RRB-JE (CBT-2) 2024

Railway Recruitment Board

Junior Engineer Examination

3800 MCQs

Fully solved multiple choice questions
with detailed explanations

Practice Book

Civil Engineering

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Corporate Office: 44-A/4, Kalu Sarai (Near Hauz Khas Metro Station), New Delhi-110016
E-mail: infomep@madeeasy.in
Contact: 9021300500
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3800 MCQs for Railway Recruitment Board (Junior Engineer) : Civil Engineering

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PREFACE

B. Singh (Ex. IES)

With the announcement of vacancies by Railway Recruitment Board (RRB) for the post of Junior 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 the first edition of the Civil Engineering Practice book for RRB-JE 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 3800 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 RRB-JE. 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 RRB-JE 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

Syllabus for Civil & Allied Engineering Exam Group – JE

S.No.	Subject
1.	**Engineering Mechanics:** Force (resolution of force, moment of force, force system, composition of forces), Equilibrium, Friction, Centroid and Center of gravity, Simple machines.
2.	**Building Construction:** Building components (substructure, superstructure), type of structure (load bearing, framed and composite structures).
3.	**Building materials:** Masonry materials (stones, bricks, and mortars), Timber and miscellaneous materials (glass, plastic, fiber, aluminum steel, galvanized iron, bitumen, PVC, CPVC, and PPF).
4.	**Construction of substructure:** job layout, earthwork, foundation (types, dewatering, coffer dams, bearing capacity).
5.	**Construction of superstructure:** stone masonry, brick masonry, Hollow concrete block masonry, composite masonry, cavity wall, doors and windows, vertical communication (stairs, lifts, escalators), scaffolding and shoring.
6.	**Building finishes:** Floors (finishes, process of laying), walls (plastering, pointing, painting) and roofs (roofing materials including RCC).
7.	**Building maintenance:** Cracks (causes, type, repairs- grouting, guniting, epoxy etc.), settlement (causes and remedial measures), and re-baring techniques.
8.	**Building drawing:** Conventions (type of lines, symbols), planning of building (principles of planning for residential and public buildings, rules and byelaws), drawings (plan, elevation, section, site plan, location plan, foundation plan, working drawing), perspective drawing.
9.	**Concrete Technology:** Properties of various types/grades of cement, properties of coarse and fine aggregates, properties of concrete (water cement ratio, properties of fresh and hardened concrete), Concrete mix design, testing of concrete, quality control of concrete (batching, formwork, transportation, placing, compaction, curing, waterproofing), extreme weather concreting and chemical admixtures, properties of special concrete (ready mix, RCC, pre-stressed, fiber reinforced, precast, high performance).
10.	**Surveying:** Types of survey, chain and cross staff survey (principle, ranging, triangulation, chaining, errors, finding area), compass survey (principle, bearing of line, prismatic compass, traversing, local attraction, calculation of bearings, angles and local attraction) leveling (dumpy level, recording in level book, temporary adjustment, methods of reduction of levels, classification of leveling, tilting level, auto level, sources of errors, precautions and difficulties in leveling), contouring (contour interval, characteristics, method of locating, interpolation, establishing grade contours, uses of contour maps), area and volume measurements, plane table survey (principles, setting, method), theodolite survey (components, adjustments, measurements, traversing), Tacheometric survey, curves (types, setting out), advanced survey equipment, aerial survey and remote sensing.
11.	**Computer Aided Design:** CAD Software (AutoCAD, Auto Civil, 3D Max etc.), CAD commands, generation of plan, elevation, section, site plan, area statement, 3D view.
12.	**Geo Technical Engineering:** Application of Geo Technical Engineering in design of foundation, pavement, earth retaining structures, earthen dams etc., physical properties of soil, permeability of soil and seepage analysis, shear strength of soil, bearing capacity of soil, compaction and stabilization of soil, site investigation and sub soil exploration.
13.	**Hydraulics:** Properties of fluid, hydrostatic pressure, measurement of liquid pressure in pipes, fundamentals of fluid flow, flow of liquid through pipes, flow through open channel, flow measuring devices, hydraulic machines.

14. **Irrigation Engineering:** Hydrology, investigation and reservoir planning, percolation tanks, diversion head works.

15. **Mechanics of Structures:** Stress and strain, shear force and bending moment, moment of inertia, stresses in beams, analysis of trusses, strain energy.

16. **Theory of structures:** Direct and bending stresses, slope and deflection, fixed beam, continuous beam, moment distribution method, columns.

17. **Design of Concrete Structures:** Working Stress method, Limit State method, analysis and design of singly reinforced and doubly reinforced sections, shear, bond and development length, analysis and design of T Beam, slab, axially loaded column and footings.

18. **Design of Steel Structures:** Types of sections, grades of steel, strength characteristics, IS Code, Connections, Design of tension and compression members, steel roof truss, beams, column bases.

19. **Transportation Engineering:** Railway Engineering (alignment and gauges, permanent way, railway track geometrics, branching of tracks, stations and yards, track maintenance), Bridge engineering (site selection, investigation, component parts of bridge, permanent and temporary bridges, inspection and maintenance), Tunnel engineering (classification, shape and sizes, tunnel investigation and surveying, method of tunneling in various strata, precautions, equipment, explosives, lining and ventilation).

20. **Highway Engineering:** Road Engineering, investigation for road project, geometric design of highways, construction of road pavements and materials, traffic engineering, hill roads, drainage of roads, maintenance and repair of roads.

21. **Environmental Engineering:** Environmental pollution and control, public water supply, domestic sewage, solid waste management, environmental sanitation, and plumbing.

22. **Advanced Construction Techniques and Equipment:** Fibers and plastics, artificial timber, advanced concreting methods (under water concreting, ready mix concrete, tremix concreting, special concretes), formwork, pre-fabricated construction, soil reinforcing techniques, hoisting and conveying equipment, earth moving machinery (exaction and compaction equipment), concrete mixers, stone crushers, pile driving equipment, working of hot mix bitumen plant, bitumen paver, floor polishing machines.

23. **Estimating and Costing:** Types of estimates (approximate, detailed), mode of measurements and rate analysis.

24. **Contracts and Accounts:** Types of engineering contracts, Tender and tender documents, payment, specifications.

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Contents

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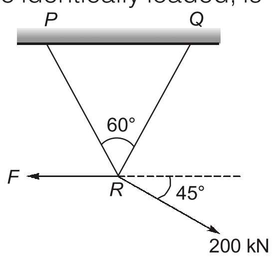
UNIT 1

Engineering Mechanics

Q.1 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

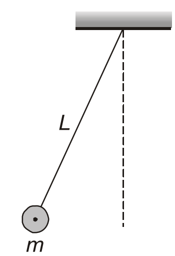
Q.2 An ideal spring with spring constant k is hung from the ceiling and a block of mass M is attached to its lower end. The mass is released with the spring initially unstreched, then the maximum extension in the spring is

(a) $\frac{2Mg}{k}$ (b) $\frac{Mg}{k}$
(c) $\frac{Mg}{2k}$ (d) $\frac{Mg}{4k}$

Q.3 A piece of wire is bent in the shape of a parabola $y = kx^2$ (y-axis vertical) with a bead of mass m on it. The bead can slide on the wire without friction. It stays at the lowest point of the parabola when the wire is at rest. The wire is now accelerated parallel to the x-axis with a constant acceleration a. The distance of the new equilibrium position of the bead, where the bead can stay at rest with respect to the wire, from the y-axis is:

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

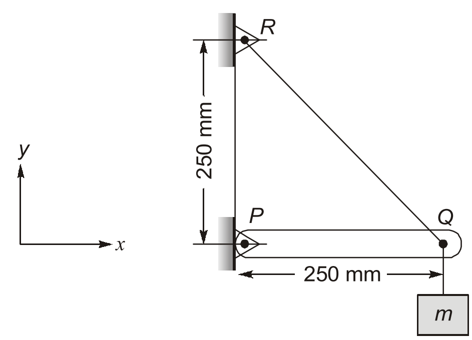
Q.4 A ball of mass 0.25 kg is attached to the end of a string having length 0.5 m. The ball is rotated on a horizontal circular path about vertical axis. The maximum tension that the string can bear is 648 N. The maximum possible value of angular velocity of ball (in radian/s) is



(a) 27 (b) 36
(c) 54 (d) 72

Q.5 A mass 25 kg is suspended from a weightless bar PQ which is supported by a cable QR and a pin at P as shown in figure below. The pin reactions at P on the bar PQ are

[Take g = 10 m/s^2]



(a) R_x = 250 N, R_y = $250\sqrt{2}$
(b) R_x = 250 N, R_y = 0
(c) R_x = 500 N, R_y = $250\sqrt{2}$
(d) R_x = 500 N, R_y = 0

Q.6 Match **List-I** with **List-II** and select the correct answer using the codes given below the lists:

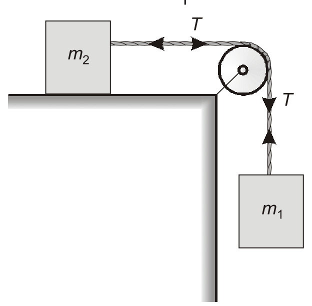
List-I
A. Stability
B. Collision of particles
C. Spinning top
D. Satellite motion

List-II
1. Minimum potential energy
2. Minimum kinetic energy
3. Euler's equation of motion
4. Conservation of moment of momentum
5. Impulse-momentum principle

Codes:

	A	B	C	D
(a)	1	2	3	4
(b)	1	5	4	3
(c)	2	5	3	4
(d)	2	5	1	3

Q.7 In the given figure, two bodies of masses m_1 and m_2 are connected by a light inextensible string passes over a smooth pulley. Mass m_2 lies on a smooth horizontal plane. When mass m_1 moves downwards, the acceleration (in m/s^2) of the two bodies is equal to

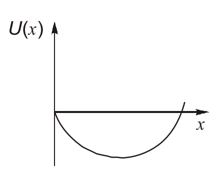


(a) $\dfrac{m_2 g}{m_1 - m_2}$ (b) $\dfrac{m_1 g}{m_1 - m_2}$

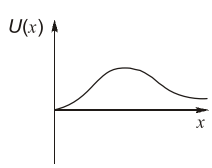
(c) $\dfrac{m_1 g}{m_1 + m_2}$ (d) $\dfrac{m_2 g}{m_1 + m_2}$

Q.8 A particle, which is constrained to move along the x-axis, is subjected to a force in the same direction which varies with the distance x of the particle from the origin as $F(x) = -kx + ax^3$. Here k and a are positive constants. For $x \geq 0$, the functional graphically form of the potential energy $U(x)$ of the particle is

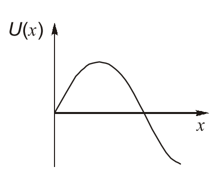
(a)



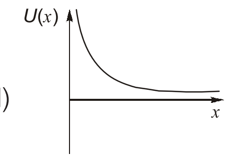
(b)



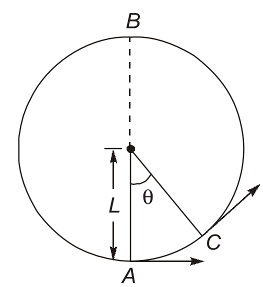
(c)



(d)



Q.9 A bob of mass M is suspended by a massless string of length L. The horizontal velocity v at position A is just sufficient to make it reach the point B. The angle θ at which the speed of the bob is half of that at A, satisfies



(a) $\theta = \dfrac{\pi}{2}$ (b) $\dfrac{\pi}{4} < \theta < \dfrac{\pi}{2}$

(c) $\dfrac{3\pi}{4} < \theta < \pi$ (d) $\dfrac{\pi}{2} < \theta < \dfrac{3\pi}{4}$

Q.10 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

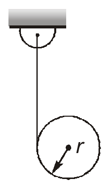
Q.11 A ball A of mass M falls under gravity from a height h and strikes another ball B of mass 2 m which is supported at rest on a spring of stiffness k. Assume perfectly inelastic impact. Immediately after the impact
(a) the velocity of ball A is zero
(b) the velocity of ball A is $\frac{1}{2}\sqrt{2gh}$
(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.12 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.13 A cord is wrapped around a cylinder of radius r and mass m as shown in the given figure. If the cylinder is released from rest, the velocity of the cylinder, after it has moved through a distance h will be



(a) $\sqrt{2gh}$ (b) $\sqrt{\frac{gh}{3}}$

(c) $\sqrt{gh}$ (d) $\sqrt{\frac{4gh}{3}}$

Q.14 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.15 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.16 In a two-particle system with particle masses m_1 and m_2, the first particle is pushed towards the centre of mass through a distance d, the distance through which second particle must be moved to keep the centre of mass at the same position is

(a) $\frac{m_1}{m_2}d$ (b) $\frac{m_2}{m_1}d$

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

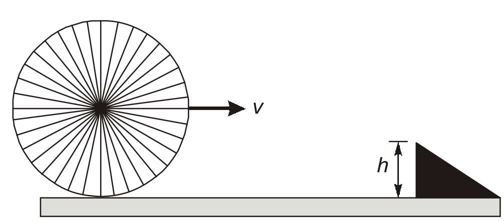
Q.17 Two solid cylinders A and B of same radius start rolling down on a fixed inclined plane from the same height at the same time. Cylinder A has most of its mass concentrated near its surface, while B has most of its mass concentrated near the axis. Which statement is correct?

(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.18 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.19 A wheel of centroidal radius of gyration k is rolling on a horizontal surface with constant velocity. It comes across an obstruction of height h. Because of its rolling speed, it just overcomes the obstruction. To determine v, one should use the principle(s) of conservation of



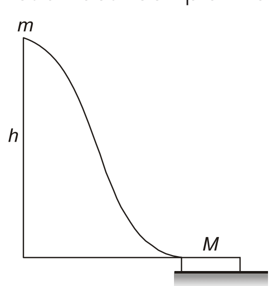
(a) Energy
(b) Linear momentum
(c) Energy and linear momentum
(d) Energy and angular momentum

Q.20 The masses of five balls at rest in a straight line are in geometric progression with ratio 2 and their coefficients of restitution are each $\frac{2}{3}$. If the first ball be started towards the second with velocity u, then the velocity communicated to 5th ball is

(a) $\left(\frac{5}{9}\right)u$ (b) $\left(\frac{5}{9}\right)^2 u$

(c) $\left(\frac{5}{9}\right)^3 u$ (d) $\left(\frac{5}{9}\right)^4 u$

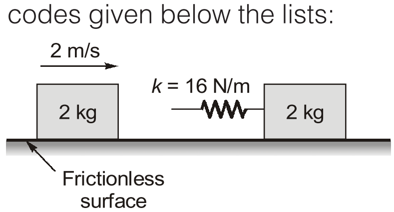
Q.21 A small disc of mass m slides down a smooth hill of height h from rest and gets on to a plank of mass M lying on the horizontal plane at the hill. Due to friction between the disc and the plank, the disc slows down and after a certain moment, moves in one piece with the plank. Then the work performed by the friction force in this process is (Ignore friction between plank and plane)



(a) $\frac{M}{m}gh$ (b) $\frac{mM}{m+M}gh$

(c) $\frac{mM}{m-M}gh$ (d) zero

Q.22 In the arrangement shown below, match **List-I** with **List-II** and select the correct answer using the codes given below the lists:



List-I

A. Velocity of centre of mass

B. Velocity of combined mass when compression in the spring is maximum

C. Maximum compression in the spring

D. Maximum potential energy stored in the spring

List-II

1. 2 SI unit

2. 1 SI unit

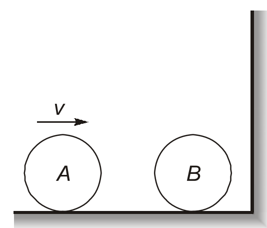
3. 0.5 SI unit

4. 0.25 SI unit

Codes:

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

Q.23 Two balls, shown in figure below, are identical, the first moving with speed v toward right and the second staying at rest. The wall at the extreme right is fixed and smooth. Assuming all collisions to be elastic.



Which of the following statements are correct?

1. There are only three collisions.
2. The speed of first ball is reduced to zero finally after all collisions.
3. Only two collisions are possible.
4. The speeds of balls remain unchanged after all collisions have taken place.

(a) 1 and 2 (b) 3 and 4

(c) 1 and 4 (d) 2 and 3

Q.24 An engine supplies a constant power P to automobile of mass m starting from rest. At an instant of time t.

1. Velocity is proportional to $\sqrt{t}$.
2. Velocity is inversely proportion to $\sqrt{P}$.
3. Displacement is proportional to $\sqrt{\frac{P}{m}}$.
4. Displacement is proportional to $t^{3/2}$.

Which of these statements are correct?

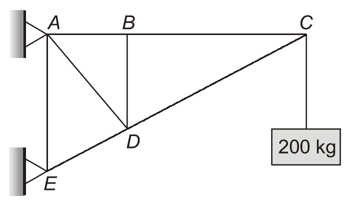
(a) 1, 2 and 3 (b) 1, 3 and 4

(c) 1, 2 and 4 (d) 1, 2, 3 and 4

Q.25 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

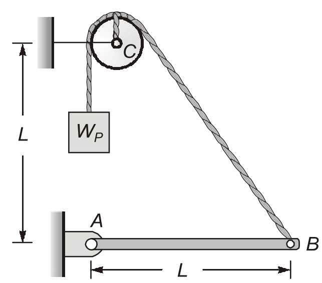
(a) $\frac{1}{2}mv^2$
(b) $\frac{1}{2}mv^3$
(c) $\frac{1}{2}m^2v^2$
(d) mv^3

Q.26 The figure shows a pin-jointed plane truss loaded at the point C by hanging a mass of 200 kg. The member BD of the truss is subjected to a load of



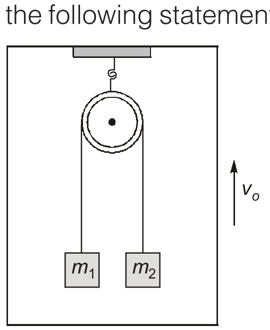
(a) 0
(b) 981 in compression
(c) 1962 in tension
(d) 1962 in compression

Q.27 A uniform, heavy rod AB of length L and weight W is hinged at A and tied to a weight W_P by a string at B. The massless string passes over a frictionless pulley (of negligible dimension) at C as shown in the figure. If the rod is in equilibrium at horizontal configuration, then



(a) $W_P = \frac{W}{2}$
(b) $W_P = \frac{W}{\sqrt{2}}$
(c) $W_P = W$
(d) $W_P = \sqrt{2}W$

Q.28 Two blocks of masses m_1 and m_2 $(m_1 > m_2)$ are connected by a massless thread, that passes over a massless smooth pulley. The pulley is suspended from the ceiling of an elevator. Now the elevator moves up with uniform velocity v_o. Which of the following statements are correct?



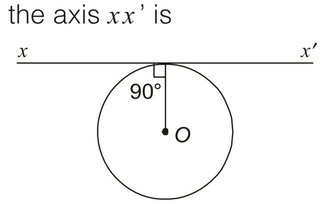
1. Magnitude of acceleration of m_1 with respect to the ground is greater than $\frac{(m_1 - m_2)}{m_1 + m_2}g$.
2. Magnitude of acceleration of m_1 with respect to ground is equal to $\frac{(m_1 - m_2)g}{m_1 + m_2}$.
3. Tension in the thread that connects m_1 and m_2 is equal to $\frac{2m_1m_2g}{m_1 + m_2}$.
4. Tension in the thread that connects m_1 and m_2 is greater than $\frac{2m_1m_2g}{m_1 + m_2}$.

(a) 1 and 3
(b) 2 and 3
(c) 2 and 4
(d) 1 and 4

Q.29 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

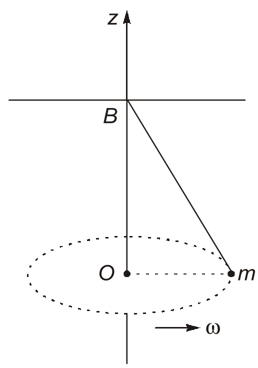
(a) they are unable to complete vertical circle
(b) they are able to complete vertical circle
(c) their system begins to oscillate about the original position of 2.4 kg mass
(d) tension in the string remains constant

Q.30 A thin wire of length L and uniform linear mass density ρ is bent into a circular loop with centre O as shown. The moment of inertia of the loop about the axis xx' is



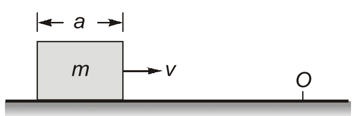
(a) $\frac{\rho L^3}{8\pi^2}$
(b) $\frac{\rho L^3}{16\pi^2}$
(c) $\frac{5\rho L^3}{16\pi^2}$
(d) $\frac{3\rho L^3}{8\pi^2}$

Q.31 A small mass m is attached to a massless string whose other end is fixed at B as shown in the figure. The mass is undergoing circular motion in the x-y plane with centre O and constant angular speed ω. If the angular momentum of system, calculated about O and B are denoted by $\vec{L}_o$ and $\vec{L}_B$ respectively, then



(a) $\vec{L}_o$ and $\vec{L}_B$ do not vary with time
(b) $\vec{L}_o$ varies with time while $\vec{L}_B$ remains constant
(c) $\vec{L}_o$ remains constant while $\vec{L}_B$ varies with time
(d) $\vec{L}_o$ and $\vec{L}_B$ both vary with time

Q.32 A cubical block of side a is moving with velocity v on the horizontal smooth plane as shown in figure below. It hits a ridge at point O. The angular speed of the block after it hits O is

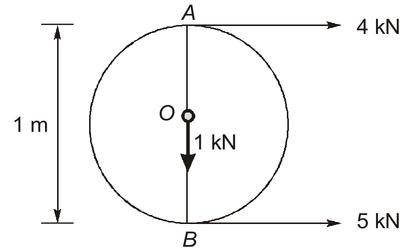


(a) $\frac{3v}{4a}$ (b) $\frac{3v}{2a}$
(c) $\frac{\sqrt{3}v}{\sqrt{2}a}$ (d) zero

Q.33 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°

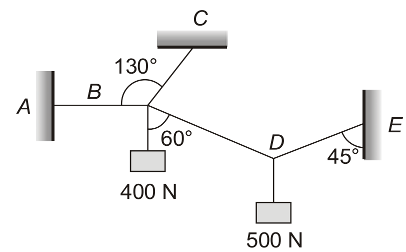
Q.34 The displacement in meters of a point is given by equation
$x = 2t^2 + 5t$; $y = 4.9t^2$
The acceleration at the end of 4th second is
(a) 7.42 m/s^2 (b) 10.58 m/s^2
(c) 3.71 m/s^2 (d) 11.00 m/s^2

Q.35 A pulley of 1 m diameter is subjected to 4 kN and 5 kN forces at A and B respectively as shown in figure. It's own weight of 1 kN acts through the centre O. Then the resultant force is



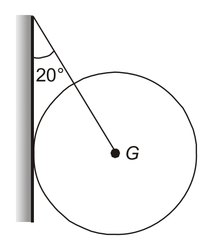
(a) 5.055 kN (b) 7.055 kN
(c) 9.055 kN (d) 11.055 kN

Q.36 A system of connected flexible cables shown in figure is supporting two loads 400 N and 500 N at points B and D. Then the tension in the segment BD will be __________ N.



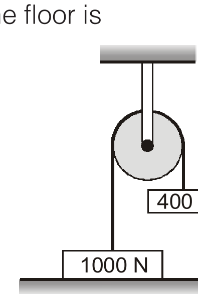
(a) 166.02 N (b) 266.02 N
(c) 366.02 N (d) 466.02 N

Q.37 A sphere weighing 300 N is tied to a smooth wall by a string as shown in figure. Determine the tension in the string __________ N.



(a) 319.15 N (b) 519.15 N
(c) 719.15 N (d) 919.15 N

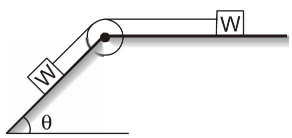
Q.38 The force with which the 1000 N block press against the floor is



(a) 400 N (b) 600 N
(c) 1000 N (d) 1200 N

Q.159 A body is resting on a plane inclined at angle 30° to horizontal. What force would be required to slide it down, if the coefficient of friction between body and plane is 0.3?
(a) Zero (b) 1 kg
(c) 5 kg (d) None of these

Q.160 Two rectangular blocks of weight 'W' each are connected by a flexible cord and rest upon a horizontal and an inclined plane with the cord passing over a pulley as shown in the figure below. If μ is the coefficient of friction for all continuous surfaces, angle 'θ' for motion of system to impede will be:



(a) $\tan\theta = \mu$ (b) $\tan(\theta/2) = \mu$
(c) $\tan(2\theta) = \mu$ (d) $\tan\theta = 2\mu$

Q.161 The maximum frictional force which comes into play when a body just begins to slide over the surface of another body is known as _____.
(a) sliding friction (b) rolling friction
(c) limiting friction (d) None of these

Q.162 A 13 m ladder is placed against a smooth vertical wall with its lower end 5 m from the wall. What should be the coefficient of friction between the ladder and floor so that it remains in equilibrium?
(a) 0.1 (b) 0.15
(c) 0.28 (d) None of these

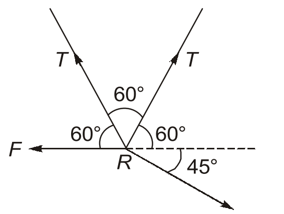
■■■■

Answers **Engineering Mechanics**

1. (c)	2. (a)	3. (c)	4. (d)	5. (b)	6. (b)	7. (c)	8. (c)
9. (c)	10. (c)	11. (c)	12. (b)	13. (d)	14. (a)	15. (a)	16. (a)
17. (d)	18. (d)	19. (d)	20. (d)	21. (b)	22. (b)	23. (c)	24. (b)
25. (b)	26. (a)	27. (b)	28. (b)	29. (b)	30. (d)	31. (c)	32. (a)
33. (b)	34. (b)	35. (c)	36. (c)	37. (a)	38. (b)	39. (c)	40. (a)
41. (c)	42. (a)	43. (d)	44. (a)	45. (b)	46. (d)	47. (a)	48. (b)
49. (b)	50. (b)	51. (c)	52. (a)	53. (a)	54. (c)	55. (a)	56. (b)
57. (a)	58. (d)	59. (d)	60. (a)	61. (b)	62. (c)	63. (a)	64. (d)
65. (d)	66. (d)	67. (b)	68. (d)	69. (b)	70. (d)	71. (d)	72. (a)
73. (a)	74. (b)	75. (c)	76. (d)	77. (d)	78. (a)	79. (d)	80. (b)
81. (b)	82. (c)	83. (a)	84. (a)	85. (a)	86. (b)	87. (b)	88. (b)
89. (a)	90. (c)	91. (b)	92. (a)	93. (d)	94. (a)	95. (b)	96. (a)
97. (a)	98. (d)	99. (d)	100. (c)	101. (d)	102. (a)	103. (b)	104. (b)
105. (d)	106. (b)	107. (a)	108. (b)	109. (a)	110. (b)	111. (d)	112. (a)
113. (d)	114. (b)	115. (d)	116. (a)	117. (b)	118. (a)	119. (c)	120. (d)
121. (b)	122. (c)	123. (c)	124. (c)	125. (a)	126. (d)	127. (a)	128. (d)
129. (a)	130. (a)	131. (b)	132. (b)	133. (b)	134. (b)	135. (b)	136. (b)
137. (c)	138. (d)	139. (b)	140. (d)	141. (d)	142. (d)	143. (d)	144. (c)
145. (c)	146. (b)	147. (a)	148. (d)	149. (c)	150. (c)	151. (b)	152. (d)
153. (b)	154. (a)	155. (d)	156. (b)	157. (a)	158. (c)	159. (a)	160. (b)
161. (c)	162. (d)						

Explanations

1. (c)



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

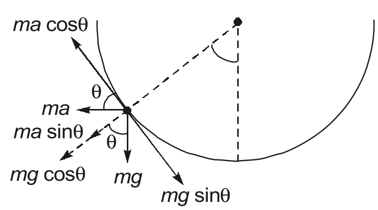
$$T\cos 60 + F = T\cos 60° + 200\cos 45°$$
$$F = 200\cos 45°$$
$$= 200 \times \frac{1}{\sqrt{2}} = 141.4 \text{ kN}$$

2. (a)

Loss in P.E. = Gain in K.E. + P.E. stored in spring

$$\text{Mg } x_{\max} = 0 + \frac{1}{2} k\, x_{\max}^2$$
$$x_{\max} = \frac{2Mg}{k}$$

3. (c)



For tangential equilibrium,

$$\text{mg}\sin\theta = ma\cos\theta$$

$$\Rightarrow \quad \tan\theta = \frac{a}{g} \quad \text{...(1)}$$

$$\text{But} \quad \tan\theta = \frac{dy}{dx} = \frac{d}{dx}\left(kx^2\right) = 2kx \quad \text{...(2)}$$

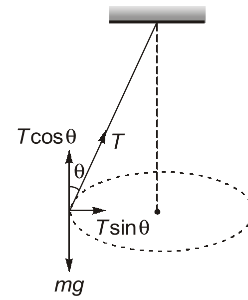
Equating equations (1) and (2), we get

$$\frac{a}{g} = 2kx$$
$$\therefore \quad x = \frac{a}{2gk}$$

4. (d)

The centripetal force is provided by $T\sin\theta$

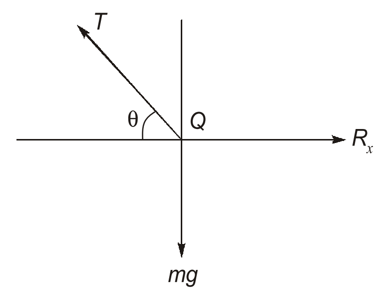
$$\therefore \quad T\sin\theta = m\omega^2 r$$
$$T\sin\theta = m\omega^2(L\sin\theta)$$



$$T = m\omega^2 L$$
$$\omega = \sqrt{\frac{T}{mL}} = \sqrt{\frac{648}{0.25 \times 0.5}}$$
$$= 72 \text{ rad/s}$$

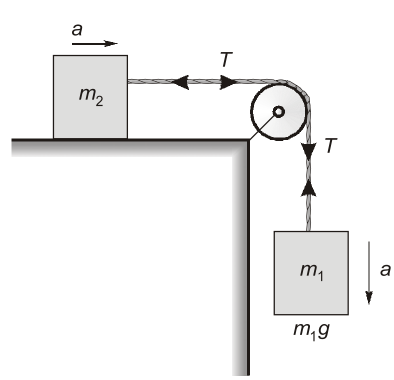
5. (b)

$$\tan\theta = \frac{250}{250} = 1$$
$$\therefore \quad \theta = 45°$$



$$T\sin 45° = mg$$
$$T\cos 45° = R_x$$
$$T = \sqrt{2} \times 25 \times 10 = 250\sqrt{2}$$
$$\therefore \quad R_x = 250\sqrt{2} \times \frac{1}{\sqrt{2}} = 250 \text{ N}$$

7. (c)



$$m_1 g - T = m_1 a \text{ and } T = m_2 a$$
$$\Rightarrow \quad a = \frac{m_1 g}{m_1 + m_2}$$

8. (c)

$$U = -\int F dx$$

$$= -\int \left(-kx + ax^3\right) dx$$

$$= \frac{kx^2}{2} - \frac{ax^4}{4}$$

P.E. is zero when $x = \sqrt{\frac{2k}{a}}$

and $x = 0$

If $x > \sqrt{\frac{2k}{a}}$

then P.E. is negative

9. (c)

As the body just reaches the top most point B, therefore

$$v_A = \sqrt{5gL} \text{ and } v_B = \sqrt{gL}$$

Let the point be C having angular displacement θ at which speed becomes half of the initial value v_A.

Using the law of conservation of energy,

Energy at A = Energy at C

$$\frac{1}{2}mv_A^2 = \frac{1}{2}mv_c^2 + mgL(1-\cos\theta)$$

$$\frac{1}{2}m\left(v_A^2 - v_C^2\right) = mgL(1-\cos\theta)$$

$$\frac{1}{2}m\left(5gL - \frac{5gL}{4}\right) = mgL(1-\cos\theta)$$

$$\frac{15}{8} = 1 - \cos\theta$$

$$\cos\theta = \frac{-7}{8}$$

So θ lies between $\frac{3\pi}{4}$ and π

or, $\frac{3\pi}{4} < \theta < \pi$

10. (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.

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

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

11. (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 $v_B = 0$)

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

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

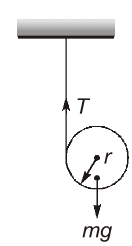
12. (b)

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

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

13. (d)

$$T \times r = I\alpha$$



or $\left(\frac{mr^2}{2}\right)\alpha = T \times r$

or $\frac{mr^2}{2} \times \frac{a}{r} = T \times r$

$\therefore$ $T = \frac{ma}{2}$

Balancing the forces,

$$mg - T = ma$$

$$T = mg - ma$$

$$\frac{ma}{2} = mg - ma$$

$\therefore$ $a = \frac{2g}{3}$

Let the velocity of the cylinder after it has moved through a distance h, be v,

$$\Rightarrow \quad v^2 - u^2 = 2aS$$

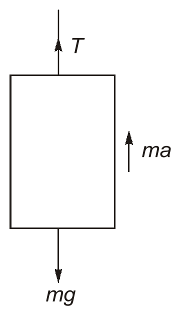
$$v^2 = 2ah \qquad (\because u = 0 \text{ and } s = h)$$

$$v^2 = 2 \times \frac{2g}{3} h$$

$$v = \sqrt{\frac{4gh}{3}}$$

14. (a)

For uniform acceleration,



$$v = at$$

$$10 = a \times 2$$

$$a = 5 \text{ m/s}^2$$

$$T - mg = ma$$

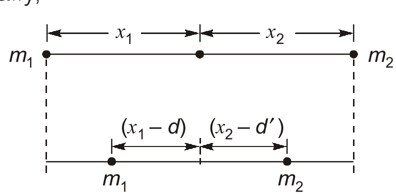
$$T = mg + ma = mg\left(1 + \frac{a}{g}\right)$$

$$= 100 \times 10^3 \left(1 + \frac{5}{10}\right)$$

$$= 150 \times 10^3 \text{ N} = 150 \text{ kN}$$

16. (a)

Initially,



$$0 = \frac{m_1(-x_1) + m_2 x_2}{m_1 + m_2}$$

$$m_1 x_1 = m_2 x_2$$

Finally,
$$0 = \frac{-m_1(x_1 - d) + m_2(x_2 - d')}{m_1 + m_2}$$

$$0 = -m_1 x_1 + m_1 d + m_2 x_2 - m_2 d'$$

$$0 = m_1 d - m_2 d'$$

$$d' = \frac{m_1 d}{m_2}$$

17. (d)

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

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

$$\therefore \quad a_A < a_B$$

$$v_A < v_B \qquad \text{(at the bottom)}$$

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

and
$$\omega_A R < \omega_B R$$

or
$$\omega_A < \omega_B$$

18. (d)

Angular momentum,

$$L = I\omega$$

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

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

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

19. (d)

To determine v, following principles are used.

(i) Conservation of angular momentum.

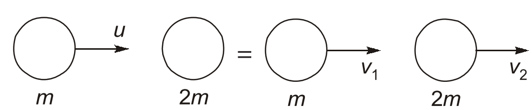
(ii) Conservation of energy.

20. (d)

Let the masses of five balls be m, $2m$, $4m$, $8m$ and $16m$.

For collision between Ist and IInd ball:

$$mu + 0 = mv_1 + 2mv_2 \qquad \text{...(1)}$$



also
$$e = \frac{v_2 - v_1}{u} = \frac{2}{3}$$

$$\therefore \quad v_2 - v_1 = \frac{2}{3}u \qquad \text{...(2)}$$

Adding equations (1) and (2), we get

$$v_2 = \frac{5}{9}u$$

Proceeding in the same way, the velocity of the fifth ball after collision will be

$$v_5 = \left(\frac{5}{9}\right)^4 u$$

21. (b)

$$\text{Loss in P.E.} = (\text{Work})_{\text{friction}} + \text{K.E. of system}$$

$$mgh = (\text{Work})_{\text{friction}} + \frac{1}{2}(M+m)v^2$$

$$mgh = (\text{Work})_{\text{friction}} + \frac{1}{2}(M+m)\left(\frac{mv}{m+M}\right)^2$$

$$(\because v = \sqrt{2gh})$$

$$mgh = (\text{Work})_{\text{friction}} + \frac{1}{2}\frac{m^2v^2}{(m+M)}$$

$$mgh = (\text{Work})_{\text{friction}} + \frac{1}{2}\frac{m^2(2gh)}{(m+M)}$$

$$\therefore \quad (\text{Work})_{\text{friction}} = mgh - \frac{m^2gh}{(m+M)}$$

$$= mgh\left[1 - \frac{m}{(m+M)}\right]$$

$$= \frac{mM}{(M+m)}gh$$

22. (b)

A. $V_{CM} = \dfrac{m_1v_1 + m_2v_2}{m_1 + m_2} = \dfrac{2\times 2+0}{2+2}$

$= 1$ m/s (1 S.I. unit)

B. Using the law of conservation of momentum,

$$m_1u_1 + m_2u_2 = (m_1 + m_2)v$$
$$2 \times 2 + 2 \times 0 = (2 + 2)v$$
$$v = 1 \text{ m/s} \qquad \text{(i.e. 1 SI unit)}$$

C. Using energy conservation,

$$\frac{1}{2}mu^2 + 0 = \frac{1}{2}(m_1+m_2)v^2 + \frac{1}{2}kx^2$$

$$\frac{1}{2}\times 2\times(2)^2 + 0 = \frac{1}{2}(2+2)\times 1^2 + \frac{1}{2}\times 16x^2$$

$$4 = 2 + 8x^2$$

$$x^2 = \frac{1}{4}$$

$$\Rightarrow \quad x = 0.5 \text{ m} \qquad \text{(i.e. 0.5 S.I. unit)}$$

D. $U = \dfrac{1}{2}kx^2 = \dfrac{1}{2}(16)(0.5)^2$

$= 2$ J (i.e. 2 S.I. unit)

23. (c)

Just before the first collision, ball *A* comes to rest and ball *B* moves with velocity *v*. Now, the ball *B* collides with the vertical wall and rebounds with the same speed *v*. When ball *B* collides with ball *A*, the ball *B* comes to rest and ball *A* moves with velocity *v*. So, statements 1 and 4 are correct.

24. (b)

$$\text{Power} = P \qquad \text{(Constant)}$$

$$Fv = P$$

$$\left(m\frac{dv}{dt}\right)v = P$$

$$\int V dv = \frac{P}{m}\int dt$$

$$\frac{v^2}{2} = \frac{P}{m}t$$

$$v = \sqrt{\frac{2Pt}{m}}$$

$$\Rightarrow \quad v \propto \sqrt{P}$$
$$\propto \sqrt{t}$$

Now, $v = \dfrac{dx}{dt} = \sqrt{\dfrac{2P}{m}}t^{1/2}$

$$\int dx = \sqrt{\frac{2P}{m}}\int t^{1/2}dt$$

$$x = \sqrt{\frac{2P}{m}}\left(\frac{t^{3/2}}{3/2}\right) = \sqrt{\frac{8P}{9m}}t^{3/2}$$

$$\Rightarrow \quad x \propto t^{3/2}$$
$$\propto \sqrt{\frac{P}{m}}$$

So, statements 1, 3 and 4 are correct.

25. (b)

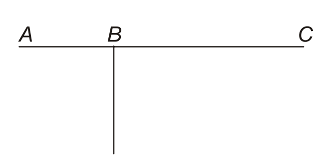
$$m = \frac{\text{mass}}{\text{length}} = \frac{dM}{dx}$$

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

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

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

26. (a)



Considering joint B as shown in the figure above, we have force balance in y-direction, i.e.

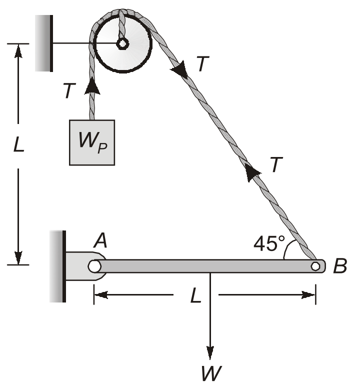
$$\Sigma F_y = 0$$

$\therefore$ Force in the member $BD = 0$

27. (b)

As mass W_P is in equilibrium,

$$W_P = T$$



For equilibrium of rod,

$$\Sigma M_A = 0$$

$$T\sin 45° \times L = W \times \frac{L}{2}$$

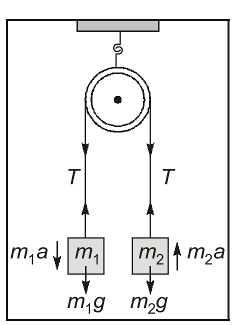
$$\Rightarrow \quad T \times \frac{L}{\sqrt{2}} = W \times \frac{L}{2}$$

$$T = \frac{W}{2} \times \sqrt{2} = \frac{W}{\sqrt{2}}$$

$$\therefore \quad W_P = \frac{W}{\sqrt{2}}$$

28. (b)

Since the lift moves with uniform velocity so the acceleration of the lift is zero.



$\therefore$ For body m_1,

$$m_1g - T = m_2a \qquad ...(1)$$

Similarly, for body m_2,

$$T - m_2g = m_2a \qquad ...(2)$$

From (1)

$$\Rightarrow \quad T = m_1g - m_1a$$

Substituting the value of T in equation (2), we get

$$m_1g - m_1a = m_2g + m_2a$$

$$(m_1 - m_2)g = (m_1 + m_2)a$$

$$\therefore \quad a = \frac{(m_1 - m_2)g}{m_1 + m_2}$$

and

$$T = m_1g - m_1 \times \frac{(m_1 - m_2)g}{m_1 + m_2}$$

$$= \frac{2m_1m_2g}{m_1 + m_2}$$

29. (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.

30. (d)

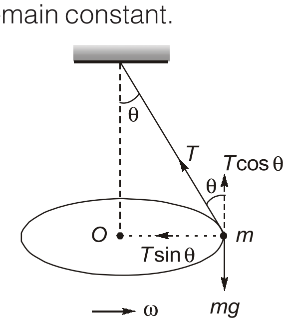
$$I_{xx}' = I + Mx^2$$

$$= \frac{1}{2}MR^2 + MR^2 = \frac{3}{2}MR^2$$

$$= \frac{3}{2}(\rho L)\left(\frac{L}{2\pi}\right)^2 = \frac{3\rho L^3}{8\pi^2}$$

31. (c)

Torque due to tension T about point B is zero while torque due to weight mg is non-zero. Hence, L_B will change with time. Torque due to $T\cos\theta$ and mg about point O will cancel each other. Also, torque to $T\sin\theta$ about point O is zero. Therefore, L_o will remain constant.



32. (a)

Let I_o be the M.I. of the cube about point O when the cube hits it. Using the law of conservation of angular momentum,

$$mv\left(\frac{a}{2}\right) = [I_{C.M.} + mx^2]\omega$$

$$\frac{mva}{2} = \left[\frac{ma^2}{6} + m\left(\frac{a}{\sqrt{2}}\right)^2\right]\omega$$

[Cube will rotate with half of diagonal as circle]

$$\Rightarrow \qquad \omega = \frac{3v}{4a}$$

33. (b)

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

$$3P^2 + Q^2 = 2(P^2+Q^2) + 2(P^2-Q^2)\cos\theta$$

$$\therefore \qquad P^2 - Q^2 = 2(P^2-Q^2)\cos\theta$$

$$\cos\theta = \frac{1}{2}$$

(angle) $\theta = 60°$

34. (b)

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

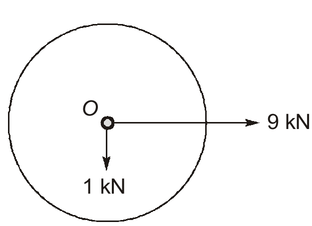
$$\text{Velocity } V_x = \frac{\partial x}{\partial t} = 4t+5\ ;\ V_y = \frac{\partial y}{\partial t} = 9.8t$$

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

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

$$= 10.58 \text{ m/s}^2$$

35. (c)



$$\text{Resultant force} = \sqrt{1+81} = \sqrt{82}$$

$$= 9.055 \text{ kN}$$

36. (c)

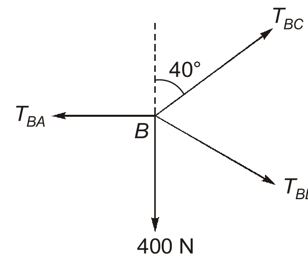


Figure (a)

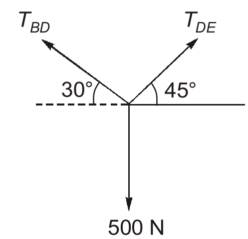


Figure (b)

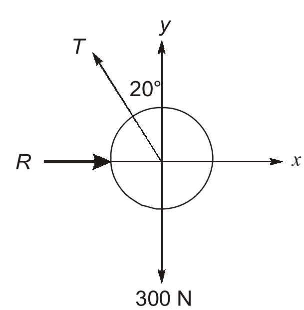
From figure (b)

$$\frac{T_{BD}}{\sin(90°+45°)} = \frac{T_{DE}}{\sin(90+30)}$$

$$= \frac{500}{\sin(180-30-45)}$$

$$T_{BD} = \frac{500\sin(135°)}{\sin(105°)} = 366.02 \text{ N}$$

37. (a)



In xy direction

$-T\sin 20°\, i + T\cos 20\, j + Ri - 300j = 0$

$(R - T\sin 20°)\, i + (0.947 - 300)j = 0$

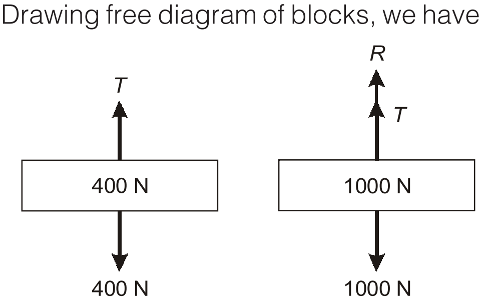
then $R - T\sin 20° = 0$

$0.94\, T - 300 = 0$

$$\text{(Tension)}\ T = \frac{300}{0.94} = 319.15\ N$$

38. (b)

Drawing free diagram of blocks, we have,



$$T = 400 \text{ N}$$
$$T + R = 1000$$
$$\therefore \quad 400 + R = 1000$$
$$R = 600 \text{ N}$$

This is the reaction from the ground and it is the same force with which the 1000 N block press against the floor.

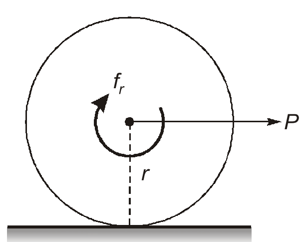
39. (c)

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

40. (a)

Torque, $$T = mg \times \frac{L}{2}$$
$$I_0 = \frac{mL^2}{3}$$
$$\alpha = \frac{T}{I_0} = \frac{mgL}{2} \times \frac{3}{mL^2} = \frac{1.5g}{L}$$

41. (c)



$$P - f = ma_{cm} - \text{2nd law} \quad \text{...(1)}$$
$$[\text{Torque}]_{cm} = I_{am}\alpha$$
$$fr = I\alpha$$
$$f = \frac{I\alpha}{r} \quad \text{...(2)}$$

from (1) and (2)

$$P - \frac{I\alpha}{r} = ma_{cm}$$
$$P - \frac{2}{5}\frac{mr^2\alpha}{r} = ma_{cm}$$
$$P - \frac{2}{5}mr\alpha = ma_{cm}$$

For rolling motion $a_{cm} = r\alpha$

$$P - \frac{2}{5}ma_{cm} = ma_{cm}$$
$$\Rightarrow \quad P = 1.4\, ma_{cm}$$
$$\Rightarrow \quad a_{cm} = 0.71\frac{P}{m}$$
$$\Rightarrow \quad K = 0.71$$

42. (a)

Acceleration of block is given by,

$$\therefore \quad a = \frac{-\mu W}{m}$$
$$\therefore \quad \frac{v\,dv}{dx} = \frac{-\mu W}{m}$$
$$\therefore \quad v\,dv = \frac{-\mu W}{m}dx$$

On integrating

$$\left[\frac{v^2}{2}\right]_{v_0}^{0} = \frac{-\mu W}{m}[dx]_0^x$$
$$0 - \frac{v_0^2}{2} = \frac{-\mu W}{m} \times x$$
$$\Rightarrow \quad \mu = \frac{mv_0^2}{2mx} = \mu = \frac{v_0^2}{2gx}$$

or

$$v^2 = u^2 + 2aS$$
$$0 = v_0^2 + 2(-ug)x$$
$$u = \frac{v_0^2}{2gx}$$

43. (d)

$$\omega_0 = 8000 \text{ rpm} = 837.33 \text{ rad/s}$$
$$t = 5 \text{ min} = 300 \text{ s}$$
$$\theta = \omega_0 t + \frac{1}{2}\alpha t^2$$
$$\alpha =$$
$$\frac{\omega - \omega_0}{t} = -\frac{837.33}{300} = -2.791 \text{ rad/s}^2$$
$$\theta = 837.33 \times 300 - 0.5 \times 2.791 \times (300)^2$$
$$= 125604 \text{ rad}$$

$\therefore$ Number of revolutions $= \dfrac{\theta}{2\pi} = 19990 \simeq 20000$