University of Southampton

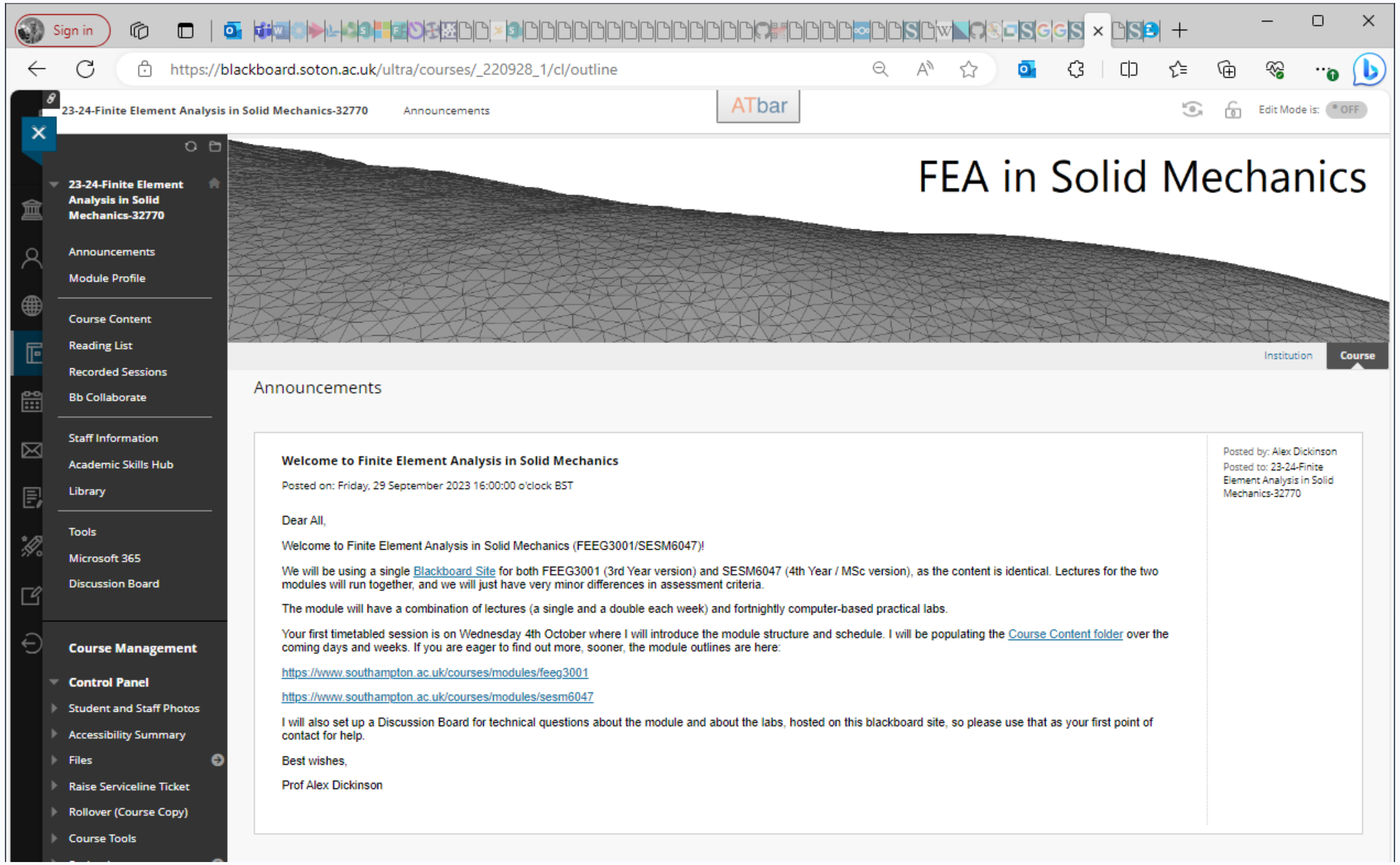
Introduction

FEEG3001/SESM6047 FEA in Solid Mechanics
Prof A S Dickinson

1st October 2024

Welcome

- Who is in the room? Backgrounds?
- Has everyone done at least one solid mechanics course?
  - Basic solid mechanics
  - Basic Matrix algebra (multiplication, transposes, ...)
- See the background maths lecture if needed



What is Finite Element Analysis (FEA)?

Join: **vevox.app** ID: **163-639-669**

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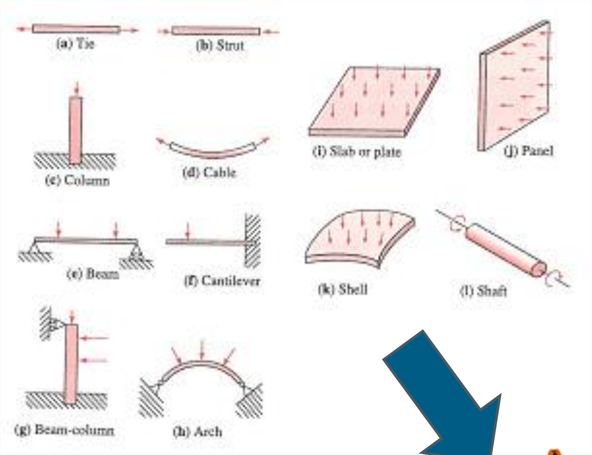
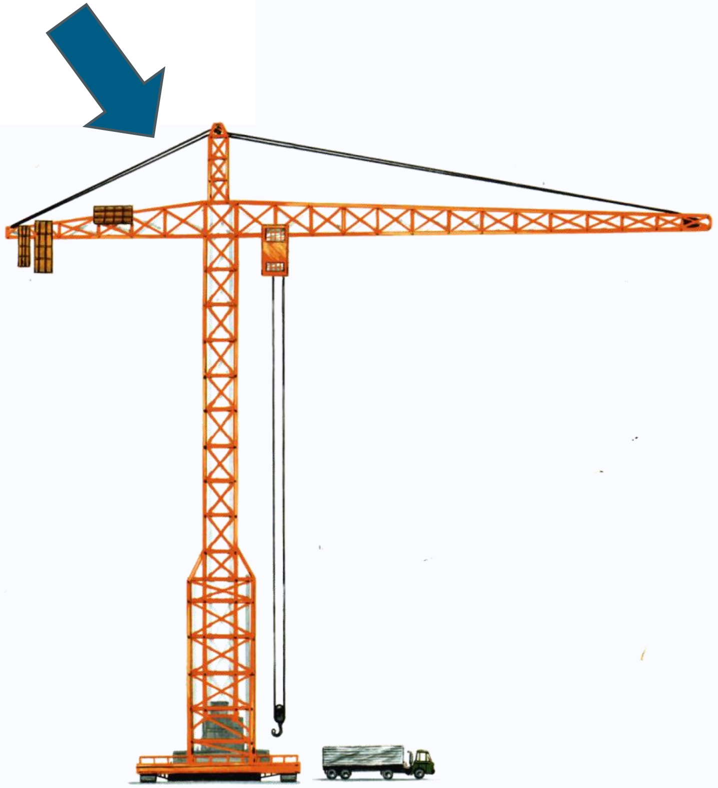
What is Finite Element Analysis (FEA)?

- Field problems
- Boundary value problems
- Described by partial differential equations
  - Heat transfer
  - Fluid flow
  - **Structural analysis (deformation, stress)**

- An alternative to Free Body Diagrams
- When complexity in shape, loading, materials make analytical approaches inappropriate



Benham et al



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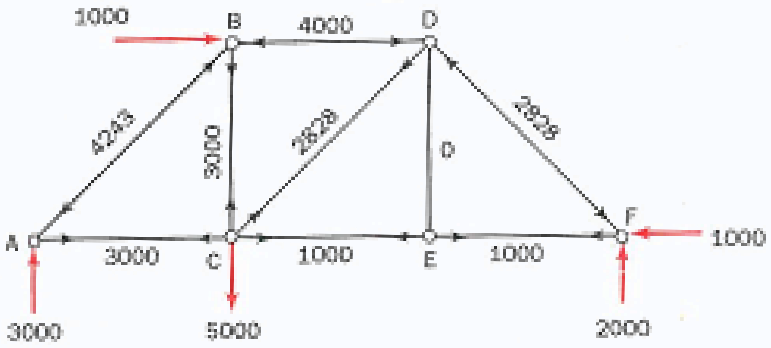
Complexity makes computation essential



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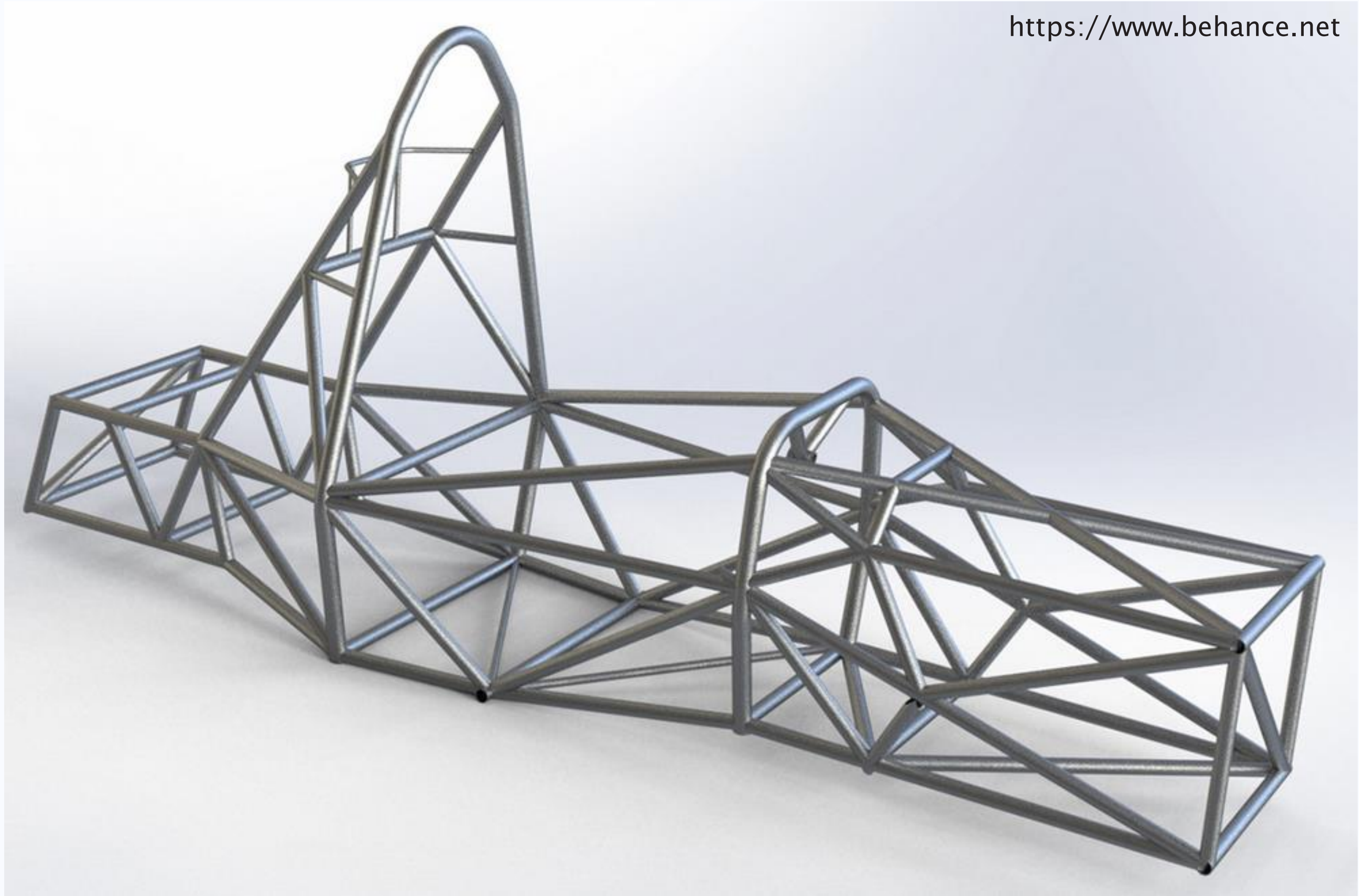
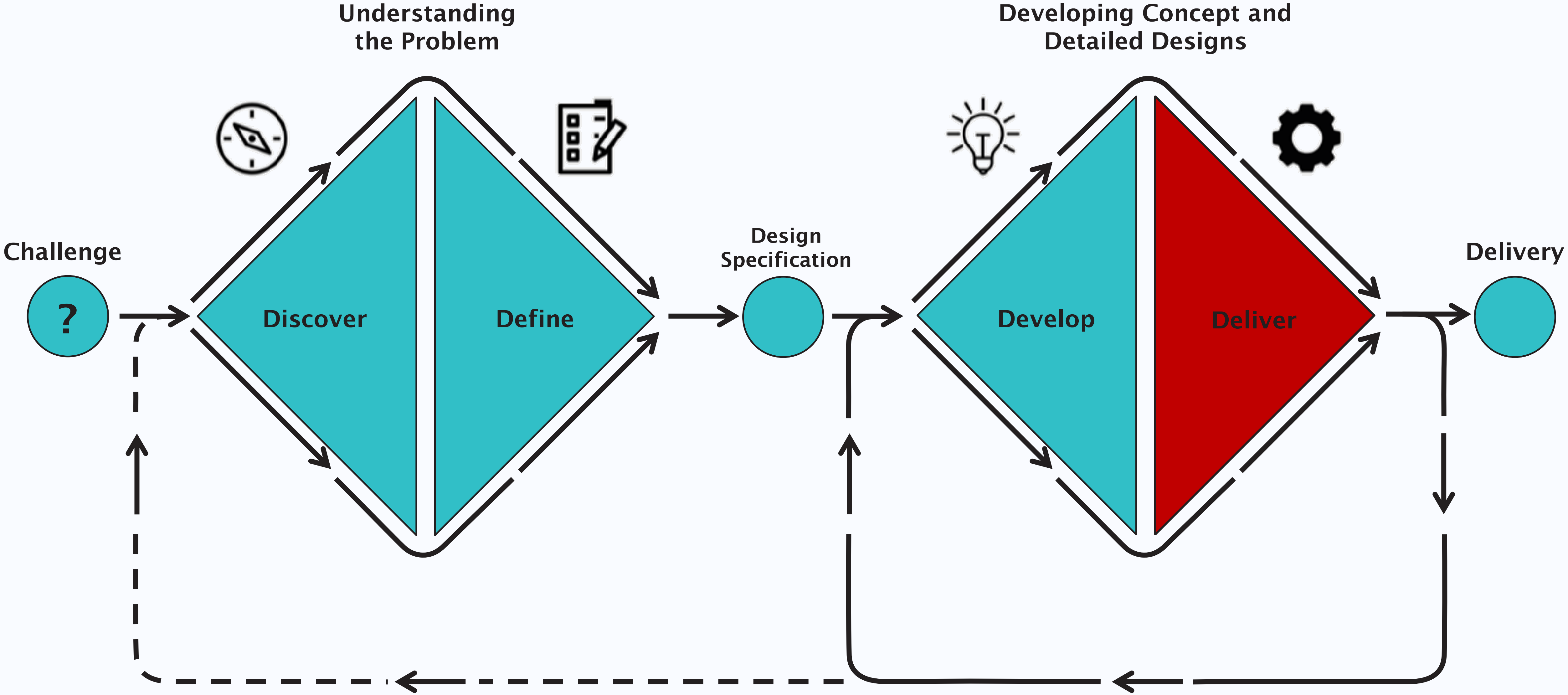
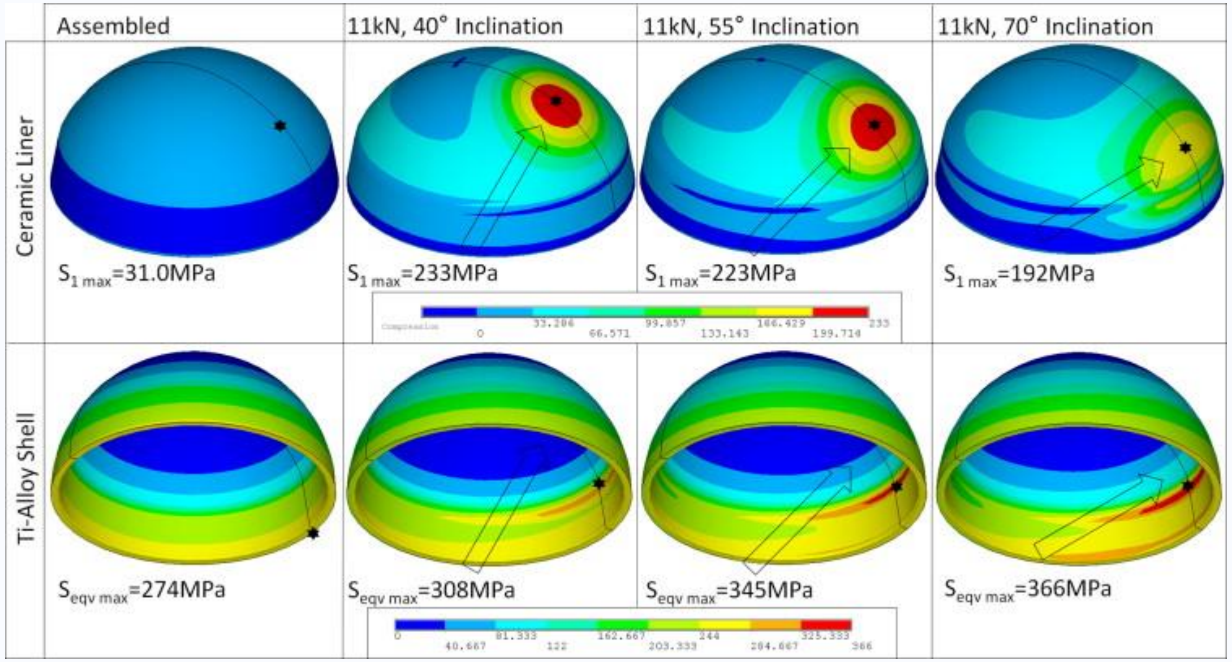


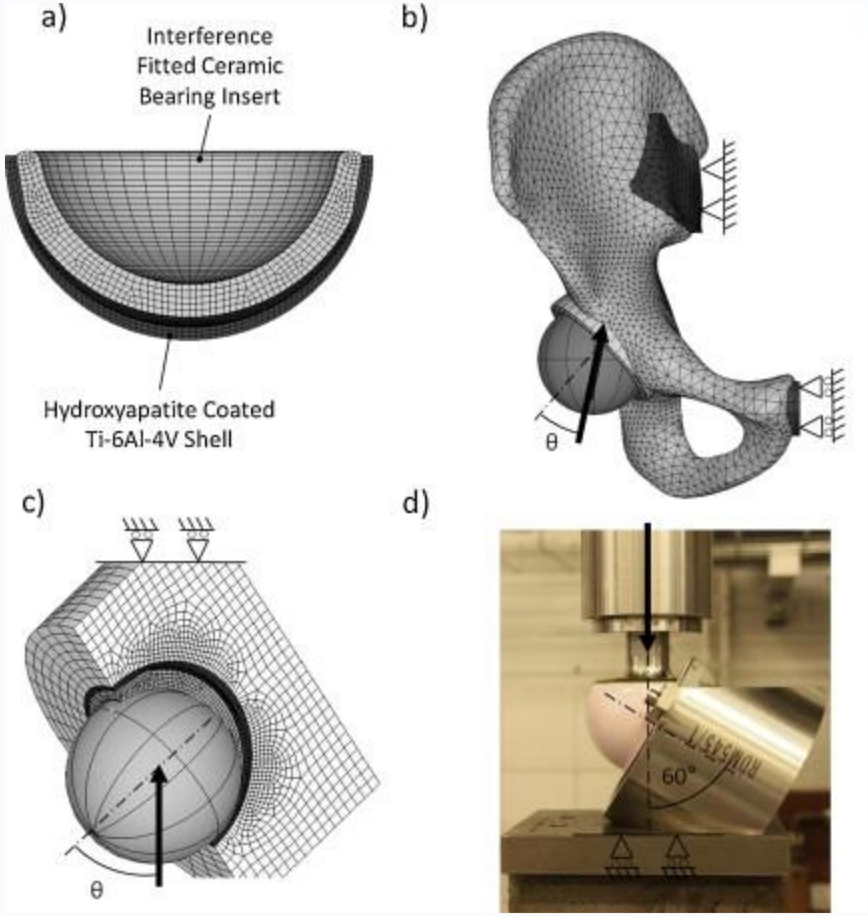
Complexity makes computation essential

FEA in the design process:



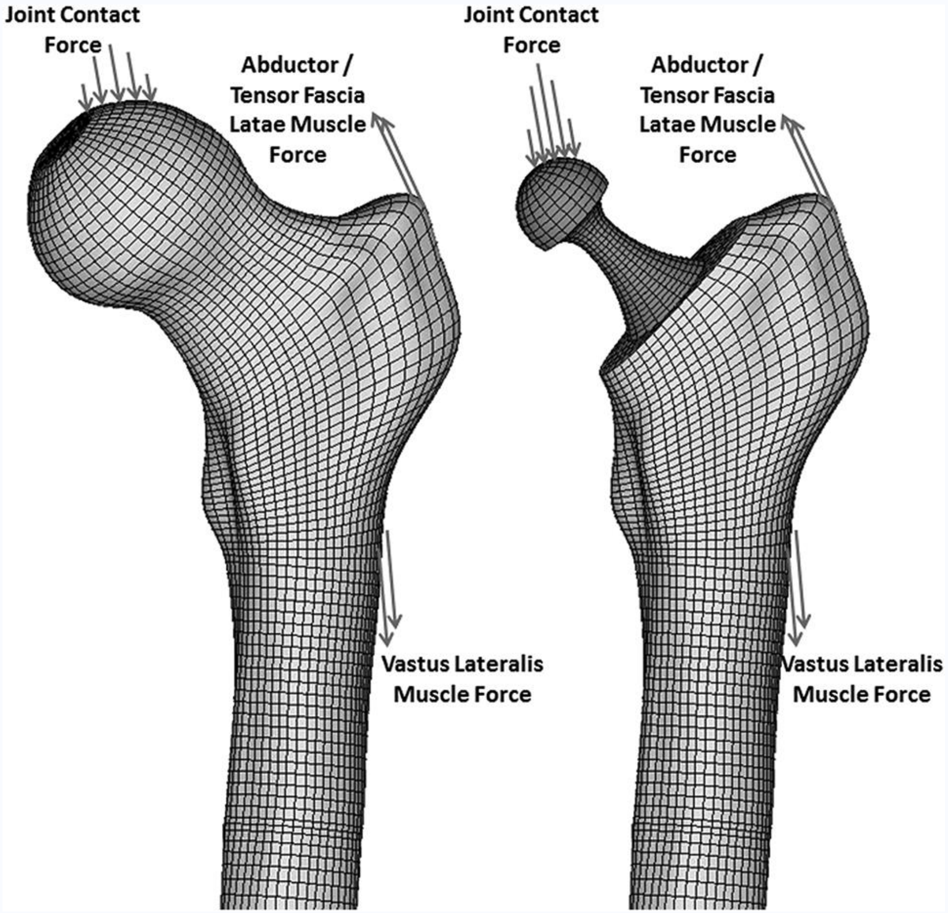
FEA in the design process:

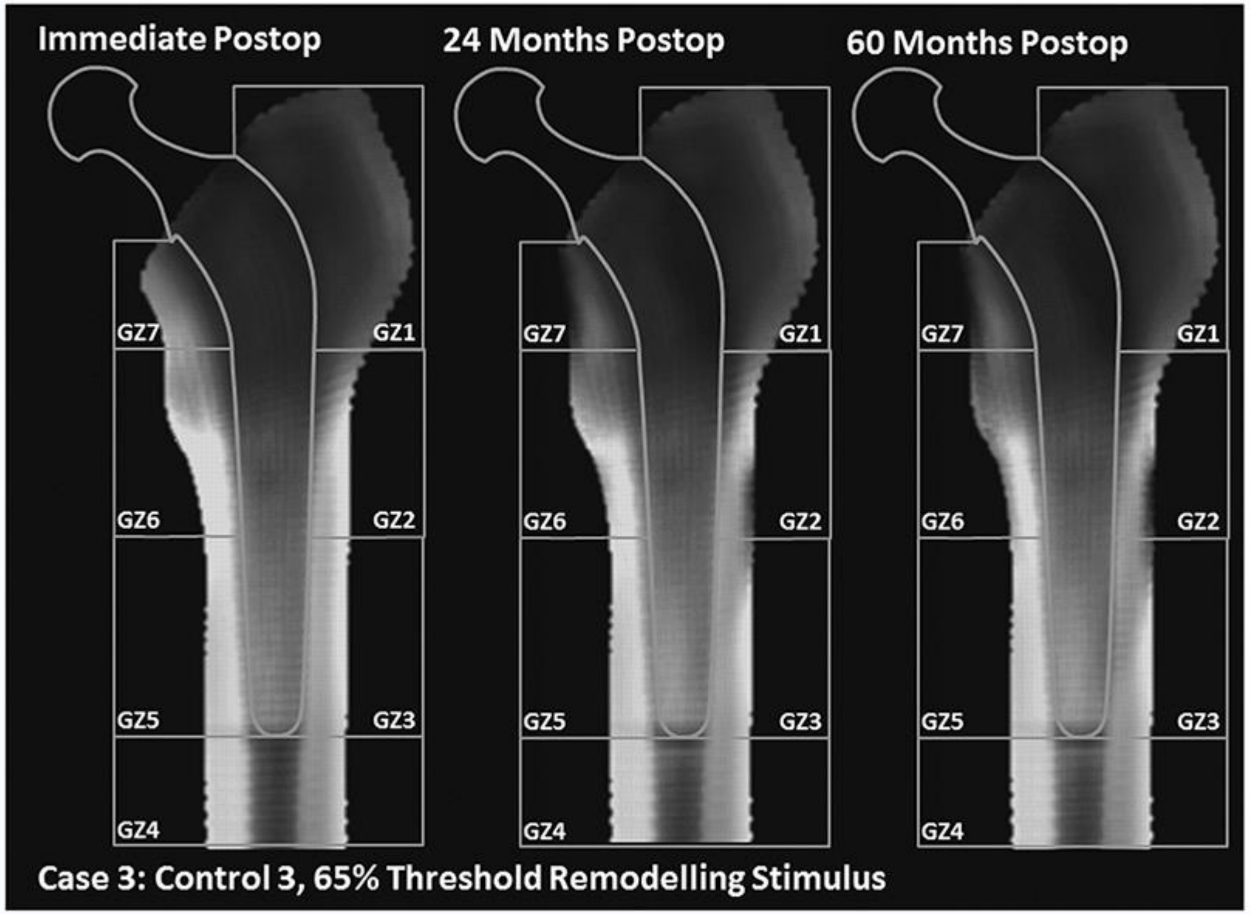




Dickinson, A. S. et al (2014). *Med Eng & Physics*. 36(1) 72-80 https://doi.org/10.1016/j.medengphy.2013.09.009

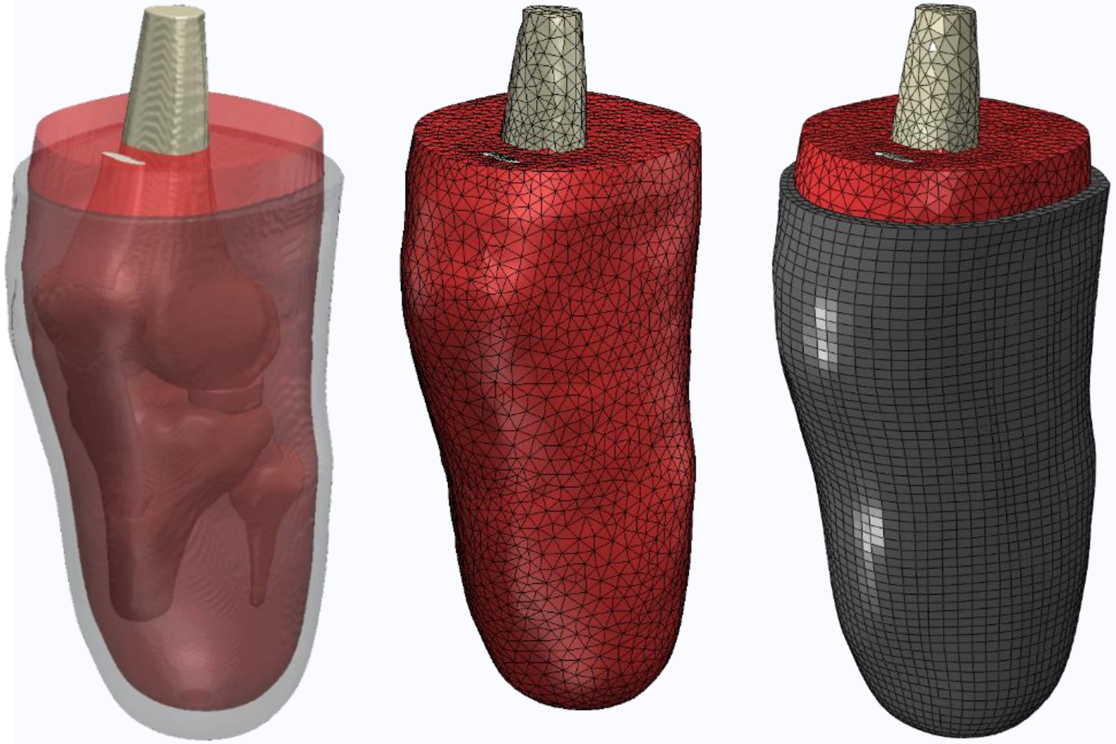
FEA in research?





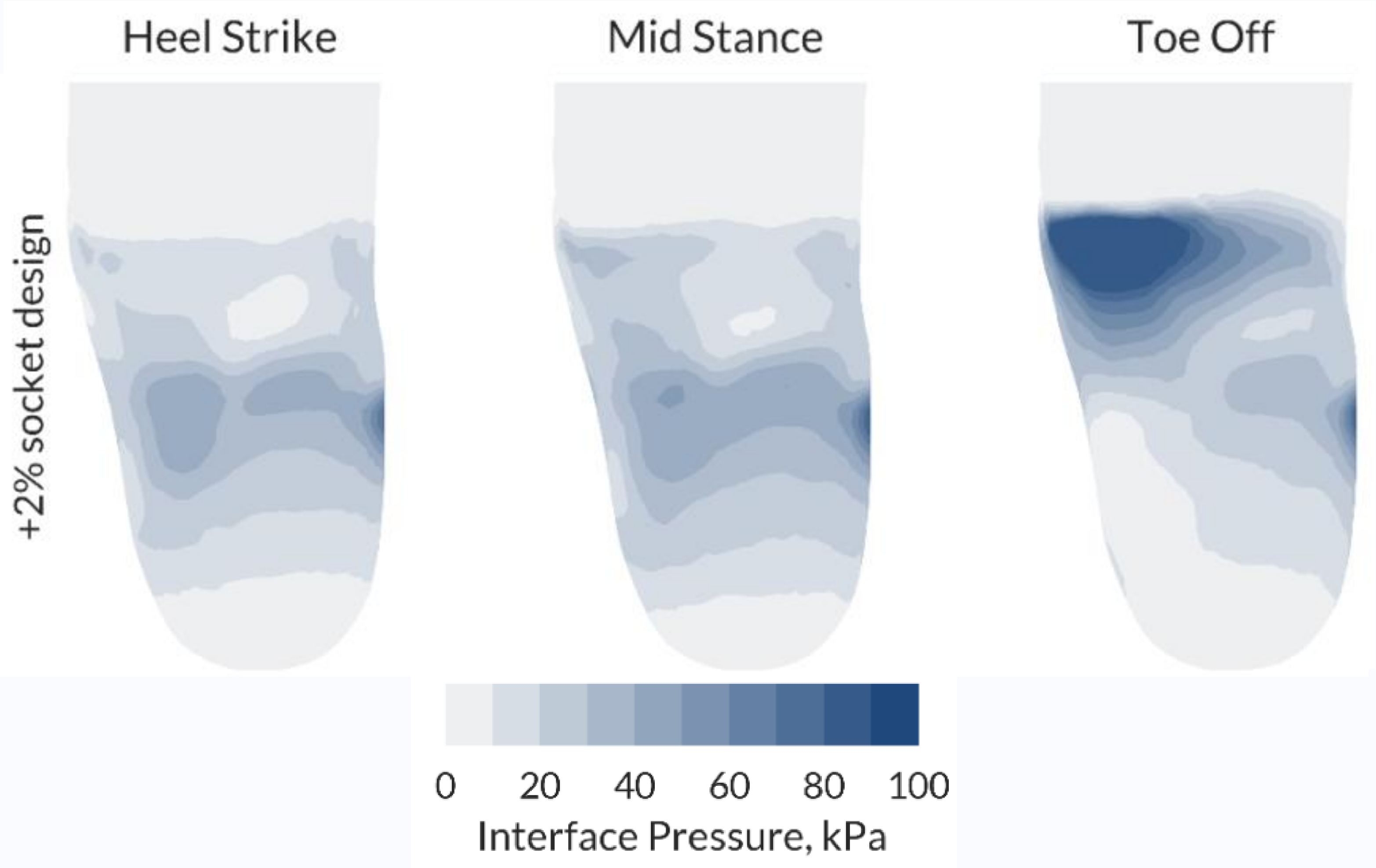
Dickinson, A. S. (2014). *J Biomech Eng*. 136(4) 041008 https://doi.org/10.1115/1.4026256

FEA in research?



Steer J.W. et al (2020). *Prosthet Orthot Intl*. https://doi.org/10.1177/0309364620967781

FEA in research?



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Warning

- Knowing a bit of FEA is dangerous
- FEA in CAD software is also dangerous
- This course will get you started
- but please develop a healthy scepticism

This Course:

- What is behind the method?
- How is it formulated?
- How do we link these to code for practical implementation?

- First statics, then dynamics (low amplitude vibration)
- We will build you a construction kit filled with elements you can use for a variety of problems
- We will use the Principle of Minimum Total Potential Energy (PMTPE)

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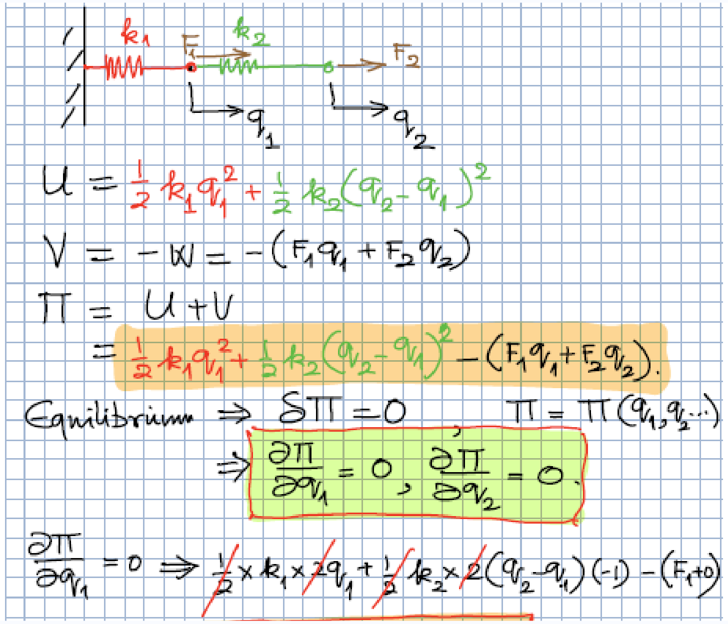
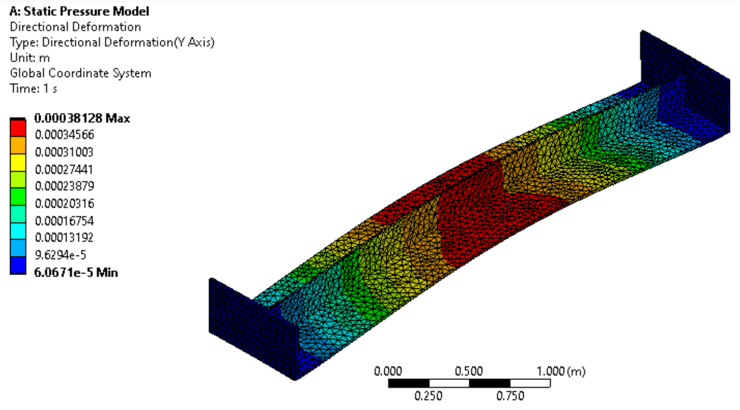
Course Overview

- Three lectures per week
  - One applications / examples / practicalities talk
  - Two theory
- One computing lab class every two weeks

- Coursework worth 50%
  - Assignment based on simulations from labs
  - Quizzes on Blackboard – formative or summative?
- Final assessment worth 50%
  - Exam, mixed long and short answer Qs





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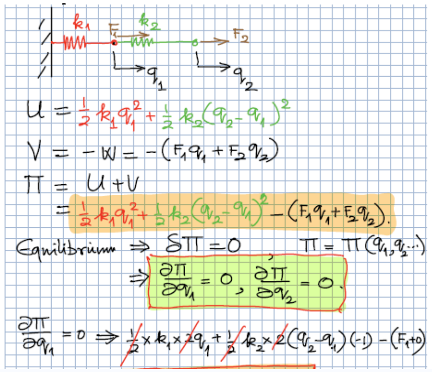
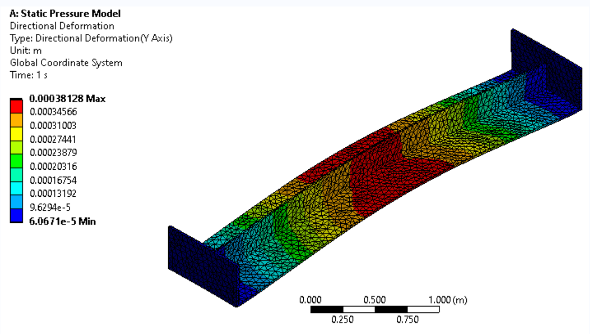
Course Overview

Commencing	30/09/2024	07/10/2023	14/10/2023	21/10/2023	28/10/2023	04/11/2023	11/11/2023	18/11/2023	25/11/2023	02/12/2023	09/12/2023	06/01/2024
Week	1	2	3	4	5	6	7	8	9	10	11	12
Lectures	1 to 3	4 to 6	7 to 9	10 to 12	13 to 15	16 to 18	19 to 21	22 to 24	25 to 27	28 to 30	31 to 33	34 to 36
Topic	1: PMTPE	1: PMTPE	2: Rods	Beams	3: Beams	4: Dynamics	4: Dynamics	4: Dynamics	5: Trusses	5: Trusses	6: Frames	Dimensions
Session 1	Intro	Assembling, Solution	Combining Rods & Springs	Rod Questions	Beam Assembly, Solution	Lagrange, Hamilton, 1, 2 DOF Systems	Dynamic Beams, Solving Dynamics	Trusses, CS	Frames, CS	Const. Strain Tris	MCQs, Exam Conditions	Revision
Session 2	PMTPE, [K], Springs	Elastic Rods [K]	Distributed Loads	Rod Questions, Beam SFs: HCs	Distributed Loads	Dynamic Rods, Reporting FEA	Mode Shapes, Rods, Shafts, Strings	TMs, Assembly	Frames and Stress Calculations	Const. Strain Tris	4-Node Rectangles	Revision
Session 3	Lab 1 intro	Shape Functions	Lab 2 intro	Beam [K]	Lab 3 intro, Modal Demo	Beam Questions, Form. MCQs	Formative MCQs	Dynamics Ex.	Python Trusses Risk-Based FEA	Truss Ex.Stress Calc, Python	Revision	Q&A, Examples
Labs		Solid Static Models		Solid Modal and Buckling Models		Shell Models		3D Models? Help/Extra		Spare. Python/ANSYS comparison?		
Cours						Assigned 08/11/24, Submitted 29/11/24						





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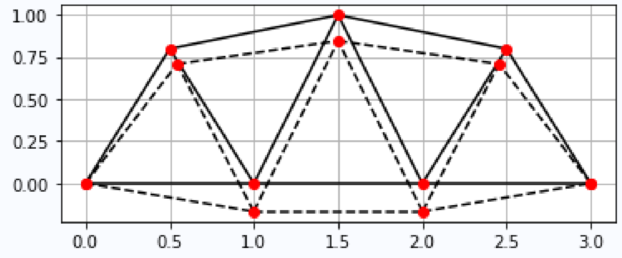


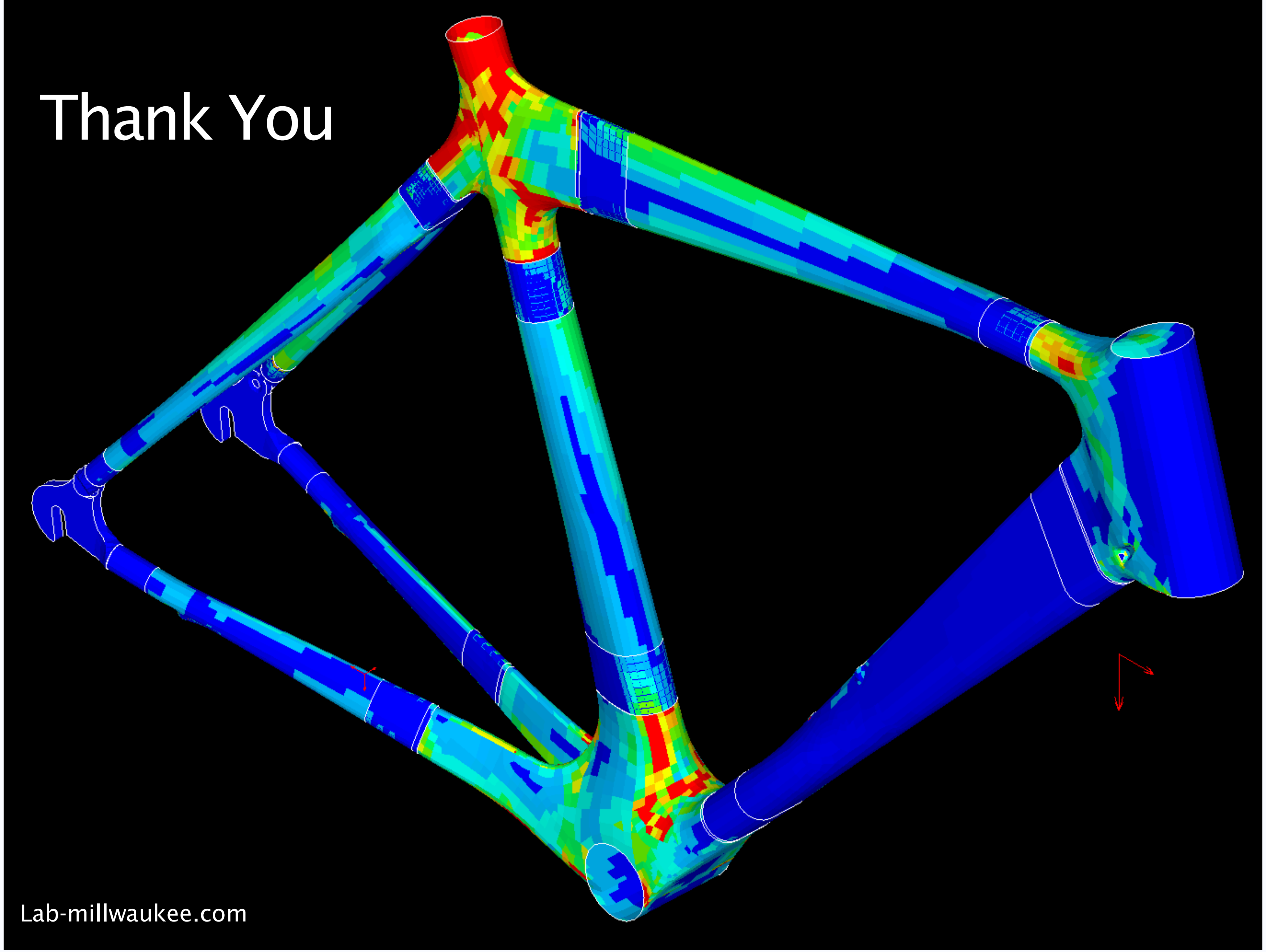
Computing Lab Arrangements

	Week	Task	Description	Application
1	2 (8-11 Oct)	ANSYS 1	Pre-processing, inc. Meshing and Element Types; Mesh Verification	Solid Ship Model 1
2	4 (22-25 Oct)	ANSYS 2	Post-Processing, Solvers and Solutions Model Validation	Solid Ship Model 2
3	6 (5-8 Nov)	ANSYS 3	Shell Model	Shell Ship Model
4	8 (19-22 Nov)	Help (labs, not assignment…)		
5	10 (3-6 Dec)	If desired, coding your own simple FE problems in Python		
	Summative Assessment:		Comparing Element Types and Appraising Results Briefing: 8th November Submission: 29th November (Blackboard Turnitin)	

How to do well on this course

- Try to see connections between the lectures and labs
- We don’t solve the software model problems on paper, but you could
- Be meticulous!
  - with your terminology
  - your workings (maths)
  - and your data organisation (labs)
- Try not to panic!

Thank You



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