



APPENDIX GA36a

LEVEL 4 ASSESSMENT SPECIFICATION

Student name:	Jesse Fall	Student ID number:	
Programme:	HNC/D MECHANICAL ENGINEERING		
Module:	ENGINEERING SCIENCE 1		
Module code:	M4X00385	Contribution to Overall Module Assessment (%):	30%
Lecturer:	EMILY NYATHI	Internal Verifier:	
Assignment Title:	PRACTICALS I & II (SIMPLE HARMONIC MOTION AND BENDING MOMENT)	Word count (or equivalent):	
Submission deadline:	20/01/2020	Return date of provisional marks & written feedback:	
Submission method:	All written assessments, where practical and possible, must be submitted via Turnitin unless otherwise instructed by the Lecturer. (Please DO NOT put this assessment specification into Turnitin or it will match many similarities with other students' submissions.) Alternative submission method (if applicable): Late submission of the assessment will result in a late penalty mark. Penalties for late submission: Up to one-week late, maximum mark of 40%. Over one week late, 0%. Only the Extenuating Circumstances Panel may approve a change to submission dates.		
Academic honesty / referencing:	Academic honesty is required. In the main body of your submission you must give credit to authors on whose research and ideas your work is based. Append to your submission a reference list that indicates the books, articles, etc. that you have used, cited or quoted in order to complete this assessment.		

STUDENT FEEDBACK FORM

This section details the *extent* to which the assessment criteria are demonstrated by you, which in turn determines your mark. The marks available for each category of skill are shown. Lecturers will use the space provided to comment on the achievement of the task(s), including those areas in which you have performed well and areas that would benefit from development/improvement.

Generic Assessment Criteria	Marks available	Marks awarded
1. Engagement with Literature Skills		
You have shown some degree of research in this assignment. However you need to reference your work using Harvard Referencing consistently throughout your assignment. You could have used more references for your work.	25	12 ✓
2. Knowledge and Understanding Skills		
You have clearly understood the theory behind the simple harmonic motion and have made some sound conclusions. However for your bending moment experiment, your FBD was not quite clear.	30	15 ✓
3. Cognitive and Intellectual Skills		
You have applied the correct equations for the Spring Constant and Simple Pendulum and made sound analysis of the given data. For the bending moment, showing detailed steps of your bending moment calculations could have scored you more points. You used excel to calculate your theoretical bending moments. However, you could have shown the application of the bending moment in your report. You also need to proof read your work and check your answers for errors.	15	8 ✓
4. Practical Application Skills		
You gave some examples of applications of the SHM in everyday activities and have made some sound recommendations based on your findings during the practical session. For the bending moment, you have identified some sources of error in your experiment and given recommendations on how to rectify them.	25	13 ✓
5. Transferable Skills for Life and Professional Practice		

your results for the Bending Moment experiment could have been presented and organised better.	5	2

Assessment Mark (Assessment marks are subject to ratification at the Exam Board. These comments and marks are to give feedback on module work and are for guidance only until they are confirmed.)	Late Submission Penalties (tick if appropriate)		50%
	Up to 1 week late (40% Max)		
	Over 1 week late (0%)		

ME

Experiment 1, Task A

Abstract

Harmonic motion:

Simple harmonic motion is a repetitive back and forth movement through a central point (compound and complex motion for multiple axis) where the maximum displacement on one side, is equal to the other, resulting in a frequency. A simple pendulum and spring system are masses that move with harmonic motion, due to a force that is proportional to the displacement, both can be represented by the simple pendulum and Hooke's law, as they are easy to interpret and visualise. *Ref?*

The simple pendulum is a practice based on Galileo's experiments on pendulums in the early 1600's, and is used to demonstrate harmonic motion and measured time. The experiment is designed to determine mass and length based on the oscillation of a weight, and is dependent on three variables (mass, length and amplitude) and these variables will be used to gain a better understanding of their roles within movements.

The goal of this experiment is to apply forces to a simple pendulum experiment that you are able to demonstrate and predict the results when changing, mass, length and amplitude. All data recorded from these results will be recorded and used to predict for accuracy and determine any errors present.

Hooke's law is a physics law is explained by Robert Hooke as the theory of elasticity, commonly demonstrated using an oscillating spring, explaining how the tension of a spring is proportional to the load applied to it, you can investigate Hooke's law by measuring how much forces stretch a spring, but this law can go further than just springs and rubber bands. *Ref?*

The goal of this experiment is to find a theoretical mass spring period.

Theory

Simple pendulum.

A simple pendulum consists of a mass (m) hanging from a fixed point at length (L), it is then elevated to an angle (ideally to the edges of a platform) and released to measure the oscillation in a given period. This should demonstrate how the pendulum behaves as a harmonic oscillator.

The harmonic oscillation calculation which can be used and manipulated for varied results is:

$$T = 2\pi\sqrt{\frac{L}{g}} \text{ or } \theta_0 \ll 1 \text{ radian}$$

The variables mass, length and angular motion can be manipulated through this equation. In order to reduce human error, the string used must be light and able to hold variable mass without breaking; a steady clamped jig should be used also to reduce swing movements in experimentation. In theory, when a variable is altered correctly, the results should differ.

Note: we can predict the time taken for one oscillation by rearranging, if a pendulum has a period of 0.5s, and $g=9.81$, the length will equal 6.21cm

Period of oscillation, The swing of a pendulum is dependent on its length, acceleration measured in g (9.81) and what angle the pendulum swings away from its horizontal axis in 0° , which is described as amplitude.

Millham, Willis I (1945.)

Pendulum oscillation has a property called isochronism, which is the sequence of events at regular intervals, which is why pendulums are so useful for timekeeping, for small swings the period is the same for different size swings, as the period of independent of amplitude. Successive swings of the pendulum, even if changing on amplitude, take the same amount of time. (A small swing is considered when the angle

θ is considered when it is small enough that $\sin(\theta)$ can be around θ when θ is converted into radians.
Cooper, Herbert J. (2007) with a large enough swing, you are able to predict and manipulated oscillations with varied Mass and length, producing different periods.

Theory, Simple Spring

Properties of materials and their ability to stretch can be described as elasticity, this can be expressed by the formulae ($F_s = kx$) which should be read as "proportional force required to stretch" where F_s is the elastic force, k is the spring constant and x is the stretch or compression of the material, these are the variables we can manipulate. If a weight, measured at mg (Mass, Acceleration due to gravity) is hung from a spring, it will cause it to stretch a distance, creating an opposite force which acts to oppose the pull of the weight. If the weight does not deform the spring, it will restore it to its original length when removed.

This expression is known as Hooke's Law, which reads that you are likely to find a relationship between force and displacement. The slope of F and X found through experimentation can be called the spring constant, and it indicated by the variable K .

Though usually applied to springs, Hooke's law can also be used to demonstrate objects that have a restoring force, such as rubber or certain plastics.

Without friction, springs should oscillate at a natural frequency forever, storing and releasing energy, in a real world example though, it will lose energy to air resistance around moving parts, and as they are stretched and released they will lose energy resulting in 'damping' eventually reducing the oscillations to zero. Nelson, Robert MG Olsen (1987).



Procedure for pendulum.

As shown in Figure 1, fix a plummet arm and a pendulum with weighted bob to a work panel. Fixed securely to workbench.

1. Set the pendulum at a length of 310mm ($L=0.31\text{m}$) with weighted bob of 200g (m)
2. Push the pendulum so its centre aligns to an edge measured at 40° , use trigonometry or an accurate protractor to measure the initial angle of swing, angle a . You can also measure the difference in height (h) from the bottom of the pendulum swing to the top.
3. Release the pendulum without force and allow it to swing freely, it should swing clear and free of any supports.
4. Using a stopwatch, measure how many times it takes to complete 10 swings (from the initial position to away and back) in seconds. Note: notice how the swings will get smaller each oscillation, but will take the same period of time to move from one side to another.
5. Repeat using varied lengths of 225mm ($L=0.225\text{m}$), 310mm ($L=0.31\text{m}$), 150mm ($L=0.15\text{m}$), weights of 150g, 50g, 200g, 100g, and degrees of 40° , 30° , 20°

Note: if using different lengths than provided, using too short of a length may result in periods to be too quick to accurately measure.

6. For each line of results, divide the time taken by 10s to find the Period (T) The angular distance used for (L) is the length, using the standard $g=9.81$, calculate the theoretical period for each combination of mass, length and angle.

7. Compare results of theoretical period, and experimental period.

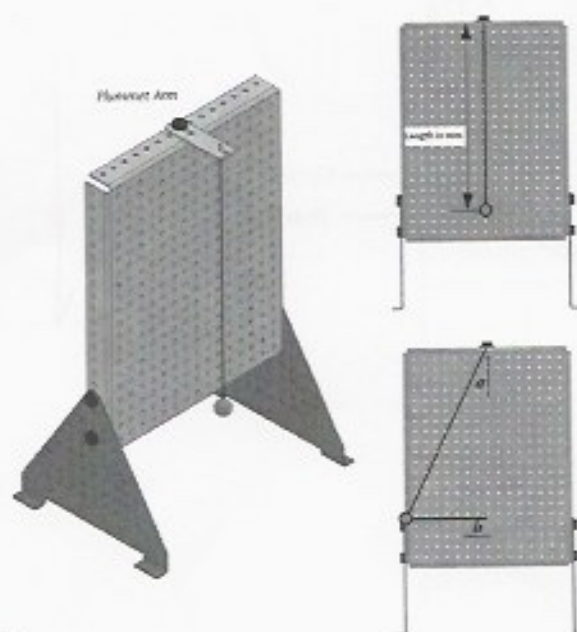


Figure 1.

Results simple Pendulum

Theoretical pendulum period example calculation: The pendulum length (l) = 300mm (0.3m)

Acceleration due to gravity (g) = 9.81 m.s^{-2} .

$$l/g = 0.3/9.81 = 0.0306$$

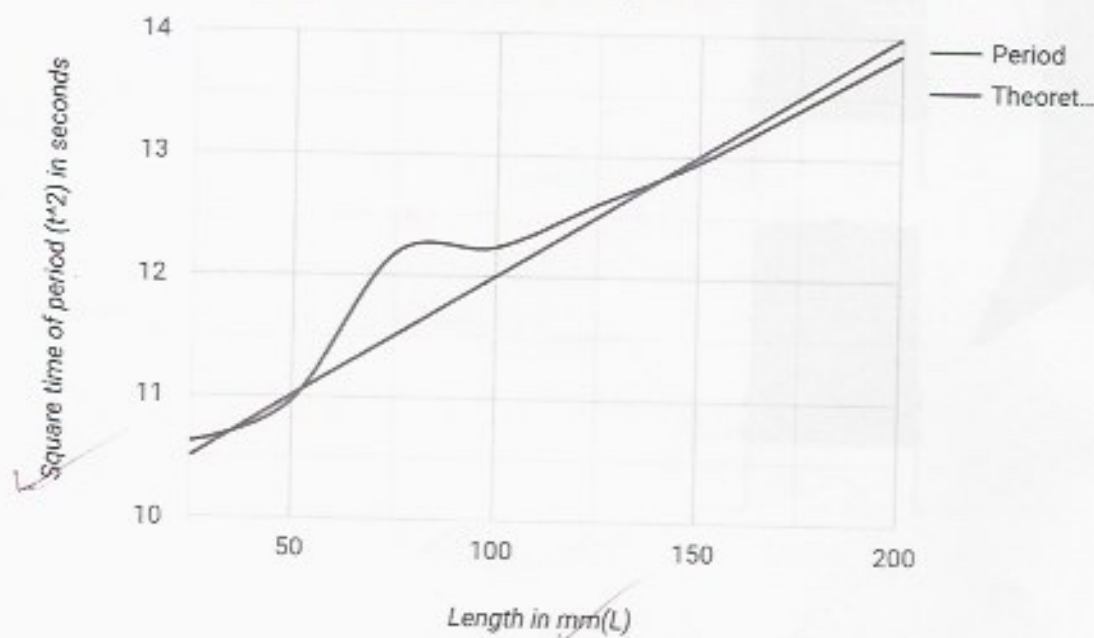
$$\sqrt{0.0306} = 0.175$$

$$2\pi \times 0.175 = 1.1 \text{ seconds theoretical period.}$$

Test results.

Column1	Length(mm)	Time (10 Oscillations)	Period (Seconds)	Theoretical Period (Seconds)
150g 40	310	13.86	1.386	1.116
50g 40	310	12.8	1.28	1.116
100g 40	310	13.26	1.326	1.116
200g 40	310	13.4	1.34	1.116
150g 40	225	12.95	1.295	0.951
50g 40	225	12.03	1.203	0.951
100g 40	225	12.37	1.237	0.951
200g 40	225	12.6	1.26	0.951
200g 30	225	12.67	1.267	0.951
100g 30	225	12.385	1.238	0.951
50g 30	225	12.18	1.218	0.951
150g 30	225	12.24	1.224	0.951
200g 20	150	10.62	1.064	0.776
100g 20	150	10.79	1.079	0.776
50g 20	150	10.65	1.065	0.776
150g 20	150	10.96	1.096	0.776

Graph between L and t^2 for a simple pendulum



pendulum conclusions,

A pendulum has a length from its fixed point to the centre of gravity of mass at the end of the string, if you pull the mass and let it go, it swings from one side to the other due to the restoring effects caused by gravity. The time taken for the mass to swing from one side to the other is half of one period; it completes a full swing when it returns to its starting position (1 period)

Gravity affects the swing, the length affects the time it takes for the pendulum to swing, a longer pendulum or less acceleration from gravity would give a longer period, however it's difficult to manipulate as it is consistent around the world, so changing the length or mass of the pendulum is a better way to show this theory.

You can calculate the value for g , in meters per second (m.s^{-1}), the value depends on accurately measuring the distance from the centre of the mass; this would be difficult to measure especially as the pendulum used is short.

Without friction, the pendulum would swing forever, but it loses energy due to gravity, friction from the pivot point and air resistance.

While the experiment may seem simple to perform and record, there are many errors which ^{may} make cause the results to be obscured and inaccurate. Errors possibly excluded from results:

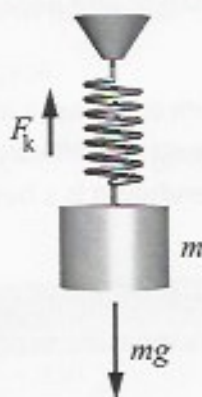
The operator using the stopwatch required a reaction time to begin and end to record proper periods, this error can be minimized by repeating the experiment multiple times, or use a laser to begin time taken when the bob passes 90° after release and stops at a given time. Using an average of experiments rather than just the one should produce more accurate results.

The measurement of the string (L) is difficult to measure accurately with rulers or meter rules; this can be rectified by using a rod rather than string that has been cut using a Vernier.



Procedure, Simple Spring.

To test the spring rate you need to do a simple load and extension measurement test, and then chart results giving you the spring rate. Note these rates as newton meters.



You will need, An L shape strut with a hole located in a vertical position clamped to a work surface, a spring and various weights.

Hang the spring from the L shape strut secured to a work surface using a clamp, attached a mass hanger directly to the bottom of the spring to enable the ability to hang various loads from the spring. Use a Vernier calliper to measure the distances; original length, stretch in length (meters).

Attach the mass hanger to the bottom of the spring and measure with the Vernier the unstretched, this will be your zero for measurements.

Now add masses of various weights, recording the stretch of the spring after it reaches equilibrium. This is your stretch in mm. If using Grams, record the mass in kg by dividing grams by 1000, then calculate the weight in newton's (mass*acceleration due to gravity)

Results Simple Spring.

Example of finding theoretical mass spring period.

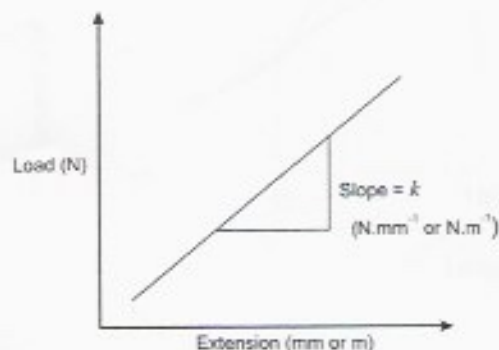
The spring rate (k) = 31 N.m^{-1} .

The mass used (m) = 0.3 (300g).

$$m/k = 0.3/31 = 0.00097$$

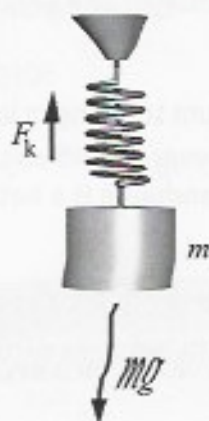
$$\sqrt{0.00097} = 0.0983$$

$$2\pi \cdot 0.0983 = 0.617 \text{ seconds theoretical period.}$$



Procedure, Simple Spring.

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Results Simple Spring.

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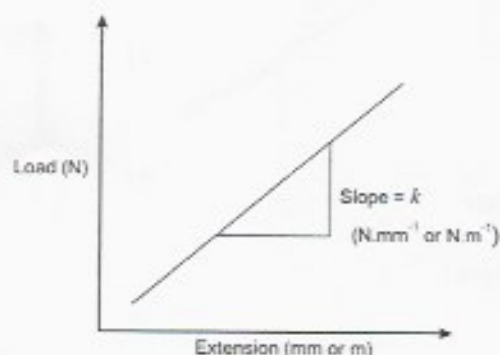
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simple spring practical.

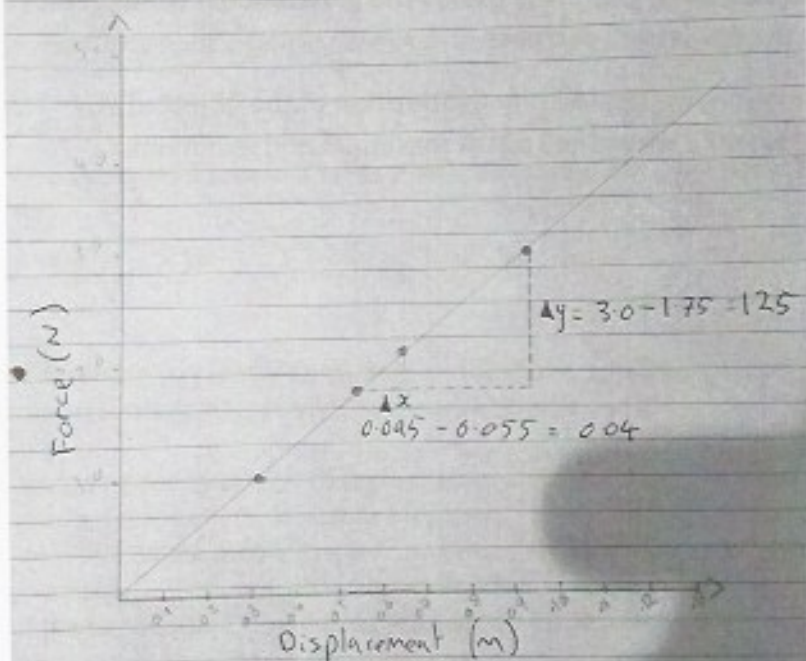
Original length = 0mm as a datum point.

Force (N)	Displacement (mm)
1N	320
1.75N	550
2N	650
3N	950

Jesse Fall

Spring constant, Hooke's Law.

Analays.



$$\frac{\Delta y}{\Delta x} = \frac{1.25}{0.04} = \boxed{31.25 \text{ N/m}} \text{ Spring constant.}$$



If we take an object in equilibrium, and we push on it, it won't just move away. There's a restoring force that returns it to equilibrium and a reparative cycle that results in a harmonic motion. An example of pushing a child on a swing, but a formal example is the pendulum as shown above, and a mass spring as shown above.

If you have an object moving towards equilibrium based on restoring forces, it is called harmonic motion. An important characteristic from both of these experiments is the period (measured in seconds) of that motion, the spring to return to its original position and a pendulum to make one full cycle of a swing, the point of these experiments was to manipulate the period.

In a mass swing oscillator, this is done by increasing the mass hanging from the spring, the period will get longer. To decrease it, the spring stiffness can be increased. As for the Simple pendulum, to increase the period, the length of the pendulum may be increased, to reduce the period the gravitational strength must be changed, as we increase the field strength, the period will decrease.

With both of these forms of simple harmonic motion, we can identify the position of the object at any time, its relative velocity and acceleration, and identify when they are at maximum and minimum.

References :

Millham, Willis I (1945.)

Time and Timekeepers: including the History, Construction, Care, and Accuracy of Clocks and Watches

Cooper, Herbert J. (2007.)

Scientific instruments New York: Hutchinson's. p. 162.

Nelson, Robert; M.g. Olsson (1987.)

American journal of physics, 54

Experiment 1, Task B.

1. The period of oscillation of an ideal, simple pendulum depends of length, L . Of the *pendulum and the acceleration of gravity, g* and is given by the following equation: $T = 2\pi\sqrt{\frac{L}{g}}$ Solve for g .

$$g = \frac{4\pi^2 L}{T^2}$$

2. Is the period of a simple pendulum dependant on the mass?

The simple pendulum does not depend on mass, only on the length and acceleration due to gravitation.

3. How long must a simple pendulum be to have a period of 1s?

$$T = 2\pi\sqrt{\frac{L}{g}} \text{ Rearrange for } L, L = \frac{T^2 g}{4\pi^2}$$

One swing would mean it takes 2 seconds for one complete oscillation.

$$L = \frac{2^2 \times 9.8}{4 \times 3.14^2} = 1\text{m}$$

4. Assuming you are safely located on the moon, and are provided with a simple pendulum, stopwatch and a metre rule, is it possible to determine the acceleration due to gravity on the moon using only these items?

Yes, by using a pendulum with multiple masses and lengths, you are able to calculate the approximate acceleration due to gravity on anywhere, including the moon.

If I WERE on the moon, I would use a mass attached to a length of string, elevate it and drop it to measure its period.

Example,

If the period was 2.5 seconds, and I used a 0.25m length of string.

$$\text{Rearrange } T = 2\pi\sqrt{\frac{L}{g}} \text{ for } g.$$

$$g = \frac{4\pi^2 L}{T^2}$$

this gives me the calculation I need to calculate the acceleration, where;

$$T=2.5 \text{ and } L=0.25$$

$$g = \frac{4\pi^2(0.25 \text{ m})}{(2.5 \text{ s})^2}$$

so,

$$g = \frac{9.9 \text{ m}}{6.3 \text{ s}^2}$$

giving us, 1.6m/s^2

5. consider your t^2 vs L graph, what are the slope values? Show that the slope is $\frac{4\pi^2}{g}$.

The equation of a pendulum is $T = 2(\pi)(l/g)^{1/2}$ squared

is $t^2 = 4(\pi)^2(l/g)$. t^2 is proportional to L according to the graph using a straight line using

$Y=mx+c$, the slopes are $4(\pi)^2$,

Where $y = y^2$

$M=(4\pi^2)/g$

$X=\text{length}$

$B=0$

Experiment 2, Bending moment in beams. Task A

Abstract

At any cross section of a material under load, there will be a shear and bending factor to maintain equal forces, (equilibrium). A bending moment is when a structure is under load from an external force or 'moment' is applied to it, causing the structure to try to bend/shear. (Gere, J.M 1996).

The bending moment can be used to verify the shape factor or the load limit on a material under pressure. The objective of this experiment is to determine theoretically the bending moment of a 1M beam separated into two pieces with loads attached, then practically test it to compare results, this process should give an insight on stresses in beam bending and can be compared to beams of different cross sections.

The experiment in practice can be compared to real life examples and is a useful practice to understand maximum stresses and potential failures, this is important when deciding on safety factor in building construction and maintenance.

Introduction

the experiment required a length of metal support by multiple struts, at a level plane to create an equilibrium, demonstrating the forces currently acting upon it are 'upward forces = downward forces', the beam is then put under load via various weights, and measuring the reaction about point R3, the area of the beam where a newton metre spring is loaded on, the readings in N will be recorded and various weighting will be applied.

Theory

The hypothesis for this experiment is that the more weight added to the beam, the cross section of R3 will have higher force acting upon it, and will demonstrate the plasticity of that moment in the beam. This will be tested via observation and practical results of the experiment.

These observations will be demonstrated via Bending Moment = Distance x Force ($D \times F$)

The moment at point r3 will be accurately measured about, $(R2 \times X2) + (R4 \times X3) - (R5 \times X6)$,

MR3 will be notated as 0, So F_v is 0.

Procedure and methodology

Parts required: Two Struts, split beam assembly 1M, Load hangers of varied weights in N, newton meter spring loaded.

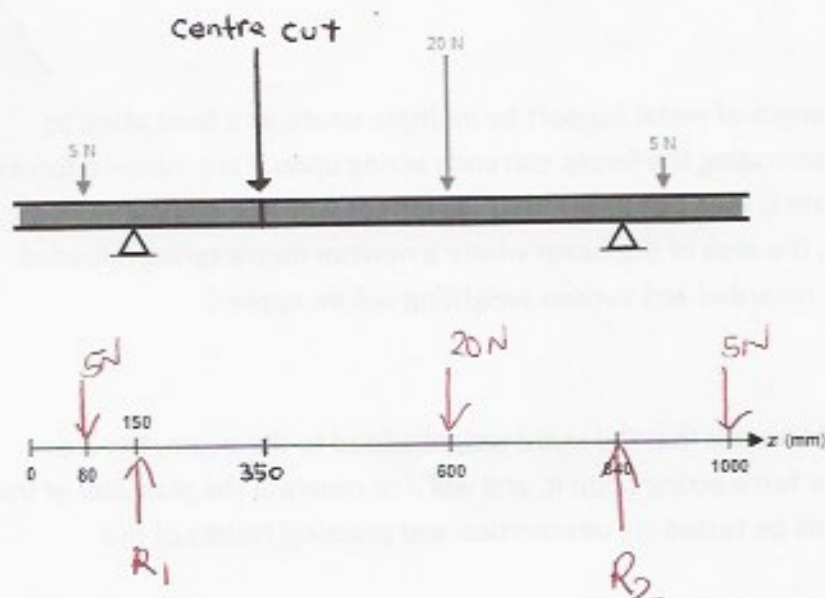
Two struts fixed to a level table or bench are to be measured apart and a beam placed atop, the measurement for each strut as 150mm and 840mm in relation to the beam.

The beam split at 330.5mm, this will require a newton meter spring attached between the beams measured at 150mm and 150mm in relation to the split in the beam. Load hangers placed at 80mm, 60mm and 90mm.

Tighten or loosen the newton meter so it takes the load until level using a gauge atop, then set the newton metre to 0.

The loads at this point will be zero, representing equilibrium.

Weights of 5N, 20N and 5N are loaded in that order, then a new reading is taken to the bending moment in N/M.



Results and Analysis.

$W_1 - R_1$

Point	Mm
R1-R2 (Weight 1)	80
R1-R3 (Strut 1)	150
R1-R4 (Weight 2)	600
R1-R5 (Centre)	335
R1-R6 (Strut 2)	840
R1-R7 (Weight 3)	900
R1-R8 (End of beam)	1000

Bm at equilibrium, N/M 0

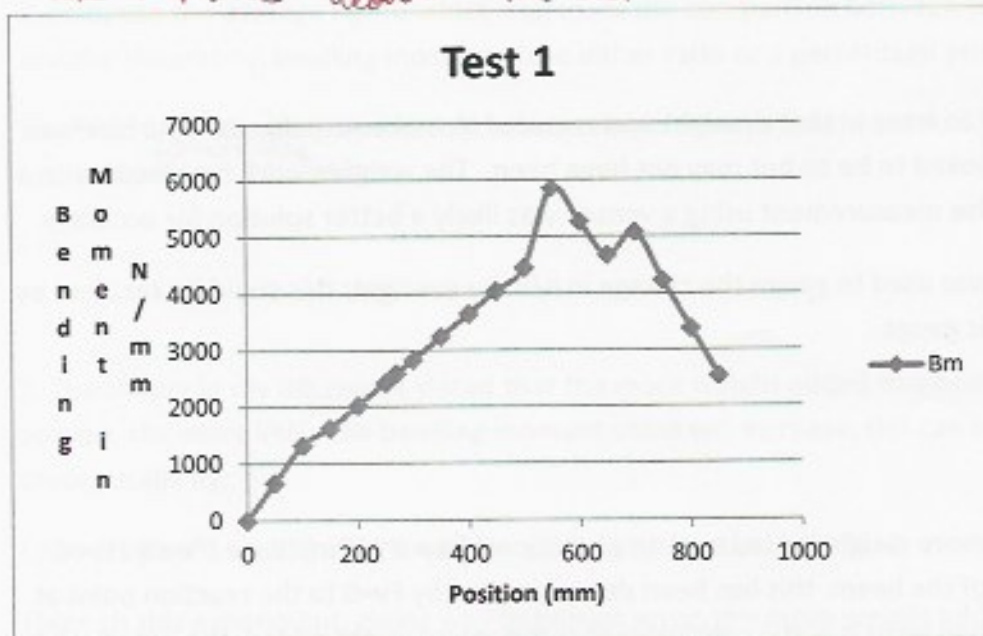
Bm at point R3, (WITH 5N @ R2, 20N @ R4, 5N @ R7) in N/M, : 3.5N/m, or 0.356 KG/m

Gathered data was inserted into excel format to represent bending moment diagram,

Experimental B.M. calculation?

Take moments about the cut

$$M_c = \text{Spring force} \times \text{drop}$$

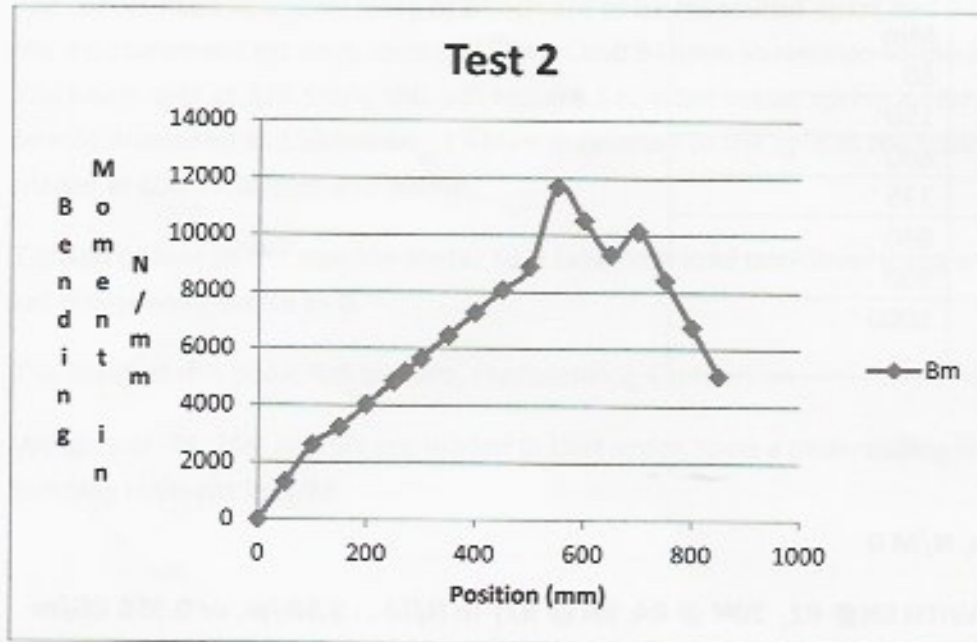


	L	A	B	WT1 (N)	P1	WT2 (N)	P2	WT3 (N)	P3	BEFORE (N)	AFTER (N)
TEST1	1000	150	840	5	80	20	600	5	900	0	350

Theoretical B_m at equilibrium, N/M 0

B_m at point R3, (WITH $10N @ R2$, $40N @ R4$, $10N @ R7$) in N/M , : $6.9/m$, 0.703 KG/m

Gathered data was inserted into excel format to represent bending moment diagram,



TEST2	1000	150	840	10	80	40	600	10	900	0	688
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Errors

Human error was an issue in that eyesight was required to make sure the work surface was level, the beam looked to be so but may not have been. The weights were measured with a rule; a more precise measurement using a veneer was likely a better solution for accuracy.

A newton metre was used to gauge the change in n/m by eyesight; this could be rectified by using an electronic gauge.

Conclusion

It is true that the more weight added to a simply support beam will increase the stress on the cross section of the beam, this has been demonstrated by $F_v=0$ to the reaction point at R3, even with human error it is still conclusive that the more weight added, the further the bending moment increases. A second test with the weights doubled produced similar results to the first test, showing that a beam with equilibrium will react in the same gradient if forces are applied evenly.

REFERENCES

Gere, J.M.; Timoshenko, S.P. (1996), *Mechanics of Materials: Forth edition*, Nelson Engineering, ISBN 0534934293

You could have used more references.

Task B

1. In the experiment in TASK 1, the first set of results were just under half of that of the second theoretical test with twice the weights in as far close to the same positions at point loads, the spring was set to zero again before each test to reduce % error, even with this, we ended up with: observed value = $7n/m$ > estimated true value according to spread sheets: $688N/m^*$

1.0174%

Giving an error of 1.74%, this being said including human error, it is likely very close to double the bending moment of the original test.

2. compute the average figure which expresses the comparison between the experiment and the theoretical bending moments (use either ratio or a percentage error).

The TASK 1 bending moment results when compared with the theoretical test results resulted with a 1.74% error. ✓

3. The theory in my lab report stated that the more weight added to a beam or cross section, the more likely the bending moment value will increase, this can be demonstrated theoretically by:

$$(R2 * X2) + (R4 * X3) + (R5 * X4) - (R6 * X6) \text{ Further: } MR, 3 = 0$$

Through this experiment, giving way to human error, the more weight added to the cross section of a simple beam will increase the bending moment of a ^{beam} moment, verifying the theory.