Mahatma Education Society’s

Pillai College of Engineering, New Panvel

REPORT ON MINI-PROJECT-1A (MEPBL301 & AEPBL301)

Department of Mechanical and Automobile Engineering

2021 - 2022

CLASS: SECOND YEAR **SEMESTER:** III **SCHEME:** R2019 (REVISED C SCHEME)

The Revised ‘C’ scheme (R2019) formally took effect for second year engineering students of Mechanical and Automobile engineering departments of Mumbai University last academic year (2020-2021), and the Project Based Learning (PBL) which was introduced in our institute in the academic year 2016-2017 and running successfully as an added course to cater to the enhanced learning of the students, was inducted as a separate mandatory course in the syllabus, under the name: **Mini-Project-1A**. This report highlights the summary of the course conducted in the semester III of the present academic year (2021-2022).

Students were instructed at the start of the semester, to form groups of 3-4 students each for the mini project. They were shortly later introduced to the topics. 2 topics were floated and students were instructed to select one of them. Ample time of about a week was given to identify their choice. Since the lockdown was still in effect due to the deadly coronavirus pandemic, topics were to be identified to enable the students to work comfortably from their homes. This was a challenge, and difficult for the faculty designing the topics, particularly since the students were mostly undertaking projects requiring some sort of fabrication or manufacturing/construction requiring some experiment or test run to be conducted to verify the theoretical or analytical results coming from the design calculations, before the pandemic happened. As such, topics relevant to only the use of computer (programming/computer modelling) apart from the application of technical knowledge (and avoiding any fabrication or construction related activity) were identified and introduced.

The two topics identified and floated to the students, are titled as follows:

Topic 1-Computer Aided Beam Analysis

Topic 2-Space Saving Furniture (Folding Table) Design

To aid the students in selecting their topic of interest, a separate orientation program was organised through online Google Meet, wherein the topics were discussed in detail and students’ queries answered. This report summarizes the contribution of both the regular students and the students who joined their second year late i.e., direct second year admitted students from diploma background (on account of pandemic, and could complete their semester-3 course requirements in the later part of the academic year, along with their regular semester-4 course).

The **problem statements** related to the **three topics** are as follows:

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Topic 1: Computer Aided Beam Analysis

1. Introduction:

A **beam** is a structural member subjected to mostly transverse loads, and withstands by resisting bending. It is important to know the structural integrity of the design of beam-like members (such as shafts, levers, frame components, beam structures, etc.) before construction or fabrication. Beam calculations for various parameters can be cumbersome if done manually, and results from commercial simulation packages (such as ANSYS etc.) are not devoid of truncation and/or round-off errors because they are based on numerical schemes.

To reduce or eliminate these issues, and to instil programming skills ensuring thorough understanding of some topics related to Strength of Materials and Engineering Mathematics subjects, an algorithm based on the analytical equations of simple beams becomes necessary to be implemented in the form of an interactive program, using any software as per the students' choice viz., MS Excel, C++, Java, Python etc.

In general, mechanical components fail either by induced stress exceeding the material limiting stress or by excessive deformation. Hence, it becomes pertinent to calculate the maximum internal forces and moments generated in beams by virtue of external loads and moments, and the corresponding stresses; as well as the slopes and deflections induced. These serve as critical factors in the selection of materials for beams. For the analysis of deflection of beams, there are various methods available, but Macaulay's method (method of Half-Range or Singularity functions) stands out as one of the best. Unfortunately, developing deflection curves using Macaulay's method can be long, tedious and prone to error if done by manually, and any changes to the original beam loading will require that all calculations be repeated. A general computer program hence becomes necessary to eliminate or limit manual beam deflection computations.

2. Objectives:

A. Develop an **interactive computer program** using **any programming language** of your choice (viz., Excel, C++, Java, Python etc.) to analyze **simple beam structures.**

B. **Validate the results of the program** with manual calculations, or from reference/text book results. Simulation results using any standard application software (such as ANSYS, etc.) may also be appended if required.

C. Once validated, **simulate the results** for different combinations of input parameters.

3. Assumptions:

a. The beam has pure or simple bending, and follows Euler-Bernoulli theory.

b. The beam is prismatic in shape, has a symmetric cross-section, and loading is such that the beam has a linearly elastic behaviour.

c. There are no internal hinges anywhere along the beam length, and the beam is statically determinate.

d. Only a combination of point loads, uniformly distributed loads, uniformly varying loads, and moments are applied as external loads on the beam (either from top or bottom). Parabolic distributed loads are excluded.

e. Inclined point loads and/or loads acting on extended frame extensions at some location of beam length need to be manually simplified and converted to vertical and horizontal load components, with the external moments if any. This is to be done prior to feeding the input data to the program.

4. Input Parameters (standard values to be entered by user):

a. Young's Modulus of Elasticity (E), in MPa

b. Area Moment of Inertia (I) about the axis of bending, in mm^4

c. Type of Beam (Cantilever or Simply Supported)

d. Total Beam Length (L, in metres)

e. Self-weight of the beam, if any (W, in kN)

f. If Simply Supported beam, distance of pin/hinge and roller supports respectively from left end of beam (in metres); and if Cantilever beam, distance in metres, of fixed support from left end of beam (whether at left or right)

g. Number of external transverse point loads (either acting up or down) with their values (in kN) and their corresponding locations from the left end of beam (in metres)

h. Number of external axial point loads (either acting towards left or right) with their values (in kN) and their corresponding locations from the left end of beam (in metres)

i. Number of external moments (either acting clockwise or counter-clockwise) with their values (in kN-m) and their corresponding locations from the left end of beam (in metres)

j. Number of uniformly distributed loads (either acting up or down) with their values (in kN) and their corresponding locations from the left end of beam (location of start and stop of udl, hence defining the range, in metres)

k. Number of uniformly varying loads (either acting up or down) with their max. values (in kN, to be given in either increasing or decreasing fashion from left to right direction) and their corresponding locations from the left end of beam (location of start and stop of uvl, hence defining the range, in metres)

5. Output Parameters (expected results from the execution of the program):

a. Reaction loads and moments (if any) at the supports.

b. Axial Force (AF), Shear Force (SF) and Bending Moment (BM) equations for any cross section along the beam length.

c. Plotting the AF, SF and BM diagrams.

d. Finding the maximum values of AF, SF and BM and their corresponding locations along the beam length.

e. Estimating the maximum shear and bending stresses, and their corresponding locations along the beam length.

f. Deflection and Slope Equations for any cross section along the beam length.

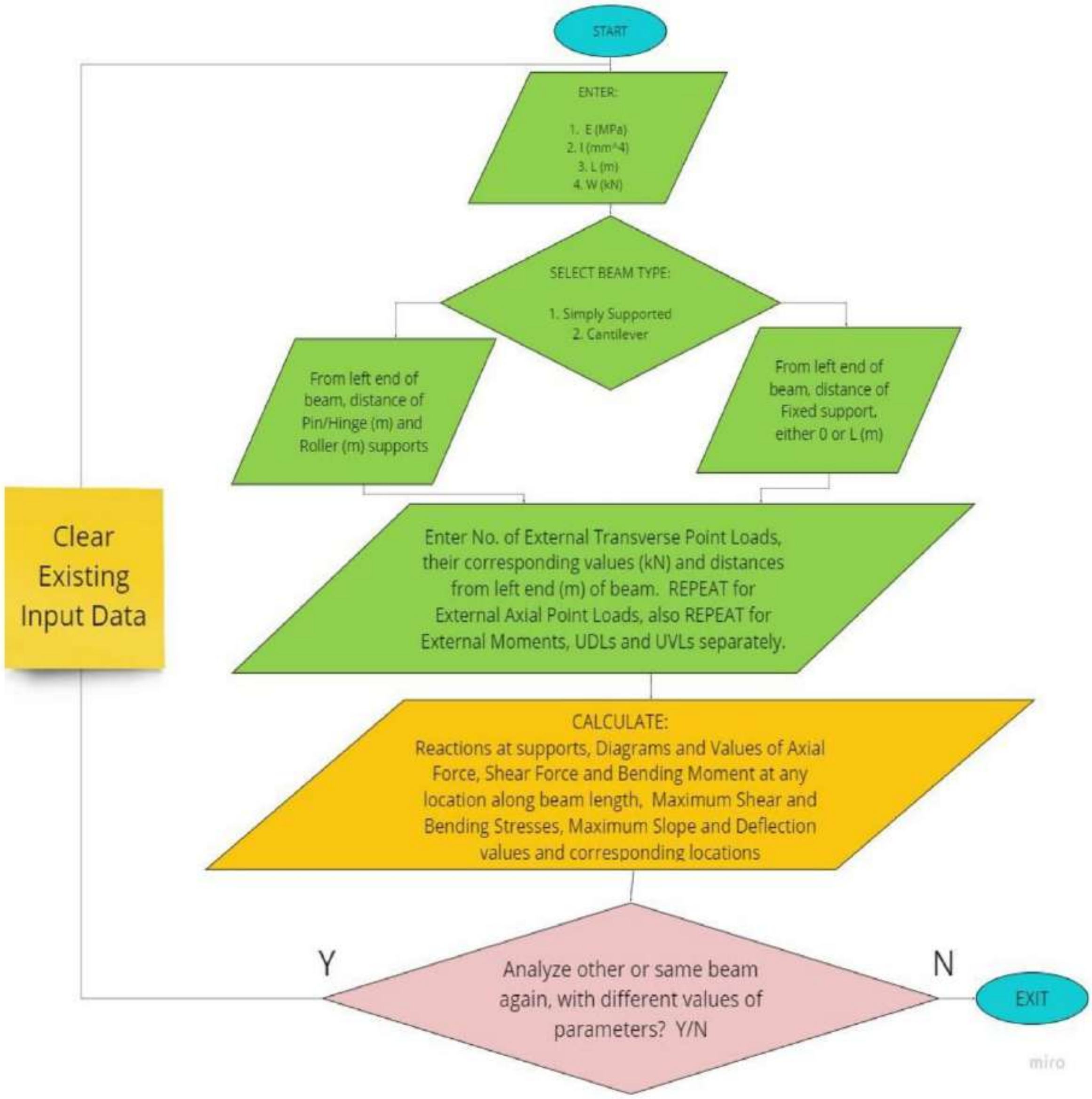
g. Max. Deflection and Max. Slope, and their corresponding locations along the beam length.

6. POINTS TO NOTE:

1. It is expected that a diverse set of programming software is used extensively for the project, by different student groups.

2. If a number of groups happen to use the same software tool for programming, care has to be taken that the programming work should be original and should be done honestly. If a particular group is found to engage in plagiarism of any sort (copy pasting some or all the contents of the program of another group), the project work shall be rejected.

Design Flow Chart



3. There shall be two evaluations: A midterm evaluation (Stage 1, tentatively dated 09 Oct 2021) and a final evaluation (Stage 2, tentatively dated 06 Nov 2021). Students need to present their work in the form of powerpoint presentation, each time.

4. Stage 1 evaluation shall comprise of creating a program for the plotting of AFD, SFD & BMD, and estimation of bending and shear stresses in the given beam. Stage 2 evaluation shall comprise programming for the estimation of slope and deflection at any point along the beam length.

5. The soft copy of the program created (with comments or necessary instructions, for the user, preferably in the program) in both stages of evaluation, shall be uploaded in a suitable Google Form by the group leader before the assessment by a panel of judges.

6. Also, a detailed and well documented report (preferably typed) in soft copy (pdf format only), and in print (if possible) shall be mailed (to Class Coordinator) and submitted to the panel of judges on or before the assessment dates. The report shall include the objectives of the mini-project, the print-copy of the actual program, brief information to execute the program with necessary nomenclature, the software and version used for programming, sample input data with loading diagram and labeling, manual calculations of the sample input for both the beam types, tabulated comparison of the results for various output parameters between the program and the manual calculation, the contribution of each of the group members in the project, feedback and comments (problems faced, outcomes of the project etc.), and the Conclusions.

7. Students must maintain a well-maintained LOG book, with plan and schedule of work, distribution of work among team members, weekly meeting record with summary. Standard formats may be downloaded from internet sources.

8. Also, a video summarizing the entire Mini-Project-1A of not more than 3-5 minutes shall be recorded and edited, so as to incorporate your group no, names of members with photos, class, your work in brief, results, conclusion, problems faced, your learning outcomes, etc.

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Topic 2 : Space-saving Furniture (Folding Table) Design

1. Introduction:

Product design describes the process of **imagining**, **creating**, and **iterating** products that solve users' problems or address specific needs in a given market. Thus, the job of a product designer or product engineer is to create functional and marketable products.

In view of this, student groups are required to think about new design concepts, and develop the best possible one for a particular application.

2. Problem Statement:

Develop a folding table with additional features possible incorporated so that, as a space saving equipment, it can be readily used in locations where availability of space is a major concern viz., in slums; or for ready use at open spaces for people like refugees, or for general use.

The product shall be developed keeping in mind:

(i) the sustainability (in terms of environmental resources), making use of available local resources to the maximum possible extent

(ii) the versatility (the ability to adapt to many different functions)

(iii) the durability (able to exist for a long time without significant deterioration in quality)

(iv) aesthetic considerations.

3. Additional Points to Note:

(i) The retractable, folding and multi-functional table is be made as a single piece - i.e., no part should be separate from assembly while folding and unfolding, but an integral part of the product, and connected to it at all times.

(ii) The folding and unfolding should be accomplished in a minimum number of steps, easy enough for a layman to understand without formal or extensive training.

(iii) The space saving ratio (i.e., the ratio of difference in volumes contained by the unit - after and before unfolding, to the unfolded volume) should be as high as possible. This shall be one of the important criteria to decide the effectiveness of the work.

(iv) To make the project versatile to the maximum extent possible, it has to be made feature-rich. Student groups can think of incorporating other features, in addition to the writing table, as follows (Note: Not all features may be possible to be included, but some can be. The list is only an indication, you may also add other features not listed here):

> Ladder, chair, space for table lamp, foot-rest, tool-box, store room (for storing books, bags & pens), laptop area, shelf, writing board as table, soft board for fixing notes, magnetic board provision, using the unit as an exercise frame equipment, using the unit as a temporary house (tent), rocking table or chair for relaxing, engraving of alphabets (as a template) for children in pre-primary grade, space for calendar/clock, partitioned workspaces etc.

Hint: To make the versatility effective, think of re-orienting the unit in part/full at some location to use it as a different product feature when required.

(v) Once fully unfolded or opened, the unit should have maximum rigidity or robustness, i.e., should not deform unduly at certain locations when a small load is applied.

(vi) The unit can be made to be fixed or portable (with wheels) in nature.

(vii) The product designed should involve minimum manufacturing operations to build leading to minimum manufacturing cost.

(viii) The raw material used should be easily available and in bulk, taking into account the sustainability consideration. As far as possible, use of waste or recycled resources for creating the product is advised, lowering the dependency on the environment. Assume any material in whole or many materials in combination – engineered wood, plastic, metal, corrugated boards, hard board, MDF board etc. Fittings used may be selected from standard available in market (hardware shops), or search through standard furniture and architecture catalogues on the same. Or, you can devise logically your own fitting to be used for a particular function.

(ix) You are strongly advised to do a literature search related to DFX (Design for Excellence), where X stands for all the desirable attributes such as manufacturability, inspection, assembly, marketability, testability, cost etc. with examples. Try to incorporate DFX in your designed product.

(x) The designed concept should be an ORIGINAL idea, though it is possible a part of the idea may be adapted from other published sources. If idea adaptation is made into your product, then cite the source clearly and mention it in your reference list.

(xi) Once the product concept has been finalized, and computer 2D/3D representations created, you may go for a physical 3D model creation by 3D printing in 1/4th scale size. You can make use of the resources (machine and material available at R-002 lab, or CNC Lab.) by paying a small fee.

(xii) References for additional related information:

1. https://www.americanhardwood.org/en/examples/our-projects/the-hoa-mai-furniture-design-competition-2021/home
2. https://www.fold.lv/en/2021/01/kagu-chair-design-competition-for-students/
3. https://honghuali.github.io/projects/foldem/foldem.pdf

(xiii) **There shall be two evaluations: A midterm evaluation (Stage 1, tentatively dated 09 Oct 2021) and a final evaluation (Stage 2, tentatively dated 06 Nov 2021). Students need to present their work in the form of powerpoint presentation, each time.**

Evaluation-1 work: Concept ideas (at least 1 from each student of the group), discussion of merits and demerits of each, selection of the final concept idea with modifications if any. Brief report to be drafted based on the work with the LOG book (see point (xv) below).

Evaluation-2 work: Computerization of the final concept idea (2D/3D) drawings, with animation of assembly (folding and unfolding). Also, furnish 3D printed model (if created by the group). Draft report based on the complete work, and the LOG Book. Lastly, a 3-5 minute video to be submitted (see point (xvi) below).

(xiv) A detailed and well documented report (preferably typed) in soft copy (pdf format only), and in print (if possible) shall be mailed (to Class Coordinator) and submitted to the panel of judges on or before the evaluation dates. The report shall include the objectives of the mini-project, various concept ideas (rough pencil sketches) with merits and demerits of each concept idea, brainstorming results, final concept idea, 2D and 3D assembly (computerized) drawings, the contribution of each of the group members in the project, feedback and comments (problems faced, outcomes of the project etc.), and the Conclusions.

(xv) Students must maintain a well-maintained LOG book, with plan and schedule of work, distribution of work among team members, weekly meeting record with summary. Standard formats may be downloaded from internet sources.

(xvi) Also, a video summarizing the entire Mini-Project-1A of not more than 3-5 minutes shall be recorded and edited, so as to incorporate your group no., names of members with photos, class, your work in brief, results, conclusion, problems faced, your learning outcomes, etc.

The **number of student groups** in the respective classes and the **extent to which the topics were selected by each class**, is tabulated as follows:

CLASS	***No. of Groups selecting TOPIC 1***	***No. of Groups selecting TOPIC 2***	***TOTAL No. of Groups in the Class***
SE MECH-A	2	14	**19**
SE MECH-B	2	15	**22**
SE AUTO	-	18	**20**

To monitor the performance of the student groups, there were 2 in-semester evaluations conducted by the faculty members of the departments. Separate rubrics were framed for each topic. The **rubrics** framed for all the three topics are highlighted as follows:

EVALUATION 1 & 2, and VIVA-VOCE RUBRICS FOR TOPIC-1:

Sr. No.	RUBRIC (FOR TOPIC-1 ONLY)	1 0%	2 25%	3 50%	4 75%	5 100%	Marks Obtained Out of 100 for each row below
		(Enter only number 1 in the particular cell below, for each row)					
1	Beam theory calculations (Parameters: AF, SF, BM, Shear & Bending Stress) for both Simply Supported & Cantilever Beams				1		75
2	Extent of Programming done (covering above parameters) including AFD, SFD, BMD (Computerized Graphical Plots)				1		75
3	Validation of programming results with theoretical results: accuracy of results obtained					1	100
4	Quality of Powerpoint and Report / Logbook documentation					1	100
5	Contribution capacity of each member in the project				1		75
6	Quality of 2-5 minute video as of Stage-1						0
	TOTAL MARKS OBTAINED (OUT OF 100):						71
	EVALUATION-1 MARKS OUT OF MAX.20 (ROUNDED UP):						15

Sr. No.	RUBRIC (FOR TOPIC-1 ONLY)	1 0%	2 25%	3 50%	4 75%	5 100%	Marks Obtained Out of 100 for each row below
		(Enter only number 1 in the particular cell below, for each row)					
1	Beam theory calculations (Parameters: AF, SF, BM, Shear & Bending Stress, SLOPE & DEFLECTION) for both Simply Supported & Cantilever Beams				1		75
2	Extent of Programming done (covering above parameters) including AFD, SFD, BMD, SLOPE & DEFLECTION (Computerized Graphical Plots)				1		75
3	Validation of programming results with theoretical results: accuracy of results obtained				1		75
4	Quality of Powerpoint and Report / Logbook documentation					1	100
5	Contribution capacity of each member in the project					1	100
6	Quality of 2-5 minute video as of Stage-2					1	100
	TOTAL MARKS OBTAINED (OUT OF 100):						88
	EVALUATION-2 MARKS OUT OF MAX.20 (ROUNDED UP):						18

Sr. No.	RUBRIC (FOR TOPIC-1 ONLY)	1	2	3	4	5	Marks Obtained
		0%	25%	50%	75%	100%	Out of 100 for each row below
		(Enter only number 1 in the particular cell below, for each row)					
1	Quality of Powerpoint document & Presentation (use of space, graphics, contents covered in slide etc.)				1		75
2	Delivery of the presentation (language, eye contact, volume & clarity, fluency, confidence & attitude etc.)				1		75
3	Subject knowledge (from presentation & Q/A sessions)					1	100
4	Quality of 3-5 minute video file (preferably .mpeg type) describing summary of entire mini-project, with narration and visuals					1	100
	TOTAL MARKS OBTAINED (OUT OF 100):						88
	VIVA-VOCE MARKS OUT OF MAX. 10 (ROUNDED UP):						9
	TOTAL MINI-PROJECT MARKS (OUT OF 50)					42	

EVALUATION 1 & 2, and VIVA-VOCE RUBRICS FOR TOPIC-2:

Sr. No.	RUBRIC (FOR TOPIC-2 ONLY)	1	2	3	4	5	Marks Obtained
		0%	25%	50%	75%	100%	Out of 100 for each row below
		(Enter only number 1 in the particular cell below, for each row)					
1	No. of Individual Design Concept Ideas Created (ideally, 1 by each member of the group); Quality of Rough Sketches, Simplicity of final design & Aesthetic Considerations.					1	100
2	VERSATILITY: Max. no. of features included in the final design concept (viz., foldable TABLE, chair, walls of cubicle room, soft board area, storage shelves, space for pen stand, space for table lamp, foot rest, space for dust bin, ladder (after reorienting the unit in different direction), sofa, bed etc. If only TABLE, allot 2 (25%) as the score.					1	100
3	Space-saving ratio of the unit [(V1 - V2) / V1] where, V1 = volume of cuboid/cylinder space when unit is UNFOLDED completely, & V2 = volume of space when FOLDED completely. This ratio approaches the maximum value of unity (always less than 1.0). Allot 5 (100%) for a value closer to 1.0					1	100
4	Quality of Powerpoint and Report / Logbook documentation				1		75
5	Contribution capacity of each member in the project				1		75
6	Quality of 2-5 minute video as of Stage-1				1		75
	TOTAL MARKS OBTAINED (OUT OF 100):						88
	EVALUATION-1 MARKS OUT OF MAX.20 (ROUNDED UP):						18

Sr. No.	RUBRIC (FOR TOPIC-2 ONLY)	1	2	3	4	5	Marks Obtained
		0%	25%	50%	75%	100%	Out of 100 for each row below
		(Enter only number 1 in the particular cell below, for each row)					
1	Quality of 3-D model constructed of the final design concept idea, 3-D Isometric (1 view) & 2D drafting (3rd angle projection) & Bill of Material (BoM) on A2 size, and its assembly & animation of folding/unfolding (Check for interferences occuring if any)					1	100
2	Aesthetic considerations and Simplicity of design				1		75
3	Sustainability (extent to which available local and renewable resources are used)				1		75
4	Quality of physical scaled 3-D model constructed (3D printing), in construction and movement of parts while folding/unfolding (check for interference if any)				1		75
5	Quality of Powerpoint and Report / Logbook documentation, Contribution capacity of each member in the project					1	100
6	Quality of 3-5 minute video as of Stage-2					1	100
	TOTAL MARKS OBTAINED (OUT OF 100):						88
	EVALUATION-2 MARKS OUT OF MAX.20 (ROUNDED UP):						18

Sr. No.	RUBRIC (FOR TOPIC-2 ONLY)	1	2	3	4	5	Marks Obtained
		0%	25%	50%	75%	100%	Out of 100 for each row below
		(Enter only number 1 in the particular cell below, for each row)					
1	Quality of Powerpoint document & Presentation (use of space, graphics, contents covered in slide etc.)					1	100
2	Delivery of the presentation (language, eye contact, volume & clarity, fluency, confidence & attitude etc.)					1	100
3	Subject knowledge (from presentation & Q/A sessions)				1		75
4	Quality of 3-5 minute video file (preferably .mpeg type) describing summary of entire mini-project, with narration and visuals					1	100
TOTAL MARKS OBTAINED (OUT OF 100):							94
VIVA-VOCE MARKS OUT OF MAX. 10 (ROUNDED UP):							10
TOTAL MINI-PROJECT MARKS (OUT OF 50)							46

The students later had to appear for the viva-voce in the presence of Internal and External Examiners, as per the rules laid down by the Mumbai University.

It was observed that very few number of groups had opted for the Topic 1 i.e., Computer Aided Beam Analysis, a topic related to the subject of Strength of Materials, presumably due to the massive efforts required in terms of theoretical understanding, and also in the programming sense. Maximum number of groups selected Topic 2 for their work.

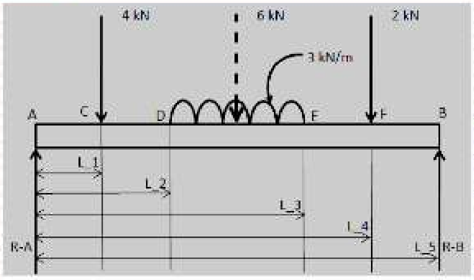
Students also submitted the source files of their project, along with a detailed report, and a Powerpoint presentation file, with log-book in some standard template (available from the internet sources) as a part of their term work. In addition, student groups also submitted a 2-5 minute edited video with voice-over and background music, describing their project work in summary. This added to their video-editing skills which is also the need of the hour.

To conclude, in spite of the difficulties posed by the pandemic and work cornered through homes, students managed to work on their mini-project topic and got to learn the technical knowledge related to the subject/s, team building and management, effective communication, presentation (written and verbal), report writing, scheduling, delegation, costing etc.

Sample work and a few snapshots of Mini-Project-1A taken during the evaluation stages or from the student reports, are provided for reference, as follows.

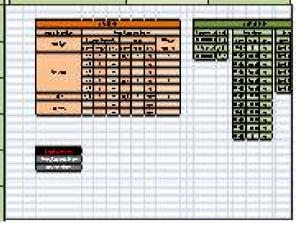
Samples of Student-group Work:

Computer-Aided Beam Analysis - Excel

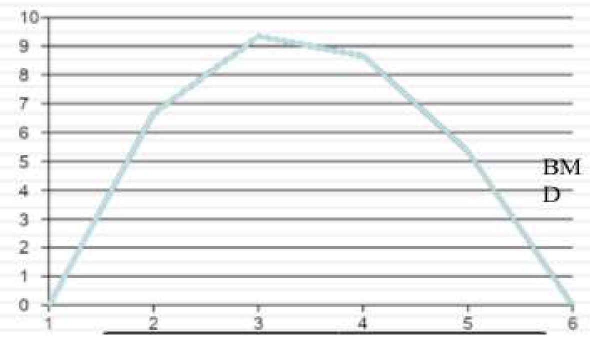


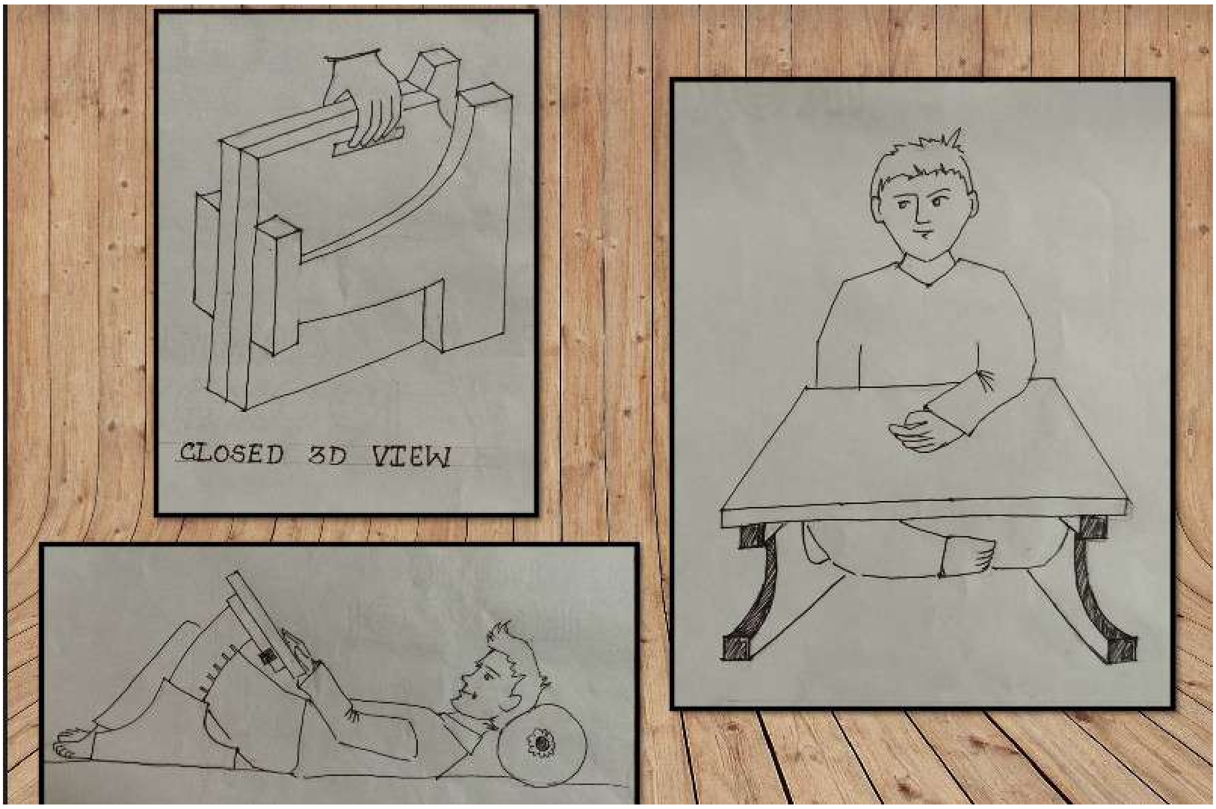
OUTPUT DATA							
Σ Moment @ A = 0		Shear Force			Bending Moment		
5.333333333	R_B	Name	Load	Unit	Name	BM	Unit
Σ Forces @ y = 0		SF @ Al	0	kN	BM @ A	0	kNm
6.666666667	R_A	SF @ Ar	6.6667	kN	BM @ C	6.6667	kNm
		SF @ Cl	6.6667	kN	BM @ D	9.3333	kNm
		SF @ Cr	2.6667	kN	BM @ E	8.6667	kNm
		SF @ Dl	2.6667	kN	BM @ F	5.3333	kNm
		SF @ Dr	2.6667	kN	BM @ B	0	kNm
		SF @ El	-3.333	kN			
		SF @ Er	-3.333	kN			
		SF @ Fl	-3.333	kN			
		SF @ Fr	-5.333	kN			
		SF @ Bl	-5.333	kN			
		SF @ Br	0	kN			

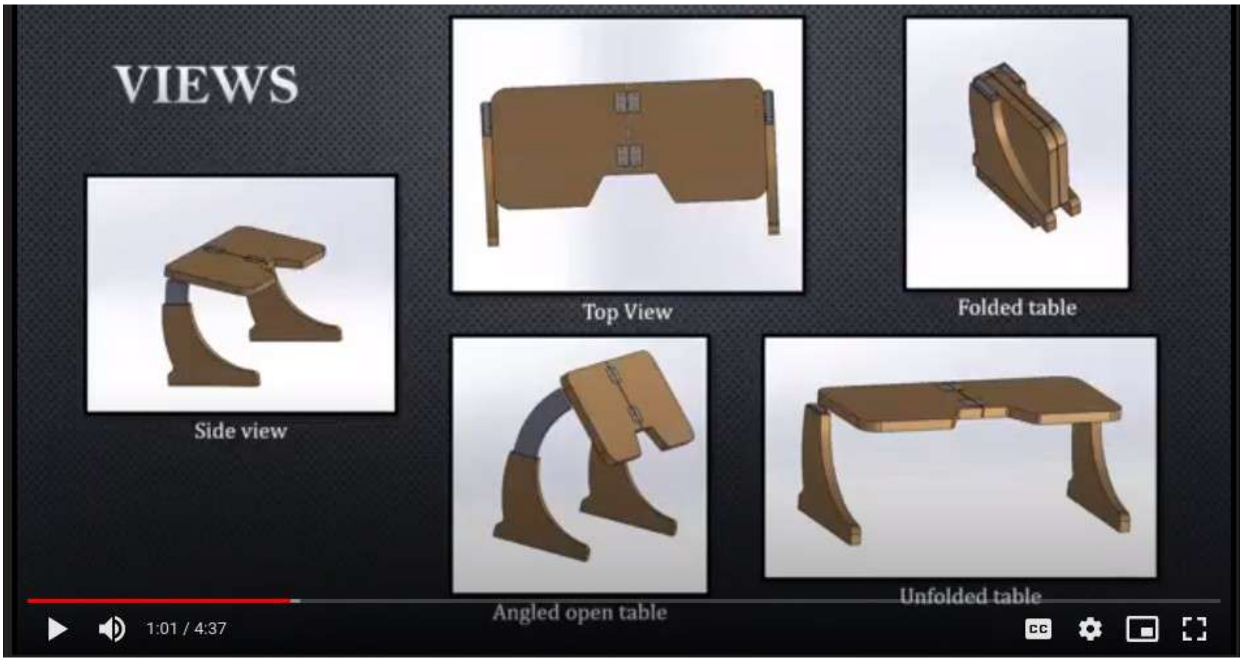
INPUT DATA							
Choose Beam Type	Simply Supported Beam						
Load Type	Distance from left			Load			Effective Load - kN
	Name	Length	Unit	Name	Load	Unit	
Point Load	L_1	1	m	W_1	4	kN	4
	L_2	2	m		-	kN	-
	L_3	4	m		-	kN	-
	L_4	5	m	W_4	2	kN	2
	L_5	6	m		-	kN	-
UDL	L_D	3	m	W_D	3	kN/m	6
Moment		-	m		-	kNm	-
		-	m		-	kNm	-



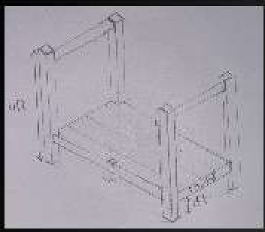
SFD & BMD using CABA

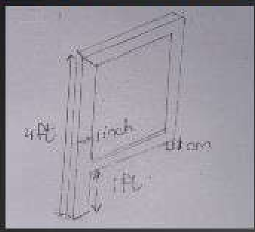


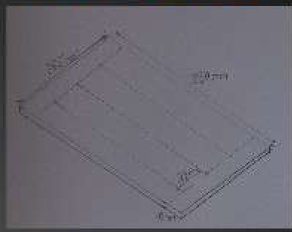

CLOSED 3D VIEW

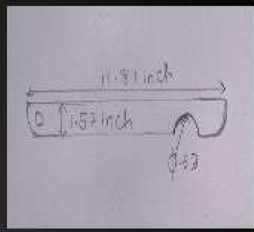

VIEWS
Top View
Folded table
Side view
Angled open table
Unfolded table
1:01 / 4:37

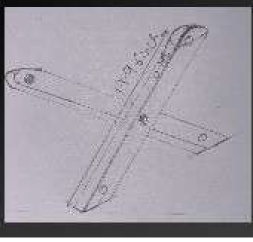
2D DRAFTING OF THE MODELS :

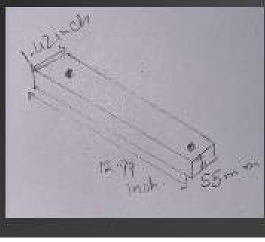


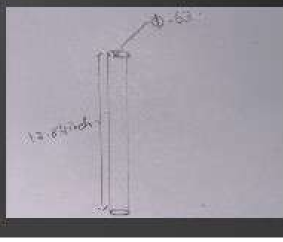


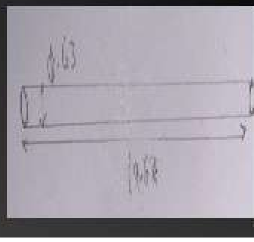




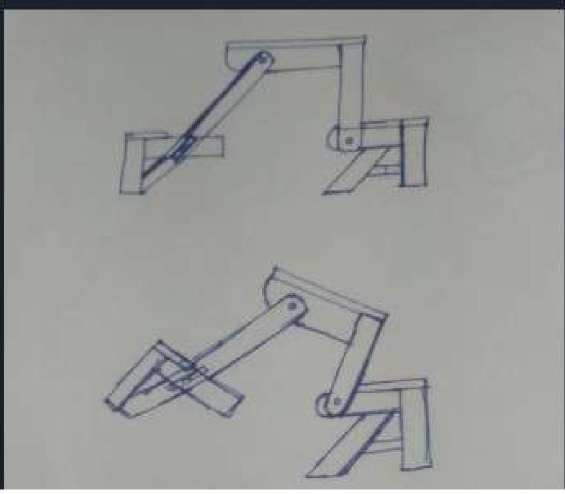


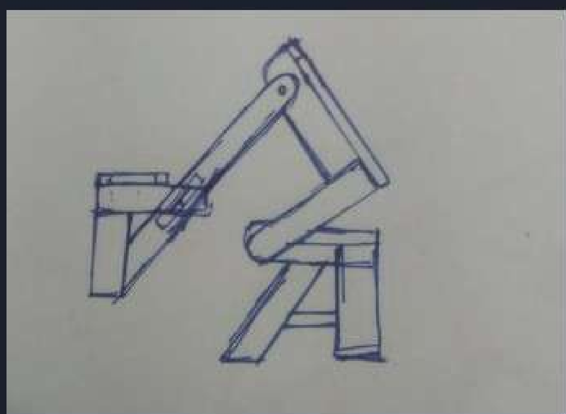


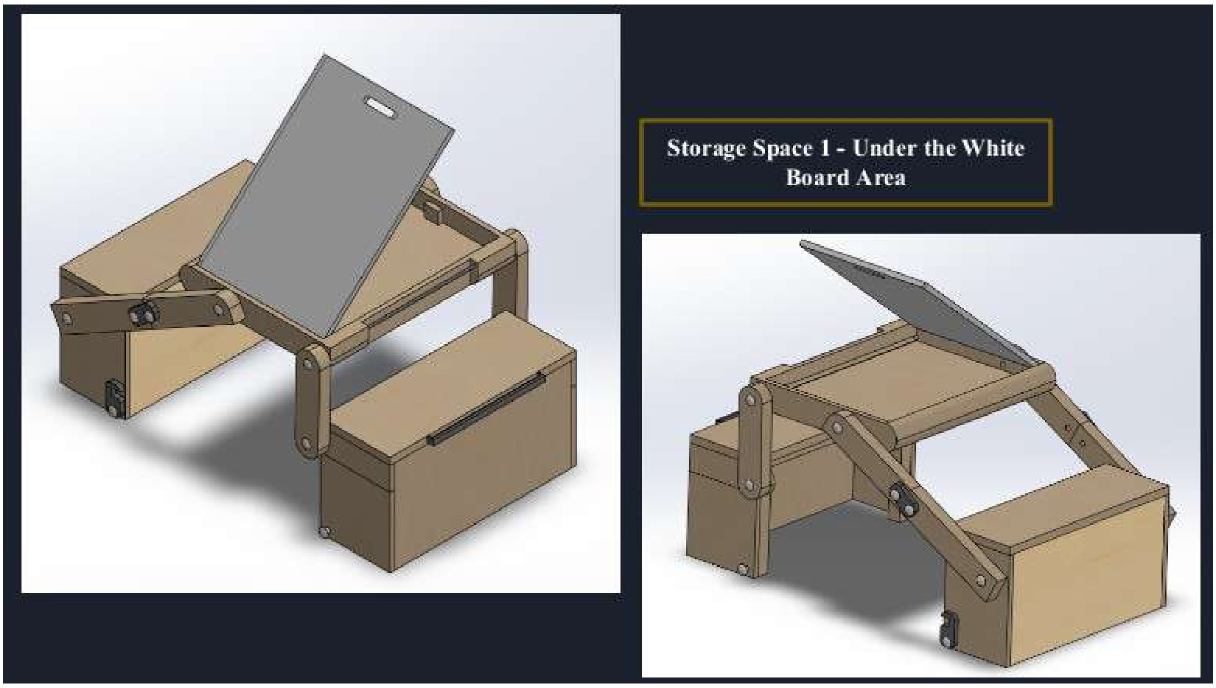


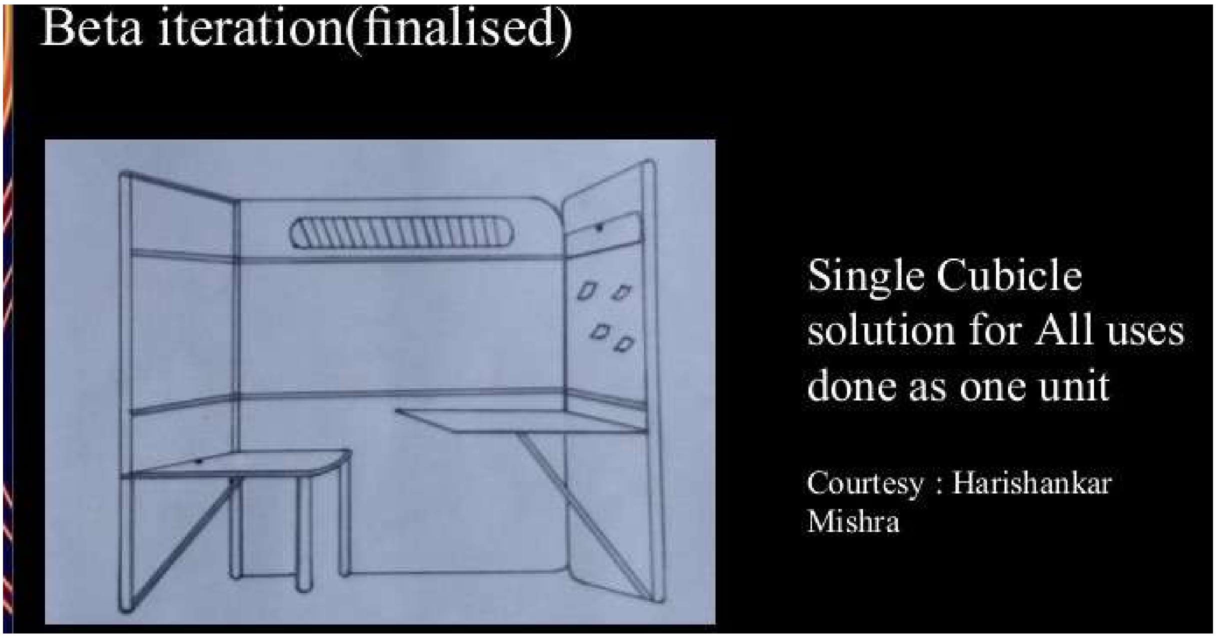


FOLDING TRANSITIONS






Storage Space 1 - Under the White Board Area


Beta iteration(finalised)
Single Cubicle solution for All uses done as one unit
Courtesy : Harishankar Mishra

3D Model