GATE WALLAH

TOPIC WISE PREVIOUS YEAR QUESTIONS WITH VIDEO SOLUTIONS

MECHANICAL ENGINEERING

- Fully solved with explanations
- Embedded QR code for Videos solutions
- Thoroughly analyzed solved papers

2008 – 2023

11 STUDENTS SCORED UNDER AIR 20

MOST AFFORDABLE
QUALITY CONTENT, INDIA'S BEST FACULTY TEAM

• GATE 2023 RESULTS •

RESULTS HON TOH KAISE – PW JAISE!

2 STUDENTS SCORED UNDER AIR 10	11 STUDENTS SCORED UNDER AIR 20	45+ STUDENTS SCORED UNDER AIR 100	300+ STUDENTS SCORED UNDER AIR 1000

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GATE WALLAH

TOPICWISE

GATE PREVIOUS YEAR QUESTIONS

2008 – 2023

MECHANICAL ENGINEERING

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PREFACE

A highly skilled professional team of GATE Wallah works arduously to ensure that the students receive the best content for their **GATE** exam.

A plethora of GATE Study Material is available in the market but GATE Wallah professionals at PW are continuously working to provide supreme quality study material for the GATE students.

From the beginning, the content team comprising Subject Matter Experts, Content Creators, Reviewers, DTP operators, Proofreaders, and others is involved in shaping the material to their best knowledge and experience to produce powerful content for the students.

GATE Wallah Faculties have adopted a novel style of presenting the content in easy-to-understand language and have provided the content team with expert guidance and supervision throughout the creation and curation of this book.

PW's GATE Wallah strongly believes in conceptual and fun-based learning. GATE Wallah provides highly exam-oriented content to bring quality and clarity to the students.

This book adopts a multi-faceted approach to mastering and understanding the concepts by having a rich diversity of questions asked in the examination and equipping the students with the knowledge for this highly competitive exam.

The main objective of this book is to provide an edge to your preparation with high-quality content & video solutions.

BOOK FEATURES

This book, especially designed for GATE aspirants, contains

- a Topic-wise set of questions from the past 16 years (2008-2023)
- Embedded QR codes for Video Solutions (by expert faculties)
- Complete explanations to help you ace your exam
- Detailed Chapter Wise Analysis of PYQs

GATE Mechanical Engineering Complete Syllabus

SECTION 1 : ENGINEERING MATHEMATICS

- **Linear Algebra:** Matrix algebra, systems of linear equations, eigenvalues and eigenvectors.
- **Calculus:** Functions of single variable, limit, continuity and differentiability, mean value theorems, indeterminate forms; evaluation of definite and improper integrals; double and triple integrals; partial derivatives, total derivative, Taylor series (in one and two variables), maxima and minima, Fourier series; gradient, divergence and curl, vector identities, directional derivatives, line, surface and volume integrals, applications of Gauss, Stokes and Green's theorems.
- **Differential Equations:** First order equations (linear and nonlinear); higher order linear differential equations with constant coefficients; Euler-Cauchy equation; initial and boundary value problems; Laplace transforms; solutions of heat, wave and Laplace's equations.
- **Complex Variables:** Analytic functions; Cauchy-Riemann equations; Cauchy's integral theorem and integral formula; Taylor and Laurent series.
- **Probability and Statistics:** Definitions of probability, sampling theorems, conditional probability; mean, median, mode and standard deviation; random variables, binomial, Poisson and normal distributions.
- **Numerical Methods:** Numerical solutions of linear and non-linear algebraic equations; integration by trapezoidal and Simpson's rules; single and multi-step methods for differential equations.

SECTION 2: APPLIED MECHANICS AND DESIGN

- **Engineering Mechanics:** Free-body diagrams and equilibrium; friction and its applications including rolling friction, belt-pulley, brakes, clutches, screw jack, wedge, vehicles, etc.; trusses and frames; virtual work; kinematics and dynamics of rigid bodies in plane motion; impulse and momentum (linear and angular) and energy formulations; Lagrange's equation.
- **Mechanics of Materials:** Stress and strain, elastic constants, Poisson's ratio; Mohr's circle for plane stress and plane strain; thin cylinders; shear force and bending moment diagrams; bending and shear stresses; concept of shear centre; deflection of beams; torsion of circular shafts; Euler's theory of columns; energy methods; thermal stresses; strain gauges and rosettes; testing of materials with universal testing machine; testing of hardness and impact strength.
- **Theory of Machines:** Displacement, velocity and acceleration analysis of plane mechanisms; dynamic analysis of linkages; cams; gears and gear trains; flywheels and governors; balancing of reciprocating and rotating masses; gyroscope.
- **Vibrations:** Free and forced vibration of single degree of freedom systems, effect of damping; vibration isolation; resonance; critical speeds of shafts.
- **Machine Design:** Design for static and dynamic loading; failure theories; fatigue strength and the SN diagram; principles of the design of machine elements such as bolted, riveted and welded joints; shafts, gears, rolling and sliding contact bearings, brakes and clutches, springs.

SECTION 3: FLUID MECHANICS AND THERMAL SCIENCES

- **Fluid Mechanics:** Fluid properties; fluid statics, forces on submerged bodies, stability of floating bodies; control-volume analysis of mass, momentum and energy; fluid acceleration; differential equations of continuity and momentum; Bernoulli's equation; dimensional analysis; viscous flow of incompressible fluids, boundary layer, elementary turbulent flow, flow through pipes, head losses in pipes, bends and fittings; basics of compressible fluid flow.
- **Heat-Transfer:** Modes of heat transfer; one dimensional heat conduction, resistance concept and electrical analogy, heat transfer through fins; unsteady heat conduction, lumped parameter system, Heisler's charts; thermal boundary layer, dimensionless parameters in free and forced convective heat transfer, heat transfer correlations for flow over flat plates and through pipes, effect of turbulence; heat exchanger performance, LMTD and NTU methods; radiative heat transfer, Stefan- Boltzmann law, Wien's displacement law, black and grey surfaces, view factors, radiation network analysis
- **Thermodynamics:** Thermodynamic systems and processes; properties of pure substances, behavior of ideal and real gases; zeroth and first laws of thermodynamics, calculation of work and heat in various processes; second law of thermodynamics; thermodynamic property charts and tables, availability and irreversibility; thermodynamic relations.
- **Applications:** Power Engineering: Air and gas compressors; vapour and gas power cycles, concepts of regeneration and reheat. I.C. Engines: Air-standard Otto, Diesel and dual cycles.
- **Refrigeration and air-conditioning:** Vapour and gas refrigeration and heat pump cycles; properties of moist air, psychrometric chart, basic psychrometric processes. Turbomachinery: Impulse and reaction principles, velocity diagrams, Pelton-wheel, Francis and Kaplan turbines; steam and gas turbines.

SECTION 4: MATERIALS, MANUFACTURING AND INDUSTRIAL ENGINEERING

- **Engineering Materials:** Structure and properties of engineering materials, phase diagrams, heat treatment, stress-strain diagrams for engineering materials.
- **Casting, Forming and Joining Processes:** Different types of castings, design of patterns, moulds and cores; solidification and cooling; riser and gating design. Plastic deformation and yield criteria; fundamentals of hot and cold working processes; load estimation for bulk (forging, rolling, extrusion, drawing) and sheet (shearing, deep drawing, bending) metal forming processes; principles of powder metallurgy. Principles of welding, brazing, soldering and adhesive bonding.
- **Machining and Machine Tool Operations:** Mechanics of machining; basic machine tools; single and multi-point cutting tools, tool geometry and materials, tool life and wear; economics of machining; principles of non-traditional machining processes; principles of work holding, jigs and fixtures; abrasive machining processes; NC/CNC machines and CNC programming.
- **Metrology and Inspection:** Limits, fits and tolerances; linear and angular measurements; comparators; interferometry; form and finish measurement; alignment and testing methods; tolerance analysis in manufacturing and assembly; concepts of coordinate-measuring machine (CMM).
- **Computer Integrated Manufacturing:** Basic concepts of CAD/CAM and their integration tools; additive manufacturing.
- **Production Planning and Control:** Forecasting models, aggregate production planning, scheduling, materials requirement planning; lean manufacturing.
- **Inventory Control:** Deterministic models; safety stock inventory control systems.
- **Operations Research:** Linear programming, simplex method, transportation, assignment, network flow models, simple queuing models, PERT and CPM.

SPECIAL ABOUT THIS BOOK

We take pride in providing high-quality study material for the **GATE** exam. Our team at **GATE WALLAH** has meticulously prepared each solution to ensure they are error-free and easy to understand.

The **GATE** exam pattern has shifted in recent years, with an increased emphasis on topics that previously received fewer questions. At **GATE WALLAH**, we understand the importance of identifying these crucial topics, and that's why we've provided a chapter-wise analysis for the last 16 years. Our analysis will help you understand the significance of each chapter and focus your preparation accordingly. We believe that this will be a valuable resource in your journey to success in the **GATE** exam.

To ensure that you focus on the most relevant questions, we have arranged the questions in this book topic-wise and year-wise in descending order. This means that the questions from the most recent years are emphasized, as we believe they are the most relevant for your **GATE** exam preparation. By studying these questions, you'll gain a deeper understanding of the exam pattern and the type of questions asked in recent years, which will help you perform better in the upcoming **GATE** exam.

We've designed the text solutions in this book to be in sync with our video solutions recorded by expert faculties, making it easier for you to understand the concepts. We understand that every student has a unique learning style, and that's why we've included both text and video solutions to cater to your needs. By using our comprehensive guide and video solutions together, you'll gain a better understanding of the concepts and be better prepared to tackle the **GATE** exam.

Steps to Open Video solutions through mobile:

(1) Scan the given embedded QR Code for a particular solution.

(2) Visit the link generated & you'll be redirect to the video solution.

GATE
MECHANICAL ENGINEERING

CONTENTS

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Engineering Mechanics

Engineering Mechanics

Syllabus

Free-body diagrams and equilibrium; friction and its applications including rolling friction, belt-pulley, brakes, clutches, screw jack, wedge, vehicles, etc.; trusses and frames; virtual work; kinematics and dynamics of rigid bodies in plane motion; impulse and momentum (linear and angular) and energy formulations; Lagrange's equation.

Chapter wise Weightage Analysis

Chapter / Paper Year	Ch.1	Ch.2	Ch.3	Ch.4	Ch.5	Ch.6	Ch.7	Ch.8	Ch.9
2008	1	0	2	0	0	3	0	0	0
2009	0	1	0	0	0	0	0	2	0
2010	0	0	0	0	0	1	0	0	0
2011	0	2	0	0	0	0	3	0	0
2012	0	0	0	0	0	1	0	0	0
2013	0	0	0	0	0	0	0	2	0
2014 (P1)	0	2	0	0	0	2	2	0	0
2014 (P2)	0	0	1	0	0	2	2	0	0
2014 (P3)	0	0	0	0	0	0	3	4	0
2014 (P4)	2	2	3	0	0	0	0	2	0
2015 (P1)	0	0	3	0	3	1	0	0	0
2015 (P2)	0	0	2	0	2	0	1	0	0
2015 (P3)	1	0	0	2	0	4	0	0	0
2016 (P1)	1	2	2	2	0	0	1	0	0
2016 (P2)	0	0	0	0	0	0	1	4	0
2016 (P3)	1	0	0	0	0	3	2	2	0
2017 (P1)	0	0	0	0	1	0	1	2	0
2017 (P2)	0	0	0	0	0	0	0	2	0
2018 (P1)	1	0	0	0	2	0	2	0	0
2018 (P2)	0	0	0	0	0	2	1	2	0
019 (P1)	0	1	2	0	0	0	0	2	0
2019 (P2)	0	0	1	0	0	1	2	0	0
2020 (P1)	2	0	1	0	0	0	2	0	0
2020 (P2)	1	1	0	0	0	1	2	0	0
2021 (P1)	2	0	0	0	0	0	0	0	2
2021 (P2)	0	2	1	0	0	0	0	2	0
2022 (P1)	0	3	2	0	0	0	0	3	0
2022 (P2)	1	1	2	0	0	0	0	2	0
2023 (P1)	0	0	0	2	0	2	2	0	0

CHAPTER

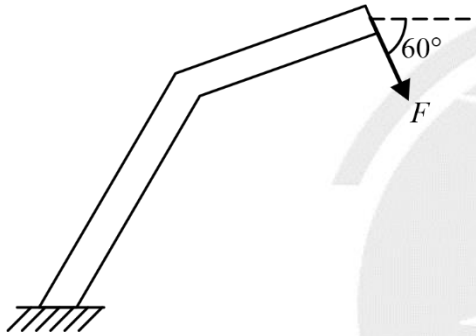
1

EQUILIBRIUM

Free Body Diagrams

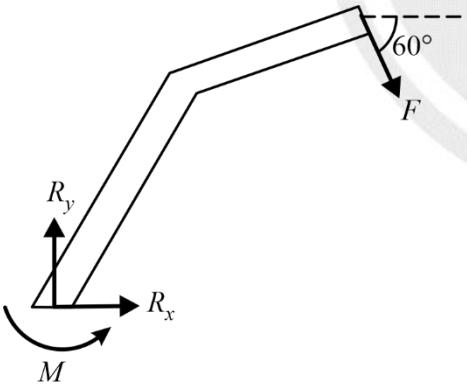
1. [MCQ] [GATE -2016:1M]

A force F is acting on a bent bar which is clamped at one end as shown in the figure.

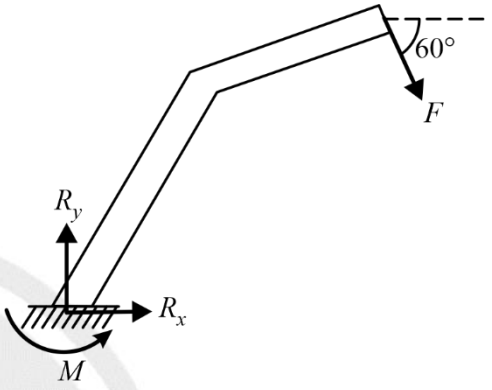


The correct free body diagram is

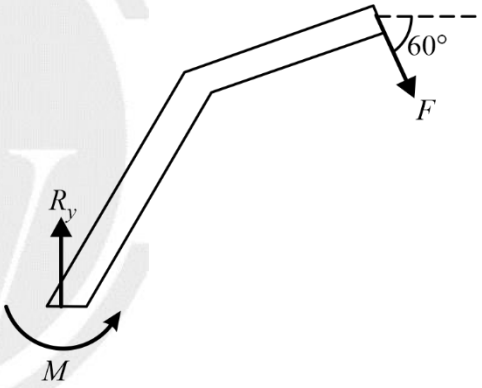
(a)



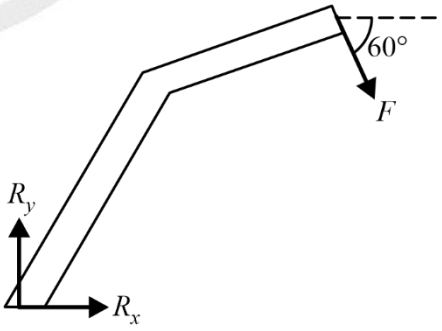
(b)



(c)



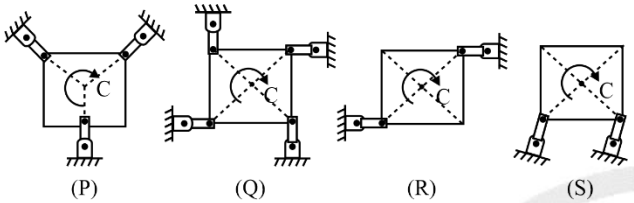
(d)



Coplanar Equilibrium Analysis

2. [MSQ] [GATE-2022:1M]

A square plate is supported in four different ways (configurations (P) to (S) as shown in the figure). A couple moment C is applied on the plate. Assume all the members to be rigid and mass-less, and all joints to be frictionless. All support links of the plate are identical



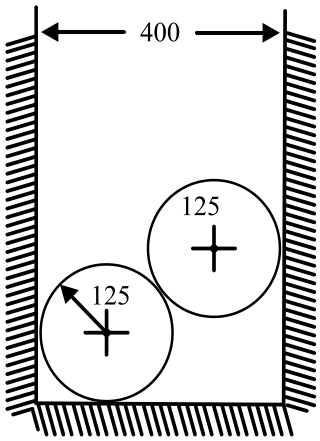
The square plate can remain in equilibrium in its initial state for which one or more of the following support configurations?

(a) Configuration (P) (b) Configuration (Q)

(c) Configuration (R) (d) Configuration (S)

3. [NAT] [GATE-2021:2M]

Two smooth identical spheres each of radius 125 mm and weight 100 N rest in a horizontal channel having vertical walls. The distance between vertical walls of the channel is 400 mm.

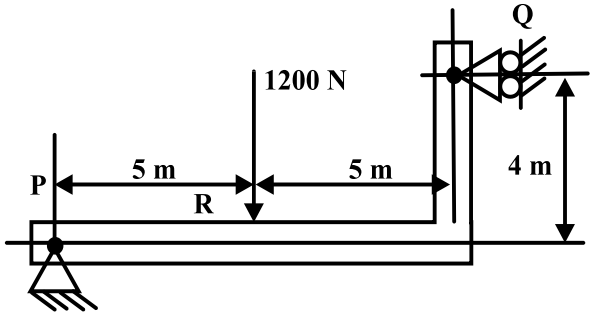


(All dimensions are in mm)

The reaction at the point of contact between two spheres is _____N **(*round off to one decimal place*)**.

4. [NAT] [GATE-2020:1M]

A beam of negligible mass is hinged at support P and has a roller support Q as shown in the figure.

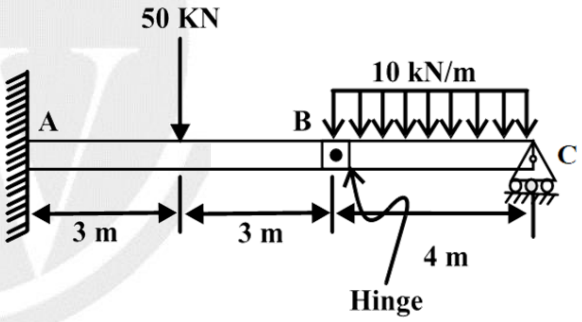


A point load of 1200 N is applied at point R. The magnitude of the reaction force at support Q is _____N.

5. [NAT] [GATE-2020:2M]

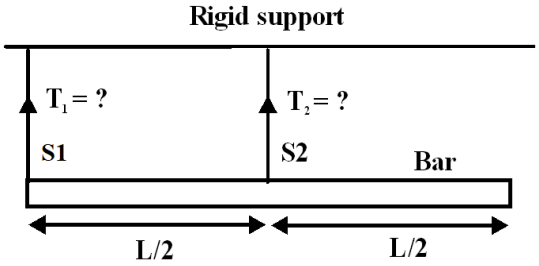
The magnitude of reaction force at joint C of the hinge-beam shown in the figure is_____kN.

(*round off to 2 decimal places*)



6. [MCQ] [GATE-2018:1M]

A bar of uniform cross section and weighing 100 N is held horizontally using two massless and inextensible strings S_1 and S_2 as shown in the figure.



The tensions in the strings are

(a) T_1 = 100 N and T_2 = 0 N

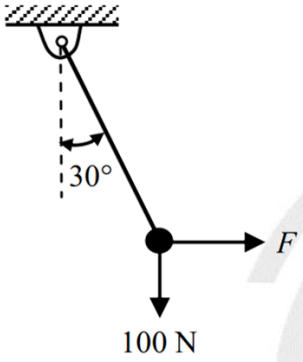
(b) T_1 = 0 N and T_2 = 100 N

(c) T_1 = 75 N and T_2 = 25 N

(d) T_1 = 25 N and T_2 = 75 N

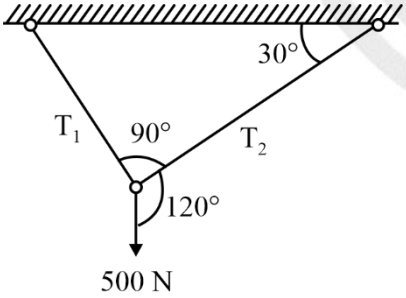
7. [NAT] [GATE-2016:1M]

A rigid ball of weight 100 N is suspended with the help of a string. The ball is pulled by a horizontal force F such that the string makes an angle of 30^0 with the vertical. The magnitude of force F (in N) is _____.



8. [MCQ] [GATE-2015:1M]

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

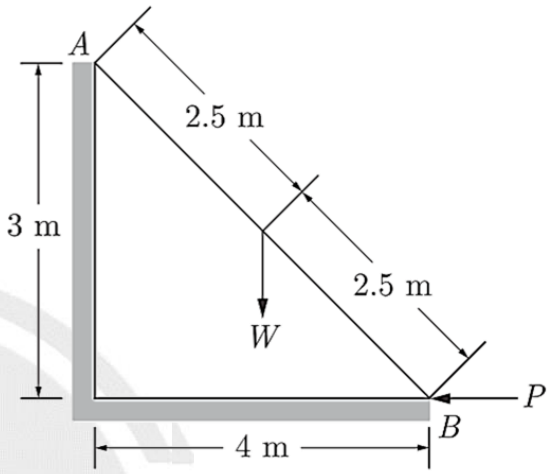


(a) 433 N and 250 N (b) 250 N and 433 N

(c) 353.5 N and 250 N (d) 250 N and 353.5 N

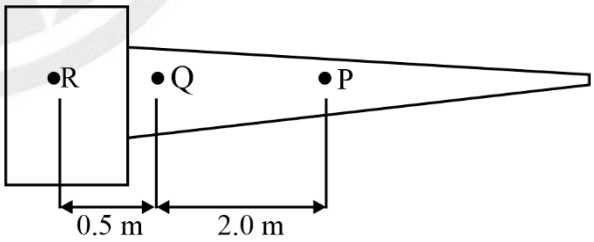
9. [NAT] [GATE-2014:2M]

A ladder AB of length 5 m and weight (W) 600 N is resting against a wall. Assuming frictionless contact at the floor (B) and the wall (A), the magnitude of the force P (in Newton) required to maintain equilibrium of the ladder is _____.



10. [MCQ] [GATE-2008:1M]

A cantilever type gate hinged at Q is shown in the figure. P and R are the centers of gravity of the cantilever part and the counterweight respectively. The mass of the cantilever part is 75 kg. The mass of the counter weight, for static balance, is



(a) 75 kg (b) 150 kg

(c) 225 kg (d) 300 kg

❑❑❑

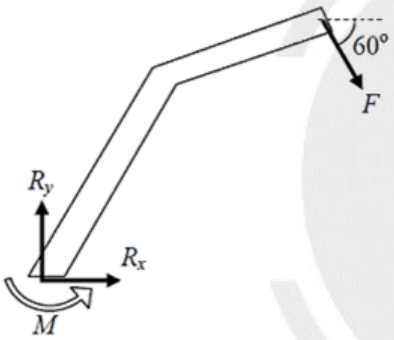
ANSWER KEY

1.	(a)	**2.**	(b, c and d)	**3.**	(124.0 to 126.0)	**4.**	(1500 N to 1500 N)
5.	(19.95 to 20.05)	**6.**	(b)	**7.**	(55 to 60)	**8.**	(a)
9.	(399 to 401)	**10.**	(d)				

SOLUTIONS

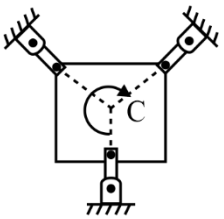
1. (a)

Fixed support will offer three reactions i-e. one vertical reaction, one horizontal reaction and one moment).

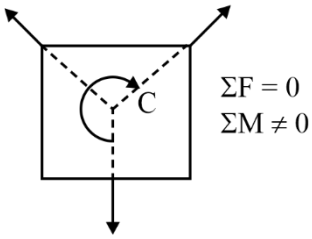


Scan for Video solution

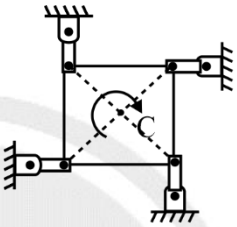
2. (b, c and d)

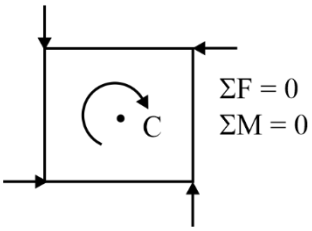


(P)



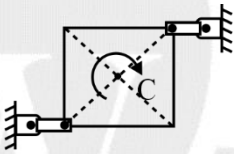
As all three support reactions are concurrent, they can support moment. Hence plate **can-not** be in equilibrium.

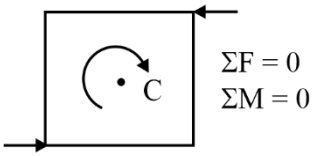




(Q)

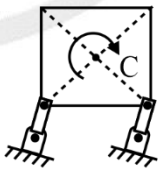
As the support reaction can support moment, plate **can be** in equilibrium.

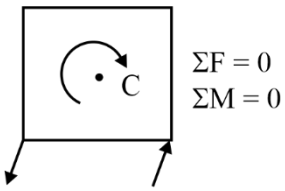




(R)

As support reaction can support moment, plate **can be** in equilibrium.





(S)

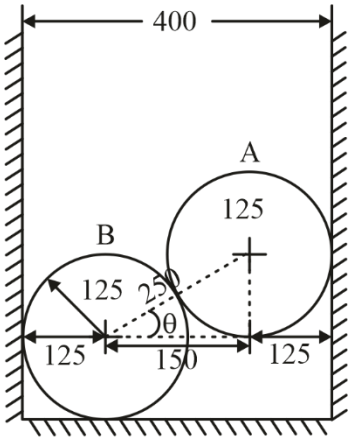
As support reaction can support moment, plate can be in equilibrium. It **can** be in equilibrium.

Configuration Q, R and S may be in equilibrium.

Scan for Video solution

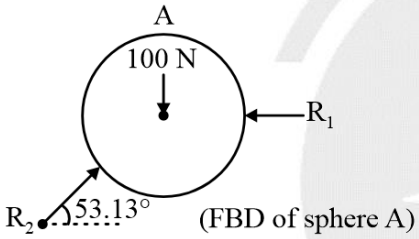
3. (124.0 to 126.0)

Given W = 100 N



All dimensions are in mm

$$\theta = \cos^{-1}\frac{150}{250} \Rightarrow \theta = 53.13°$$



(FBD of sphere A)

$\Sigma F_y = 0 \Rightarrow R_2 \sin 53.13° - 100 = 0$

$\Rightarrow$ **$R_2 = 125$ N**

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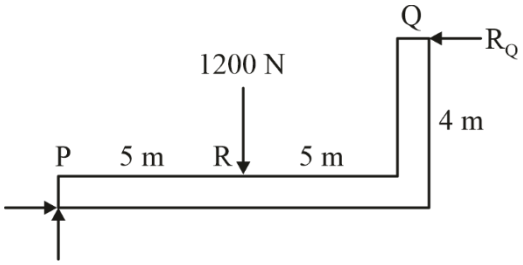
4. (1500 N to 1500 N)



$\Sigma M_P = 0$

$R_Q \times 4 - 1200 \times 5 = 0 \Rightarrow$ **$R_Q = 1500$ N**

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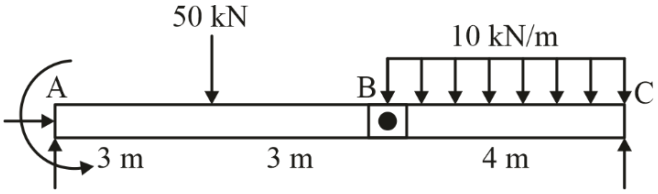
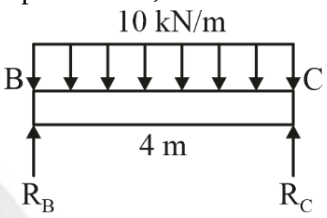
5. (19.95 to 20.05)



Draw FBD of portion BC;



$\Sigma M_B = 0 \Rightarrow R_C \times 4 - (10 \times 4) \times 2 = 0$

$\Rightarrow$ **$R_C = 20$ kN**

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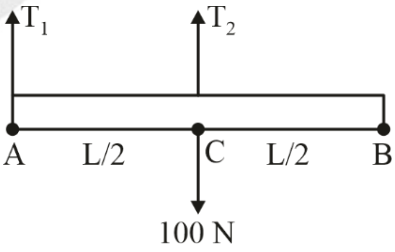
6. (b)

Given,

W = 100 N



$\Sigma M_C = 0 \Rightarrow T_1 \times \frac{L}{2} = 0 \Rightarrow T_1 = 0$

$\Sigma F_y = 0 \Rightarrow T_2 - 100 = 0 \Rightarrow$ **$T_2 = 100$ N**

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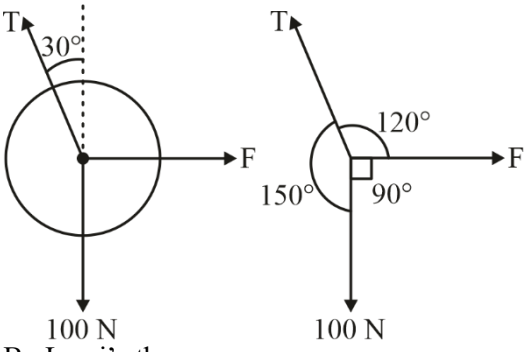
7. (55 to 60)



By Lami's theorem;

$$\frac{F}{\sin 150^\circ} = \frac{100}{\sin 120^\circ} \Rightarrow \boxed{F = 57.73\,N}$$

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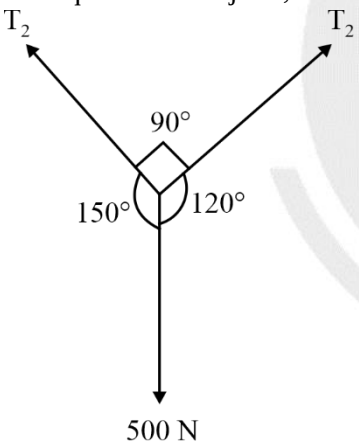
8. (a)

Consider the equilibrium of joint,



By Lami's theorem,

$$\frac{500}{\sin 90^\circ} = \frac{T_1}{\sin 120^\circ} = \frac{T_2}{\sin 150^\circ}$$

$$\Rightarrow \quad T_1 = 500 \times \frac{\sin 120^o}{\sin 90^o} \Rightarrow \boxed{T_1 = 433N} \text{ and,}$$

$$\Rightarrow \quad T_2 = 500 \times \frac{\sin 150^o}{\sin 90^o} \Rightarrow \boxed{T_2 = 250N}$$

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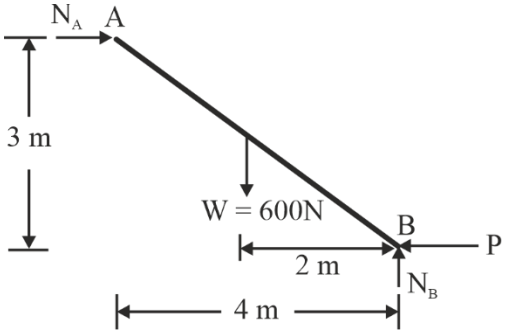
9. (399 to 401)

Given, W = 600 N



$\Sigma F_x = 0 \Rightarrow N_A - P = 0 \Rightarrow \quad N_A = P$ ..... (i)

$\Sigma M_B = 0 \Rightarrow N_A \times 3 - 600 \times 2 = 0$

$\Rightarrow N_A = 400$ N

From Equations (i), $\boxed{P = 400\,N}$

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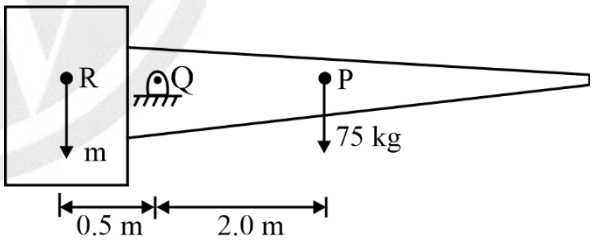
10. (d)



For static balance;

$\Sigma M_Q = 0 \Rightarrow m \times 0.5 - 75 \times 2 = 0$

$\Rightarrow \quad \boxed{m = 300\ kg}$

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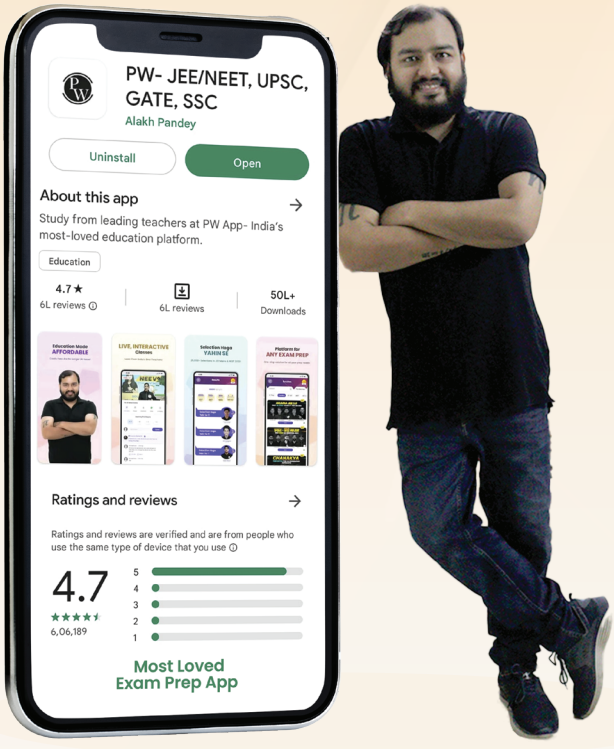

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