AE3212-II: Simulation, Verification and Validation

Structures Assignment

11/02/2020

TU Delft

Objective Structures Assignment

- **Create a numerical model** of a structure
- **Interpret a given model** of the structure
- **Verify** the numerical model of the structure
- **Interpret given experimental data** of a similar structure
- **Validate** the numerical model of the structure

Learn to be critical of your own work and that of others

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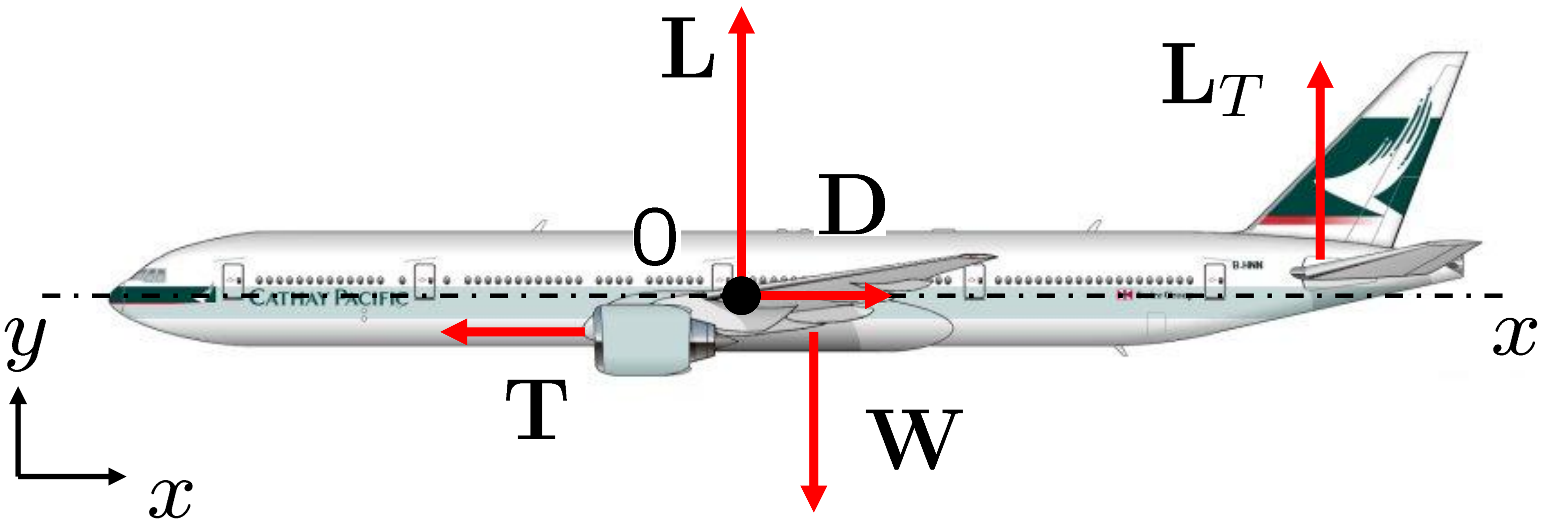
Modelling a Structure

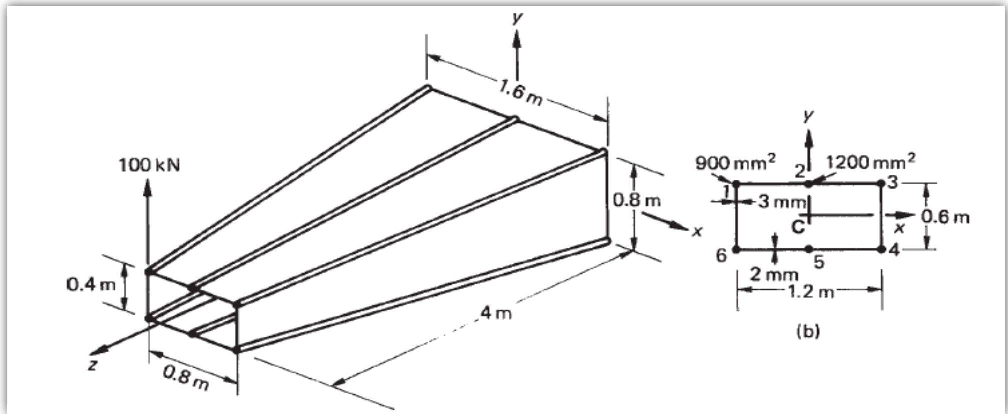
 https://www.eztoys.com/new-mould-klm-100-years-boeing-787-10-ph-bka-ngmodel-56001-scale-1-400.html

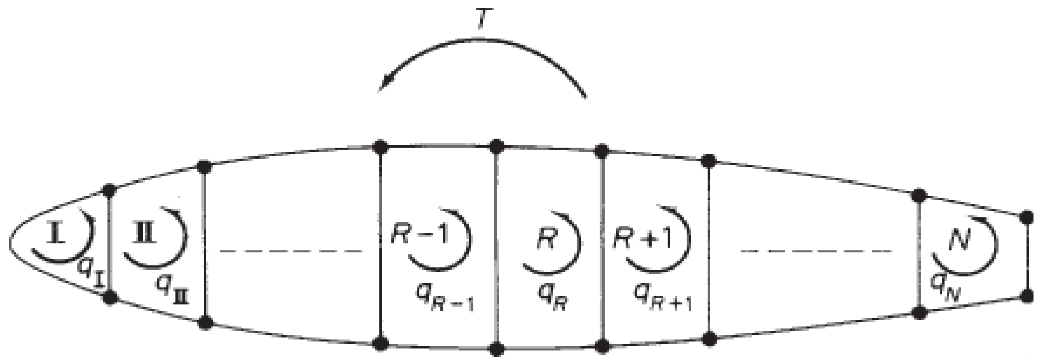
Modelling a Structure: Statics



Modelling a Structure: SA

AE2135-I: Structural Analysis and Design





Modelling a Structure

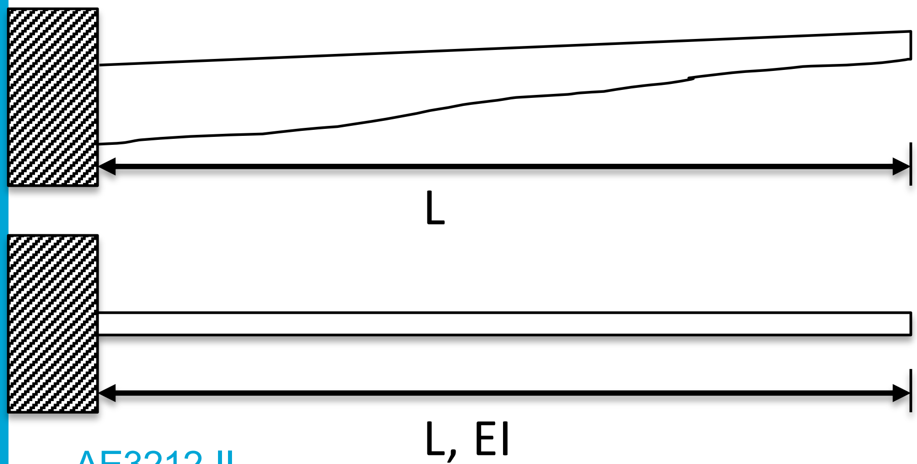
- Complex
- Continuous
- Non-linear

- Simplified
- Discretized
- Linearized

Modelling a wing

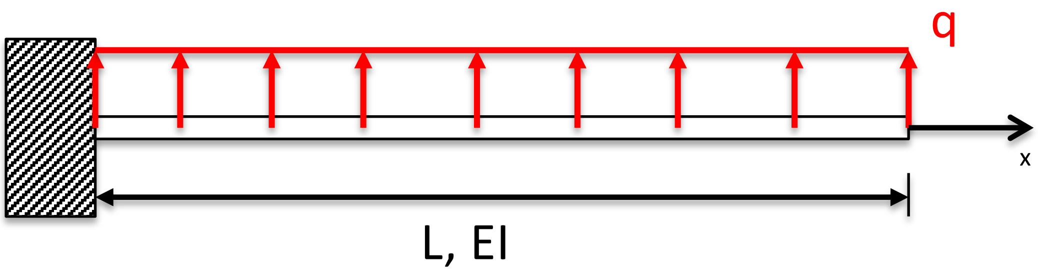
Deflections?

Schematize wing



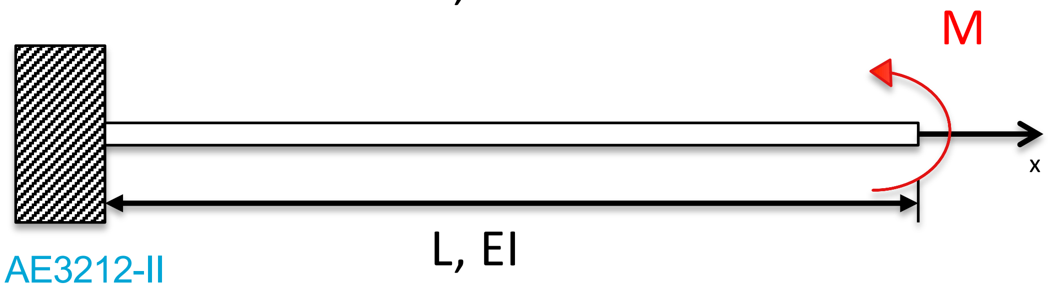
Simplify wing

Deflection of a cantilever beam



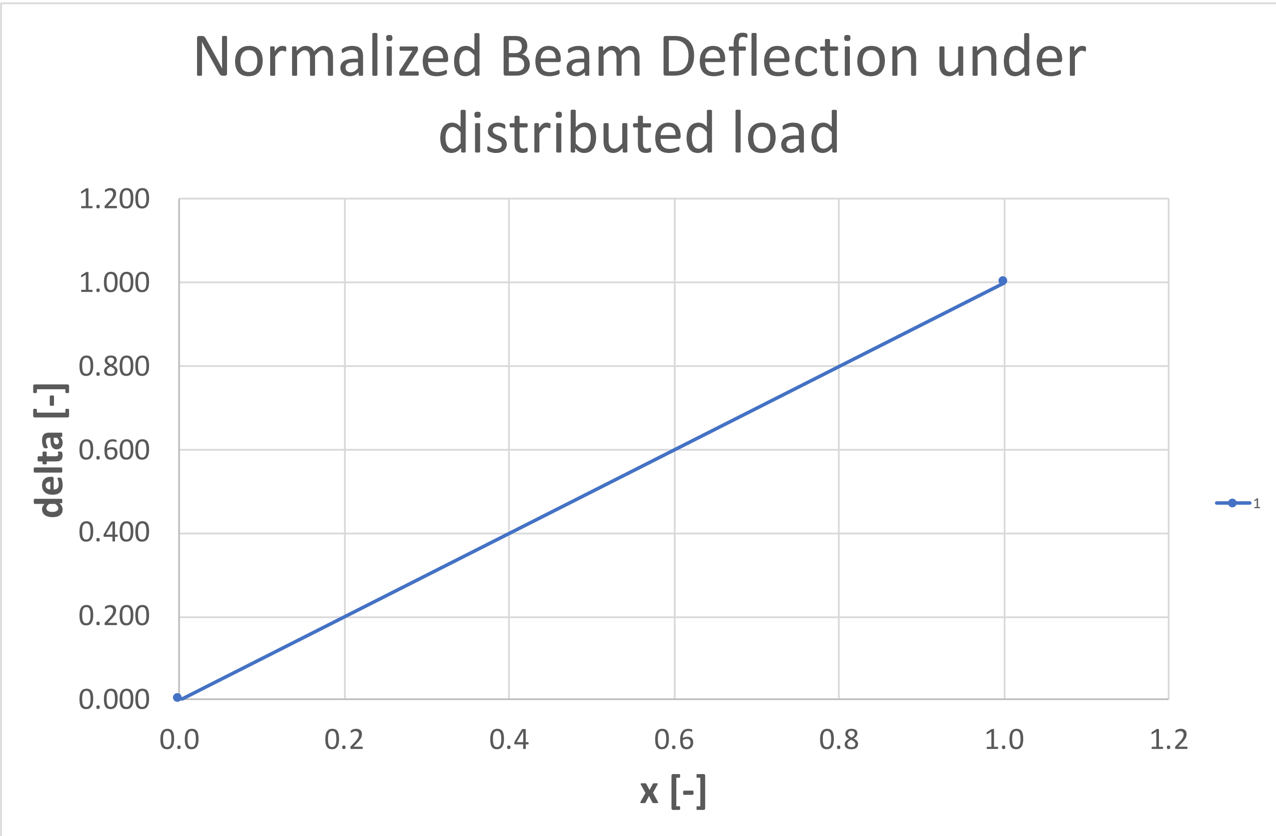
$$\delta_{\text{tip}} = \frac{qL^4}{8EI} \qquad \theta_{\text{tip}} = \frac{qL^3}{6EI}$$

$$\delta_{\text{tip}} = \frac{PL^3}{3EI} \qquad \theta_{\text{tip}} = \frac{PL^2}{2EI}$$

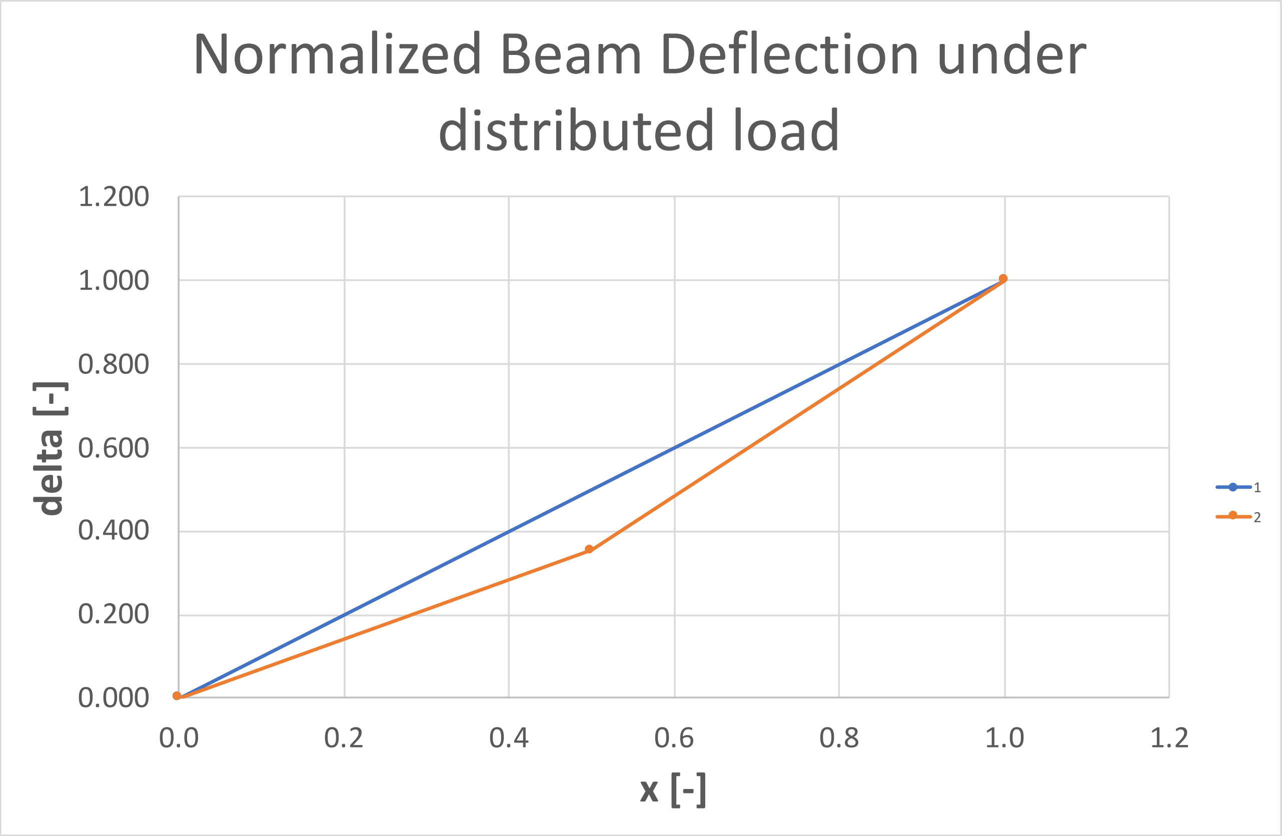


$$\delta_{\text{tip}} = \frac{ML^2}{2EI} \qquad \theta_{\text{tip}} = \frac{ML}{EI}$$

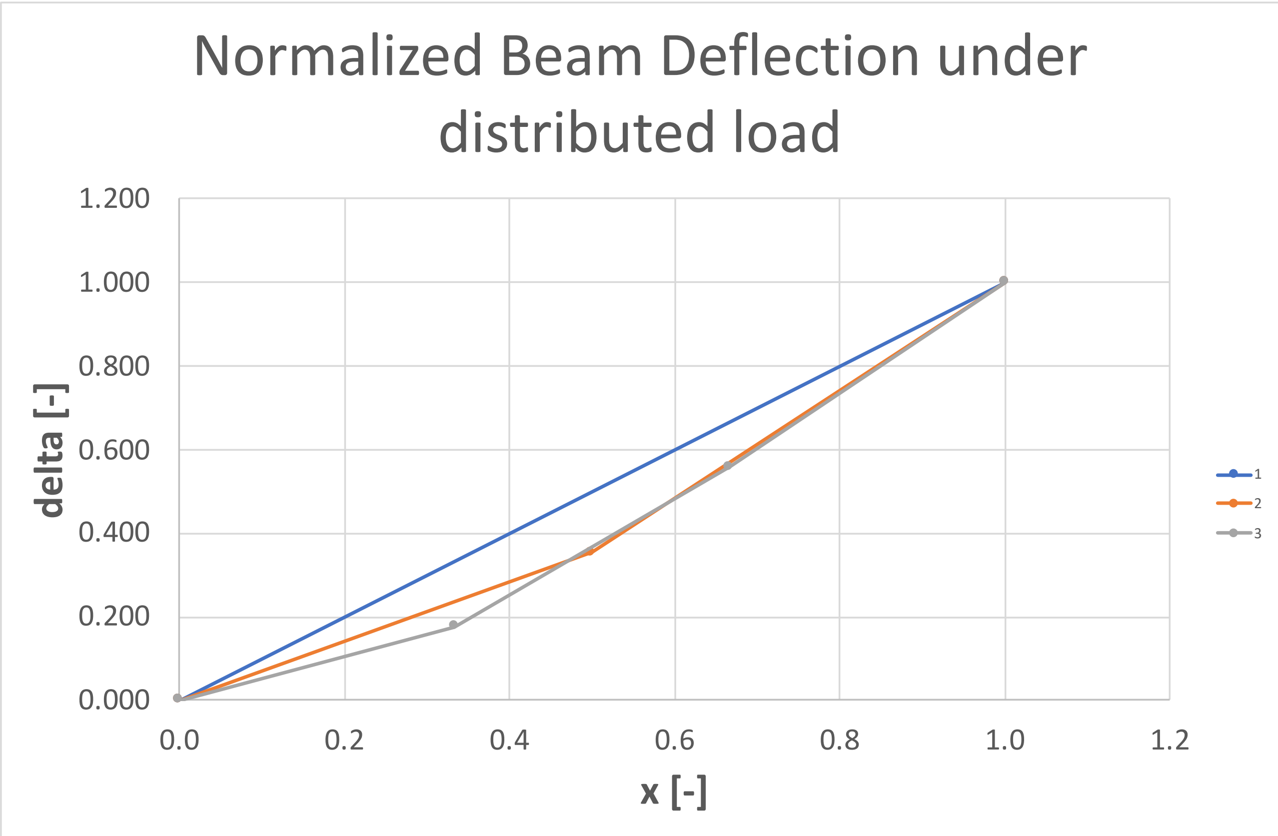
Result Simulation Simple wing example



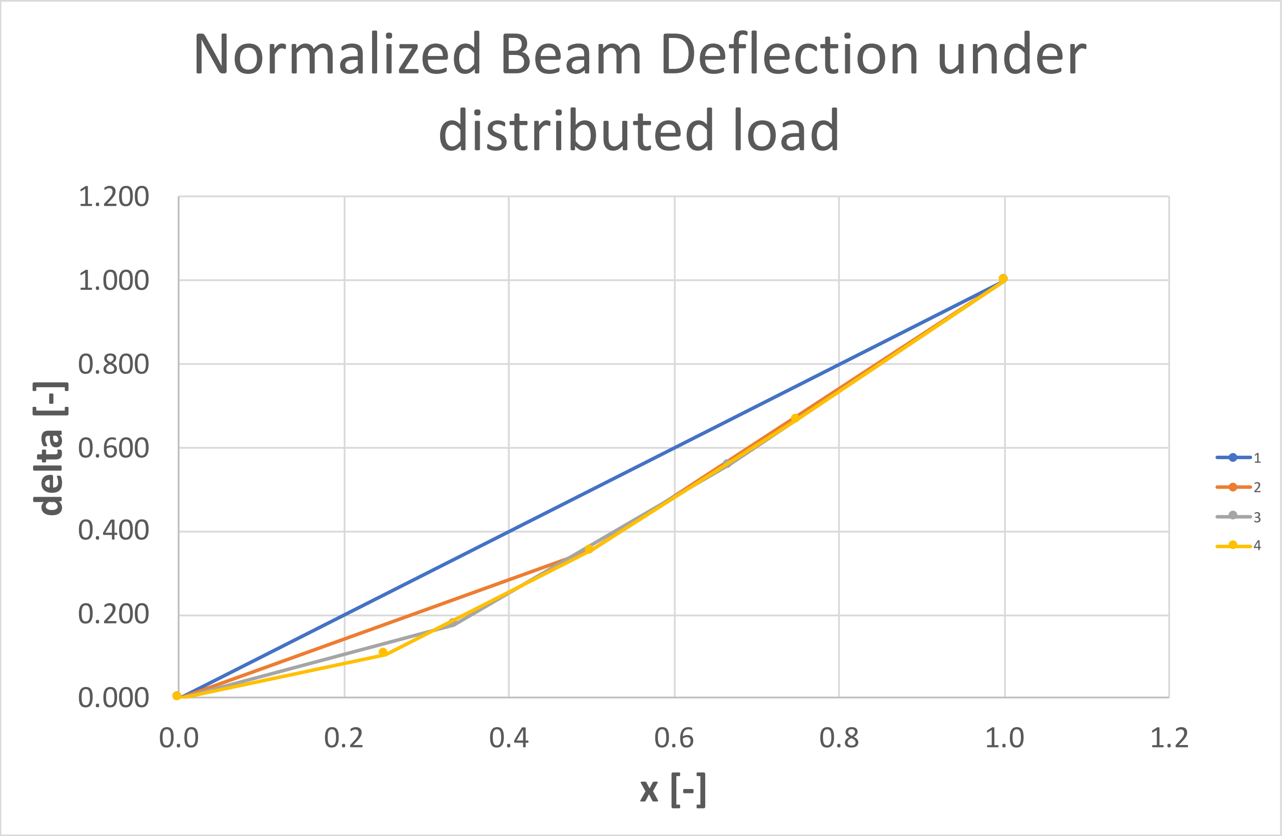
Result Simulation Simple wing example n = 2



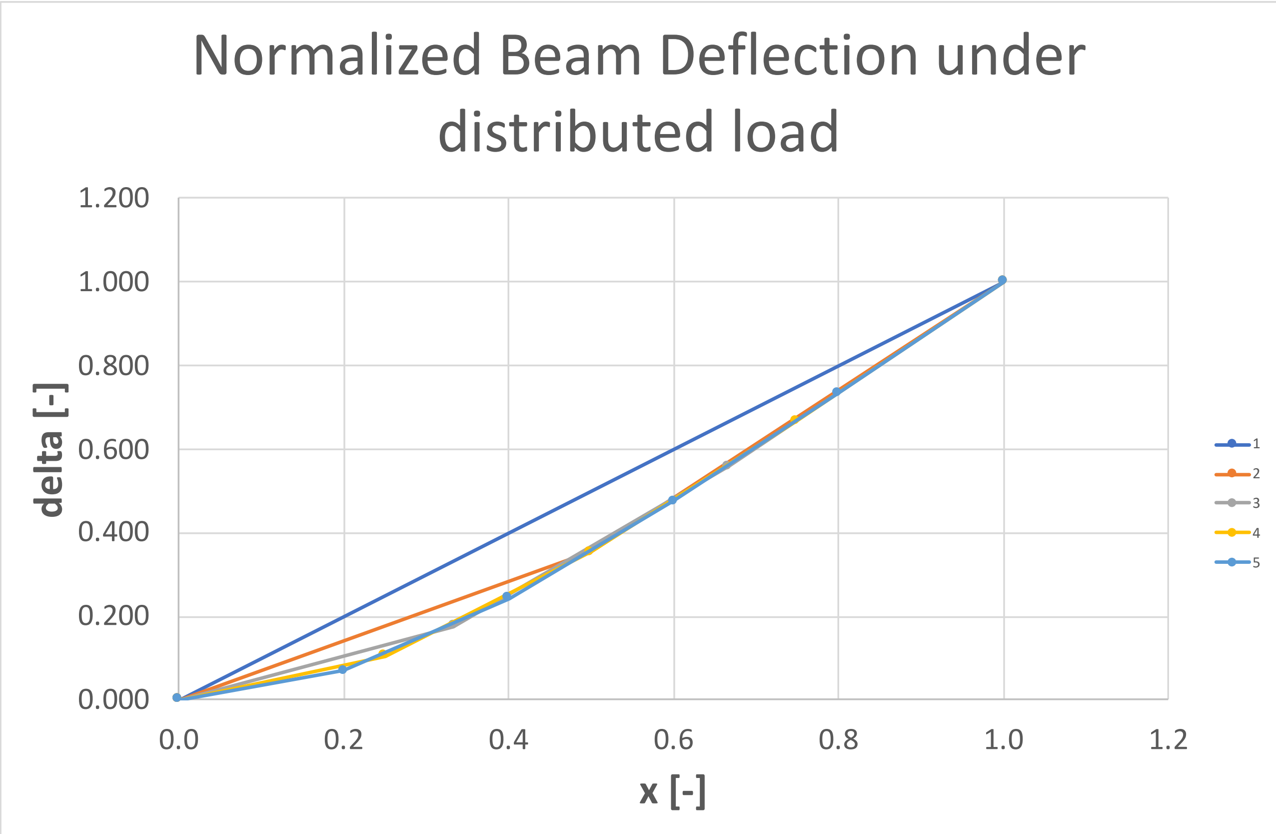
Result Simulation Simple wing example n = 3



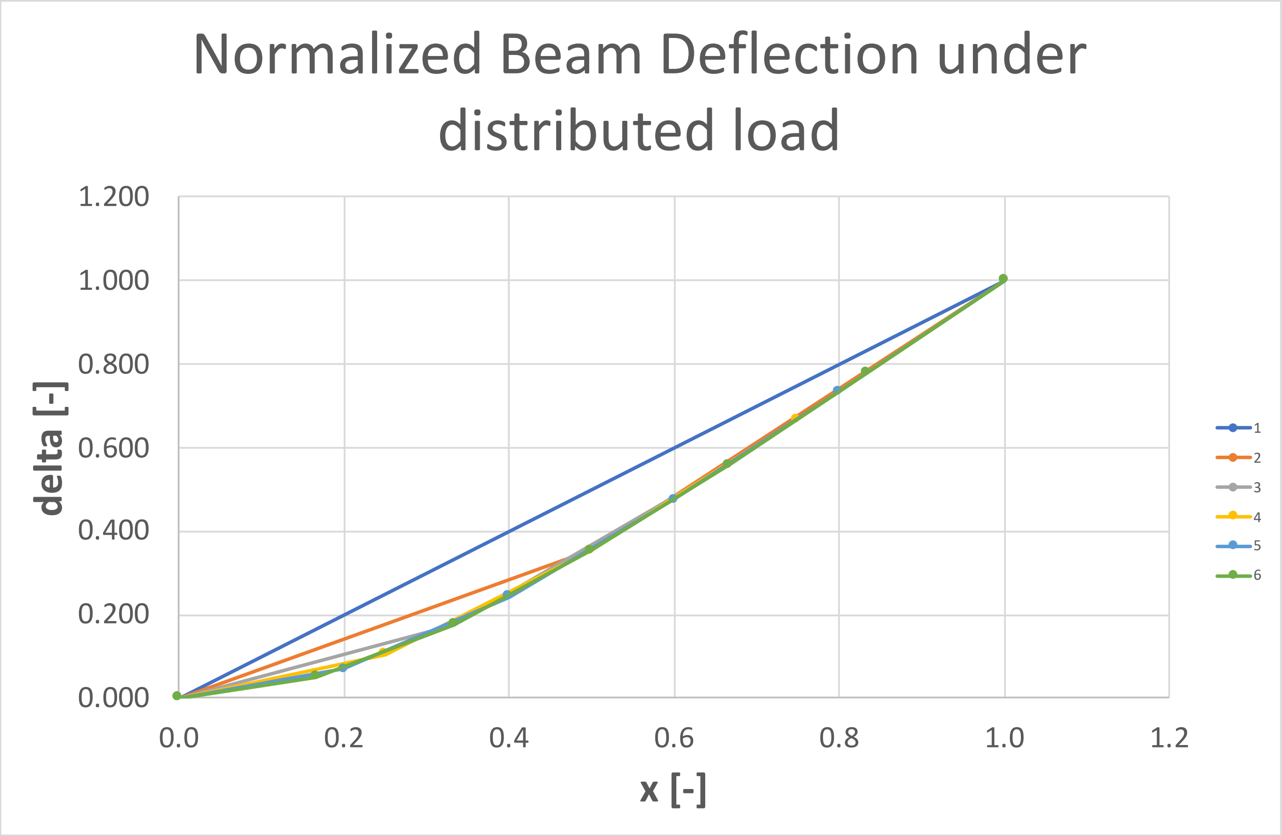
Result Simulation Simple wing example n = 4



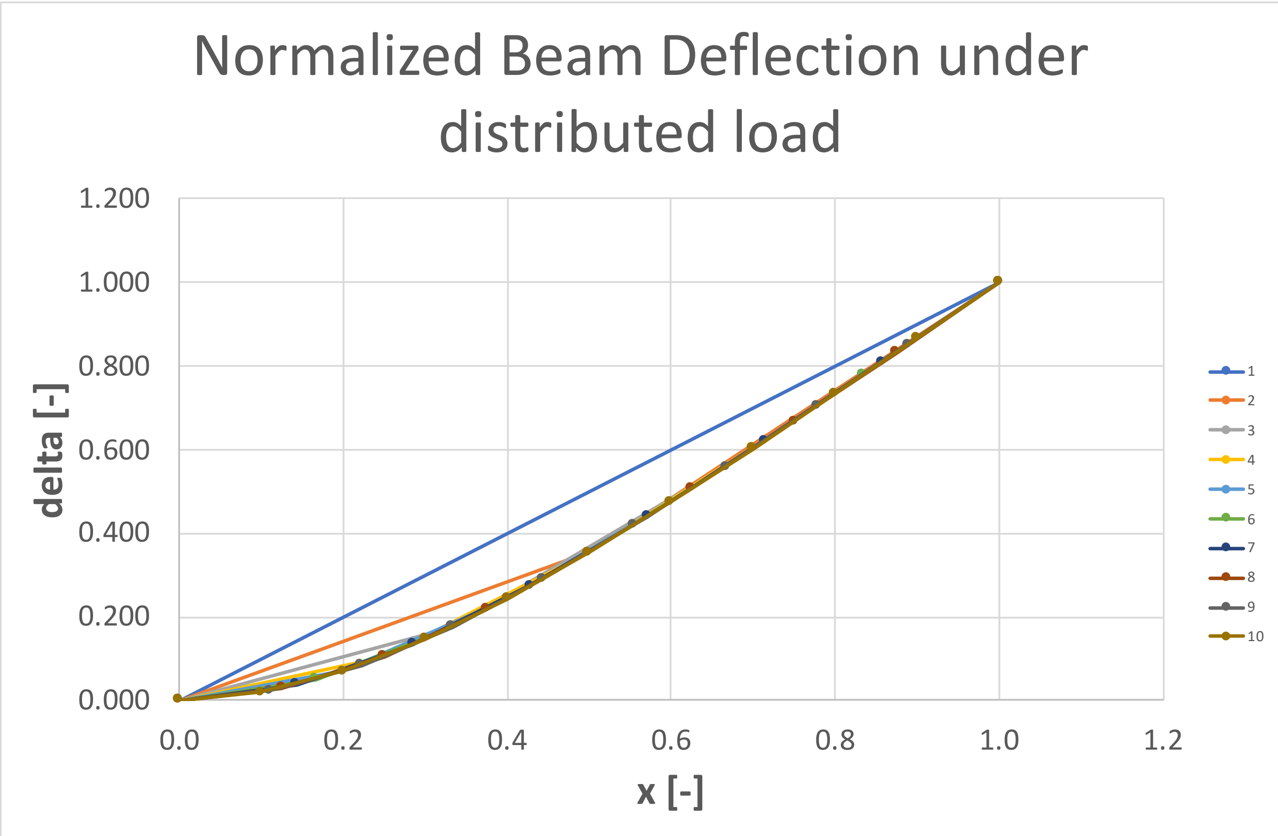
Result Simulation Simple wing example n = 5



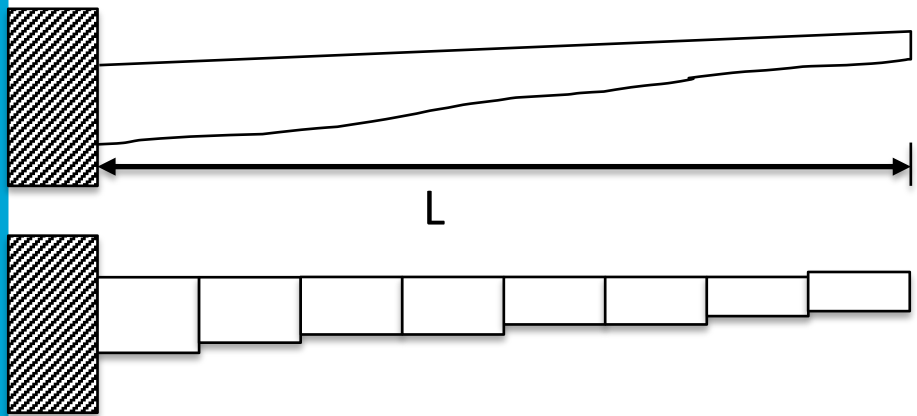
Result Simulation Simple wing example n = 6



Result Simulation Simple wing example n = 10



Modelling a wing

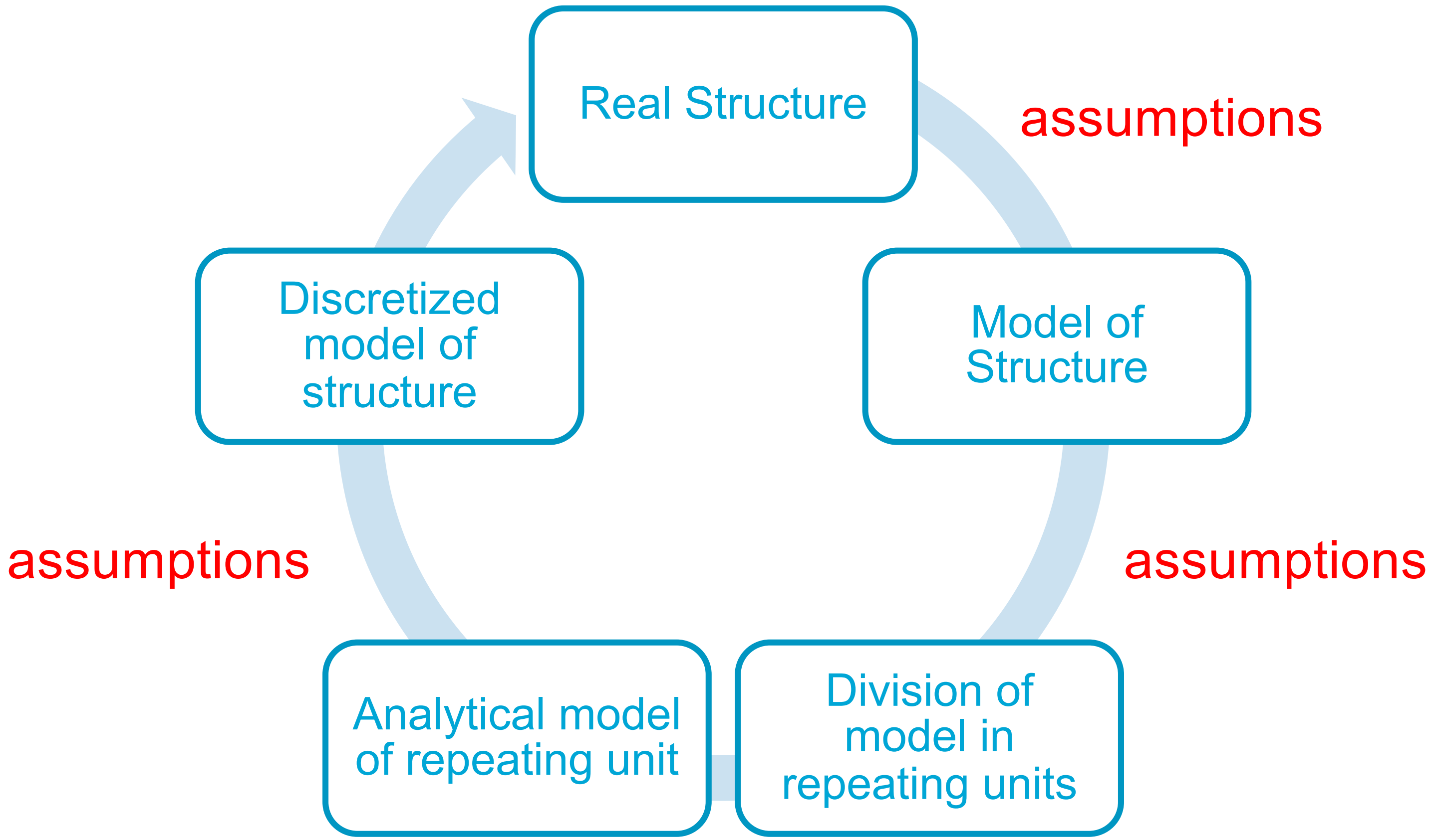


Deflections?

Schematize wing

Simplify wing

Modelling a structure



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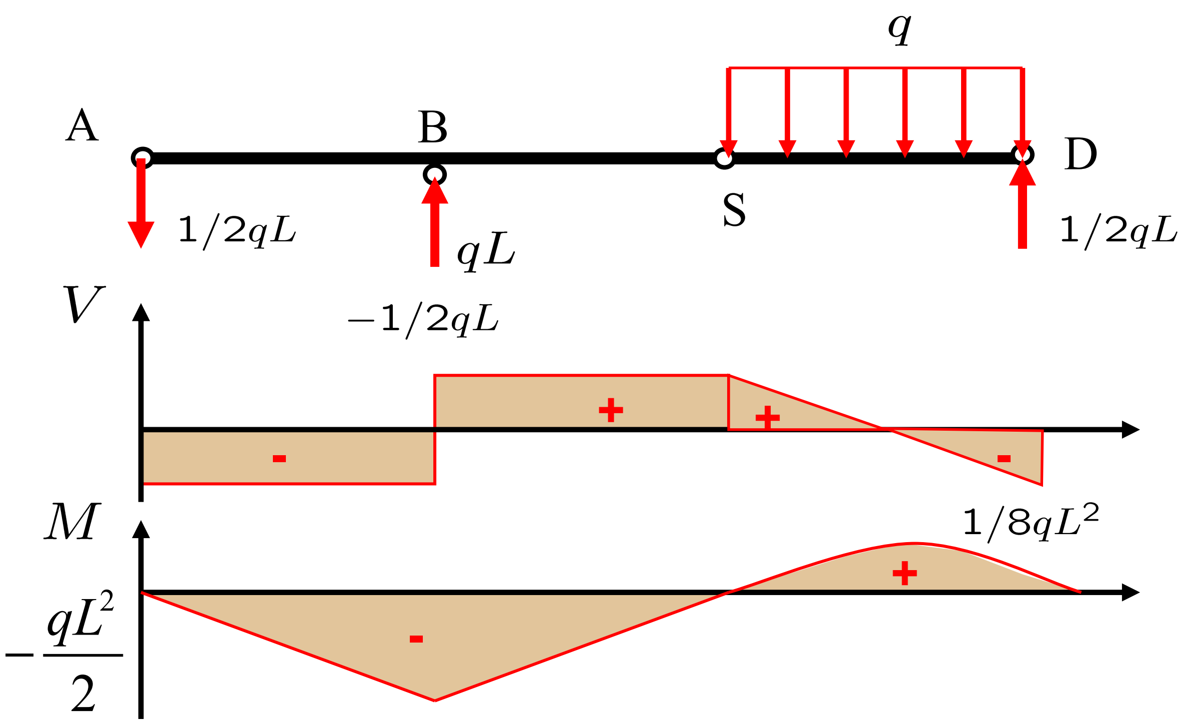
Engineering Mechanics:

	Static Analysis ($\Sigma F = 0$)		Dynamic Analysis ($\Sigma F = ma$)
External Analysis: • Particle • Rigid Body	Statics (AE1130-I)		Dynamics (AE1130-II)
Internal Analysis: • Solids	Solid Mechanics (AE1108-II)	Structural Analysis (AE2135-I)	Vibrations (AE2106)
• Fluids	Aerodynamics (AE1110, AE2130)		
• Energy	Physics I, Power & Propulsion (AE1240, AE2230-II)		

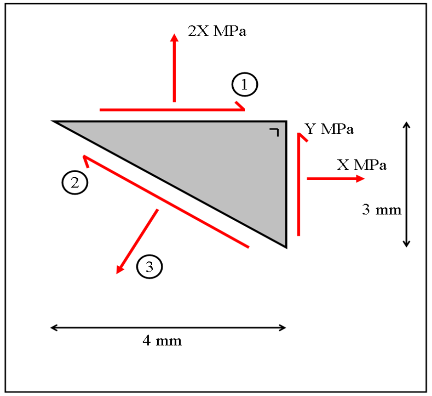
1st year BSc Structures related

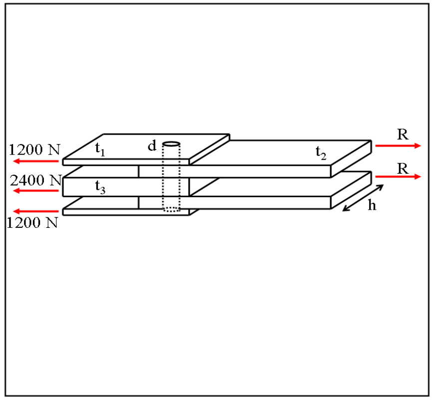
AE1130-I: Statics

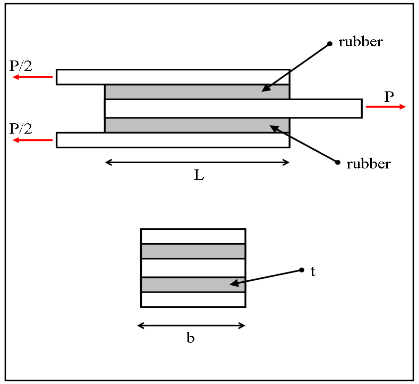


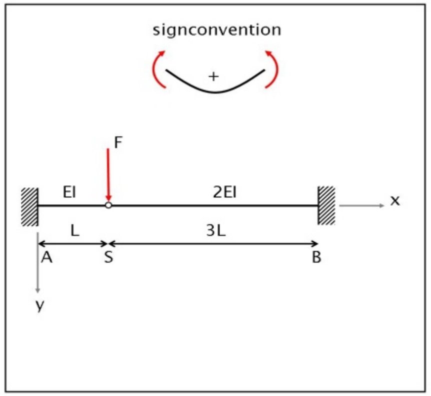
1st year BSc Structures related

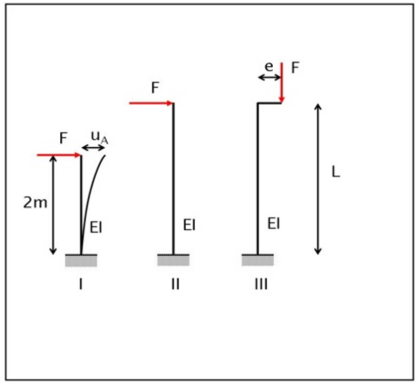
AE1108: Aerospace Materials and Structures

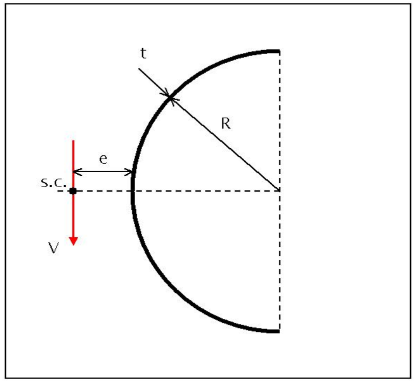






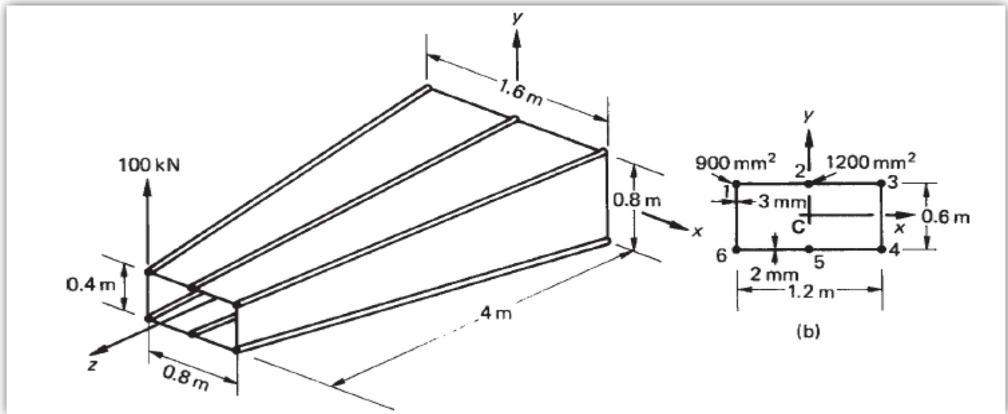


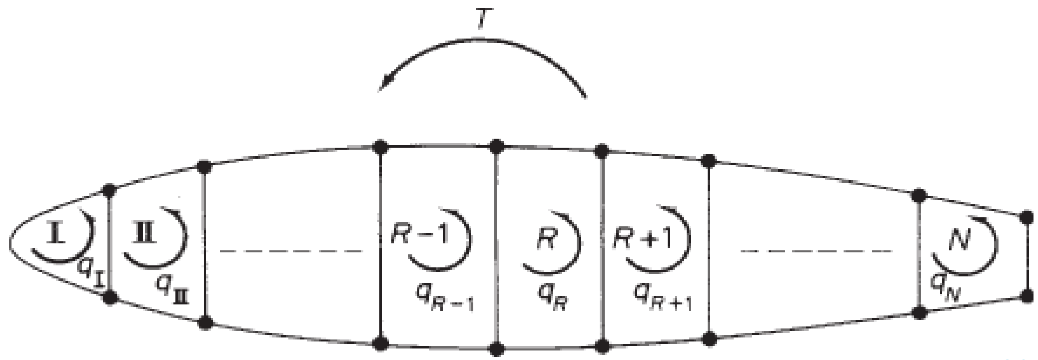




2nd year BSc Structures related

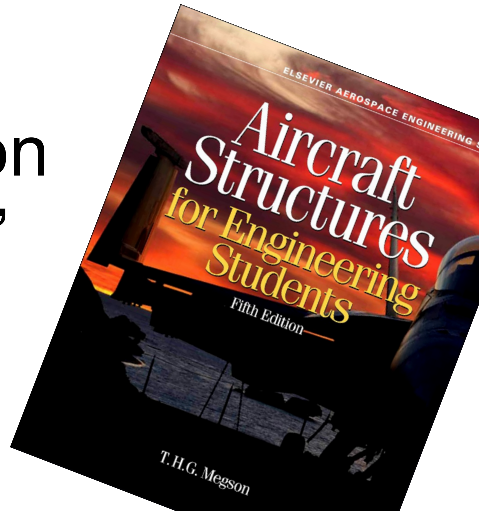
AE2135-I: Structural Analysis and Design





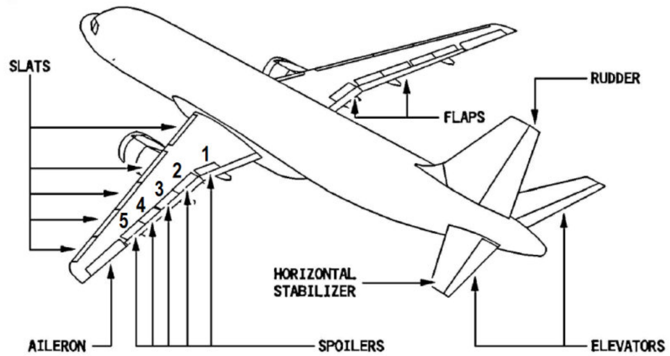
Review …

- Refresh your knowledge on structural analysis
- Enroll for AE1130-I on Brightspace
- Enroll for AE1108-II on Brightspace
- Enroll for AE2135-I on Brightspace
- Use Megson & Hibbeler
- Read hand out "A primer on deflection of statically indeterminate structures"



Structures assignment 2020

As a group of stress engineers, you will create a preliminary, numerical structural analysis tool to compute the maximum deflection of the leading edge and trailing edge of the aileron and stresses in the aileron for a given extreme loading case.



http://theflyingengineer.com/tag/alleviation/

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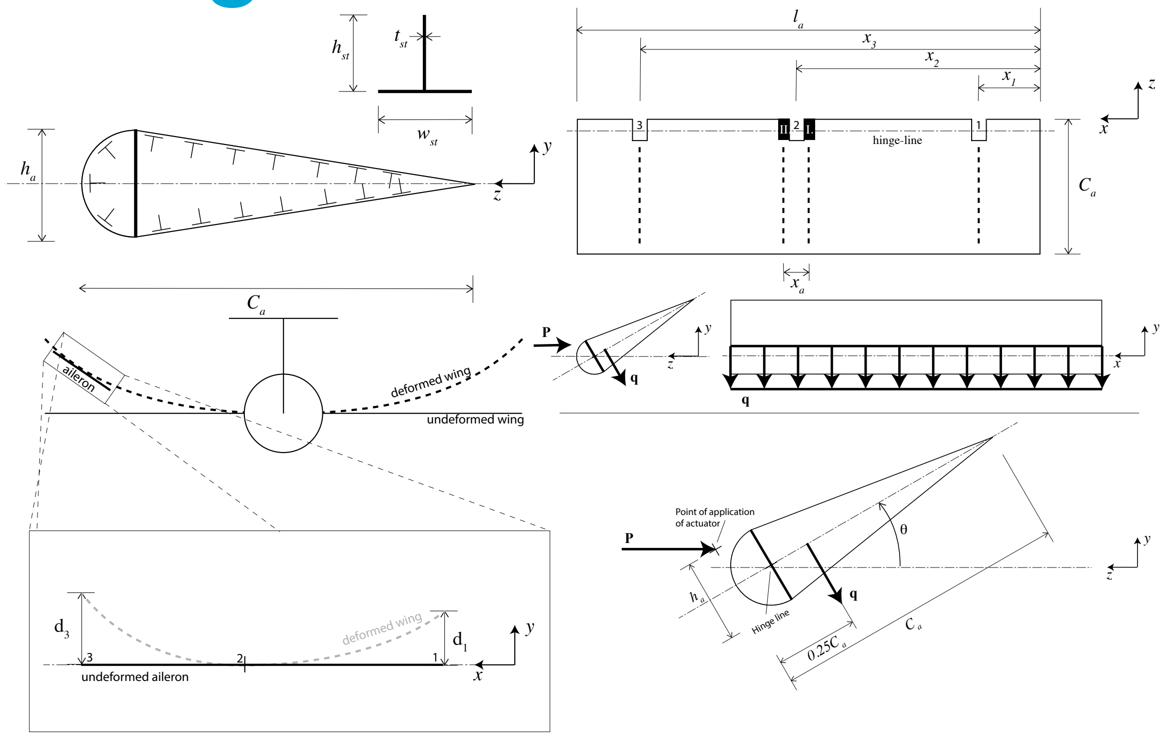
Structures assignment 2020

- Thin-walled structure
- Aileron under critical loading
  - 3 hinge points + bent wing
  - Maximum deflection
  - Actuator jammed



- Displacement driven
  - Analyse displacement of leading and trailing edges
  - Analyse displacements and stresses

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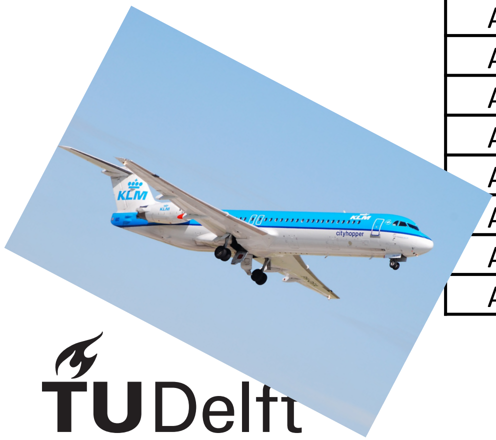
Aircraft type

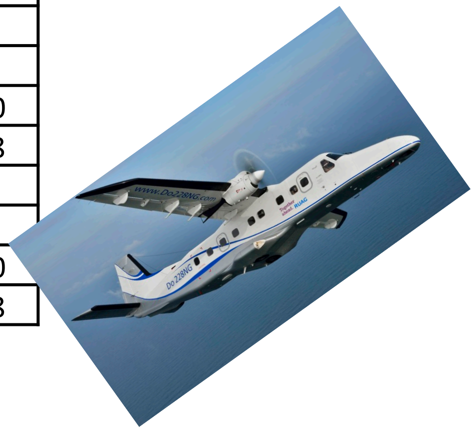
Group allocation

Group	Aircraft
A01	A320
A02	CRJ700
A03	Do 228
A04	F100
A05	A320
A06	CRJ700
A07	Do 228
A08	F100
A09	A320
A10	CRJ700
A11	Do 228
A12	F100
A13	A320
A14	CRJ700
A15	Do 228
A16	F100
A17	A320

Group	Aircraft
A18	CRJ700
A19	Do 228
A20	F100
A21	A320
A22	CRJ700
A23	Do 228
A24	F100
A25	A320
A26	CRJ700
A27	Do 228
A28	F100
A29	A320
A30	CRJ700
A31	Do 228
A32	F100
A33	A320
A34	CRJ700

Group	Aircraft
A35	Do 228
A36	F100
A37	A320
A38	CRJ700
A39	Do 228
A40	F100
A41	A320
A42	CRJ700
A43	Do 228
A44	F100
A45	A320
A46	CRJ700
A47	Do 228
A48	F100
A49	A320
A50	CRJ700
A51	Do 228





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Numerical model for SVV

- Must be on knowledge obtained in your BSc →
  FEM is not allowed!
- Needs to be sufficiently different from the provided verification model →
  no Rayleigh-Ritz method or close derivative
- Shear flows **not** to be calculated **analytically**
- Please refrain from building a generic tool.
  It already is complicated enough to build a dedicated model for your assignment!

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Verification model

- Provided
  - PDF: DESCRIPTION OF THE VERIFICATION MODEL USED IN THE AE3212-II PROJECT
  - Python code of the model per aircraft type
- Expected
  - Understand the method used
  - Identify assumptions made
  - Apply the model to your own problem
  - Present the results obtained for the model

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Verification of your model

- Define criteria that make the models fit for comparison
- Analysis of the aileron using the provided model
- Think of tests to compare both models in a fair way

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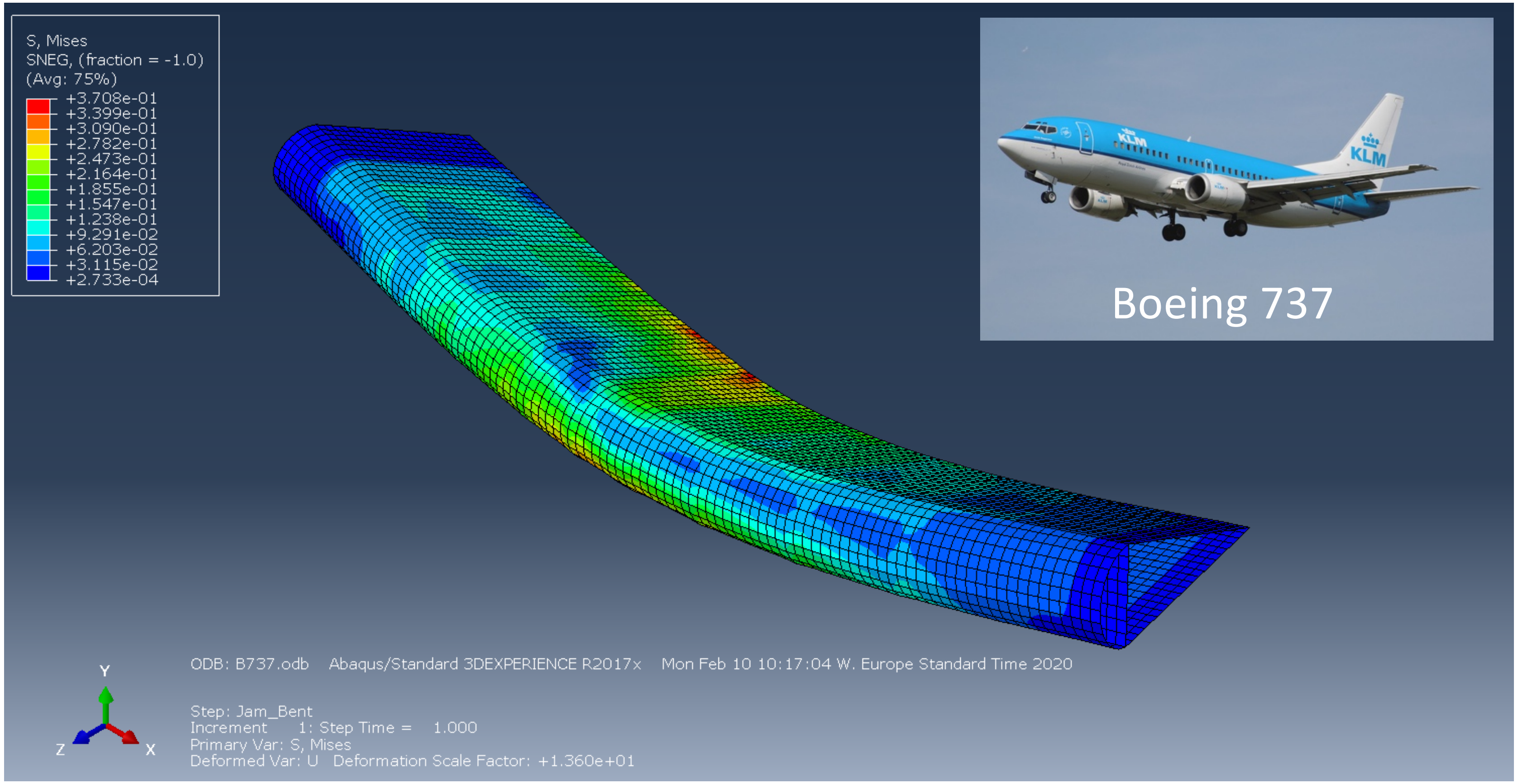
Results of numerical experiment



Validation data

- Provided
  - A description of the numerical experiment
  - Finite Element results for three load cases
- Expected
  - Understand the method used
  - Interpret the experimental data
  - Identify assumptions made in the numerical experiment
  - Present the results of the numerical experiment

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Validation of your model

- Define criteria that make the models and experiment fit for comparison
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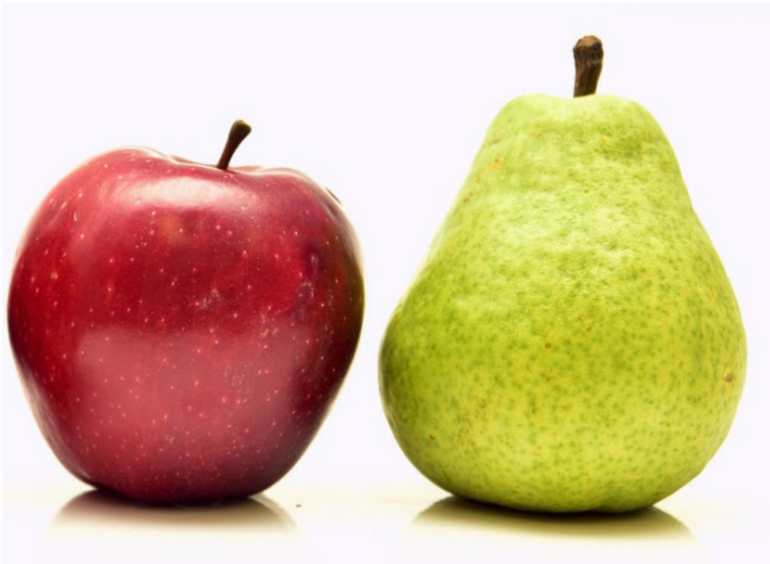

The very early days…

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AERO RESEARCH TECHNICAL NOTES

From —The Director of Research and Development, Aero Research Limited

Duxford, Cambridge
Telephone: Sawston 167-8

BULLETIN No. 34
October 1945

WAR WORK

This bulletin is a reproduction, made by the courtesy of the editor of Aircraft Production, of an article which appeared in the July (1945) issue of Aircraft Production, describing one of our war time research jobs.

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The very early days…

A FIGHTER FUSELAGE IN SYNTHETIC MATERIAL

Introduction

The state of emergency which existed in Britain during the later months of 1940 demanded an all-embracing review of the country's resources of material supply. The fall of France eliminated as a source of supply (and placed at the disposal of the enemy) some of the largest bauxite deposits in the world and among the measures considered at the time was the possibility of building aircraft from materials, other than light alloys, which could be produced in the British Isles. In August of that year, Aero Research Ltd., were asked, as a result of a proposal put forward by themselves, to build an experimental Spitfire fighter fuselage in order to determine whether synthetic material could be used satisfactorily for such a purpose.

Page 1

The very early days…

- The “fiber placement machine” of the 1940s…

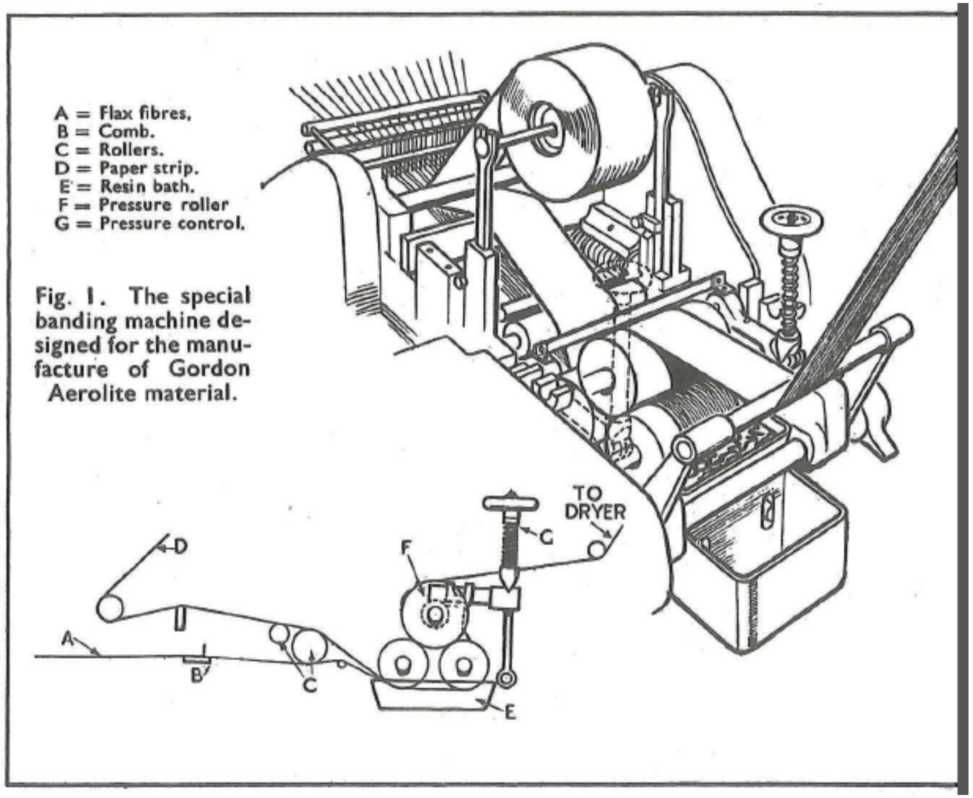


Fig. 1. The special banding machine designed for the manufacture of Gordon Aerolite material.

The very early days…

- The fuselage…

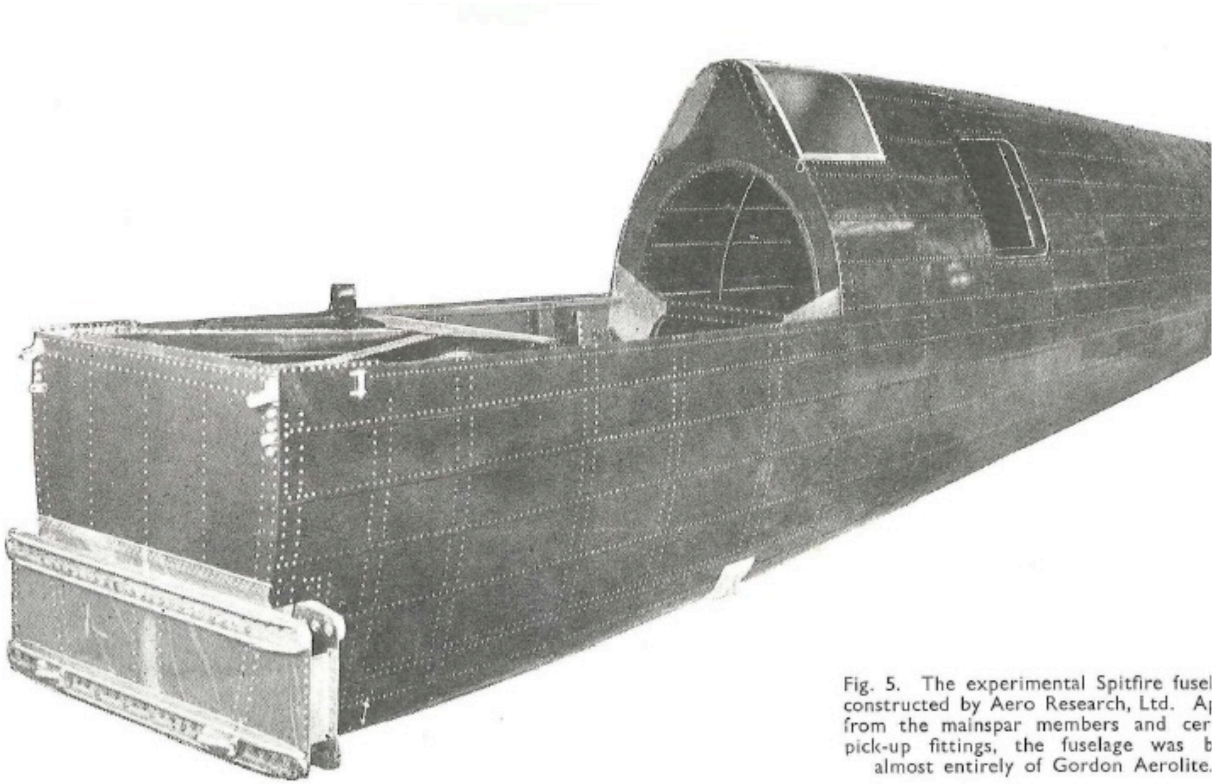


Fig. 5. The experimental Spitfire fusel
constructed by Aero Research, Ltd. A
from the mainspar members and cer
pick-up fittings, the fuselage was b
almost entirely of Gordon Aerolite.

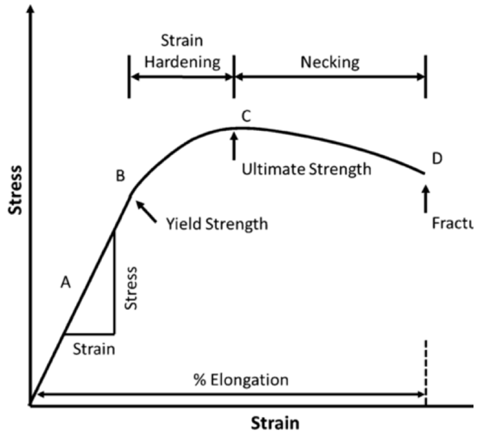
The very early days…

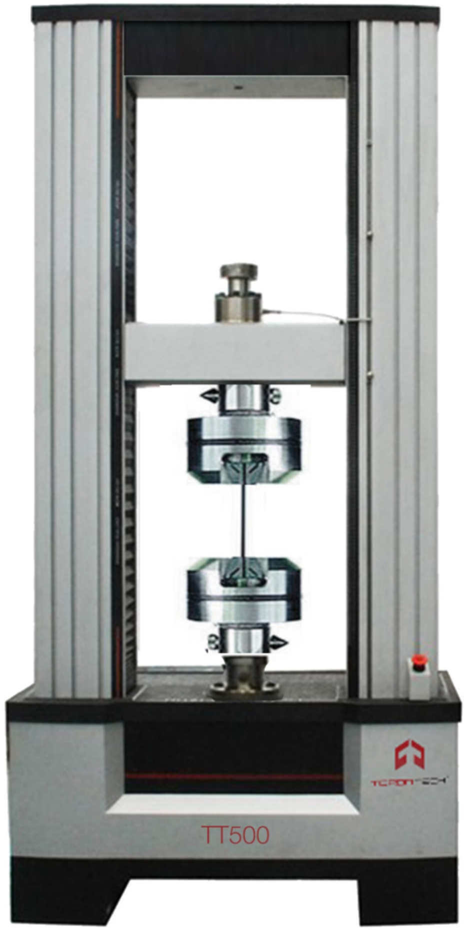
- Full-scale test results…

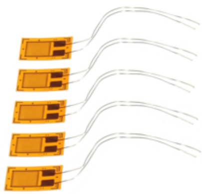
TEST RESULTS ON GORDON AEROLITE FUSELAGE		
ype of Load	Magnitude	Result
load on ilplane	90 per cent. of 1,000lb.	Undamaged
re of pres- e back	90 per cent. of 8g.	Undamaged
load on ilplane	Fuselage just failed at 100 per cent. of fully factored load (3,700 lb).	

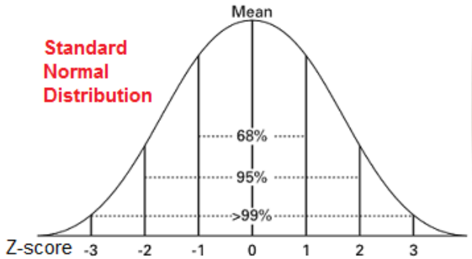
Error sources

- Measurement error
  - Inaccuracy
  - Human error
  - Misalignment
- Standard Normal Distribution
  - Variation
  - Damage





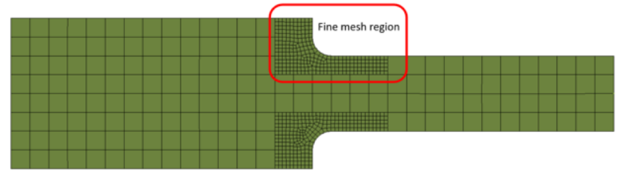


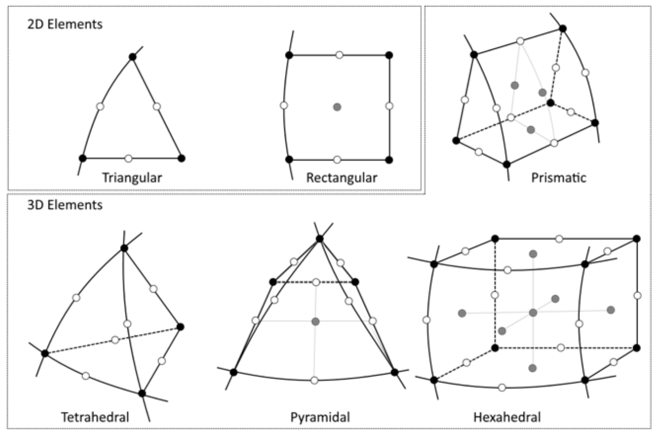


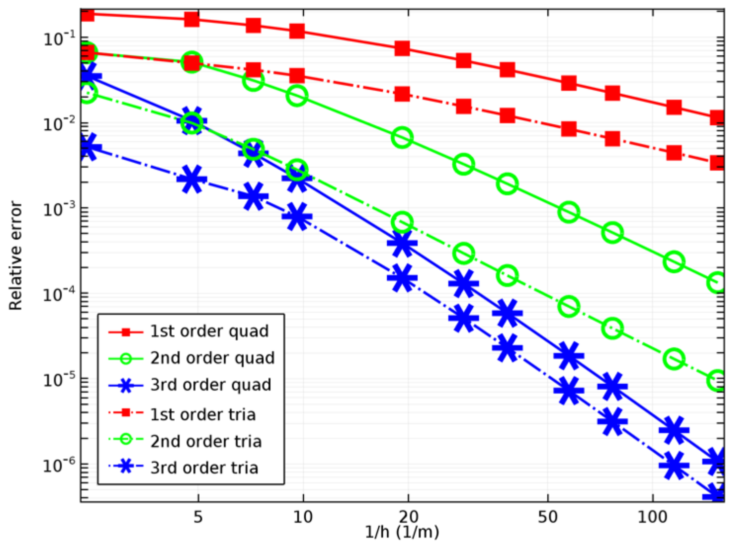
Significant figures!

Error sources

- Element type
- Discretization
- Boundary conditions
- Numerical accuracy & convergence







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Documents provided to you

- Structures Assignment
- Aircraft Allocation & Aircraft Data
- Verification model
- A primer for Structural Analysis
- Description of the Validation Data
- FEM results