UPPSC-AE 2025

Uttar Pradesh Public Service Commission

Combined State Engineering Services Exam

Assistant Engineer

3400+ MCQs

Fully solved multiple choice questions
with detailed explanations

Practice Book
Civil Engineering

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PREFACE

B. Singh (Ex. IES)

With the announcement of vacancies by Uttar Pradesh Public Service Commission (UPPSC) for the post of Assistant Engineer, it has given hope for many engineers between jobs. MADE EASY has always been a success partner for engineers right from the onset of engineering education up to they get a formal tag of engineer.

Owing to needs of students to utilise this opportunity in a fruitful way, it gives me great happiness to introduce Civil Engineering Practice book for UPPSC-AE Examination. While preparing this book utmost care has been taken to cover all the chapters and variety of concepts which may be asked in the exam. It contains more than 3400^{+} multiple choice questions with answer key and detailed explanations, segregated in subject wise manner to disseminate all kind of exposure to students in terms of quick learning. Attempt has been made to bring out all kind of probable competitive questions for the aspirants preparing for UPPSC. This book also help every student to perform in an extraordinary way.

Full efforts have been made by MADE EASY team to provide error free solutions and explanations. The book not only covers the syllabus of UPPSC but also useful for other examinations conducted by various Public Service Commissions.

Our team has made their best efforts to make the book error-free. Nonetheless, we would highly appreciate and acknowledge if you find and share any printing/conceptual error. It is impossible to thank all individuals who helped us, but I would like to sincerely acknowledge all the authors, editors and reviewers for putting in their efforts to publish this book.

B. Singh (Ex. IES)
Chairman and Managing Director
MADE EASY Group

Uttar Pradesh Public Service Commission
Combined State Engineering Services Examination

Assistant Engineer

Civil Engineering

Paper-I (Part A)

Engineering Mechanics, Strength of Materials and Structural Analysis:

Units and Dimensions, SI units, vectors, concept of force, Concept of particle and rigid body Concurrent, Non- Concurrent and parallel forces in a plane, moment of force and varignon`s theorem free body diagram, conditions of equilibrium Principle of virtual work, equivalent force system. First and second Moment of area, Mass moment of inertia, Static Friction, inclined plane and bearings, kinematics and kinetics, kinematics in Cartesion and Polar Coordinates, motion under uniform and non-uniform acceleration, motion under gravity, Kinetics of particle: Momentum and Energy principles, D` Alembert`s principle, Collision of elastic bodies, rotation of rigid, bodies, simple harmonic motion.

Strength of Materials:

Simple Stress and Strain, Elastic constants, axially loaded compression members, Shear force and bending moment, theory of simple bending, bending stress, Shear Stress, Beams of uniform strength, Leaf Spring, close coiled helical springs, Strain Energy in direct stress, bending & shear. Deflection of beams; Macaulay's method, Mohr's Moment area method, Conjugate beam method, unit load method, Torsion of shafts, Transmission of power, Elastic stability of columns, Euler's Rankin's and Secant formulae. Principal stresses and strains in two dimensions, Mohr's Circle, Theories of Elastic Failure, Thin and Thick cylinder, Stresses due to internal and external pressure- Lame's equations.

Structural Analysis :

Castiglianios theorems I and II, Unit load method of consistent deformation applied to beams and pin jointed trusses. Slope-deflection, moment distribution, Kani's method of analysis and column Analogy method applied to indeterminate beams and rigid frames. Rolling loads and influence lines: Influence lines for reactions of beam, shear force and bending moment at a section of beam. Criteria for maximum shear force and bending moment in beams traversed by a system of moving loads, influence lines for simply supported plane pin jointed trusses,Arches: Three hinged, two hinged and fixed arches, rib shortening and temperature effects, influence lines in arches, Matrix methods of analysis: Force method and displacement method of analysis of indeterminate beams and rigid frames. Plastic Analysis of beams and frames: Theory of plastic bending, plastic analysis, statical method, Mechanism method. Unsymmetrical bending: Moment of inertia, product of inertia, position of neutral axis and principal axis, calculation of bending stresses.

(Part B)

Design of Structures: Steel, Concrete and Masonry Structures

Structural Steel Design:

Factors of safety and load factors, rivetted, bolted and welded joints and its connections, Design by working, stress/limit state method of tension and compression member, beams of built up section, rivetted and welded plate girders, gantry girders, stancheons with battens and lacings, slab and gussetted column bases, Design of highway and railway bridges: Through and deck type plate girder, Warren girder, Pratt truss.

Design of Concrete and Masonry Structures

Reinforced Concrete:

Working Stress and Limit State Method of design-Recommendations of B.I.S. codes, design of one way and two way slabs, stairs-case slabs, simple and continuous beams of rectangular, T and L sections, compression members under direct load with or without eccentricity, isolated and combined footings, Cantilever and counter-fort type retaining walls,Water tanks: Design requirements as per B.I.S. code for rectangular and circular tanks resting on ground, Prestressed concrete: Methods and systems of prestressing, anchorages, analysis and design of sections for flexure based on working stress, losses of prestress, Earth quake resistant design of building as per BIS code. Design of brick masonry as per I. S. Codes, Design of masonry retaining walls.

(Part C)

Building Materials, Construction Technology, Planning and Management

Building Materials:

Physical properties of construction materials with respect to their use: stones bricks, tiles, lime, glass, cement, mortars, Concrete, concept of mix design, pozzolans, plasticizers, super plasticizers, Special concrete: roller compacted concrete, mass concrete, self compacting concrete, ferro cement, fibre reinforced concrete, high strength concrete, high performance concrete, Timber: properties, defects and common preservation treatments, Use and selection of materials for various uses e.g. Low cost housing, mass housing, high rise buildings.

Constructions Technology, Planning and Management:

Masonry constructions using brick, stone, construction detailing and strength characteristics paints, varnishes, plastics, water proofing and damp proofing materials. Detailing of walls, floors, roofs, staircases, doors and windows. Plastering, pointing, flooring, roofing and construction features. Retrofitting of buildings, Principle of planning of building for residents and specific uses, National Building code provisions and uses. Basic principles of detailed and approximate estimating, specifications, rate analysis, principles of valuation of real property. Machinery for earthwork, concreting and their specific uses, factors affecting selection of construction equipments, operating cost of equipments. Construction activity, schedules, organizations, quality assurance principles. Basic principle of network CPM and PERT uses in construction monitoring, cost optimization and resource allocation. Basic principles of economic analysis and methods. Project profitability: Basis principles of financial planning, simple toll fixation criterions.

Geo Technical Engineering and Foundation Engineering

Types of soils, phase relationships, consistency limits particles size distribution, classifications of soils, structure and clay mineralogy. Capillary water, effective stress and pore water pressure, Darcy's Law, factors affecting permeability, determination of permeability, permeability of stratified soil deposits. Seepage pressure, quick sand condition, compressibility and consolidation, Terzaghi's theory of one dimensional consolidation, consolidation test. Compaction of soil, field control of compaction total stress and effective stress parameters, pore pressure parameters, shear strength of soils, Mohr Coulomb failure theory, shear tests.

Earth pressure at rest, active and passive pressures, Rankin's theory Coulomb's wedge theory, Graphical method of earth pressure on retaining wall, sheetpile walls, braced excavation, bearing capacity, Terzaghi and other important theories, net and gross bearing pressure. Immediate and consolidation settlement, stability of slope, total stress and effective stress methods, conventional methods of slices, stability number. Subsurface exploration, methods of boring, sampling, penetration tests, pressure meter tests, essential features of foundation, types of foundation, design criteria, choice of type of foundation, stress distribution in soils, Boussinesq's theory, Westergaard method, Newmarks chart, pressure bulb, contact, pressure, applicability of different bearing capacity theories, evaluation of bearing capacity from filed tests, allowable bearing capacity, settlement analysis, allowable settlement, proportioning of footing, isolated and combined footings, rafts, pile foundation, types of piles, plies capacity, static and dynamic analysis, design of pile groups, pile load test, settlement of piles lateral loads, foundation for bridges, Ground improvement techniques: sand drains, stone columns, grouting, soil stabilization geotextiles and geomembrane, Machine foundation: Natural frequency, design of machine foundations based on the recommendation of B.I.S. codes.

Paper-II (Part A)

Fluid Mechanics, Open Channel Flow, Hydraulic Machines and Hydro-power Engineering

Fluid Mechanics : Fluid properties and their roles in fluid motion, fluid statics including forces acting on plane and curved surfaces, Kinematics and Dynamics of Fluid flow: Velocity and acceleration, stream lines, equation of continuity, irrotational and rotational flow, velocity potential and stream functions, flownet, methods of drawing flownet, source and sink, flow separation, free and forced vorties.

Flow control volume equation, continuity, momentum and energy equations, Navier- Strokes equation, Euler's equation of motion and application to fluid flow problems, pipe flow, plane, curved, stationary and moving vanes sluice gates, weirs, orifice meters and Venturi meters.

Dimensional Analysis and Similitude: Buckingham's Pi-theorem, dimensionless parameters, similitude theory, model laws, undistorted and distorted models.

Laminar flow : Laminar flow between parallel, stationary and moving plates, flow through pipes.

Boundary Layer : Laminar and turbulent boundary layer on a flat plate, laminar sub-layer, smooth and rough boundaries, submerged flow, drag and lift and its applications.

Turbulent flow through pipes : Characteristics of turbulent flow, velocity distribution, pipe friction factor, hydraulic grade line and total energy line, siphons, expansion and contractions in pipes pipe networks, water hammer in pipes and surge tanks.

Open Channel Flow : Flow types, uniform and nonuniform flows, momentum and energy correction factors, Specific energy and specific force, critical depth, resistance equations and roughness coefficient, rapidly varied flow, flow in transitions, Brink flow, Hydraulic jump and its applications, waves and surges, gradually varied flow, classification of surface profiles, control section, Integration of varied flow equation and their solution.

Hydraulic Machines and Hydropower:
Centrifugal pumps-Types, characteristics, Net Positive Suction-head (NPSH), specific speed, Pumps in series and parallel. Reciprocating pumps, Air vessels, Hydraulic ram, efficiency parameters, Rotary and positive displacement pumps, diaphragm and jet pumps.

Hydraulic turbines : types, classification, Choice of turbines, performance parameters, controls, characteristics, specific speed.

Principles of hydropower development : Types, layouts and component works, surge tanks, 'types and choice, Flow duration curves and dependable flow, Storage and pondage, Pumped storage plants, Special types of hydel plants.

(Part B)

Hydrology and Water Resources Engineering

Hydrology: Hydrologic cycle, precipitation, evaporation, transpiration, infiltration, overland flow, hydrographs, flood frequency analysis, flood routing through a reservoir, channel flow routing- Muskingam method.

Ground Water Flow : Specific yield, storage coefficient, coefficient of permeability, confined and unconfined aquifers, radial flow into a well under confined and unconfined conditions, Openwells and tube wells. Ground and surface water recourses single and multipurpose projects, storage capacity of reservoirs, reservoir losses, reservoir sedimentation. Water requirements of crops consumptive use, duty and delta, irrigation methods, Irrigation efficiencies.

Canals : Distribution systems for cannal irrigation, canal capacity, canal losses, alignment of main and distributory canals, Design of cannal by kennedy's and Lacey's thoeorie, Water logging and its prevention.

Diversion head works : Compenents, Principles and design of weirs on permeable and impermeable foundations, Khosla's theory, Bligh's creep theory Storage works. Cross drainage works. Types of dams, design principles of gravity and earth dams, stability analysis. Spillways: Spillway types energy dissipation.

River training : Objectives of river training, methods of river training and bank protection.

(Part C)

Transportation Engineering

Highway Engineering : Principles of Highway alignments, classification and geometric design, elements and standards for roads.

Pavement: flexible and rigid pavements Design principles and methodology. Construction methods and materials for stabilized soil. WBM, Bituminous works and Cement Concrete roads.

Surface and sub-surface drainage arrangements for roads, culvert structures. Pavement distresses and strengthening by overlays. Traffic surveys and their application in traffic planning, Typical design features for channelized, intersection, rotary etc., signal designs, standard traffic signs and markings.

Railway Engineering: Permanent way, ballast, sleeper, chair and faslenings, points, crossings, different types of turn outs, cross-over, setting out of points, Maintenance of track, super elevation, creep of rails ruling gradients, track resistance tractive effort, curve resistance, Station yards and station buildings, platform sidings, turn outs, Signals and interlocking, level crossings.

Air port Engineering : Layouts, Planning and design.

(Part D)

Environmental Engineering

Water supply: Estimation of water demand, impurities in water and their significance, physical, chemical and bacteriological parameters and their analysis, waterborne diseases, standards for potable water.

Water collection & treatment: Intake structures, principles and design of sedimentation tank, coagulation cum flocculation units slow sand filter, rapid sand filter and pressure filter, theory & practices of chlorination, water softening, removal of taste and salinity, Sewerage Systems, Domestic and industrial wastes, storm, sewage, separate and combined systems, flow through sewers, design of sewers.

Waste water characterization: Solids, Dissolved oxygen (DO), BOD COD, TOC, and Nitrogen, Standards for disposal of effluent in normal water course and on to land.

Waste water treatment: Principles and design of wastewater Treatment units-- Screening, grit chamber, sedimentation tank activated sludge process, trickling filters, oxidation ditches, oxidation ponds, septic tank; Treatment and disposal of sludge; recycling of waste water.

Solid waste management: Classification, Collection and disposal of solid waste in rural and urban areas, Principles of solid waste management.

Environmental pollution : Air and water pollution and their control acts. Radioactive waste and their disposal Environmental impact assessment of Thermal power Plants, mines and river valley projects, Sustainable development.

(Part E)

Survey and Engineering Geology

(a) Surveying: Common methods and instruments for distance and angle measurements in Civil Engineering works, their use in plane table traverse survey, levelling, triangulation, contouring and topographical maps. Survey layouts for culverts canal, bridge, roads, railway alignment and buildings.

Basic principles of photogrammetry and remote sensing.

Introduction to Geographical information system.

Engineering Geology : Basic concepts of Engineering geology and its applications in projects such as dams, bridges and tunnels.

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Contents

■■■■

UNIT 1

Engineering Mechanics

Q.1 Varignon's theorem is applicable only when the forces are:
(a) coplanar (b) concurrent
(c) non-concurrent (d) parallel

Q.2 Match **List-I** with **List-II** and select the correct answer using the codes given below the lists:

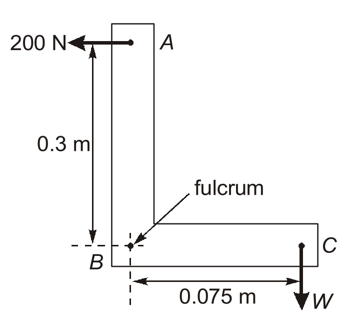
List-I
A. Lami's theorem
B. Varignon's theorem
C. Newton's first law of motion
D. Polygon law of forces

List-II
1. Determination of the position of resultant of parallel forces.
2. Definitions of the general condition of equilibrium.
3. Determination of resultant of non-parallel forces.
4. Estimation of the three forces on a body in equilibrium.

Codes:

	A	B	C	D
(a)	4	1	2	3
(b)	1	4	3	2
(c)	1	4	2	3
(d)	4	1	3	2

Q.3 A horizontal force of 200 N is applied at A to lift the weight *W* at *C* as shown in the figure. The value of weight *W*, will be



(a) 200 N (b) 400 N
(c) 600 N (d) 800 N

Q.4 If two forces P and Q act at an angle θ the resultant of these two forces would make an angle α with P such that

(a) $\tan\alpha = \dfrac{Q\sin\theta}{P - Q\sin\theta}$

(b) $\tan\alpha = \dfrac{P\sin\theta}{P + Q\sin\theta}$

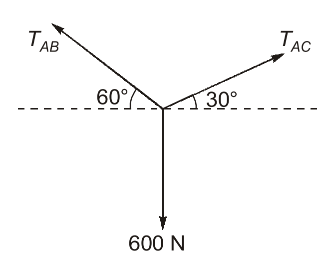
(c) $\tan\alpha = \dfrac{Q\sin\theta}{P + Q\cos\theta}$

(d) $\tan\alpha = \dfrac{P\sin\theta}{Q - P\cos\theta}$

Q.5 The sum of the magnitudes of two forces acting at a point is 18 and the magnitude of their resultant is 12. If the resultant is 90° with the forces of smaller magnitude, the magnitude of forces are
(a) 10 and 8 (b) 9 and 9
(c) 5 and 13 (d) 6 and 12

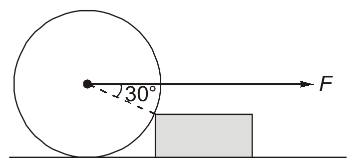
Q.6 If the magnitude of maximum and minimum resultant forces of the two forces acting on a particle are 40 kN and 10 kN respectively, then the two forces would be
(a) 25 kN and 15 kN
(b) 20 kN and 20 kN
(c) 20 kN and 10 kN
(d) 20 kN and 5 kN

Q.7 If a point *A* is in equilibrium under the action of the applied forces, the value of tensions T_{AB} and T_{AC} are respectively



(a) 520 N and 300 N (b) 300 N and 520 N
(c) 450 N and 150 N (d) 150 N and 450 N

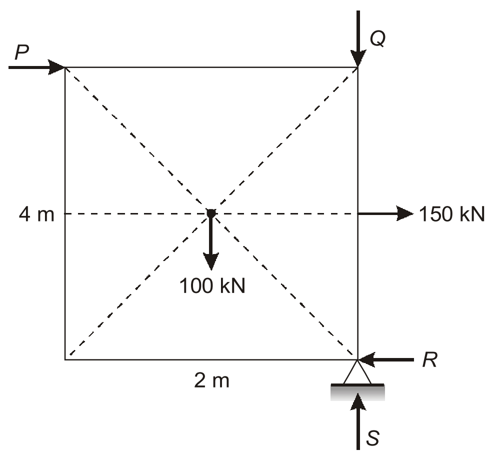
Q.8 A roller of weight *W* is rolled over the wooden block as shown in figure below. The pull *F* required to just cause the said motion is:



(a) $\frac{W}{2}$ (b) W

(c) $\sqrt{3}W$ (d) $2W$

Q.9 A rectangular plate is held in equilibrium by then application of forces as shown in figure. What is the magnitude of the force *P*?



(a) 35 kN (b) 50 kN
(c) 100 kN (d) 200 kN

Q.10 Three forces acting at a point 'O' are

$P_1 = (3\hat{i} + 6\hat{j})N$

$P_2 = (-1.5\hat{i} + 4.5\hat{j})N$

$P_3 = (-10.5\hat{i} + 1.5\hat{j})N$

If a fourth force P_4 is added such that the point '*O*' is in equilibrium, then force P_4 will be

(a) $(-15\hat{i} + 15\hat{j})N$ (b) $(-9\hat{i} + 12\hat{j})N$

(c) $(-9\hat{i} + 12\hat{j})N$ (d) $(-15\hat{i} + 15\hat{j})N$

Q.11 Two non-collinear equal parallel forces acting in opposite direction will have
(a) no resultant force and moment
(b) a moment but no resultant force
(c) a resultant force but no moment
(d) a moment and a resultant force

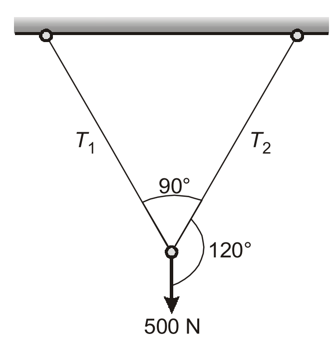
Q.12 The vector product of two non-zero vectors is zero if and only if the vectors are
(a) perpendicular (b) concurrent
(c) parallel or collinear (d) co-planar

Q.13 What is the torque of the force $\vec{F} = (2\hat{i} + 4\hat{j} + 3\hat{k})N$, which acts at a point $\vec{r} = (3\hat{i} - 2\hat{j} + \hat{k})m$ about the origin?

(a) $10\hat{i} + 7\hat{j} - 16\hat{k}$ (b) $-10\hat{i} - 7\hat{j} + 16\hat{k}$

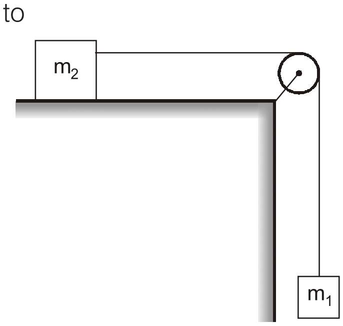
(c) $6\hat{i} - 8\hat{j} + 6\hat{k}$ (d) $-6\hat{i} + 8\hat{j} - 6\hat{k}$

Q.14 A weight of 500 N is supported by two metallic ropes as shown in figure. The values of tensions T_1 and T_2 are respectively



(a) 433 N and 250 N (b) 250 N and 433 N
(c) 353.5 N and 250 N (d) 250 N and 353.5 N

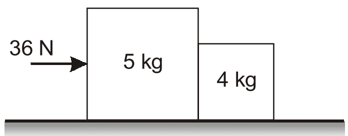
Q.15 In the given figure, two bodies of masses m_1 and m_2 are connected by a light inextensible string passing over a smooth pulley mass m_2 lies on a smooth horizontal plane. When mass m_1 moves downwards, the acceleration of the two bodies is equal to



(a) $\frac{m_1 g}{m_1 + m_2}$ (b) $\frac{m_2 g}{m_1 - m_2}$

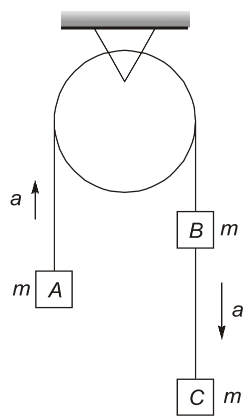
(c) $\frac{m_2 g}{m_1 + m_2}$ (d) $\frac{m_1 g}{m_1 - m_2}$

Q.16 Two rigid bodies of mass 5 kg and 4 kg are at rest on a frictionless surface until acted upon by a force of 36 N as shown in the figure the contact force generated between the two bodies is:



(a) 4.0 N (b) 7.2 N
(c) 9.0 N (d) 16.0 N

Q.17 Three equal weights of mass m each are hanging on a string shown in figure passing over a fixed pulley. The tensions in the string connecting weight *A* to *B*.



(a) mg (b) $\frac{mg}{2}$
(c) $\frac{2}{3}mg$ (d) $\frac{4}{3}mg$

Q.18 A monkey of mass m climbs up to a rope hung over a fixed pulley. The opposite end of the rope is tied to a weight of mass M lying on a horizontal plane. Neglecting the friction, the tension of the rope when the monkey is just hanging with the rope

(a) $\frac{mM}{(M+m)}g$ (b) $\frac{mM}{(M-m)}g$
(c) mg (d) Mg

Q.19 The principle of virtual work states that the virtual work is zero for
(a) a body moving with constant linear velocity
(b) a body rotating with constant angular velocity
(c) a body in equilibrium
(d) a body moving with constant linear acceleration

Q.20 A body of mass 110 kg is moving over a smooth surface, whose equation of motion is given by the relation
$S = 6t + 8t^2$
where S is in m and t is in seconds.
Find the magnitude of force responsible for this motion
(a) 1760 N (b) 488.89 N
(c) 986.64 N (d) 2113.68 N

Q.21 The time variation of the position of a particle in rectilinear motion is given by $x = 2t^3 + t^2 + 2t$. If v is the velocity (in m/s) and the acceleration (in m/s^2), the motion started with
(a) v = o, a = 0 (b) v = 0, a = 2
(c) v = 2, a = 0 (d) v = 2, a = 2

Q.22 Match **List-I** with **List-II** and select the correct answer

List-I
A. Average acceleration.
B. Instantaneous acceleration
C. Uniform motion
D. Uniformly acceleration motion

List-II
1. a = constant
2. a = 0
3. $\frac{\Delta V}{\Delta t}$
4. $\lim_{\Delta t \to 0} \frac{\Delta V}{\Delta t}$

Codes:

	A	B	C	D
(a)	2	4	3	1
(b)	4	3	2	1
(c)	3	4	1	2
(d)	3	4	2	1

Q.23 A particle starts from origin at $t = 0$ with a velocity $5.0\hat{i}$ and moves in x-y plane under action of force which produces a constant acceleration of $(3.0\hat{i} + 2.0\hat{j})$ m/s^2. The y-axis coordinate of the particle at the instant its abscissa coordinate is 84 m is ________.
(a) 36 m (b) 40 m
(c) 25 m (d) 49 m

Q.24 A particle moves along a straight line such that its displacement at any time 't' is given by $S = (t^3 - 6t^2 + 3t + 4)$m. The velocity of the particle when its acceleration is zero

(a) 9 m/s (b) 6 m/s
(c) 12 m/s (d) 7 m/s

Q.25 A body is released from a height and falls freely towards the earth. Exactly 1 sec later another body is released. The distance between two bodies 2 sec after the release of the second body, if g = 9.8 m/s^2.

(a) 15.4 m (b) 24.5 m
(c) 16.4 m (d) 21.4 m

Q.26 Given that for a particle the initial velocity is 'u' the angle of projection to the horizontal is α and x and y are the coordinates of a point on the trajectory. Match List-I with List-II and select the correct answer using the codes given below the lists.

List-I

A. Maximum height **B.** Time of flight
C. Range **D.** Trajectory

List-II

1. $\left(\dfrac{2u\sin\alpha}{g}\right)$

2. $\dfrac{u^2\sin 2\alpha}{g}$

3. $y = x\tan\alpha - \dfrac{1}{2}g\left[\dfrac{x^2}{u^2}\right](1+\tan^2\alpha)$

4. $\dfrac{u^2\sin^2\alpha}{2g}$

Codes:

	A	B	C	D
(a)	1	4	3	2
(b)	4	2	3	1
(c)	4	1	2	3
(d)	4	1	3	2

Q.27 A particle is projected vertically upward with an initial velocity u. If g is the acceleration due to gravity, then which of the following is the greatest height 'h' attained by it?

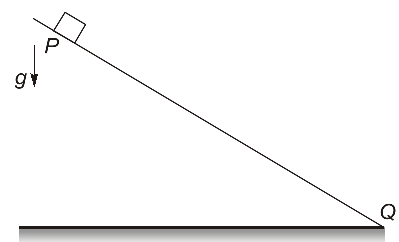
(a) $h = \dfrac{2u^2}{g}$ (b) $h = \dfrac{u^2}{g}$

(c) $h = \dfrac{u^2}{2g}$ (d) $h = \dfrac{u^2}{4g}$

Q.28 A 12 kg mass rests on a surface for which the coefficient of friction $\mu = 0.15$. What is the smallest force that can be given to the mass an acceleration of 3 m/s^2? (Take g = 10 m/s^2)

(a) 120 N (b) 100 N
(c) 65 N (d) 54 N

Q.29 A block of mass m is released from point P on a rough inclined plane with inclination angle θ shown in the figure below. The coefficient of friction is 'μ'. If $\mu < \tan\theta$, then the time taken by the block to reach another point 'Q' on the inclined plane, where $PQ = S$ is:



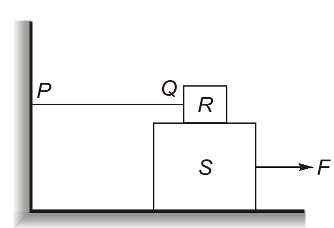
(a) $\sqrt{\dfrac{2s}{g\cos\theta(\tan\theta - \mu)}}$

(b) $\sqrt{\dfrac{2s}{g\cos\theta(\tan\theta + \mu)}}$

(c) $\sqrt{\dfrac{2s}{g\sin\theta(\tan\theta - \mu)}}$

(d) $\sqrt{\dfrac{2s}{g\sin\theta(\tan\theta + \mu)}}$

Q.30 A block R of mass 100 kg is placed on a block S of mass 150 kg as shown in figure block R is tied to the wall by a massless and inextensible string PQ. If coefficient of static friction for all surfaces is 0.4 the minimum force F(in kN) needed to move the block S is:



(a) 0.69 (b) 0.88
(c) 0.98 (d) 1.37

Q.31 If a thin trapezoidal plate of larger width '*p*' and smaller width '*q*' and height '*h*' is to hang horizontally, the point of support for its suspension shall have to pass through the point (along the axis of symmetry)

(a) $\left(\frac{2p+q}{p+q}\right)\frac{h}{3}$ from the larger edge

(b) $\frac{h}{2}$ from the smaller edge

(c) $\left(\frac{2p+q}{p+q}\right)\frac{h}{3}$ from the smaller edge

(d) $\frac{h}{2}$ from the larger edge

Q.32 If m_1, m_2, m_3 .... are the masses of very small portions of a body and x_1, x_2, x_3.... are their distances from a fixed straight line, the radius of gyration of the body about the given straight line is given by

(a) $\Sigma m x$ (b) $\left(\frac{\Sigma mx^2}{\Sigma m}\right)^{\frac{1}{2}}$

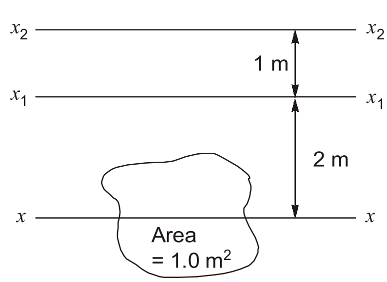
(c) $\frac{\Sigma mx^2}{\Sigma mx}$ (d) $\frac{\Sigma m^2 x}{\Sigma mx}$

Q.33 A right-angled triangular lamina has breadth '*b*' and depth '*d*'. The moment of inertia about a line parallel to base '*b*' at a distance of *d*/2 will be

(a) $\frac{5bd^3}{24}$ (b) $\frac{11bd^3}{72}$

(c) $\frac{bd^3}{24}$ (d) $\frac{7bd^3}{72}$

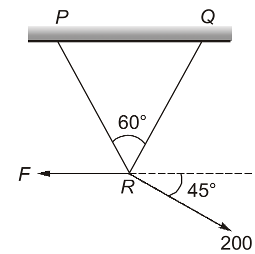
Q.34 xx, x_1x_2 and x_2x_2 are parallel axes of which xx is the centroidal axis. If moment of inertia of the figure about x_1x_2 axis is 10 m^4, what is the moment of inertia of the figure about x_2x_2 axis?



(a) 10 m^4 (b) 11 m^4

(c) 14 m^4 (d) 15 m^4

Q.35 The force *F* such that both the bars *PR* and *QR* (*PR* and *QR* are equal in length) as shown in the figure are identically loaded, is



(a) 200 kN (b) 100 kN

(c) 141.4 kN (d) 173.2 kN

Q.36 Particles of mass 12 kg and 6 kg are released from a separation of 90 m and move towards each other under the mutual gravitational force. They will hit each other at a distance of

(a) 20 m from the initial position of 6 kg

(b) 20 m from the initial position of 12 kg

(c) 30 m from the initial position of 12 kg

(d) 30 m from the initial position of either mass

Q.37 A ball *A* of mass *M* falls under gravity from a height *h* and strikes another ball *B* of mass 2 m which is supported at rest on a spring of stiffness *k*. Assume perfectly inelastic impact. Immediately after the impact

(a) the velocity of ball *A* is zero

(b) the velocity of ball *A* is $\frac{1}{2}\sqrt{2gh}$

(c) the velocity of both balls is $\frac{1}{3}\sqrt{2gh}$

(d) the velocity of both balls is $\frac{1}{2}\sqrt{2gh}$

Q.38 A solid sphere is rolling without slipping on a horizontal surface. The ratio of its rotational kinetic energy to its translational kinetic energy is

(a) $\frac{7}{2}$ (b) $\frac{2}{5}$

(c) $\frac{2}{7}$ (d) $\frac{2}{9}$

Q.39 An elevator weighting 100 kN attains an upward velocity of 10 m/s in two seconds with uniform acceleration. The tension in the cable will be

(a) 150 kN (b) 200 kN

(c) 50 kN (d) 25 kN

Q.40 Match **List-I** with **List-II** and select the correct answer using the codes given below the lists:

List-I
- **A.** Newton's first law of motion
- **B.** Newton's second law of motion
- **C.** Lami's theorem
- **D.** Polygon law of forces

List-II
1. Determination of the resultant of non-parallel forces.
2. Definition of the general condition of equilibrium.
3. Determines the rate of change of momentum.
4. Estimation of the three forces on a body in equilibrium.

Codes:

	A	B	C	D
(a)	2	3	4	1
(b)	2	1	3	4
(c)	1	2	4	3
(d)	1	3	2	4

Q.41 Two solid cylinders *A* and *B* of same radius start rolling down on a fixed inclined plane from the same height at the same time. Cylinder *A* has most of its mass concentrated near its surface, while *B* has most of its mass concentrated near the axis. Which statement is correct?
(a) Both cylinders *A* and *B* reach the ground at the same time
(b) Cylinder *A* has larger linear acceleration than cylinder *B*
(c) Both cylinders reach the ground with same translational kinetic energy
(d) Cylinder *B* reaches the ground with larger angular speed

Q.42 A body of mass 1.5 kg rotating about an axis with angular velocity of 0.3 rad/s has an angular momentum of 7.2 kgm^2/s. The radius of gyration of the body about an axis of rotation is
(a) 0.6 m (b) 1.6 m
(c) 2 m (d) 4 m

Q.43 An engine pumps out water continuously through a hose with a velocity *v*. If *m* is the mass per unit length of water jet, the rate at which the kinetic energy is imparted to water is
(a) $\frac{1}{2}mv^2$ (b) $\frac{1}{2}mv^3$
(c) $\frac{1}{2}m^2v^2$ (d) mv^3

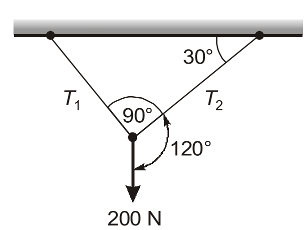
Q.44 A mass 2.4 kg is suspended from massless string of length 50 cm. Initially, the mass is at rest with the string along the vertical. Another object of mass 600 gram and moving horizontally at a speed of 50 m/s, hits the suspended body and sticks to it, then
(a) they are unable to complete vertical circle
(b) they are able to complete vertical circle
(c) their system begins to oscillate about the original position of 2.4 kg mass
(d) tension in the string remains constant

Q.45 The resultant of two forces $(P + Q)$ and $(P - Q)$ is equal to $\sqrt{3P^2 + Q^2}$. The forces are then inclined to each other, at the angle of
(a) 30° (b) 60°
(c) 90° (d) 120°

Q.46 The displacement in meters of a point is given by equation
$x = 2t^2 + 5t$; $y = 4.9t^2$
The acceleration at the end of 4th second is
(a) 7.42 m/s^2 (b) 10.58 m/s^2
(c) 3.71 m/s^2 (d) 11.00 m/s^2

Q.47 A particle is moving along a circular path. Equation of angular velocity is $\omega = 12 + 9t - 3t^2$ rad/s, where *t* is in seconds. Maximum angular speed of particle can be
(a) 14.75 rad/s (b) 16.75 rad/s
(c) 18.75 rad/s (d) 20.75 rad/s

Q.48 A weight of 200 N is supported by two metallic ropes as shown in the figure. The ratio of tensions T_1/T_2 is



(a) 1.732 (b) 2.732
(c) 3.732 (d) 4.732

Q.49 A block of weight 100 N rests on a rough horizontal base with friction coefficient 0.5. A force F acts on it as shown in figure. The maximum value of *F* such that the block remains at rest is

Q.102 The wheels of a moving car posses
(a) potential energy only
(b) kinetic energy of translation only
(c) kinetic energy of rotation only
(d) kinetic energy of translation and rotation both

Q.103 The total energy possessed by a system of moving bodies
(a) is constant at every instant
(b) varies from point to point
(c) is maximum in the start and minimum at the end
(d) is minimum in the start and maximum at the end

Q.104 When the spring of a watch is wound, it will posses
(a) strain energy (b) kinetic energy
(c) heat energy (d) electrical energy

Q.105 Two balls of equal mass and of perfectly inelastic material are lying on the floor. One of the ball with velocity v is made to struck the second stationary ball. Both the balls after impact will move with a velocity
(a) v (b) $v/2$
(c) $v/4$ (d) $v/8$

■■■■

Answers Engineering Mechanics

1.	(b)	2.	(a)	3.	(d)	4.	(c)	5.	(c)	6.	(a)	7.	(a)	8.	(c)
9.	(b)	10.	(b)	11.	(b)	12.	(c)	13.	(b)	14.	(a)	15.	(a)	16.	(d)
17.	(d)	18.	(a)	19.	(c)	20.	(a)	21.	(d)	22.	(d)	23.	(a)	24.	(a)
25.	(b)	26.	(c)	27.	(c)	28.	(d)	29.	(a)	30.	(d)	31.	(c)	32.	(b)
33.	(c)	34.	(d)	35.	(c)	36.	(c)	37.	(c)	38.	(b)	39.	(a)	40.	(a)
41.	(d)	42.	(d)	43.	(b)	44.	(b)	45.	(b)	46.	(b)	47.	(c)	48.	(a)
49.	(c)	50.	(a)	51.	(a)	52.	(b)	53.	(c)	54.	(a)	55.	(c)	56.	(d)
57.	(a)	58.	(b)	59.	(b)	60.	(b)	61.	(b)	62.	(a)	63.	(d)	64.	(c)
65.	(b)	66.	(b)	67.	(d)	68.	(d)	69.	(c)	70.	(d)	71.	(b)	72.	(a)
73.	(c)	74.	(c)	75.	(a)	76.	(d)	77.	(d)	78.	(d)	79.	(a)	80.	(b)
81.	(d)	82.	(b)	83.	(a)	84.	(b)	85.	(b)	86.	(c)	87.	(c)	88.	(b)
89.	(d)	90.	(a)	91.	(c)	92.	(c)	93.	(d)	94.	(a)	95.	(b)	96.	(d)
97.	(c)	98.	(b)	99.	(b)	100.	(a)	101.	(d)	102.	(d)	103.	(a)	104.	(a)
105.	(b)														

Explanations

2. (a)

Lami's theorem: In statics, Lami's theorem is an equation relating the magnitudes of three coplanar, concurrent and non-collinear forces which keeps an object in static equilibrium, with the angles directly opposite to the corresponding forces,

$$\frac{A}{\sin\alpha} = \frac{B}{\sin\beta} = \frac{C}{\sin\gamma}$$

Where,

A, B, C are the magnitude of three coplanar, concurrent and non-collinear forces which keeps the object in static equilibrium, and α, β and γ are the angles directly opposite to the forces A, B and C respectively.

Polygon Law's of forces: If a number of forces acting simultaneously on a particle be represented in magnitude and direction by the sides of a polygon taken in order, their resultant may be represented in magnitude and direction by the closing side of the polygon taken in opposite order.

Newton's first Law of Motion: When viewed in an inertial reference frame, an object either remains at rest or moves with constant velocity, unless acted upon by an external force.

Varignon's Theorem: The moment about any point of the resultant of several concurrent forces is equal to the sum of the moments of the particular forces about the same point.

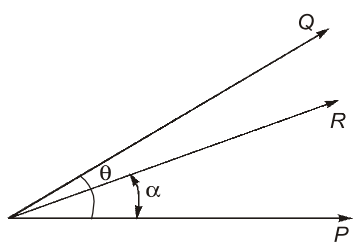
3. (d)

Taking moment about fulcrum B,

$200 \times 0.3 = W \times 0.075$

$$W = \frac{200 \times 0.3}{0.075} = 800 \text{ N}$$

4. (c)



$$R\sin\alpha = Q\sin\theta$$
$$R\cos\alpha = Q\cos\theta + P$$
$$\Rightarrow \quad \tan\alpha = \frac{Q\sin\theta}{Q\cos\theta + P}$$

5. (c)

Let P be the smaller force,

$P + Q = 18$ ...(1)

$R = (P^2 + Q^2 + 2PQ\cos\theta)^{1/2} = 12$ ...(2)

Also,

$$\frac{Q\sin\theta}{P + Q\cos\theta} = \tan\alpha = \tan 90° = \infty$$

$\Rightarrow P + Q\cos\theta = 0$ ...(3)

Subtracting eq. (3) eq. (1)

$P + Q\cos\theta - P - Q = 0 - 18$

$Q(1 - \cos\theta) = 18$...(4)

Now, operating square of eq. (2- eq. (1)

$18^2 - (12)^2 = 2PQ(1 - \cos\theta)$

$180 = 2PQ(1 - \cos\theta)$ ...(5)

Operate eq. (4) subtract eq. (5)

$$\frac{Q(1-\cos\theta)}{2PQ(1-\cos\theta)} = \frac{18}{180}$$

$2P = 10$

$P = 5$

From eq. (1); Q = 18 – 5 = 13

So, magnitude of forces are 5 and 13.

6. (a)

Resultant of two forces,

$$R = \sqrt{P^2 + Q^2 + 2PQ\cos\theta}$$

R will be maximum when, $\cos\theta = 1$

$$R_{max} = \sqrt{P^2 + Q^2 + 2PQ} = \sqrt{(P+Q)^2} = P + Q$$

R will be minimum when, $\cos\theta = -1$

$$R_{min} = \sqrt{P^2 + Q^2 - 2PQ} = \sqrt{(P-Q)^2} = P - Q$$

$P + Q = 40$

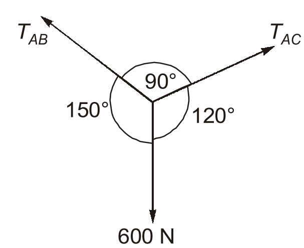
$P - Q = 10$

$2P = 50$

$P = 25$ kN; $Q = 15$ kN

7. (a)

Method : 1



$$\frac{T_{AB}}{\sin 120°} = \frac{T_{AC}}{\sin 150°} = \frac{600}{\sin 90°}$$

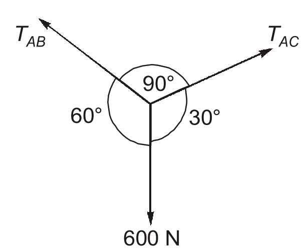
$T_{AB} = 600\sin 120° = 519.61$

$= 520$ N

$T_{AC} = 600\sin 150° = 300$ N

Method : 2

In equilibrium:



$\Sigma F_x = 0$

$T_{AC}\cos 30° - T_{AB}\cos 60° = 0$

$$T_{AC} = T_{AB}\frac{\cos 60°}{\cos 30°} = \frac{T_{AB}}{\sqrt{3}} \quad ...(i)$$

Vertical forces $\Sigma F_y = 0$

$T_{AC}\sin 30° + T_{AB}\sin 60° - 600 = 0$

$T_{AC} + \sqrt{3} \cdot T_{AB} = (600 \times 2)$

$T_{AC} + \sqrt{3} \cdot T_{AB} = 1200$ ...(ii)

From eq. (i) and eq. (ii)

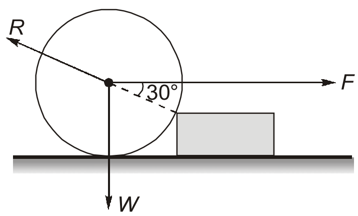
$$\frac{T_{AB}}{\sqrt{3}} + \sqrt{3}\cdot T_{AB} = 1200$$

$$4T_{AB} = 1200\sqrt{3}$$

$$T_{AB} = 300\sqrt{3} = 519.61 \text{ N} \simeq 520 \text{ N}$$

and $$T_{AC} = \frac{T_{AB}}{\sqrt{3}} = \frac{300\sqrt{3}}{\sqrt{3}} = 300 \text{ N}$$

8. (c)



$$R\cos 60° = W$$

$$R \times \frac{1}{2} = W$$

$$R = 2W$$

Also, $F = R\cos 30° = 2W \times \frac{\sqrt{3}}{2} = \sqrt{3}\ \text{W}$

9. (b)

Since, the rectangular plate is held in equilibrium,

$$\Sigma M_{\text{Hinge}} = 0$$

P × 4 + 150 × 2 = 100 × 1

$$P = \frac{(100-300)}{4} = -50 \text{ kN}$$

Magnitude of force, $P = 50$ kN

10. (b)

For equilibrium

$P_1 + P_2 + P_3 + P_4 = 0$

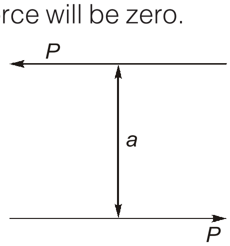
$P_4 = -(P_1 + P_2 + P_3)$

$$= -\left(3\hat{i} + 6\hat{i} - 1.5\hat{j} + 4.5\hat{j} - 10.5\hat{i} + 1.5\hat{j}\right)$$

$$= -\left(-9\hat{i} + 12\hat{j}\right) = \left(9\hat{i} - 12\hat{j}\right)N$$

11. (b)

Since equal forces are in opposite direction, so, resultant force will be zero.



moment = (Pa)

12. (c)

$$\left|\vec{A}\times\vec{B}\right| = AB\sin\theta$$

When, $\theta = 0°$

$\left|\vec{A}\times\vec{B}\right| = 0$, because $\sin\theta = 0$

When two non-zero vectors are parallel or collinear their vector product is zero.

13. (b)

Torque (τ):

$$\vec{\tau} = \vec{r}\times\vec{F} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 3 & -2 & 1 \\ 2 & +4 & 3 \end{vmatrix}$$

$$= \hat{i}(-10) - \hat{j}(+7) + \hat{k}(12+4)$$

$$= -10\hat{i} - 7\hat{j} + 16\hat{k}$$

14. (a)

Using Lami's theorem

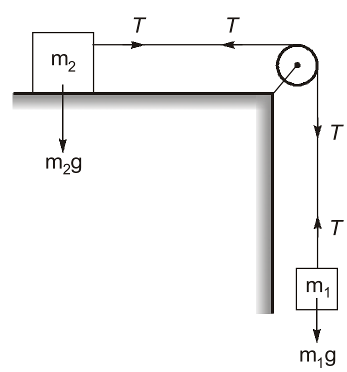
$$\frac{T_1}{\sin 120°} = \frac{F}{\sin 90°}$$

$$T_1 = 500 \sin 120° = 433 \text{ N}$$

Also, $$\frac{T_2}{\sin\left[360° - (120 + 90°)\right]} = \frac{500}{\sin 90°}$$

$$T_2 = 250 \text{ N}$$

15. (a)



$T = m_2a$

Also, for block of mass m_1

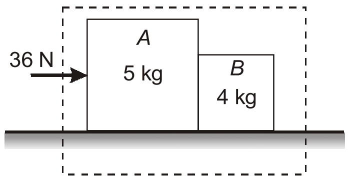
for block of mass m_2

$-T + m_1g = m_1a$

$m_1g - m_2a = m_1a$

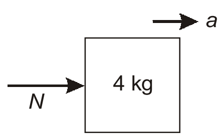
$$a = \frac{m_1 g}{m_1 + m_2}$$

16. (d)



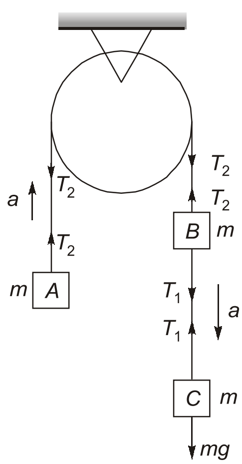
Considering 5 kg and 4 kg together in a system applying Newton's 2nd law,

$$a = \frac{F}{m} = \frac{36}{9} = 4 \text{ m/s}^2$$

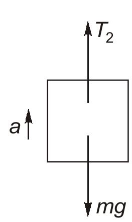


$$N = m_B a = 4 \times 4 = 16 \text{ N}$$

17. (d)

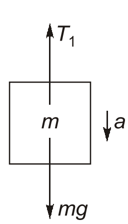


For block A:



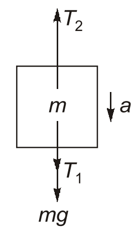
$$T_2 - \text{mg} = \text{ma}$$
$$T_2 = m(g + a) \quad \text{...(1)}$$

For block C:



$$\text{mg} - T_1 = \text{ma}$$
$$T_1 = m(g - a) \quad \text{...(2)}$$

For block B:



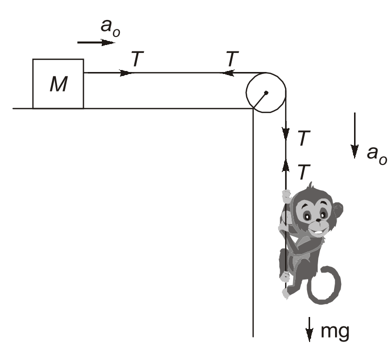
$$T_1 + \text{mg} - T_2 = \text{ma} \quad \text{...(3)}$$

put value of T_1 and T_2 in eq. (3)

$$mg - ma + mg - mg - ma = ma$$
$$mg = 3ma$$
$$a = \frac{g}{3}$$
$$T_2 = m\left(g + \frac{g}{3}\right) = \frac{4mg}{3}$$

Hence, tensions in string contained with A and B is 4/3 mg

18. (a)



If the monkey does not move on the rope, the acceleration of both bodies will be the same, equal to a_o. The equations of motion are

For mass M,

$$T = M_{a0} \quad \text{...(1)}$$

For mass m (Monkey):

$$mg - T = ma_0 \quad \text{...(2)}$$

Solving eq. (1) and eq (2)

$$T = \frac{Mm}{M+m} g$$

20. (a)

$$S = 6t + 8t^2$$
$$V = \frac{dS}{dt} = 6 + 16t$$
$$a = 16 \text{ m/s}^2$$
$$F = ma = 110 \text{ kg} \times 16 \text{ m/s}^2$$
$$= 1760 \text{ N}$$

21. (d)

$$x = 2t^3 + t^2 + 2t$$

Velocity, V

$$V = \frac{dx}{dt} = 6t^2 + 2t + 2$$

At $t = 0$, $v = 2$ m/s

Acceleration, a

$$a = \frac{dv}{dt} = 12t + 2$$

At $t = 0$, a = 2 m/s^2,

23. (a)

The position of the particle at time 't' is given by

$$\vec{r}(t) = \vec{u}t + \frac{1}{2}\vec{a}t^2$$

$$= (5.0\hat{i})t + \frac{1}{2}(3.0\hat{i} + 2.0\hat{j})t^2$$

$$= (5t + 1.5t^2)\hat{i} + t^2\hat{j}$$

$\therefore$ $x(t) = 5t + 1.5t^2$

$y(t) = t^2$

Given $x(t) = 84$ m

$84 = 5t + 1.5t^2$

$1.5t^2 + 5t - 84 = 0$

$$t = \frac{-5 \pm \sqrt{(5)^2 - 4\times1.5\times(-84)}}{2\times1.5}$$

$$= \frac{-5 \pm 23}{3}$$

Neglecting -ve sign

$$t = \frac{18}{3} = 6 \text{ sec}$$

$$y(t) = (6)^2 = 36 \text{ m}$$

24. (a)

Given, $s = t^3 - 6t^2 + 3t + 4$

$$\frac{ds}{dt} = V = 3t^2 - 12t + 3$$

$$a = \frac{dv}{dt} = 6t - 12$$

when $a = 0$

i.e. $6t - 12 = 0$

$t = 2$ sec

$\Rightarrow$Velocity of particle

$V = 3 \times (2)^2 - 12 \times 2 + 3$

$= -9$ m/sec

– ve sign implies that body is moving towards the origin.

25. (b)

2nd body falls for 2 sec.

$$h_2 = \frac{1}{2}g(2)^2 = 2g \quad ...(i)$$

1st body falls for (2 + 1) = 3 sec

$$h_1 = \frac{1}{2}g(3)^2 = 4.5g \quad ...(ii)$$

Separation between two bodies 2 sec after the release of 2nd body.

$d = h_1 - h_2$

$= 4.5g - 2g = 2.5 \times g$

$= 2.5 \times 9.8 = 24.5$ m

26. (c)

Trajectory of parabolic motion is given by

$$y = x\tan\alpha - \frac{gx^2}{2u^2}(1 + \tan^2\alpha)$$

27. (c)

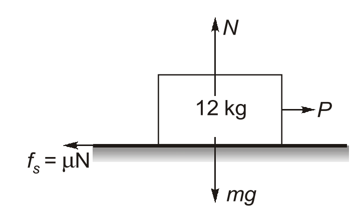
$$V^2 = u^2 + 2(-g)h$$

Since, at maximum height, final velocity = 0

$$u^2 - 2gh = 0$$

$$h = \frac{u^2}{2g}$$

28. (d)



$N = Mg$

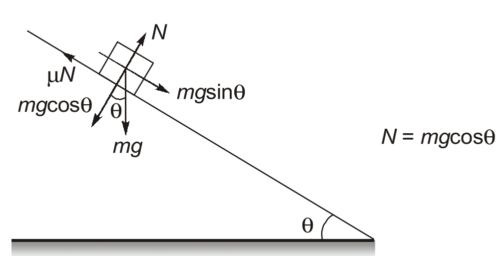
$P - \mu N = ma$

$P = m(mg) + ma = m(\mu g + a)$

$= 12(0.15 \times 10 + 3)$

$= 12 \times 4.5 = 54$ N

29. (a)



From Newton's 2nd law of motion,

$$mg\sin\theta - \mu mg\cos\theta = ma$$

$$a = g\sin\theta - \mu g\cos\theta$$

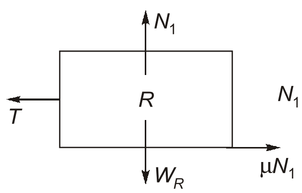
$$s = ut + \frac{1}{2}at^2 \qquad (u = 0)$$

$$s = \frac{1}{2}(g\sin\theta - \mu g\cos\theta)t^2$$

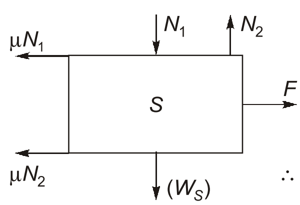
$$t = \sqrt{\frac{2s}{g\cos\theta(\tan\theta - \mu)}}$$

30. (d)

FBD of block R and S:



$N_1 = W_R$



$N_2 = N_1 + W_S$

$\therefore N_2 = W_R + W_S$

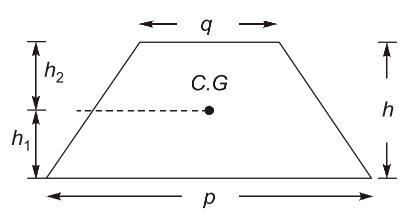
In limiting eq.

$$F \geq \mu N_1 + \mu N_2$$
$$\geq \mu(N_1 + N_2)$$
$$= \mu(W_R + W_R + W_S)$$

$= 0.4(100 + 100 + 150) \times 9.81$

$= 1373.4$ N $= 1.37$ kN

31. (c)



The centre of gravity from larger edge 'p'

$$h_1 = \frac{(p+2q)}{(p+q)}\frac{h}{3}$$

The centre of gravity from smaller edge 'q'

$$h_2 = \frac{(2p+q)}{(p+q)}\frac{h}{3}$$

The support shall pass through centre of gravity (C.G.).

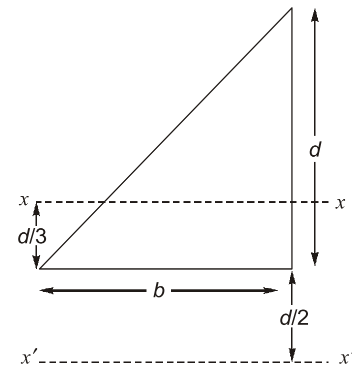
32. (b)

Moment of inertia $I = \Sigma mx^2$ and total mass $M = \Sigma m$

$$\text{Radius of gyration} = \sqrt{\frac{I}{M}} = \left(\frac{\Sigma mx^2}{\Sigma m}\right)^{1/2}$$

33. (c)

The centroidal axis parallel to base will be $d/3$ away from base.



Moment of inertia about centroidal axis

$$IG = \frac{bd^3}{36}$$

Moment of inertia about an axis $\frac{d}{2}$ away from base

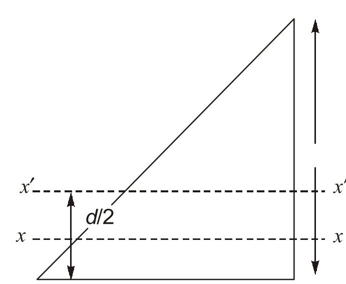
$$I_{x'x'} = I_G + A\left(\frac{d}{2} + \frac{d}{3}\right)^2 = \frac{bd^3}{36} + \frac{bd}{2}\left(\frac{5d}{6}\right)^2$$

$$= \frac{3}{8}bd^3$$

Taking distance $\frac{d}{2}$ away from base towards the apex.

Distance of $x' - x'$ axis

from centroid $= \frac{d}{2} - \frac{d}{3} = \frac{d}{6}$



$$\therefore \qquad I_{x'x'} = \frac{bd^3}{36} + \frac{bd}{2} \times \left(\frac{d}{6}\right)^2 = \frac{bd^3}{24}$$

34. (d)

Moment of inertia about $x_1 - x_1$ using parallel axis theorem

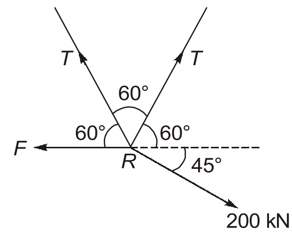
$$I_{x1x1} = I_{xx} + A \times (2)^2$$

$$\therefore \qquad I_{xx} = 10 - 1 \times 4 - 6 \text{ m}^4$$

Moment of inertial about $x_2 - x_2$ using parallel axis theorem

$$I_{x2x2} = I_{xx} + A \times (3)^2$$
$$= 6 + 1 \times 9 = 15 \text{ m}^4$$

35. (c)



Since *PR* and *QR* are identically loaded, so considering horizontal equilibrium,

$$T\cos 60 + F = T\cos 60° + 200\cos 45°$$
$$F = 200\cos 45°$$
$$= 200 \times \frac{1}{\sqrt{2}} = 141.4 \text{ kN}$$

36. (c)

They will hit at the centre of mass. Let r_1 be distance of centre of mass from 12 kg and r_2 be distance of centre of mass from 6 kg.

$$r_1 = \left(\frac{m_2}{m_1 + m_2}\right) r = \left(\frac{6}{12+6}\right) \times 90 = 30 \text{ m}$$

$$r_2 = \left(\frac{m_1}{m_1 + m_2}\right) r = \left(\frac{12}{12+6}\right) \times 90 = 60 \text{ m}$$

37. (c)

The velocity of ball *A* before impact, $V_A = \sqrt{2gh}$

Using principle of conservation of momentum,

$m_A v_A + m_B v_B = (m_A + m_B)v$ ($\because$ For inelastic impact, $v_A' = v_B' = v$ and $v_B = 0$)

$$\therefore m \times \sqrt{2gh} + 0 = (m + 2m)v$$

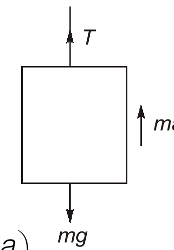
$$v = \frac{m\sqrt{2gh}}{3m} = \frac{1}{3}\sqrt{2gh}$$

38. (b)

$$\frac{E_{\text{rotational}}}{E_{\text{translational}}} = \frac{\frac{1}{2}I\omega^2}{\frac{1}{2}mv^2}$$

$$= \frac{\frac{1}{2}\left(\frac{2}{5}mR^2\right)\frac{v^2}{R^2}}{\frac{1}{2}mv^2} = \frac{2}{5}$$

39. (a)



For uniform acceleration,

$$v = at$$
$$10 = a \times 2$$
$$a = 5 \text{ m/s}^2$$
$$T - mg = ma$$
$$T = mg + ma = mg\left(1 + \frac{a}{g}\right)$$
$$= 100 \times 10^3\left(1 + \frac{5}{10}\right)$$
$$= 150 \times 10^3 \text{ N} = 150 \text{ kN}$$

41. (d)

We have $a = \dfrac{g\sin\theta}{1 + \dfrac{k^2}{R^2}}$

For cylinder *A*, radius of gyration is more than that for cylinder *B*.

$\therefore$ $a_A < a_B$

$v_A < v_B$ (at the bottom)

$\Rightarrow$ $(\text{K.E.})_A < (\text{K.E.})_B$

and $\omega_A R < \omega_B R$

or $\omega_A < \omega_B$

42. (d)

Angular momentum, $L = I\omega$

$$L = (mk^2)\omega$$

$\therefore$ $k^2 = \dfrac{L}{m\omega}$

or $k = \sqrt{\dfrac{L}{m\omega}} = \sqrt{\dfrac{7.2}{1.5 \times 0.3}} = 4 \text{ m}$

43. (b)

$$m = \frac{\text{mass}}{\text{length}} = \frac{dM}{dx}$$

$$\text{K.E.} = \frac{1}{2}Mv^2$$

$$\frac{d}{dt}(\text{K.E.}) = \frac{1}{2}\left(\frac{dM}{dt}\right)v^2 = \frac{1}{2}\left(\frac{dM}{dx}\frac{dx}{dt}\right)v^2$$

$$= \frac{1}{2}(m \cdot v)v^2 = \frac{1}{2}mv^3$$

44. (b)

The velocity at the lowest point required to complete vertical circle is

$$V_L = \sqrt{5gL} = \sqrt{5 \times 10 \times 0.50} = 5 \text{ m/s}$$

Using the law of conservation of linear momentum,

We have $m_1u_1 + m_2u_2 = (m_1 + m_2)v$

$2.4 \times 0 + 0.6 \times 50 = (2.4 + 0.6)v$

$$v = \frac{30}{3} = 10 \text{ m/s}$$

which is greater than $v_L = \sqrt{5gL}$, hence the system will complete vertical circle.

45. (b)

$$\left(\sqrt{3P^2 + Q^2}\right)^2 = \{(P+Q)^2 + (P-Q)^2$$
$$+ 2(P+Q)(P-Q)\cos\theta\}$$
$$3P^2 + Q^2 = 2(P^2 + Q^2) + 2(P^2 - Q^2)\cos\theta$$
$$\therefore \quad P^2 - Q^2 = 2(P^2 - Q^2)\cos\theta$$
$$\cos\theta = \frac{1}{2}$$

(angle) $\theta = 60°$

46. (b)

displacement $x = 2t^2 + 5t$ $\quad y = 4.9t^2$

$$\text{Velocity } V_x = \frac{\partial x}{\partial t} = 4t + 5\,;\; V_y = \frac{\partial y}{\partial t} = 9.8t$$

$$\text{acceleration } a_x = \frac{\partial^2 x}{\partial t^2} = 4\,;\; a_y = \frac{\partial^2 y}{\partial t^2} = 9.8$$

$$\text{Total acceleration (a)} = \sqrt{a_x^2 + a_y^2} = \sqrt{4^2 + 9.8^2}$$
$$= 10.58 \text{ m/s}^2$$

47. (c)

$$\omega = (12 + 9t - 3t^2)$$
$$\frac{d\omega}{dt} = 9 - 6t = 0,\ t = 1.5 \text{ s}$$
$$\omega_{max} = 12 + 9 \times 1.5 - 3 \times 1.5^2$$
$$= 12 + 13.5 - 6.75 = 18.75 \text{ rad/s}$$

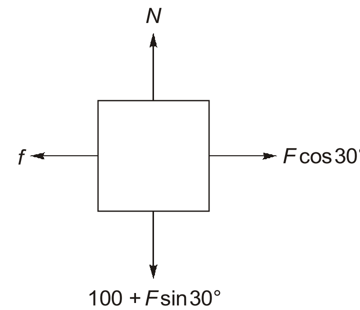
48. (a)

Using Lami's theorem,

$$\frac{T_1}{\sin 120} = \frac{T_2}{\sin(360 - (90 + 120))}$$
$$\therefore \quad \frac{T_1}{T_2} = \frac{\sin 120}{\sin 150} = 1.732$$

49. (c)

The FBD of the block is



where, f = Friction force = μN

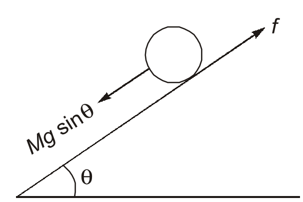
Now, $F\cos 30° = f = \mu N$ ...(1)

and, $100 + F\sin 30° = N$ ...(2)

Using (1) and (2), we get,

$$\frac{\sqrt{3}}{2}F = 0.5(100 + 0.5F)$$
$$\Rightarrow \quad 0.866F = 50 + 0.25F$$
$$\Rightarrow \quad 0.616F = 50$$
$$\therefore \quad F = \frac{50}{0.616} = 81.17 \text{ N}$$

50. (a)



Let the friction force be 'f'

So, $Mg\sin\theta - f = Ma$

and $fR = I\alpha = I\dfrac{a}{R}$

$$\therefore \quad a = \frac{g\sin\theta}{\left(1 + \dfrac{I}{MR^2}\right)}$$

51. (a)