MEC1223/AEE1001 Engineering Mechanics
Individual Project (15% of the Module Mark)
AY2023/24, Trimester 2

Name Student ID	
Date of Submission	Submission Week 10 Friday (15 Mar), 11:59 PM

Q1. Axial Loading of Stepped Rod (30 Marks)

A stepped rod *ABCD* consisting of solid circular segments is subjected to three axial forces, as shown in Figure Q1. Solve the problem using both analytical solutions and finite element analysis. Use the Excel sheet provided to determine the dimensions of the stepped rod and applied forces.

(A) Develop Finite Element (FE) Models to determine the stresses and displacements in each of the segments of the loaded stepped rod. Use 3 mesh sizes, coarse, medium and fine, in your analysis (size of fine mesh should not be greater than 10mm).

(B) Determine the stresses and displacements in each of the segments of the loaded stepped rod using analytical solutions. Include the axial load diagram.

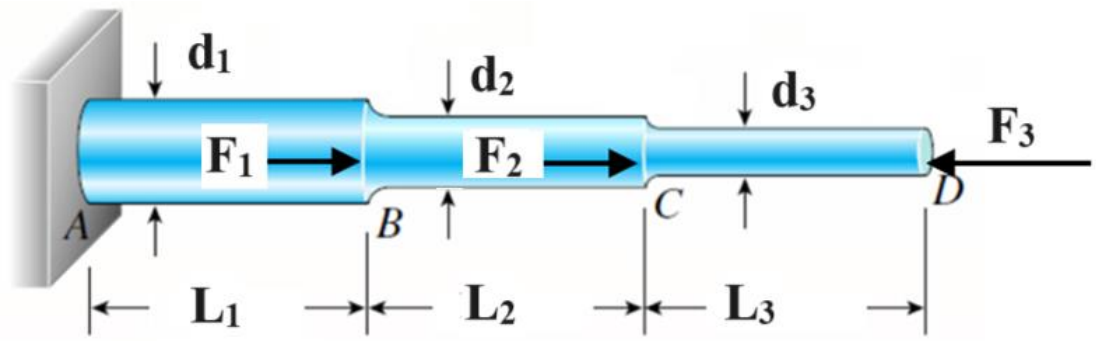
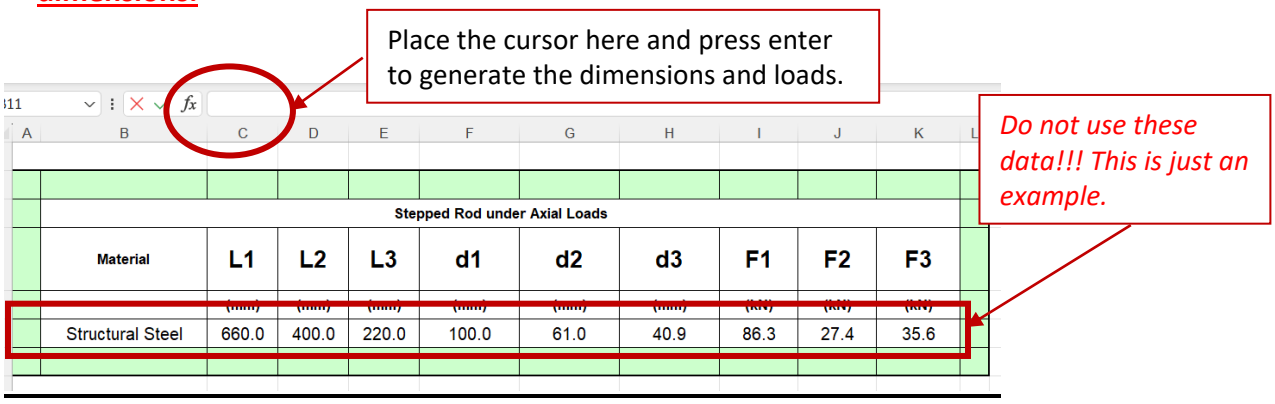


Figure Q1

Note: Use the Excel sheet provided to determine the values of the load and the dimensions.



Write the results of your FE and Analytical Solutions using the template shown in Table 1. Briefly discuss your results and compare the results of the FE models and analytical solutions.

Table 1: Axial Loading

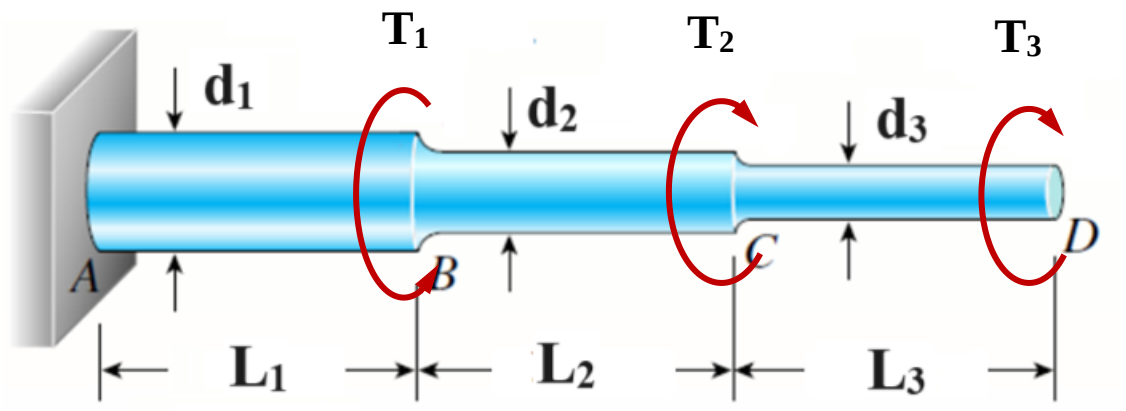
Parameter		FEA using ANSYS			Analytical Solution
		Coarse Mesh	Medium	Fine Mesh	
Stress MPa	AB				
	BC				
	CD				
Displacement mm	AB				
	BC				
	CD				

Q2. <u>Torsion of Cantilevered Shaft (25 Marks)</u>

Using the geometry developed in Q1, apply torsional loads to the geometry as shown in Figure Q2. Solve the problem using both analytical solutions and finite element analysis. Use the Excel sheet provided to determine the applied torque

(A) Develop Finite Element (FE) Models to determine the shear stress in each of the segments of the loaded stepped rod. Use 3 mesh sizes, coarse, medium and fine, in your analysis. (size of fine mesh should not be greater than 10mm)

(B) Determine the shear stress in each of the segments of the loaded stepped rod using analytical solutions (Include the torque diagram). Compare your results with the analytical solutions.



<u>Figure Q2</u>

Table 2: Torsion

Parameter		FEA using ANSYS			Analytical Solution
		Coarse Mesh	Medium	Fine Mesh	
Stress MPa	AB				
	BC				
	CD				

Q3. Cantilever Beam in Bending (45 Marks)

(a) Develop a finite element model for a cantilever beam. Use an I-beam or Rectangular Hollow Cross-section (RHS)

(b) Determine the dimensions, e.g Length and the cross-sectional dimensions using the Excel sheet.

(c) Apply a concentrated load at the free end of the cantilever beam. The load can be determined using the Excel Sheet.

(d) Solve the stress and deflection using both Finite Element using Ansys (consider 10mm mesh sizes in your FE model) and analytical solutions (include Shear-Force and Bending Moment Diagrams). Compare your results and discuss results.

(e) Increase the height h by 25% and retain the other dimensions. Using analytical solutions, calculate the new stress and deflection. Discuss what you observe.

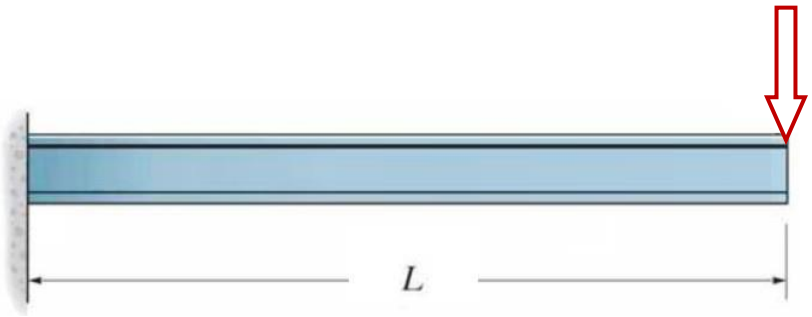
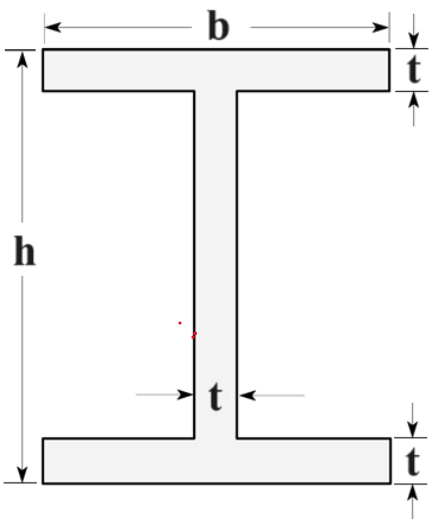
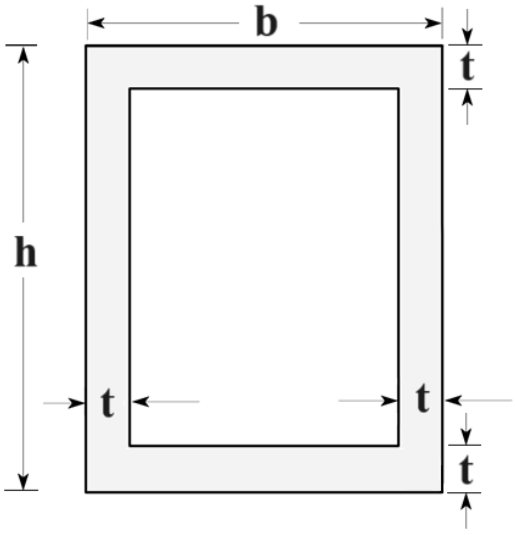


Figure Q3



I-Beam



RHS

Table 3: Beam in Bending

Parameter	FEA using ANSYS	Analytical Solution
Stress (MPa)		
Displacement/Deflection (mm)		

Present the following for each problem.

1. **Schematic Diagram/Free Body Diagram**
2. **Analytical Solution**
   - Show your work to arrive at the solutions, e.g stress and/or displacement.
3. **Finite Element Model**
   - Include mesh (best result), method of meshing, Boundary Conditions (Loads and Supports)
   - Contour plots of stress and deformation of best results (lower % difference with analytical solution)
4. **Results and Discussions**
   - Discuss your results and evaluate the accuracy of the FE results compared with the analytical/experimental results.

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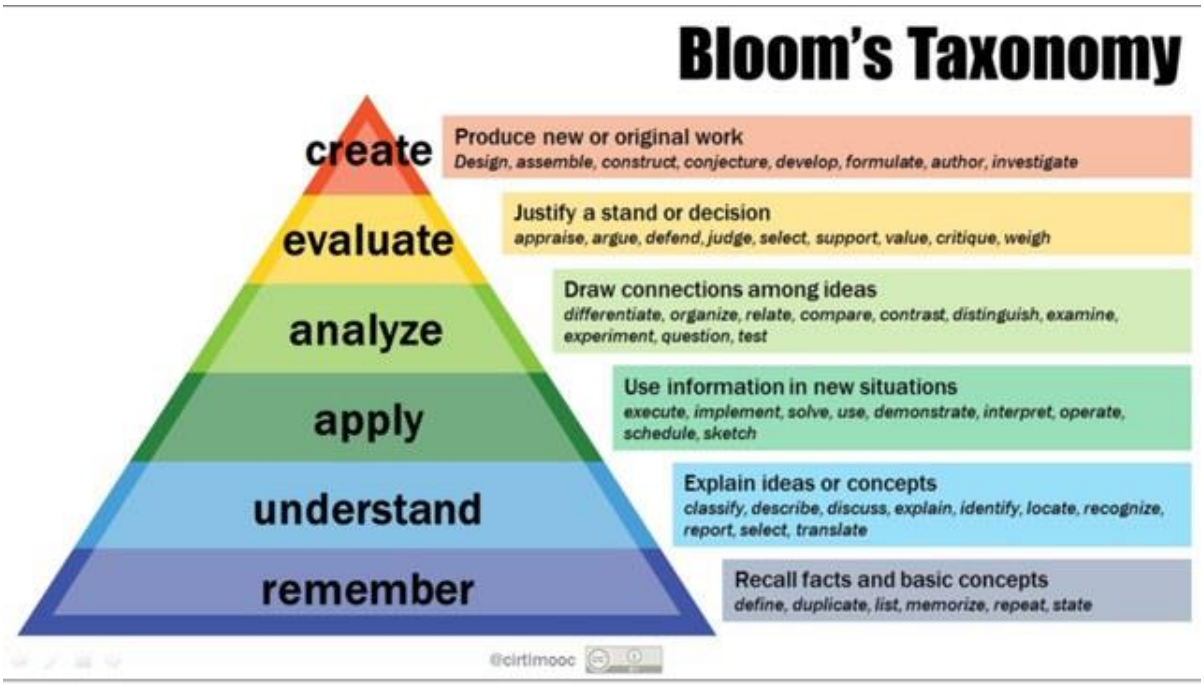
Students of SIT are expected to hold themselves to the highest standard of integrity at all times. Where a student is alleged to have committed an act of misconduct, SIT may take appropriate disciplinary actions in accordance with the Student Disciplinary Policy. Students may receive appropriate counselling during the course of disciplinary hearings and actions. Students may also appeal against the decision and sanctions imposed by the disciplinary bodies.



Center for Teaching. (n.d.). Retrieved August 22, 2016, from https://cft.vanderbilt.edu/guides-sub-pages/blooms-taxonomy/

Rubrics

Grade Range (Highest to Lowest)	**A**	**B**	**C**	**D**	**E**	**F**
Descriptor	Excellent	Very Good	Good	Satisfactory	Weak	Poor
Writing	*Exceptionally clear, precise and concise English. Excellent spelling & grammar, few typos.*	*Clear and well written, easy to understand, and mostly free of errors.*	*Most of the text is clear and easily understood. There are some issues with grammar and spelling.*	*The text can be understood but some elements are not entirely clear. A sizeable volume of errors is noticeable.*	*Hard to understand much of the text. Significant spelling errors and grammatical flaws.*	*The volume and nature of the grammatical errors, combined with poor writing makes this report difficult to read.*
Presentation & Figures	*Professional standard of presentation. All illustrations are well formatted and presented.*	*A clear and consistent presentation style making it easy to read. Most of the figures are clear and well presented.*	*There are some minor flaws in the presentation and the clarity of the figures, but overall a well presented report.*	*A number of basic errors present – inconsistent use of styles, margins etc. Figures are satisfactory.*	*Significant flaws in the presentation detracting from the overall impression of the report. Flawed figures – badly drawn and untidy,*	*Unacceptable presentation: untidy and inconsistent use of styles. Figures are messy and unclear.*
Organisation and Structure	*Structure is entirely correct with all sections correctly placed. Reading contents gives clear overview.*	*A well organised report with all sections logically placed enhancing understanding of work.*	*A report which is sufficiently well organised to make reading report easy.*	*There may be some issues with the structure, but these don't detract from overall quality.*	*There are flaws in the way the report is structured which damages the overall quality of the report.*	*Serious flaws in structure which makes it difficult to read and understand the report.*
Technical Content & Quality of Analysis	*Well informed and authoritative discussion of a significantly complex technical problem. Excellent breadth and depth of knowledge.*	*Clear and reasoned arguments indicating a very good grasp of a difficult technical problem.*	*Arguments presented are of a reasonable technical level, and have been well considered and clearly stated.*	*The arguments presented are of reasonable technical depth and show a satisfactory understanding.*	*Only limited critical discussion of the technical problem studied. Suggests limited understanding of problem.*	*Very little evidence of critical discussion of technical work or results. Superficial understanding of problem.*