Techno India NJR Institute of Technology

Course File

Engineering Mechanics (3CE3- 04)

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For Techno India NJR Institute of Technology
पंकज पोरवाल
Dr. Pankaj Kumar Porwal
(Principal)

RAJASTHAN TECHNICAL UNIVERSITY, KOTA

SYLLABUS

II Year - III Semester: B.Tech. (Civil Engineering)

3CE3-04: ENGINEERING MECHANICS

Credit: 2
2L+0T+0P

Max. Marks: 100 (IA:20, ETE:80)
End Term Exam: 2 Hours

SN	CONTENT	Hrs.
1	**Introduction: objective, scope and outcome of the course.**	1
2	**Statics of particles and rigid bodies:** Fundamental laws of mechanics, Principle of transmissibility, System of forces (conservative and non-conservative), Resultant force, Resolution of force, Moment and Couples, Resolution of a force into a force and a couple, Free body diagram, Equilibrium, Conditions for equilibrium, Lami's theorem.	4
3	**Plane trusses:** Types of structures, Trusses, Support Conditions, Types of Loadings, Classification of trusses, Determinacy of trusses, Basic assumptions of truss analysis (zero force member, tension or compression member), Method of joints, Method of sections.	4
4	**Centroid & Moment of inertia (M.I.):** Location of centroid, Moment of inertia (mass and area), Parallel axis and perpendicular axis theorems, M.I of composite section, M.I. of solid bodies, Polar moment of inertia, principle axis and principle moment of inertia.	4
5	**Virtual work:** Principle of Virtual Work, Active forces and active force diagram, Stability of equilibrium. **Work, Energy and Power:** Work of a force, weight and couple, Power, Efficiency, Energy, Kinetic energy of rigid body, Principle of work and energy, Conservation of energy.	4
6	**Friction:** Types of Friction, Laws of friction, Angle of friction, Angle of repose, Ladder, Wedge, Belt Friction.	2
7	**Springs**: Stiffness of springs, springs in series and parallel, Introduction to laminated plate springs, leaf spring, close coiled helical springs, open coiled springs.	2
8	**Simple Stresses and Strains:** Concept of stress and strain in three dimensions and generalized Hooke's law; Young's modulus, Shear stress, Shear strain, Modulus of rigidity, Complementary shear stress; Poisson's ratio, Volumetric strain, Bulk modulus, relation between elastic constants, Stress and strain thin cylinder and spherical cell under internal pressure.	7
	TOTAL	28

Course Overview:

Engineering Mechanics is the practical application of mechanics concerned with the behavior ofbodies subjected to external forces or displacement. The main objective of this course to help student's development a thorough understanding of the theories and principle and thereby acquire analytical capability required to solve real life problems On successful completion of the course, the student will be able to, the i. Use scalar and vector analytic techniques for determining forces in statically determinate structure. ii. Apply fundamental concepts of kinetics and kinematics of particles for analysis of simple practical problem.

a) Relevance to Branch: The subject has the significance to understand & develop intuitive understanding of the subject to present a wealth of real-world engineering examples to give studentsa feel of how engineering mechanics is useful in engineering practices.

b) Relevance to Society: Providing an adequate information about the mechanics which are beneficial to the society development and comfort to the occupant.

c) Relevance to self-knowledge: Understand concept of mechanical behavior of materials and calculations of same using appropriate equations.

d) Relevance to an environment: Engineering mechanics is the discipline devoted to the solution of mechanics problems through the integrated application of mathematical, scientific, and engineering principles. Special emphasis is placed on the physical principles underlying modern engineering design

Course Outcomes:

3CE3-04	Cognitive Level	Engineering Mechanics
3CE3-04.1	Understand	Describe free body diagrams and Solve the resultant of forces and/or moments.
3CE3-04.2	Apply	Apply laws of mechanics to determine efficiency of simple machines with consideration of friction.
3CE3-04.3	Apply	Execute solutions for planar frames and analyses the motion.
3CE3-04.4	Apply	Apply Newton's laws and conservation laws to elastic collisions and motion of rigid bodies.
3CE3-04.5	Apply	Solve the centroid and second moment of area of sections.

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Prerequisites:

1. To demonstrate knowledge of mathematics and mechanics with logics in resolution and composition of force systems
2. to demonstrate the ability to relate kinematics with kinetic equations on linear displacement, velocity and acceleration
3. To develop the confidence for self learning in application of equilibrium conditions for co-planar and non co-planar force system..
4. correlate power; work and energy to solve practical problems.
5. solve practical examples related to curvilinear motion.

Course Outcome Mapping with Program Outcome:

Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO233.1	2	2	2	2	0	1	1	0	0	0	0	1	1	1	0
CO233.2	2	2	2	2	1	1	0	0	0	1	0	0	1	1	0
CO233.3	2	2	2	1	2	2	2	2	1	1	2	1	1	1	0
CO233.4	2	2	2	1	2	2	2	2	1	1	2	1	1	1	0
CO233.5	2	2	2	2	1	1	0	0	0	1	0	0	1	1	0
CO233 (AVG)	2	2	2	1.6	1.2	1.4	1	0.8	0.4	0.8	0.8	0.6	1	1	0

Course Coverage Module Wise:

Lecture No.	Unit	Topic
1	**1**	INTRODUCTION: Objective, scope and outcome of the course.
2	**2**	Student should be able to understand Fundamental laws of mechanics, Principle of transmissibility
3	2	Student should be able to understand System of forces (conservative and non-conservative), Resultant force, Resolution of force
4	2	Student should be able to understand Moment and Couples, Resolution of a force into a force and a couple
5	2	Student should be able to understand Free body diagram, Equilibrium, Conditions for equilibrium, Lami's theorem
6	3	Student should be able to understand Plane trusses: Types of structures, Trusses, Support Conditions, Types of Loadings
7	3	Student should be able to understand Classification of trusses, Determinacy of trusses, Basic assumptions of truss analysis(zero force member, tension or compression

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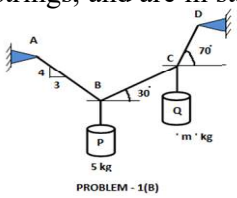
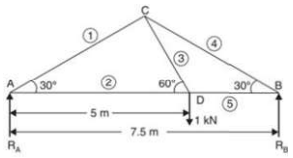
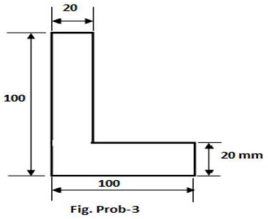
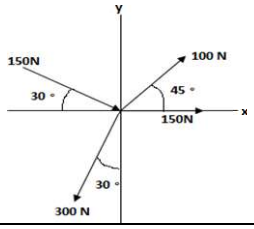
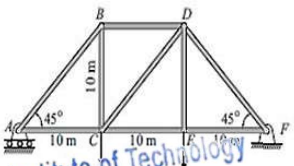
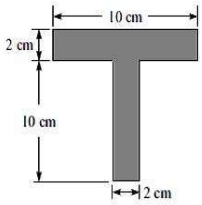
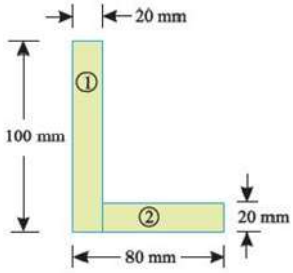
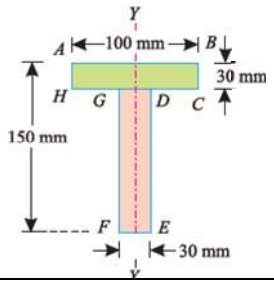
		member)
8	3	Student should be able to understand METHOD OF JOINTS
9	3	Student should be able to understand Method of sections
10	4	Student should be able to understand CENTROID & MOMENT OF INERTIA (M.I.): Location of centroid, Moment of inertia (mass and area)
11	4	Student should be able to understand Parallel axis and perpendicular axis theorems
12	4	Student should be able to understand M.I of composite section, M.I. of solid bodies
13	4	Student should be able to understand Polar moment of inertia, principle axis and principle moment of inertia
14	5	Student should be able to understand Virtual work: Principle of Virtual Work, Active forces boundaries
15	5	Student should be able to understand Active force diagram, Stability of equilibrium
16	5	Student should be able to understand Work of a force, weight and couple, Power, Efficiency, Energy
17	5	Student should be able to understand Kinetic energy of rigid body, Principle of work and energy, Conservation of energy
18	6	Student should be able to understand Types of Friction, Laws of friction, Angle of friction, Angle of repose
19	6	Student should be able to understand Ladder, Wedge, Belt Friction
20	7	Student should be able to understand Stiffness of springs, springs in series and parallel, Introduction to laminated plate springs
21	7	Student should be able to understand Leaf spring, close coiled helical springs, open coiled springs
22	8	Student should be able to understand Concept of stress and strain in three dimensions
23	8	Student should be able to understand generalized Hooke's law; Young's modulus
24	8	Student should be able to understand Shear Stress, Shear Strain
25	8	Student should be able to understand Modulus of rigidity, Complementary shear stress
26	8	Student should be able to understand Poisson's ratio, Volumetric strain, Bulk modulus
27	8	Student should be able to understand Relation between elastic constants
28	8	Student should be able to understand Stress and strain thin cylinder and spherical cell under internal pressure

TEXT/REFERENCE BOOKS

1. Vector Mechanics for Engineers, Beer and Johnston, Tata McGraw-Hill.
2. Engineering Mechanics, Hibbeler, Pearson Education.
3. Engineering Mechanics, Meriam and Kraige, John Wiley & Sons.
4. Engineering Mechanics, Timoshenko and Young, Tata McGraw Hill.
5. Engineering Mechanics, Shames, Pearson Education.

Course Level Problems (Test Items):

CO.NO.	Problem description
1	A. Explain various types of system of forces with suitable examples. B. In the figure shown below, masses P and Q are suspended with inelastic strings, and are in static equilibrium. Determine the mass of block Q.  PROBLEM - 1(B) C. Determine the support reactions and force in all members of the Truss shown below. 
2	A. Compute the centroid of area shown in figure below and find moment of inertia of area about horizontal axis passing through its centroid  Fig. Prob-3 B. State and prove law of parallelogram of forces C. Determine the magnitude and direction of the resultant of force system shown in figure below. 
3	A. Determine the support reactions and forces in members AB, BD and CD, of the Truss shown below.  B. Compute the centroid of the area shown in figure below. Then find its

	moment of inertia about the horizontal centroidal axis. All dimensions in 'cm'.  C. Prove the parallel axes theorem for moment of inertia
4	A. Prove the perpendicular axes theorem for moment of inertia. A. Find the Centroid of following plane figures:-  B. Find the Centroid of following plane figures:- 

Assessment Methodology:

1. Practical exam in lab where they have to analyze problem statement. (Once in a week)
2. Assignments one from each unit.
3. Midterm subjective paper based on topics as mentioned in the modules. (Twice during the semester)
4. Final paper at the end of the semester subjective.

Teaching and Learning resources unit-wise:

A. INTRODUCTION: Objective, scope and outcome of the course.

Video Tutorials: https://youtu.be/Vb1aMHC1_BM

Theory concepts: https://pe.gatech.edu/courses/introduction-engineering-mechanics#:~:text=Engineers%20are%20the%20ultimate%20problem%20solvers.&text=It%20addresses%20the%20modeling%20and,and%20physics%20covering%20classical%20mechanics.

Sample Quiz: https://jamdbokhtier.com/introduction-to-engineering-mechanics-quiz-answer/

B. Plane Trusses and frame.

Video Tutorials: https://youtu.be/3-4wNORPjXY

Theory concepts: https://academic.csuohio.edu/duffy_s/511_07.pdf

Sample ppt: https://www.sanfoundry.com/engineering-mechanics-questions-answers-simple-trusses/

C. Centroid and MOI.

Video Tutorials: https://youtu.be/TqOVBD4OrNo

Theory concepts: https://web.iit.edu/sites/web/files/departments/academic-affairs/academic-resource-center/pdfs/Moment_Inertia.pdf

Sample Quiz: https://edurev.in/course/quiz/attempt/-1_Test-Centroid-Of-A-Body/8efd846d-d943-4906-8bcb-c9b6806a977b

D. Simple Stress and Strain

Video Tutorials: https://youtu.be/KGCyT2oVa_A

Theory concepts: https://www.jntua.ac.in/gate-online-classes/registration/downloads/material/a158938439610.pdf

Sample Quiz: https://testbook.com/objective-questions/mcq-on-simple-stress-and-strain--5eea6a0b39140f30f369de96

E. Work Energy and Power

Video Tutorials: https://youtu.be/65Ytcr-KweQ

Theory concepts: https://www.physicsclassroom.com/class/energy

Sample Quiz: https://www.sparknotes.com/physics/workenergypower/review/quiz/

F. Friction

Video Tutorials: https://youtu.be/4ygO9IonVKY

Theory concepts: https://en.wikipedia.org/wiki/Friction

Sample Quiz: https://www.ducksters.com/science/quiz/friction_questions.php

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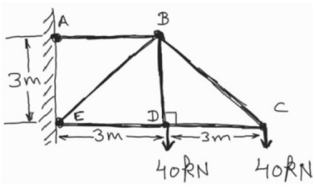
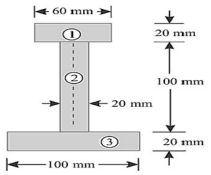
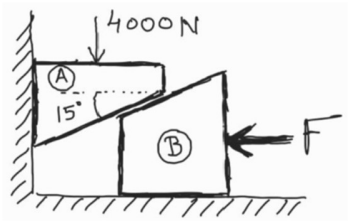
Important Question:

Q.No	Questions	CO
1.	Find the forces in all members of the truss shown in figure below. Also state whether the forces are compressive or tensile in nature. Use method of joints. 	
2.	Find the moment of inertia of the section shown in figure below, about the horizontal axis passing through its centroid. ***Given:*** considering the bottom edge of lamina as reference, the location of centroid is: $\bar{y} = 60.8\ mm$. 	
3.	A load of 4000 N is placed on wedge A (see figure given below). Find the force F (applied on wedge B) that is required to lift the loaded wedge A. Both the wedges have no weight of their own. The coefficient of friction on all surfaces is 0.2. 	
4.	The resultant of the two forces, when they act at an angle of 60° is 14 N. If the same forces are acting at right angles, their resultant is $\sqrt{136}$N. Determine the magnitude of the two forces.	

2E2005

Roll No. _____ Total No of Pages: 4

2E2005

B. Tech. II Sem. (Main / Back) Exam., May - 2017

Common to all Branch

205 Engineering Mechanics

Time: 3 Hours

Maximum Marks: 80
Min. Passing Marks Main: 26
Min. Passing Marks Back: 24

Instructions to Candidates:

*Attempt any **five questions,** selecting **one question** from **each unit.** All questions carry **equal** marks. Schematic diagrams must be shown wherever necessary. Any data you feel missing suitably be assumed and stated clearly.*

Units of quantities used/calculated must be stated clearly.

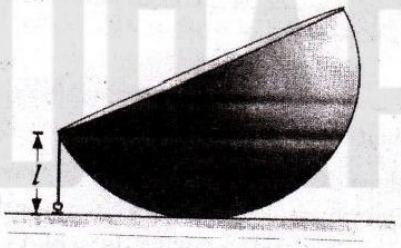
Use of following supporting material is permitted during examination. (Mentioned in form No. 205)

1. NIL 2. NIL

UNIT – I

Q.1 (a) State and explain the Varignon's theorem. [8]

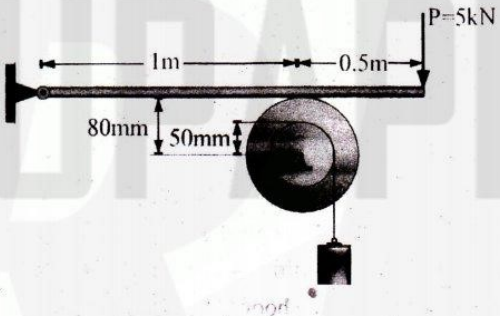
(b) A hemisphere of radius r and weight W is placed with its curved surface on a smooth table and a string of length l (< r) is attached to a point on its rim and to a point on the table as shown in Figure. Find the tension of the string. [8]



OR

Q.1 (a) Explain the principal of virtual work? [8]

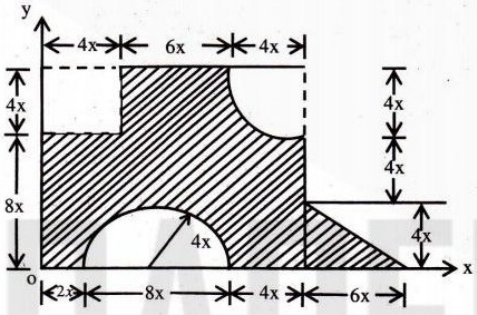
(b) What is the maximum load W that a force will hold up, if the coefficient of friction between lever and pulley is 0.2 in the arrangement shown in Figure? Neglect the weight of lever. [8]



UNIT – II

Q.2 (a) Determine the moment of inertia of a thin elliptical disk of mass m, having axial radius of a and b. [8]

(b) Determine the centroid of the composite figure about x-y coordinate. Take x = 40 mm. [8]



OR

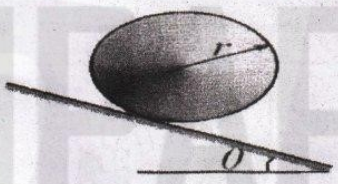
Q.2 (a) Explain the reversibility and law of machine. [8]

(b) The number of teeth on the worm wheel of a single worm and worm wheel is 60. Calculate the velocity ratio if the diameter of effort wheel is 25 cm and that of load drum is 12.5 cm. The effort required to lift a load of 600 N by this machine is 20 N. Find the efficiency of the machine. [8]

UNIT – III

Q.3 (a) Define the angle of friction and angle of repose. [8]

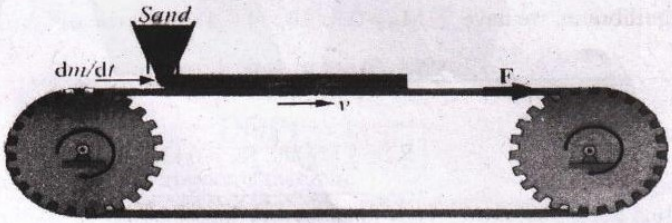
(b) Find the minimum value of the coefficient of friction between a body and a plane, so that the body may roll without slipping. The radius of gyration and radius of body are k and r, respectively [Fig.] [8]



OR

Q.3 (a) Derive can expression for the limiting ratio of tension in a V-belt over pulley. [8]

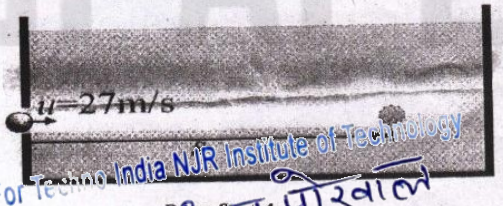
(b) Sand drops continuously from a hooper on to a moving belt as show in Figure. What force and power are required to keep the belt moving at a constant speed? [8]



UNIT – IV

Q.4 (a) Find Range, time of flight and maximum height for a projectile motion. [8]

(b) A sphere is fired horizontally into a viscous liquid with an initial velocity of 27 m/s [Fig.] If it experiences a deceleration a = -6 t m/s_2, where t is in seconds, determine the distance traveled before it stops. [8]



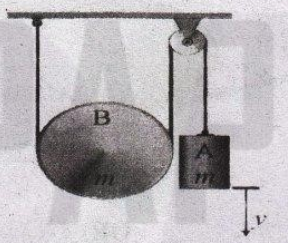
OR

Q.4 (a) Define and explain Newton's law of motion for rotational motion. [8]

(b) If the system shown in figure is released from rest, find

(i) velocity v of the falling block A as a function of y, and [4]

(ii) tensions of the string. [4]



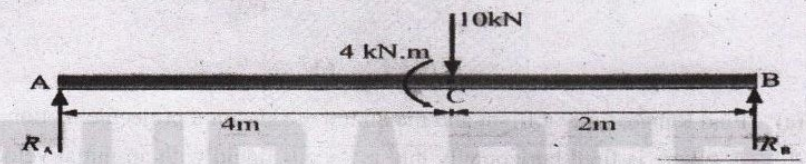
UNIT – V

Q.5 (a) Explain the principal of work and energy. [8]

(b) By transferring a load 10 kN at C by a force 10 kN and a moment 4 kNm, we draw free body diagram of the beam [Fig.] and applying equations of equilibrium, we have $\sum M_A = 0 \Rightarrow 10 \times 4 - 4 - R_B \times 6 = 0$ [8]

$$\sum F_y = 0 \Rightarrow R_A + R_B - 10 = 0$$

$R_A = 4$ kN and $R_B = 6$ kN



OR

Q.5 Write short note on:

(a) Conservation of Energy [8]

(b) Conservation of angular momentum [8]

[Total No. of Pages : 4]

2E2005

B.Tech. II Semester (Main/ Back) Examination, June/July - 2016
205 Engineering Mechanics

Time : 3 Hours **Maximum Marks : 80**
Min. Passing Marks : 26

Instructions to Candidates:

*Attempt any **five** questions, selecting **one question** from **each unit**. All questions carry **equal** marks. (Schematic diagrams must be shown wherever necessary. Any data you feel missing suitably be assumed and stated clearly. Units of quantities used/calculated must be stated clearly.*

Unit - I

1. a) Describe force and State its application. Give a detailed classification of system of force. **(6)**

   b) A light string ABCDE whose extremity A is fixed, has weights W_1 and W_2 attached to it at B and C. It passes round a small smooth peg at D carrying a weight of 300 N at the free end E as shown in the Fig. (i) If in the equilibrium position, BC is horizontal and AB and CD make 150^0 and 120^0 with BC, find : (i) Tensions in the portions AB, BC and CD of the string and (ii) Magnitudes of weights W_1 and W_2. **(6+4)**

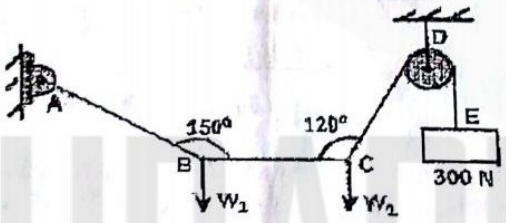


Fig. (i)

OR

1. a) State and Prove Lami's Theorem. **(8)**

b) Two beams AC and CD are hinged at C and are supported by rollers at A and D and a hinge support is provided at B as shown in Fig. (ii). Using principle of virtual work, determine the reactions at the hinge C and at support B, when a load of 600 N is acting at point E. **(8)**

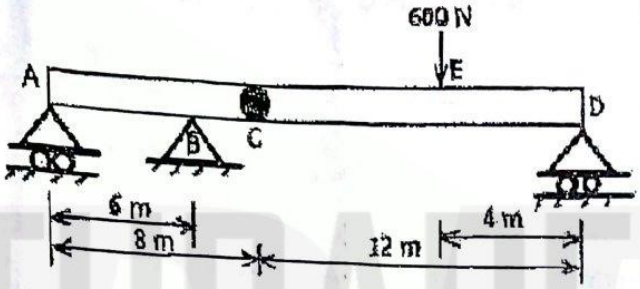


Fig. (ii)

Unit - II

2. a) State the law of machine. Derive an expression for the efficiency of a machine. **(6)**

b) Find the moment of inertia about the horizontal and vertical axis (X-X and Y-Y) passing through the centroid of the section shown in Fig. (iii). **(6+4)**

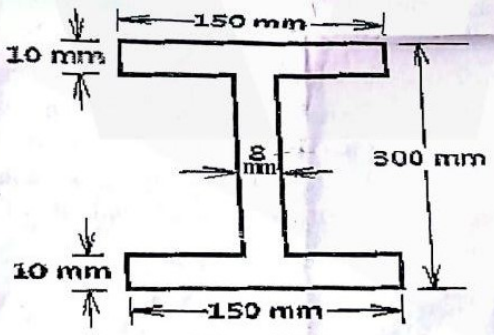


Fig. (iii)

OR

2. a) A machine lifts a load of 250 N by an effort of 160 N, at another instant the same machine lifts the load of 375 N by an effort of 175 N. If the velocity ratio of the machine is 20, determine :

i) Law of machine,

ii) Efficiency of the machine at 375 N &

iii) Efforts lost in friction at 250 N load. **(2+2+2)**

b) A uniform lamina as shown in fig. (iv) consists of a rectangle, a semicircle and a triangle. Determine the centroid of the lamina. All dimensions are in mm. **(10)**

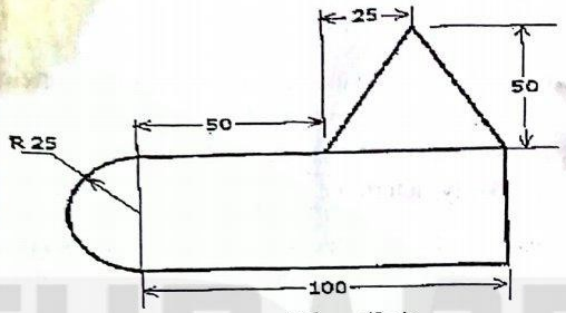


Fig. (iv)

Unit - III

3. a) Define angle of repose. Show that the angle of repose is equal to angle of static friction. **(6)**

b) A uniform ladder 3 m long weighs 200 N. It is placed against a wall making an angle of 60^0 with the floor. The co-efficient of friction between the wall and the ladder is 0.25 and that between the ladder and the floor is 0.35. The ladder in addition to its own weight has to support a man of 1000 N at its top. Calculate :

i) The horizontal force P to be applied to the ladder at the floor level to prevent slipping.

ii) If the force P is not applied, what should be the minimum inclination of ladder with the horizontal, so that there is no slipping of it? **(5+5)**

OR

3. a) Derive an expression for the ratio of belt tensions on the tight side and slack side for a flat belt passing over a fixed pulley in terms of co - efficient of friction and angle of contact of belt over pulley. **(8)**

b) A ladder of weight 390 N and 6 m long is placed against a vertical wall at an angle of 30^0 with wall. The co-efficient of friction between the ladder and the wall is 0.25 and that between ladder and floor is 0.38. Find how high a man of weight 1170 N can ascend, before the ladder begins to slip. **(8)**

Unit - IV

4. a) A stone is thrown vertically upwards with a velocity 20 m/s from the top of the tower of 25m height. Make calculations for the following parameters :

i) The maximum height to which the stone will rise in its flight. **(2+2+2)**

ii) Velocity of the stone during its downward travel at a point in the same level as the point of projection.

iii) Time required for the stone to reach the ground.

b) What is Projectile motion? Derive the expression for the horizontal range, maximum height and time of flight. **(4+3+3)**

OR

4. a) Two guns are pointed at each other, one upwards at an angle of 30^0 and the other at the same angle of depression. The muzzles of the guns are 40 m apart. If the guns are shot with velocities of 350 m/s upwards and 300 m/s downwards respectively, determine when and where the shots will meet. **(8)**

b) A particle moves along horizontal direction and its position at any instant is prescribed by the relation $X = 3t^3 - 5t^2$, where X is in m and t is in seconds, determine : **(2+2+2+2)**

i) Displacement during t = 2 sec. to 5 sec.

ii) Average velocity during t = 2 sec. to 5 sec. and instantaneous velocity at t = 2sec.

iii) Average acceleration during t = 2 sec. to 5 sec. and instantaneous acceleration at t = 5 sec.

iv) Distance travelled in first 5 sec.

Unit - V

5. a) Explain the principle of work and energy and derive an expression for the same. **(8)**

b) A pile hammer of 250 kg mass is made to fall freely on a pile from a height of 6 m. If the hammer comes to rest in 0.012 sec, determine (i) the change in momentum, (ii) impulse and (iii) average force. **(3+2+3)**

OR

5. a) State impulse momentum relation. A shell of mass 60 kg is fired horizontally with a velocity of 250 m/s by a gun of 3000 kg mass. Make calculations for : **(2+2+2+2)**

i) The velocity with which the gun recoils,

ii) The uniform force required to stop the gun in 0.5 m distance, and

iii) The time required to stop the gun. It may be presumed that momentum of the system comprising the gun and the shell is conserved.

b) From what height, must a heavy elastic ball be dropped on a floor, so that after rebounding thrice it will reach a height of 9 meters? Take $e = (0.5)^{1/3}$. **(8)**