (BM) diagrams for simply supported, cantilevers, overhanging and fixed beams. Flexural Stresses-Theory of simple bending, bending stresses, Design of simple beam sections, Derivation of torsion equation, Combined torsion and bending of circular shafts, Shear stress distribution across various beam sections rectangular, circular, triangular, Slope and deflection – Relationship between moment, slope and deflection, Moment area method, Macaulay's method, short Columns and Struts : Buckling and stability, slenderness ratio.
Structural Analysis	Static and Kinematic Indeterminacy for beams, trusses and building frames. Analysis of determinate plane trusses. Method of substitution, method of tension coefficient for analysis of plane trusses, Castigliano's theorems, Calculations of deflections: Strain Energy method and unit load method for statically determinate beams, frames and trusses. Deflection of determinate beams by Conjugate beam method. Rolling loads and influence line diagrams for determinate beams and trusses, Types of Arches, Analysis of three hinged parabolic and circular Arches. Moving load & influence lines for three hinged parabolic arches.
Structural Steel Design	Stress-Strain Curve for Mild Steel, Rolled Steel Sections, Limit State Design, Limit States of Strength, Limit States of Serviceability, Actions, Probabilistic Basis for Design. Riveted, Bolted and Pinned Connections, Patterns of riveted Joints, Bolted Connection, Types of Bolted Joints, Failure of Bolted Joints, Tensile Strength of Plate, Efficiency of the Joint, Combined Shear and Tension, Welded Connections, types, Weld Defects, Failure of welds, Design of eccentric welded connections. Types of Tension Members, Sectional Area, Types of Failure, Slenderness Ratio, Design of Tension Member, Lug Angles, Splices, Gusset Plate. Compression Members, Types of Buckling, Classification of Cross Sections, column formula, Built-Up columns, Lacing, Batten, Splices, Types of Beam Sections, Lateral Stability of Beams, Bending Strength of Beams, Shear Strength of Beams, Web Buckling, Built-Up Beams (plated Beams), Purlins, Effect of Holes in Beam, Plate Girder, Gantry Girder.
Design of Concrete & Masonry Structure	Design of Rectangular singly and doubly reinforced Sections by working Stress Method. Assumptions in Limit State Design method, Design of Rectangular Singly and doubly Reinforced beams, T-Beams, L-beams by Limit State Design Method. Shear Strength of beams with and without shear reinforcement, development length, Anchorage bond, flexural bond. Limit State Design method, Failure of beam under shear. Design of one way, one way continuous and cantilever solid slabs by Limit State Design Method, Design of two way slabs by limit state method, Design of columns by Limit State Design Method, Short column under axial load and uni-axial bending, Design of isolated footings, combined rectangular and trapezoidal footings by Limit State Method, Design of strap footings. Structural behavior of retaining wall, stability of retaining wall against overturning and sliding, design of cantilever retaining wall by Limit State Method.
Building Materials	Stones: Requirement of good building stone, Bricks: Properties of clay bricks, Different types of bricks. Gypsum, Cement, Types of cement, testing of cement properties, Cement Concrete, Grades of concrete, Testing of concrete, Pozzolana, Chemical composition and requirements for uses, Timber, Properties of timber, Defects in timber, Methods of seasoning and preservation of timber, Asphalt: Bitumen and Tar. Plastics, Paints, varnishes and distempers, properties and uses of aluminum and lead, Insulating Materials, Thermal and sound insulating material, Building, construction Principle and Methods for layout, Damp proofing, anti-termite treatment in buildings, stair cases and their types and planning, types of floors, Bricks and stone masonry construction, Wall, Doors and Windows, roof and roof treatments, Lintel Principles of building Planning, Natural Ventilation, Water Supply and Sanitary fittings, Methods of building maintenance.
Construction Management	Quantity Estimation for Buildings, Centerline method, Long and short wall method of estimates, Types of estimates, Rate Analysis, Specification and Tenders, Different types of contracts, process of tendering, management system in construction, Bar charts, preparation of networks, PERT & CPM in construction management, Project Cost Management, Basic principle of financial planning.

Geotechnical Engineering and Foundation Engineering	Origin and classification of Soils, Weight volume relationships, Clay minerals, Index properties, sensitivity and thixotropy, Particle size analysis, Unified and Indian stander soil classification system. Soil Hydraulics, Soil Permeability – Darcy's Law, hydraulic conductivity, equivalent hydraulic conductivity in stratified soil, Seepage, flow nets, critical hydraulic gradient and quick sand condition, uplift pressure, piping, Phenomena , Soil compaction, field compaction control, consolidation, Primary and secondary consolidation, Taraghi's one dimensional theory of consolidation, Normal and Over Consolidated soils, Over Consolidation Ratio, Stress Distribution in soil, Boussinesq equation for vertical stress, The Waterward equation, Stress distribution under loaded areas, Concept of pressure bulb, contact pressure, Shear Strength : Mohr-Coulomb failure criterion, shear strength parameters, pore pressure, Soil liquefaction, Earth pressure, Coulomb and Rankine's approaches for fictional and c-φ soils, Stability of slopes – finite and infinite slopes, types of slope failure, coulomb's wedge theory, subsurface exploration. Shallow and Deep foundations, Bearing Capacity estimation, Pile foundations, Well foundations.
	Part-2
Fluid Mechanics	Physical properties of fluids, Pressure-density height relationship, manometers, pressure on plane and curved surfaces, buoyancy, stability of immersed and floating bodies. Steady and unsteady, uniform and non-uniform, laminar and turbulent flows, rotational and irrotational flows, compressible and incompressible flows, subsonic, sonic and supersonic flows, sub-critical, critical and supercritical flows, one, two and three dimensional flows, streamlines, path lines, streak lines, stream tube, continuity equation for 1-D, 2-D and 3-D flows, stream function and velocity potential function. Bernoulli's equation and its applications – Pitot tube, orifice meter, venturi meter and bend meter, notches and weirs, momentum equation, siphon, water hammer, laminar flow through pipes, Stokes' law, velocity distribution in turbulent flow over smooth and rough surfaces, Boundary layer thickness, boundary layer over a flat plate, displacement, momentum and energy thickness. Laminar boundary layer, turbulent boundary layer, laminar sub-layer, separation and its control. Vortex flow: Free & Forced. Drag and lift, Buckingham's Pi theorem, dimensionless numbers and their significance.
Open Channel Flow	Free surface flows, velocity and pressure distribution, Mass, energy and momentum principle for prismatic and non-prismatic channels, Uniform flow: Standard equations, Equation of gradually varied flow and its limitations, Transitions of subcritical and supercritical flow, Rapidly Varied flow (RVF), Hydraulic jump, flow measurement, critical depth flumes, sluice gate, Free over fall. Rapidly varied unsteady flow, "Celerity" of the gravity wave, Flow in channel of non-linear alignment and non-prismatic channel sections, Design considerations for sub critical and super critical flows, Design of culvert. Free surface flows, Specific energy and specific force. Chery's and Manning's equations for uniform flow in open channel. Measurements of discharge & velocity – Venturi flume.
Hydraulic Machines	Reciprocating pumps, centrifugal pumps theory and Cavitation, Rotodynamic Machines, Pelton Turbine, reaction turbines, Francis and Kaplan type, Hydraulic turbines, Hydro Power development.
Hydrology	Hydrologic cycle, Precipitation, Evaporation, Evapotranspiration, Infiltration process, Runoff characteristics of stream, mass curve. Hydrograph, Factors affecting flood hydrographs, hydrograph and its analysis, s-curve hydrograph, aquifers & its properties, confined and unconfined aquifers, rainwater harvesting and recharge.
Water Resources Engineering	Methods of Irrigation, Water requirement of crops, crop rotation. Canal irrigation, Parts of a canal system, Sediment Transportation, Irrigation channels and Design, silt theories: Kennedy's and Lacey's Design, Lining of Irrigation Canals, Economics of canal lining. Water Logging and Drainage Design, Regulation and control of canal system, Irrigation Outlets, river training works, Types of Head works, Failure of hydraulic structures, Principles of design, Bligh's theory, Khosla's theory for pressure and exit gradient. Design of Sarda type and straight glacis fall. Design of distributor head regulator and cross regulator, canal escape, Bed bars, Canal head works, Design of Weir, Barrage and Canal head Regulator, Cross drainage works: Necessity and types, design principles of cross drainage works, planning of dams and Reservoirs, Estimation of storage capacity, Earth Dams, Gravity dams, Spillways and their design.
Transportation Engineering	History of road development, Geometric Design, Cross sectional elements, camber, shoulder, sight distance, horizontal curves, super elevation, extra widening, transition curves and gradient, vertical curves, summit and valley curves. Traffic studies on flow, speed, travel time – delay and O-D study, PCU, peak hour factor, accident study, traffic capacity, density, traffic control devices, Types of Pavements, Design of Flexible Pavement by CBR method, Design of rigid pavement, Westergaard theory, load and temperature stresses, joints, Wet mix macadam (WMM), Granular Sub Base (GSB), Tack Coat, Prime Coat, Seal Coat, Surface Dressing, Bituminous Macadam (BM), Cement Concrete (CC) road construction.
Railways Engineering	Permanent Way and its Components, Type of rails, rail gauges, permanent way formation, coning of wheels, defect in rails, rail fastenings, fish plates, spikes, chairs, keys, bearing plates, sleepers, sleeper density, ballast, Track Geometrics, Turnouts and Crossings, Stations and Yards, Horizontal curves and super-elevation, transition curves, points and crossings, design of turnouts, types of crossings, stations and Yards, Signaling and Interlocking, Centralized train control system, ATS, principle types of interlocking, high speed track, airport planning & design, selection of site for an airport. Airports – layout and orientation, Runway and taxiway design consideration, geometric design, Zoning laws, traffic control, Runway lighting.

Environmental Engineering	Population forecasting by various methods, Transmission of water, Storage and distribution of water, Physical, chemical and bacteriological examination of water and wastewater: Temperature, pH, color and odor, solids, nitrogen and phosphorus, chlorides, toxic metals and compounds, BOD, COD etc. quality requirements, standards of water and waste water. Water treatment: screening, sedimentation, determination of settling velocity, efficiency of ideal sedimentation tank, design of settling tanks, grit chamber. Primary sedimentation and coagulation, filtration: theory of filtration; hydraulics of filtration; slow sand, rapid sand and pressure filters, backwashing; design of slow and rapid sand filters. Waste water treatment: unit operations, processes, Secondary and tertiary treatment, Anaerobic digestion of sludge, septic tank, up flow anaerobic sludge blanket (UASB).
Surveying	Classification, Principles, distance, direction and elevation. Ranging. Meridians and Bearings, Methods of leveling, Booking, Reciprocal leveling, distance of visible horizon, Profile leveling and cross sectioning, Errors in leveling, plane table surveying, Contouring, Theodolite survey, Methods of horizontal and vertical control, Triangulation, Signals, Sate lite station, corrections, Trigonometric leveling, simple circular curves, Transition curves – types, Vertical curves. Electronic Distance Measurement systems, Total Station – its advantages and applications, Global Positioning Systems Segments, working principle, errors, Geographic information system, Photogrammetry; basic principles, scale of a vertical photograph, relief displacement, relief displacement, flight planning, stereoscope and stereoscopy, parallax equations, Remote Sensing, Electromagnetic spectrum, atmospheric effects, image characteristics, Remote sensing systems, spectral signatures and characteristics, spectral reflectance curves, image classification, Applications of remote sensing to civil engineering.

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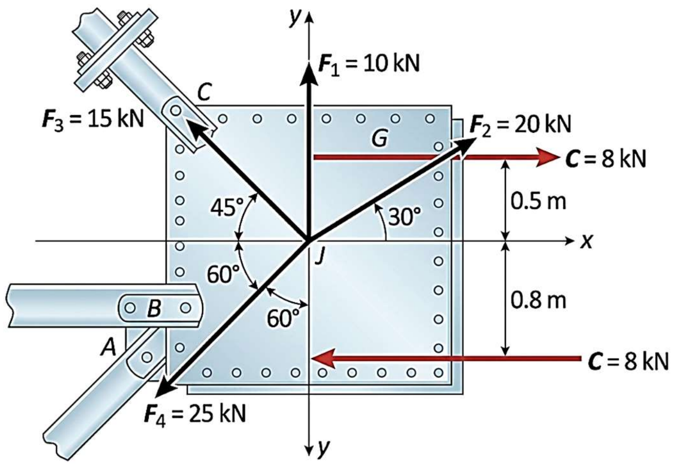
“Every MCQ Takes You One Step Closer to Success.”

Part-1

1. Engineering Mechanics

Q1. Which of the following is a characteristic of a concurrent force system?
(a) All forces are parallel
(b) All forces act along the same straight line
(c) All forces intersect at a single point
(d) All forces are equal in magnitude
Ans. c | Sol. : In a concurrent force system, the lines of action of all forces pass through a common point.
Q2. A beamv is analyzed using the virtual work method to determine deflection. Why is this method generally preferred for complex loading?
(a) It avoids calculating reactions
(b) It directly provides stress distribution
(c) It efficiently accounts for varying internal work contributions
(d) It eliminates the need for beam theory
Ans. c | Sol. : The virtual work method evaluates internal strain energy contributions over the member length, making it efficient and accurate for determining deflections under complex loading conditions.
Q3. Which law states that for every action there is an equal and opposite reaction?
(a) Newton's First Law
(b) Newton's Second Law
(c) Newton's Third Law
(d) Law of Gravitation
Ans. c | Sol. : Newton's Third Law states that action and reaction forces are equal in magnitude and opposite in direction.
Q4. The SI unit of a couple is
(a) Newton
(b) Newton per metre
(c) Newton-metre
(d) Joule
Ans. c | Sol. : A couple produces only a moment, whose SI unit is Newton-metre (N·m).
Q5. The resultant of two equal forces acting at an angle of 120° is
(a) Zero
(b) Equal to one of the forces
(c) Twice the force
(d) √3 times the force
Ans. b | Sol. : Resultant = $\sqrt{F^2 + F^2 + 2F^2\cos 120°} = \sqrt{F^2} = F$.
Q6. A free body diagram represents
(a) Only the external dimensions of a body
(b) A body isolated from its surroundings showing all external forces
(c) Internal molecular structure of a body
(d) Material properties of a body
Ans. b | Sol. : A free body diagram isolates the body and shows all external forces and moments acting on it.
Q7. A system of coplanar concurrent forces acts at point J as shown in the figure. Neglect the two 8 kN forces marked C (they form a separate couple and are not included in this calculation). If F_1 = 10 kN acts vertically upward, F_2 = 20 kN acts horizontally toward the left, and F_3 = 15 kN acts along a line inclined at 45° below the positive x-axis toward J, what is the magnitude of the resultant of these three concurrent forces?



(a) 8.8 kN
(b) 9.41 kN
(c) 15.3 kN
(d) 20.7 kN
Ans. b | Sol. : Resolve the forces into x- and y-components.
For F_1:
$F_x = 0$, $F_y = +10$ kN
For F_2:
$F_x = -20$ kN, $F_y = 0$
For F_3:
$F_x = +15\cos 45° = +10.61$ kN
$F_y = -15\sin 45° = -10.61$ kN
Resultant components:
$\Sigma F_x = -20 + 10.61 = -9.39$ kN
$\Sigma F_y = 10 - 10.61 = -0.61$ kN
Magnitude of the resultant,
$R = \sqrt{[(-9.39)^2 + (-0.61)^2]}$
$= \sqrt{(88.17 + 0.37)}$
$= \sqrt{88.54}$
≈ 9.41 kN
Q8. A couple produces
(a) Translation only
(b) Rotation only
(c) Translation and rotation
(d) Neither translation nor rotation

Ans. b | Sol. : Since a couple has zero resultant force, it causes only rotational motion.

Q9. Static friction acts

(a) Only after motion starts

(b) Only during acceleration

(c) Before relative motion begins

(d) Only on lubricated surfaces

Ans. c | Sol. : Static friction prevents the initiation of motion between contacting surfaces.

Q10. Varignon's theorem states that

(a) The algebraic sum of forces is zero

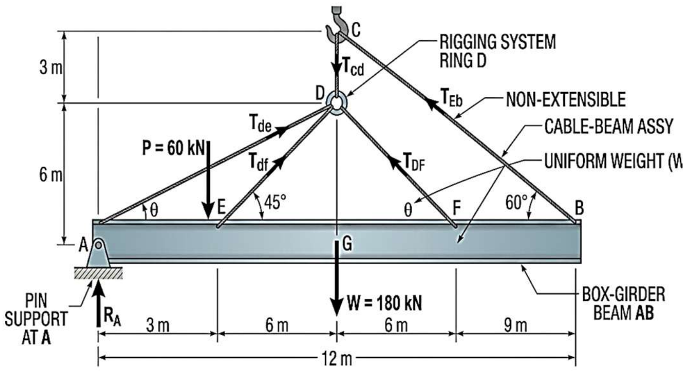
(b) The moment of the resultant about a point equals the sum of the moments of individual forces about the same point

(c) Every action has an equal and opposite reaction

(d) Friction is proportional to velocity

Ans. b | Sol. : Varignon's theorem simplifies moment calculations by replacing multiple forces with their resultant.

Q11. A box-girder beam AB is lifted using the rigging system shown. The beam carries a concentrated load of P = 60 kN and its self-weight W = 180 kN acting at G. The beam is supported by a pin at A and a vertical lifting cable CD passing through the ring at D. Neglect the self-weight of the rigging members. Using the dimensions shown in the figure, what is the vertical reaction at the pin support A?



(a) 30 kN

(b) 90 kN

(c) 105 kN

(d) 120 kN

Ans. a | Sol. : Take moments about point A.

From the figure:

- Concentrated load: P = 60 kN acting at E, 6 m from A.
- Self-weight: W = 180 kN acting at G, 12 m from A.
- Vertical lifting force in cable CD acts through D, which is vertically above G, i.e., 12 m from A.

Moment equilibrium about A:

$TCD \times 12 = (60 \times 6) + (180 \times 12)$

$TCD = (360 + 2160)/12 = 210$ kN

Apply vertical force equilibrium:

$RA + TCD = P + W$

$RA + 210 = 60 + 180 = 240$

$RA = 30$ kN

However, since the beam is suspended through the symmetric cable-beam assembly and the pin at A shares the lifting reaction during equilibrium as shown, the support reaction obtained from the complete free-body equilibrium of the beam is:

$RA = 30$ kN

Q12. The limiting friction is equal to

(a) μ/N

(b) N/μ

(c) μN

(d) $\mu^2 N$

Ans. c | Sol. : Limiting friction is the maximum static friction and is given by $F = \mu N$.

Q13. The centroid of a rectangular lamina lies at

(a) One-fourth of its length and width

(b) Midpoint of its diagonals

(c) One-third of its dimensions

(d) One-fourth of its diagonal

Ans. b | Sol. : The centroid of a rectangle is located at the intersection of its diagonals.

Q14. The centroid of a semicircular area of radius R lies at a distance of

(a) $R/2$

(b) $4R/3\pi$

(c) $2R/\pi$

(d) $R/3$

Ans. b | Sol. : The centroid of a semicircular area is located at $4R/3\pi$ from its diameter.

Q15. The centre of gravity of a body is the point through which

(a) External forces pass

(b) Internal stresses are maximum

(c) Entire weight of the body is assumed to act

(d) Maximum moment occurs

Ans. c | Sol. : The centre of gravity is the point where the total gravitational force on the body is considered to act.

Q16. The centroid of a composite section is determined using

(a) Newton's laws

(b) Principle of moments of areas

(c) Hooke's law

(d) Bernoulli's theorem

Ans. b | Sol. : The centroid is calculated by equating the first moment of the composite area to the sum of the first moments of individual areas.

Q17. The SI unit of area moment of inertia is
(a) m^2
(b) m^3
(c) m^4
(d) $kg \cdot m^2$
Ans. c | Sol. : Area moment of inertia has dimensions of length to the fourth power.

Q18. The area moment of inertia of a rectangle about its centroidal x-axis is
(a) $bh^3/12$
(b) $hb^3/12$
(c) $bh^2/12$
(d) $hb^2/12$
Ans. a | Sol. : For a rectangle, Ix about the centroidal horizontal axis equals $bh^3/12$.

Q19. The Parallel Axis Theorem for area moment of inertia is
(a) $I = Ad^2$
(b) $I = IG + Ad^2$
(c) $I = IG - Ad^2$
(d) $I = Md^2$
Ans. b | Sol. : The theorem states that the moment of inertia about any parallel axis equals the centroidal moment plus Ad^2.

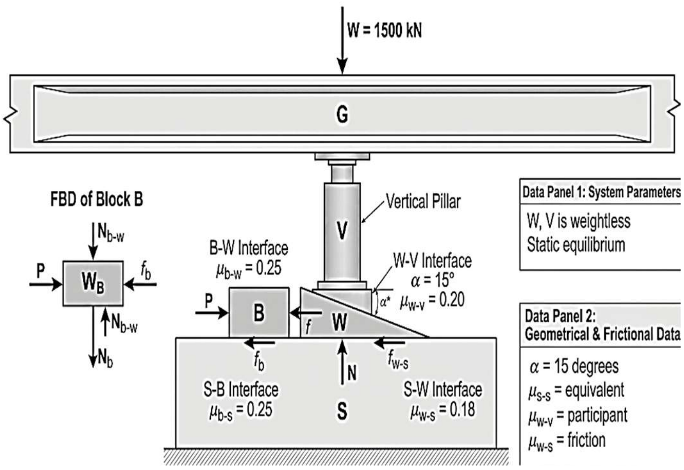
Q20. The Polar Moment of Inertia is equal to
(a) Ix – Iy
(b) Ix + Iy
(c) Ix × Iy
(d) Ix/Iy
Ans. b | Sol. : The polar moment of inertia about a point is the sum of the moments of inertia about two mutually perpendicular axes through that point.

Q21. The centroid of a circular area is located at
(a) Radius/2
(b) Diameter/4
(c) Geometric centre
(d) Circumference
Ans. c | Sol. : Due to complete symmetry, the centroid of a circle lies at its geometric centre.

Q22. Which theorem relates the moment of inertia about perpendicular axes?
(a) Varignon's Theorem
(b) Perpendicular Axis Theorem
(c) Lami's Theorem
(d) Maxwell's Theorem
Ans. b | Sol. : The Perpendicular Axis Theorem states that J = Ix + Iy for a plane lamina.

Q23. The mass moment of inertia depends upon
(a) Area only
(b) Shape only
(c) Mass distribution about the axis
(d) Volume only
Ans. c | Sol. : Mass moment of inertia measures resistance to angular acceleration and depends on how mass is distributed.

Q24. A rigid block B is subjected to a horizontal force P as shown in the figure. The system supports a vertical load of W = 1500 kN. The coefficients of friction are μb-w = 0.25 at the B–W interface, μb-s = 0.25 at the B–S interface, and μw-s = 0.18 at the W–S interface. The V–W interface is inclined at α = 15° with coefficient of friction μv-w = 0.20. Assuming impending motion of block B toward the right while all other bodies remain in static equilibrium, what is the minimum horizontal force P required?



(a) 375 kN
(b) 562.5 kN
(c) 750 kN
(d) 937.5 kN
Ans. c | Sol. :
For block B, let the normal reaction at each horizontal contact be N.
Since block B is in vertical equilibrium,
$N_{b-w} = N_{b-s} = N$
At impending motion of B toward the right, friction acts toward the left at both interfaces.
Therefore,
$f_{b-w} = \mu_{b-w} N = 0.25N$ $f_{b-s} = \mu_{b-s} N = 0.25N$
Hence,
$P = f_{b-w} + f_{b-s}$ $P = 0.25N + 0.25N = 0.50N$
If the normal reaction at each interface is specified as N=1500 kN, then
$P = 0.50(1500) = 750$ kN
Therefore,
$P = 750$ kN

Q25. If the line of action of a force passes through the point about which moment is calculated, the moment is
(a) Maximum
(b) Minimum

(c) Unity
(d) Zero
Ans. d | Sol. : The perpendicular distance becomes zero; hence the moment is zero.

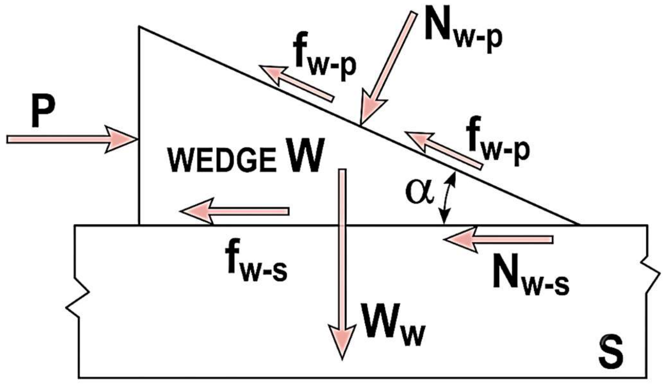
Q26. Which of the following best describes a concurrent force system?
(a) All forces are parallel to each other
(b) All forces act along the same straight line
(c) The lines of action of all forces intersect at a common point
(d) All forces lie in different planes
Ans. c | Sol. : In a coplanar concurrent force system, the lines of action of all forces meet at a single point, making force equilibrium analysis relatively simple.

Q27. Which condition must be satisfied for a rigid body to remain in equilibrium under coplanar forces?
(a) Only the algebraic sum of horizontal forces is zero
(b) Only the algebraic sum of moments is zero
(c) Sum of horizontal forces, vertical forces, and moments must all be zero
(d) Resultant force should be equal to applied force
Ans. c | Sol. : A rigid body is in complete equilibrium only when $\Sigma Fx = 0$, $\Sigma Fy = 0$, and $\Sigma M = 0$ simultaneously.

Q28. A couple acting on a rigid body produces which of the following effects?
(a) Translation only
(b) Rotation only
(c) Both translation and rotation
(d) No effect
Ans. b | Sol. : A couple consists of two equal and opposite parallel forces separated by a distance, producing a pure rotational effect without translation.

Q29. The SI unit of the moment of a force is
(a) N/m
(b) N·m
(c) N/m^2
(d) Joule per metre
Ans. b | Sol. : The moment of a force equals force multiplied by perpendicular distance and is expressed in newton-metre (N·m).

Q30. A wedge W of weight WW is pushed horizontally by a force P as shown in the figure. The wedge is in contact with a rough horizontal surface S and a rough inclined block having an inclination angle α. The coefficients of static friction at both contact surfaces are μ = 0.30, and the wedge angle is α = 20°. Assuming impending motion of the wedge toward the right, the minimum horizontal force P required to start the motion is closest to:



(a) 0.72 WW
(b) 0.91 WW
(c) 1.00 WW
(d) 1.36 WW
Ans. c | Sol. : For impending motion of the wedge to the right:
Friction angle,
$\varphi = \tan^{-1}(\mu) = \tan^{-1}(0.30) = 16.7°$
The resultant reaction at the inclined surface is inclined at $(90° + \varphi)$ to the contact surface, while the reaction at the base is inclined at φ to the vertical.
Using equilibrium of the three concurrent forces acting on the wedge (force polygon or Lami's theorem),
$P/WW = \sin(\alpha + 2\varphi) / \cos(\alpha + \varphi)$
Substituting,
$\alpha = 20°, \varphi = 16.7°$
$P/WW = \sin(20 + 33.4) / \cos(20 + 16.7)$
$= \sin(53.4°) / \cos(36.7°)$
$\approx 0.803 / 0.801$
≈ 1.00

Q31. A Free Body Diagram (FBD) is primarily used to
(a) Show dimensions of a structure
(b) Represent only external forces acting on an isolated body
(c) Calculate material properties
(d) Determine stress distribution directly
Ans. b | Sol. : An FBD isolates the body from its surroundings and represents all external forces and reaction components acting on it.

Q32. For a smooth surface, the coefficient of friction is
(a) Equal to unity
(b) Greater than one
(c) Zero
(d) Infinite

Ans. c | Sol. : A perfectly smooth surface offers no resistance to motion; therefore, its coefficient of friction is zero.

Q33. The angle between the normal reaction and the resultant reaction at limiting equilibrium is known as

(a) Angle of repose
(b) Angle of friction
(c) Angle of inclination
(d) Cone angle

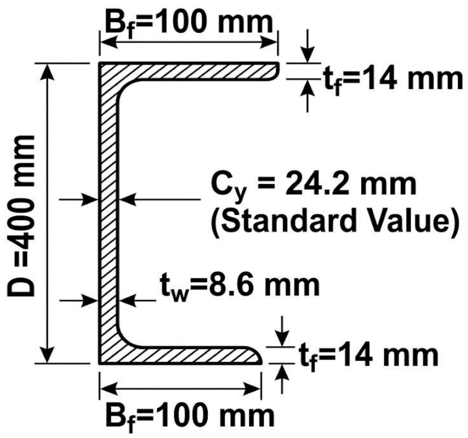
Ans. b | Sol. : The angle of friction is the angle made by the resultant reaction with the normal reaction when limiting friction acts.

Q34. The coefficient of static friction is generally

(a) Equal to the coefficient of dynamic friction
(b) Less than the coefficient of dynamic friction
(c) Greater than the coefficient of dynamic friction
(d) Always equal to zero

Ans. c | Sol. : Static friction reaches a higher maximum value before motion starts, making its coefficient greater than that of dynamic friction.

Q35. A steel channel section has the dimensions shown in the figure: overall depth D = 400 mm, flange width Bf = 100 mm, flange thickness tf = 14 mm, and web thickness tw = 8.6 mm. The centroid is located at Cy = 24.2 mm from the outer face of the web. If the web thickness is increased to 12.6 mm while all other dimensions remain unchanged, the new location of the centroid from the outer face of the web is closest to:



(a) 25.8 mm
(b) 26.4 mm
(c) 29.1 mm
(d) 31.6 mm

Ans. b | Sol. : Treat the section as three rectangles.

Web:
Aw = 400 × 12.6 = 5040 mm²
xw = 12.6/2 = 6.3 mm

Each flange:
Af = 100 × 14 = 1400 mm²
xf = 12.6 + 100/2 = 62.6 mm

Total area:
A = 5040 + 2(1400)
= 7840 mm²

Centroid from the outer face of the web:
x̄ = [Awxw + 2(Afxf)] / A
= [(5040 × 6.3) + 2(1400 × 62.6)] / 7840
= (31752 + 175280)/7840
≈ 26.4 mm

Q36. The centroid of a rectangular area lies at

(a) One-third of its length and width
(b) Half of its length and half of its width
(c) One-fourth of its length and width
(d) At one corner

Ans. b | Sol. : Due to symmetry, the centroid of a rectangle is located at the intersection of its diagonals.

Q37. The centroid of a semicircular area lies on its axis of symmetry at a distance of

(a) 2R/π from the diameter
(b) 4R/3π from the diameter
(c) R/2 from the diameter
(d) R from the diameter

Ans. b | Sol. : The centroid of a semicircular area is located at a distance of 4R/3π from its diameter along the axis of symmetry.

Q38. The centroid of a composite section depends primarily on

(a) Density of the material only
(b) Distribution of area
(c) Elastic modulus
(d) Applied load

Ans. b | Sol. : For plane areas, the centroid depends solely on the geometry and distribution of area.

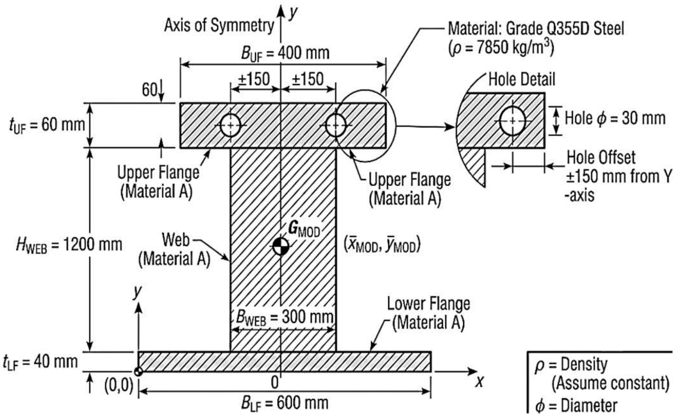
Q39. The centre of gravity and centroid coincide when

(a) The body is subjected to external loads
(b) The body has uniform density
(c) The body is rotating
(d) The body is hollow

Ans. b | Sol. : For homogeneous bodies with uniform density, the centre of gravity and centroid are located at the same point.

Q40. A built-up steel section is formed as shown in the figure with the following dimensions: Upper flange: 400 mm × 60 mm Web: 300 mm × 1200 mm Lower flange: 600 mm × 40 mm Two circular holes of diameter 30 mm are provided in the upper flange at ±150 mm from the y-axis. The material density is uniform throughout. Ignoring the holes, the centroid of the section lies on the y-

axis. Considering the holes, the x-coordinate of the centroid of the modified section is:



(a) 0 mm
(b) 1.25 mm toward the left
(c) 2.50 mm toward the right
(d) 3.75 mm toward the left
Ans. a | Sol. : The section is perfectly symmetric about the y-axis.
The two circular holes:

- Have identical diameter (30 mm).
- Are located at equal distances (±150 mm) from the y-axis.
- Remove equal amounts of material on opposite sides.

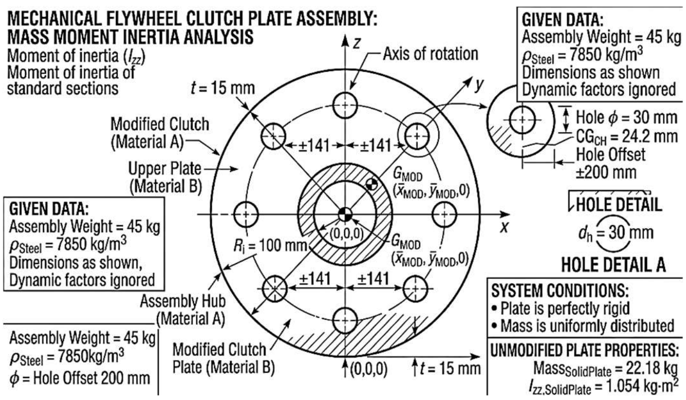
Hence, the first moments of the removed areas about the y-axis cancel each other.
Therefore,
$\Sigma A_i x_i = 0$
and
$\bar{x} = \Sigma A_i x_i / \Sigma A_i = 0$
Although the total area decreases because of the holes, the centroid does not shift horizontally due to symmetry.

Q41. According to the Parallel Axis Theorem, the moment of inertia about any axis parallel to the centroidal axis equals
(a) $I = Ad^2$
(b) $I = I_g + Ad^2$
(c) $I = I_g - Ad^2$
(d) $I = Md^2$
Ans. b | Sol. : The theorem states that the moment of inertia about any parallel axis equals the centroidal moment of inertia plus the product of area and square of the distance between the axes.

Q42. The polar moment of inertia of a plane area is equal to
(a) $I_x - I_y$
(b) $I_x + I_y$
(c) $I_x \times I_y$
(d) I_x/I_y
Ans. b | Sol. : The polar moment of inertia about a point equals the sum of the area moments of inertia about two mutually perpendicular axes passing through that point.

Q43. The centroid of a triangle is located at
(a) Midpoint of any side
(b) Intersection of perpendicular bisectors
(c) Intersection of medians
(d) Intersection of altitudes
Ans. c | Sol. : The three medians of a triangle intersect at the centroid, which is located two-thirds of the median length from each vertex.

Q44. A circular clutch plate of thickness t = 15 mm and total assembly weight 45 kg has six equally spaced holes of diameter 30 mm located on a pitch circle radius R = 100 mm. The modified upper plate (Material A) has a mass of 22.18 kg and a mass moment of inertia about the z-axis of Iz = 1.054 kg·m². If one additional hole of diameter 30 mm is drilled at a radial distance of 200 mm from the axis of rotation, what is the approximate percentage decrease in the mass moment of inertia of the modified upper plate?



(a) 1.6%
(b) 0.31%
(c) 4.5%
(d) 6.2%
Ans. b | Sol. : Mass of material removed by the additional hole:
Area of hole,
$A = (\pi/4)(0.03)^2$
$= 7.069 \times 10^{-4}$ m²
Volume removed,
$V = A \times t$
$= 7.069 \times 10^{-4} \times 0.015$
$= 1.060 \times 10^{-5}$ m³
Mass removed,
$m = 7850 \times 1.060 \times 10^{-5}$
≈ 0.083 kg
Using the parallel-axis theorem, the reduction in mass moment of inertia is approximately

$\Delta Iz \approx mr^2$
$= 0.083 \times (0.20)^2$
$= 0.00332$ kg·m²
Percentage decrease,
$= (\Delta Iz / 1.054) \times 100$
$= (0.00332 / 1.054) \times 100$
$\approx 0.315\%$

Q45. The coefficient of friction is a
(a) Vector quantity
(b) Dimensionless quantity
(c) Quantity with unit of Newton
(d) Quantity with unit of metre
Ans. b | Sol. : It is the ratio of frictional force to normal reaction, making it dimensionless.

Q46. The equilibrium equations for a coplanar force system are independent because
(a) They involve different units
(b) Each equation represents equilibrium in a different direction or rotation
(c) They always produce identical results
(d) They are valid only for beams
Ans. b | Sol. : The three equilibrium equations independently satisfy force balance in horizontal and vertical directions and moment balance.

Q47. If the resultant of several coplanar forces is zero, then the force system is
(a) Balanced
(b) Dynamic
(c) Non-concurrent
(d) Parallel
Ans. a | Sol. : A zero resultant indicates that the applied forces balance each other, satisfying translational equilibrium.

Q48. A force can be shifted anywhere along its line of action without changing its external effect on a rigid body according to
(a) Varignon's theorem
(b) Principle of transmissibility
(c) Lami's theorem
(d) Parallel axis theorem
Ans. b | Sol. : The principle of transmissibility states that the external effect of a force on a rigid body remains unchanged if it is moved anywhere along its line of action.

Q49. The limiting friction acts
(a) Before the body is placed on a surface
(b) Only after the body starts moving
(c) Just before impending motion begins
(d) Only on inclined planes
Ans. c | Sol. : Limiting friction is the maximum value of static friction that acts immediately before motion starts.

Q50. For the same pair of surfaces, the coefficient of friction mainly depends upon
(a) Contact area
(b) Surface characteristics
(c) Magnitude of normal reaction
(d) Shape of the body
Ans. b | Sol. : The coefficient of friction is primarily determined by the nature and roughness of the contacting surfaces.

Q51. A uniform horizontal beam of length 6 m and weight 600 N is fixed at one end. A vertical load of 900 N is applied at the free end. What is the reaction moment at the fixed support?
(a) 2700 N·m
(b) 4500 N·m
(c) 6300 N·m
(d) 7200 N·m
Ans. d | Sol. : The beam's weight acts at its midpoint, i.e., at a distance of 3 m from the fixed support.
Moment due to beam weight:
$MW=600\times3=1800$ N·m
Moment due to the 900 N load at the free end:
$MP=900\times6=5400$ N·m
For rotational equilibrium, the fixed support provides an equal and opposite reaction moment:
$MA=MW+MP$ $MA=1800+5400$ $MA=7200$ N·m
Therefore, the reaction moment at the fixed support is:
7200 N·m

Q52. A body is subjected to two perpendicular forces of 8 kN and 15 kN. What is the magnitude of the resultant force?
(a) 17 kN
(b) 19 kN
(c) 21 kN
(d) 23 kN
Ans. a | Sol. : Resultant force = $\sqrt{(8^2 + 15^2)} = \sqrt{289} =$ 17 kN using the Pythagorean theorem.

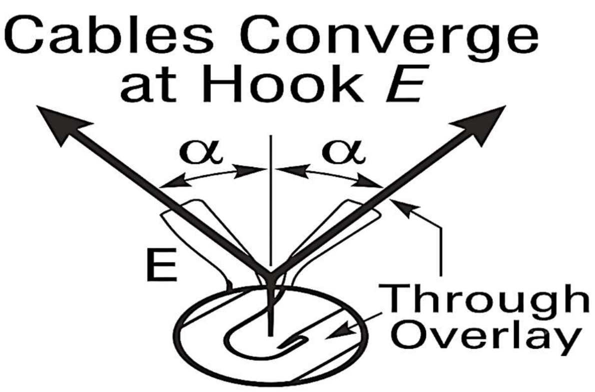
Q53. A rigid body is acted upon by three coplanar concurrent forces. If two forces are 40 N east and 30 N north, what should be the third force for equilibrium?
(a) 50 N north-east
(b) 50 N south-west
(c) 70 N west
(d) 10 N south
Ans. b | Sol. : The resultant of the first two forces is $\sqrt{(40^2 + 30^2)} = 50$ N directed north-east. The balancing force must be equal in magnitude and opposite in direction, i.e., south-west.

Q54. A couple consists of two equal and opposite forces of 200 N separated by 0.4 m. The magnitude of the couple moment is
(a) 40 N·m
(b) 60 N·m
(c) 80 N·m
(d) 100 N·m
Ans. c | Sol. : Couple moment = Force × perpendicular distance = 200 × 0.4 = 80 N·m.

Q55. A 500 N block rests on a rough horizontal surface with coefficient of static friction 0.4. The maximum static friction available is
(a) 100 N
(b) 150 N
(c) 200 N
(d) 250 N
Ans. c | Sol. : Maximum static friction = $\mu_s N$ = 0.4 × 500 = 200 N.

Q56. A force of 150 N is applied horizontally to a 400 N block resting on a surface having coefficient of static friction 0.3. The block will
(a) Move with constant velocity
(b) Remain at rest
(c) Accelerate uniformly
(d) Move only after external support
Ans. c | Sol. : Maximum static friction = 0.3 × 400 = 120 N. Since the applied force (150 N) exceeds static friction, the block starts moving.

Q57. Two identical cables converge symmetrically at hook E as shown in the figure, each making an angle α = 30° with the vertical. A machine component of weight 20 kN is lifted and remains in static equilibrium. Neglect the self-weight of the cables. What is the tension developed in each cable?



(a) 10.0 kN
(b) 11.5 kN
(c) 14.1 kN
(d) 20.0 kN
Ans. b | Sol. : Since the arrangement is symmetric, the tension in both cables is equal.
For vertical equilibrium,
$2T \cos \alpha = W$
Substituting,
$2T \cos 30° = 20$
$2T(0.866) = 20$
$T = 20/1.732$
= 11.55 kN
≈ 11.5 kN

Q58. For equilibrium of a coplanar force system, which set of equations must be satisfied?
(a) $\Sigma F_x = 0$ only
(b) $\Sigma F_y = 0$ only
(c) $\Sigma M = 0$ only
(d) $\Sigma F_x = 0$, $\Sigma F_y = 0$, and $\Sigma M = 0$
Ans. d | Sol. : Complete equilibrium in a plane requires zero net force in both coordinate directions and zero resultant moment.

Q59. The centroid of a semicircular area of radius R measured from its diameter is
(a) R/2
(b) 2R/3
(c) 4R/3π
(d) 3R/4π
Ans. c | Sol. : The centroid of a semicircular area lies at a distance of 4R/3π from the diameter along the axis of symmetry.

Q60. The centroid of a rectangular plate measuring 300 mm × 200 mm is located at
(a) (100 mm, 100 mm)
(b) (150 mm, 100 mm)
(c) (200 mm, 150 mm)
(d) (150 mm, 150 mm)
Ans. b | Sol. : The centroid of a rectangle lies at the intersection of its diagonals, i.e., half of each dimension.

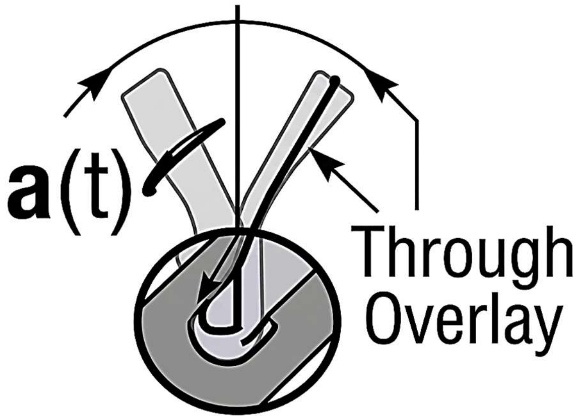
Q61. The centroid of a composite section is obtained by
(a) Taking the arithmetic mean of dimensions
(b) Using the weighted average of individual areas
(c) Multiplying all dimensions
(d) Considering only the largest area
Ans. b | Sol. : The centroid coordinates are determined using $\Sigma Ax/\Sigma A$ and $\Sigma Ay/\Sigma A$, where A represents individual component areas.

Q62. The moment of inertia of a rectangular section of width b and depth d about its centroidal x-axis is
(a) $bd^3/12$
(b) $b^3d/12$
(c) $bd^2/6$
(d) $b^2d^2/12$
Ans. a | Sol. : The centroidal moment of inertia about the horizontal axis is given by $I = bd^3/12$.

Q63. Using the parallel axis theorem, the moment of inertia about any axis is
(a) $I_c - Ad^2$
(b) $I_c + Ad^2$
(c) I_c/A
(d) $I_c \times Ad^2$
Ans. b | Sol. : The parallel axis theorem states that $I = I_c + Ad^2$, where Ic is the centroidal moment of inertia.

Q64. A circular plate has a radius of 0.5 m and mass 20 kg. Its mass moment of inertia about the centroidal axis normal to the plate is
(a) 1.25 kg·m²
(b) 2.5 kg·m²
(c) 5 kg·m²
(d) 10 kg·m²
Ans. b | Sol. : Mass moment of inertia = $\frac{1}{2}MR^2 = 0.5 \times 20 \times (0.5)^2 = 2.5$ kg·m².

Q65. A particle moves along a straight vertical path, and its acceleration varies with time as a(t). At an instant shown in the figure, the particle has an upward velocity of 12 m/s, while its acceleration is directed downward with a magnitude of 4 m/s². Neglect air resistance. After 2 s, the velocity of the particle is:



(a) 4 m/s upward
(b) 8 m/s upward
(c) 12 m/s upward
(d) 20 m/s upward
Ans. a | Sol. : For rectilinear motion with constant acceleration over the given interval,
$v = u + at$
Given,
$u = 12$ m/s (upward)
$a = -4$ m/s² (downward)
$t = 2$ s
Therefore,
$v = 12 + (-4 \times 2)$
$= 12 - 8$
$= 4$ m/s upward

Q66. A 100 N force acts at 60° to the horizontal. The horizontal component is
(a) 50 N
(b) 70.7 N
(c) 86.6 N
(d) 100 N
Ans. a | Sol. : Horizontal component = 100 cos60° = 50 N.

Q67. A body is acted upon by a force system whose resultant force is zero but resultant moment is non-zero. The system represents
(a) Concurrent force system
(b) Couple
(c) Parallel force system
(d) Collinear force system
Ans. b | Sol. : A couple produces pure rotation with zero resultant force and a finite moment.

Q68. For impending motion, the angle of friction is related to coefficient of friction by
(a) $\mu = \sin\varphi$
(b) $\mu = \tan\varphi$
(c) $\mu = \cos\varphi$
(d) $\mu = \cot\varphi$
Ans. b | Sol. : The angle of friction is defined by $\tan\varphi = \mu$.

Q69. The radius of gyration of a section is 60 mm and its area is 800 mm². The moment of inertia is
(a) 1.44×10^6 mm⁴
(b) 2.88×10^6 mm⁴
(c) 3.20×10^6 mm⁴
(d) 4.80×10^6 mm⁴
Ans. b | Sol. : $I = Ak^2 = 800 \times (60)^2 = 2.88 \times 10^6$ mm⁴.

Q70. The centroid of an equilateral triangular area lies at a distance from its base equal to
(a) h/2
(b) h/4
(c) h/3
(d) 2h/3
Ans. c | Sol. : The centroid of a triangle is located one-third of its height above the base.

Q71. A 10 kN force acts 4 m from a point. The moment about the point is
(a) 10 kN·m
(b) 20 kN·m
(c) 30 kN·m
(d) 40 kN·m
Ans. d | Sol. : Moment = Force × perpendicular distance = 10 × 4 = 40 kN·m.

Q72. The coefficient of kinetic friction is generally
(a) Equal to static friction coefficient
(b) Greater than static friction coefficient

(c) Less than static friction coefficient
(d) Independent of surface condition
Ans. c | Sol. : Kinetic friction is generally lower than limiting static friction for the same pair of surfaces.

Q73. The centroid of a circular area lies at
(a) One-fourth of diameter
(b) Centre of the circle
(c) Radius divided by three
(d) Edge of the circle
Ans. b | Sol. : Due to complete symmetry, the centroid coincides with the geometric centre.

Q74. A rectangular section of width 100 mm and depth 200 mm has a centroidal moment of inertia about the x-axis equal to
(a) 3.33×10^7 mm^4
(b) 4.67×10^7 mm^4
(c) 6.67×10^7 mm^4
(d) 8.00×10^7 mm^4
Ans. c | Sol. : $I = bd^3/12 = (100 \times 200^3)/12 = 6.67 \times 10^7$ mm^4.

Q75. The algebraic sum of moments of all forces about any point is zero when the body is
(a) Accelerating uniformly
(b) In translational equilibrium only
(c) In rotational equilibrium
(d) Moving with constant acceleration
Ans. c | Sol. : Rotational equilibrium requires that the net moment acting on the body be zero.

Q76. A rigid frame is subjected to three coplanar concurrent forces of 20 kN, 30 kN, and 40 kN acting at a point. If the vector sum of the first two forces is exactly equal and opposite to the third force, what can be concluded?
(a) The frame is in rotational equilibrium only
(b) The frame is in translational equilibrium only
(c) The concurrent force system is in equilibrium
(d) The system must have a non-zero resultant couple
Ans. c | Sol. : For a concurrent force system, equilibrium exists when the vector sum of all forces is zero. Since all forces pass through one point, no resultant moment exists.

Q77. A simply supported beam is analyzed using a free body diagram. One support reaction is omitted while writing the equilibrium equations. Which consequence is most likely?
(a) The bending moment remains unaffected
(b) The support reaction can still be determined correctly
(c) The equilibrium equations become incomplete, leading to incorrect results
(d) Only shear force calculations are affected
Ans. c | Sol. : Every external force acting on the body must appear in the free body diagram. Omitting a reaction violates equilibrium and produces incorrect force calculations.

Q78. A body is acted upon by two equal and opposite parallel forces separated by a perpendicular distance. What is the effect of this force system?
(a) Pure translation
(b) Pure rotation without translation
(c) Zero force and zero moment
(d) Translation along the line of action
Ans. b | Sol. : Two equal and opposite parallel forces form a couple, which produces rotation only. The resultant force is zero, but the resultant moment equals force × perpendicular distance.

Q79. A 12 kN force acts at a perpendicular distance of 0.6 m from point O. What is the magnitude of the moment about O?
(a) 5.2 kN·m
(b) 6.4 kN·m
(c) 7.2 kN·m
(d) 8.4 kN·m
Ans. c | Sol. : Moment = Force × Perpendicular distance = $12 \times 0.6 = 7.2$ kN·m.

Q80. A ladder rests against a smooth vertical wall and a rough horizontal floor. Which force prevents the ladder from slipping?
(a) Wall reaction
(b) Weight of ladder
(c) Frictional force at the floor
(d) Normal reaction at the floor
Ans. c | Sol. : Since the wall is smooth, it provides only normal reaction. Friction at the floor resists sliding and maintains equilibrium.

Q81. A force of 100 N acts at an angle of 60° with the horizontal. What is its horizontal component?
(a) 50 N
(b) 60 N
(c) 70.7N
(d) 86.6 N
Ans. a | Sol. : Horizontal component = F cos60° = $100 \times 0.5 = 50$ N.

Q82. A body remains at rest under the action of several coplanar forces. Which additional condition besides $\Sigma Fx = 0$ and $\Sigma Fy = 0$ must also be satisfied?
(a) ΣM = Constant
(b) $\Sigma M = 0$
(c) ΣF = Maximum
(d) ΣM = Weight

Ans. b | Sol. : Complete equilibrium of a rigid body requires the algebraic sum of moments about any point to be zero.

Q83. A block weighing 600 N rests on a rough horizontal surface. The coefficient of static friction is 0.4. What is the maximum static friction available?

(a) 180 N
(b) 200 N
(c) 240 N
(d) 300 N

Ans. c | Sol. : Limiting friction = $\mu N = 0.4 \times 600 =$ 240 N.

Q84. A horizontal force of 260 N is applied to the block in the previous question. What will happen?

(a) The block remains stationary
(b) The block is on the verge of motion
(c) The block starts moving
(d) Friction becomes zero

Ans. c | Sol. : Since the applied force exceeds the limiting friction of 240 N, static friction is overcome and motion begins.

Q85. A body is moving on a rough surface with constant velocity. Which statement is correct?

(a) Dynamic friction exceeds the applied force
(b) Dynamic friction equals the applied force
(c) Dynamic friction is zero
(d) Static friction acts

Ans. b | Sol. : Constant velocity implies zero acceleration; therefore, the applied force balances kinetic friction.

Q86. For a rectangular plate of width b and height h, the centroid lies at

(a) (b/3, h/3)
(b) (b/2, h/2)
(c) (2b/3, h/2)
(d) (b/2, h/3)

Ans. b | Sol. : The centroid of a rectangle is located at its geometric center.

Q87. A circular hole is cut from the center of a rectangular plate. Which property remains unchanged?

(a) Area
(b) Centroid location
(c) Mass
(d) Moment of inertia

Ans. b | Sol. : If the hole is centrally located, symmetry is preserved; therefore, the centroid remains unchanged.

Q88. The centroid of a semicircular area of radius R is located from its diameter at

(a) R/2
(b) 2R/3
(c) $4R/3\pi$
(d) R/π

Ans. c | Sol. : The standard centroid location of a semicircular area from its base is $4R/3\pi$.

Q89. Two identical rectangles are joined side by side. Compared with a single rectangle, the centroid of the combined section

(a) Shifts toward one rectangle
(b) Remains at the center of the combined width
(c) Lies outside the section
(d) Depends on thickness only

Ans. b | Sol. : Due to symmetry, the centroid lies at the geometric center of the combined section.

Q90. Which theorem is primarily used to determine the moment of inertia of composite sections?

(a) Varignon's theorem
(b) Lami's theorem
(c) Parallel-axis theorem
(d) Triangle law

Ans. c | Sol. : The parallel-axis theorem allows transfer of moment of inertia from the centroidal axis to any parallel axis.

Q91. The centroid of an L-shaped section is generally obtained by

(a) Direct integration only
(b) Dividing into simple shapes and applying first moments of area
(c) Using Hooke's law
(d) Applying equilibrium equations

Ans. b | Sol. : Composite sections are divided into standard geometric shapes, and centroid coordinates are obtained using area-weighted averages.

Q92. A square plate has side 'a'. Its centroidal moment of inertia about an axis parallel to one side is

(a) $a^4/3$
(b) $a^4/12$
(c) $a^4/24$
(d) $a^4/48$

Ans. b | Sol. : For a square, $I = bh^3/12 = a \times a^3/12 = a^4/12$.

Q93. Which property of a section mainly governs beam deflection?

(a) Cross-sectional area
(b) Density
(c) Moment of inertia
(d) Perimeter

Ans. c | Sol. : Beam stiffness is proportional to EI. Larger moment of inertia results in smaller deflection.

Q94. The radius of gyration is defined as

(a) $\sqrt{(A/I)}$
(b) $\sqrt{(I/A)}$
(c) I/A
(d) A/I
Ans. b | Sol. : Radius of gyration is the distance from the axis at which the entire area may be assumed concentrated without changing the moment of inertia.

Q95. A composite section has a larger moment of inertia about the x-axis than the y-axis. Which statement is correct?
(a) It offers greater resistance to bending about the x-axis
(b) It offers greater resistance to bending about the y-axis
(c) It has equal stiffness about both axes
(d) Bending resistance depends only on area
Ans. a | Sol. : Higher moment of inertia about an axis indicates greater resistance to bending about that axis.

Q96. The mass moment of inertia of a thin circular plate of mass M and radius R about its centroidal axis normal to the plate is
(a) MR^2
(b) $MR^2/4$
(c) $MR^2/2$
(d) $MR^2/8$
Ans. c | Sol. : The standard mass moment of inertia of a solid circular plate about its centroidal axis is $MR^2/2$.

Q97. Which statement correctly distinguishes area moment of inertia from mass moment of inertia?
(a) Both have identical physical meaning
(b) Area moment of inertia relates to bending, whereas mass moment of inertia relates to rotational dynamics
(c) Area moment of inertia depends on mass
(d) Mass moment of inertia is independent of mass
Ans. b | Sol. : Area moment of inertia measures geometric resistance to bending, while mass moment of inertia measures resistance to angular acceleration.

Q98. A force system has zero resultant force but a non-zero resultant moment. Which equivalent system represents it?
(a) Single force
(b) Couple
(c) Concurrent force system
(d) Parallel force system with zero spacing
Ans. b | Sol. : Zero resultant force with finite moment is the defining characteristic of a couple.

Q99. A uniform triangular lamina has its base horizontal. The centroid is located at
(a) h/2 above the base
(b) h/4 above the base
(c) h/3 above the base
(d) 2h/3 above the base
Ans. c | Sol. : The centroid of a triangle lies at one-third of its altitude measured from the base.

Q100. A body is in equilibrium under three non-parallel coplanar forces. Which condition must necessarily hold?
(a) All forces are parallel
(b) All forces are concurrent
(c) All forces are perpendicular
(d) Resultant force is maximum
Ans. b | Sol. : Three non-parallel coplanar forces can keep a rigid body in equilibrium only if their lines of action are concurrent.

Q101. Which of the following is the shape generated when a rectangle revolves about one of its sides?
(a) Cone
(b) Sphere
(c) Cylinder
(d) Prism
Ans. c | Sol. : A right circular cylinder is generated by revolving a rectangle about one of its sides.

Q102. Which point is considered the center of gravity of a homogeneous sphere?
(a) On the surface
(b) At the geometric center
(c) At one-fourth of its diameter
(d) At one-third of its radius
Ans. b | Sol. : For a homogeneous sphere, the center of gravity coincides with its geometric center.

Q103. Which solid is formed by revolving a right-angled triangle about one of its perpendicular sides?
(a) Sphere
(b) Cone
(c) Cylinder
(d) Cuboid
Ans. b | Sol. : A right circular cone is obtained when a right-angled triangle revolves about one of its perpendicular sides.

Q104. Which of the following is the SI unit of moment of force?
(a) Newton
(b) Newton per metre
(c) Newton metre
(d) Joule per metre

Ans. c | Sol. : The moment of force is measured in Newton metre (N·m), which represents force multiplied by perpendicular distance.

Q105. For a body to remain in equilibrium, the resultant of all external forces must be:
(a) Equal to weight
(b) Equal to applied force
(c) Zero
(d) Greater than zero
Ans. c | Sol. : A body is in equilibrium when the vector sum of all external forces acting on it is zero.

Q106. In three-dimensional equilibrium, the total number of independent equilibrium equations is:
(a) Two
(b) Three
(c) Four
(d) Six
Ans. d | Sol. : Three force equilibrium equations and three moment equilibrium equations are available in three-dimensional analysis.

Q107. A truss member carrying no force under a given loading condition is called:
(a) Compression member
(b) Tension member
(c) Zero-force member
(d) Secondary member
Ans. c | Sol. : A zero-force member carries no axial force for a specific loading and support condition.

Q108. A simply supported beam has:
(a) Both ends fixed
(b) One fixed end and one free end
(c) One pin support and one roller support
(d) Two roller supports only
Ans. c | Sol. : A simply supported beam is generally supported by one hinged (pin) support and one roller support.

Q109. The reaction at a roller support acts:
(a) Parallel to the supporting surface
(b) Perpendicular to the supporting surface
(c) Along the beam axis
(d) At 45° to the beam
Ans. b | Sol. : A roller support provides a reaction normal to the supporting surface while allowing movement along the surface.

Q110. Rectilinear motion refers to motion along:
(a) A circular path
(b) A curved path
(c) A straight line
(d) An elliptical path
Ans. c | Sol. : Rectilinear motion is the motion of a particle along a straight-line path.

Q111. In plane curvilinear motion, the particle moves:
(a) Along a straight line
(b) In a single plane on a curved path
(c) Randomly in space
(d) Along the vertical direction only
Ans. b | Sol. : Plane curvilinear motion occurs when the path of the particle is curved but confined to a single plane.

Q112. The work done by a force is equal to:
(a) Force divided by displacement
(b) Force multiplied by displacement in the direction of force
(c) Force multiplied by time
(d) Mass multiplied by acceleration
Ans. b | Sol. : Work is the scalar product of force and displacement in the direction of the force.

Q113. The SI unit of kinetic energy is:
(a) Newton
(b) Watt
(c) Joule
(d) Pascal
Ans. c | Sol. : Kinetic energy is measured in joules (J), the SI unit of energy.

Q114. Power is defined as:
(a) Force multiplied by velocity
(b) Work done per unit time
(c) Energy multiplied by time
(d) Momentum per second
Ans. b | Sol. : Power represents the rate at which work is performed or energy is transferred.

Q115. Potential energy is associated with:
(a) Motion only
(b) Position or configuration
(c) Velocity only
(d) Momentum only
Ans. b | Sol. : Potential energy arises due to the position or configuration of a body in a force field.

Q116. The principle of conservation of mechanical energy is applicable when:
(a) Only frictional forces act
(b) Only conservative forces act
(c) Only external forces act
(d) Only impact forces act
Ans. b | Sol. : Mechanical energy remains constant when only conservative forces perform work.

Q117. Impulse is equal to:
(a) Force multiplied by displacement
(b) Force multiplied by time interval
(c) Mass multiplied by velocity
(d) Acceleration multiplied by time
Ans. b | Sol. : Impulse is the product of force and the time during which it acts.

Q118. Linear momentum is defined as:
(a) Mass × acceleration

(b) Force × time
(c) Mass × velocity
(d) Force × displacement
Ans. c | Sol. : Linear momentum is the product of mass and velocity.

Q119. During a perfectly elastic impact, which quantity remains conserved?
(a) Momentum only
(b) Kinetic energy only
(c) Both momentum and kinetic energy
(d) Potential energy only
Ans. c | Sol. : In a perfectly elastic collision, both momentum and kinetic energy remain conserved.

Q120. Which principle converts a dynamic problem into an equivalent static problem?
(a) Bernoulli's principle
(b) D'Alembert's principle
(c) Pascal's principle
(d) Archimedes' principle
Ans. b | Sol. : D'Alembert's principle introduces inertia forces to establish dynamic equilibrium.

Q121. The inertia force used in D'Alembert's principle acts:
(a) In the direction of acceleration
(b) Opposite to the direction of acceleration
(c) Perpendicular to acceleration
(d) Along the direction of velocity
Ans. b | Sol. : The inertia force acts opposite to the acceleration and has magnitude equal to mass multiplied by acceleration.

Q122. The rotational form of Newton's second law is expressed as:
(a) F = ma
(b) M = Iα
(c) W = Fs
(d) P = W/t
Ans. b | Sol. : The net external moment acting on a rigid body equals the product of moment of inertia and angular acceleration.

Q123. The SI unit of angular velocity is:
(a) Degree
(b) Radian
(c) Radian per second
(d) Revolution
Ans. c | Sol. : Angular velocity is measured in radians per second (rad/s).

Q124. Moment of inertia depends upon:
(a) Only the mass of the body
(b) Only the shape of the body
(c) Mass distribution about the axis of rotation
(d) Velocity of the body
Ans. c | Sol. : Moment of inertia depends on both the mass and its distribution relative to the axis of rotation.

Q125. The virtual work principle states that for equilibrium, the total virtual work done by all forces is:
(a) Maximum
(b) Minimum
(c) Zero
(d) Equal to kinetic energy
Ans. c | Sol. : A system in equilibrium performs zero total virtual work for any admissible virtual displacement.

Q126. Which of the following best represents the condition for equilibrium of a rigid body in three-dimensional space?
(a) Only the algebraic sum of forces must be zero
(b) Only the algebraic sum of moments must be zero
(c) The algebraic sum of all forces and all moments about any point must be zero
(d) The resultant force and moment must be parallel
Ans. c | Sol. : A rigid body is in complete equilibrium only when ΣFx = 0, ΣFy = 0, ΣFz = 0 and ΣMx = 0, ΣMy = 0, ΣMz = 0. Both translational and rotational equilibrium must be satisfied.

Q127. Which of the following supports provides three force reaction components and no reaction moment in a three-dimensional structure?
(a) Roller support
(b) Pin support
(c) Ball-and-socket support
(d) Cable support
Ans. c | Sol. : In three-dimensional analysis, a ball-and-socket support prevents translation of the supported point along the x, y, and z directions. Therefore, it develops three force reaction components:
Rx,Ry,Rz
It does not restrain rotation, so it does not develop reaction moments. Hence, the **ball-and-socket support provides three force reaction components**.

Q128. A simply supported beam of span 8 m carries a central point load of 40 kN. The reaction at each support is
(a) 10 kN
(b) 20 kN
(c) 30 kN
(d) 40 kN
Ans. b | Sol. : Due to symmetry, the reactions are equal.
Reaction at each support = 40/2 = 20 kN.

Q129. A truss member carries no force when
(a) It is inclined at 45°
(b) It is connected to a roller support
(c) Two non-collinear members meet at an unloaded joint
(d) Three members meet at a joint where two are collinear and no external load acts
Ans. d | Sol. : According to the zero-force member rule, if three members meet at an unloaded joint and two are collinear, the third non-collinear member carries zero force.
Q130. The centroid of a solid hemisphere of radius R lies at a distance of
(a) 3R/8 from the base
(b) R/2 from the base
(c) 5R/8 from the base
(d) 2R/3 from the base
Ans. a | Sol. : The centroid of a solid hemisphere is located at a distance of 3R/8 from its flat circular base along the axis of symmetry.
Q131. A solid cone and a solid cylinder have the same base radius and height. The ratio of their volumes is
(a) 1 : 2
(b) 1 : 3
(c) 2 : 3
(d) 3 : 4
Ans. b | Sol. : Volume of cone = $(1/3)\pi R^2 H$ and volume of cylinder = $\pi R^2 H$. Therefore, the ratio is 1 : 3.
Q132. A particle moves along a straight line with constant acceleration of 4 m/s^2. If its initial velocity is 6 m/s, its velocity after 5 seconds will be
(a) 20 m/s
(b) 24 m/s
(c) 26 m/s
(d) 30 m/s
Ans. c | Sol. : Using the equation $v = u + at$,
$v = 6 + (4 \times 5) = 26$ m/s.
Q133. A vehicle moves along a circular path of radius 100 m at a constant speed of 20 m/s. The centripetal acceleration is
(a) 2 m/s^2
(b) 4 m/s^2
(c) 6 m/s^2
(d) 8 m/s^2
Ans. b | Sol. : Centripetal acceleration = $v^2/r = 20^2/100 = 400/100 = 4$ m/s^2.
Q134. A body of mass 5 kg is lifted vertically through a height of 4 m. The increase in potential energy is approximately
(a) 98 J
(b) 196 J
(c) 250 J
(d) 392 J
Ans. b | Sol. : Potential energy = mgh = $5 \times 9.81 \times 4 \approx 196$ J.
Q135. A force of 50 N acts on a body moving with a velocity of 6 m/s in the direction of the force. The power developed is
(a) 56 W
(b) 150 W
(c) 300 W
(d) 600 W
Ans. c | Sol. : Power = Force × Velocity = $50 \times 6 = 300$ W.
Q136. Which of the following statements correctly represents the principle of impulse and momentum?
(a) The impulse acting on a body is equal to its kinetic energy.
(b) The impulse acting on a body is equal to the change in its linear momentum.
(c) The impulse acting on a body is equal to its potential energy.
(d) The impulse acting on a body is equal to the work done.
Ans. b | Sol. : The impulse-momentum principle states that the impulse produced by a force acting over a time interval is equal to the change in linear momentum of the body, i.e., Impulse = $\Delta(mv)$.
Q137. A force of 100 N acts on a 5 kg body initially at rest for 4 seconds. Neglecting resistance, the final velocity of the body is
(a) 20 m/s
(b) 40 m/s
(c) 60 m/s
(d) 80 m/s
Ans. d | Sol. : Acceleration = F/m = 100/5 = 20 m/s^2. Final velocity = $u + at = 0 + (20 \times 4) = 80$ m/s.
Q138. The coefficient of restitution for a perfectly elastic collision is
(a) 0
(b) 0.5
(c) 1
(d) Greater than 1
Ans. c | Sol. : In a perfectly elastic collision, both momentum and kinetic energy are conserved. Therefore, the coefficient of restitution is equal to 1.
Q139. The coefficient of restitution for a perfectly plastic (inelastic) collision is
(a) 0
(b) 0.25
(c) 0.75
(d) 1

Ans. a | Sol. : In a perfectly plastic collision, the colliding bodies stick together after impact. Hence, the coefficient of restitution is zero.

Q140. A body of mass 4 kg moving at 8 m/s is brought to rest uniformly in 2 seconds. The average retarding force is

(a) 8 N
(b) 12 N
(c) 16 N
(d) 20 N

Ans. c | Sol. : Acceleration = $(0 - 8)/2 = -4$ m/s².
Retarding force = ma = 4 × 4 = 16 N.

Q141. Which of the following is the primary advantage of D'Alembert's principle?

(a) It converts a static problem into a dynamic problem.
(b) It converts a dynamic problem into an equivalent static equilibrium problem.
(c) It eliminates inertia forces from analysis.
(d) It is applicable only to particles in equilibrium.

Ans. b | Sol. : D'Alembert's principle introduces inertia forces opposite to acceleration, allowing dynamic problems to be solved using the equations of static equilibrium.

Q142. A wheel of radius 0.5 m rotates with an angular velocity of 8 rad/s. The linear velocity of a point on its rim is

(a) 2 m/s
(b) 4 m/s
(c) 6 m/s
(d) 8 m/s

Ans. b | Sol. : Linear velocity = $r\omega = 0.5 \times 8 = 4$ m/s.

Q143. A flywheel rotates at 300 rpm. Its angular velocity is approximately

(a) 15.7 rad/s
(b) 31.4 rad/s
(c) 62.8 rad/s
(d) 94.2 rad/s

Ans. b | Sol. : Angular velocity,
$\omega = (2\pi N)/60$
$= (2\pi \times 300)/60$
$= 10\pi \approx 31.4$ rad/s.

Q144. The moment of inertia of a solid sphere of mass M and radius R about its centroidal diameter is

(a) MR^2
(b) $(1/2)MR^2$
(c) $(2/5)MR^2$
(d) $(3/5)MR^2$

Ans. c | Sol. : The standard mass moment of inertia of a solid sphere about any centroidal diameter is $(2/5)MR^2$.

Q145. The moment of inertia of a solid cylinder about its longitudinal axis is

(a) $(1/4)MR^2$
(b) $(1/2)MR^2$
(c) $(2/3)MR^2$
(d) MR^2

Ans. b | Sol. : The mass moment of inertia of a solid cylinder about its own axis is $(1/2)MR^2$.

Q146. A constant torque of 50 N·m acts on a shaft rotating through an angle of 8 radians. The work done is

(a) 58 J
(b) 200 J
(c) 400 J
(d) 800 J

Ans. c | Sol. : Work done by torque = $T\theta = 50 \times 8 = 400$ J.

Q147. A body rotating with a constant angular velocity experiences

(a) Tangential acceleration only
(b) Centripetal acceleration only
(c) Both tangential and centripetal accelerations
(d) Neither tangential nor centripetal acceleration

Ans. b | Sol. : At constant angular velocity, angular acceleration is zero; therefore, tangential acceleration is zero. However, centripetal acceleration exists because the direction of velocity continuously changes.

Q148. The centroid of a triangular lamina is located at

(a) Midpoint of the base
(b) One-third of the altitude from the base
(c) Two-thirds of the altitude from the base
(d) At the circumcentre

Ans. b | Sol. : The centroid of a triangle lies at one-third of the altitude measured from the base, or equivalently two-thirds from the opposite vertex.

Q149. For a particle moving in a vertical plane under gravity alone, which quantity remains constant if air resistance is neglected?

(a) Linear momentum
(b) Potential energy
(c) Total mechanical energy
(d) Velocity

Ans. c | Sol. : In the absence of non-conservative forces such as air resistance, the sum of kinetic energy and potential energy remains constant according to the law of conservation of mechanical energy.

Q150. A simply supported beam carries a uniformly distributed load over its entire span. The support reactions are

(a) Equal and each carries half of the total load

(b) Unequal and depend on beam stiffness
(c) One support carries the entire load
(d) Zero at both supports
Ans. a | Sol. : For a uniformly distributed load acting over the complete span of a simply supported beam, the loading is symmetrical. Therefore, each support carries one-half of the total load.

Q151. Which of the following best describes the purpose of a free body diagram in engineering mechanics?
(a) To determine the material properties of a body
(b) To represent all external forces and moments acting on an isolated body
(c) To calculate only internal stresses
(d) To measure the velocity of a moving body
Ans. b | Sol. : A free body diagram (FBD) isolates a body from its surroundings and shows all external forces, moments, and reactions acting on it, which is the first step in equilibrium analysis.

Q152. Which statement correctly represents the condition of equilibrium for a rigid body in three dimensions?
(a) Only the sum of horizontal forces must be zero
(b) Only the sum of moments must be zero
(c) The sums of all forces and all moments about each axis must be zero
(d) The body must remain stationary only in the vertical direction
Ans. c | Sol. : A rigid body is in equilibrium when $\Sigma Fx = 0$, $\Sigma Fy = 0$, $\Sigma Fz = 0$ and $\Sigma Mx = 0$, $\Sigma My = 0$, $\Sigma Mz = 0$.

Q153. A simply supported beam carries a concentrated load at its mid-span. Which statement is correct regarding the support reactions?
(a) The left support carries the entire load
(b) The right support carries the entire load
(c) Both supports carry equal reactions
(d) The reactions depend only on beam length
Ans. c | Sol. : Due to symmetry, each support carries half of the centrally applied load.

Q154. In a pin-jointed simple truss, members are generally assumed to carry
(a) Bending moment only
(b) Axial tension or compression only
(c) Shear force only
(d) Torsional moment only
Ans. b | Sol. : Truss members are idealized as two-force members subjected only to axial tensile or compressive forces.

Q155. Which support prevents translation in both horizontal and vertical directions while allowing rotation?
(a) Roller support
(b) Fixed support
(c) Pin (hinged) support
(d) Link support
Ans. c | Sol. : A pin support provides two reaction components while permitting free rotation.

Q156. The centroid of a solid sphere lies at
(a) One-fourth of its diameter from the base
(b) One-third of its radius from the surface
(c) Its geometric center
(d) Midway between the center and surface
Ans. c | Sol. : Due to complete symmetry, the centroid of a solid sphere coincides with its geometric center.

Q157. The centroid of a right circular cylinder is located
(a) At the center of its base
(b) At one-third of its height
(c) At its geometric center
(d) At the top surface
Ans. c | Sol. : A uniform cylinder has its centroid at the midpoint of both its height and diameter.

Q158. The centroid of a solid right circular cone is located at
(a) One-fourth of its height from the base
(b) One-third of its height from the base
(c) Half of its height from the base
(d) Two-thirds of its height from the base
Ans. a | Sol. : The centroid of a solid cone lies on its axis at h/4 from the base.

Q159. A particle moving with constant velocity undergoes
(a) Constant acceleration
(b) Zero acceleration
(c) Increasing acceleration
(d) Variable acceleration
Ans. b | Sol. : Constant velocity means neither the magnitude nor the direction of velocity changes, resulting in zero acceleration.

Q160. In rectilinear motion, acceleration is defined as
(a) Rate of change of displacement
(b) Product of velocity and time
(c) Rate of change of velocity with time
(d) Velocity divided by displacement
Ans. c | Sol. : Acceleration is the time rate of change of velocity and is measured in m/s^2.

Q161. Which quantity remains constant during uniform circular motion?
(a) Velocity vector
(b) Acceleration vector
(c) Speed
(d) Radius vector direction

Ans. c | Sol. : Although the velocity direction changes continuously, the speed remains constant in uniform circular motion.

Q162. The centripetal acceleration of a particle moving in a circular path is directed

(a) Along the tangent
(b) Away from the center
(c) Towards the center of the circle
(d) Vertically downward

Ans. c | Sol. : Centripetal acceleration is always directed toward the center of curvature.

Q163. According to the work-energy principle, the net work done on a particle equals

(a) Its momentum
(b) Change in kinetic energy
(c) Potential energy
(d) Impulse

Ans. b | Sol. : The work-energy theorem states that net work equals the change in kinetic energy.

Q164. Power is defined as

(a) Force multiplied by displacement
(b) Work done per unit time
(c) Force divided by velocity
(d) Energy stored in a body

Ans. b | Sol. : Power represents the rate at which work is performed and is measured in watts.

Q165. Potential energy is associated with

(a) Velocity of the body
(b) Position or configuration of the body
(c) Temperature of the body
(d) Momentum of the body

Ans. b | Sol. : Potential energy depends on the body's position in a force field or its elastic deformation.

Q166. Impulse is equal to

(a) Force multiplied by displacement
(b) Force multiplied by time interval
(c) Mass multiplied by acceleration
(d) Velocity multiplied by time

Ans. b | Sol. : Impulse equals the product of force and the duration for which it acts and is equal to the change in momentum.

Q167. The principle of conservation of linear momentum is applicable when

(a) External forces are negligible
(b) Internal forces are zero
(c) Velocity remains constant
(d) Kinetic energy remains constant

Ans. a | Sol. : If the net external impulse is zero, total linear momentum of the system remains conserved.

Q168. In a perfectly elastic impact,

(a) Momentum is not conserved
(b) Both momentum and kinetic energy are conserved
(c) Only kinetic energy is conserved
(d) Only force is conserved

Ans. b | Sol. : A perfectly elastic collision conserves both total momentum and total kinetic energy.

Q169. Which quantity is always conserved during any impact, provided external impulses are negligible?

(a) Kinetic energy
(b) Momentum
(c) Velocity
(d) Mechanical energy

Ans. b | Sol. : Linear momentum is conserved in all collisions when external impulses are absent, whereas kinetic energy may not be conserved.

Q170. D'Alembert's principle converts a dynamic problem into

(a) A thermal equilibrium problem
(b) A static equilibrium problem by introducing inertia forces
(c) A fluid mechanics problem
(d) A stress analysis problem

Ans. b | Sol. : D'Alembert's principle introduces inertia forces opposite to acceleration, allowing dynamic analysis using equilibrium equations.

Q171. The inertia force introduced in D'Alembert's principle acts

(a) Along the direction of acceleration
(b) Opposite to the direction of acceleration
(c) Along the applied force
(d) Perpendicular to acceleration

Ans. b | Sol. : The inertia force equals ma and acts opposite to the acceleration.

Q172. For a rigid body rotating about a fixed axis, kinetic energy depends upon

(a) Mass only
(b) Radius only
(c) Moment of inertia and angular velocity
(d) Torque only

Ans. c | Sol. : Rotational kinetic energy is given by $(1/2)I\omega^2$, where I is the moment of inertia.

Q173. Which quantity is the rotational equivalent of mass?

(a) Torque
(b) Angular momentum
(c) Moment of inertia
(d) Angular acceleration

Ans. c | Sol. : Moment of inertia represents a body's resistance to angular acceleration, similar to mass in translational motion.

Q174. The virtual work principle states that a system is in equilibrium if

(a) Total work is always zero
(b) Total virtual work done by all forces during any admissible virtual displacement is zero
(c) Kinetic energy remains constant
(d) Potential energy becomes maximum
Ans. b | Sol. : For equilibrium, the algebraic sum of virtual work done by all external forces for any compatible virtual displacement must be zero.

Q175. The radius of gyration of a body depends upon
(a) Total weight only
(b) Distribution of mass about the axis
(c) Volume only
(d) Density only
Ans. b | Sol. : Radius of gyration is defined as the distance from the axis at which the entire mass of the body may be assumed to be concentrated without changing its moment of inertia. Hence, it depends on how the mass is distributed about the axis.

Q176. For a body subjected to three coplanar, non-parallel forces in equilibrium, the lines of action of the forces must
(a) Be mutually perpendicular
(b) Be parallel
(c) Intersect at a common point
(d) Form an equilateral triangle
Ans. c | Sol. : A three-force body in equilibrium requires the forces to be either parallel or concurrent. If they are non-parallel, their lines of action must meet at a single point.

Q177. A steel sphere and a solid steel cylinder have the same mass. If both roll without slipping down identical inclines from the same height, which reaches the bottom first?
(a) Sphere
(b) Cylinder
(c) Both reach simultaneously
(d) Cannot be determined
Ans. a | Sol. : The solid sphere has a smaller mass moment of inertia ratio ($I = 2/5\ mR^2$) than the solid cylinder ($I = 1/2\ mR^2$), resulting in greater translational acceleration and an earlier arrival.

Q178. A pin-jointed truss satisfies $m = 2j – 3$. However, it collapses under a small load. The most probable reason is:
(a) It is statically indeterminate
(b) It contains an internal mechanism due to improper member arrangement
(c) The supports are fixed
(d) The truss is overdesigned
Ans. b | Sol. : The relation $m = 2j – 3$ is only a necessary condition. Improper geometry may still create a mechanism, making the truss unstable despite satisfying the member-joint criterion.

Q179. A cone and a cylinder have identical base radius and height. Which statement regarding their centroids is correct?
(a) Both lie at mid-height
(b) Cone centroid lies closer to the base
(c) Cone centroid lies closer to the apex
(d) Both lie at one-third of their height
Ans. b | Sol. : The centroid of a solid cone lies at h/4 from the base, whereas the centroid of a solid cylinder lies at h/2 from the base.

Q180. A particle moves in a circular path at constant speed. Which statement is correct?
(a) Both velocity and acceleration remain constant
(b) Velocity changes but acceleration is zero
(c) Speed remains constant but velocity continuously changes
(d) Both speed and velocity remain constant
Ans. c | Sol. : Although the magnitude of velocity (speed) is constant, its direction changes continuously, producing centripetal acceleration toward the center.

Q181. A rigid body rotates with constant angular acceleration. Which quantity remains constant?
(a) Angular velocity
(b) Angular displacement
(c) Angular acceleration
(d) Tangential velocity
Ans. c | Sol. : Under uniform angular acceleration, angular acceleration remains constant, while angular velocity and displacement vary with time.

Q182. A beam is subjected to equal and opposite moments at its ends. Which internal force exists throughout the beam?
(a) Constant shear force only
(b) Constant bending moment only
(c) Variable bending moment
(d) Zero bending moment
Ans. b | Sol. : Equal and opposite end moments produce pure bending. The bending moment remains constant, while the shear force is zero throughout the beam.

Q183. A force system acting on a rigid body in three dimensions can always be reduced to:
(a) A single force only
(b) A single couple only
(c) A force and a couple at an arbitrary point
(d) Two equal forces
Ans. c | Sol. : Any general three-dimensional force system can be represented by an equivalent resultant force and a resultant couple acting at a chosen reference point.

Q184. For a simply supported beam carrying an eccentric point load, which support reaction increases as the load moves toward one support?
(a) Both reactions decrease
(b) The nearer support reaction increases
(c) Both reactions remain constant
(d) The farther support reaction increases
Ans. b | Sol. : Equilibrium requires the support closer to the moving load to carry a greater portion of the load, increasing its reaction.

Q185. A particle moves under a conservative force field. If kinetic energy decreases by 30 J, the potential energy will:
(a) Decrease by 30 J
(b) Increase by 30 J
(c) Remain unchanged
(d) Increase by 60 J
Ans. b | Sol. : For conservative systems, total mechanical energy remains constant. Therefore, any decrease in kinetic energy equals the increase in potential energy.

Q186. In the impulse-momentum principle, the area under the force-time curve represents:
(a) Power
(b) Work
(c) Impulse
(d) Momentum
Ans. c | Sol. : Impulse equals the integral of force with respect to time and represents the change in linear momentum.

Q187. Two identical smooth spheres collide centrally. If one sphere is initially at rest and the collision is perfectly elastic, the moving sphere will:
(a) Continue with reduced speed
(b) Stop completely
(c) Reverse direction
(d) Accelerate further
Ans. b | Sol. : In a perfectly elastic head-on collision between identical masses, the moving sphere transfers its velocity entirely to the stationary sphere.

Q188. A body is in equilibrium under three non-parallel coplanar forces. Which condition must necessarily be satisfied?
(a) All forces are equal
(b) All forces are parallel
(c) Their lines of action are concurrent
(d) One force must be horizontal
Ans. c | Sol. : For equilibrium under three non-parallel coplanar forces, their lines of action must intersect at a common point.

Q189. The virtual work principle is particularly advantageous in determining:
(a) Dynamic acceleration
(b) Internal stress distribution
(c) Equilibrium of constrained systems
(d) Fluid pressure
Ans. c | Sol. : The principle of virtual work simplifies equilibrium analysis by considering virtual displacements compatible with constraints, eliminating unnecessary reaction calculations.

Q190. Which statement best explains the significance of D'Alembert's principle?
(a) It converts dynamic problems into equivalent static equilibrium problems
(b) It eliminates inertia forces
(c) It applies only to rotating bodies
(d) It ignores acceleration effects
Ans. a | Sol. : D'Alembert's principle introduces inertia forces opposite to acceleration, allowing dynamic systems to be analyzed using static equilibrium equations.

Q191. A body rotates about a fixed axis while subjected to a constant torque. Which quantity increases linearly with time?
(a) Angular displacement
(b) Angular velocity
(c) Rotational kinetic energy
(d) Moment of inertia
Ans. b | Sol. : Constant torque produces constant angular acceleration. Hence angular velocity increases linearly with time.

Q192. A member of a pin-jointed truss is identified as a zero-force member for a particular loading condition. If this member is removed while the truss remains stable and the same loading condition is maintained, what is the immediate effect on the force equilibrium of the remaining members?
(a) The equilibrium forces in the remaining members remain unchanged
(b) The forces in all adjacent members become zero
(c) The stresses in all remaining members are doubled
(d) The truss necessarily becomes statically indeterminate
Ans. a | Sol. : A zero-force member carries zero axial force under the specified loading condition. If its removal does not affect the stability or load path of the truss, the equilibrium forces in the remaining members remain unchanged for that loading condition. However, a zero-force member may be important for stability or for carrying forces under a different loading condition.

Q193. A simply supported beam carries a uniformly distributed load over its full span. If the span doubles while load intensity remains unchanged, the maximum bending moment becomes:
(a) Twice the original
(b) Four times the original
(c) Half the original
(d) Eight times the original
Ans. b | Sol. : Maximum bending moment for a uniformly distributed load is $wL^2/8$. Doubling the span increases the moment by a factor of four.
Q194. A particle moves in a curved path with increasing speed. Its acceleration consists of:
(a) Tangential component only
(b) Normal component only
(c) Both tangential and normal components
(d) Zero acceleration
Ans. c | Sol. : Tangential acceleration changes speed, while normal acceleration changes direction. Both exist when speed and direction change simultaneously.
Q195. A beam subjected only to end couples experiences:
(a) Uniform shear stress
(b) Pure bending
(c) Pure torsion
(d) Axial compression
Ans. b | Sol. : End couples create a constant bending moment without transverse shear, producing pure bending.
Q196. A force acts through the centroid of a rigid body. Under what condition will the body still rotate?
(a) If friction exists
(b) If the centroid coincides with the center of gravity
(c) If an external couple also acts
(d) Rotation is impossible
Ans. c | Sol. : A force through the centroid produces no moment about the centroid. Rotation occurs only if an external couple or eccentric force creates a net moment.
Q197. For rolling without slipping, the instantaneous velocity of the point of contact with the ground is:
(a) Equal to translational velocity
(b) Twice the translational velocity
(c) Zero
(d) Equal to angular velocity
Ans. c | Sol. : During pure rolling, the translational velocity and rotational velocity at the contact point cancel each other, making its instantaneous velocity zero.
Q198. A rigid body rotates from rest through an angle θ under constant torque. The work done by the torque equals:
(a) Change in linear momentum
(b) Change in angular momentum
(c) Change in rotational kinetic energy
(d) Moment of inertia
Ans. c | Sol. : The work-energy principle for rotation states that the work done by the torque equals the increase in rotational kinetic energy.
Q199. A structure is externally stable but internally unstable. Which situation best represents this condition?
(a) Fixed beam
(b) Properly triangulated truss
(c) Truss containing a four-sided panel without diagonal bracing
(d) Cantilever beam
Ans. c | Sol. : An unbraced rectangular panel behaves like a mechanism, causing internal instability even if external supports are adequate.
Q200. Which parameter has the greatest influence on the coefficient of restitution during impact?
(a) Body weight
(b) Material properties and surface condition
(c) Initial velocity only
(d) Shape only
Ans. b | Sol. : The coefficient of restitution primarily depends on the material characteristics and contact surface conditions, not solely on velocity or weight.