University of Nottingham Malaysia

Department of Mechanical, Materials and Manufacturing Engineering

MMME4109 Finite Element Analysis - Coursework 2 (30%)

(Submission deadline: 19th of April 2023)

Program and Learning Outcome

Program Outcome of the module		
PO1	–	Ability to apply knowledge of mathematics, science, mechanical engineering fundamentals and specialization to the solutions of complex engineering problems;
PO2	–	Ability to identify, formulate, conduct research literature and analyse complex engineering problems using principles of mathematics, natural sciences and mechanical engineering sciences;
PO5	–	Ability to develop and apply appropriate techniques, resources, and innovative engineering tools to complex mechanical engineering activities;
Learning Outcome of the module		
LO1	–	Comprehend the underlying FE mathematical theory required to gain an insight into how FE technology works
LO2	–	Understand and appreciate the principles of applying FE technology to practical engineering problems including non-linear problems
LO3	–	Evaluate the accuracy of FE solutions, the sources of potential error and the limitations of the FE technique applications
LO4	–	Select and evaluate an appropriate FE approach for modelling a given engineering problem
LO5	–	Gain hands-on experience of running linear and non-linear state of the art FEA software code widely used in industry.

Learning Objective

- To implement finite element method and analyse nonlinear structural problems using ANSYS.

Instructions

- This is an individual assignment. You are required to submit a report that answer all the questions.
- Please submit your report as a single PDF file via Moodle Turnitin.
- Plagiarism will be penalized.

Problem definition

A simplified heart wall geometry can be represented by two layers of open half truncated prolate spheroid as shown in Figure 1. Given the height of the inner wall is h cm, diameter is d cm and uniform wall thickness is t mm (refers the values in Table 2). The inner surface of the heart wall is subjected to an internal pressure P which causes to its volume expansion during heart filling. This study aims to investigate the stresses in the heart wall.
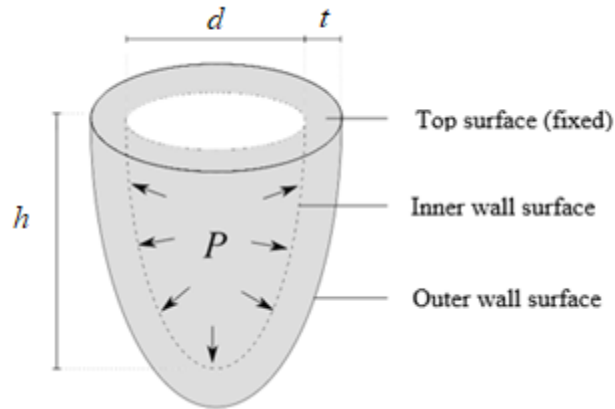

Figure 1: Geometry

Assume isotropic material properties for the heart wall with Young's modulus, $E = 50$ kPa, Poisson ratio, $v = 0.49$ and yield stress, $\sigma_y = 10$ kPa. After yielding, the material behaviour in the plastic range is described in Table 1.

Table 1: Mechanical properties

Plastic strain	Stress (kPa)
0.00	10
0.02	12
0.04	15
0.06	20
0.08	25
0.10	30

Task

1. Discuss briefly the possible choice of continuum/structural elements that can be used to obtain finite element solution of this problem. Select the most appropriate element for this problem and explain why.

2. By using ANSYS, construct a FE model based on your choice in Q1 with an arbitrary value for *P*. Describe your FE approach in a table which should include the information of geometry, material properties, boundary conditions, mesh and special features (if any). *No screenshot diagram of ANSYS implementation is required for this table.*

3. Conduct mesh convergence study by using *h*-method and/or *p*-method with at least three different mesh densities. By selecting three different mesh densities to show the mesh distributions and the following results for each model.
   a)   Contour plots of Von Mises stress and equivalent total strain of the heart wall.
   b)   Contour plots of circumferential and radial stresses of the heart wall.
   c)   Line graphs of circumferential and radial stresses across the wall thickness.
   Based on your observations, compare and discuss on which mesh density would you consider to be suitable for this analysis.

4. Using your chosen mesh density in Q3, determine the pressure *Py* where plasticity is initiated.

5. Run an elastic-plastic analysis of three load steps by applying the following pressures in a single run:

   Step 1: $P = 0.5 \times Py$
   Step 2: $P = 1.2 \times Py$
   Step 3: $P = 0.05 \times Py$

   Provide the FE steps taken with appropriate diagrams for reader to comprehend the pre- and post-processing inputs. Then, provide the following results for each load step:
   a)   Contour plots of Von Mises stress, Von Mises strain, and equivalent total strain.
   b)   Graph of maximum Von Mises stress against maximum equivalent total strain for all load sub-steps (by selecting a point in the geometry). Indicate the location of the selected point.
   Discuss these results by relating your observations to plasticity.

6. Show the force convergence plot of your analysis. Discuss this plot by relating your observations to the iteration and convergence of the nonlinear solution.

To avoid all students having the same geometry to analyse, please use the following table for the values of h, d and t.

Table 2: Values of the geometrical dimensions

Last digit of student ID	Value of h (cm)	Value of d (cm)	Value of t (mm)
0	5.0	3.0	6.0
1	5.5	3.0	6.0
2	6.0	3.0	6.5
3	6.0	3.5	6.5
4	6.5	3.5	7.0
5	6.5	4.0	7.0
6	5.0	4.0	7.5
7	5.5	4.0	7.5
8	5.0	4.5	8.0
9	5.5	4.5	8.0

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REPORT ASSESSMENT CRITERIA FORM

Student Name	:
Student ID	:
Assignment Title	: MMME4109 Finite Element Analysis – Coursework 2
Submission Deadline	: 19th April 2023 (Wednesday)

	1-4	5-9	10-12	13-16	17-20	Marks (%)
FE model (25%)	Poor FE model. Parts of the analysis are done. A few of the FE steps are included without necessary details and diagrams.	Adequate FE model. Parts of the analysis are done. Some of the FE steps are included with limited details and diagrams.	Good FE model. All analysis is done. Most of the FE steps are included with details and diagrams.	Excellent FE model. All analysis is done correctly. All FE steps are included with good details and diagrams.	Outstanding FE model. All analysis is done correctly. All FE steps are included with precise details and diagrams.	
Mesh convergence study (25%)	Poor analysis. Inappropriate mesh considerations and outcome evaluation without justification.	Adequate analysis. Limited mesh considerations and adequate outcome evaluation with little justifications.	Good analysis. Appropriate mesh considerations and outcome evaluation with justifications.	Excellent analysis. Good mesh considerations and proper outcome evaluation with justifications.	Outstanding analysis. Thorough mesh considerations and precise outcome evaluation with justifications.	
Result and Discussion (40%)	Poor result quality and presentation. Incorrect discussion.	Adequate result quality and presentation. Fair discussion.	Good result quality and presentation. Proper discussion.	Excellent result quality and presentation. Detailed and comprehensive discussion.	Outstanding result quality and presentation. Thorough and insightful discussion.	
Overall Report Clarity (10%)	Poor writing and difficult to follow. Major spelling and grammatical errors.	Acceptable writing and difficult to follow. Some spelling and grammatical errors.	Clear writing and engaging to read. Some spelling and grammatical errors.	Very clear writing and engaging to read. Minor spelling and grammatical errors.	Very clear writing and engaging to read. No spelling and grammatical error.	
					Total marks of CW2 (100%)	