RRB JE

Mechanical Engineering

Chapterwise

Solved Papers

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Complied & Written By

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2nd Stage CBT : Short listing of Candidates for the 2nd Stage CBT exam shall be based on the normalized marks obtained by them in the 1st Stage CBT Exam. Total number of candidates to be shortlisted for 2nd Stage shall be 15 times the community wise total vacancy of Posts notified against the RRB as per their merit in 1st Stage CBT. However, Railways reserve the right to increase/decrease this limit in total or for any specific category(s) as required to ensure availability of adequate candidates for all the notified posts.

Duration : 120 minutes *(160 Minutes for eligible PwBD candidates accompanied with Scribe)*

No of Questions : 150

Syllabus : The Questions will be of objective type with multiple choices and are likely to include questions pertaining to General Awareness, Physics and Chemistry, Basics of Computers and Applications, Basics of Environment and Pollution Control and Technical abilities for the post. The syllabus for General Awareness, Physics and Chemistry, Basics of Computers and Applications, Basics of Environment and Pollution Control is common for all notified posts under this CEN as detailed below:-

a) **General Awareness :** Knowledge of Current affairs, Indian geography, culture and history of India including freedom struggle, Indian Polity and constitution, Indian Economy, Environmental issues concerning India and the World, Sports, General scientific and technological developments etc.

b) **Physics and Chemistry:** Up to 10th standard CBSE syllabus.

c) **Basics of Computers and Applications:** Architecture of Computers; input and Output devices; Storage devices, Networking, Operating System like Windows, Unix, Linux; MS Office; Various data representation; Internet and Email; Websites & Web Browsers; Computer Virus.

d) **Basics of Environment and Pollution Control:** Basics of Environment; Adverse effect of environmental pollution and control strategies; Air, water and Noise pollution, their effect and control; Waste Management, Global warming; Acid rain; Ozone depletion.

e) **Technical Abilities:** The educational qualifications mentioned against each post shown in Annexure-A, have been grouped into different exam groups as below. Questions on the Technical abilities will be framed in the syllabus defined for various Exam Groups given at Annexure-VII-A, B, C, D, E, F & G.

The section wise Number of questions and marks are as below :

Subjects	No. of Questions	Marks for each Section
	Stage-II	Stage-II
General Awareness	15	15
Physics & Chemistry	15	15
Basics of Computers and Applications	10	10
Basics of Environment and Pollution Control	10	10
Technical Abilities	100	100
Total	150	150
Time in Minutes	120	

The section wise distribution given in the above table is only indicative and there may be some variations in the actual question papers.

Minimum percentage of marks for eligibility in various categories: UR -40%, OBC-30%, SC-30%, ST -25%. This percentage of marks for eligibility may be relaxed by 2% for PwBD candidates, in case of shortage of PwBD candidates against vacancies reserved for them.

Virtual calculator will be made available on the Computer Monitor during 2nd Stage CBT.

2nd Stage Syllabus for Mechanical & Allied Engineering Exam Group – JE

1. **Engineering Mechanics :** Resolution of forces, Equilibrium and Equilibrant, parallelogram law of forces, triangle law of forces, polygon law of forces and Lami's theorem, couple and moment of a couple, condition for equilibrium of rigid body subjected to number of coplanar non-concurrent forces, definition of static friction, dynamic friction, derivation of limiting angle of friction and angle of repose, resolution of forces considering friction when a body moves on horizontal plane and inclined plane, calculation of moment of inertia and radius of gyration of : (a) I-Section (b) channel section (c) T-Section (d) L-Section (Equal & unequal lengths) (e) Z-Section (f) Built up sections (simple cases only), Newton's laws of motion (without derivation), motion of projectile, D'Alembert's principle, definition law of conservation of energy, law of conservation of momentum.
2. **Material Science :** Mechanical properties of engineering materials – tensile strength, compressive strength, ductility, malleability, hardness, toughness, brittleness, impact strength, fatigue, creep resistance. Classification of steels, mild steel and alloy steels. Importance of heat treatment. Heat treatment processes – annealing, normalizing, hardening, tempering, carburizing, nitriding and cyaniding.
3. **Strength of Materials :** Stress, strain, stress strain diagram, factor of safety, thermal stresses, strain energy, proof resilience and modules of resilience. Shear force and bending moment diagram – cant leaver beam, simply supported beam, continuous beam, fixed beam. Torsion in shafts and springs, thin cylinder shells.
4. **Machining :** Working principle of lathe. Types of lathes – Engine lathe – construction details and specifications. Nomenclature of single point cutting tool, geometry, tool signature, functions of tool angles. General and special operations – (Turning, facing, taper turning thread cutting, knurling, forming, drilling, boring, reaming, key way cutting), cutting fluids, coolants and lubricants. Introduction to shaper, slotter, plainer, broaching, milling and manufacture of gears, heat treatment process applied to gears.
5. **Welding :** Welding – Introduction, classification of welding processes, advantages and limitations of welding, principles of arc welding, arc welding equipment, choice of electrodes for different metals, principle of gas (oxy-acetylene) welding, equipment of gas welding, welding procedures (arc & gas), soldering and brazing techniques, types and applications of solders and fluxes, various flame cutting processes, advantages and limitations of flame cutting, defects in welding, testing and inspection modern welding methods, (submerged, CO2, atomic – hydrogen, ultrasonic welding), brief description of MIG & TIG welding.
6. **Grinding & Finishing Process :** Principles of metal removal by grinding, abrasives, natural and artificial, bonds and binding processes, vitrified, silicate, shellac rubber, grinding machines, classification: cylindrical, surface, tool & cutter grinding machine, construction details, relative merits, principles of centreless grinding, advantages & limitations of centreless grinding work, holding devices, wheel maintenance, balancing of wheels, coolants used, finishing by grinding, honing, lapping, super finishing, electroplating, basic principles – plating metals, applications, hot dipping, galvanizing tin coating, parkerising, anodizing, metal spraying, wire process, powder process and applications, organic coatings, oil base paint, lacquer base enamels, bituminous paints, rubber base coating.
7. **Metrology :** Linear measurement – Slip gauges and dial indicators, angle measurements, bevel protractor, sine bar, angle slip gauges, comparators (a) mechanical (b) electrical (c) optical (d) pneumatic. Measurement of surface roughness; methods of measurements by comparison, tracer instruments and by interferometry, collimators, measuring microscope, interferometer, inspection of machine parts using the concepts of shadow projection and profile projection.
8. **Fluid Mechanics & Hydraulic Machinery :** Properties of fluid, density, specific weight, specific gravity, viscosity, surface tension, compressibility capillarity, Pascal's law, measurement of pressures, concept of buoyancy. Concept of Reynold's number, pressure, potential and kinetic energy of liquids, total energy, laws of conservation, mass, energy and momentum, velocity of liquids and discharge, Bernoulli's equation and assumptions, venturimeters, pitottube, current meters. Working principle & constructional details of centrifugal pump, efficiencies – manometric efficiency, volumetric efficiency, mechanical efficiency and overall efficiency, cavitation and its effect, working principle of jet & submersible pumps with line diagrams.
9. **Industrial Management :** Job analysis, motivation, different theories, satisfaction, performance reward systems, production, planning and control, relation with other departments, routing, scheduling, dispatching, PERT and CPM, simple problems. Materials in industry, inventory control model, ABC Analysis, Safety stock, re-order, level, economic ordering quantity, break even analysis, stores layout, stores equipment, stores records, purchasing procedures, purchase records, Bin card, Cardex, Material handling, Manual lifting, hoist, cranes, conveyors, trucks, fork trucks.
10. **Thermal Engineering :** Laws of thermo dynamics, conversion of heat into work vice versa , laws of perfect gases, thermo dynamic processes – isochoric, isobaric, isothermal hyperbolic, isentropic, polytrophic and throttling, modes of heat transfer, thermal conductivity, convective heat transfer coefficient, Stefan Boltzman law by radiation and overall heat transfer coefficient. Air standards cycles – Carnot cycle, Otto cycle, Diesel cycle, construction and working of internal combustion engines, comparison of diesel engine and petrol engine. Systems of internal combustion engine, performance of internal combustion engines. Air compressors their cycles refrigeration cycles, principle of a refrigeration plant.

RRB JE Previous Exam Papers Analysis Chart

Sr. No.	Exam	Year	Question
RRB JE 2019			
1.	RRB JE CBT-II	29.08.2019	100
2.	RRB JE CBT-II	30.08.2019	100
3.	RRB JE CBT-II	31.08.2019	100
RRB JE 2015			
4.	RRB JE 2015	26.08.2015 Shift-I	21
5.	RRB JE 2015	26.08.2015 Shift-II	24
6.	RRB JE 2015	26.08.2015 Shift-III	22
7.	RRB JE 2015	27.08.2015 Shift-I	25
8.	RRB JE 2015	27.08.2015 Shift-II	26
9.	RRB JE 2015	27.08.2015 Shift-III	21
10.	RRB JE 2015	28.08.2015 Shift-I	18
11.	RRB JE 2015	28.08.2015 Shift-II	20
12.	RRB JE 2015	28.08.2015 Shift-III	22
13.	RRB JE 2015	29.08.2015 Shift-I	24
14.	RRB JE 2015	29.08.2015 Shift-I	19
15.	RRB JE 2015	29.08.2015 Shift-I	23
16.	RRB JE 2015	30.08.2015 Shift-III	22
17.	RRB JE 2015	01.09.2015 Shift-I	20
18.	RRB JE 2015	01.09.2015 Shift-II	21
19.	RRB JE 2015	01.09.2015 Shift-III	19
20.	RRB JE 2015	02.09.2015 Shift-I	18
21.	RRB JE 2015	02.09.2015 Shift-II	17
22.	RRB JE 2015	02.09.2015 Shift-III	18
23.	RRB JE 2015	03.09.2015 Shift-I	15
24.	RRB JE 2015	03.09.2015 Shift-II	19
25.	RRB JE 2015	03.09.2015 Shift-III	20
26.	RRB JE 2015	04.09.2015 Shift-II	18
27.	RRB JE 2015	16.09.2015 Shift-I	21
28.	RRB Ranchi JE 2015	04.01.2015 Yellow Paper	20
29.	RRB Ranchi JE 2015	04.01.2015 Red Paper	25

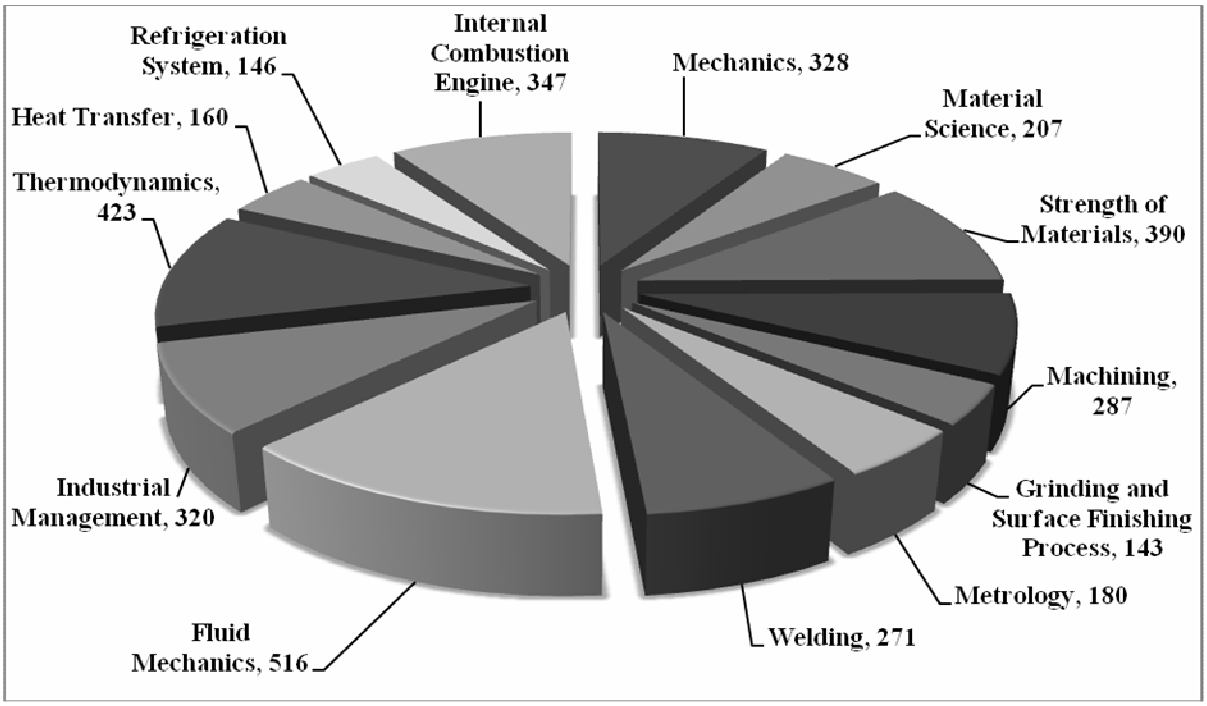
RRB JE/Sr. SE Exam 2014			
30.	RRB JE (Bilaspur/Kolkata/Mumbai/Guwahati) 2014	14.12.2014 SET : 01 Red Paper	20
31.	RRB JE (CHENNAI) 2014	14.12.2014 SET : 02 Red Paper	26
32.	RRB JE (Bilaspur/Guwahati/Patna) 2014	14.12.2014 SET : 03 Green Paper	25
33.	RRB JE (Muzaffarpur) 2014	14.12.2014 SET : 04 Green Paper	28
34.	RRB JE (Bilaspur/Guwahati) 2014	14.12.2014 SET : 05 Yellow Paper	31
35.	RRB JE (Patna/Muzaffarpur/Chennai/Ahmedabad/ Bangalore) 2014	14.12.2014 SET : 06 Yellow Paper	21
36.	RRB Sr. SE (Bilaspur/Secunderabad) 2014	21.12.2014 SET : 07 Red Paper	18
37.	RRB Sr. SE (Bilaspur/Secunderabad) 2014	21.12.2014 SET : 08 Green Paper	25
38.	RRB Sr. SE (Bilaspur/Secunderabad) 2014	21.12.2014 SET : 09 Yellow Paper	21
39.	RRB Sr. SE (BHOPAL) 2014	21.12.2014	15
DMRC/LMRC/JMRC/NMRC/BMRCL JE Exam			
40.	DMRC JE 2017	18.02.2017	75
41.	DMRC JE 2016	06.03.2016	75
42.	DMRC JE 2015	15.03.2015	75
43.	DMRC JE 2014	07.09.2014	75
44.	DMRC JE 2013	21.07.2013	75
45.	DMRC JE 2017	22.09.2017	75
46.	DMRC JE 2018	20.04.2018	75
47.	LMRC JE 2016	17.03.2016	75
48.	LMRC JE 2015	26.06.2015	75
49.	JMRC JE 2012	23.12.2012	50
50.	NMRC JE 2017	05.03.2017	75
51.	JMRC JE 2017	10.06.2017	50
52.	BMRCL JE 2019	24 Feb. 2019	75
OTHER RAILWAY JE & SSE Exams.			
53.	RRB Bhubneshwar JE-II 2010	19.12.2010	19
54.	RRB Allahabad JE 2010	19.12.2010	25
55.	RRB Allabahad SSE 2010	19.12.2010	23

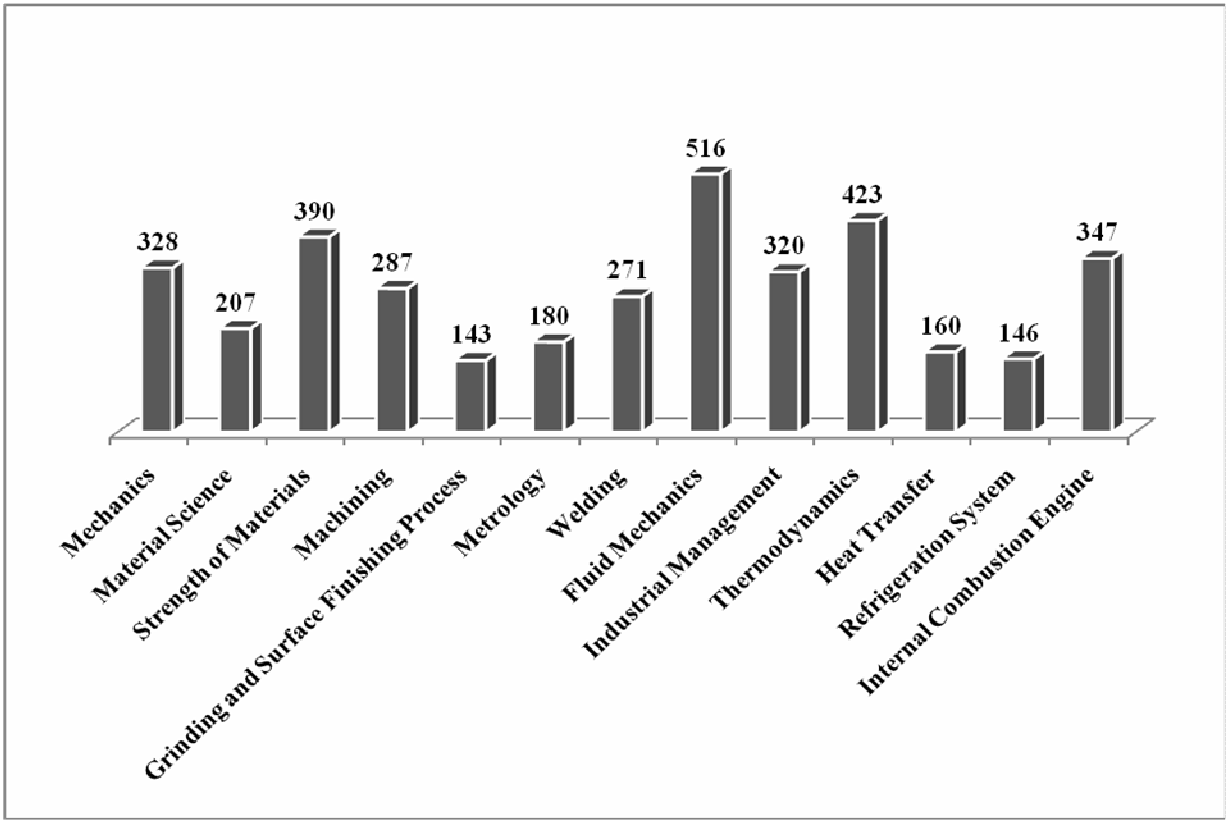
56.	RRB Mumbai JE 2008	05.10.2008	28
57.	RRB Mumbai SSE 2008	05.10.2008	31
58.	RRB Mumbai JE 2010	19.12.2010	22
59.	RRB Mumbai SSE 2010	19.12.2010	26
60.	RRB Bhubneshwar JE-II 2010	19.12.2010	20
61.	Konkan Railway STA 2017	2017	24
62.	Konkan Railway TA 2017	2017	18
63.	Konkan Railway SSE 2015	2015	31
64.	RRB Kolkata Diesel JE 2009	25.10.2009	23
65.	RRB Chandigarh SSE 2009	25.10.2009	26
66.	RRB Mumbai C&G JE 2009	25.10.2009	24
67.	RRB Gorakhpur RDSO SSE 2009	25.10.2009	25
68.	RRB Jammu JE 2009	25.10.2009	23
69.	RRB Malda SSE 2009	25.10.2009	27
70.	RRB Allahabad JE 2009	25.10.2009	21
71.	RRB Mumbai C&G SSE 2009	25.10.2009	26
72.	RRB Patna JE	25.10.2009	23
73.	RRB Bhopal TM SSE 2009	25.10.2009	24
74.	RRB Allahabad SSE 2012	09.09.2012	25
75.	RRB Banglore SSE 2012	09.09.2012	29
76.	RRB Kolkala SSE 2012	09.09.2012	18
77.	RRB Gorakhpur Design SSE 2012	09.09.2012	23
78.	RRB Bhopal SSE 2012	09.09.2012	25
79.	RRB Chandigarh SSE 2012	09.09.2012	28
80.	RRB Jammu SSE 2012	09.09.2012	23
81.	RRB Allahabad JE 2012	09.09.2012	21
82.	RRB Bhubneshwar JE II 2008	29.11.2008	25
83.	Konkan Railway STA 2017	2017	23
84.	Konkan Railway TA 2017	2017	24
85.	Konkan Railway SSE 2015	2015	20
86.	RRB Kolkata Diesel JE 2009	25.10.2009	22
87.	RRB Bhopal Section Engineer,	24.11.2002	24

88.	RRB Bhopal & Mumbai Apprentice Section Engg.	23.03.2003	28
89.	RRB Secunderabad Section Engineer (Mech.)	29.06.2008	22
90.	RRB Bangalore Section Engineer (Mech.)	01.02.2009	23
91.	RRB Chandigarh Section Engineer,	15.03.2009	25
92.	RRB Chennai Section Engineer,	12.02.2012	27
93.	RRB Chandigarh Section Engineer (Mech.),	26.02.2012	24
94.	RRB Chandigarh Section Engineer,	26.02.2012	29
95.	RRB Jammu Section Engg., 2013	2013	20
96.	RRB Bhubaneswar Section Engg (Mech.) ,	19.08.2001	18
97.	RRB Kolkata Engg. (P.Way),	20.02.2000	15
98.	RRB Kolkata Apprentice Engg.,	14.10.2001	20
99.	RRB Bangalore Material Engg.	21.11.2004	23
100.	RRB Bangalore Material Engg,	21.11.2004	21
101.	RRB Kolkata Mech. Engg.,	06.02.2005	15
102.	RRB Allahabad Junior Engineer-II [Mech. DSL (C&W)],	08.01.2006	15
103.	RRB Kolkata Jr. Engineer-II Mech. DRG & Design,	11.06.2006	15
104.	RRB Kolkata Technical-Engg.,	20.08.2006	28
105.	RRB Chennai Technical (Eng.),	15.04.2007	25
106.	RRB Bangalore Technical (Eng.),	22.04.2007	27
107.	RRB Secunderabad Technical (Eng.),	20.05.2007	22
108.	RRB Patna Technical Eng.,	27.07.2008	28
109.	RRB Thiruvananthapuram Section Eng. (Mech.),	04.01.2009	19
110.	RRB Bangalore Section Eng. (Mech.),	01.02.2009	23
111.	RRB Chandigarh Section Eng. Mech.	15.03.2009	26
112.	RRB Chandigarh Section Eng. (Mech.),	26.02.2012	27
113.	RRB Chandigarh Section Eng. (Mech.),	26.02.2012	29
114.	RRB Bhopal Section Engineer,	24.11.2002	20
		Total	**4300**

Note : After due analysis of the above question papers, **4300** Questions related to **Mechanical, JE & SSC and Other Railway Exams** have been presented chapter wise. Questions of repetitive and similar nature have been included so that the technique of asking questions can benefit the competitors.

Trend Analysis of Previous Year RRB JE Papers Through Bar Graph and Pie Chart





01.

Mechanics

Resolution of forces, Equilibrium and Equilibrant, parallelogram law of forces, triangle law of forces, polygon law of forces and Lami's theorem, couple and moment of a couple, condition for equilibrium of rigid body subjected to number of coplanar non-concurrent forces, definition of static friction, dynamic friction, derivation of limiting angle of friction and angle of repose, resolution of forces considering friction when a body moves on horizontal plane and inclined plane, calculation of moment of inertia and radius of gyration of : (a) I-Section (b) channel section (c) T-Section (d) L-Section (Equal & unequal lengths) (e) Z-Section (f) Built up sections (simple cases only), Newton's laws of motion (without derivation), motion of projectile, D'Alembert's principle, definition law of conservation of energy, law of conservation of momentum.

1. Law of Forces and Analysis

1. Three forces acting on a rigid body are represented in magnitude, direction and line of action by the three sides of a triangle taken in order. The forces are equivalent to a couple whose moment is equal to-

(a) Thrice the area of the triangle
(b) Twice the area of the triangle
(c) The area of the triangle
(d) Half the area of the triangle

RRB JE 29-08-2019

Ans. (b) : If three forces acting on a rigid body are represented in magnitude, direction and line of action by the three sides of a triangle taken in order, then these forces are equivalent to a couple whose moment in equal to twice the area of the triangle.

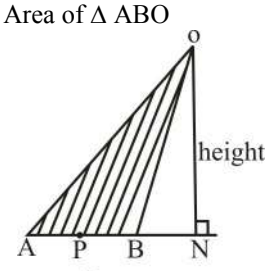
$M = P \times ON$

$\because$ P = AB,

Then, $M = AB \times ON$

$M = Base \times height$

$\therefore \quad M = 2 \times$ Area of Δ ABO



2. The weight of an object on the Moon is W_m and its weight on the Earth is W_e. Which of the following formulas is CORRECT?

(a) $W_m = 6 \times W_e$ (b) $W_m = 3 \times W_e$
(c) $W_m = (1/6) \times W_e$ (d) $W_m = (1/3) \times W_e$

RRB JE 29-08-2019

Ans. (c) : As we know that,

$$\frac{\text{Weight of the object on the moon}}{\text{Weight of the object on the earth}} = \frac{1}{6}$$

Thus the weight of the object on the moon

$= \frac{1}{6} \times$ its weight on the earth

$$\boxed{W_m = \frac{1}{6} \times W_e}$$

3. If the line of action of all the forces are along the same line, then the forces are said to be-

(a) Collinear forces
(b) Coplanar concurrent forces
(c) Non-coplanar non-concurrent forces
(d) Coplanar parallel forces

RRB JE 29-08-2019

Ans. (a) : If the line of action of all the forces are along the same line, then the forces are said to be collinear forces.

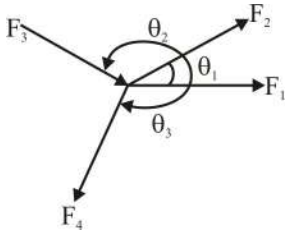
- The forces, which meet at one point, are known as concurrent forces.
- The forces, whose line of action lies on the same plane are known as coplanar forces.

4. The algebraic sum of the resolved parts of a number of forces in a given direction is equal to the resolved part of their resultant in the same direction. This is known as-

(a) Principle of resolution of forces
(b) All of the options
(c) Principle of transmissibility of forces
(d) Principle of independence of forces

RRB JE 29-08-2019

Ans. (a) : According to the principle of resolution of forces the algebraic sum of the resolved parts of a number of forces in a given direction is equal to the resolve part of their resultant in the same direction.



$$R = \sqrt{\Sigma F_x^2 + \Sigma F_y^2}$$

$$\tan\theta = \frac{\Sigma F_y}{\Sigma F_x}$$

$$F_x = F_1\cos 0^0 + F_2\cos\theta_1 - F_3\cos\theta_2 + F_4\cos(360-\theta_3)$$

$$F_y = F_1\sin 0^0 + F_2\sin\theta_1 - F_3\sin\theta_2 + F_4\sin(360-\theta_3)$$

5. If 'α' is the angle between two forces P and Q, then the angle made by the direction of the resultant 'θ' relative to the force P is given by-

(a) $\theta = \tan^{-1}\left(\frac{Q\sin\alpha}{P+Q\cos\alpha}\right)$

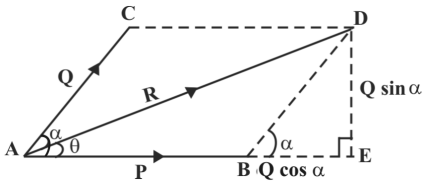
(b) $\theta = \cos^{-1}\left(\frac{P\sin\alpha}{Q+P\cos\alpha}\right)$

(c) $\theta = \sin^{-1}\left(\frac{Q\sin\alpha}{Q+P\cos\alpha}\right)$

(d) $\theta = \sin^{-1}\left(\frac{P\sin\alpha}{P+Q\cos\alpha}\right)$

RRB JE 30-08-2019

Ans. (a) :



ΔAED

$$\tan\theta = \frac{\text{Perpendicular}}{\text{Base}} = \frac{Q\sin\alpha}{P+Q\cos\alpha}$$

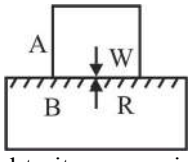
$$\therefore \quad \boxed{\theta = \tan^{-1}\left(\frac{Q\sin\alpha}{P+Q\cos\alpha}\right)}$$

6. Action and reaction act on–

(a) Different bodies but in same direction
(b) Same body but in opposite direction
(c) Same body and in same direction
(d) Different bodies but in opposite direction

RRB JE 31-08-2019

Ans. (d) Action and reaction act on different bodies but in opposite direction.



Body A is subjected to its own weight (W) in the form of action and body B oppose this action in the form of reaction (R).

& $\boxed{R = W}$ (But opposite in direction)

7. What is the value of the acceleration due to gravity (g) of Earth?

(a) 5.4 m s^{-2} (b) 9.8 m s^{-2}
(c) 3.8 m s^{-2} (d) 6.8 m s^{-2}

RRB JE 31-08-2019

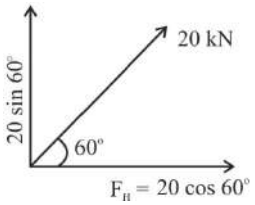
Ans. (b) Acceleration due to gravity is the acceleration gained by an object due to gravitational force. Its SI unit is m/s^2. The standard value of gravity on the surface of the earth at sea level is $9.8 m/s^2$.

8. The horizontal component of tensile force in a wire that makes 60° with horizontal and is carrying a force of 20 kN is-

(a) 30 kN (b) 18 kN
(c) 10 kN (d) 25 kN

RRB JE 31-08-2019

Ans. (c)



Horizontal Component (F_H) = 20 cos 60°

$$= 20\times\frac{1}{2}$$

$$= 10\text{kN}$$

9. Polygon of forces is useful for computing the resultant of

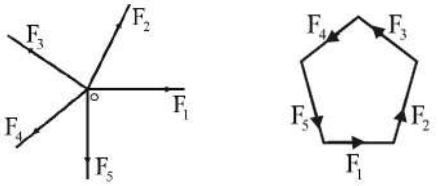
(a) Concurrent spatial forces
(b) Coplanar parallel forces
(c) Coplanar Concurrent forces
(d) Coplanar Collinear forces

(RRB Bhubneshwar JE-II 19.12.2010)

Ans. (c) Polygon of forces is useful for computing the resultant of coplanar concurrent forces.

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

- If all the concurrent force acting on a body shows as the sides of polygon in direction & magnitude then they are in equilibrium.



10. A drum weighting 60 N and holding 40 kgf of water is raised from a well by means of a wheel and axle with an effort of 120 N. Its mechanical advantage (MA) will be.....

(a) 0.83 (b) 4.5
(c) 3.77 (d) 3

DMRC JE 17.04.2018, 4:30-6:45 pm

Ans : (c) Weight of drum (W) = 60 N
Weight of water to be lifted = 40 kgf = 40 × 9.81 N
Effort (P) = 120 N

$$\text{Mechanical advantage (MA)} = \frac{W}{P}$$

$$= \frac{60+40\times 9.81}{120} = 3.77$$

11. The force applied on a body of mass 100 kg to produce an acceleration of 5 m/s^2 is

(a) 500 N (b) 100 N

(c) 20 N (d) 10 N

(RRB Bhopal SSE 09.09.2012)

Ans. (a) : m = 100 kg a = 5 m/s^2

F = ma

= 100 × 5 = 500 N

12. The law of parallelogram of forces gives the resultant of-

(a) Parallel forces

(b) Two coplanar concurrent forces

(c) Like parallel forces

(d) Non Coplanar concurrent forces

DMRC JE 22.09.2017

RRB Bhopal Section Engineer, 24.11.2002

Ans. (b) : When the line of action of acting forces lies in same plane and meeting at a point to each other said to be coplanar concurrent forces.

Parallelogram law of forces - If two forces, acting at a point are represented in magnitude and direction by the two sides of the parallelogram drawn from one of its angular points, their resultant is represented both in magnitude and direction by the diagonal of the parallelogram passing through that angular point.

13. The point of application of the resultant of all the forces which tends to cause rotation in the body about a certain axis is known as.....

(a) center of gravity

(b) the point of meta centre

(c) point of suspension

(d) centre of percussion

(Konkan Railway TA 2017)

Ans. (d) The point of application of the resultant of all the forces which tends to cause rotation in the body about a certain axis is known as centre of percussion.

Sometimes, the centre of oscillation is termed as centre of percussion. it is defined on suspended body so that the reaction at the support is zero.

14. Which equilibrium is used for two forces?

(a) Same line of action

(b) Equal in magnitude

(c) Opposite in direction

(d) All of the above options

DMRC JE 17.04.2018 12:15-2:30 PM

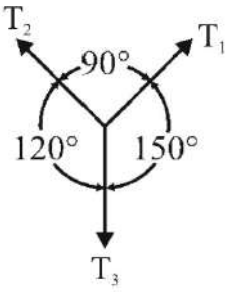
RRB Bhopal & Mumbai Apprentice Section Engg. 23.03.2003

Ans : (d) If only two forces act on a body that is in equilibrium, then they must be equal in magnitude, co-linear and opposite in sense.

$F_1 = F_2$

$\boxed{F_1 - F_2 = 0}$

15. If three coplanar concurrent forces acting at a point 'O' are in equilibrium, then ratio of forces T_1/T_2 & T_1/T_3 respectively are

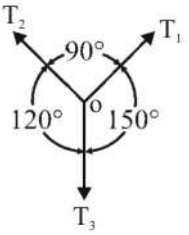


(a) $\sqrt{3}$ and $\frac{\sqrt{3}}{2}$ (b) $\sqrt{\frac{3}{2}}$ and $\sqrt{3}$

(c) 1 and $\frac{1}{2}$ (d) $\frac{1}{2}$ and 1

(RRB Allahabad SSE 19.12.2010)

Ans : (a)



According to Lami's Theorem–

$$\frac{T_1}{\sin 120°} = \frac{T_2}{\sin 150°} = \frac{T_3}{\sin 90°}$$

So,

$$\frac{T_1}{T_2} = \frac{\sin 120°}{\sin 150°} = \frac{\sqrt{3}/2}{1/2} = \sqrt{3}$$

$$\boxed{\frac{T_1}{T_2} = \sqrt{3}}$$

$$\frac{T_1}{T_3} = \frac{\sin 120°}{\sin 90°} = \frac{\sqrt{3}/2}{1} = \frac{\sqrt{3}}{2}$$

$$\boxed{\frac{T_1}{T_3} = \frac{\sqrt{3}}{2}}$$

16. According to Lami's theorem

(a) the three forces must be equal

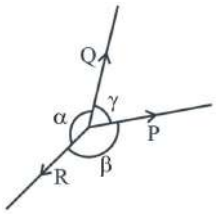
(b) the three forces must be at 120° to each other

(c) the three forces must be in equilibrium

(d) if the three forces acting at a point are in equilibrium, then each force is proportional to the sine of the angle between the other two

(JMRC JE 10.06.2017)

Ans : (d) According to the Lami's theorem, if the three forces acting at a point are in equilibrium then each force is proportional to the sine of the angle between the other two.



$$\frac{P}{\sin\alpha}=\frac{Q}{\sin\beta}=\frac{R}{\sin\gamma}$$

17. Two equal forces are acting at a point with an angle of 60^0 between them the resultant is $50\sqrt{3}$ N, the magnitude of each force will be :

(a) 100 N (b) 150 N
(c) 50 N (d) $50\sqrt{3}$ N

(RRB Mumbai JE 05.10.2008)

Ans. (c) $\because R^2 = P^2 + Q^2 + 2PQ\cos\theta$

If P = Q [given]

Then

$$R^2 = P^2 + P^2 + 2P \times P \cos 60$$

$$R = \sqrt{P^2 + P^2 + 2 \times P^2 \times \frac{1}{2}}$$

$$50\sqrt{3} = \sqrt{3P^2}$$

$$\boxed{P = 50N}$$

$\therefore$ Magnitude of each forces will be 50 N.

18. Two equal forces of magnitude 10 Newton act at an angle of 90°. Their resultant is equal to:

(a) 10 N (b) 10 √2 N
(c) 10 √3 N (d) 20 N

(RRB Mumbai SSE 19.12.2010)

Ans. (b) Given, P = Q = 10 N

$\theta = 90°$

We know that,

$$\text{Resultant (R)} = \sqrt{P^2 + Q^2 + 2PQ\cos\theta}$$

$$= \sqrt{10^2 + 10^2 + 2 \times 10 \times 10 \times \cos 90°}$$

$$= \sqrt{200} = 10\sqrt{2}$$

$$R = 10\sqrt{2}N$$

19. Choose the CORRECT option regarding the effect of forces acting on the body?

(a) Introduces internal stress.
(b) Balance the other forces acting on it.
(c) Retard its motion
(d) All option are correct

(DMRC JE 2013)

Ans. (d) : A force can produce the following effects on the body–

(i) It introduces internal stresses.
(ii) It balances all the forces acting on the body so that body will remain in equilibrium.
(iii) It can move a stationary body
(iv) It can stop a moving body.
(v) It can change the direction, shape and size of a body.

20. The resultant force of five coplanar forces can be found out by

(a) Law of polygon
(b) Laws of equilibrium
(c) Law of parallelogram
(d) Lami's Theorem

DMRC JE 17.04.2018 12:15-2:30 PM

Ans : (a) Resultant of five coplanar force can be obtained by Polygon's law.

- **Law of polygon –** If any number of coplanar concurrent forces can be represented in magnitude & direction by the sides of a polygon taken in order then their resultant will be represented by closing side of the polygon taken in opposite order.

21. Point of application of all force in concurrent system is:

(DMRC 18.02.2017, 8.30 a.m)

(a) one point (b) two point
(c) perpendicular plane (d) plane

Ans : (a) When two or more than two forces act on a body, they are said to form a system of forces.

(1) **Coplaner force –** The force whose lines of action lie on the same plane.
(2) **Concurrent force –** If the forces applied to a body are such that their lines of action meet at a single point

22. What term is used for the combined effect of all the forces on a body?

(a) Load (b) Stress
(c) Strain (d) None of the above

(DMRC JE 20.04.2018)
RRB Bhopal & Mumbai Apprentice Section Engg. 23.03.2003

Ans. (a) The combined effect of all the forces on a body is load.

The overall force to which a structure is subjected in supporting a weight or mass in resisting external applied forces.

e.g. weight of vehicle on bridge, weight lifted by crane, air and water pressure at wall etc.

23. The dimensional formula of the force is————

(a) MLT^2 (b) MLT^{-2}
(c) MLT^{-1} (d) $ML^{-1}T^{-1}$

(Konkan Railway STA 2017)

Ans. (b) : Force = mass × acceleration

Mass (m) = kg

Acceleration (a) = m/s^2

Now, dimensional formula of force

$F = [M] \times [LT^{-2}]$

$= [MLT^{-2}]$

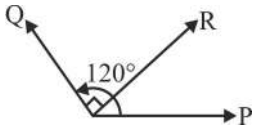
24. Two forces act at an angle of 120^0. If the greater force is 50 N and their resultant is perpendicular to the smaller force, the smaller force is ..... N

(RRB Kolkata Diesel JE 25.10.2009)

(a) 20 (b) 25
(c) 30 (d) 35

Ans : (b)

$\theta = 120°$
$\alpha = 90°$
$P = 50$ N
$Q = ?$



Let, $P > Q$

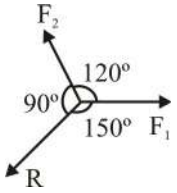
$\because \quad \tan\alpha = \dfrac{P\sin\theta}{Q + P\cos\theta}$

$\Rightarrow \quad \tan 90° = \dfrac{50 \times \sin 120°}{Q + 50 \times \cos 120°}$

$Q + 50 \times \cos 120° = 0$

$\boxed{Q = 25\text{ N}}$

Second method -

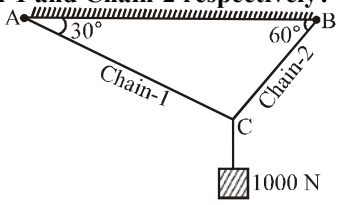


$$\frac{F_1}{\sin 90°} = \frac{F_2}{\sin 150°} = \frac{R}{\sin 120°}$$

$$F_2 = \frac{F_1}{\sin 90°} \times \sin 30°$$

$$F_2 = \frac{50}{2} = 25\text{kg}$$

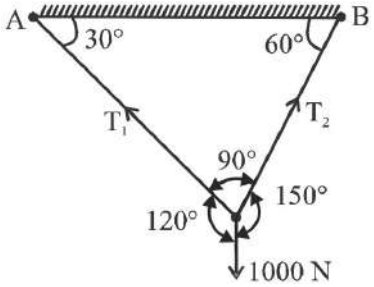
25. A weight of 1000 N is supported by two chains as shown in Figure. What will be the tension in Chain-1 and Chain-2 respectively?



(RRB Jammu JE 25.10.2009)
RRB Bhopal Section Engineer, 24.11.2002

(a) 500 N; 866 N (b) 500 N; 433 N
(c) 1000 N; 866 N (d) 1000 N; 433 N

Ans : (a)



From Lammi's Theorem–

$$\frac{1000}{Sin\,90} = \frac{T_1}{Sin\,150^0} = \frac{T_2}{Sin\,120^0}$$

$\boxed{T_1 = 500\text{ N}}$

$\boxed{T_2 = 866.6\text{ N}}$

26. The algebric sum of all the force acting on a body is zero, then the body may be in equilibrium provide the force are

(RRB Malda SSE 25.10.2009)

(a) Parallel (b) Like parallel
(c) Unlike parallel (d) Concurrent

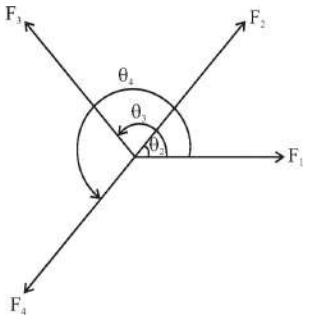
Ans : (d) The algebraic sum of all the force acting on a body is zero, then the body may be in equilibrium provide the force are concurrent.
Such a set of forces, whose resultant is zero, are known as equilibrium forces.
The force, which brings the set of forces in equilibrium is called an equilibrant.
It is equal to the resultant force in magnitude but opposite in direction.

27. If a number of forces are acting at a point, the resultant will be inclined at an angle θ with the horizontal, such that

(RRB Allahabad JE 25.10.2009)

(a) $\tan\theta = \sum H / \sum V$ (b) $\tan\theta = \sum V / \sum H$
(c) $\tan\theta = \sum V \times \sum H$ (d) None of these

Ans : (b)



$F_x = F_1\cos 0° + F_2\cos\theta_2 + F_3\cos\theta_3 + F_4\cos\theta_4 + \ldots.$
$F_y = F_1\sin 0° + F_2\sin\theta_2 + F_3\sin\theta_3 + F_4\sin\theta_4 + \ldots\ldots.$

$$\tan\theta = \frac{F_x}{F_y} = \frac{\Sigma V}{\Sigma H}$$

Resultant force, $(R) = \sqrt{F_x^2 + F_y^2} = \sqrt{(\Sigma V)^2 + (\Sigma H)^2}$

Where, ΣV = Sum of vertical forces
ΣH = Sum of horizontal forces

28. What is the effect of force applied on a rigid body?

(Konkan Railway SSE 2015)

(a) acceleration
(b) retardation
(c) changing direction of motion
(d) all of the above

Ans. (d) Effect of force applied on a rigid body–
1. Change the motion of a body (acceleration or retardation)
2. Retard the motion of a body.
3. Changing direction of motion.
4. Balance the forces already acting on a body.
5. Give rise to the internal stresses in a body.

29. ..... is the force or torque that is necessary just to initiate motion from rest.

(RRB Patna JE 25.10.2009)

(a) Backlash (b) Terminal
(c) Static calibration (d) Stiction

Ans : (d) Stiction force or torque that is necessary just to initiate motion from rest.
Stiction :- It is normally expressed as a percentage or fraction of full scale.

30. If the resultant of two forces P and Q acting at an angle θ makes an angle α with the force P, then :
(RRB Bhopal TM SSE 25.10.2009)
RRB Secunderabad Section Engineer (Mech.) 29.06.2008

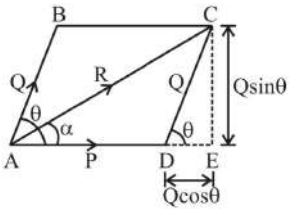
(a) $\tan\alpha = \frac{P\sin\theta}{P+Q\cos\theta}$

(b) $\tan\alpha = \frac{P\cos\theta}{P+Q\cos\theta}$

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

(d) $\tan\alpha = \frac{Q\cos\theta}{P+Q\sin\theta}$

Ans : (c)



According to law of parallelogram.

In ΔAEC, $\tan\alpha = \frac{CE}{AE}$

$$\tan\alpha = \frac{CE}{AD+DE}$$

$$\boxed{\tan\alpha = \frac{Q\sin\theta}{P+Q\cos\theta}}$$

31. How can the resultant of two forces P and Q (such that P > Q) acting along the same straight line, but in opposite direction be given as ?
(RRB Chandigarh SSE 09.09.2012)

(a) P + Q (b) P – Q
(c) P/Q (d) Q/P

Ans : (b)

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

if $\theta = 180^0$ ($\because$ Opposite direction)

$= \sqrt{P^2+Q^2+2PQ\cos180^0}$ $\left(\cos180^o = -1\right)$

$= \sqrt{P^2+Q^2-2PQ}$

$= \sqrt{(P-Q)^2}$

$= P - Q$

32. When can the forces be called as Non-coplaner non-concurrent forces?
(RRB Jammu SSE 09.09.2012)

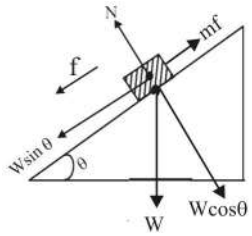
(a) Meet at one point, but their lines of action do not lie on the same plane
(b) Do not meet at one point and their lines of action do not lie on the same plane
(c) Do not meet at one point and their lines of action lie on the same plane
(d) Meet at one point and their line of action lie on the same plane

Ans : (b) A system of forces whose line of action does not meet at a point and lines of action does not lie on the same plane.

33. When a body slides down an inclined surface, the acceleration (f) of the body is given by :
(RRB Allahabad JE 09.09.2012)

(a) f = g (b) f = g sin θ
(c) f = g cos θ (d) f = g tan θ

Ans. (b) Given, acceleration = f



When body slides downward-
Then, $W\sin\theta = mf$
$mg\sin\theta = mf$
So, $f = g\sin\theta$ (No friction is considered)

34. What is the SI unit of force?
(DMRC 18.02.2017, 8.30 a.m)

(a) Dyne (b) Newton
(c) Kilogram (d) Watt

Ans : (b) Force (F) = mass (m) × acceleration (a)

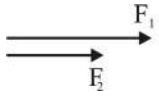
Unit of force $\Rightarrow kg\times\frac{m}{s^2}$

- Unit of force is kg-m/s^2 in M.K.S system and Newton in S.I system and Dyne in C.G.S system.

35. Which of the following concurrent forces cannot have a resultant of 4 N
(BMRCL JE 24 Feb. 2019)

(a) 2N and 4N (b) 2N and 6N
(c) 2N and 8 N (d) All of these

Ans : (c) For maximum resultant–Angle between two forces should be zero.



$R_{max} = F_1+F_2$ $[\theta=0^o]$

For minimum resultant–Angle between two forces should be 180º.

$R_{min} = F_1 - F_2$ $[\theta=180^o]$

Forces	R_{max}	R_{min}
2N and 4N	6	2
2N and 6N	8	4
2N and 8N	10	6

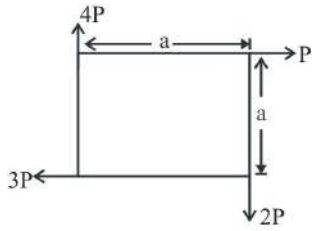
So, concurrent forces cannot have resultant of 4N for 2N and 8N forces.
because for this (R_{max} = 10N & R_{min} = 6N) and 4N is not lies in this range.

36. Four forces P, 2P, 3P & 4P act along the sides of a square, taken in order, The resultant force is
(RRB Bhubneshwar JE II 29.11.2008)

(a) zero (b) $\sqrt{5}P$

(c) $2\sqrt{2}P$ (d) 2P

Ans : (c)



$\Sigma V = 4P - 2P = 2P$

$\Sigma H = 3P - P = 2P$

$R = \sqrt{(\Sigma H)^2 + (\Sigma V)^2} = \sqrt{(2P)^2 + (2P)^2}$

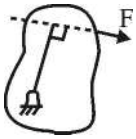
$R = 2\sqrt{2}P$

37. The unit of moment is
(RRB Malda SSE 25.10.2009)

(a) N/m (b) N-m

(c) N/m^2 (d) N-m/sec

Ans : (b) Moment of a force– It depends on the magnitude of the force and the distance from the axis of rotation.



Moment of a force – Magnitude of the force X the perpendicular distance of the line of action of the force from the point.

Unit = N – m

38. Forces are called concurrent when their lines of action meet at.
(RRB Bhubneshwar JE-II 19.12.2010)

(a) One point

(b) Two points

(c) A Plane

(d) Perpendicular planes

Ans. (a) :

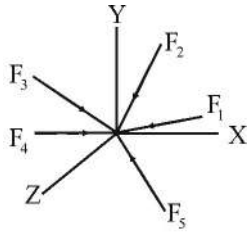
- The forces, which meet at one point, are known as concurrent forces.
- The forces, whose lines of action lie on the same plane are known as coplanar forces.
- The forces, which meet at one point and their lines of action also lie on the same plane are called, coplanar concurrent forces.
- The forces, which do not meet at one point but their lines of action lie on the same plane, are known as coplanar non-concurrent forces.

39. A Rigid body is subjected to non-coplaner concurrent force system of the body is to remain in a state of equilibrium, then
(RRB Mumbai SSE 05.10.2008)

(a) $\Sigma F_x = \Sigma F_y = \Sigma F_z = 0$ (b) $\Sigma M_x = \Sigma M_y = 0$

(c) $\Sigma M_y = \Sigma M_z = 0$ (d) $\Sigma M_y \times \Sigma M_z = 0$

Ans : (a)



Equilibrium conditions, for non-coplanor concurrent forces:-

$\Sigma F_x=0$, $\Sigma F_y=0$ & $\Sigma F_z=0$

- For Non coplaner, non- concurrent forces:-

$\Sigma F_x=0$, $\Sigma F_y=0$, $\Sigma F_z=0$

$\Sigma M_x=0$, $\Sigma M_y=0$, $\Sigma M_z=0$

40. Force acting on a rope in a tug of war, is an example of :
(RRB Mumbai JE 19.12.2010)

(a) Collinear force

(b) Coplanar force

(c) Coplanar concurrent force

(d) Coplanar non-concurrent force

Ans : (a) Force acting in tug of war is an example of collinear forces.

- **Collinear forces-** When the line of action of forces are acting along the same line for a system.

41. Two equal forces are acting at a point with an angle of 60^0 between them. The magnitude of each force, if the resultant force is 36 N, is :
(RRB Mumbai SSE 19.12.2010)

(a) 15.63 N (b) 25.12 N

(c) 20.78 N (d) 17.89 N

Ans : (c) $R = \sqrt{P^2 + Q^2 + 2PQ.\cos\theta}$ $(\theta = 60^0)$

$36 = \sqrt{P^2 + P^2 + 2P^2.\cos 60^0}$ $\{P = Q\}$

$36 = \sqrt{2P^2 + P^2}$

$36 = \sqrt{3P^2}$

$36 = \sqrt{3}P$

$\Rightarrow \quad P\sqrt{3} = 36$

$P = 20.78N$

42. A particle acted upon by two forces is in equilibrium. Then, the angle between the two forces is equal to :
(DMRC JE 2013)

(a) 0^0 (b) 45^0

(c) 90^0 (d) 180^0

Ans. (d) : Resultant force (R) = $\sqrt{P^2 + Q^2 + 2PQ\cos\theta}$

$\because$ forces are in equilibrium

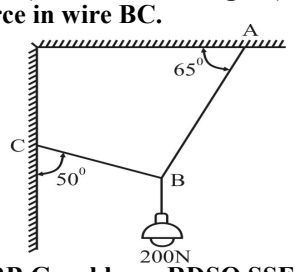
$\therefore$ P = Q and Resultant, R = 0

Hence resultant, $0 = P^2 + P^2 + 2PP\cos\theta$

$\cos\theta = -1$

$\therefore \quad \theta = 180^0$

43. An electric light fixture weighing 200 N is supported (as shown in figure). Determine tensile force in wire BC.



(RRB Gorakhpur RDSO SSE 25.10.2009)
RRB Bhopal Section Engineer, 24.11.2002

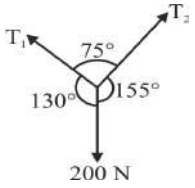
(a) 20N (b) 87.5 N
(c)158.6 N (d) 120 N

Ans : (b)

$$\frac{T_1}{\sin 155°} = \frac{T_2}{\sin 130°} = \frac{200}{\sin 75°}$$

$$\frac{T_1}{\sin 155°} = \frac{200}{\sin 75°}$$

$$T_1 = 200 \times \frac{\sin 155°}{\sin 75°} = 87.5 \text{ N}$$



2. Moment

44. According to the law of moments, if a number of coplanar forces acting on a particle are in equilibrium, then-

(a) Their algebraic sum is zero
(b) The algebraic sum of their moments about any point is equal to the moment of their resultant force about the same point
(c) Their lines of action are at equal distances
(d) The algebraic sum of their moments about any point in their is zero

RRB JE 29-08-2019

Ans. (d) : Law of moments–
It state, "If a body is in rotational equilibrium under the action of a number of forces, the sum of the clockwise moments of the forces about any point is equal to the anti-clockwise moments of the forces about the same point." Mathematically.

Sum of clockwise moments = Sum of anti-clockwise moment.

Varignon's principle of moment–
It states, "If a number of coplanar forces are acting simultaneously on a particle, the algebraic sum of the moment of all the forces about any point is equal to the moment of their resultant force about the same point."

45. The product of area and square of distance of centre of gravity of the area from that axis is known as-

(a) Second moment of area
(b) Mass moment of inertia
(c) Second moment of mass
(d) First moment of area

RRB JE 29-08-2019

Ans. (a) The product of area and square of distance of centre of gravity of the area from that axis is known as second moment of area (I).

$I = Ak^2$

Unit $\rightarrow m^4$

If $I = mk^2$,

Unit $\rightarrow$ kg-m^2

Then I is called second moment of mass
where, A = Area of section
K = Radius of gyration
m = mass of the body

46. An example of rotational motion is-

(a) Spinning of earth
(b) Movement of a car on a straight road
(c) Motion of earth around the sun
(d) Movement of drawer of a table

RRB JE 29-08-2019

Ans. (a) : Motion of a body around a fixed line or its axis, is called rotational motion.
Examples : - Spinning of earth, motion of wheel or fan around its own axis etc.

47. According to the principle of moments are-

(a) If a system of coplanar forces are in equilibrium, then their algebraic sum is zero
(b) Positive and negative couples can be balanced
(c) If a system of coplanar forces are in equilibrium, then the algebraic sum of their moments about any point in their plane is zero
(d) The algebraic sum of the moments of any two forces about any point are equal to the moment of the resultant about the same point

RRB JE 30-08-2019

Ans. (c) : According to the principle of moments–
If a system of coplanar forces are in equilibrium, then the algebraic sum of their moments about any point in their plane is zero.
Varignon's principle of moments –
The algebraic sum of the moments of any two forces about any point are equal to the moment of the resultant about the same point.

48. The total momentum of a system of masses (i.e. moving bodies) in any one direction remains constant, unless acted upon by an external force in that direct. This statement is called-

(a) Principle of conservation of energy
(b) Newton's first law of motion
(c) Principle of conservation of momentum
(d) Law of transmissibility of forces

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Ans. (c) : Principal of conservation of momentum- It states that the total momentum of moving masses in a system in any one direction remains constant unless acted upon by an external force in that direction.
Momentum before impact = Momentum after impact

$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$

49. In a screw jack, the effort required to lift the load is given by:
(Where, W = Load lifted, α = Helix angle, and φ = Angle of friction)

(a) $P = W\tan(\varphi - \alpha)$ (b) $P = W\tan(\alpha - \varphi)$
(c) $P = W\tan(\alpha + \varphi)$ (d) $P = W\cos(\alpha + \varphi)$

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Ans. (c) : For screw jack –

The effort required to lift the load, $(P) = W\tan(\alpha + \varphi)$

Efficiency of screw jack $(\eta) = \dfrac{\tan\alpha}{\tan(\alpha+\varphi)}$

Maximum efficiency of screw jack $(\eta) = \dfrac{1-\sin\varphi}{1+\sin\varphi}$

Maximum efficiency of screw jack is obtained when,

$$\boxed{\alpha = 45^\circ - \frac{\varphi}{2}}$$

50. The centre of gravity of a quadrant of a circle lies along its central radius at a distance of

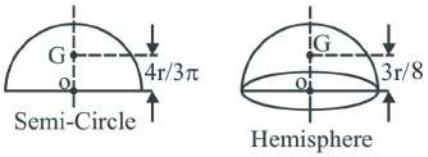
(a) 0.3 R (b) 0.424 R

(c) 0.5 R (d) 0.6 R

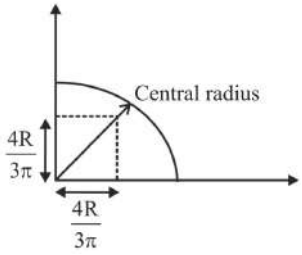
(Konkan Railway STA 2017)

RRB Bangalore Section Engineer (Mech.) 01.02.2009

Ans : (d)



Quadrant circle–



$$R = \sqrt{\left(\frac{4R}{3\pi}\right)^2 + \left(\frac{4R}{3\pi}\right)^2}$$

$$= \sqrt{2\times\left(\frac{4R}{3\pi}\right)^2}$$

$$= \frac{4R}{3\pi}\times\sqrt{2}$$

$$= 0.60021$$

51. The centre of gravity of a triangle is located at the point of .....

(a) intersection of its altitudes

(b) intersection of bisector of angles

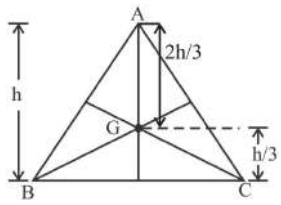
(c) intersection of diagonals

(d) concurrence of the medians

(Konkan Railway TA 2017)

RRB Secunderabad Section Engineer (Mech.) 29.06.2008

Ans. (d) Center of gravity of triangle is a point where all the three medians of triangle interest. C.G. is located h/3 distance from bottom & $\dfrac{2h}{3}$ distance from top.



52. CG of a plane lamina is not at its geometrical centre, if it is a:

(a) Circle

(b) Square

(c) Rectangle

(d) Right angled triangle

(RRB Kolkata Diesel JE 25.10.2009)

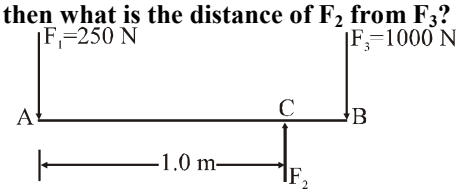
RRB Bhopal & Mumbai Apprentice Section Engg. 23.03.2003

Ans : (d) Centre of gravity is the point through which whole weight of the body acts, irrespective of its position.

- Except right angled triangle CG of circle, square and rectangle is lies at its geometrical centre.

So, for right angle triangle C.G. & geometrical centre not at same point.

53. Three parallel forces F_1, F_2 and F_3 are acting on a log as shown in Figure and the body is in equilibrium. If force F_1 = 250 N and F_3 = 1000 N; and the distance between F_1 and F_2 is 1.0m, then what is the distance of F_2 from F_3?

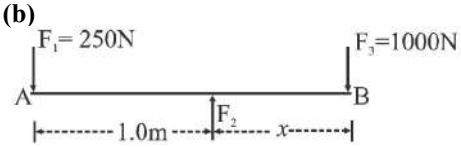


(RRB Chandigarh SSE 25.10.2009)

(a) 0.50 m (b) 0.25 m

(c) 0.75 m (d) 0.15 m

Ans : (b)



$250 + 1000 = F_2$

$\boxed{F_2 = 1250N}$

Taking moment about point 'A' $\Rightarrow$

$1000\,[1 + x] - F_2 \times 1 = 0$

$1000\,(1 + x) = 1250$

$$1 + x = \frac{1250}{1000}$$

$$\boxed{x = 0.25\,m}$$

54. A 16 N force produce a moment of 64 Nm. The moment arm is

(RRB Mumbai C&G JE 25.10.2009)

(a) 2 m (b) $\sqrt{2}$ m

(c) 8 m (d) 4 m

Ans : (d) Force (F) = 16 N

Torque (T) = 64 N-m

Torque = Force × Moment arm

$64 = 16 \times$ Moment arm

Moment arm = $\frac{64}{16} = 4\,m$

55. According to the law of moments, if a number of coplanar forces acting on a particle are in equilibrium then

(a) their algebraic sum is zero
(b) their lines of action are at equal distances
(c) the algebraic sum of their moments about any point in their plane is zero
(d) the algebraic sum of their moments about any point is equal to the moments of their resultant force about the same point

(DMRC JE 20.04.2018)

Ans. (c) : According to the law of moments, if a number of coplanar forces acting on a particle are in equilibrium. Then, the algebraic sum of their moments about any point in their plane is zero.

56. Varignon's theorem of moments states that if a number of coplaner forces acting on a particle are in equilibrium, then

(RRB Gorakhpur RDSO SSE 25.10.2009)

(a) Their algebraic sum is zero
(b) Their lines of action are at equal distance
(c) The algebraic sum of their moments about any point is their plane is zero
(d) The algebraic sum of their moments about any point is equal to the moments of their resultant forces about the same point

Ans : (d) Varignon's Principle of Moments (or Law of Moments)–It states that if a number of coplanar forces acting on a particle are in equilibrium then the algebraic sum of their moments about any point is equal to the moment of their resultant force about the same point.

57. Varignon's theorem is related to :

(RRB Jammu JE 25.10.2009)

(a) Principle of moments
(b) Principle of momentum
(c) Principle of force
(d) Principle of inertia

Ans : (a) Varignon's Principle of Moments (or Law of Moments)–It states that if a number of coplanar forces acting on a particle are in equilibrium then the algebraic sum of their moments about any point is equal to the moment of their resultant force about the same point.

3. Couple

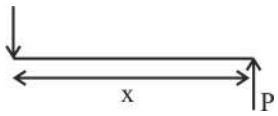
58. A couple produces ..... type of motion.

(a) Combination of translatory and rotational
(b) Translatory
(c) Rotational
(d) Reciprocating

RRB JE 30-08-2019

Ans. (c) : The two equal and opposite forces whose lines of action are parallel to each other, form a couple.

Moment of a couple = $P \times x$



- A couple produces rotational type of motion.

59. The rate of change of displacement of a body is called-

(a) Acceleration (b) Velocity
(c) Momentum (d) Impulse

RRB JE 30-08-2019

Ans. (b) : The rate of change of displacement of a body is called velocity.

$$v = \frac{ds}{dt}$$

and $$a = \frac{dv}{dt} = \frac{d^2s}{dt^2}$$

60. The distance between the forces acting in the couple is–

(a) Always a fixed distance
(b) A finite variable distance
(c) Zero
(d) Infinity

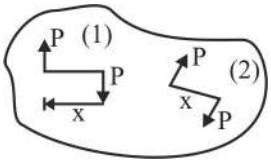
RRB JE 31-08-2019

Ans. (b) The two equal and opposite forces, whose lines of action are different, form a couple.

Couple = Px

- The distance between the forces acting in the couple is a finite variable distance.

i.e. (1) = (2)



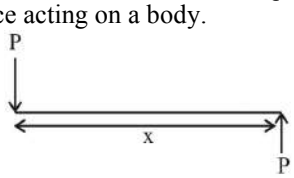
61. A couple consists of :

(a) Two like parallel forces of different magnitudes
(b) Two unlike parallel forces of different magnitudes
(c) Two like parallel forces of same magnitude
(d) Two unlike parallel forces of same magnitude

DMRC JE 17.04.2018 12:15-2:30 PM

Ans : (d) Two parallel force equal in magnitude and opposite in direction and separated by a definite distance are said to form a couple.

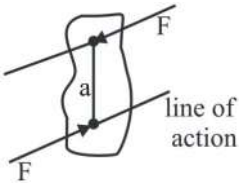
- A couple is formed when two equal and unlike parallel force acting on a body.



Example of couple–
1. Trying to turn a key in lock
2. Force exerted by hands on steering wheel
3. Force exerted by the tip of a screwdriver on the head of a screw.

62. Two equal and opposite parallel forces whose line of actions are different will form a ____
(a) arm of a couple (b) torque
(c) moment (d) couple
(RRB Allahabad JE 25.10.2009)

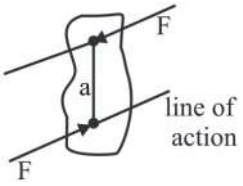
Ans. (d) : When two equal, opposite and parallel forces with different lines of action act on a body. They constitute a pair.
- When two equal forces whose lines of action are different and opposite, act on a body at a distance (a), the product of any force (F) and distance (a) between these forces is called couple.



$C = F \times a$

63. When two equal, opposite and parallel forces with different lines of action act on a body, they constitute a.....
(RRB Mumbai C&G SSE 25.10.2009)
(a) Moment (b) Couple
(c) Inertia (d) None of the above

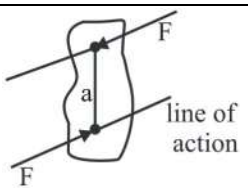
Ans. (b) : When two equal, opposite and parallel forces with different lines of action act on a body. They constitute a pair.
- When two equal forces whose lines of action are different and opposite, act on a body at a distance (a), the product of any force (F) and distance (a) between these forces is called couple.



$C = F \times a$

64. When trying to turn a key in lock, which of the following is applied?
(DMRC 18.02.2017, 8.30 a.m)
(RRB Patna JE 25.10.2009)
(a) Lever (b) Couple
(c) Moment (d) Coplanar force

Ans : (b) When two equal, opposite and parallel forces with different lines of action act on a body. They constitute a pair.
- When two equal forces whose lines of action are different and opposite, act on a body at a distance (a), the product of any force (F) and distance (a) between these forces is called couple.

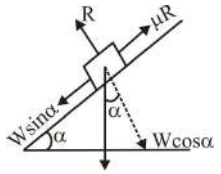


$C = F \times a$

4. General Conditions of Equilibrium

65. A block weighing W = 20 kN is resting on an inclined plane which makes and angle of 30º to the horizontal. The component of gravity force parallel to inclined plane is-
(a) 17.32 kN (b) 10 kN
(c) 5 kN (d) 14.14 kN
RRB JE 29-08-2019

Ans. (b) : Given , W = 20 kN
$\alpha = 30^\circ$

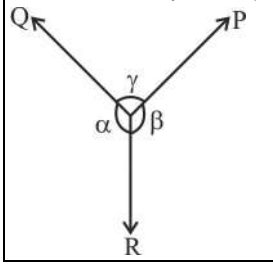


The component of gravity force parallel to inclined plane (F) = W sinα
$= 20 \times \sin 30^\circ = 10\text{kN}$

66. Which of the following states that, "If a body is in equilibrium, under the action of three concurrent forces, each force is proportional to the sine of the angle between the other two forces"?
(a) Varignon's theorem
(b) Lami's theorem
(c) Parallelogram law of forces
(d) Transmissiblity of forces
RRB JE 31-08-2019

Ans. (b) According to Lami's theorem – "If a body is in equilibrium, under the action of three concurrent forces, each force is proportanal to the sine of the angle between the other two forces.

i.e. $\frac{P}{\sin\alpha} = \frac{Q}{\sin\beta} = \frac{R}{\sin\gamma}$



67. The centre of percussion of a homogeneous uniform rod of length ℓ, pivoted at one end, from the pivot is

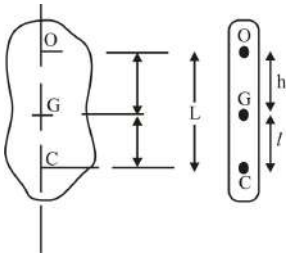
(a) $\frac{\sqrt{3}}{2}\ell$ (b) $\frac{2}{3}\ell$

(c) $\frac{1}{\sqrt{3}}\ell$ (d) $\sqrt{2}\ell$

(RRB Bhopal TM SSE 25.10.2009)

Ans. (b) : The center of percussion is the point on an extended massive object attached to a pivot where a perpendicular impact will produce no reactive shock at the pivot. Translational and rotational motions cancel at the pivot when an impulsive blow is struck at the center of percussion.

For homogeneous uniform rod the center of percussion from any end of pivot is $\rightarrow \frac{2}{3}\ell$



The centre of percussion (c) is below the centre of gravity (G), and at a distance of

$$\boxed{\ell = \frac{(K_G)^2}{h}} \quad .....(i)$$

$$I_G = \frac{mL^2}{12} = mk_G^2$$

$$\boxed{K_G^2 = \frac{L^2}{12}}$$

$$\ell = \frac{\left(L^2/12\right)}{L/2} \quad \left[h = \frac{L}{2}\right]$$

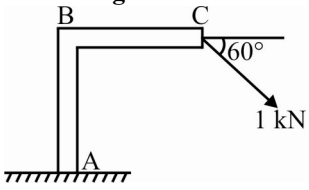
$$\boxed{\ell = \frac{L}{6}}$$

$OC = h + \ell$

$$OC = \frac{L}{2} + \frac{L}{6}$$

$$\boxed{OC = \frac{4L}{6} = \frac{2L}{3}}$$

68. Calculate the value of thrust (in kN) at the point A for the figure shown below.

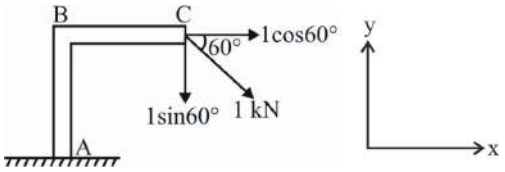


(a) 0.866 (b) 0.5

(c) 2 (d) 3

(RRB Allahabad SSE 09.09.2012)

Ans. (a) :



Component of 1 kN on C along y–direction

$= 1 \sin 60^o$

$= \frac{\sqrt{3}}{2}\text{kN}$

$= 0.866\,\text{kN}$

Hence transferring this vertical component force 0.866 kN on point B, one couple and thrust force on B will be induced.

69. What is the CORRECT option for a rigid body to be in the equilibrium when the body is under the action of three forces?

(a) The forces acting on the body are equal.

(b) The line of action of these forces are parallel to each other

(c) The line of action of these forces meet in a point

(d) The line of action of these forces are parallel to each other and the line of action of these forces meet in a point both

(RRB Banglore SSE 09.09.2012)

Ans : (*) A rigid body to be in the equilibrium when the body is under the action of three

Forces -

(i) The lines of action are coplanar.
(in the same plane)

(ii) The lines of action are meeting at a point.

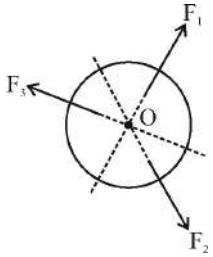
(iii) The vector sum of these forces is equal to the zero.

Three force system - [Non-Parallel forces]

To keep 3-forces in equilibrium they must be coplanar and co-current.

(i) $\vec{P} + \vec{Q} + \vec{R} = 0$ Coplanar

(ii) $\sum M = 0 \rightarrow$ Concurrent



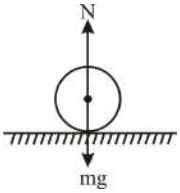
70. When the position of the body is either in rest or in uniform velocity, then the body is said to be in the.....

(a) rest (b) uniform motion

(c) rotational motion (d) equilibrium

(RRB Kolkala SSE 09.09.2012)

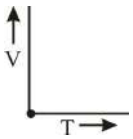
Ans. (d) : Body is rest



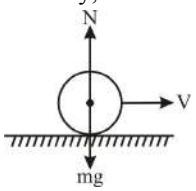
$N = mg$

$F_g = N - mg = 0, F_x = 0$

$\boxed{F_x = 0, F_b = 0}$



Body is in uniform velocity,



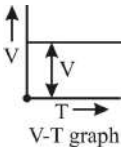
Uniform velocity,

So, $a = 0$

$F_x = ma = 0$

$F_y = N - mg = 0$

$\boxed{F_x = 0, F_y = 0}$



V-T graph

When the position of the body is in rest or in uniform velocity, then the body is said to be in equilibrium.

71. A system is said to be in equilibrium when the resultant of all forces acting on it is.....

(a) negative (b) infinity
(c) zero (d) one

DMRC JE 17.04.2018, 4:30-6:45pm

Ans : (c) A body is in equilibrium when the vector sum of external forces and moments is zero

$$\sum F_x = 0, \sum M = 0$$
$$\sum F_y = 0$$
$$\sum F_z = 0$$

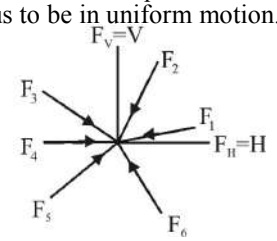
72. In case of concurrent and coplanar forces, the condition of equilibrium is

(RRB Gorakhpur Design SSE 09.09.2012)

(a) $\sum H = 0; \sum V = 0; \sum M = 0$
(b) $\sum H = 0; \sum V = 0$
(c) $\sum H = 0; \sum V \neq 0$
(d) $\sum H = 0; \sum M = 0$

Ans. (b) In case of concurrent coplanar, the condition of equilibrium, $\Sigma H = 0$ & $\Sigma V = 0$

- A body is said to be in equilibrium when it is in rest or continuous to be in uniform motion.

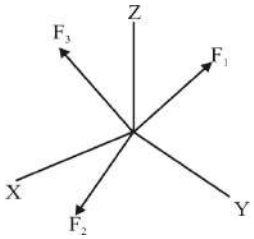


73. The forces which meet at one point and have their lines of action in different planes are called .....

(RRB Chandigarh SSE 09.09.2012)

(a) coplanar non–concurrent forces
(b) non–coplanar concurrent forces
(c) non–coplanar non–concurrent forces
(d) intersecting forces

Ans. (b) The force which meet at one point and have their line of action in different planes are called non coplanar concurrent forces.



Non coplanar concurrent force

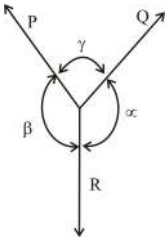
74. Which theorem is used for the equilibrium of the body applied with three concurrent coplanar forces?

(RRB Jammu SSE 09.09.2012)
RRB Chandigarh Section Engineer, 15.03.2009

(a) Pythagoras theorem
(b) Hamilton theorem
(c) Lami's theorem
(d) Varignon's theorem

Ans. : (c) Lami's theorem–An equation relating magnitudes of three coplanar concurrent forces to keep body in static equilibrium.

$$\frac{P}{\sin\alpha} = \frac{Q}{\sin\beta} = \frac{R}{\sin\gamma}$$



- It states that if three coplanar forces acting at a point be in equilibrium, then each force is proportional to the sine of the angle between the other two forces.

Pythagoras theorem–It is used to measure angle and side of triangle.

Varignon's principle−Moment of a force about any point is equal to the sum of the moments of the components of that force about the same point.

75. A body is acted upon by a force system. In general, how can it be brought to equilibrium?

(RRB Allahabad JE 09.09.2012)

(a) By the application of a force acting on a suitable point on the body

(b) By the application of a force acting anywhere along a suitable line

(c) By the application of a force acting along a suitable line and a moment along the direction of the force

(d) By the application of a wrench acting anywhere on the body

Ans. (c) : A body is acted by force system. In general, it be brought to equilibrium by the application of a force acting along a suitable line and a moment along the direction of the force.

When a body has a net force and a net moment (torque) acting to a combination of forces, all the forces acting on the body may be replaced by a single (imaginary) force called the resultant. The body can be brought into equilibrium by applying to its real force at the same point, equal and opposite to the resultant.

For equilibrium body -

$\sum F = 0$

$\sum M = 0$

76. What are the equlibrium conditions to be satisfied for a particle applied with a system of non-coplanar, concurrent forces?

(RRB Bhubneshwar JE II 29.11.2008)

(a) $\Sigma F_x=0$ & $\Sigma F_y=0$

(b) $\Sigma F_x=0$, $\Sigma F_y=0$ $\Sigma F_z=0$, $\Sigma M_x=0$ $\Sigma M_y=0$ & $\Sigma M_z=0$

(c) $\Sigma F_x=0$, $\Sigma F_y=0$ & $\Sigma M_{z\text{-axis}}=0$

(d) $\Sigma F_x=0$, $\Sigma F_y=0$ & $\Sigma F_z=0$

Ans. : (d) Equilibrium conditions, for non-coplanor concurrent forces:-

$\Sigma F_x=0$, $\Sigma F_y=0$ & $\Sigma F_z=0$

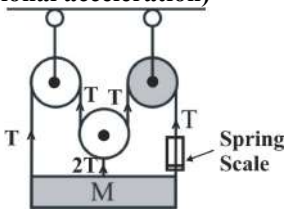
- For Non coplaner , non- concurrent forces:-

$\Sigma F_x=0$, $\Sigma F_y=0$, $\Sigma F_z= 0$

$\Sigma M_x=0$, $\Sigma M_y=0$, $\Sigma M_z=0$

77. Consider the given figure depicting a spring scale that indicates a tension "T" in the right hand cable of a pulley system. Calculate the mass "M" :

(Neglect mass of pulley and ignore friction between cable and pulley however g depicts gravitational acceleration)



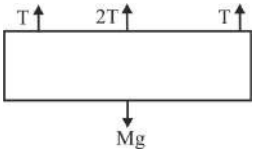
(JMRC JE 10.06.2017)

(a) 2T/g (b) 4T/g

(c) T/g (d) $T(1 + e^{4\pi})g$

Ans : (b)

$\sum F_v = 0$



$T + T + 2T - Mg = 0$

$Mg = 4T$

$$\boxed{M = \frac{4T}{g}}$$

78. The conditions of equilibrium for coplanner non-concurrent forces are

(a) $\Sigma H = 0, \Sigma V = 0$

(b) $\Sigma H = 0, \Sigma M = 0$

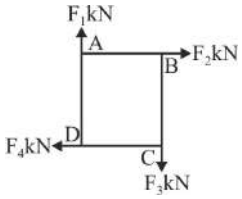
(c) $\Sigma V = 0, \Sigma M = 0$

(d) $\Sigma V = 0, \Sigma H = 0, \Sigma M = 0$

(RRB Bhopal SSE 09.09.2012)

Ans. (d) : Condition for equilibrium of coplanar and non concurrent forces

$\Sigma V = 0, \Sigma H = 0, \Sigma M = 0$



79. Concurrent forces are those forces whose lines of action :

(BMRCL JE 24 Feb. 2019)

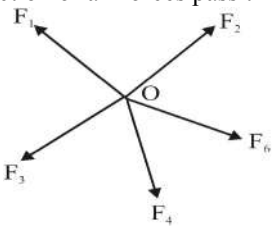
(a) line on the same line

(b) meet at one point

(c) meet on the same plane

(d) none of these

Ans : (b) Concurrent force system is the system when lines of action of all forces pass through a point.



Concurrent force system

- The forces whose lines of action are parallel to each other are called parallel forces.

5. Friction

80. Coulomb friction is the friction between-

(a) Solids and liquids

(b) Two lubricated surfaces

(c) Bodies having relative motion

(d) Two dry surfaces

RRB JE 29-08-2019

Ans. (d) : Coulomb law of friction–
According to this law Coulomb friction is the friction between two dry contacting surfaces.

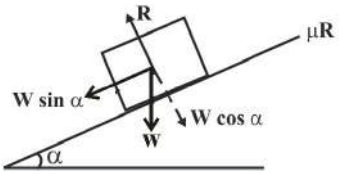
- The coulomb law states when sliding takes place the tangential friction force is proportional to the magnitude of the normal contact force.
- It is not dependent on relative tangential velocity.

81. The minimum angle made by an inclined plane with the horizontal such that an object placed on the inclined surface just begins to slide is called-

(a) Angle of elevation (b) Angle of friction
(c) Angle of Repose (d) Angle of latitude

RRB JE 29-08-2019

Ans. (c) : The minimum angle made by an inclined plane with the horizontal such that an object placed on the inclined surface just begins to slide is called angle of repose.



$W\cos\alpha = R$ --------(i)

$W\sin\alpha = \mu R$

$W\sin\alpha = \mu W\cos\alpha$

$\tan\alpha = \mu = \tan\alpha$

For minimum angle at which objects begins to slide is known as Repose angle.

82. Which of the following is INCORRECT in the laws of dry friction?

(a) The frictional force always acts in a direction opposite to that in which the body tends to move
(b) The force of friction is dependent of the area of contact between the two surfaces
(c) The magnitude of the limiting friction bears a constant ratio to the normal reaction between the two contacting surfaces
(d) The force of friction depends upon the roughness/smoothness of the surfaces

RRB JE 29-08-2019

Ans. (b) : According to law of dry Friction :-

(i) The frictional force always acts in a direction opposite to that in which the body tends to move.
(ii) The force of friction is independent of the area of contact between the two surfaces.
(iii) The magnitude of the limiting friction bears a constant ratio to the normal reaction between the two contacting surfaces.

i.e, $\boxed{\mu = \frac{f}{R}}$

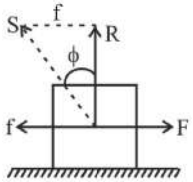
(iv) The force of friction depends upon the roughness smoothness of the surfaces.

83. The angle between the resultant reaction and normal to the plane on which the motion of body is impending is known as–

(a) Angle of limiting friction
(b) Angle of repose
(c) Angle of friction
(d) Angle of zenith

RRB JE 31-08-2019

Ans. (a) The angle betwen the resultant reaction and normal to the plane on which the motion of body is impending is known as angle of limiting friction.



ϕ = Angle between R and S

$\boxed{S = \sqrt{f^2 + R^2}}$

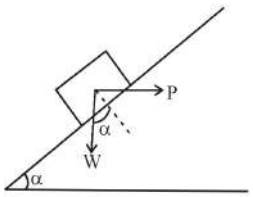
where, S = Resultant force of friction and normal reaction
R = Normal reaction
F = Friction force

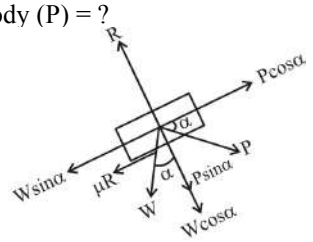
84. If 'W' is weight of a body, 'α' is angle of an inclined plane and 'ϕ' is angle of friction, then the force required to drag the body when it is just impending to move up the plane, is–

(a) $W\sin(\alpha + \phi)$ (b) $W\tan(\alpha + \phi)$
(c) $W\sec(\alpha + \phi)$ (d) $W\cos(\alpha + \phi)$

RRB JE 31-08-2019

Ans. (b)
Given, W = weight of body
α = Inclination angle of plane
ϕ = friction angle
For required to drag the body (P) = ?





From figure,
$\Sigma V = 0$
$P\cos\alpha = f + W\sin\alpha$
$= \mu R + W\sin\alpha$

$$R = \frac{P\cos\alpha + W\sin\alpha}{\frac{\sin\phi}{\cos\phi}} \quad \text{....(i)}$$

$\Sigma H = 0$
$R = W\cos\alpha + P\sin\alpha$ .....(ii)
From eqn. (i)

$$\frac{\cos\phi(P\cos\alpha + W\sin\alpha)}{\sin\phi} = W\cos\alpha + P\sin\alpha$$

$P\cos\alpha\cos\phi - W\cos\phi\sin\alpha = W\cos\alpha.\sin\phi + P\sin\alpha.\sin\phi$
$P(\cos\alpha.\cos\phi - \sin\alpha.\sin\phi) = W(\cos\phi\sin\alpha + \sin\phi.\cos\alpha)$
$P\cos(\phi+\alpha) = W\sin(\phi+\alpha)$

$\therefore \boxed{P = W\tan(\phi + \alpha)}$

85. If 'α' is the helix angle and 'ϕ' is the angle of friction then, when will the efficiency of a screw jack be maximum?

(a) $\alpha = 90^o + \phi$ (b) $\alpha = 45^o + (\phi/2)$

(c) $\alpha = 45 - (\phi/2)$ (d) $\alpha = 90^o - \phi$

RRB JE 31-08-2019

Ans. (c)

Given, α = Helix angle,

ϕ = Friction angle,

We know that,

Efficiency of screw Jack, $(\eta) = \dfrac{\tan\alpha}{\tan(\phi+\alpha)}$

For maximum efficiency,

$$\alpha = 45^o - \frac{\phi}{2}$$

& $\boxed{\eta_{max} = \dfrac{1-\sin\phi}{1+\sin\phi}}$

86. Limiting force of friction is the–

(a) Tangent of angle between normal reaction and resultant of normal reaction and limiting friction

(b) Ratio of limiting friction and normal reaction

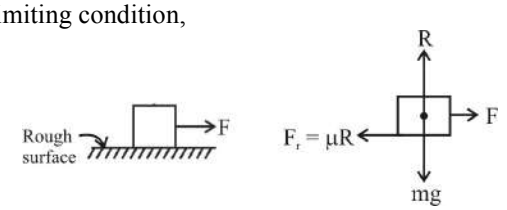
(c) Friction force acting when the body is just about to move

(d) Friction force acting when the body is in motion

RRB JE 31-08-2019

Ans. (c) The maximum value of friction force, which comes into play, when a body just begins to move relative to other body, it is known as limiting friction force.

In limiting condition,



Value of limiting frtiction force (F_r) = μR

when body is just begin to move,

Limiting friction force = Net external force

$\boxed{\mu R = F}$

87. A body is pulled up on an inclined plane of inclination 20° to the horizontal. The angle of friction between the body and the plane is 17°. The force required to pull the body up the plane is minimum when it is applied:

(a) At angle of 20° to the plane

(b) At angle of 17° to the plane

(c) In the horizontal direction

(d) Along the plane

(RRB Allahabad SSE 19.12.2010)

Ans. (b) According to the question,

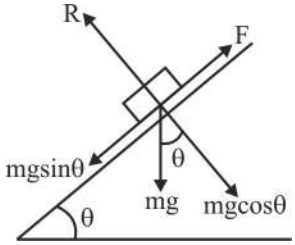
$\theta = 20^o$.

Friction angle, $\phi = 17^o$

$\because \phi < \theta \Rightarrow$ So, body will be slide down on the plane without any use an external force.

But to pull up on the plane more force is required.

So, the force required to pull the body up the plane is minimum when it is applied to an angle of 17º to the plane.



88. The maximum inclination of a plane at which a body can remain in equilibrium over the plane, entirely by the assistance of friction is called :

(a) Coefficient of Friction

(b) Angle of repose

(c) Angle of resultant

(d) Angle of friction

DMRC JE 17.04.2018 12:15-2:30 PM

Ans : (b) The friction between objects that are stationary is called static friction.

- The friction experienced by a body, when at rest, is known as static friction.
- The friction experienced by a body, when body in motion, is known as dynamic (kinetic) friction.

$\boxed{f_{st} > f_{dy}}$

89. The co-efficient of friction is the

(a) angle between normal reaction and the resultant of normal reaction and the limiting force

(b) ratio of limiting friction and normal reaction

(c) the friction force acting when the body is just about to move

(d) the friction force acting when the body is in friction

(RRB Bhubneshwar JE-II 19.12.2010)

Ans : (b) co-efficient of friction $(\mu) = \dfrac{f}{R}$

90. In a rough plane moving object in forward direction if friction angle is 30^0 then coefficient of friction?

(a) 0.422 (b) 0.211

(c) 0.877 (d) 0.577

DMRC JE 17.04.2018, 4:30-6:45pm

Ans : (d) Friction force $(F) = \mu R$

$\Rightarrow \mu = \dfrac{F}{R} = \tan\phi$

$\mu = \tan 30^o \Rightarrow \boxed{\mu = 0.577}$

91. The friction of a body is high when the coefficient of friction is.....

(a) low (b) average

(c) high (d) zero

DMRC JE 17.04.2018, 4:30-6:45pm

Ans : (c) Formula, $\boxed{F = \mu R}$

F = frictional force]
R= Normal reaction
μ = Coefficient offriction

$\boxed{F \propto \mu}$

$\mu\uparrow \quad F\uparrow$

So, if friction of a body is high, the coefficient of friction will also be high.

92. The cause of friction between two surface is.....

(a) load
(b) the material & roughness
(c) the material
(d) roughness

DMRC JE 17.04.2018, 4:30-6:45pm
RRB Chennai Section Engineer, 12.02.2012

Ans : (b) Friction is the force resisting the relative motion of solid surfaces, fluid layers, material elements sliding each other.

$\boxed{F = \mu R}$

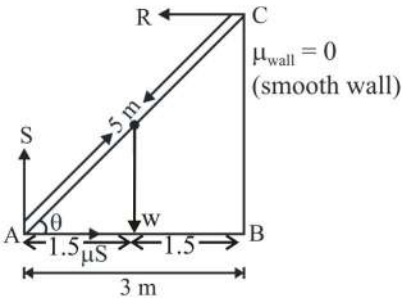
- Cause of friction between two surfaces is the material & roughness.

93. A 5 m long ladder is resting on a smooth vertical wall with its lower end 3 m from the wall. What should be the coefficient of friction between the ladder and the floor for equilibrium?

(a) $\frac{1}{2}$ (b) $\frac{3}{8}$
(c) $\frac{1}{3}$ (d) $\frac{3}{5}$

(RRB Gorakhpur Design SSE 09.09.2012)

Ans. (b) :



in ΔABC

$$BC^2 = AC^2 - AB^2 = 25 - 9 = 16$$

$\therefore \quad \boxed{BC = 4m}$

Let, the coefficient of friction between the ladder and the floor is μ.

Upper point reaction of ladder and wall is (R).

$\because$ Wall is smooth

$\therefore$ Coefficient of friction (μ_{wall}) = 0

In equilibrium state–

$$\sum V = 0$$

$$S = W \qquad \text{.....(i)}$$

Moment about point (C)

$$R \times 0 + S \times 3 = W \times \frac{3}{2} + \mu S \times 4$$

$$3S = \frac{3W}{2} + 4\mu S$$

$$\frac{3}{2}S = 4\mu S \qquad \text{[from equation (i)]}$$

$$\mu = \frac{3}{2} \times \frac{1}{4}$$

$\therefore \quad \boxed{\mu = \frac{3}{8}}$

94. An elephant is stopped by a rope wound twice around the rough trunk of a tree. If the elephant exerts a pull of 1000 kgf, the minimum force required to stop the elephant is (Coefficient of friction between the rope and the tree is 0.3)

(a) 1000 kgf (b) 300 kgf
(c) 700 kgf (d) 23 kgf

(RRB Bhubneshwar JE II 29.11.2008)

Ans. (d) : For two round (θ) = 720° = 4π (rad)

Formula,

$$\boxed{\frac{T_1}{T_2} = e^{\mu\theta}}$$

Given,

T_1 = 100 kg-f
μ = 0.3

$$\frac{T_1}{T_2} = e^{\mu\theta}$$

$$\frac{1000}{T_2} = e^{0.3 \times 4\pi}$$

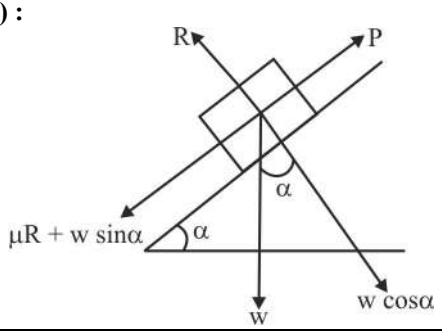
$\boxed{T_2 = 23.054 \text{ kg} - \text{f}}$

95. If ϕ is the limiting angle of friction for the contact surfaces and α is the angle of inclination of the plane to the horizontal, then the efficiency of the inclined plane for the motion of the body up the plane due to the effort, which is applied parallel to the plane, is given by _____

(a) $\frac{\sin\alpha\cos\phi}{\sin(\alpha+\phi)}$ (b) $\frac{\sin\alpha\cos\phi}{\sin(\alpha-\phi)}$
(c) $\frac{\sin(\alpha+\phi)}{\sin\alpha\cos\phi}$ (d) $\frac{\sin(\alpha-\phi)}{\sin\alpha\cos\phi}$

(Konkan Railway STA 2017)

Ans. (a) :



$\sum V = 0$

$R = w\cos\alpha$.....(1)

$\sum H = 0 -$

$P = \mu R + w\sin\alpha$

From equation (1)−

$P = \mu \times w\cos\alpha + w\sin\alpha$

$$P = \frac{\sin\phi \times w\cos\alpha + \cos\phi \times w\sin\alpha}{\cos\phi}$$

$$\frac{P}{w} = \frac{\sin\phi \times \cos\alpha + \cos\phi \times \sin\alpha}{\cos\phi}$$

$$\frac{P}{w\sin\alpha} = \frac{\sin(\phi+\alpha)}{\sin\alpha.\cos\phi} \qquad (\sin\alpha\ )$$

$$= \frac{w\sin\alpha}{P}$$

$$\boxed{\eta = \frac{\sin\alpha.\cos\phi}{\sin(\phi+\alpha)}}$$

96. Dynamic friction as compared to static friction is

(a) same (b) more

(c) less (d) none of the above

(RRB Bhopal SSE 09.09.2012)

Ans. (c) : Static and sliding friction:- The impending motion of the body is opposed by static friction.

- When the external force exceeds the maximum limit of static friction the body begins to move.

Kinetic friction :- Once the body is in motion, it is subjected to slide or kinetic friction which opposes relative motion between two surfaces in contact.

97. If Angle of friction is zero, the body will experience:

(a) Limiting friction

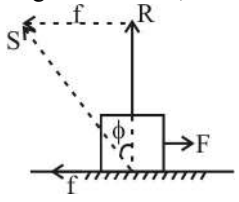
(b) Zero friction

(c) The force of friction will act normal to direction of motion

(d) None of these

(RRB Mumbai SSE 19.12.2010)

Ans : (b) Angle made by the resultant of normal reaction (R) and limiting friction (f) with the normal reaction is called angle of friction,



$$\tan\phi = \frac{f}{R} \qquad (\because \tan\phi = \mu)$$

if $\mu = 0$

$\tan\phi = 0$

$$0 = \frac{f}{R} \Rightarrow \boxed{f = 0}$$

So, if angle of friction is zero then body will experience zero friction force.

98. When the friction comes into action between the two running parts of a machine, it results in the production of .....

(a) light (b) oil

(c) energy (d) heat

(RRB Bhubneshwar JE-II 19.12.2010)

Ans : (d)

- When the friction comes into action between the two running parts of a machine it results in production of heat.
- $\boxed{\mu_{static} > \mu_{dynamic}}$

99. A block of mass 20 kg is placed on a horizontal surface. Co-efficient of static friction and coefficient of kinetic friction between the block and surface are 0.5 and 0.4 respectively. What is the minimum force required to be applied on the block in horizontal direction so that the block just starts to move. Consider g = 10 m/sec^2.

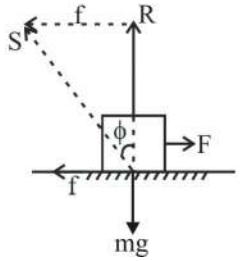
(a) 10N (b) 8N

(c) 80N (d) 100N

(RRB Allahabad JE 19.12.2010)

Ans. (d) : Given, Mass of block (m) = 20 kg

Coefficient of static friction between block and surface (μ_s) = 0.5 and coefficient of kinetic friction (μ_k) = 0.4



$R = mg = 20 \times 10$

$R = 200$ N

Required minimum force to start move,

$F = \mu_s \times R = 0.5 \times 200$

$F = 100$ N

100. The value of the coefficient of friction between the box and the surface is 0.20 which prevents the box from sliding. If the box decelerates with 'a' (m/s^2), then calculate the deceleration, if the force applied is 'ma'.

(a) 2 (b) 2.5

(c) 3 (d) 3.5

(JMRC JE 10.06.2017)

Ans. (a) We know that $F = ma$

$\mu = 0.20$, $a = ?$

$F = \mu.R$

$F = ma = \mu R$

$R = mg$

$ma = 0.2 \times mg$

$a = 0.2 \times 10$ $(g = 10)$

Hence $a = 2$ m/s^2

101. The substance used in the reduction of friction between the two surfaces in the relative motion is known as.....

(a) refrigerants (b) solvents
(c) lubricants (d) absorbent

(RRB Allahabad JE 19.12.2010)
RRB Chandigarh Section Engineer (Mech.), 26.02.2012

Ans : (c) The substance used in reduction of friction between two surfaces in the relative is known as lubricants.

Functions of lubrication :

(a) It reduce friction forces between the mouing components.
(b) It reduces the wear & tear components.
(c) It increases the life of machine & engine components.

102. Choose the option which is INCORRECT about the term friction.

(a) Friction produces heat
(b) It leads to the decrease in the velocity of object
(c) It leads to the increase in the velocity of object
(d) It can stop the moving object

(RRB Mumbai JE 19.12.2010)

Ans. (c) : Consider the following points regarding friction

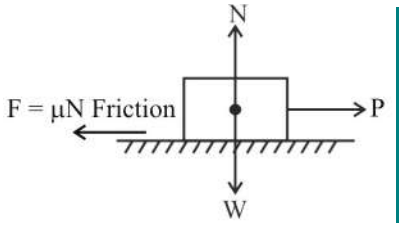
(i) Friction produces heat.
(ii) Friction leads to the decrease in the velocity of object.
(iii) Friction can stop the moving object
(iv) Friction opposes the motion.

103. Which of the given formula is CORRECT for calculating the angle of static friction ϕ_s?

(a) $\tan^{-1}\mu_s$ (b) $\sin^{-1}\mu_s$
(c) $\cos^{-1}\mu_s$ (d) None of these

(DMRC JE 20.04.2018)

Ans. (a)

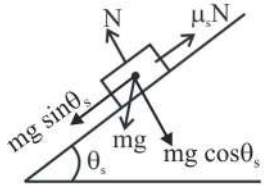


It is observed that the block does not move until the applied force P reaches a maximum value P_{max}. Thus from P = 0 up to P = P_{max}, the frictional force adjust itself so that it is just sufficient to stop the motion. It was observed by coulomb that P_{max} is proportional to the normal reaction of the surface of the object.

$P_{max} \propto N$

$F_{max} = \mu_s N$

Where μ_s is known as the co-efficient of static friction.



A quick way of estimating the value of static friction is to look at the motion of object on an inclined plane.

$mg \cos\theta_s = N$ .....(i)

$mg \sin\theta_s = \mu_s N$ .....(ii)

From equation (i) and (ii)

$\tan\theta_s = \mu_s$

$\therefore \boxed{\theta_s = \tan^{-1}\mu_s}$

104. Choose the CORRECT statement about the kinetic friction and the static friction.

(a) Kinetic friction is lesser than the static friction
(b) Kinetic friction is greater than static friction
(c) Kinetic friction is equal to static friction
(d) Kinetic friction is equal to contact force

(RRB Malda SSE 25.10.2009)

Ans. (a) The force necessary to induce motion is always bigger than the one necessary to continue the motion. So the kinetic friction is smaller than the static one. It will say that $\boxed{f_{st} > f_{dy}}$

105. The static friction:

(RRB Bhubneshwar JE II 29.11.2008)

(a) bears a constant ratio to the normal reaction between the two surfaces
(b) is independent of the area of contact, between the two surfaces
(c) always acts in a direction, opposite to that in which the body tends to move
(d) all of the above

Ans. (d) : About to static friction -

- Bears a constant ratio to the normal reaction between the two surfaces.
- It is independent of the area of contact, between the two surfaces.
- Always acts in a direction opposite to that in which the body tends to move.
- The force of friction depends upon the roughness of the surfaces.

106. Which of the following option is CORRECT about the methods used to reduce the friction?

(a) Making a rough surface
(b) Use of lubricants
(c) Use of sand particles
(d) None of these

(RRB Patna JE 25.10.2009)

Ans. (b) : One of the methods to reduce the friction is use of lubricants.

methods to reduce friction-

- For objects that move in fluids such as boats, planes cars etc. the shape of their body is streamlined in order to reduce the friction between the body of the objects as the fluidd.
- By polishing the surface, as polishing makes the surface smooth & friction can be reduced.
- Using lubricants.
- When objects are soled over the surface, the friction between the rolled object & surface can be reduced by using ball bearings.

107. Which of the following terms best describes the frictional force?

(a) None contact force (b) Contact force
(c) Static force (d) None of these

(RRB Chandigarh SSE 09.09.2012)
RRB Chandigarh Section Engineer, 26.02.2012

Ans. (b) A frictional force is defined as a force which resists the relative motion between the contacting surfaces hence it is also known as contact force.

108. The frictional force which acts on the body when the body tends to move is known as _____.

(RRB Bhubneshwar JE II 29.11.2008)

(a) normal reaction
(b) limiting force of friction
(c) gravitational force
(d) None of these

Ans : (b)

- The maximum frictional force which comes into play when a body just begins to side over an other surface is called limiting friction.
- **Rolling friction –** The friction experienced by a body, when balls or rollers are interposed between the two surfaces, is known as rolling friction.
- **Sliding friction –** The friction, experienced by a body, when it slide over another body is known as sliding friction.
- The friction, experienced by a body, when at rest is known as static friction.

109. A spring scale reads 20N as it pulls a 5.0 kg mass across a table. What is the magnitude of the force exerted by the mass on the spring scale?

(RRB Gorakhpur RDSO SSE 25.10.2009)

(a) 4.0N (b) 5.0N
(c) 20.0N (d) 49.0N

Ans : (c) According to the Newton's third law of motion- When one object exerts a force on another, the latter body exerts the force in the opposite direction of the first.
Same thing happens in this case.
So, Force exerted by the mass on the spring scale = 20N

110. It is easier to roll a heavy cylinder over a surface because :

(RRB Bhopal SSE 09.09.2012)

(a) Kinetic friction is less than rolling friction
(b) Rolling friction is much less than kinetic friction
(c) Absence of static friction
(d) Absence of kinetic friction

Ans : (b) Rolling a heavy cylinder over a surface is easier because – $\mu_{kinetic} >> \mu_{rolling}$

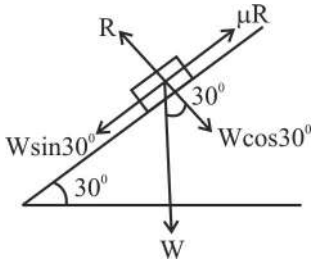
- Rolling friction is quite small as compared to the sliding friction. That is why heavy loads are transported by placing them on carts with wheels.
- In rolling the surface at contact donot sub each other.

111. A body is resting on a plane inclined at angle 30^0 to horizontal. What force would be required to slide it down, if the coefficient of friction between body and plane is 0.3 ?

(RRB Chandigarh SSE 25.10.2009)

(a) Zero (b) 1 kg
(c) 5 kg (d) None of these

Ans. (a) :



downward force along plane–

$W\sin 30 = W \times \frac{1}{2} = 0.5W$.....(i)

Friction force between plane and body–

$\mu R = 0.3 \times R$ ..... (ii)

$(\because R = W\cos 30^0 = W \times \frac{\sqrt{3}}{2})$

$\therefore$ Friction force $0.3 \times \frac{\sqrt{3}}{2} W = 0.259W$

$\because$ The downward force is greater than friction force

So, zero force has to be applied to bring the body downward.

112. The friction between objects that are stationary is called

(Konkan Railway TA 2017)
(RRB Bhopal SSE 09.09.2012)

(a) static friction (b) rolling friction
(c) Kinetic friction (d) dynamic friction

Ans : (a) When there is no motion between the objects, then frictional force between the object is called static friction.
Magnitude of static friction–

$f_s \le \mu_s N$
μ_s = Coefficient of static friction
N = Normal reaction

113. The rolling friction is the friction experienced by a body, when the body:

(RRB Chandigarh SSE 09.09.2012)

(a) is in motion
(b) is at rest
(c) just begins to slide over the surface of the other body
(d) none of the above

Ans. (d) : When a body rolls over another body, frictional force experienced by the body is known as rolling friction. When a body slides over another body, the frictional force experienced by the body is known as sliding friction.

114. The coefficient of friction between two surfaces may be defined as the constant of proportionality between the applied tangential force and the normal reaction:

(RRB Allahabad SSE 19.12.2010)

(a) at the instant of application of force
(b) at any instant when body is at rest
(c) at the instant of impending motion
(d) at an instant after motion takes place

Ans. (c) : The coefficient of friction between two surfaces many be defined as the constant of proportionality between the applied tangential force and the normal reaction at the instant of impending motion.

Coefficient of friction (μ) =

$$\frac{\text{Tangential force / limiting frictional force}}{\text{Normal reaction}}$$

115. The coefficient of friction depends on which of the following factors?

(a) Shape of surfaces
(b) Strength of surfaces
(c) Nature of surfaces
(d) All option are correct

(RRB Chandigarh SSE 25.10.2009)
(RRB Mumbai JE 19.12.2010)

Ans : (c) Friction is a opposing force, which acts in the opposite direction of the movement of the block. It is two types–

(i) Static friction, (ii) Dynamic friction

- **Law of static friction–**

(i) Always acts in opposite direction of force
(ii) Magnitude of the force of friction is exactly equal to applied force (in limiting friction condition)
(iii) Force of friction is independent of the area of contact between two surface.
(iv) Force of friction depend on nature of surface (smoothness or roughness).

116. Angle of friction is the

(RRB Jammu SSE 09.09.2012)

(a) Angle between normal reaction and the resultant of normal reaction and the limiting frictional force
(b) Ratio of limiting friction and normal reaction
(c) Ratio of static and dynamic friction
(d) None of the above

Ans : (a) Angle of friction- It is the angle which the resultant of the limiting friction and the normal reaction makes with the normal reaction.

Coefficient of frication (μ) = It is the ratio of the magnitude of limiting force of friction to the normal reaction b/w surface in contact.

$$\mu = \frac{F}{R} \Rightarrow \frac{\mu R}{R} = \mu$$

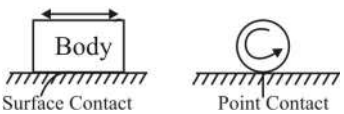
$$\boxed{\phi = \tan^{-1}\mu}$$

117. Rolling friction is

(a) Lesser than sliding friction
(b) More than sliding friction
(c) Equal to sliding friction
(d) Equal to kinetic friction

(RRB Chandigarh SSE 25.10.2009)

Ans : (a)



Friction is a type of force which opposes the relative motion of body. It depends upon the mass, contact surface as well as roughness of surface. If contact surface are more, the friction force more & viceversa.

If body is slide then more surface is in contact surface area, so more friction force generate & if rolling occurs then only point contact i.e. less contact surface.
Hence, rolling friction is less than sliding friction.
Static friction > Sliding friction > Rolling friction

118. The ratio of limiting friction and normal reaction is known as :

(a) coefficient of friction (b) angle of friction
(c) angle of repose (d) sliding friction

(RRB Allahabad SSE 19.12.2010)

Ans. (a) : The ratio of limiting friction and normal reaction is known as coefficient of friction.

Coefficient of Friction $\boxed{\mu = \frac{F}{R_N}}$

Where,
F = Limiting friction
R_N = Normal Reaction

119. The dynamic friction is the friction experienced by a body when the body :

(a) is in motion (b) Is at rest
(c) Sides over surface (d) None of above

(DMRC JE 2013)

Ans : (a) The dynamic friction is the friction experienced by a body when the body is in motion. It is also called kinetic friction. It is the following two types–

(A) Sliding friction;
(B) Rolling friction.

- The friction, experienced by a body, when it slides over another body, is known as sliding friction.
- The friction experienced by a body, when balls or rollers are interposed between the two surfaces, is known as rolling friction.

120. The direction of frictional force acting on a body which can slide on a fixed surface is:

(a) In the direction of motion
(b) Normal to the direction of motion
(c) Unpredictable
(d) Opposite to the direction of motion

(DMRC JE 20.04.2018)
(RRB Kolkata Diesel JE 25.10.2009)

Ans. (d) : The direction of frictional force is always opposite to the direction of motion. Friction always tends to oppose the applied force.

The frictional force which resists the real relative sliding motion between two contact surfaces is known as sliding or kinetic friction.

$$\boxed{F_{sliding} = \mu_k . N}$$

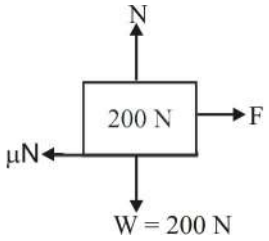
Where $\mu_k \rightarrow$ Sliding friction coefficient
$N \rightarrow$ Normal reaction

121. A body of weight 200 N is placed on a horizontal plane. If the co-efficient of friction between the body and the horizontal plane is 0.3, the horizontal force required to just slide the body on the plane is _____

(a) 60 N (b) 90 N
(c) 30 N (d) 120 N

(RRB Jammu SSE 09.09.2012)

Ans. (a) : Given,
Weight of body = 200 N
$\mu = 0.3$



FBD of the figure
horizontal force required to just slide = Friction force
$F = \mu N$
$= 0.3 \times 200$
$\boxed{F = 60\ N}$

122. Limiting force of friction is the :
(a) tangent of angle between normal-reaction and the resultant of normal reaction and limiting friction
(b) ratio of limiting friction and normal reaction
(c) the friction force acting when the body is just about to move
(d) the friction force acting when the body is in motion

(Konkan Railway STA 2017)
RRB Chandigarh Section Engineer, 26.02.2012

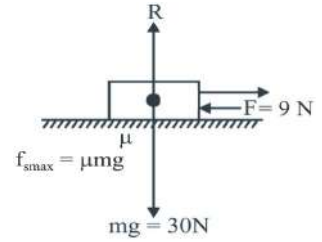
Ans. (c) :
- The maximum valve of frictional force, which comes into play, when a body just begins to slide over the surface of the other body, is known as limiting force of friction.
- The friction, experienced by a body, when in motion, is called dynamic friction. It is also called kinetic friction. It is of the following two types.

a - Sliding friction
b- Rolling friction

123. A body of weight 30 N rests on a horizontal floor. A gradually increasing horizontal force is applied to the body which just starts moving when the force is 9 N. The coefficient of friction between the body and the floor will be
(a) 10/3 (b) 3/10
(c) 1/3 (d) 1/9

(RRB Bhubneshwar JE II 29.11.2008)

Ans. : (b)



$\therefore \Sigma V = 0$
$R = 30\ N$
$R = W = mg$
$\therefore f_{max} = \mu.R$
$f_{max} = 30\mu$

In just starts moving condition
Applied force = max friction force
$9 = 30\ \mu$

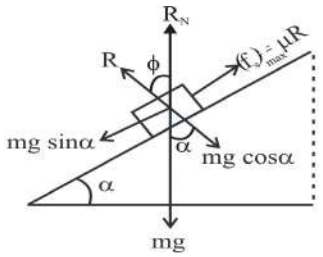
$$\mu = \frac{9}{30} = \frac{3}{10} = 0.3$$

$$\boxed{\mu = \frac{3}{10}}$$

124. A body of weight W is placed on a rough inclined plane. The inclination of the plane with the horizontal is less than the angle of friction. The body will
(a) be in equilibrium (b) move downwards
(c) move upwards (d) None of the above

(RRB Chandigarh SSE 25.10.2009)

Ans. : (a)



Let the body is in just in slide condition the
$f_{max} = mg \sin\alpha$
$\mu mg \cos\alpha = mg \sin\alpha$
$\tan\phi = \tan\alpha\ (\because \mu = \tan\phi)$
$\because \phi > \alpha$
Then $\boxed{\tan\phi > \tan\alpha}$
ie body will be in equilibrium condition

125. The maximum frictional force which comes into play when a body just begins to slide over another surface is called :
(a) limiting friction (b) sliding fiction
(c) rolling friction (d) kinematic friction

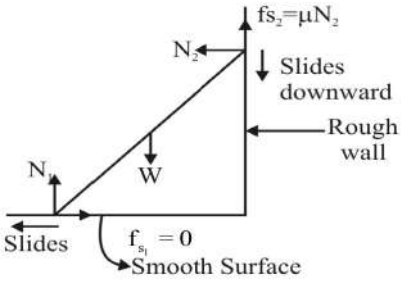
(RRB Allahabad JE 19.12.2010)

Ans. (a) :
- The maximum frictional force which comes into play when a body just begins to slide over another surface is called limiting friction.
- **Rolling friction –** The friction experienced by a body, when balls or rollers are interposed between the two surfaces, is known as rolling friction.
- **Sliding friction –** The friction, experienced by a body, when it slide over another body is known as sliding friction.
- The friction, experienced by a body, when at rest is known as static friction.

126. A ladder rests on a smooth ground against a rough wall. The force of friction acts
(a) Away from the wall at the upper end
(b) Towards the wall at the lower end
(c) Upward at the upper end
(d) Downwards at the upper end

(RRB Mumbai JE 05.10.2008)

Ans : (c) If ladder rest on a smooth ground against a rough wall the friction force acts in upward direction at the upper end.

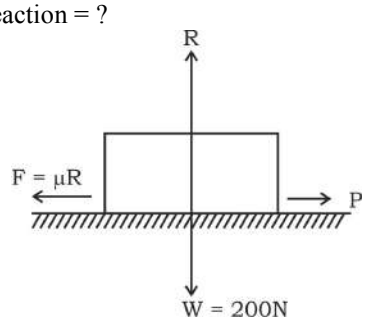


127. A body weighing 200 N is placed on a rough horizontal plane. If the value of co-efficient of friction is 0.6 then the normal reaction will be:

(a) 120 N (b) 200 N
(c) 150 N (d) 300 N

(Konkan Railway STA 2017)

Ans. (b) : Body weight = 200 N
Coefficient of friction = 0.6
Normal Reaction = ?



$\sum V = 0$

$\boxed{R = 200N}$

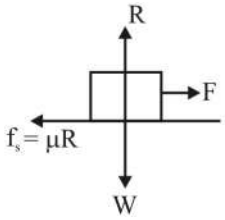
$\therefore$ the normal reaction will be 200 N.

128. A body weight of 200 N is resting on a rough horizontal plane, and can be just moved by a force of 80 N applied horizontally, what will the value of the coefficient of friction

(a) 0.4 (b) 0.5
(c) 0.3 (d) None

(RRB Gorakhpur RDSO SSE 25.10.2009)

Ans. (a)



Given that -
W = 200 N
F = 80 N
R = W = 200 N
If body in just move condition,

$F = \mu R$

$$\mu = \frac{F}{R} = \frac{80}{200} = \frac{2}{5}$$

$\boxed{\mu = 0.4}$

129. The maximum value of frictional force when the motion is impending is known as

(a) Limiting friction (b) Dynamic friction
(c) Static friction (d) Sliding friction

(RRB Patna JE 25.10.2009)

Ans : (a) Maximum value of frictional force when the motion is impending known as limiting friction. The friction force when body is at rest condition is known as static friction.

130. The rolling resistance is because of the friction between the

(RRB Jammu SSE 09.09.2012)

(a) Wheel rim and tyre
(b) Tyre and road surface
(c) Wheel rim and road surface
(d) None of these

Ans. (b) : Rolling resistance is because of the friction between tyre & road surface.

$\boxed{f_{rolling} < f_{static}}$

• Rolling resistance is the force resisting the motion when a body rolls on a surface.

$\boxed{F = C_{rr}N}$

F = Force
C_{rr} = dimensionless rolling resistance coefficient
N = Normal force

131. The coefficient of rolling resistance, for a steel wheel of 200 mm diameter which rolls on a horizontal steel roll, is 0.3 mm. The steel wheel carries a load of 600 N. The force necessary to roll the wheel along the rail is :

(RRB Kolkala SSE 09.09.2012)

(a) 90 N (b) 180 N
(c) 90 kN (d) 270 N

Ans : (b) d = 200 mm, C_{rr}= 0.3, w = 600 N

$\boxed{R = w}$

Formula,

$F = C_{rr}R$
$F = 0.3 \times 600$
$\boxed{F = 180N}$

132. The value of frictional force is-

(a) More than external force
(b) Equal to the external force
(c) Less than the external force
(d) None of these

(RRB Allahabad JE 09.09.2012)

Ans. (b) : If an object is moving at a constant speed the force of friction must equal the applied (horizontal) external force, and for it to be accelerating or decelerating, the force of friction and the applied force must be unequal.

$f = \mu N$
f = friction force
μ = coefficient of friction
N = Normal reaction

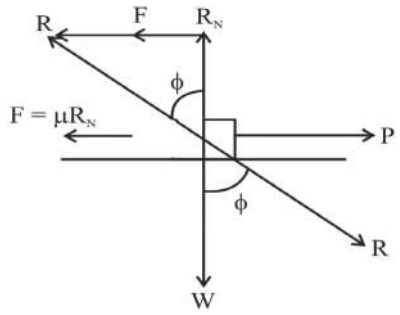
133. Tangent of angle of friction is equal to :

(a) kinetic friction (b) limiting friction
(c) angle of repose (d) coefficient of friction

(JMRC JE 10.06.2017)

Ans. (d) Tangent of angle of friction is equal to coefficient of friction.

$\boxed{\tan\phi = \mu}$ [ϕ = Angle of friction)



$$\tan\phi = \frac{F}{R_N} = \frac{\mu R_N}{R_N} = \mu$$

so $\boxed{\tan\phi = \mu}$ μ = [Coefficient of Friction]

6. Moment of Inertia and Radius of Gyration

134. What is the Moment of Inertia of a Quarter circle about its Diametral Axis?

(a) $\pi d^4/128$ (b) $\pi d^4/256$

(c) $\pi d^4/64$ (d) $\pi d^4/36$

RRB JE 29-08-2019

Ans. (b) : $\bar{x} = \bar{y} = \frac{4r}{3\pi}$

Area of quarter circle (A) = $\frac{\pi r^2}{4}$

$I_x = I_1 y = \frac{\pi r^4}{16} = \frac{\pi d^4}{256}$

135. The moment of inertia of a rectangular section 3 cm wide and 4 cm deep about X-X axis passing through centre is-

(a) 9 cm^4 (b) 12 cm^4

(c) 16 cm^4 (d) 20 cm^4

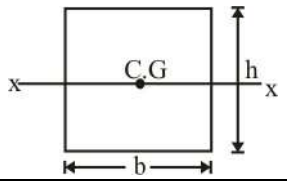
RRB JE 29-08-2019

Ans. (c) : Given, b = 3cm, h = 4cm

Moment of inertia about X - X

Axis, = $\frac{bh^3}{12}$

= $\frac{3\times 4^3}{12} = 16 cm^4$



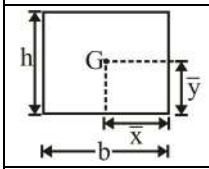
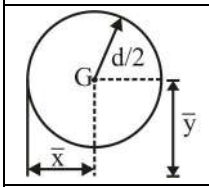
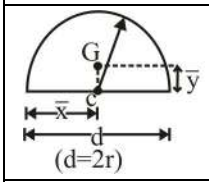
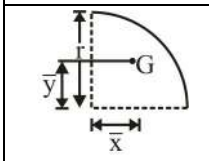
136. The center of gravity of a semi-circle lies at a distance of ..... from its base measured along the vertical radius.

(a) $3r/4\pi$ (b) $8r/3\pi$

(c) $4r/3\pi$ (d) $3r/8\pi$

RRB JE 29-08-2019

Ans. (c) : The center of gravity of a semi-circle lies at a distance of $4r/3\pi$ from its base measured along the vertical radius

Different section	$\bar{y}$	$\bar{x}$
	$\frac{h}{2}$	$\frac{b}{2}$
	$\frac{d}{2}$	$\frac{d}{2}$
	$\frac{4r}{3\pi}$	$\frac{d}{2}$
	$\frac{4r}{3\pi}$	$\frac{4r}{3\pi}$

137. The area moment of inertia of a semi-circular region having diameter 'd' about its diametric axis is-

(a) $\pi d^2/36$ (b) $\pi d^2/256$

(c) $\pi d^4/128$ (d) $\pi d^4/64$

RRB JE 30-08-2019

Ans. (c) : The area moment of inertia of a semi circular region about it's diametric axis,

$$I_d = \frac{\pi d^4}{128} = \frac{\pi r^4}{8}$$

For circular disc, $I_x = I_y = \frac{1}{4}\pi r^4$

For triangle, $I_G = \frac{1}{36} bh^3$

For rectangle, $I_x = \frac{1}{12} bh^3$

138. If no external torque acts on a rigid body, then the product of its moment of inertia and the angular velocity about the axis of rotation must remain constant" is the statement of-

(a) Law of parallelogram forces

(b) Law of polygon of forces

(c) Law of triangular forces

(d) Law of conservation of angular momentum

RRB JE 30-08-2019

Ans. (d) : "If no external torque acts on a rigid body, then the product of its moment of inertia and the angular velocity about the axis of rotation must remain constant" is the statement of law of conservation of angular momentum. i.e. $I\omega = C$

139. The science which deals with the action of forces on bodies such that the bodies are at rest is called-

(a) Kinematics (b) Statics
(c) Statistics (d) Dynamics

RRB JE 30-08-2019

Ans. (c) : Statistics deals with the equilibrium of bodies under the action of forces. The body can be at rest or in uniform motion (without acceleration) and the net force on the body is zero.

Dynamics deals with the motion of the body under the action of force, hence it deals with accelerated bodies.

140. The unit of moment of inertia of mass of–

(a) m^2/kg (b) $kg–m^2$
(c) kg/m (d) kg/m^2

RRB JE 31-08-2019

Ans. (b) Moment of inertia of a body is also known as second moment of mass.

For any body, $\boxed{I = mk^2}$

So, It's unit = $kg \times m^2$
$= kg - m^2$

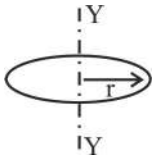
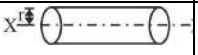
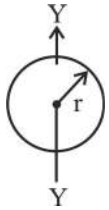
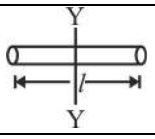
- Unit of moment of inertia of in area,
$= m^4$

141. The moment of inertia of a solid cylinder of mass 'm', radius 'r' and length 'l' about the longitudinal axis or polar axis is–

(a) $mr^2/4$ (b) $mr^2/8$
(c) $mr^2/6$ (d) $mr^2/2$

RRB JE 31-08-2019

Ans. (d) The moment of inertia of a solid cylinder of mass 'm', radius 'r' and length '*l*' about the longitudinal axis or polar axis is $\frac{mr^2}{2}$.

Solid	About	Figure	M.O.I.
Ring	Through centre		$I_{YY} = mr^2$
Solid cylinder	Through centre		$I_{XX} = \frac{mr^2}{2}$
Solid sphere	Though centre		$I_{YY} = \frac{2}{5}mr^2$
Hollow sphere	Through centre		$I_{YX} = \frac{2}{3}mr^2$
Long uniform rod	Through centre		$\frac{1}{2}ml^2$

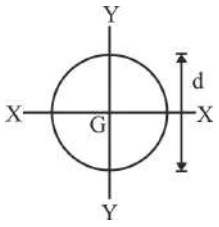
142. The Moment of Inertia of a circular area of diameter 'd' about its diameter axis is–

(a) $\pi d^2/64$ (b) $\pi d^2/36$
(c) $\pi d^3/36$ (d) $\pi d^4/64$

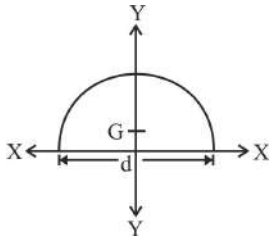
RRB JE 31-08-2019

Ans. (d) The moment of inertia of a circular area of diameter 'd' about its diameter axis,

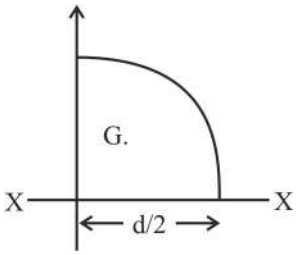
$I_{XX} = I_{YY} = \frac{\pi d^4}{64}$



- M.O.I. of semicircular area about its' diameter axis, $I_{XX} = \frac{\pi d^4}{128}$



- M.O.I. of quarter circular area about it's diameter axis, $I_{XX} = \frac{\pi d^4}{256}$



143. Moment of inertia of a rectangular section having width (b) and depth (d) about an axis passing through its centre of gravity and parallel to the depth, is–

(a) $db^3/36$ (b) $db^3/12$
(c) $bd^3/12$ (d) $bd^3/36$

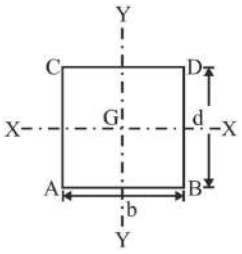
RRB JE 31-08-2019

Ans. (b)

- I_G paralplel to it's depth, $(I_G)_Y = \frac{db^3}{12}$
- $(I_G)_x$ parallel to it's width,

$$(I_G)_X = \frac{bd^3}{12}$$

- $\boxed{I_{AB} = \frac{bd^3}{3}}$



144. Built up sections also known as

(a) Standard section (b) Compound section
(c) Both the above (d) None of these

(RRB Chandigarh SSE 25.10.2009)

Ans : (b) Built up sections are also known as compound sections.

Built up section–These are members made up by a fabricator from two or more standard sections.

- Built up members are specified by designer when the desired properties or configuration cannot be obtained in a single netrolled section.

145. I-section, channel-section, T-section, L-section and Z-section are known as

(a) Compound section (b) Built up section
(c) Standard section (d) (a) and (b) both

(RRB Banglore SSE 09.09.2012)

Ans. (c) : I-section, channel section, T-section, L-section & Z-sections are known as standard sections.

- These sections are used as beams & struts.

146. Which of the following is correct expression for second moment of inertia is

(RRB Mumbai JE 19.12.2010)
RRB Jammu Section Engg., 2013

(a) $I = AK^2$ (b) $I = (AK)^2$
(c) $I = \frac{A}{K^2}$ (d) $I = \sqrt{\frac{A}{K^2}}$

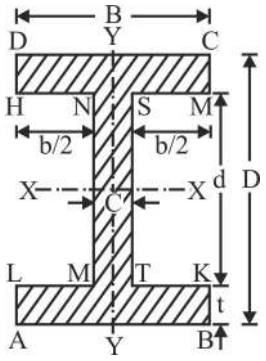
Ans. (a) : Second moment of inertia is a geometric property of an area which measures how its points are distributed with regards to an arbitrary axis, providing a measure of how efficiency the cross sectional shape can resist bending caused by loading.

$I = AK^2$

K = Radius of gyration

A = Area of body

147. What is the value of moment of inertia of I-section about centre of gravity through X–X and Y–Y axis, given figure below.



(a) $I_{XX} = \frac{BD^3 - bd^3}{12}$, $I_{YY} = \frac{2tb^3 + dc^3}{12}$

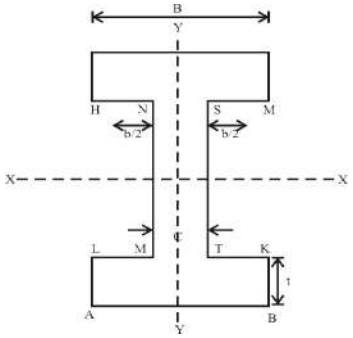
(b) $I_{XX} = \frac{ab^3 - c(b-2t)^3}{12}$, $I_{YY} = \frac{2tb^3 + dc^3}{12}$

(c) $I_{XX} = \frac{B^3D - b^3d}{12}$, $I_{YY} = \frac{2t^3b + d^3c}{12}$

(d) None of these

(RRB Jammu JE 25.10.2009)

Ans. (a) :



Moment of Inertia of I-section about X-X axis–

MI of rectangular section ABCD–2 × MI of rectangular section LMNH

$$= \frac{BD^3}{12} - 2 \times \frac{b}{2} \times \frac{d^3}{12}$$

$$\boxed{I_{XX} = \frac{BD^3 - bd^3}{12}}$$

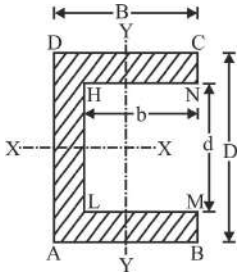
Moment of Inertia of I-section about Y-Y axis–

MI of rectangular section ABKL + MI of rectangular section DCHM + MI of rectangular section NSMT–

$$2 \times (I)_{DCMH} + (I)_{NMST}$$

$$= \frac{2tb^3 + dc^3}{12} + \frac{dc^3}{12}$$

148. What is the value of moment of inertia of Channel-section about centre of gravity through X–X, given figure below.



(a) $I_{XX} = \left[\frac{BD^2 - bd^3}{12}\right]$ (b) $I_{XX} = \left[\frac{B^2D - bd^3}{12}\right]$

(c) $I_{XX} = \left[\frac{BD^2 - b^3d}{8}\right]$ (d) $I_{XX} = \left[\frac{B^3D - b^3d}{12}\right]$

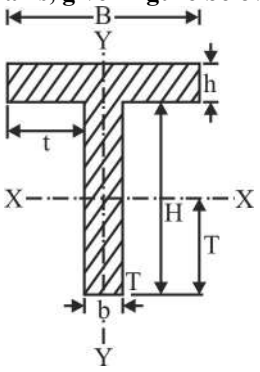
(RRB Banglore SSE 09.09.2012)
RRB Jammu Section Engg., 2013

Ans. (a) : $(I)_{ABCD} - (I)_{LMNH}$

$$\frac{BD^3}{12} - \frac{bd^3}{12}$$

$$I_{XX} = \left[\frac{BD^3 - bd^3}{12}\right]$$

149. What is the value of moment of inertia of T-section about centre of gravity through X–X and Y–Y axis, given figure below.



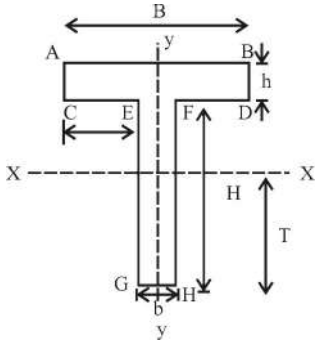
(a) $I_{YY} = \frac{b^3H}{12} + \frac{B^3h}{12}$ (b) $I_{YY} = \frac{b^3H^3}{12} + \frac{B^3h^3}{12}$

(c) $I_{YY} = \frac{bH^3}{12} + \frac{Bh^3}{12}$ (d) $I_{YY} = \frac{b^3H}{12} - \frac{B^3h}{12}$

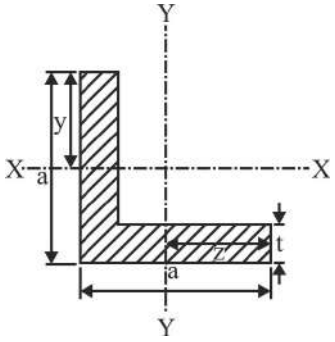
(RRB Mumbai C&G SSE 25.10.2009)

Ans. (a) : $IYY = (I)_{ABCD} + (I)_{EFGH}$

$$\boxed{I_{YY} = \frac{hB^3}{12} + \frac{b^3H}{12}}$$



150. What is the value of moment of inertia of L-section about centre of gravity through X–X and Y–Y axis, given figure below.



(a) $I_{XX} = \frac{1}{3}\left[ty^3 - a(a-y)^3 + (a-t)(a+y-t)^3\right]$

(b) $I_{XX} = \frac{1}{3}\left[ty^3 - a(a-y)^3 + (a-t)(a-y-t)^3\right]$

(c) $I_{XX} = \frac{1}{3}\left[ty^3 + a(a+y)^3 - (a+t)(a-y+t)^3\right]$

(d) $I_{XX} = \frac{1}{3}\left[ty^3 + a(a-y)^3 - (a-t)(a-y-t)^3\right]$

(RRB Bhubneshwar JE II 29.11.2008)

Ans. (d) : Moment of inertia about X-X axis,

$$I_{XX} = \frac{1}{3}\left[ty^3 + a(a-y)^3 - (a-t)(a-y-t)^3\right]$$

Moment of inertia about Y-Y axis,

$$I_{YY} = \frac{1}{3}\left[tz^3 + a(a-z)^3 - (a-t)(a-z-t)^3\right]$$

Area of L - cross section (A) = t (2a – t)

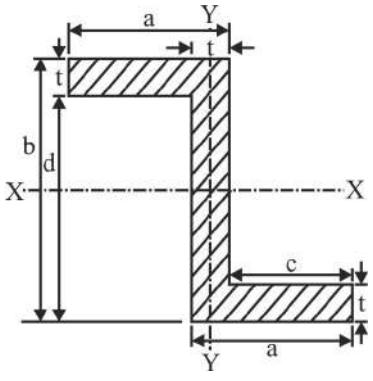
The radius of gyration about X-X axis,

$$K_{XX} = \sqrt{\frac{I_{XX}}{A}} = \sqrt{\frac{\left[ty^3 + a(a-y)^3 - (a-t)(a-y-t)^3\right]}{3t(2a-t)}}$$

The radius of gyration about Y-Y axis,

$$K_{YY} = \sqrt{\frac{I_{YY}}{A}} = \sqrt{\frac{tz^3 + a(a-z)^3 - (a-t)(a-z-t)^3}{3t(2a-t)}}$$

151. What is the value of moment of inertia of Z-section about centre of gravity through X–X and Y–Y axis, given figure below.



(a) $I_{XX} = \dfrac{ab^3 - c(b+2t)^3}{12}$,

$I_{YY} = \dfrac{b(a-c)^3 + 2c^3d - 6a^2cd}{12}$

(b) $I_{XX} = \dfrac{ab^3 - c(b-2t)^3}{12}$,

$I_{YY} = \dfrac{b(a+c)^3 - 2c^3d - 6a^2cd}{12}$

(c) $I_{XX} = \dfrac{ab^3 + c(b-2t)^3}{12}$,

$I_{YY} = \dfrac{b(a-c)^3 - 2c^3d + 6a^2cd}{12}$

(d) $I_{XX} = \dfrac{ab^3 + c(b+2t)^3}{12}$,

$I_{YY} = \dfrac{b(a+c) - 2c^3d - 6a^2cd}{12}$

(RRB Gorakhpur RDSO SSE 25.10.2009)

Ans. (b) : Moment of inertia about X-X axis,

$$I_{XX} = \frac{ab^3 - c(b-2t)^3}{12}$$

Moment of inertia about Y-Y axis,

$$I_{YY} = \frac{b(a+c)^3 - 2c^3d - 6a^2cd}{12}$$

$A = t\,[(b + 2(a - t)]$

The radius of gyration about X-X axis,

$$K_{XX} = \sqrt{\frac{I_{XX}}{A}} = \sqrt{\frac{ab^3 - c(b-2t)^3}{12t[b+2(a-t)]}}$$

The radius of gyration about Y-Y axis,

$$K_{YY} = \sqrt{\frac{I_{YY}}{A}} = \sqrt{\frac{b(a+c)^3 - 2c^3d - 6a^2cd}{12t[b+2(a-t)]}}$$

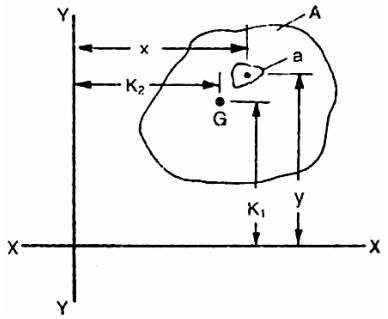
152. Second moment of area known as

(a) Area moment of inertia
(b) Mass moment of inertia
(c) Newton's first law
(d) None of these

(RRB Mumbai JE 19.12.2010)

Ans. (a) : Second moment of area, also known as area moment of inertia, is a geometrical property of an area which reflects how its points are distributed with regard to an arbitrary axis

Unit = m^4

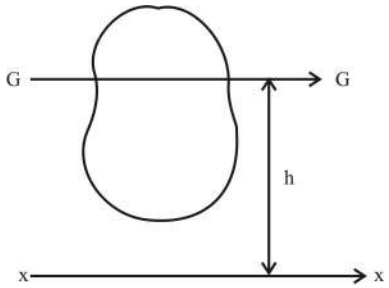


153. Expression for theorem of parallel axis is

(a) $I_{X-X} = I_{G-G} + Ah^2$ (b) $I_{ZZ} = I_{XX} + I_{YY}$
(c) $I_{X-X} = AK^2$ (d) $I_{XX} = I_{YY} = MK^2$

(JMRC JE 10.06.2017)

Ans. (a) : Parallel axis theorem–



Parallel axis theorem can be used to determine the second moments of area of a rigid body about an axis, given the body's centroid, the area of the cross section and the perpendicular distance between the axis

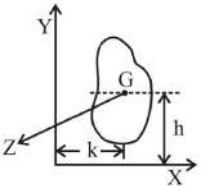
$$\boxed{I_{XX} = I_{GG} + A \times h^2}$$

154. According to perpendicular axis theorem,

(a) $I_{zz} = I_{xx} + I_{yy}$ (b) $I_{zz} = I_{xx} + ah^2$
(c) $I_{zz} = I_{xx} \times I_{yy}$ (d) $I_{zz} = I_{xx}^2 + I_{yy}^2$

(RRB Mumbai SSE 05.10.2008)

Ans. (a) : According to perpendicular axis theorem–



$$\boxed{I_{zz} = I_{xx} + I_{yy}}$$

The perpendicular axis theorem states that the moment of inertia of a planer lamina about an axis perpendicular to the plane of the lamina is equal to the sum of the moments of inertia of the lamina about the two axes at right angles to each other, in its own plane intersecting each other at the point where the perpendicular axis passes through it.

• **According to parallel axis theorem**

$$\boxed{I_{XX} = I_G + ah^2}$$

155. A section made by combining of two or more than two standard section know as

(a) Compound section (b) Built up section
(c) Standard section (d) (a) and (b) both

(DMRC JE 20.04.2018)

Ans. (d) : A section made by combining of two or more than two standard sections are known as compound section & built up section.

156. Radius of gyration K is equal to

(a) $\sqrt{\dfrac{I}{A}}$ (b) $\sqrt{\dfrac{A}{I}}$

(c) $\sqrt{IA}$ (d) $\left(\dfrac{I}{A}\right)^2$

(RRB Gorakhpur RDSO SSE 25.10.2009)

Ans. (a) : Radius of gyration– Radius of gyration of a body about its axis of rotation may be defined as the distance from the axis of rotation at which if the whole mass of the body were concentrated

$I = AK^2$

$K = \sqrt{\frac{I}{A}}$

I = Moment of inertia

157. CG of a plane lamina is not at its geometrical centre, if it is a:

(a) Circle (b) Square

(c) Rectangle (d) Right angled triangle

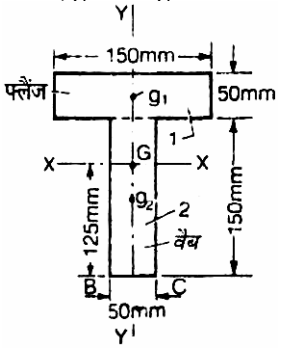
(RRB Bhubneshwar JE-II 19.12.2010)

Ans : (d) Centre of gravity is the point through which whole weight of the body acts, irrespective of its position.

- Except right angled triangle CG of circle, square and rectangle is lies at its geometrical centre.

So, for right angle triangle C.G. & geometrical centre not at same point.

158. What is the value of moment of inertia of T-section about centre of gravity through X–X and Y–Y axis, given figure below.



(a) 53.125×10^6 mm^4, 15.625×10^6 mm^4

(b) 33.225×10^5 mm^4, 14.325×10^5 mm^4

(c) 43.225×10^6 mm^4, 55.600×10^6 mm^4

(d) 30.120×10^6 mm^4, 15.125×10^6 mm^4

(RRB Gorakhpur Design SSE 09.09.2012)

Ans. (a) : Divide the entire T-section into rectangles.

Area of rectangle $(a_1) = 150 \times 50 = 75 \times 10^2$ mm^2

Area of rectangle $(a_2) = 150 \times 50 = 75 \times 10^2$ mm^2

Because T-section is symmetrical on Y–Y axis. Therefore its center of gravity will be on the G, Y–Y axis.

So we only find the height of G from BC.

Height of center of gravity (g_1) from BC of rectangle (1)

$y_1 = 200 - 25 = 175$ mm

Height of center of gravity (g_2) of T-section from BC is $\bar{y}$, then

$$\bar{y} = \frac{a_1 y_1 + a_2 y_2}{A}$$

Where, $A = a_1 + a_2 = 75 \times 10^2 + 75 \times 10^2 = 15 \times 10^3$ mm^2

$$\therefore \quad \bar{y} = \frac{75\times10^2\times175 + 75\times10^2\times75}{75\times10^2 + 75\times10^2} = 125 \text{ mm}$$

Now, the moment of inertia of rectangle (1) parallel to the X–X axis andv passing through g_1.

$$I_{XX_{g1}} = \frac{150\times50^3}{12} = 1.5625 \times 10^6 \text{ mm}^4$$

moment of inertia of rectangle (1) about X–X axis,-

$$I_{XX_1} = I_{XX_{g1}} + a_1 \times h_1^2$$

Where, $h_1 = 175 - 125 = 50$ mm

$$\therefore \quad I_{XX_1} = 1.5625 \times 10^6 + 75 \times 10^2 \times 50^2$$

$$= 20.3125 \times 10^6 \text{ mm}^4$$

again moment of inertia of rectangle (2) parallel to the X–X axis and on axis passing through g_2 -

$$I_{XX_{g2}} = \frac{50\times150^3}{12} = 14.0625 \times 10^6 \text{ mm}^4$$

Moment of inertia of rectangle (2) about X–X axis

$$I_{XX_2} = I_{XX_{g2}} + a_2 \times h_2^2$$

where $h_2 = 125 - 75 = 50$ mm

$$\therefore \quad I_{XX_2} = 14.0625 \times 10^6 + 75 \times 10^2 \times 50^2$$

$$= 32.8125 \times 10^6 \text{ mm}^4$$

$\therefore$ Moment of inertia of the entire T-section at X–X axis-$I_{XX} = I_{XX_1} + I_{XX_2} = 20.3125\times10^6 + 32.8125 \times 10^6$

$$= 53.125 \times 10^6 \text{ mm}^4$$

Since the T-section is symmetric on Y–Y, the moment of inertia of each rectangle will pass directly on Y–Y,

Moment of inertia of rectangle (1) at Y–Y,

$$I_{YY_1} = \frac{50\times150^3}{12} = 14.0625 \times 10^6 \text{ mm}^4$$

Moment of inertia of rectangle (2) at Y–Y axis.

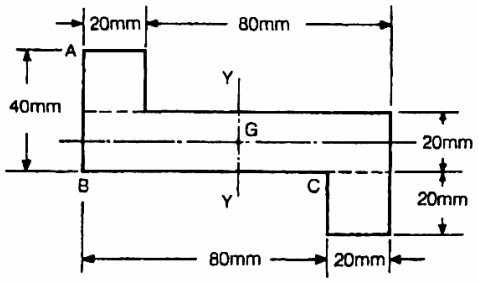
$$I_{YY_2} = \frac{150\times50^3}{12} = 1.5625 \times 10^6 \text{ mm}^4$$

Therefore the moment of inertia of the T-section at Y–Y is-

$$I_{YY} = I_{YY_1} + I_{YY_2} = 14.0625 \times 10^6 + 1.5625 \times 10^6$$

$$= 15.625 \times 10^6 \text{ mm}^4$$

159. A section shown in figure, position of centre and moment of inertia about X-axis will be



(a) 413.34×10^3 mm^4 (b) 313.72×10^3 mm^4

(c) 212.46×10^3 mm^4 (d) 443.35×10^3 mm^4

(RRB Mumbai JE 05.10.2008)

RRB Bhubaneswar Section Engg (Mech.), 19.08.2001

Ans. (a) : Section is symmetric about x-axis & y-axis so distance of centroid G from AB $= \frac{20+80}{2} = 50$ mm

Height of centroid G from BC $= \frac{20}{2} = 10$ mm

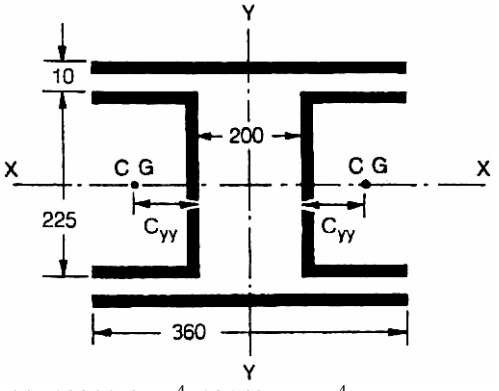
Now moment of inertia about X-X of cross section

$$I_{XX} = \frac{100\times 20^3}{12} + 2\left[\frac{20\times 20^3}{12} + (20\times 20)\times 20^2\right]$$

$= [6.667 + 34.667] \times 10^4$

$= 413.34 \times 10^3$ mm^4

160. A joint section is formed by two channels and two plates. The channels are standard and are spaced 200mm from back to back. The measurement of channel 225mm×80mm. On the flanges of the channel one plate is fixed by rivet at top and bottom as show in figure. The size of the plate is 360mm × 10 mm. The value of I_{xx} and I_{yy} of this combined section. It the area of cross section A = 33.01 cm^2, I_{xx} =2694.6cm^4, I_{vv} = 187.2 cm^2 and C_{vv} = 2.3 cm



(a) 19300.4 cm^4, 18140.57 cm^4
(b) 15335.7 cm^4, 18138.57 cm^4
(c) 17237.5 cm^4, 15138.75 cm^4
(d) 14325.2 cm^4, 16161.77 cm^4

(Konkan Railway STA 2017)

Ans. (b) :

$$I_{XX} = 2\times 2694.6 + 2\left[\frac{36\times 1^3}{12} + 36\times 1(11.25+0.5)^2\right]$$

$= 15335.7$ cm^4

$$I_{YY} = 2\left[187.2 + 33.01(10+2.3)^2 + \frac{1\times 36^3}{12}\right]$$

$= 18138.57$ cm^4

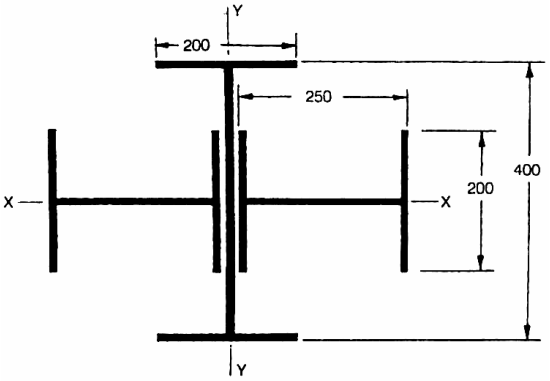
161. A section is made by joining three rolled steel joints in the shape of a cross as shown in the figure. The larger joist is 400mm×200 and the smaller joist is 250mm ×200mm, smaller joists are added to each side of the web of the larger joists. The valve of I_{xx}, I_{yy} and radii of gyration if the properties of the joist are as follow-

Large Joist : A = 85.01 cm^2, web thickness = 8.6 mm

I_{XX} = 23426.7 cm^4, I_{YY} = 1388.0 cm^4,

Shorter Joist :A = 52.05 cm^2, I_{XX} = 5943.1 cm^4

I_{YY} = 857.5 cm^4



(a) 11.53 cm, 12.74 cm (b) 12.73 cm, 15.75 cm
(c) 13.63 cm, 14.64 cm (d) 15.20 cm, 17.18 cm

(RRB Mumbai C&G JE 25.10.2009)

Ans. (a) :

$I_{XX} = 23426.7 + 2 \times 857.5$

$= 25141.7$ cm^4

$$I_{YY} = 1388 + 2\left[5943.1 + 52.05\left(12.5 + \frac{0.86}{2}\right)^2\right]$$

$= 30678.15$ cm^4

$I_{XX} = A\,K_{XX}^2$

$$K_{XX}^2 = \frac{I_{XX}}{A} = \frac{25141.7}{189.11} = 132.947$$

$$K_{YY}^2 = \frac{I_{YY}}{A} = \frac{30678.15}{189.11} = 162.224$$

$\boxed{K_{XX} = 11.53 \text{ cm}}$

$\boxed{K_{YY} = 12.74 \text{ cm}}$

162. According to parallel axis theorem for a plane area A, the M.I. about the axes XX and YY separated by distance r

(a) $I_y = I_x + Ar^2$ (b) $I_y = I_x - Ar^2$

(c) $I_x + I_y = Ar^2$ (d) $\frac{I_x}{I_y} = Ar^2$

(RRB Jammu SSE 09.09.2012)

Ans : (a) The moment of inertia of a body about an axis parallel to the body passing through its centre is equal to the sum of the moment of inertia of the body about the axis passing through the centre and the product of the mass of the body & square of the distance of between the two axes.

So, according to question →

The M.O.I. about the axes X-X and Y-Y separated by distance r -

$I_y = I_x + Ar^2$

[Considering area of the body]

163. M.I. of a hollow circular cross section (inside diameter d and outside diameter D) about horizontal axis is

(a) $\frac{\pi}{16}\left(D^4 - d^4\right)$ (b) $\frac{\pi}{16}\left(D^3 - d^3\right)$

(c) $\frac{\pi}{32}\left(D^4 - d^4\right)$ (d) $\frac{\pi}{64}\left(D^4 - d^4\right)$

(RRB Mumbai SSE 19.12.2010)

RRB Bhubaneswar Section Engg (Mech.), 19.08.2001

Ans : (d) $I_{XX} = \frac{\pi(D^4 - d^4)}{64}$

$I_{YY} = \frac{\pi(D^4 - d^4)}{64}$

$I_{ZZ} = I_{XX} + I_{YY}$

$I_{ZZ} = \frac{\pi(D^4 - d^4)}{64} + \frac{\pi(D^4 - d^4)}{64} = \frac{\pi(D^4 - d^4)}{32}$

164. The M.I. of hollow circular section about a central axis perpendicular to section as compared to its M.I. about horizontal axis is

(a) same (b) double

(c) half (d) four times

(Konkan Railway TA 2017)

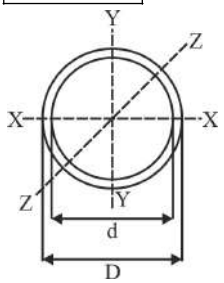
Ans : (b) $I_{XX} = \frac{\pi(D^4 - d^4)}{64}$

$I_{ZZ} = \frac{\pi(D^4 - d^4)}{32}$

$\frac{I_{ZZ}}{I_{XX}} = \frac{\pi(D^4 - d^4)}{32} \Big/ \frac{\pi(D^4 - d^4)}{64}$

$\frac{I_{ZZ}}{I_{XX}} = ?$

$\boxed{I_{ZZ} = 2 \times I_{XX}}$



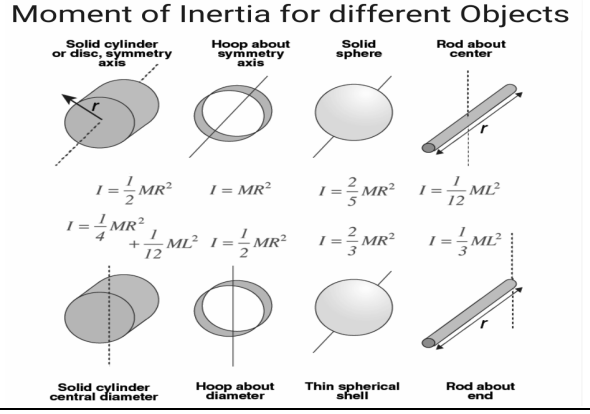
165. Moment of inertia of a right circular cylinder of radius r and mass M about its axis is given by

(a) Mr^2 (b) $\frac{Mr^2}{2}$

(c) $\frac{Mr^2}{4}$ (d) $\frac{Mr^2}{12}$

(RRB Mumbai C&G SSE 25.10.2009)

Ans : (a)



166. Match the correct answer from Group B for the statements given in Group A.

Group A	Group B
(a) C.G. of a rectangle	(i) is at ts centre
(b) C.G. of a triangle	(ii) is at intersection of its diagonals
(c) C.G. of a circle	(iii) is at $\frac{4r}{3\pi}$ from its base along the vertical radius
(d) C.G. of a semicircle	(iv) is at $\frac{h}{4}$ from its base along the vertical axis
(e) C.G. of a hemisphere	(v) is at intersection of its medians
(f) C.G. of a right circular cone	(vi) is at $\frac{3r}{8}$ from its base along the vertical radius

(a) (ii), (v), (i), (iii), (vi), (iv)

(b) (i), (vi), (i), (iii), (v), (iv)

(c) (ii), (vi), (iii), (i), (v), (iv)

(d) (iii), (iv), (i), (ii), (vi), (v)

(RRB Gorakhpur Design SSE 09.09.2012)

Ans. (a) :

Body	Axis of rotation	Moment of Inertia
Uniform circular ring of radius R	Perpendicular to its plane & through the center	MR^2
Uniform circular ring of radius R	diameter	$\frac{MR^2}{2}$
Uniform circular disc of radius R	Perpendicular to its plane through the center	$\frac{MR^2}{2}$
Solid sphere of radius R	diameter	$\frac{2}{5}MR^2$
A hollow sphere of radius R	diameter	$\frac{2}{3}MR^2$

167. Moment of inertia is the :

(a) second moment of force

(b) second moment of area

(c) second moment of mass

(d) all of these

(RRB Malda SSE 25.10.2009)

Ans : (d)

Body	Centre of gravity
Rectangle	Where its diagonal intersect
Uniform rod	At its middle point
Triangle	Where the three medians of triangle intersect

Semicircle	$\frac{4r}{3\pi}$ from its base measured along vertical radius
Hemisphere	$\frac{3r}{8}$ from its base measured along the vertical radius
Right circular solid cone	$\frac{h}{4}$ from its base measured along vertical radius

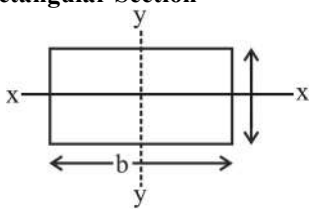
168. Moment of Inertia of a rectangular section having width (b) and depth (d) about an axis passing through its CG and parallel to the depth (d) is

(a) $\frac{db^3}{12}$ (b) $\frac{db^3}{18}$

(c) $\frac{db^3}{6}$ (d) $\frac{db^3}{36}$

(RRB Mumbai SSE 19.12.2010)

Ans. (a) : Rectangular Section–



- Moment of inertia–

$$\boxed{I_{yy} = \frac{db^3}{12}}$$

- An axis passing through its C.G. and parallel to the width (b). Than moment of inertia–

$$\boxed{I_{xx} = \frac{bd^3}{12}}$$

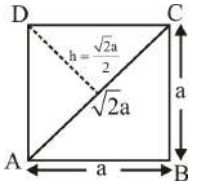
169. The moment of inertia of a square of side 'a' about its diagonal is;

(a) $a^2/12$ (b) $a^3/8$

(c) $a^4/12$ (d) $a^4/16$

(RRB Malda SSE 25.10.2009)

Ans. (c) : The moment of inertia of a square of side 'a' about its diagonal is $a^4/12$.



Diagonal $= \sqrt{2}a$

Height of triangle ACD $= \frac{AC}{2} = \frac{\sqrt{2}a}{2} = \frac{a}{\sqrt{2}}$

M.O.I. of the square about the diagonal

$(I_{square})_{diagonal} = 2\times (I_{triangle})_{Base}$

$= 2\times\frac{bh^3}{12}$

$= \frac{2\times\left(a\sqrt{2}\right)\times\left(\frac{a}{\sqrt{2}}\right)^3}{12}$

$\boxed{(I square)_{diagonal} = \frac{a^4}{12}}$

170. The moment of inertia of a rectangular section 3 cm wide and 4 cm deep about X-X axis passing through centre is-

(a) 9 cm^4 (b) 12 cm^4

(c) 16 cm^4 (d) 20 cm^4

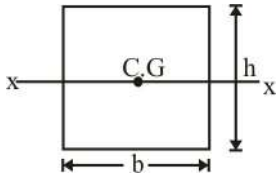
(DMRC JE 22.09.2017)

Ans. (c) : Given, b = 3m, h = 4cm

Moment of inertia about X - X

$I_{xx} = \frac{bh^3}{12}$

$= \frac{3\times 4^3}{12} = 16cm^4$



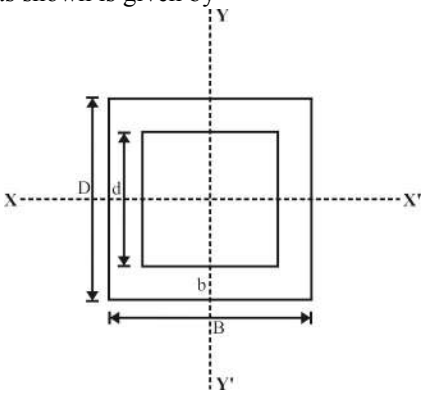
171. Moment of inertia of hallow rectangular section having outer depth 'D' and breadth 'B' and dimension of inner rectangle are depth 'd' and width 'b' about horizontal axis passing through centroid is :

(a) $\frac{BD^3}{12}$ (b) $\frac{bd^3}{12}$

(c) $\frac{BD^3 - bd^3}{12}$ (d) $\frac{BD^2 - bd^2}{12}$

(DMRC JE 2013)

Ans. (c) : The moment of inertia of hollow rectangular section as shown is given by–



when axis passing through centroied

then, $I_{XX} = \frac{BD^3}{12} - \frac{bd^3}{12}$ and

When axis parallel to Y – Y' axis, then

$I_{YY} = \frac{DB^3}{12} - \frac{db^3}{12}$

172. Moment of inertia of a circular section is :

(a) $\frac{\pi d^4}{64}$ b) $\frac{\pi d^4}{16}$

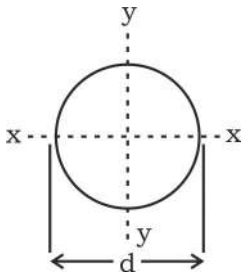
(c) $\frac{\pi d^3}{64}$ (d) None of these

(RRB Kolkata Diesel JE 25.10.2009)

Ans. (a) :

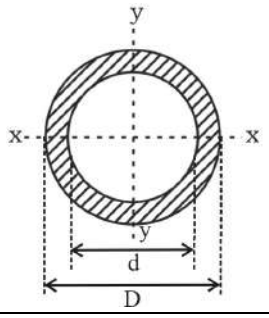
- The moment of inertia of a circular section of diameter, 'd'.

$$I_{xx} = I_{yy} = \frac{\pi d^4}{64}$$



- the moment of inertia of a hollow circular section of outer diameter D and inner diameter d,

$$\boxed{I_{xx} = I_{yy} = \frac{\pi}{64}\left(D^4 - d^4\right)}$$



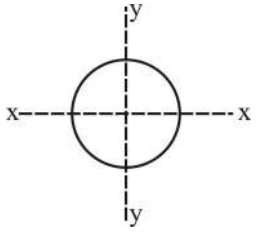
173. Moment of Inertia of a circular section about an axis perpendicular to the sections is

(a) $\pi d^3/16$ (b) $\pi d^3/32$

(c) $\pi d^4/32$ (d) $\pi d^4/64$

(RRB Allahabad JE 25.10.2009)

Ans. (c) : Moment of inertia of a circular section about an axis perpendicular to the section is $\pi d^4/32$.



Moment of inertia about x-x axis is–

$I_{xx} = \pi d^4/64$

Moment of inertia about y-y axis is–

$I_{yy} = \pi d^4/64$

According to perpendicular axis theorem–

$$I_{zz} = I_{xx} + I_{yy}$$

$$I_{zz} = \frac{\pi d^4}{64} + \frac{\pi d^4}{64}$$

$$\boxed{I_{zz} = \frac{\pi d^4}{32}}$$

174. A polar moment of Inertia for hollow shaft with external diameter and internal diameter is given by:

(a) $\frac{\pi\left(D^3 - d^3\right)}{32}$ (b) $\frac{\pi\left(D^4 - d^4\right)}{32}$

(c) $\frac{\pi\left(D^3 - d^3\right)}{16}$ (d) $\frac{\pi\left(D^2 - d^2\right)}{8}$

(RRB Allahabad SSE 09.09.2012)

Ans. (b) : A polar moment of Inertia for hollow shaft with external diameter and internal diameter is given by $\frac{\pi\left(D^4 - d^4\right)}{32}$.

175. Moment of inertia of a body does not depend upon :

(a) angular velocity of the body

(b) mass of the body

(c) distribution of mass in the body

(d) axis of rotation of body

(RRB Kolkala SSE 09.09.2012)

Ans. (a) : Moment of Inertia– Moment of inertia or moment of mass is defined as the sum of the product of the mass of every particle with its square of a distance from the axis of rotation.

Moment of mass about x - axis

$$I_{xx} = \frac{\int \rho a v y^2}{\int \rho dv} \quad .....(1)$$

$$I_{yy} = \frac{\int \rho a v x^2}{\int \rho dv} .....(2)$$

Equation (1) & (2) Show that moment of inertia or moment of mass depends upon mass of body (dm), distribution of mass in the body (ρ) and axis of rotation (I_{xx} & I_{yy})

176. Mass moment of inertia has unit of _____

(a) kg-m^2 (b) kg-m^4

(c) kg/m^2 (d) kg/m^4

(RRB Bhubneshwar JE-II 19.12.2010)

Ans. (a) : Mass moment of inertia is the second moment of mass of the body.

and $\boxed{I = mk^2}$ kg-m^2

- Area moment of inertia has unit of m^4 or mm^4.

177. The units of moment of inertia of an area are

(a) kg m^2 (b) m^4

(c) kg/m^2 (d) m^3

(DMRC JE 2013)

RRB Bhubaneswar Section Engg (Mech.) , 19.08.2001

Ans. (b) The unit of moment of inertia of an area is m^4.

- Moment of inertia may be defined as the moment of moment i.e. second moment of area or mass of a body.
- Moment of inertia of area = ak^2
- Moment of inertia of mass = mk^2

Where (k = Radius of gyration)

Note – In S.I. units, the unit of mass moment of inertia is kg-m^2 and the moment of inertia of the area is expressed in m^4 or mm^4.

7. Motion of Projectile

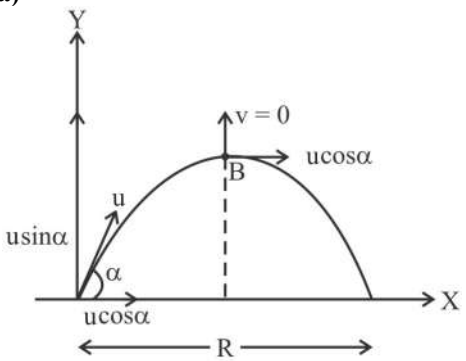
178. If 'α' is angle of projection and 'u' is velocity of projection for a projectile, then its horizontal range is given by:

(a) $R = (u^2 \sin 2\alpha)/g$ (b) $R = (u^2 \sin\alpha) / g$

(c) $R = (u^2 \cos 2\alpha)/g$ (d) $R = (u^2 \cos\alpha)/g$

RRB JE 31-08-2019

Ans. (a)



(1) Horizontal range

$$R = \frac{u^2 \sin 2\alpha}{g}$$

R will be max, if $\alpha = 45^0$

(2) Time of flight

$$(T) = 2t = \frac{2u \sin\alpha}{g}$$

(3) Maximum height

$$(H) = \frac{u^2 \sin^2\alpha}{2g}$$

179. A person standing on a tower of height 60m throws an object upwards with a velocity of 40m/s at an angle 30° to horizontal. Find the total time taken by the object to gain maximum height and fall on the ground (take g = 10m/s^2)

(a) 3 s (b) 20 s

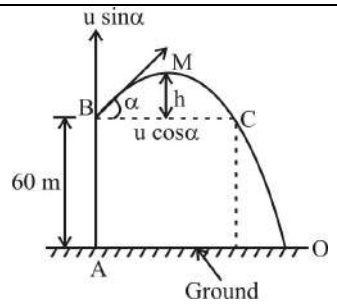
(c) 6 s (d) 16 s

(Konkan Railway STA 2017)

Ans : (c) Given, u = 40 m/s, $\alpha = 30^o$, h = 60 m

Let time taken by the object to gain maximum height is t_1 and then to fall on the ground is t_2

$T = t_1 + t_2 = ?$



$$\because \quad h = \frac{u^2 \sin^2\alpha}{2g} = \frac{40^2 \times \sin^2 30}{2 \times 10} = \frac{40 \times 40 \times \frac{1}{4}}{20}$$

$= 20$ m

$$t_1 = \frac{u \sin\alpha}{g} = \frac{40 \times \frac{1}{2}}{10} = 2 \sec$$

When body fall after reaching point 'M'

Then, H = h + 60 = 20 + 60 = 80 m

Then $H = u' t_2 + \frac{1}{2} g t_2^2$

(u' = initial velocity at point M = 0)

$$80 = 0 + \frac{1}{2} \times 10 \times t_2^2$$

$t_2 = 4$ sec

Then, $T = t_1 + t_2 = 2 + 4$

$= 6$ sec

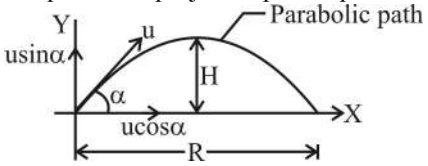
180. For a maximum horizontal range, the angle of projection of a projectile should be-

(a) 30° (b) 45°

(c) 60° (d) 75°

(RRB Gorakhpur RDSO SSE 25.10.2009)

Ans. (b) : Equation of projectile path is parabola,



$$y = x \tan\alpha - \frac{gx^2}{2u^2 \cos^2\alpha}$$

Time of flight $(T) = \frac{2u \sin\alpha}{g}$

Horizontal range $(R) = \frac{u^2 \sin 2\alpha}{g}$

$$R_{max} = \frac{u^2}{g} \quad \text{when, } \alpha = 45°$$

So, for maximum range (horizontal), the angle of projection of a projectile should be 45°.

181. A ball is projected up vertically with a velocity of 9.8 m/s. The time it takes to reach the ground is

(a) 0.5 s (b) 4 s

(c) 2 s (d) 9.8 s

(RRB Allahabad SSE 09.09.2012)

Ans. (c) : When ball is projected up vertically, then time taken to reach maximum height–

$$t = \frac{u\sin\alpha}{g} \qquad \left(\because\ \alpha = 90^0\right)$$

$$\therefore \qquad t = \frac{9.8\sin 90°}{9.8} = 1\,\text{sec}$$

Total time taken to reach the ground = $2t = 2 \times 1$

$$\boxed{T = 2\,\text{sec}}$$

182. A particle is projected at such an angle with the horizontal that the maximum height attained by the particle is one-fourth of the horizontal range. The angle of projection should be :

(RRB Chandigarh SSE 09.09.2012)

(a) 30° (b) 45°
(c) 60° (d) 15°

Ans : (b) Horizontal range $\left(R\right) = \frac{u^2\sin 2\alpha}{g}$

Maximum height $(H_{max}) = \frac{u^2\sin^2\alpha}{2g}$

According to question,

$$(H_{max}) = \frac{1}{4} \times (R)$$

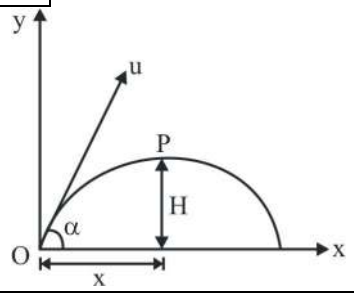
$$\frac{u^2\sin^2\alpha}{2g} = \frac{1}{4}\frac{u^2\sin 2\alpha}{g}$$

$$\frac{u^2\sin^2\alpha}{2g} = \frac{1}{4}\frac{u^2 \times 2\sin\alpha\cos\alpha}{g}$$

$\sin\alpha = \cos\alpha$

$\tan\alpha = 1$

$\boxed{\alpha = 45°}$



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

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

(c) $h = \frac{1}{2}\frac{u^2}{g}$ (d) $h = \frac{1}{4}\frac{u^2}{g}$

(RRB Bhubneshwar JE II 29.11.2008)

Ans. (c) Initial velocity = u, and final velocity = v
gravitational acceleration = g, maximum height = h

$v^2 = u^2 - 2gh$

maximum height at final velocity $v = 0$

$0 = u^2 - 2gh$

$$\Rightarrow \qquad \boxed{h = \frac{u^2}{2g}}$$

184. If the velocity of projection is u m/sec and the angle of projection is α°, the maximum height of the projectile on a horizontal plane is

(a) $\frac{u^2\cos^2\alpha}{2g}$ (b) $\frac{u^2\sin^2\alpha}{2g}$

(c) $\frac{u^2\tan^2\alpha}{2g}$ (d) $\frac{u^2\sin^2\alpha}{g}$

(RRB Jammu SSE 09.09.2012)

Ans : (b) Projectile motion–

(Maximum height) $H_{max} = \frac{u^2\sin^2\alpha}{2g}$

(Range) $R = \frac{u^2\sin 2\alpha}{g}$

Range is maximum when $\alpha = 45°$

$$\boxed{R_{max} = \frac{u^2}{2g}}$$

Time of flight $(T) = \frac{2u\sin\alpha}{g}$

185. The total time taken by a projectile to reach maximum height and to return back to the ground, is known as.

(a) time of flight (b) range
(c) time of range (d) time of rotation

(RRB Chandigarh SSE 25.10.2009)
RRB Kolkata Engg. (P.Way), 20.02.2000

Ans : (a) Total time taken by a projectile to reach maximum height and to return back to ground is known as time of flight

$$\boxed{T = \frac{2u\sin\alpha}{g}}$$

u = Initial velocity
α = Angle of projection with the horizontal.

186. The path of the projectile is.

(a) a parabola (b) circle
(c) ellipse (d) hyperbola

(RRB Jammu JE 25.10.2009)

Ans : (a) Cartesian equation–

$$Y = x\tan\alpha - \frac{gx^2}{2u^2\cos^2\alpha}$$

Since, this is the equation of a parabola, therefore, the path

187. The distance, between the point of projection and the point where the projectile strikes the ground, is known as.

(a) range (b) height
(c) time of flight (d) none of these

(RRB Bhopal TM SSE 25.10.2009)

Ans : (a) In case of projectile motion, distance between the point of projection and the point where the projectile strikes the ground is known as range

$\text{Range}(R) = \dfrac{u^2 \sin 2\alpha}{g}$

Range will be maximum if $\boxed{\alpha = 45^\circ}$

188. The time of flight (t) of a projectile on an upward inclined plane is:

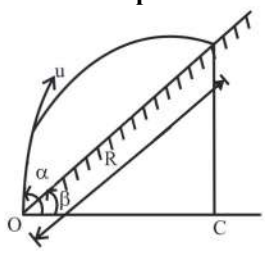
(RRB Mumbai C&G SSE 25.10.2009)

(a) $t = \dfrac{g\cos\beta}{2u\sin(\alpha-\beta)}$ (b) $t = \dfrac{2u\sin(\alpha-\beta)}{g\cos\beta}$

(c) $t = \dfrac{g\cos\beta}{2u\sin(\alpha+\beta)}$ (d) $t = \dfrac{2u\sin(\alpha+\beta)}{g\cos\beta}$

where, u = Velocity of projection
α = Angle of projection, and
β = Inclination of the plane with the horizontal

Ans : (b) Upward inclined plane–



Time of flight (T) $= \dfrac{2u\sin(\alpha-\beta)}{g\cos\beta}$

Range (R) $= \dfrac{2u^2 \sin(\alpha-\beta)\cos\alpha}{g\cos^2\beta}$

189. The time of flight of a projectile on downward inclined plane depends upon:

(a) angle of projection
(b) angle of inclination of the plane
(c) both (a) and (b)
(d) none of these

(RRB Mumbai SSE 05.10.2008)

Ans : (c) Downward inclined plane–

$T = \dfrac{2u\sin(\alpha+\beta)}{g\cos\beta}$

Range (R) $= \dfrac{2u^2 \sin(\alpha+\beta)\cos\alpha}{g\cos^2\beta}$

α = Angle of projection
β = Inclination of plane with the horizontal

190. The range of projectile (R) on an upward inclined plane is:

(a) $\dfrac{g\cos^2\beta}{2u^2\sin(\alpha+\beta)\cos\alpha}$

(b) $\dfrac{2u^2\sin(\alpha+\beta)\cos\alpha}{g\cos^2\beta}$

(c) $\dfrac{g\cos^2\beta}{2u^2\sin(\alpha-\beta)\cos\alpha}$

(d) $\dfrac{2u^2\sin(\alpha-\beta)\cos\alpha}{g\cos^2\beta}$

(RRB Bhubneshwar JE-II 19.12.2010)

Ans : (d) Upward inclined plane–

Range of projectile (R) = $\dfrac{2u^2\sin(\alpha-\beta)\cos\alpha}{g\cos^2\beta}$

Range will be maximum, when:

$\boxed{\alpha = 45^\circ + \dfrac{\beta}{2}}$

191. The range of projectile will be maximum for a given velocity of projectile, when the angle of projection (α) is:

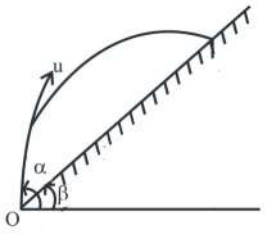
(a) $\dfrac{\beta}{2}$ (b) $\dfrac{30^\circ+\beta}{2}$

(c) $45^\circ + \dfrac{\beta}{2}$ (d) $\dfrac{60^\circ+\beta}{2}$

(JMRC JE 10.06.2017)

Ans : (c) In case of upward inclined plane, range of projectile will be maximum when

$\boxed{\alpha = 45^\circ + \dfrac{\beta}{2}}$



α = angle of projection with horizontal.

192. The range of projectile on a downward inclined plane is ..... the range on upward inclined plane for the same velocity of projection and angle of projection.

(a) less than (b) more than
(c) equal to (d) None of these

(RRB Allahabad SSE 19.12.2010)

Ans : (b) Upward inclined plane,

$R_U = \dfrac{2u^2\sin(\alpha-\beta)\cos\alpha}{g\cos^2\beta}$

Downward inclined plane,

$R_D = \dfrac{2u^2\sin(\alpha+\beta)\cos\alpha}{g\cos^2\beta}$

$\boxed{R_D > R_U}$

193. A projectile fired at 45° attains a maximum height of 40 m. Its range will be

(Konkan Railway SSE 2015)

(a) 20 m (b) 40 m
(c) 80 m (d) 160 m

Ans : (d) Angle of projection (α) = 45°

H_{max} = 40 m

$$\boxed{H_{max} = \frac{u^2 \sin^2 \alpha}{g}}$$

$$40 = \frac{u^2 \sin^2 45^\circ}{2 \times g}$$

$$40 = \frac{u^2}{2g} \times \frac{1}{2}$$

$$\boxed{80 = \frac{u^2}{2g}} \quad \text{..... (i)}$$

$$\text{Range (R)} = \frac{u^2 \sin^2 \alpha}{g}$$

from eq. (i) $\frac{u^2}{g} = 160$

R = 160 × sin 90

$\boxed{R = 160 \text{ m}}$

194. The maximum height of a projectile on a horizontal plane, is:

(a) $\frac{u^2 \sin^2 \alpha}{2g}$ (b) $\frac{u^2 \cos^2 \alpha}{2g}$

(c) $\frac{u^2 \sin^2 \alpha}{g}$ (d) $\frac{u^2 \cos^2 \alpha}{g}$

(RRB Allahabad JE 09.09.2012)

Ans : (a) Projectile motion–

Maximum height $\left(H_{max}\right) = \frac{u^2 \sin^2 \alpha}{2g}$

The time of flight (t)	$\frac{2u \sin \alpha}{g}$
The horizantal Range (R)	$\frac{u^2 \sin 2\alpha}{g}$

For given velocity of projectile the range will be maximum when $\sin 2\alpha = 1$ (or) $\alpha = 45^\circ$.

195. The direction of projectile for the range to be maximum on the inclined plane of 30° to horizontal should be

(a) 30° with vertical (b) 45° with vertical

(c) 60° with vertical (d) none of the above

(RRB Allahabad SSE 09.09.2012)

Ans : (a) In case of inclined plane,

Range will be maximum $\boxed{\alpha = 45 + \frac{\beta}{2}}$

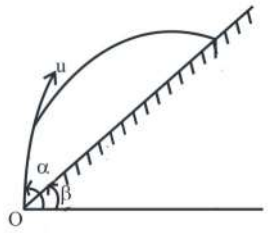
Inclination of plane with the horizontal (β) = 30°

$$\alpha = 45 + \frac{30}{2} = 60^\circ$$

$\boxed{\alpha = \text{Angle of projection with horizontal}}$

Angle of projection with vertical = 90 – α

= 90 – 60 = 30°



196. A ball is projected vertically upward with a certain velocity. It takes 40 seconds for its upwards journey. The time taken for its downward journey is

(a) 10 s (b) 20 s

(c) 30 s (d) 40 s

(RRB Bhopal SSE 09.09.2012)

Ans : (d)

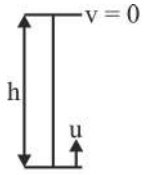


Fig. (1)

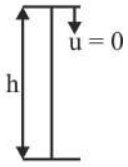


Fig. (2)

$v = u - gt$

v = Final velocity

g = gravitational acceleration

t = time

$0 = u - 10 \times 40$

$u = 400$ m/sec

$v^2 = u^2 - 2gh$

$0 = u^2 - 2gh$

$u^2 = 2gh$

$$h = \frac{400 \times 400}{2 \times 10} = 8000 \text{ m}$$

$$h = ut + \frac{1}{2}gt^2$$

$\boxed{u = 0}$

$$h = \frac{1}{2}gt'^2$$

$$t'^2 = \frac{8000 \times 2}{10}$$

$t' = 40$ sec

197. Range of a projectile is equal to height of projectile when angle of projection is

(Konkan Railway TA 2017)

(a) $\tan^{-1}(4)$ (b) $\tan^{-1}(2)$

(c) $\tan^{-1}(1)$ (d) none of above

Ans : (a) Range of a projectile (R) $= \frac{u^2 \sin 2\alpha}{g}$

Height of projectile (H) $= \frac{u^2 \sin^2 \alpha}{2g}$

Range = Height of projectile

$$\frac{u^2 \sin 2\alpha}{g} = \frac{u^2 \sin^2 \alpha}{2g}$$

$$2 \sin\alpha \cos\alpha = \frac{\sin^2 \alpha}{2}$$

$4 \cos\alpha = \sin\alpha$

$\tan\alpha = 4$

$\boxed{\alpha = \tan^{-1}(4)}$

198. Which of the following statement is correct in connection with projectiles?

(a) A path, traced by a projectile in the space, is known as trajectory

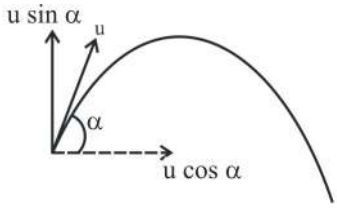
(b) The velocity with which a projectile is projected, is known as the velocity of projection

(c) The angle, with the horizontal, at which a projectile is projected is known as angle of projection

(d) All of the above

(RRB Gorakhpur RDSO SSE 25.10.2009)

Ans : (d)



Important terms in case of projectile motion–

1. Trajectory–A path traced by a projectile in a space

2. Velocity of projection –The velocity with which projectile is projected.

3. Angle of projection–The angle with the horizontal, at which a projectile is projected is known as angle of projection.

So, in this all of the above options are correct.

199. The Cartesian equation of trajectory is

(RRB Patna JE 25.10.2009)

RRB Kolkata Apprentice Engg., 14.10.2001

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

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

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

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

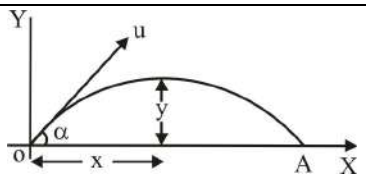
Where u = Velocity of projection

α = Angle of projection, and

x, y = co-ordinates of any point on the trajectory after t seconds.

Ans : (c) Cartesian equation,

$$\boxed{y = x \tan \alpha - \frac{gx^2}{2u^2 \cos^2 \alpha}}$$



Consider a point P as the position of particle, after time t seconds with x and y as co-ordinates.

The equation of the path of a projectile or the equation of trajectory is-

$$y = x \tan \alpha - \frac{g.x^2}{2u.\cos^2 \alpha}$$

Since this is the equation of a parabola, therefore the path traced by a projectile is a parabola.

8. Law of Motion

200. The frequency of a sound wave is 50 Hz and its wavelength is 4m. What is the distance travelled by the sound wave in 3 s?

(a) 200 m (b) 300 m

(c) 100 m (d) 600 m

RRB JE 29-08-2019

Ans. (d) : Given :

Frequency = 50 Hz

Wavelength = 4 m

So, the velocity of wave = Frequency × Wavelength

= 50 × 4

= 200 m/s

So, the distance traveled by the sound wave in 3 second is 200 × 3 = 600 m

201. Which of the following equation of motion can be used to determine distance or displacement travelled by a body directly?

(a) $s = ut + (at^2 / 2)$

(b) $v^2 - u^2 = 2as$

(c) $v = u + at$

(d) Both $v^2 - u^2 = 2as$ and $s = ut + (at^2 / 2)$

RRB JE 30-08-2019

Ans. (d) : The second equation of motion $s = ut + (at^2 / 2)$ and third equation of motion $v^2 - u^2 = 2as$ can be used to determine distance or displacement travelled by a body directly.

202. What is the magnitude of the maximum disturbance in the medium on either side of the mean value called?

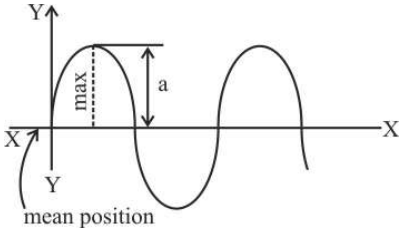
(a) Frequency (b) Oscillation

(c) Amplitude (d) Wavelength

RRB JE 31-08-2019

Ans. (c) The magnitude of the maximum disturbance or displacement in the medium on either side of the mean value is called amplitude.

a = amplitude



203. A man pulls a cart of mass 100 kg and produces in acceleration of 2 m/sec^2. What is the force exerted by the man?

(a) 250 N (b) 150 N
(c) 100 N (d) 200 N

DMRC JE 17.04.2018 12:15-2:30 PM

Ans : (d) m = 100 kg, a = 2 m/sec^2

$\boxed{F = ma}$

$F = 100 \times 2$

$\boxed{F = 200\ N}$

204. Newton's Second law of motion gives a relation between force, mass and.....

(a) velocity (b) displacement
(c) acceleration (d) time

DMRC JE 17.04.2018, 4:30-6:45pm

Ans : (c) According to Newton's second law of motion–Rate of change of momentum is directly proportional to applied force,

$$F \propto \frac{dp}{dt}$$

$$F \propto \frac{d(mv)}{dt}$$

$\boxed{F \propto m.a}$

$\boxed{F = m.a}$

F = External force
m = Mass
a = acceleration

205. The relation F = m × a is based on.....

(a) Newton's third law of motion
(b) D' Alembert's principle
(c) Newton's first law of motion
(d) Newton's second law of motion

DMRC JE 17.04.2018, 4:30-6:45pm

Ans : (d) $\boxed{F = ma}$

- It is based on Newton's second law of motion.

Note–
Newton's Ist law of motion – define force
Newton's IInd law of motion – tells about magnitude of force.

206. A bucket of water of 50 kg is lifted vertically upwards with a uniform acceleration of 0.5 m/s^2 (g = 10 m/s^2) calculate the tension in the rope?

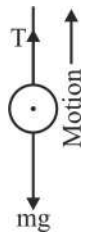
(a) 525 N (b) 475 N
(c) 25 N (d) 52.5 N

(RRB Gorakhpur Design SSE 09.09.2012)

Ans. (a) : Given that-

m = 50 kg, a = 0.5 m/s^2, g = 10 m/s^2

F = m.a = T – mg



$F_{net} = T - mg \quad (\because T > mg)$

ma = T – mg

Tension in the rope when raised-

(T) = ma + mg = m (a + g)

= 50 (0.5 + 10) = 525 N

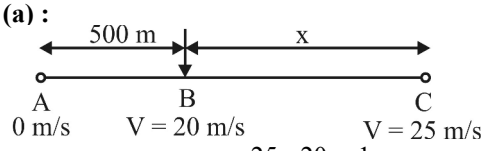
$\therefore \quad \boxed{T = 525\ N}$

207. A car starts from rest and accelerates uniformly to a speed of 72 km per hour over 500 m. If a further acceleration raises the speed to 90 km per hour in 10 seconds. The further distance moved by car is.....

(a) 225 m (b) 200 m
(c) 150 m (d) 250 m

(RRB Allahabad JE 09.09.2012)

Ans. (a) :



Acceleration from B to C $= \frac{25-20}{10} = \frac{1}{2}\ m/s^2$

$$S = ut + \frac{1}{2}at^2$$

$$= 20 \times 10 + \frac{1}{2}\left(\frac{1}{2}\right).10^2$$

$\boxed{S = 225\ m}$

208. The velocity of a mass of 5 kg after falling a height of 5 m from rest would be approximately equal to:

(a) 5 m/sec (b) 10 m/sec
(c) 25 m/sec (d) 50 m/sec

(Konkan Railway STA 2017)

Ans. (b) m = 5 kg

h = 5 m

u = 0

$\boxed{v^2 = u^2 + 2gh}$

$v^2 = 2 \times 10 \times 5$

$v^2 = 100$

$\boxed{v = 10\ m/sec}$

209. A ball of mass 1kg moving with the velocity of 2m/s collide directly with another stationary ball of mass 2kg and comes to rest after impact. The velocity of second ball after impact is:

(a) Zero (b) 0.5 m/s
(c) 1.0 m/s (d) 2.0 m/s

(RRB Gorakhpur RDSO SSE 25.10.2009)

Ans : (c) According to the law of momentum conservation equation–

Momentum before collision=Momentum after collision

$$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$$
$$1 \times 2 + 2 \times 0 = 1 \times 0 + 2 \times v_2$$
$$2 = 2v_2$$
$$v_2 = 1.0 \text{ m/s}$$

210. A body moves, from rest with a constant acceleration of 5 m/s^2. The distance covered in 5 sec. is:

(a) 25 m (b) 62.5 m
(c) 50 m (d) 125 m

(RRB Banglore SSE 09.09.2012)

Ans : (b) Given,

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

$t = 5$ sec.

Then,

$$\because \quad s = ut + \frac{1}{2}at^2$$
$$= 0 \times 5 + \frac{1}{2} \times 5 \times 5^2 = 62.5 \text{ m}$$

$\boxed{s = 62.5 \text{ m}}$

211.If a ball which is dropped from a height of 2.25 m on a smooth floor attains the height of bounce equal to 1.00m, the coefficient of the restitution between the ball and the floor is equal to :

(a) 0.25 (b) 0.50
(c) 0.67 (d) 0.33

(Konkan Railway SSE 2015)

Ans : (c) Given,

The height of the body to be dropped (h) = 2.25 m

The height of body after hitting to floor (x) = 1 m, e =?

$$\because \quad x = e^2h$$
$$e = \sqrt{\frac{1}{2.25}} = 0.67$$

Where,

e = coefficient of the restitution.

212. Thrust generation in the rocket propulsion is based on the following:

(a) Newton's second law of motion
(b) Buoyancy force
(c) Pascal's law
(d) Newton third law of motion

(RRB Mumbai C&G SSE 25.10.2009)

Ans. (d) : Thrust generation in the rocket propulsion is based on Newton's third law of motion.

Newton's third law of motion–When two bodies interact, they apply forces to one another that are equal in magnitude and opposite in direction.

213. The acceleration of a body is expressed by-

(a) $\frac{dv}{dt}$ (b) $\frac{d^2s}{dt^2}$

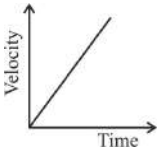
(c) $v\frac{dv}{ds}$ (d) All of the above

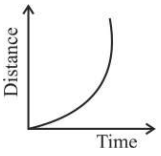
(BMRCL JE 24 Feb. 2019)

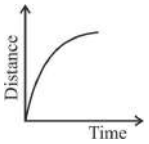
Ans. (d) : Acceleration is a vector quantity as it has both magnitude and direction .

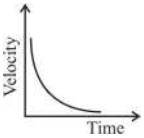
- It is the first derivative of velocity with respect to time i.e. (dv/dt).
- It is the second derivative of position with respect to time i.e. (d^2s/dt^2).
- It is the product of velocity and first derivative of velocity with respect to position i.e. v (dv/ds).

214. Choose the CORRECT graph for the motion of an object moving with the linearly increasing acceleration with respect to time.

(a) 

(b) 

(c) 

(d) 

(DMRC JE 20.04.2018)

Ans. (b)

$a = f(t)$

acceleration is linear function of time ($a = t$)

$$a = \frac{dv}{dt}$$
$$t = \frac{dv}{dt}$$
$$\int dv = \int t\,dt$$
$$v = \frac{t^2}{2} + c_1$$
$$\frac{dx}{dt} = \left(\frac{t^2}{2} + c_1\right)$$
$$\int dx = \int \left(\frac{t^2}{2} + c_1\right) dt$$
$$x = \frac{t^3}{6} + c_1t + c_2$$

Above equation indicate cubic relation between time and distance.

So, correct graph for linearly increasing acceleration with respect to time–