

LEVEL 4 ASSESSMENT SPECIFICATION

Student name:	Tom Westcott	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:	Nigel Evans
Assignment Title:	PRACTICALS I & II (SIMPLE HARMONIC MOTION AND BENDING MOMENT)	Word count (or equivalent):	
Submission deadline:	13/01/2020	Return date of provisional marks & written feedback:	21/01/2020
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 referenced your work, but you need to stick to academic sources and use Harvard Referencing style consistently in text.	25	13
2. Knowledge and Understanding Skills		
You have used appropriate equations to analyse your results and presented your findings in a logical manner.	30	20
3. Cognitive and Intellectual Skills		
You used graphs, tables and diagrams to explain your findings and also made some sound judgements from your findings and theoretical results.	15	11
4. Practical Application Skills		
You have identified applications of the SHM and Bending of Beams in the engineering sector and have also identified errors in your findings making sound recommendations.	25	18
5. Transferable Skills for Life and Professional Practice		
Demonstrates very good skills for employment requiring the exercise of personal responsibility and decision-making.	5	3

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)		65%
	Up to 1 week late (40% Max)		
	Over 1 week late (0%)		

Simple Harmonic Motion Experiment

Report – Tom Westcott

Abstract:

We conducted a series of experiments on simple harmonic motion first using Hooke's law to calculate the spring constant by suspending a mass from a spring to determine the amount of extension. Then using the spring constant k to determine the period of oscillation of a spring in simple harmonic motion. We then conducted a second experiment on a simple pendulum to determine the effects of mass, length and release angle on the period of oscillation. The measurements were made using a mass suspended from a length of string, recording the period of 10 oscillations with a stopwatch to find an average. The period was found to be proportional to the length of string used but not proportional to the mass or the angle at release.

Introduction:

Simple harmonic motion is a repetitive motion back and forth through a position of equilibrium, the time for 1 complete oscillation is constant and is known as the period and the force on the object in motion is always towards the equilibrium position. (Encyclopædia Britannica, inc., 2019)

Many physical systems exhibit simple harmonic motion, including electrons in an A/C circuit and vibrating particles in a sound wave. We will be investigating it in the context of an oscillating spring and a swing pendulum.

In a spring we calculate the forces using Hooke's law which states that, for relatively small deformations of an object, the displacement or size of the deformation is directly proportional to the deforming force or load. (Encyclopædia Britannica, inc., 2017) or mathematically :

(1)

$$F = kx$$

Where F is the applied force, k is the spring constant and x is the change in length

By applying a force to a spring and measuring the resulting extension we can calculate the spring constant for a given spring.

(2)

$$T = 2\pi\sqrt{\frac{m}{k}}$$

Using equation (2) and the value of k we have previously calculated for our spring we can further calculate the theoretical period of oscillation T for any mass m .

In a second experiment we investigated simple harmonic motion in a simple pendulum.

Experiment 1 – Simple harmonic motion in a spring

Methodology:

Using a clamp stand and a clamp a spring was suspended, its length was determined using a meter rule. A weight was then suspended from the spring and its length was measured again. The initial length is then subtracted from the final length to give the extension. The process was then repeated with a series of masses and their results recorded in a spreadsheet.

Using the spreadsheet, the results were then graphed, the value of the spring constant k is calculated by working out the gradient of the graph.

Results:

Weight(N)	Original Length(mm)	Final Length (mm)	Extension(mm)
0	20	20	0
5	20	28	8
7	20	33	13
10	20	40	20
15	20	49	29

Figure (1)

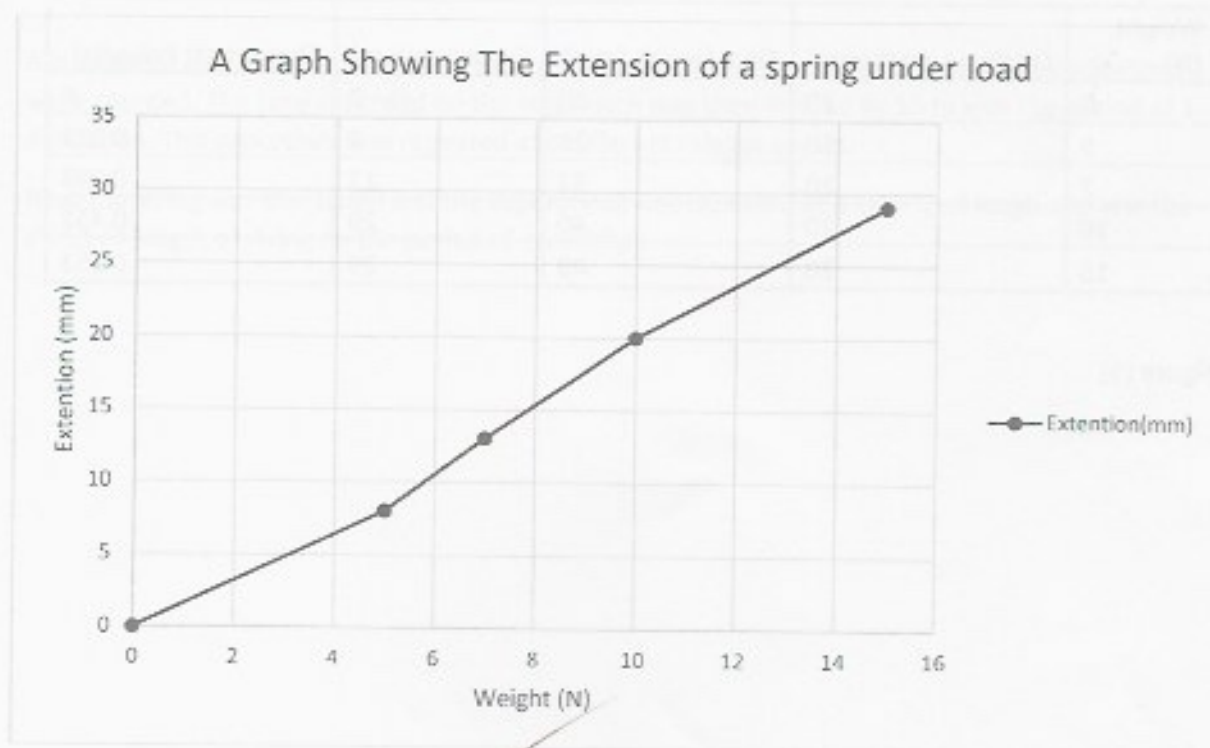


Figure (2)

To calculate the spring constant k it is necessary to find the gradient of the graph in figure (2):

$$k = \frac{\Delta F}{\Delta x}$$

$$k = 1933 \text{ N/mm} = 1933 \text{ N/m}$$

Now that we have calculated the spring constant for our given spring this can be used to calculate the theoretical period of oscillation T for the spring undergoing simple harmonic motion for each mass we tested using equation (2):

$$T = 2\pi \sqrt{\frac{m}{k}}$$

$$T = 2\pi \sqrt{\frac{5}{1933}}$$

$$T = 0.319 \text{ seconds}$$

Performing this calculation for all the masses tested gives the following table:

Weight (N)	Original Length(mm)	Final Length (mm)	Extension(mm)	Theoretical Period(s)
0	20	20	0	0
5	20	28	8	0.319
7	20	33	13	0.378
10	20	40	20	0.452
15	20	49	29	0.553

Figure (3)

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10	20	40	20	0.452
15	20	49	29	0.553

Figure (3)

Experiment 2 – Simple Pendulum

Methodology:

Using a clamp stand a mass was suspended from a length of string as shown in figure (4), starting at 50cm long, a mass of 100g was attached to the string and allowed to hang freely. Using a protractor, the mass was displaced by a given angle and then released to swing from the string.

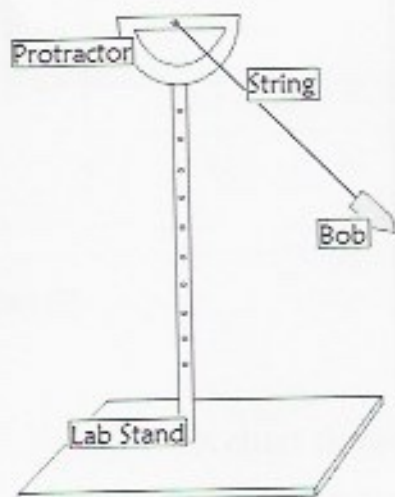


Figure (4) – Simple pendulum set up

A stopwatch was started at the same time as the mass was released and 10 complete oscillations were counted. The time recorded on the stopwatch was then divided by 10 to give the period of 1 oscillation. This procedure was repeated at 3 different release angles.

Next the string was shortened and the experiment was repeated at a variety of lengths to test the effect of length of string on the period of oscillation.

Results

Table of Results

Angle	Length (m)	Time for 10 Oscillations (s)	Period (s)
40	0.5	14.4	1.44
30	0.5	14.66	1.466
20	0.5	14.3	1.43
40	0.4	12.97	1.297
30	0.4	12.71	1.271
20	0.4	12.79	1.279
40	0.27	10.75	1.075
30	0.27	10.89	1.089
20	0.27	10.81	1.081
40	0.16	8.58	0.858
30	0.16	8.94	0.894
20	0.16	8.62	0.862
40	0.095	7.18	0.718
30	0.095	7.3	0.73
20	0.095	6.84	0.684

Figure (5)

From The results shown in figure (5) we can see that the angle at which the pendulum was released does not affect the period of oscillation so I will take an average of the 3 attempts at each length and plot a graph of average period against length.

Length (m)	Time for 10 Oscillations (s)	Period (s)	Average Period (s)
0.5	14.3	1.43	1.445333333
0.4	12.79	1.279	1.282333333
0.27	10.81	1.081	1.081666667
0.16	8.62	0.862	0.871333333
0.095	6.84	0.684	0.710666667

Figure (6)

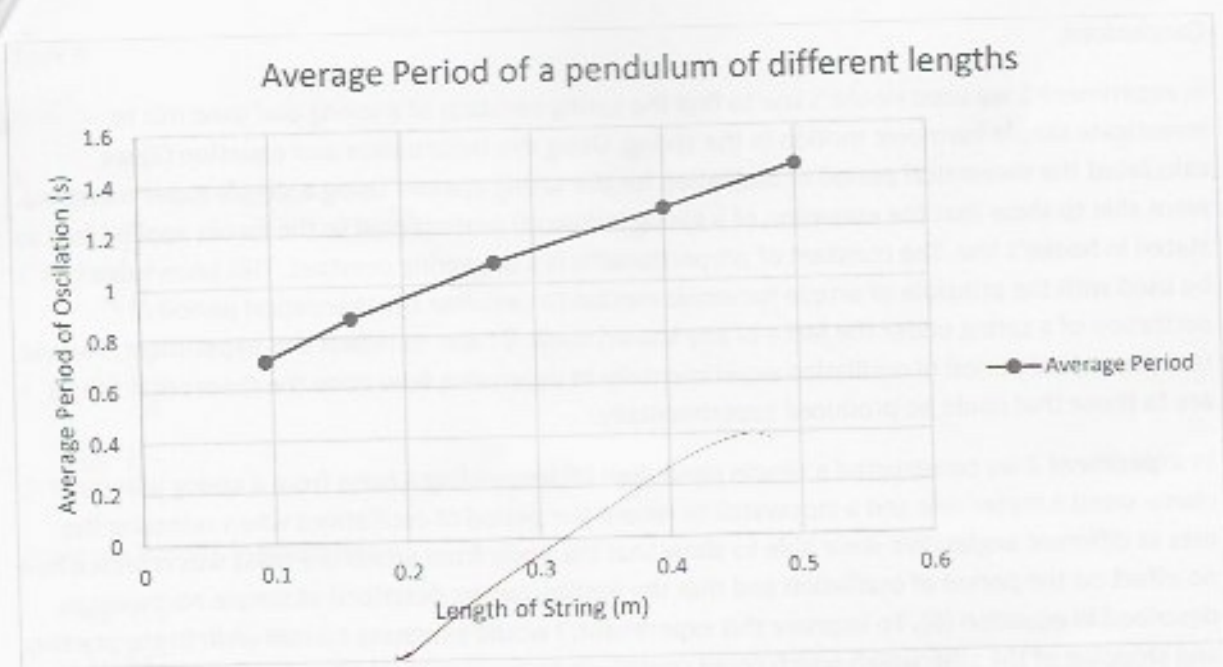


Figure (7)

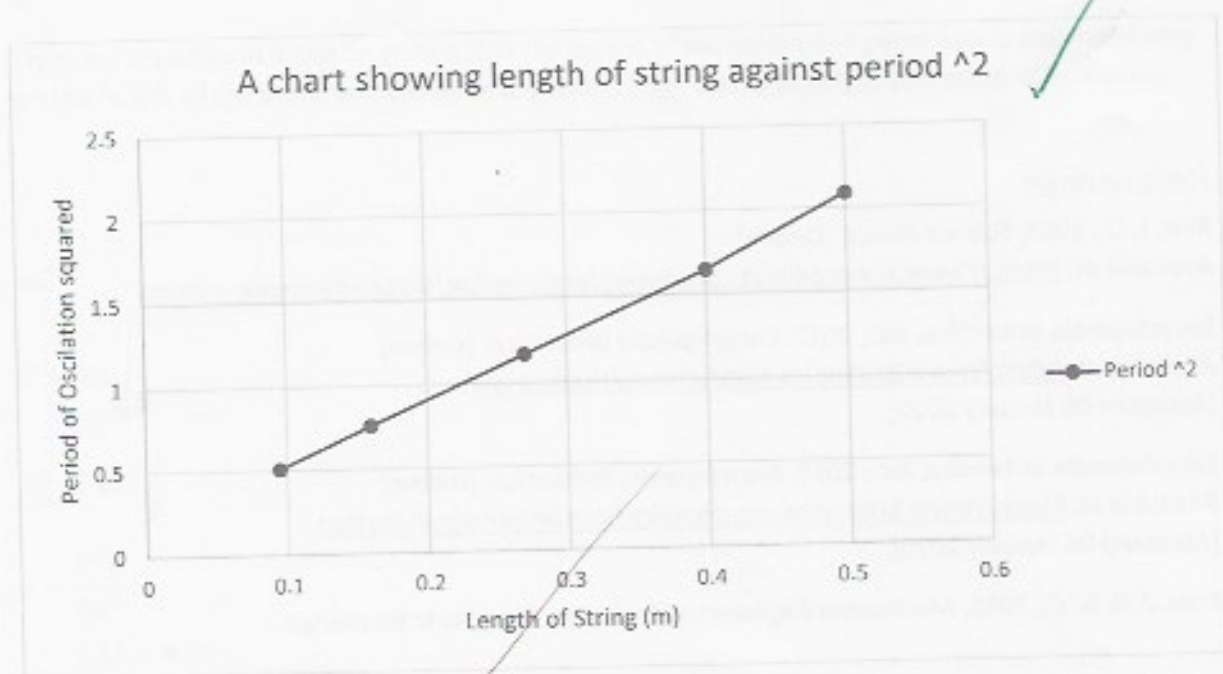


Figure (8)

Conclusions:

In experiment 1 we used Hooke's law to find the spring constant of a spring and used this to investigate simple harmonic motion in the spring. Using this information and equation (2) we calculated the theoretical period of oscillation for the spring system. Using a simple experiment, we were able to show that the extension of a spring is directly proportional to the forces applied to it as stated in Hooke's law. The constant of proportionality is k the spring constant. This knowledge can be used with the principle of simple harmonic motion to calculate the theoretical period of oscillation of a spring under the force of any known mass. If I was to repeat this experiment, I would test theoretical period of oscillation experimentally to determine how close the theoretical values are to those that could be produced experimentally.

In experiment 2 we constructed a simple pendulum by suspending a mass from a spring using a clamp stand a meter rule and a stopwatch to record the period of oscillations when releasing the mass at different angles. We were able to show that the angle from which the mass was released had no effect on the period of oscillation and that the motion can be described as simple harmonic as described in equation (6). To improve this experiment, I would eliminate human error in the starting and stopping of the stop watch which could contribute to inaccuracies in the results. This could be achieved by using a photogate and software to record the time much more accurately.

References

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Ross, J. B. & C., 2015. *Mechanical Engineering Principles*. New York: Routledge.

Task B

i.

$$T = 2\pi \sqrt{\frac{l}{g}}$$

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

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

From my Results in figure (6):

$$g = \frac{4\pi^2 0.4}{1.282^2} = 9.61 \text{ ms}^{-2}$$

ii.

From my experiment it can be shown that the period of oscillation of a pendulum is depended only on the length of the string and the force of gravity. Mass does not effect the period of oscillation.

iii.

$$T = 2\pi \sqrt{\frac{l}{g}}$$

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

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

$$l = \frac{1.5^2 \times 9.81}{4\pi^2} = 0.559 \text{ m}$$

iv.

using the items provided you could set up an experiment similar to the one we have carried out in experiment 2. Recording the length of string used and the time for 1 oscillation and using the equation $g = \frac{4\pi^2 l}{T^2}$ the acceleration due to gravity on the moon could be calculated.

v.

Comparing T^2 against l gives a graph shown above in figure (8). The graph shows a straight line with the equation:

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

Comparing this to the equation of a straight line $y = mx + c$ where m is the gradient and c is a constant it can be seen that in the case of a simple pendulum $m = \frac{4\pi^2}{g}$ and $c=0$

Bending Moments in a Beam Experiment

Report – Tom Westcott

Abstract:

We conducted an experiment on a simple supported beam to determine the stresses within the beam at various points along its length under the action of concentrated loads. The Experiment was repeated with various loads to test the hypothesis that with increasing loads shear stress and bending moments will also increase.

Introduction:

A bending moment M is defined as a turning effect of a force acting at a perpendicular distance from a point on a beam.

(1)

$$M = F \times d$$

Where M is the Moment, F the force and d is the distance

'The Shear Force at any section of a beam represents the tendency for that portion of the beam on one side of the section to slide or shear laterally relative to the other portion.' (Bolton, 2006)

Forces on a beam are caused by any loads on the beam and also by the supports of the beam. This is an important element in the design of beams for structural engineering as bending moments and shear forces can cause failures in structures, therefore a structural element such as a beam must be designed with bending moments and shear forces in mind to prevent failures.

For a beam to be in equilibrium the sum of the clockwise moments must equal the sum of the anticlockwise moments:

(2)

$$\sum \text{Clockwise moments} = \sum \text{Anticlockwise moments}$$

By convention we say that clockwise moments are positive and anticlockwise moments are negative.

From Newtons third law we know that for every action there is an equal and opposite reaction. From this we can see that applying a load to a beam causes an equal and opposite force to act on the beam from the supports. For example:

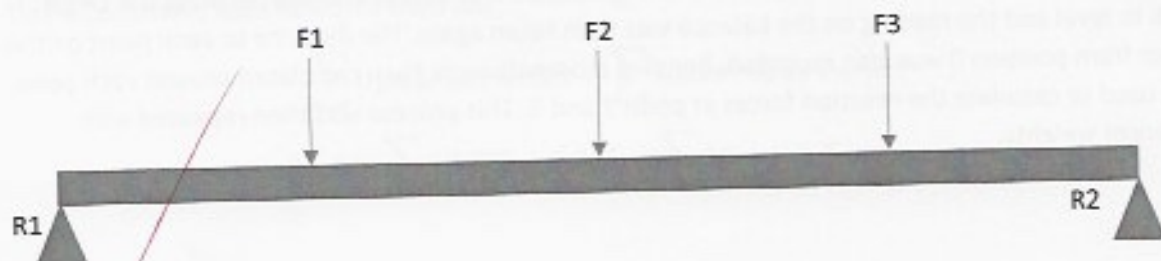


Figure (1)

Applying Newtons third law to figure (1) gives:

(3)

$$F_1 + F_2 + F_3 = R_1 + R_2$$

Where F_1 , F_2 , F_3 are forces caused by loads on the beam and R_1 and R_2 are the reactions caused by the supports on the beam.

In our experiment we will use the principles above to calculate the bending moments and forces acting on our beam at each point along its length.

Methodology:

A Beam was set up as shown in figure (2) on a level work bench, the beam is split into 2 section which are connected by a spring balance. The beam was placed on 2 supports at positions 2 and 5 and the spring balance adjusted by tightening a nut so that the beam was level, this was checked with a spirit level and the reading on the spring balance was taken.

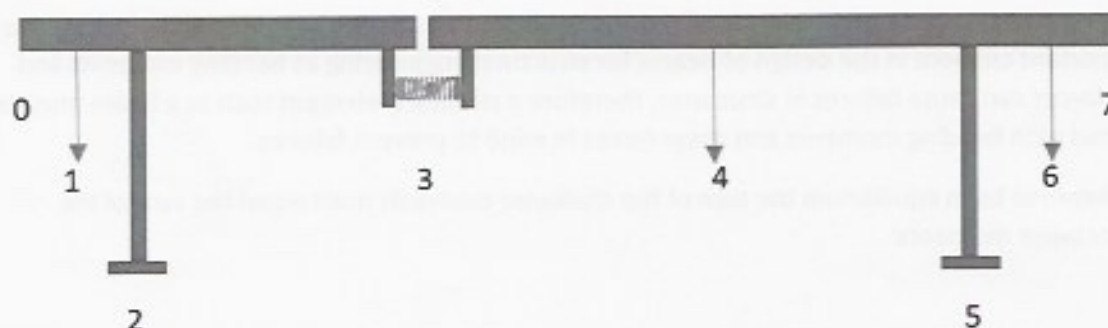


Figure (2)

Next 3 weights were suspended from the beam at positions 1,4,6 and the distance of each from the end of the beam, position 0, were measured using a meter rule. The force exerted on the beam by the weights caused the beam to sag, so the spring balance was tightened again to bring the beam back to level and the reading on the balance was then taken again. The distance to each point on the beam from position 0 was also recorded. Bending moments were then calculated around each point and used to calculate the reaction forces at point 2 and 5. This process was then repeated with different weights.

My Experiment was set up as shown in figure(2) with the dimensions as shown in figure (3)

Position	Distance from 0 (mm)	Load (N)
0	0	0
1	48	5
2	130	R ₂
3	330	0
4	557	10
5	793	R ₅
6	947	5
7	1000	0

Figure (3)

Calculations:

To work out the reaction caused by the supports I will use equations (1) and (2) to take moments about point 2:

$$\begin{aligned}
 \sum \text{Clockwise moments} &= \sum \text{Anticlockwise moments} \\
 10 \times (577 - 130) + 5 \times (947 - 130) &= 5 \times (130 - 48) + R_5 \times (793 - 130) \\
 4470 + 4085 &= 410 + 663R_5 \\
 663R_5 &= 8145 \\
 R_5 &= 12.285N
 \end{aligned}$$

And taking moments about point 5:

$$\begin{aligned}
 \sum \text{Clockwise moments} &= \sum \text{Anticlockwise moments} \\
 R_2 \times (793 - 130) + 5 \times (947 - 793) &= 5 \times (793 - 48) + 10 \times (793 - 577) \\
 663R_2 + 770 &= 3725 + 2160 \\
 663R_2 &= 5115 \\
 R_2 &= 7.715N
 \end{aligned}$$

This is consistent with Newton's third law:

$$\begin{aligned}
 \sum \text{Upwards Forces} &= \sum \text{Downwards Forces} \\
 \sum 12.285 + 7.715 &= \sum 10 + 5 + 5
 \end{aligned}$$

Theoretical Bending moments at point 3:

$$\text{Bending moment} = Wa \cdot \frac{L-a}{L}$$

Where W is the reading on the spring, L the length between the supports 2 and 5, and a is distance from 2 to 3.

So bending moment at point 3 is:

$$\text{Bending Moment} = 3 \times 200 \left(\frac{663 - 200}{663} \right)$$

$$\text{Bending Moment} = 419.0 \text{ Nmm} = 0.419 \text{ Nm}$$

Practical Bending moment at point 3 using Equation (1):

$$M = F \times D$$

$$M = 3 \times 0.15$$

$$M = 0.45 \text{ Nm}$$

Starting from position 0 on the left of the beam and using the convention that upwards shear forces are positive I calculated the shear forces at each point along the beam.

Position	Distance from 0 (mm)	Load (N)	Shear Force (N)
0	0	0	0
1	48	-5	-5
2	130	7.715	2.715
3	330	0	2.715
4	577	-10	-7.285
5	793	12.285	5
6	947	-5	0
7	1000	0	0

Figure (4)

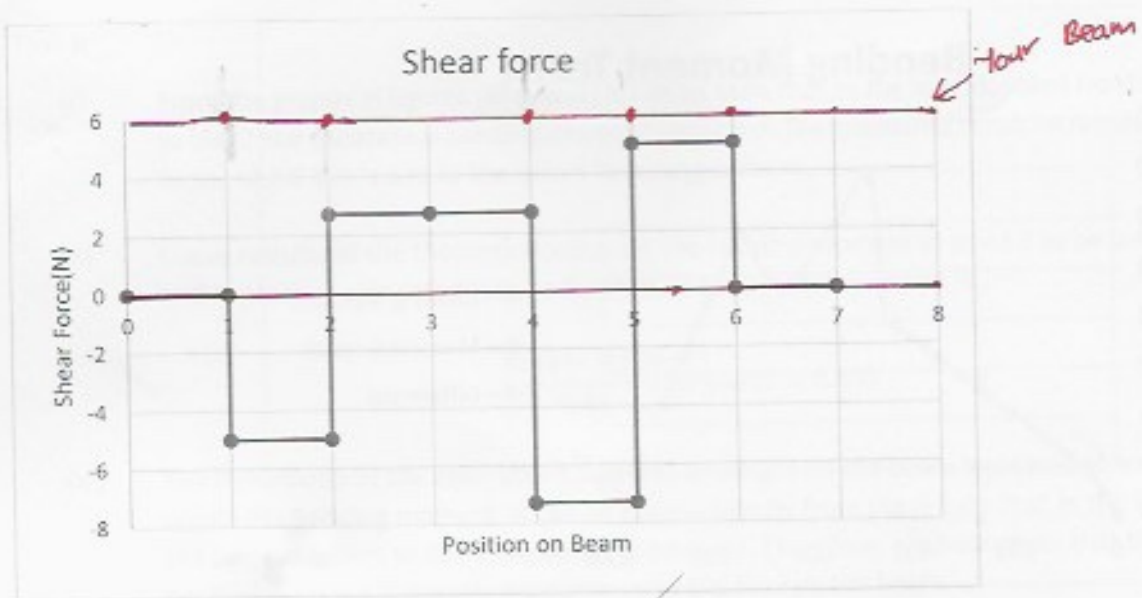


Figure (5)

Bending moments

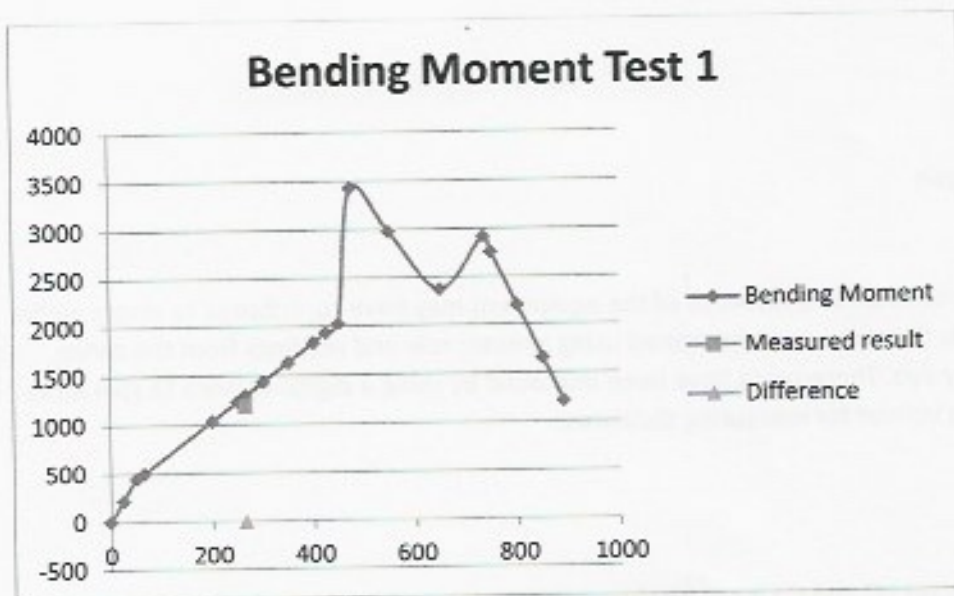


Figure (6)

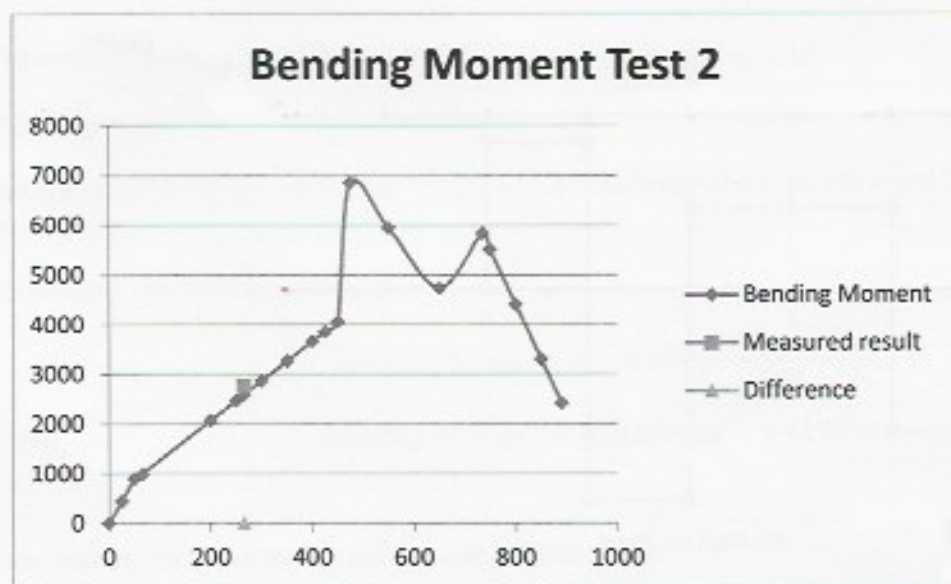


Figure (7)

Set up	L	A	D	WT1 (N)	P1	WT2 (N)	P2	WT3 (N)	P3	BEFORE (N)	AFTER (N)
TEST1	1000	130	793	5	48	10	605	5	947	1.5	3
TEST2	1000	130	793	10	48	20	605	10	947	1.2	4.7

Figure (8)

Conclusions and analysis

Errors

Errors in measurements down to limitations of the equipment may have contributed to errors within my results for example distances were measured using a meter rule and readings from the spring balance were taken by eye. These could have been improved by using a digital balance to give more accurate readings or a vernier for measuring distances.

Conclusions

From the graphs in figures (6) and (7) it can be shown that by increasing the load on the beam does indeed increase the maximum bending moment within the beam, from a maximum moment of 3307.5N/mm in test 1 to a maximum of 6615N/mm in test 2. Also shown in the graph is the theoretical bending moment and the measured result and it can be seen that the difference is within the margin of error.

Task B

- (i) From the graphs in figures (6) and (7) it can be seen that as the load doubled from test 1 to test 2 the theoretical bending moments doubled. The measured result increased by a factor of 2.3 this is due to the errors in my experiment.
- (ii) I have calculated the theoretical value for the bending moment at point 3 to be 0.419Nm and in practice calculated it to be 0.45Nm so the percentage error is:

$$\frac{0.45 - 0.419}{0.45} \times 100\% = 6.8\%$$

- (iii) The Hypothesis of the experiment was that as weight on the beam increased so too would the bending moment. It can be shown directly from the results that as the load on the beam doubled so to do the bending moment. Therefore, I can conclude that the bending moment is directly proportional to the load on the beam.

References

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Budynas, R. G., 2015. *Shigley's Mechanical Engineering Design*. New York: McGraw-Hill Education.