ENGG102 - Students' handouts– Part 1

Project 2 B - Predict required Counterbalance Mass to achieve equilibrium (to balance a static load)

Student Learning Outcomes (SLO):

This week's activities will focus on Learning Outcomes 1, 2, 3, 5, 6, and 7 as below -

1. Describe the role of abstraction, simplification and the use of assumptions and mathematical relationships in solving problems encountered by engineers.
2. Develop free body diagrams to analyse the forces and moments acting on and within structural elements and structural systems.
3. Apply logical engineering design practices to multi-faceted problems involving engineering mechanics.
4. Describe the impact of the application of engineering mechanics on engineering activities across a number of engineering disciplines.
5. Demonstrate self-directed learning related to solving problems in engineering.
6. Undertake and present engineering calculations, designs, research and critical analysis in a professional manner.
7. Work as a productive member of a team, recognising roles, responsibilities and accountabilities of individuals in a team.

Announcements:

1. *Safety risks have been identified for Project 2B. While using the testing rig you MUST wear sturdy closed-type shoes and safety glasses. You are not allowed in the class in thongs or similar shoes.*
2. *Teams MUST submit their Project 2B Design and Reflection Report as a word file via Moodle, by 11:59pm on Thursday of week 9.*

Task 1: Predict required Counterbalance Mass to achieve equilibrium & the specified deflection

At least 2 identical beams should be manufactured by the instructor and made ready for testing by the groups. Each group need to take the required measurements to determine the beam length, its second moment of area; **I** of the beam. Assume the Young’s modulus E=1.06 GPa.

NOTE:

1. ***Each team is allowed to set up and test their predictions.***
2. ***Suggest The instrutor briefly demonstrate this to the first team - and the other teams all watch!***
3. ***For full details, please refer to the ENGG102 Project 2B - part 2 of this handout.***

A lift system is required to lift an end mass (m) of 500 suspended from a pulley boom. The lift is to be driven by a counterbalance mass (M) on an adjustable inclined plane (40° ≤ θ ≤ 55°) connected to the pulley by a non-elastic cord as shown in Figure 1 below –

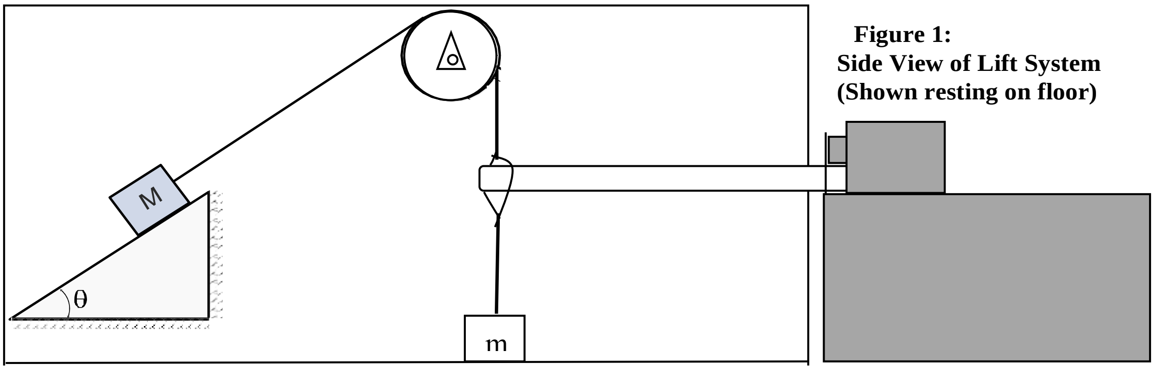

Figure 1:
Side View of Lift System (Shown resting on floor)

To test this lift system, teams will use the counterbalancing mass on an inclined friction plane test rig to lift a 500 mass suspended from the pulley.

Position 2: Test

The first test is done by placing counterbalancing masses on the inclined plane load carrier to achieve equilibrium as noted below in figure 2.
You will first attempt to predict the required counterbalance mass and then test your predictions by setting up the counterbalancing mass on the inclined plane test rig by adding masses gradually until equilibrium positions is achieved as the 500g mass is just lifted off the ground.

Position 3: Test

The second test is done by placing counterbalancing masses on the inclined plane load carrier to achieve a deflection 2 mm as below in figure 3.
You will first attempt to predict the required counterbalance mass and then test your predictions by setting up the counterbalancing mass on the inclined plane test rig by adding masses gradually until a 2 mm defection is achieved.

- **Equilibrium Position:** (See Figure 2)

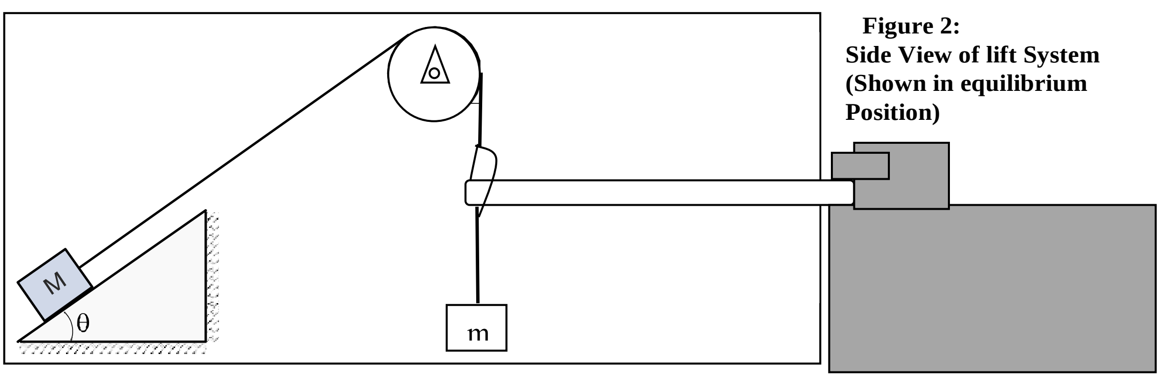

Figure 2:
Side View of lift System (Shown in equilibrium Position)

- **Equilibrium Position:** (See Figure 3)

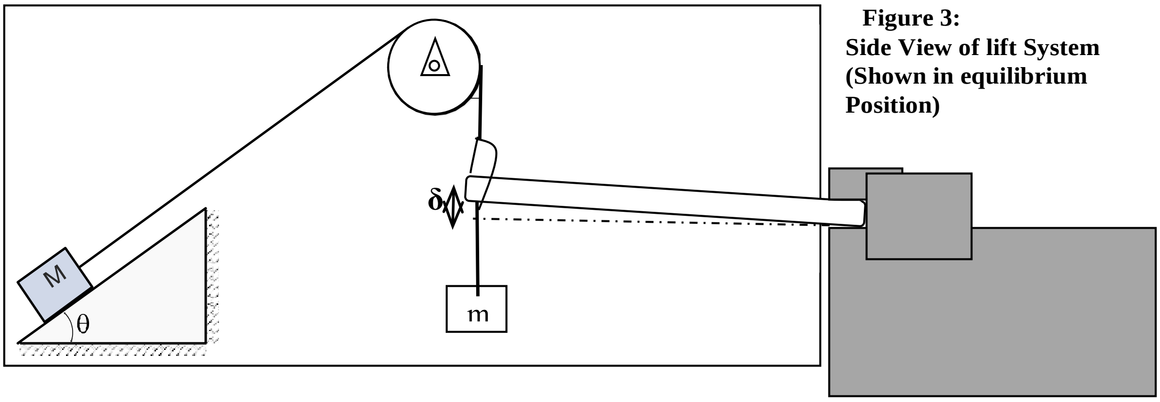

Figure 3:
Side View of lift System (Shown in equilibrium Position)

Recap **(10 minutes)**

The main points of the tutorial class -

1. *The basic concept and approach to finding Centroids and 2nd Moment of Area.*
2. *WHAT happened and suggest some reasons WHY?* Compare the findings of your 2nd Moment of Area Exercise. Contribute to a brief class discussion.
3. *Teams MUST hold regular Team Meetings and keep minutes:*

ENGG102: Project 2B : Part 2

Predict the required Counterbalance Mass to achieve equilibrium and a limit switch simulated by a specified deflection of a cantilever beam

A: Predict required Counterbalance Mass to achieve equilibrium & the specified deflection

A lift system is required to lift an end mass (m) of 500g suspended from a pulley boom. The lift is to be driven by a counterbalance mass (M) on an adjustable inclined plane (40° ≤ θ ≤ 55°) connected to the pulley by a non-elastic cord as shown in Figure 1 below –

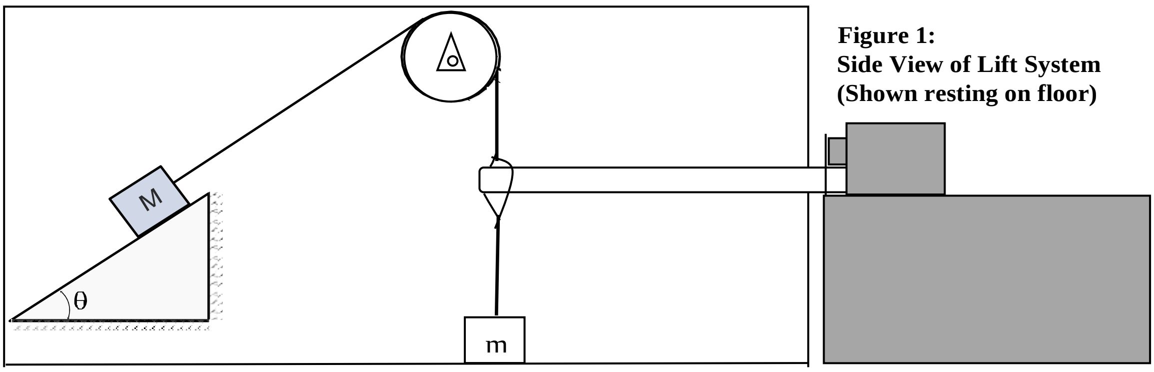

Figure 1:
Side View of Lift System
(Shown resting on floor)

To test this lift system, teams will use the counterbalancing mass on an inclined friction plane test rig to lift a 500g mass suspended from the pulley.

Position 2: Test

The first test is done by placing counterbalancing masses on the inclined plane load carrier to achieve equilibrium as noted below in figure 2.

You will first attempt to predict the required counterbalance mass and then test your predictions by setting up the counterbalancing mass on the inclined plane test rig by adding masses gradually until equilibrium positions is achieved as the 100g mass is just lifted off the ground.

Position 3: Test

The second test is done by placing counterbalancing masses on the inclined plane load carrier to achieve a deflection 2 mm as below in figure 3.

You will first attempt to predict the required counterbalance mass and then test your predictions by setting up the counterbalancing mass on the inclined plane test rig by adding masses gradually until a 2 mm defection is achieved.

These notes are based on originals developed by Richard Dwight and Cameron Lam They have been updated by Josip Horvat and Tim McCarthy They have been updated and are used by Khaled El-Akruti in 2017 and by Sana Amir in 2019.

- **Equilibrium Position:** (See Figure 2)

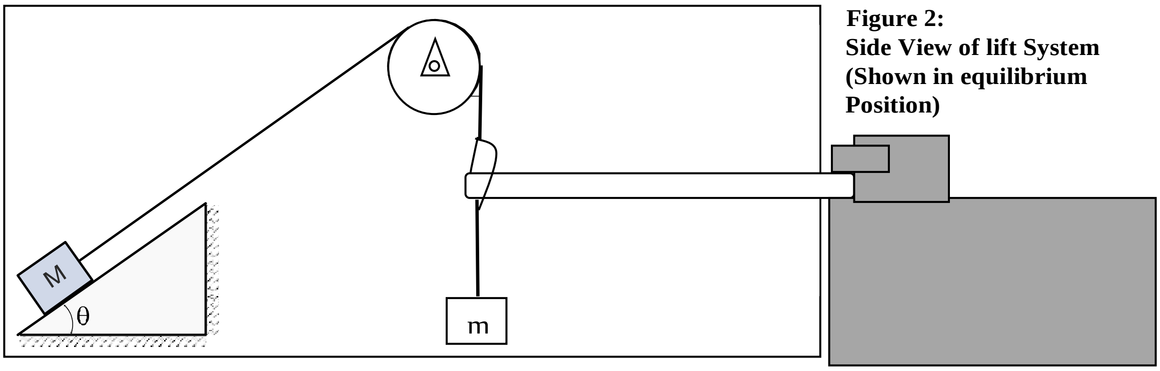

Figure 2:
Side View of lift System (Shown in equilibrium Position)

- **Equilibrium Position:** (See Figure 3)

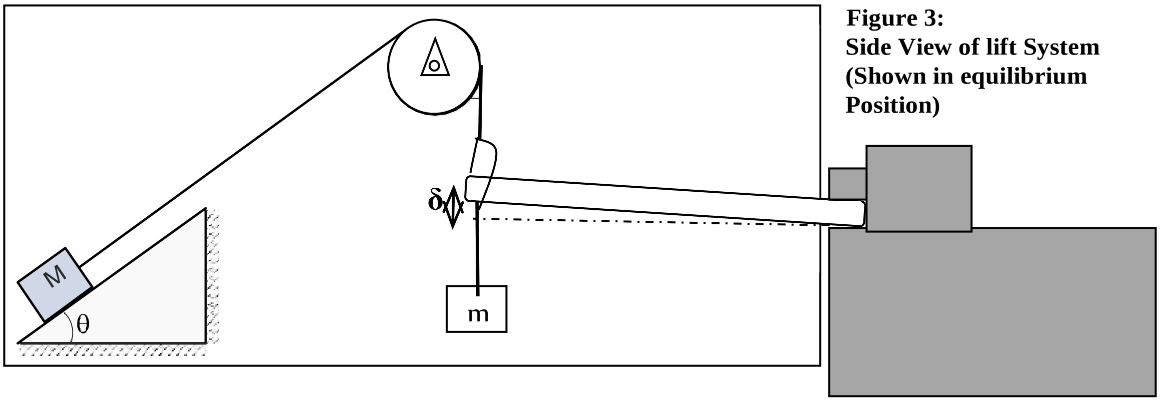

Figure 3:
Side View of lift System (Shown in equilibrium Position)

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To achieve this you will follow the procedure below -

Step 1: Choose angle ϴ of the Inclined Plane. Note that this must lie in the range 40° < ϴ < 55°

Step 2: Select a Friction Material Slider. Choose from Wool OR Wood

Step 3: Predict by using appropriate calculations the total mass of the Friction Material Slider and additional masses to achieve equilibrium.

B: Test predictions using counterbalancing masses on the inclined plane test rig

Step 1: Set the inclined plane to their desired height or angle.

Step 2: Tie one piece of string to the friction material slider at the top of the inclined plane whilst the string is passed over the pulley then tie other end to 500g mass resting back on the floor.

Step 3: Then place your calculated mass onto the friction material slider so that the hanging mass just lifts off the floor when the **equilibrium *Position is achieved***. (See Figure 1) Note if the system remains at equilibrium or not.

Step 4: If the system does not reach equilibrium at Step 3 above, then place additional mass (or remove mass if too heavy) on the friction material slider to achieve equilibrium. Record the actual total mass used on friction slider to achieve equilibrium.

Step 5: Teams are to complete the Results Table on the whiteboard, recording the following -

- Friction Slider material used
- Angle of inclined plane used
- Hanging mass used
- Previously calculated mass including slider required for equilibrium.
- Actual mass required above to achieve ***Equilibrium Position.***
- **Ratio** of Prediction (ie previously calculated) vs. Actual Mass.
- Comments on anything else important - ie WHAT happened and WHY

Step 12: Use the Project 2B Results Table provided on Moodle to record all Team's results for your Project 2B Design and Reflection Report.

Then record your results in the Results Table provided, draw comparisons with other teams, and document your reflections and conclusions in the *Project 2B Design and Reflection Report* due for submission via Moodle by 11:59pm on _____(date)____.

Classroom Health and Safety

Safety risks are identified for this project while using the testing rig are -

- A mass of up to 500 g will be used to apply a force on the beam and masses of up to 3 kg may be used to counter-balance the crane. These weights may fall from the testing rig, potentially hurting your feet.
- The crane arm may also be flung over, potentially catapulting the beam or some of the masses used across the room. This may cause serious injury or damage.

To avoid this -

- Wear sturdy closed-type shoes. **You are not allowed to be in the class in thongs or similar shoes.**
- Keep your feet away from the potential falling path of the weights at all times.
- ALWAYS wear safety glasses when testing the system.

Submission:

1. **Teams will submit Project 2B as a word file through Moodle, by 11:59pm on time by number of each team member.**
2. **Reports also MUST include Project 2B Assessment Marking Sheet separately with the Team's details completed at the top of each form. A word form is provided in each project handout for that purpose.**
3. **One student per team is to submit the report. That student will receive the feedback and must share it with other teammates.**
4. **If for some reason a team needs to re-submit their report, a different team member must do this as it only allows one submission per report per student.**

Guidelines for preparing your Project 2B Report

The Report of Project 2B report must be submitted as one word-document during the last week, no later than **11:59 on tutorial day of week 9**. It is a team report and normally each member in the team will be awarded the same mark. The reflection report **must show clear evidence of team work** and the contributions from each member.

Use the Report Structure list provided below. Teams should use these headings for their reports. Teams should assess their own work by using the Project 2B Assessment Marking Sheet (See the version form provided in Moodle) before submitting their report.

Anything missed will result in lost marks. *Please properly proofread your report before submitting!*

Report structure:

The report should contain the following -

1. Assignment cover sheet with name and student number for each team member.
2. Project 2B Assessment Marking Sheet with Team Information Include Team number and names, place, time and date of design exercise. Use the word version provided in Moodle.
3. Title page and Contents page
4. Statement of purpose of this report
5. Your calculations, with appropriate FBDs with all calculations to predict the total mass to give system equilibrium. Make sure you define the problem first.
6. Results for your equilibrium tests at Position 1 and 2 and results for the rest of the teams
7. A comparison of your Team's results to the other teams (WHAT happened)
8. Reflection (WHY it happened) - most of the marks go for this section
9. Mapping of what you have done in the subject so far with the learning outcomes mentioned in the Subject outline. Include a short commentary for each.
10. Conclusion
11. References used (evidence of further reading)
12. Appendix A: Minutes of team meetings (evidence of teamwork)

What is a Reflection?

A good "Reflection" for this report would contain the following -

1. Reflection on the calculation process to predict the total counterbalance mass for equilibrium position. What were the most difficult concepts and challenges to your thinking that took most time?
2. Reflection on your Team's performance in predicting the counterbalance mass required and how close your results were to the tested values relative to the others. WHY did some Teams perform better than others?
3. What improvements would you make to your prediction and calculation process if you were to repeat the experiment?
4. Reflect on your understanding of how sliding masses behave on an inclined plane. Try to identify what relevant knowledge you had prior to the experiment, what you gained during the exercise and what gaps you have identified. What can you do about filling those gaps? What additional literature could you read to support your responses?
5. An analysis of how agreement was achieved in your team on the prediction/calculation process. How good was you decision making process? Took too long? Not enough debate? Did you consider enough options?

ENGG102 Project 2B Design and Reflection Report: Assessment sheet

Laboratory number:________________________Tutors name:_______________________

Team Number:________ Date and time of exercise:__________________________

Names and ID Numbers: ____

Aspect	Comment	Mark
ENGG102 Project 2B Design and Reflection Report: Assessment sheet. Use PDF version from Moodle	**Minus 3 marks if this Self Assessment Sheet is not included with the Project 2B Design and Reflection Report**	
Appendix B: Minutes of Team Meetings (evidence of teamwork)	**Minus 5 marks if Minutes of Team Meetings (more than one!) are not included with this Report**	
Structure of report, team information etc (as per "what report should contain")	0.5 mark for each item 3-10 (see Report structure above).	/5
Overall Presentation	Neatness Spelling Grammar Diagrams Professionalism	/10
Problem definition	Define the problem. Identify concepts involved. What you are able to calculate and what you assumed.	/5
Analysis and calculations	Clearly present all calculations using the 6-step method. Include all appropriate FBDs with calculations to predict the total mass to give system equilibrium. Concepts or issues that are not yet known and affect the accuracy of calculations should be identified.	/20
Results including comparison with other team(s) WHAT happened!	Comparison table of all results with commentary on table. Discussion of results including comparison of all team's results and main factual findings. Identify best performing teams.	/10
Reflections – identify some reasons for the performance of your beam and other teams. WHY it happened! Consider the various aspects of the task (Challenges with new concepts, assumptions made). Discuss how your predictions and calculations might be improved, what knowledge might be needed, and concepts considered.	To achieve top marks (35-40/40) in this section your report must demonstrate clear and insightful reflection considering own solution and others in the class. Demonstrates further reading and critical analysis. To achieve 25-35/40 your report must describe the performances of your solution and some others. Itemisation of knowledge gaps and some critique of yours and others predictions. To achieve 0-25/40: Describes own solution with limited reference to other beams.	/40
Mapping of learning outcomes	Identifies all the relevant outcomes from subject outline and discusses how well each is addressed.	/5
Conclusion	1 or 2 paragraphs that draw appropriate conclusions from evidence presented in report. Include the main results, both numerical and qualitative.	/5
Total		/100

ATTACHMENT 1: Project 2B: position 2 - Results Table

ATTACHMENT 2: Project 2B: position 3 - Results Table

TEAM	Inclined Plane Angle (θ in degrees)	Slider Friction Material (B, A, S, W)	Hanging Mass (m in g)	Predicted Counter Mass incl Slider (M in g)	Actual Counter Mass incl Slider (M in g)	RATIO of Prediction vs. Actual	Observations - Anything unusual, explaining briefly WHAT happened and WHY
A							
B							
C							
D							
E							
F							
G							
H							
I							

ATTACHMENT 2: Project 2B: position 3 - Results Table

T E A M	Inclined Plane Angle (θ in degrees)	Slider Friction Material (B, A, S, W)	Beam Free Length (L)	2nd Moment of Area (I) m^4)	Target deflect-tion mm	Hanging Mass (m in g)	Predicted Counter Mass incl Slider (M in kg)	Actual Counter Mass incl Slider (M in kg)	RATIO of Prediction vs. Actual	Observations - Anything unusual, explaining briefly WHAT happened and WHY
A										
B										
C										
D										
E										
F										
G										
H										
I										