LABORATORY MANUAL

18MEL66 – COMPUTER AIDED MODELLING AND ANALYSIS LAB

2019-20

INSTITUTE OF TECHNOLOGY

DEPARTMENT OF MECHANICAL ENGINEERING

ATRIA INSTITUTE OF TECHNOLOGY
Adjacent to Bangalore Baptist Hospital
Hebbal, Bengaluru-560024

Department of Mechanical Engineering

Vision

To be a center of excellence in Mechanical Engineering education and interdisciplinary research to confrontreal world societal problems with professional ethics.

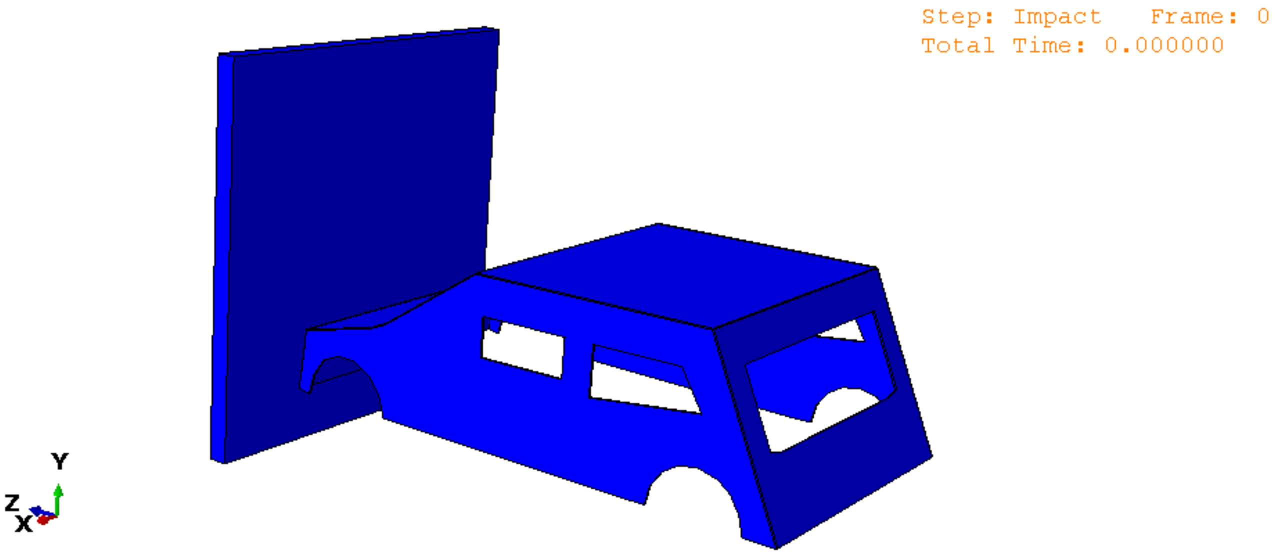
Mission

1. To push the frontiers of pedagogy amongst the students and develop new paradigms in research.

2. To develop products, processes, and technologies for the benefit of society in collaboration withindustry and commerce.

3. To mould the young minds and build a comprehensive personality by nurturing strong professionals with human ethics through interaction with faculty, alumni, and experts from academia/industry.

COMPUTER AIDED ENGINEERING



Computer aided engineering primarily uses Computer Aided Design (CAD) software, which are sometimes called CAE tools. CAE tools are being used, for example, to analyse the robustness and performance of components and assemblies. The term encompasses simulation, validation, and optimisation of products and manufacturing tools. In the future, CAE systems will be major providers of information to help support design teams in decision making. Computer-aided engineering is used in many fields such as automotive, aviation, space, and shipbuilding industries.

ATRIA INSTITUTE OF TECHNOLOGY

Department of Mechanical Engineering

6th Semester

Modeling and
Analysis Lab (FEA)
17MEL68

ACADEMIC YEAR 2020

NAME OF THE STUDENT : ---

UNIVERSITY SEAT Number : ---

BATCH : ---

PREPARED BY

Mr Mithun C M

ATRIA INSTITUTE OF TECHNOLOGY

Department of Mechanical Engineering

CERTIFICATE

*This is to certify that Mr. /Ms.*____

*bearing USN*__________________*of*___________*semester and*_______*section has satisfactorily completed the course of experiments in* ***Modeling and Analysis Lab (FEA)****, code* 17MEL68 *prescribed by the Visvesvaraya Technological University, Belagavi of this Institute for the academic year 20 – 20*

MARKS	
Maximum Marks	**Marks Obtained**

Signature of Faculty-In-Charge

Head of the Department *Date*

PREFACE

FEA is the acronym for ‘finite elements analysis’. Based on the finite element method (FEM), it is a technique that makes use of computers to predict the behavior of varied types of physical systems such as deformation of solids, heat conduction, and fluid flow. FEA software, or FEM software, is a very popular tool used by engineers and physicists because it allows the application of physical laws to real-life scenarios with precision, versatility, and practicality. The Modeling & Analysis Laboratory contributes to educate the undergraduate students of 6th semester B.E, VTU Belagavi in the field of Mechanical Engineering.

The objectives of this laboratory are to impart practical knowledge on analysis of simple structures like beams, bars, truss subjected to simple and complex loading patterns. It also focuses on practical study of dynamic systems of beams subjected to forced responses. With the study of thermal analysis concepts, the concepts of conduction, convection in a composite walls and fins cane be understood.

Demonstration exercises are provided to understand concepts of Mechanics of Materials, Machine kinematics and dynamics, Heart transfer. Various experiments are made to understand the industry oriented concepts.

I acknowledge Dr. M S Rajendra Kumar, head of the department for his valuable guidance and suggestions as per Revised Blooms Taxonomy in preparing the lab manual.

SYLLABUS

Subject Code	: 18MEL66	IA Marks	:	40
No. of Practical Hrs. / Week	: 03	Exam Hours	:	03
Total No. of Practical Hrs.	: 42	Exam Marks	:	60

Students are expected-

- To acquire basic understanding of Modelling and Analysis software
- To understand the concepts of different kinds of loading on bars, trusses and beams, and analyse the results pertaining to various parameters like stresses and deformations.
- To lean to apply the basic principles to carry out dynamic analysis to know the natural frequencies of different kind of beams.

PART –A

Study of a FEA package and modelling and stress analysis of:

a. Bars of constant cross section area, tapered cross section area and stepped bar

b. Trusses – (**Minimum 2 exercises of different types)**

c. Beams – Simply supported, cantilever, beams with point load , UDL, beams with varying load etc. **(Minimum 6 exercises)**

d. Stress analysis of a rectangular plate with a circular hole.

PART –B

Thermal Analysis – 1D & 2D problem with conduction and convection boundary conditions **(Minimum 4 exercises of different types)**

Dynamic Analysis to find:

a) Natural frequency of beam with fixed – fixed end condition

b) Response of beam with fixed – fixed end conditions subjected to forcing function

c) Response of Bar subjected to forcing functions

PART –C

a. Demonstrate the use of graphics standards (IGES, STEP etc) to import the model from modeler to solver.

b. Demonstrate one example of contact analysis to learn the procedure to carry out contact analysis.

c. Demonstrate at least two different types of example to model and analyse bars or plates made from composite material.

COURSE OUTCOMES

CO1: Use the modern tools to formulate the problem, create geometry, discretise, apply boundary conditions to solve problems of bars, truss, beams, and plate to find stresses with different-loading conditions.

CO2: Demonstrate the ability to obtain deflection of beams subjected to point, uniformly distributed and varying loads and use the available results to draw shear force and bending moment diagrams.

CO3: Analyse and solve 1D and 2D heat transfer conduction and convection problems with different boundary conditions.

CO4: Carry out dynamic analysis and finding natural frequencies of beams, plates, and bars for various boundary conditions and also carry out dynamic analysis with forcing functions.

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List of figures

1 Stress analysis of a bar of uniform rectangular cross-section

1.1 Aim

To determine the nodal displacement, stress and reaction force for a given bar of uniform cross section subjected to uni-axial tensile load.

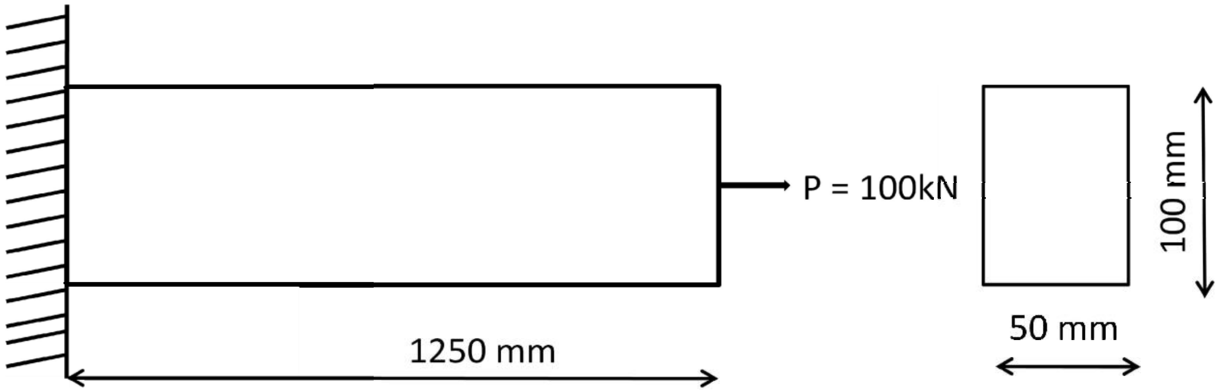

Figure 1-1 : Rectangular bar subjected to Uni-axial load

1.2 Specification of the bar

Length of the bar	l	= 1250 mm
Height of the bar	h	= 100 mm
Thickness of the bar	t	= 50 mm
Cross section area of the bar	A = h x t	= 5000 mm^2
Material of the bar		= Mild Steel
Young's Modulus of the Material	E	= 210 GPa
Poisson ratio	μ	= 0.3
Force applied	P	= 100 kN

1.3 Analytical solution

Displacement of the bar	δ	$= \frac{Pl}{AE} =$
Stress in the bar	σ	$= \frac{P}{A} =$
Strain in bar	ϵ	$= \frac{\delta l}{l} =$

1.5 Numerical solution

2 Stress analysis of a bar of uniform circular cross-section

2.1 Aim

To determine the nodal displacement, stress and reaction force for a given bar of uniform cross section subjected to uni-axial tensile load.

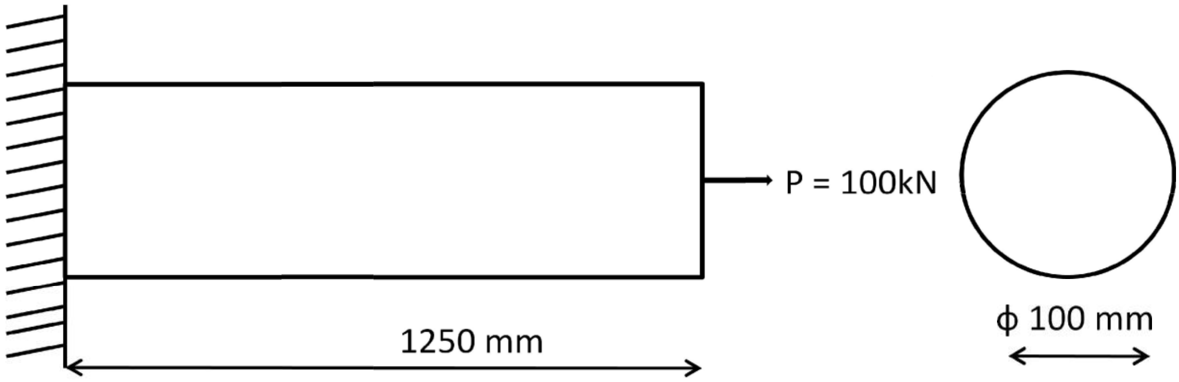

Figure 2-1 : Rod subjected to Uni-axial load

2.2 Specification of the bar

Length of the bar	l	= 1250 mm
Diameter of the rod	d	= 100 mm
Cross section area of the bar	$A = \frac{\pi}{4}d^2$	= 7850 mm^2
Material of the bar		= Mild Steel
Young's Modulus of the Material	E	= 210 GPa
Poisson ratio	μ	= 0.3
Force applied	P	= 100kN

2.3 Analytical solution

Displacement of the bar	δ	$= \frac{Pl}{AE} =$
Stress in the bar	σ	$= \frac{P}{A} =$
Strain in bar	ϵ	$= \frac{\delta l}{l} =$

2.5 Numerical solution

3 Stress analysis of a compound bar of uniform rectangular cross-section

3.1 Aim

To determine the nodal displacement, stress and reaction force for a given bar of uniform cross section subjected to uni-axial tensile load.

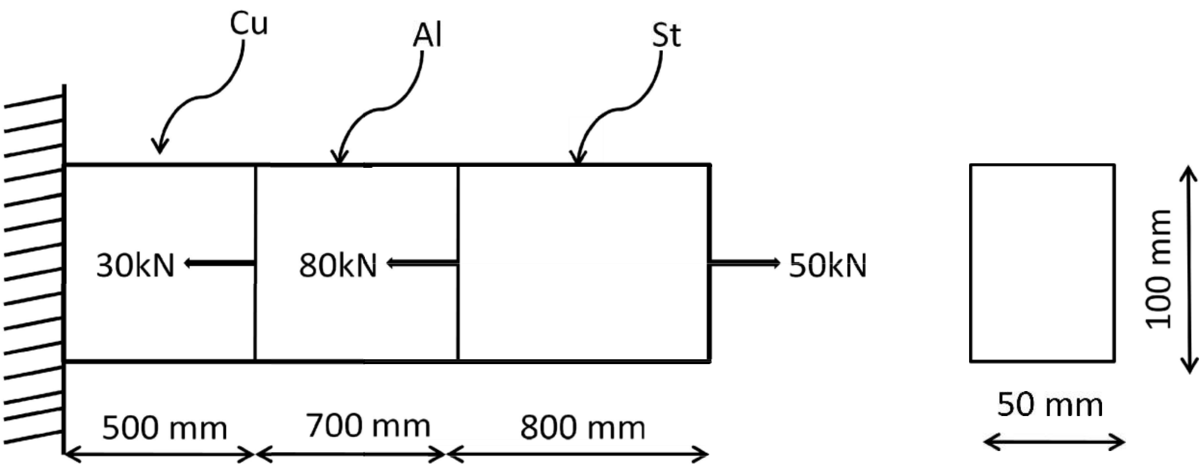

Figure 3-1 : Rectangular bar of different materials subjected to axial load

3.2 Specification of the bar

Length of the bar 1	l_1	= 800mm
Height of the bar 1	h_1	= 100mm
Thickness of the bar 1	t_1	= 50mm
Cross section area of the bar 1	A_1	= 5000mm^2
Material of the bar 1		= Mild Steel
Young's Modulus of the Material 1	E_1	= 210 GPa
Poisson ratio of bar 1	μ_1	= 0.3
Force on bar 1	P_1	= 50kN
Length of the bar 2	l_2	= 700mm
Height of the bar 2	h_2	= 100mm
Thickness of the bar 2	t_2	= 50mm

Cross section area of the bar 2	A_2	= 5000mm^2
Material of the bar 2		= Aluminium
Young's Modulus of the Material 2	E_2	= 80GPa
Poisson ratio of bar 2	μ_2	= 0.28
Force on bar 2	P_2	= - 30kN
Length of the bar 3	l_3	= 500mm
Height of the bar 3	h_3	= 100mm
Thickness of the bar 3	t_3	= 50mm
Cross section area of the bar 3	A_3	= 5000mm^2
Material of the bar 3		= Copper
Young's Modulus of the Material 3	E_3	= 120GPa
Poisson ratio of bar 3	μ_3	= 0.35
Force on bar 3	P_3	= - 60kN

3.3 Analytical solution

Displacement of the bar 1	δ_1	= $\frac{P_1 l_1}{A_1 E_1}$	
Stress in the bar 1	σ_1	= $\frac{P_1}{A_1}$	
Strain in bar 1	ϵ_1	= $\frac{\delta l_1}{l_1}$	
Displacement of the bar 2	δ_2	= $\frac{P_2 l_2}{A_2 E_2}$	
Stress in the bar 2	σ_2	= $\frac{P_2}{A_2}$	
Strain in bar 2	ϵ_2	= $\frac{\delta l_2}{l_2}$	
Displacement of the bar 3	δ_3	= $\frac{P_3 l_3}{A_3 E_3}$	

Stress in the bar 3	σ_3	$= \frac{P_3}{A_3}$	
Strain in bar 3	ϵ_3	$= \frac{\delta l_3}{l_3}$	
Total displacement of bar	δ	$= \delta_1 + \delta_2 + \delta_3$	

3.4 Calculations

3.5 Numerical solution

4 Stress analysis of a bars with cross section varying in steps

4.1 Aim

To determine the nodal displacement, stress and reaction force for a given bar of stepped cross section subjected to uni-axial tensile load.

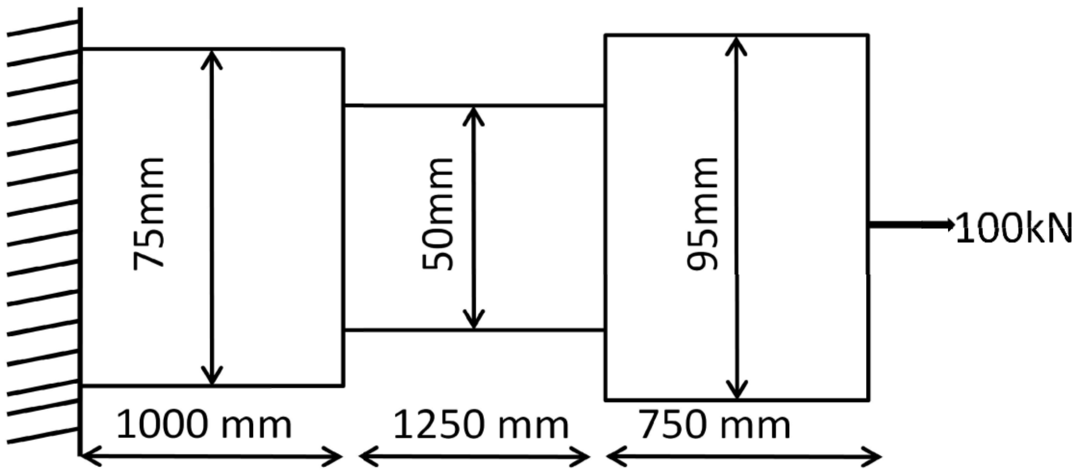

Figure 4-1 : Rectangular bar of varying cross section subjected to Uni-axial load

The thickness of all the bars is 10mm

4.2 Specification of the bar

Length of the bar 1	l_1	= 750mm
Height of the bar 1	h_1	= 95mm
Thickness of the bar 1	t_1	= 10mm
Cross section area of the bar 1	A_1	= 950mm^2
Material of the bar 1		= Mild Steel
Young's Modulus of the Material 1	E_1	= 210 GPa
Poisson ratio of bar 1	μ_1	= 0.3
Length of the bar 2	l_2	= 1250mm
Height of the bar 2	h_2	= 50mm
Thickness of the bar 2	t_2	= 10mm
Cross section area of the bar 2	A_2	= 500mm^2

Material of the bar 2		= Mild Steel
Young's Modulus of the Material 2	E_2	= 210 GPa
Poisson ratio of bar 2	μ_2	= 0.3
Length of the bar	l_3	= 1000mm
Height of the bar 3	h_3	= 75mm
Thickness of the bar 3	t_3	= 10mm
Cross section area of the bar 3	A_3	= 750mm^2
Material of the bar 3		= Mild Steel
Young's Modulus of the Material 3	E_3	= 210 GPa
Poisson ratio of bar 3	μ_3	= 0.3
Force applied	P	= 100kN

4.3 Analytical solution

Displacement of the bar 1	δ_1	= $\frac{P_1 l_1}{A_1 E_1}$	
Stress in the bar 1	σ_1	= $\frac{P_1}{A_1}$	
Strain in bar 1	ϵ_1	= $\frac{\delta l_1}{l_1}$	
Displacement of the bar 2	δ_2	= $\frac{P_2 l_2}{A_2 E_2}$	
Stress in the bar 2	σ_2	= $\frac{P_2}{A_2}$	
Strain in bar 2	ϵ_2	= $\frac{\delta l_2}{l_2}$	
Displacement of the bar 3	δ_3	= $\frac{P_3 l_3}{A_3 E_3}$	
Stress in the bar 3	σ_3	= $\frac{P_3}{A_3}$	
Strain in bar 3	ϵ_3	= $\frac{\delta l_3}{l_3}$	

Total elongation of the bar	δ	$= \delta_1 + \delta_2 + \delta_3$	

4.4 Calculations

4.5 Numerical solution

5 Stress analysis of a bars with cross section varying in steps

5.1 Aim

To determine the nodal displacement, stress and reaction force for a given bar of stepped cross section subjected to uni-axial tensile load.

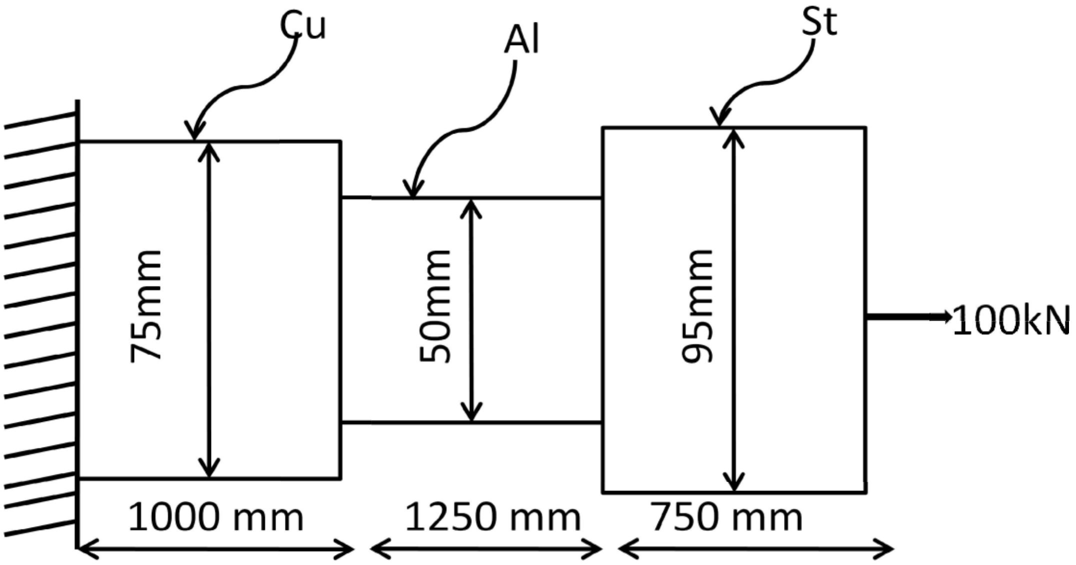

Figure 5-1 : Rectangular bar of varying cross section & different materials subjected to Uni-axial load

The thickness of all the bars is 10mm

5.2 Specification of the bar

Length of the bar 1	l_1	= 750mm
Height of the bar 1	h_1	= 95mm
Thickness of the bar 1	t_1	= 10mm
Cross section area of the bar 1	A_1	= 950mm^2
Material of the bar 1		= Mild Steel
Young's Modulus of the Material 1	E_1	= 210 GPa
Poisson ratio of bar 1	μ_1	= 0.3
Length of the bar 2	l_2	= 1250mm
Height of the bar 2	h_2	= 50mm

Thickness of the bar 2	t_2	= 10mm
Cross section area of the bar 2	A_2	= 500mm^2
Material of the bar 2		= Aluminium
Young's Modulus of the Material 2	E_2	= 80 GPa
Poisson ratio of bar 2	μ_2	= 0.3
Length of the bar	l_3	= 1000mm
Height of the bar 3	h_3	= 75mm
Thickness of the bar 3	t_3	= 10mm
Cross section area of the bar 3	A_3	= 750mm^2
Material of the bar 3		= Copper
Young's Modulus of the Material 3	E_3	= 120 GPa
Poisson ratio of bar 3	μ_3	= 0.35
Force applied	P	= 100kN

5.3 Analytical solution

Displacement of the bar 1	δ_1	= $\frac{P_1 l_1}{A_1 E_1}$	
Stress in the bar 1	σ_1	= $\frac{P_1}{A_1}$	
Strain in bar 1	ϵ_1	= $\frac{\delta l_1}{l_1}$	
Displacement of the bar 2	δ_2	= $\frac{P_2 l_2}{A_2 E_2}$	
Stress in the bar 2	σ_2	= $\frac{P_2}{A_2}$	
Strain in bar 2	ϵ_2	= $\frac{\delta l_2}{l_2}$	
Displacement of the bar 3	δ_3	= $\frac{P_3 l_3}{A_3 E_3}$	

Stress in the bar 3	σ_3	= $\frac{P_3}{A_3}$	
Strain in bar 3	ϵ_3	= $\frac{\delta l_3}{l_3}$	
Total elongation of the bar	δ	= $\delta_1 + \delta_2 + \delta_3$	

5.4 Calculations

5.5 Numerical solution

6 Stress analysis of rods with cross section varying in steps

6.1 Aim

To determine the nodal displacement, stress and reaction force for a given bar of stepped cross section subjected to uni-axial tensile load.

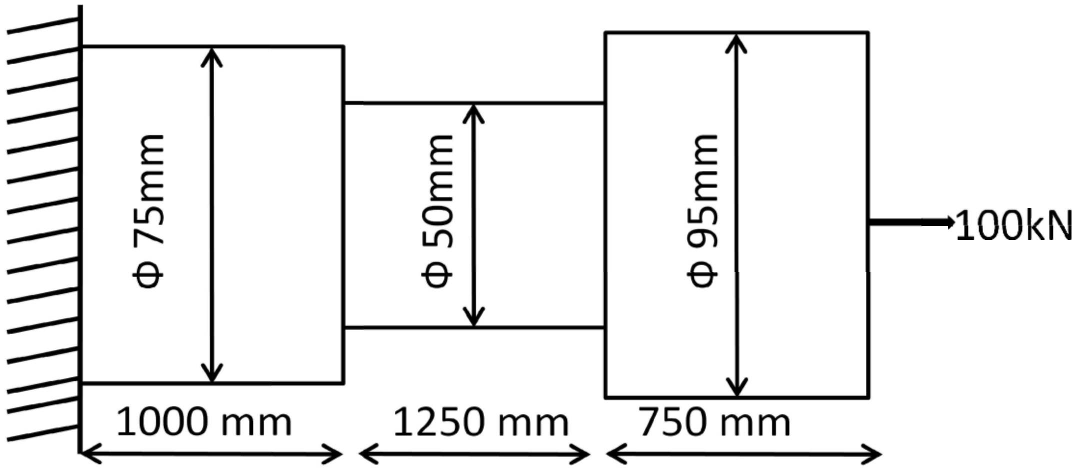

Figure 6-1 : Rod of varying cross section subjected to Uni-axial load

6.2 Specification of the bar

Length of the rod 1	l_1	= 750mm
Diameter of the rod 1	d_1	= 95mm
Cross section area of the rod 1	$A = \frac{\pi}{4} {d_1}^2$	= 7084.6mm^2
Material of the rod 1		= Mild Steel
Young's Modulus of the Material	E_1	= 210 GPa
Poisson ratio of the rod 1	μ_1	= 0.3
Force applied	P	= 100kN
Length of the rod 2	l_2	= 1250mm
Diameter of the rod 2	d_2	= 50mm
Cross section area of the rod 2	$A = \frac{\pi}{4} {d_2}^2$	= 1962.5mm^2
Material of the rod 2		= Mild Steel

Young's Modulus of the Material	E_2	= 210 GPa
Poisson ratio of the rod 2	μ_2	= 0.3
Force applied	P	= 100kN
Length of the rod 3	l_3	= 1000mm
Diameter of the rod 3	d_3	= 75mm
Cross section area of the rod 3	$A = \frac{\pi}{4} {d_3}^2$	= 4415.62mm^2
Material of the rod 3		= Mild Steel
Young's Modulus of the Material	E_3	= 210 GPa
Poisson ratio of the rod 3	μ_3	= 0.3
Force applied	P	= 100kN

6.3 Analytical solution

Displacement of the bar 1	δ_1	$= \frac{P_1 l_1}{A_1 E_1}$	
Stress in the bar 1	σ_1	$= \frac{P_1}{A_1}$	
Strain in bar 1	ϵ_1	$= \frac{\delta l_1}{l_1}$	
Displacement of the bar 2	δ_2	$= \frac{P_2 l_2}{A_2 E_2}$	
Stress in the bar 2	σ_2	$= \frac{P_2}{A_2}$	
Strain in bar 2	ϵ_2	$= \frac{\delta l_2}{l_2}$	
Displacement of the bar 3	δ_3	$= \frac{P_3 l_3}{A_3 E_3}$	
Stress in the bar 3	σ_3	$= \frac{P_3}{A_3}$	
Strain in bar 3	ϵ_3	$= \frac{\delta l_3}{l_3}$	
Total elongation of the bar	δ	$= \delta_1 + \delta_2 + \delta_3$	

6.5 Numerical solution

7 Stress analysis of a bars with tapered cross section

7.1 Aim

To determine the nodal displacement, stress and reaction force for a given bar of tapered cross section subjected to uni-axial tensile load.

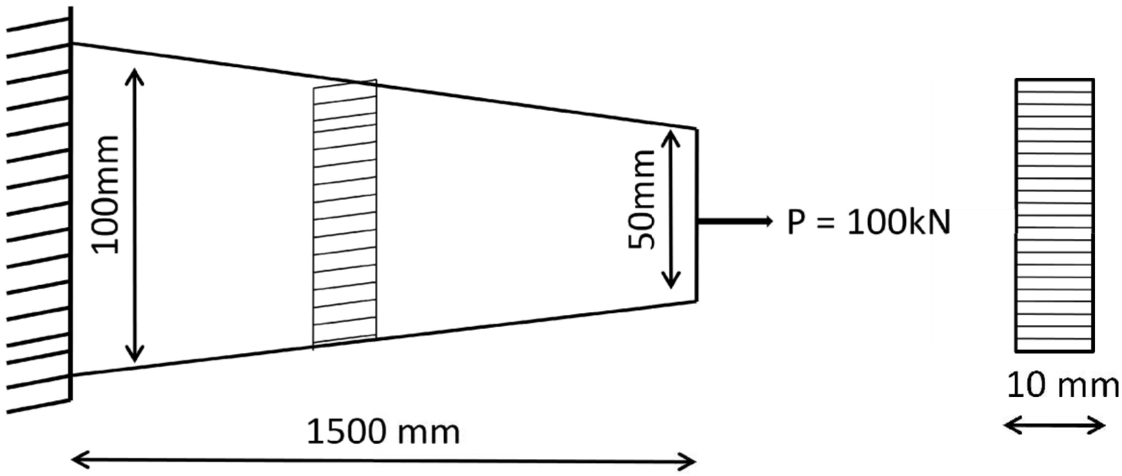

Figure 7-1 : Rectangular bar of tapered cross section subjected to Uni-axial load

7.2 Specification of the bar

Length of the bar	l	= 150mm	
Height of the bar at one end	b_1	= 100mm	
Height of the bar at other end	b_2	= 50mm	
Thickness of the bar	t	= 10mm	
Material of the bar		= Mild Steel	
Young's Modulus of the Material	E	= 210GPa	
Poisson ratio	μ	= 0.3	
Force applied	P	= 100kN	

7.3 Analytical solution

Displacement of the bar	δ	$= \frac{Pl\ln\frac{b_1}{b_2}}{tE\,(b_1-b_2)}$	

7.5 Numerical solution

8 Stress analysis of a bars with tapered circular cross section

8.1 Aim

To determine the nodal displacement, stress and reaction force for a given rod of tapered cross section subjected to uni-axial tensile load.

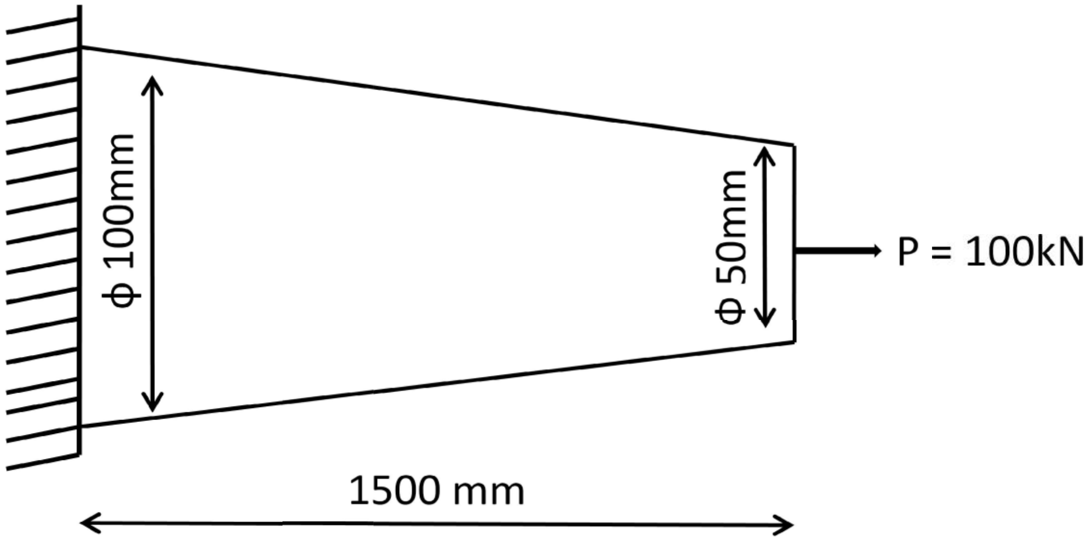

Figure 8-1 : Rod of tapered cross section subjected to Uni-axial load

8.2 Specification of the bar

Length of the bar	l	= 1500mm
Diameter of the bar at one end	d_1	= 100mm
Diameter of the bar at other end	d_2	= 50mm
Material of the bar		= Mild Steel
Young's Modulus of the Material	E	= 210 GPa
Poisson ratio	μ	= 0.3
Force applied	P	= 100kN

8.3 Analytical solution

Displacement of the bar	δ	$= \frac{4Pl}{\pi E d_1 d_2}$	
Strain in bar	ϵ	$= \frac{\delta l}{l}$	

8.5 Numerical solution

9 Stress analysis of a truss 1

9.1 Aim

To determine the stress developed and displacement of the given truss member.

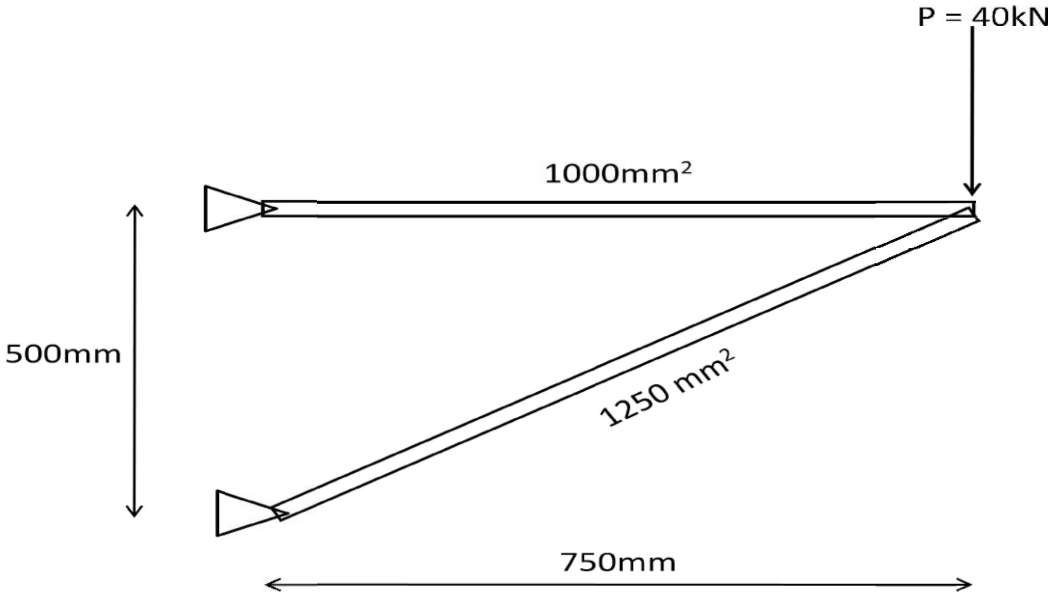

Figure 9-1 : 2 structured truss member subjected to loading

9.2 Specification of the truss

Area of section 1	A_1	= 1000mm^2
Area of section 2	A_2	= 1250mm^2
Load on the truss member	P	= 40kN
Material of the member		= Mild Steel
Young's Modulus of the Material	E	= 210 GPa

9.3 Analytical solution

Maximum displacement of truss	δ	=	=
Maximum stress in the member	σ	=	=

9.5 Numerical solution

10 Stress analysis of truss 2

10.1 Aim

To determine the stress developed and displacement of the given truss member.

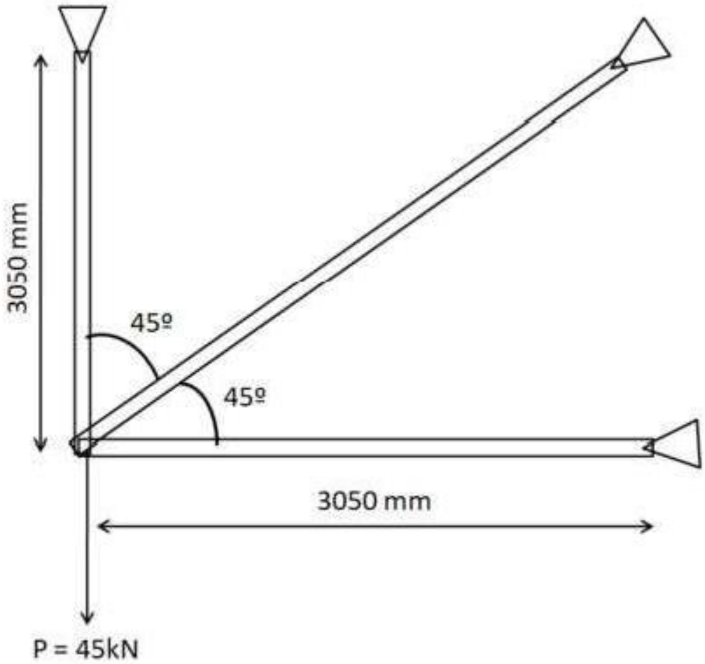

Figure 10-1 : 3 structured truss member subjected to loading

10.2 Specification of the truss

Area of all truss members	A	= 1300 mm^2
Load on the truss member	P	= 45kN
Material of the member		= Mild Steel
Young's Modulus of the Material	E	= 210 GPa

10.3 Analytical solution

Maximum displacement of truss	δ	=	=
Maximum stress in the member	σ	=	=

10.4 Calculations

10.5 Numerical solution

11 SFD & BMD for a cantilever beam subjected to point load

11.1 Aim

To draw the SFD & BMD for a given cantilever beam to point load

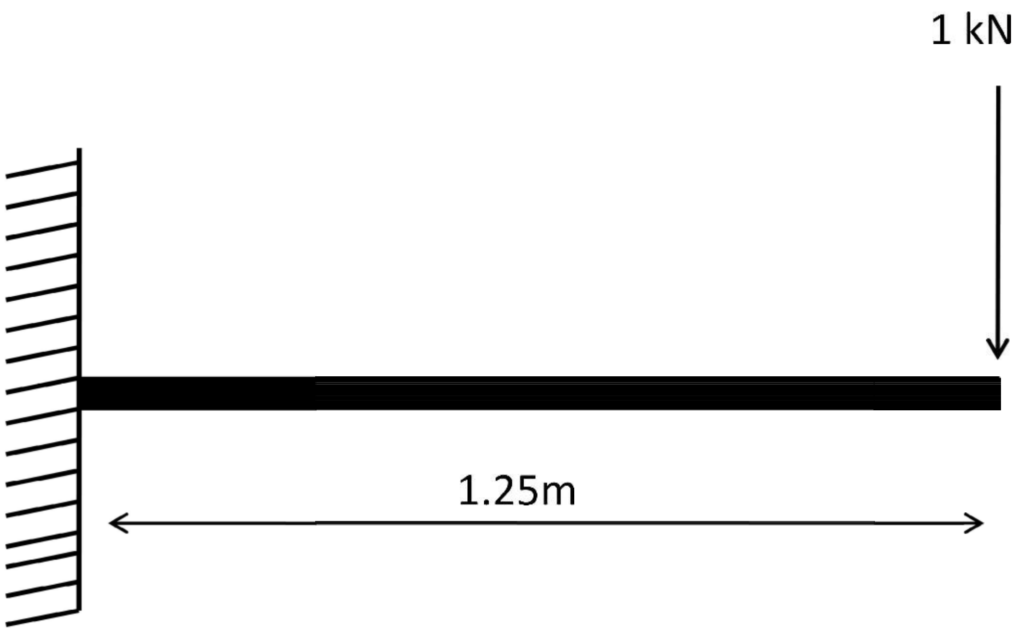

Figure 11-1 : Cantilever beam subjected to Point load

11.2 Specification of the beam

Length of the beam	l	= 1250 mm
Height of the beam	h	= 100 mm
Width of the beam	b	= 25 mm
Area Moment of inertia	I	= 2.08 x 10^6 mm^4
Material of the beam		= Mild Steel
Maximum bending moment	M	= 1.25 x 10^6 N-mm
Distance from the neutral fibre	y	= 50 mm
Young's Modulus of the Material	E	= 210 GPa
Force applied	P	= 1kN

11.3 Analytical solution

Deflection of the beam	δ	$= \frac{Pl^3}{3EI}$	
Bending stress	σ	$= \frac{My}{I}$	

11.4 Calculations

11.5 Numerical solution

12 SFD & BMD for a cantilever beam subjected to a UDL

12.1 Aim

To draw the SFD & BMD for a given cantilever beam subjected to UDL

12 SFD & BMD for a cantilever beam subjected to a UDL

12.1 Aim

To draw the SFD & BMD for a given cantilever beam subjected to UDL

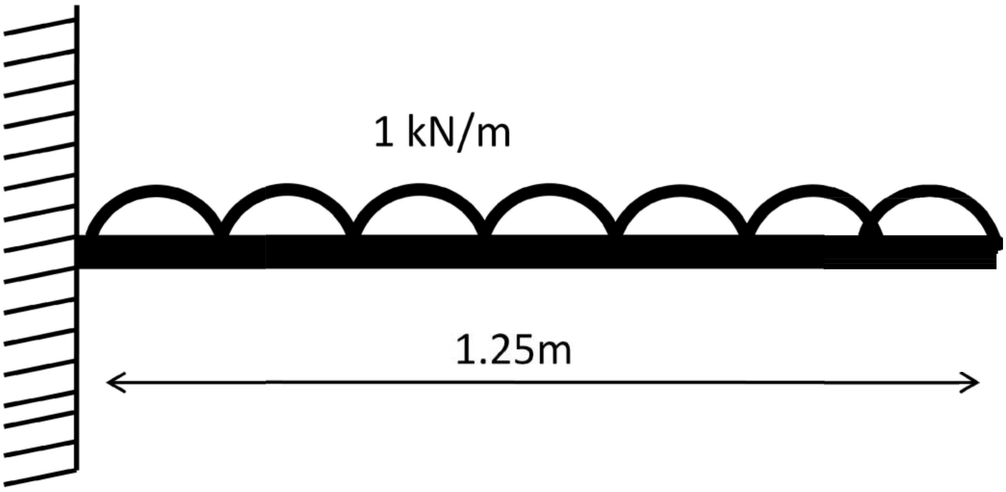

Figure 12-1 : Cantilever beam subjected to UDL

12.2 Specification of the beam

Length of the beam	l	= 1250mm
Height of the beam	h	= 100 mm
Width of the beam	b	= 25 mm
Area Moment of inertia	I	= 2.08 x 10^6 mm^4
Material of the beam		= Mild Steel
Maximum bending moment	M	= 781250 N-mm
Distance from the neutral fibre	y	= 50 mm
Young's Modulus of the Material	E	= 210 GPa
Uniformly distributed load	w	= 1kN/m

12.3 Analytical solution

Deflection of the beam	δ	$= \frac{wl^4}{8EI}$	

13 SFD & BMD for a cantilever beam subjected to a UVL

13.1 Aim

12.4 Calculations

To draw the SFD & BMD for a given cantilever beam subjected to UVL

12.5 Numerical solution

13 SFD & BMD for a cantilever beam subjected to a UVL

13.1 Aim

To draw the SFD & BMD for a given cantilever beam subjected to UVL

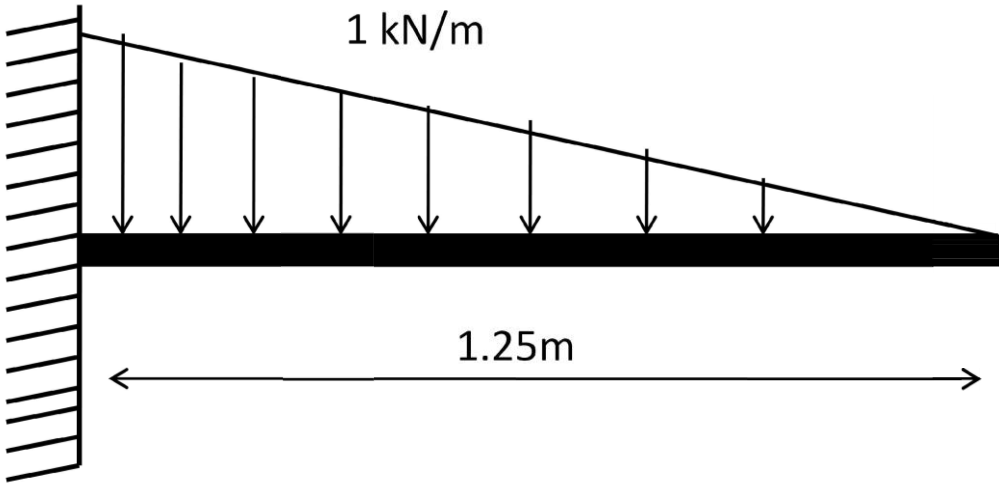

Figure 13-1 : Cantilever beam subjected to UVL

13.2 Specification of the beam

Length of the beam	l	= 1250mm
Height of the beam	h	= 100 mm
Width of the beam	b	= 25 mm
Area Moment of inertia	I	= 2.08×10^6 mm^4
Material of the beam		= Mild Steel
Maximum bending moment	M	= 260416 N-mm
Distance from the neutral fibre	y	= 50 mm
Young's Modulus of the Material	E	= 210 GPa
Uniformly varying load	w	= 1kN/m

13.3 Analytical solution

Deflection of the beam	δ	= $\frac{wl^4}{30EI}$	

13 SFD & BMD for a cantilever beam subjected to a UVL

13.1 Aim

To draw the SFD & BMD for a given cantilever beam subjected to UVL

13.4 Calculations

13.5 Numerical solution

14 SFD & BMD for a cantilever beam subjected to combined loading

14.1 Aim

To draw the SFD & BMD for a given cantilever beam subjected to combined loading

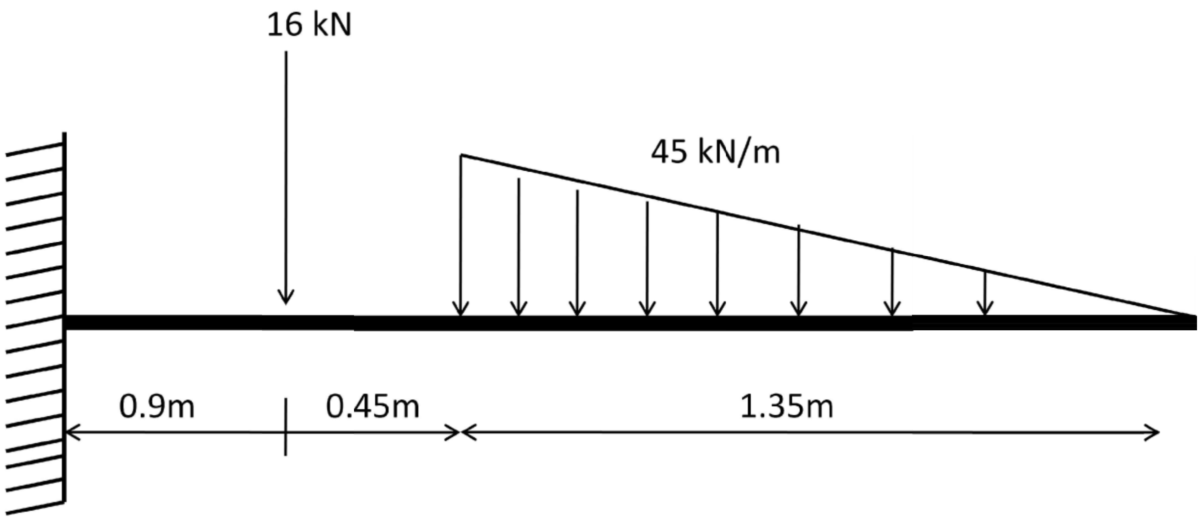

Figure 14-1 : Cantilever beam subjected to combined loading

14.2 Specification of the beam

Length of the beam	l	= 2700mm	
Height of the beam	h	= 250 mm	
Width of the beam	b	= 100 mm	
Area Moment of inertia	I	= 130.208 x 10^6 mm^4	
Material of the beam		= Mild Steel	
Maximum bending moment	M	= 110 x 10^6 N-mm	
Distance from the neutral fibre	y	= 50mm	
Young's Modulus of the Material	E	= 210 GPa	

14.3 Analytical solution

Bending stress	σ	= $\frac{My}{I}$	

14.4 Calculations

14.5 Numerical solution

I

15 SFD & BMD for a simply supported beam subjected to a point load

15.1 Aim

To draw the SFD & BMD for a given simply supported beam subjected to point load

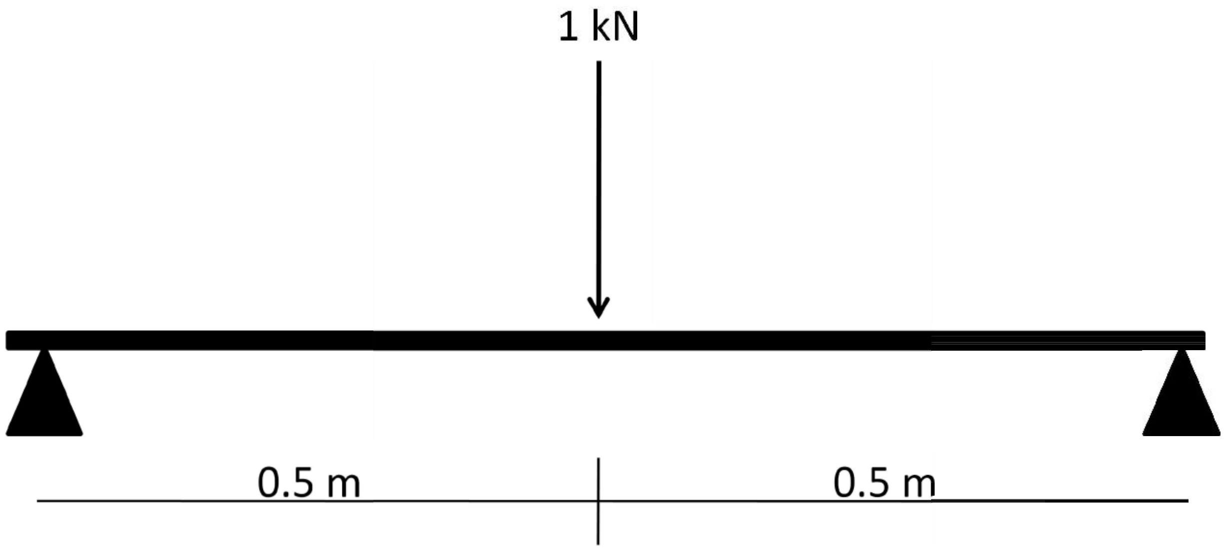

Figure 15-1 : Simply supported beam subjected to point load

15.2 Specification of the beam

Length of the beam	l	= 1250mm
Height of the beam	h	= 100 mm
Width of the beam	b	= 25mm
Area Moment of inertia	I	= 2.08×10^6 mm^4
Material of the beam		= Mild Steel
Maximum bending moment	M	= 250000N-mm
Distance from the neutral fibre	y	= 50mm
Young's Modulus of the Material	E	= 210 GPa
Force applied	P	= 1kN

15.3 Analytical solution

Deflection of the beam	δ	$= \frac{Pl^3}{48EI}$	
Bending stress	σ	$= \frac{My}{I}$	

15.4 Calculations

15.5 Numerical Solution

16 SFD & BMD for a simply supported beam subjected to a UDL

16.1 Aim

To draw the SFD & BMD for a given simply supported beam subjected to UDL

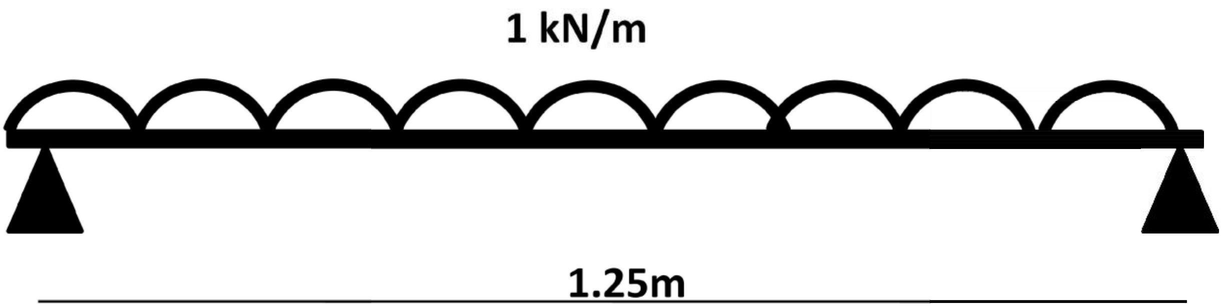

Figure 16-1 : Simply supported beam subjected to UDL

16.2 Specification of the beam

Length of the beam	l	= 1250mm
Height of the beam	h	= 100 mm
Width of the beam	b	= 25mm
Area Moment of inertia	I	= 2.08 x 10^6 mm^4
Material of the beam		= Mild Steel
Maximum bending moment	M	= 195312.5 N-mm
Distance from the neutral fibre	y	= 50mm
Young's Modulus of the Material	E	= 210 GPa
Uniformly distributed load	w	= 1kN/m

16.3 Analytical solution

Deflection of the beam	δ	= $\frac{5wl^4}{384EI}$	
Bending stress	σ	= $\frac{My}{I}$	

16.4 Calculations

16.5 Numerical solution

17 SFD & BMD for a simply supported beam subjected to combined loading

17.1 Aim

To draw the SFD & BMD for a given simply supported beam subjected to combined loading

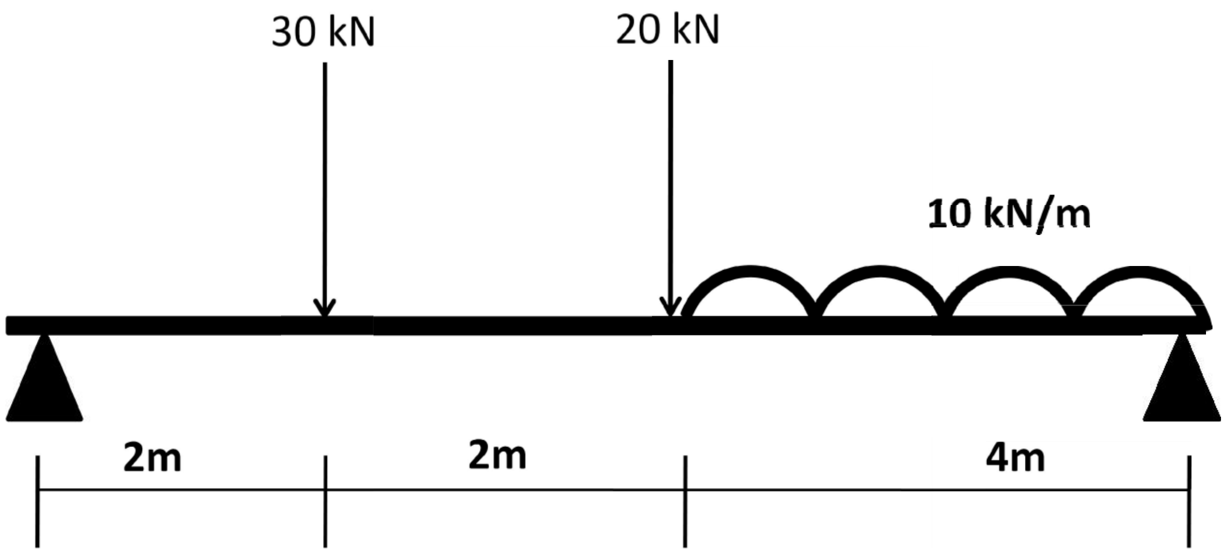

Figure 17-1 : Simply supported beam subjected to combined loads

17.2 Specification of the beam

Length of the beam	l	= 8000mm
Height of the beam	h	= 250 mm
Width of the beam	b	= 100 mm
Area Moment of inertia	I	= 130.208 x 10^6 mm^4
Material of the beam		= Mild Steel
Maximum bending moment	M	= 110 x 10^6 N-mm
Distance from the neutral fibre	y	= 50mm
Young's Modulus of the Material	E	= 210 GPa

17.3 Analytical solution

Bending stress	σ	$= \frac{My}{I}$	

17.4 Calculations

17.5 Numerical Solution

I

18 Stress analysis of a rectangular plate with a circular hole

18.1 Aim

To find the stress distribution for a plate with hole subjected to load

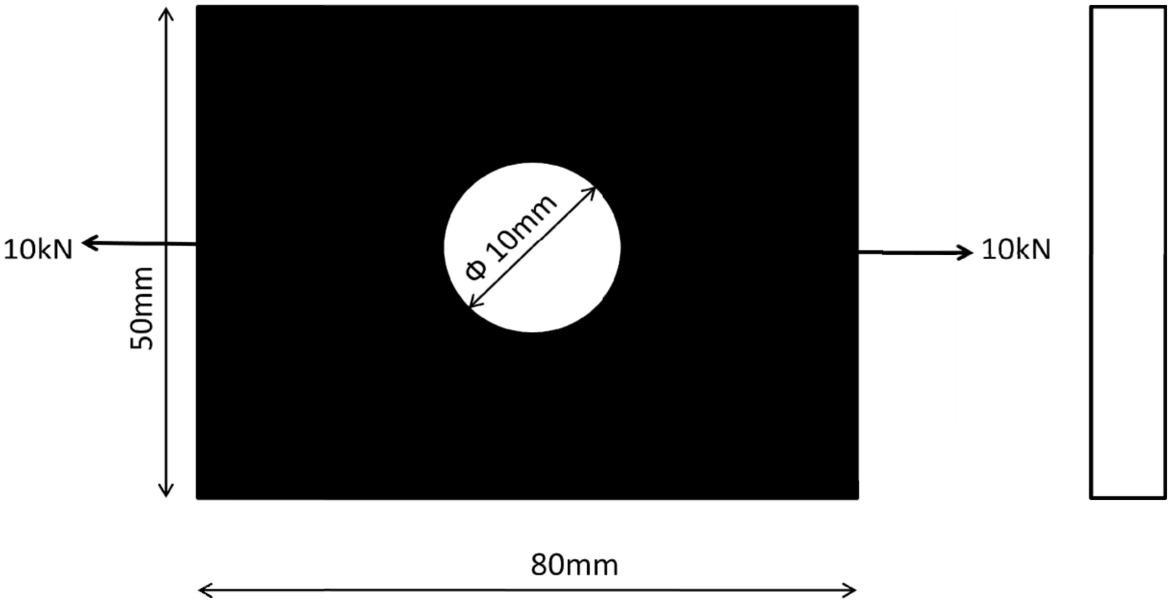

Figure 18-1 : Rectangular plate with a hole subjected to tensile load

18.2 Specification of the plate

Length of the plate	l	= 80mm
Width of the plate	w	= 50mm
Thickness of the plate	t	= 10 mm
Material of the plate		= Mild Steel
Diameter of the hole	d	= 10mm
Axial Load	F	= 10kN
Young's Modulus of the Material	E	= 210 GPa

18.3 Analytical solution

Nominal Stress	$\sigma_{nominal}$	$= \frac{F}{(w-d)t}$	
Stress concentration factor	K_{σ}	$= \frac{\sigma_{max}}{\sigma_{nominal}}$	

Maximum Stress	σ_{max}	= K_{σ} x $\sigma_{nominal}$	

18.4 Calculations

18.5 FE solution

19 Stress analysis of a rectangular plate with a elliptical hole

19.1 Aim

To find the stress distribution for a plate with elliptical hole subjected to load

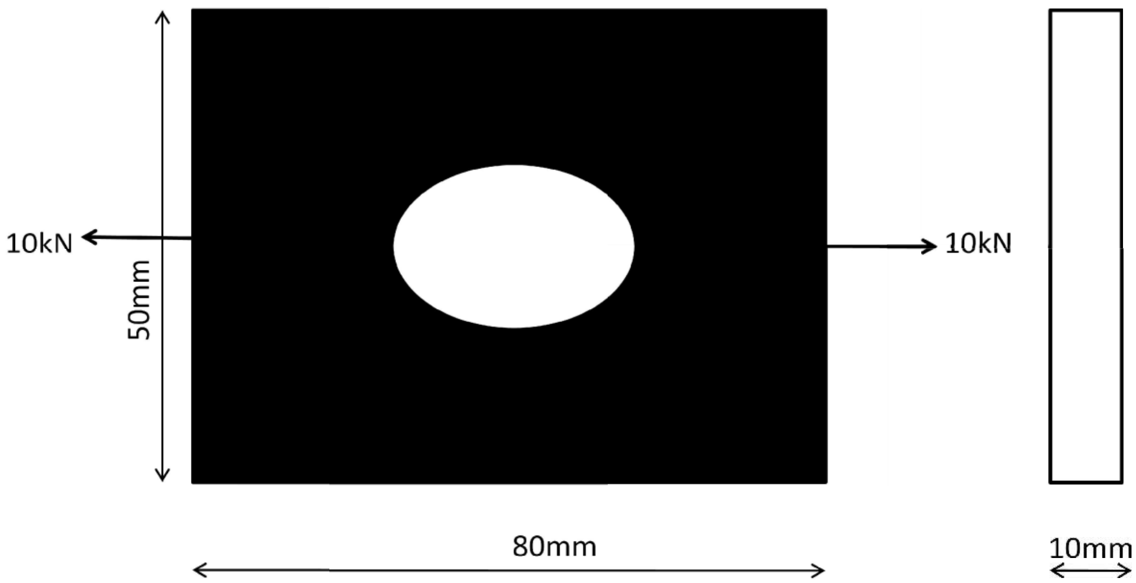

Figure 19-1 : Rectangular plate with a elliptical hole subjected to tensile load

19.2 Specification of the plate

Length of the plate	l	= 80mm
Width of the plate	w	= 50mm
Thickness of the plate	t	= 10 mm
Material of the plate		= Mild Steel
Semi Major axis	2a	= 20mm
Semi Minor axis	2b	= 10mm
Axial Load	F	= 10kN
Young's Modulus of the Material	E	= 210 GPa

19.3 Analytical solution

Nominal Stress	$\sigma_{nominal}$	$= \frac{F}{(w-2b)t}$	

Stress concentration factor	K_σ	$= \frac{\sigma_{max}}{\sigma_{nominal}}$	
Maximum Stress	σ_{max}	$= K_\sigma$ x $\sigma_{nominal}$	

19.4 Calculations

19.5 Numerical solution

20 Modal analysis for a cantilever beam

20.1 Aim

To find the natural frequencies of a cantilever beam

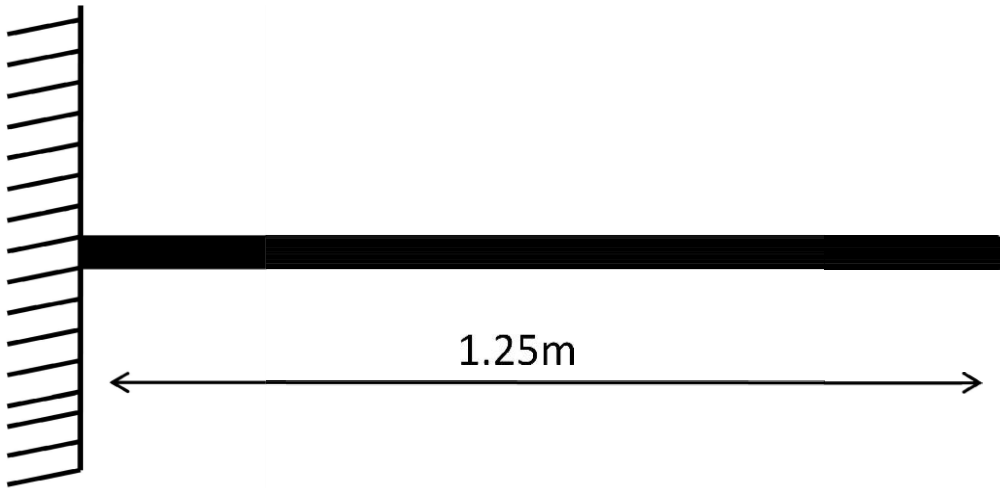

Figure 20-1 : Modal analysis for a cantilever beam

20.2 Specifications of the beam

Length of the beam	l	= 1250mm
Height of the beam	h	= 100 mm
Width of the beam	b	= 25 mm
Area Moment of inertia	I	= 2.08 x 10^6 mm^4
Material of the beam		= Mild Steel
Youngs Modulus	E	= 210 GPa
Area of the beam	A	= 250 mm^2
Mass density of the given material	ρ	= 7830kg/m^3

20.3 Analytical solution

Natural frequency	ω	$= (\beta l)^2 \sqrt{\frac{EI}{\rho A l^4}}$
	$\beta_1 l$	= 1.875104

	$\beta_2 l$	= 4.694091
	$\beta_3 l$	= 7.854757
	$\beta_4 l$	= 10.995541
1st mode	ω_1	
2nd mode	ω_2	
3rd mode	ω_3	
4th mode	ω_4	

20.4 Calculations

20.5 Numerical solution

21 Modal analysis for a fixed - fixed beam

21.1 Aim

To find the natural frequencies of a cantilever beam

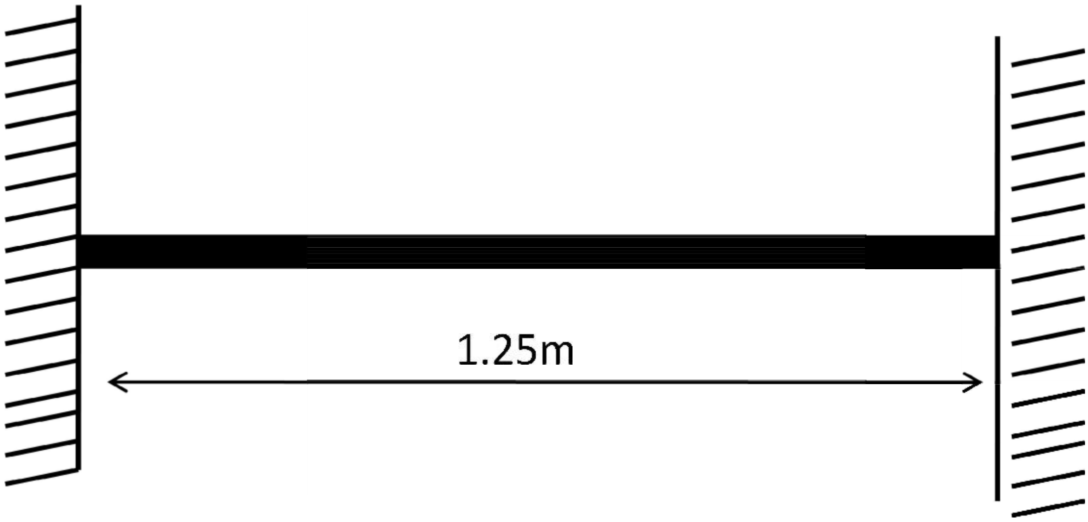

Figure 21-1 : Modal analysis for a fixed - fixed beam

21.2 Specifications of the beam

Length of the beam	l	= 1250mm
Height of the beam	h	= 100 mm
Width of the beam	b	= 25 mm
Area Moment of inertia	I	= 2.08×10^6 mm^4
Material of the beam		= Mild Steel
Youngs Modulus	E	= 210 GPa
Area of the beam	A	= 250 mm^2
Mass density of the given material	ρ	= 7830kg/m^3

21.3 Analytical solution

Natural frequency	ω	$= (\beta l)^2 \sqrt{\frac{EI}{\rho A l^4}}$

	$\beta_1 l$	= 4.730041
	$\beta_2 l$	= 7.853205
	$\beta_3 l$	= 10.995608
	$\beta_4 l$	= 14.137165
1st mode	ω_1	
2nd mode	ω_2	
3rd mode	ω_3	
4th mode	ω_4	

21.4 Calculations

21.5 Numerical solution

22 One dimensional steady state heat conduction

22.1 Aim

To determine the heat loss and temperature distribution in a composite plane wall

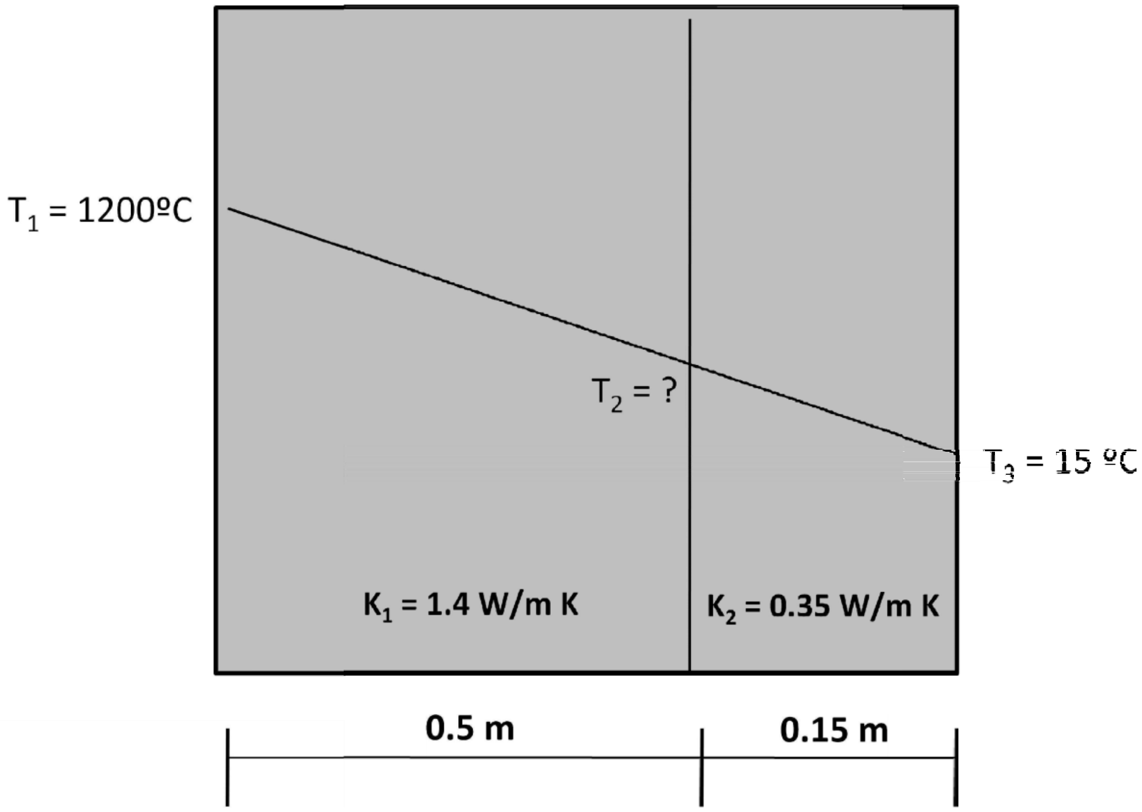

Figure 22-1 : Plane wall subjected to steady state heat conduction

22.2 Specification of the wall

Thickness of wall 1	t_1	= 0.5m
Thermal conductivity of wall 1	k_1	= 1.4 W/m-k
Thickness of wall 2	t_2	= 0.15m
Thermal conductivity of wall 2	k_2	= 0.35 W/m-k

22.3 Analytical solution

Heat loss per unit area	q	$= \frac{T_1 - T_3}{\frac{L_1}{K_1} - \frac{L_2}{K_2}}$	= 1450W
Intermediate temperature	T_2	$= T_1 - \frac{q t_1}{k_1}$	= 682 ºC

22.4 Calculations

22.5 Numerical solution

23 One dimensional steady state heat conduction - convection

23.1 Aim

To determine the heat loss and temperature distribution in a composite plane wall

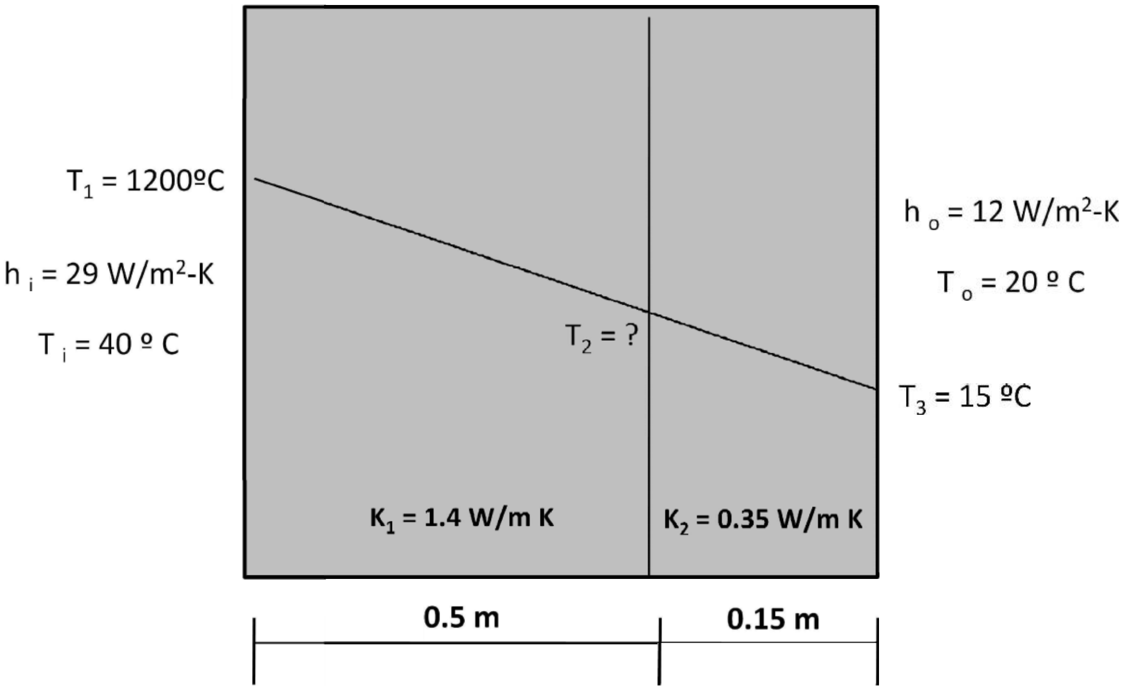

Figure 23-1 : Composite wall subjected to conduction - convection

23.2 Specification of the wall

Thickness of wall 1	t_1	= 0.5m
Thermal conductivity of wall 1	k_1	= 1.4 W/m-k
Thickness of wall 2	t_2	= 0.15m
Thermal conductivity of wall 2	k_2	= 0.35 W/m-k
Convective heat transfer coefficient	h_i	= 29 W/ m^2-K
	h_o	= 12 W/ m^2-K
Inlet ambient temperature	T_i	= 40 ºC
Outlet ambient temperature	T_o	= 15 ºC

23.3 Analytical solution

Heat loss per unit area q = h A (δT) = 33.64kW

Intermediate temperature T_2

23.4 Calculations

23.5 Numerical solution

23.4 Calculations

24 Temperature distribution in a infinite long fin

24.1 Aim

To determine the temperature distribution in a infinite long fin

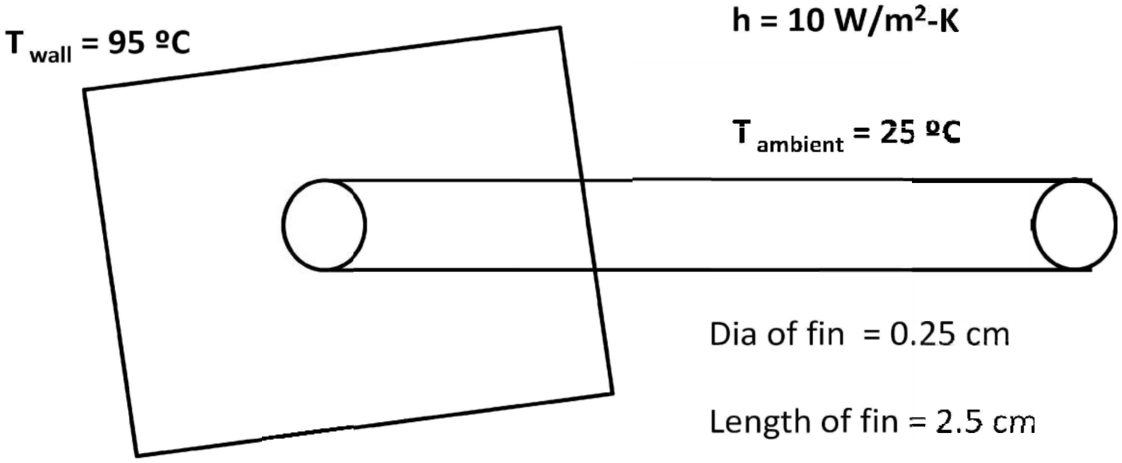

Figure 24-1 : Circular fin of infinite length

24.2 Specification of the fin

Diameter of fin	d	= 0.25 c m
Length of fin	l	= 2.5 cm
Temperature of wall	t_{wall}	= 95 ºC
Ambient temperature	$t_{ambient}$	= 25 ºC
Convective heat transfer coefficient	h_i	= 10 W/ m^2-K
Thermal conductivity of fin	K	= 396 W/m-K
Perimeter of fin	p	= π * d

24.3 Analytical solution

	m	$= \sqrt{\frac{hP}{KA}}$	= 2.01 /m
Heat loss per unit area	q	= m K A Θ_o	= 0.865W

23.4 Calculations

24.5 Numerical solution

23.4 Calculations

DEPARTMENT OF MECHANICAL ENGINEERING

Vision:

To be centre of excellence in Mechanical Engineering equipping students with top notch competencies in the domain of information technology.

Mission:

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- Establishing learning ambience with best infrastructure facilities