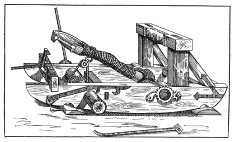


NAME:____Prachi Singhroha__ Roll No:_101903545   Group:2CO21

This submission is original work and no part is plagiarized (Prachi) _______________(Date)___________

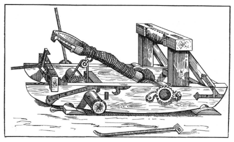
THAPAR INSTITUTE
OF ENGINEERING & TECHNOLOGY
(Deemed to be University)

MECHANICAL ENGINEERING DEPARTMENT

Thapar Institute of Engineering and Technology, Patiala

ASSIGNMENT - 3.
DESIGN AGAINST FAILURE UNDER *STATIC* ACTIONS

UTA013 Engineering Design Project-I



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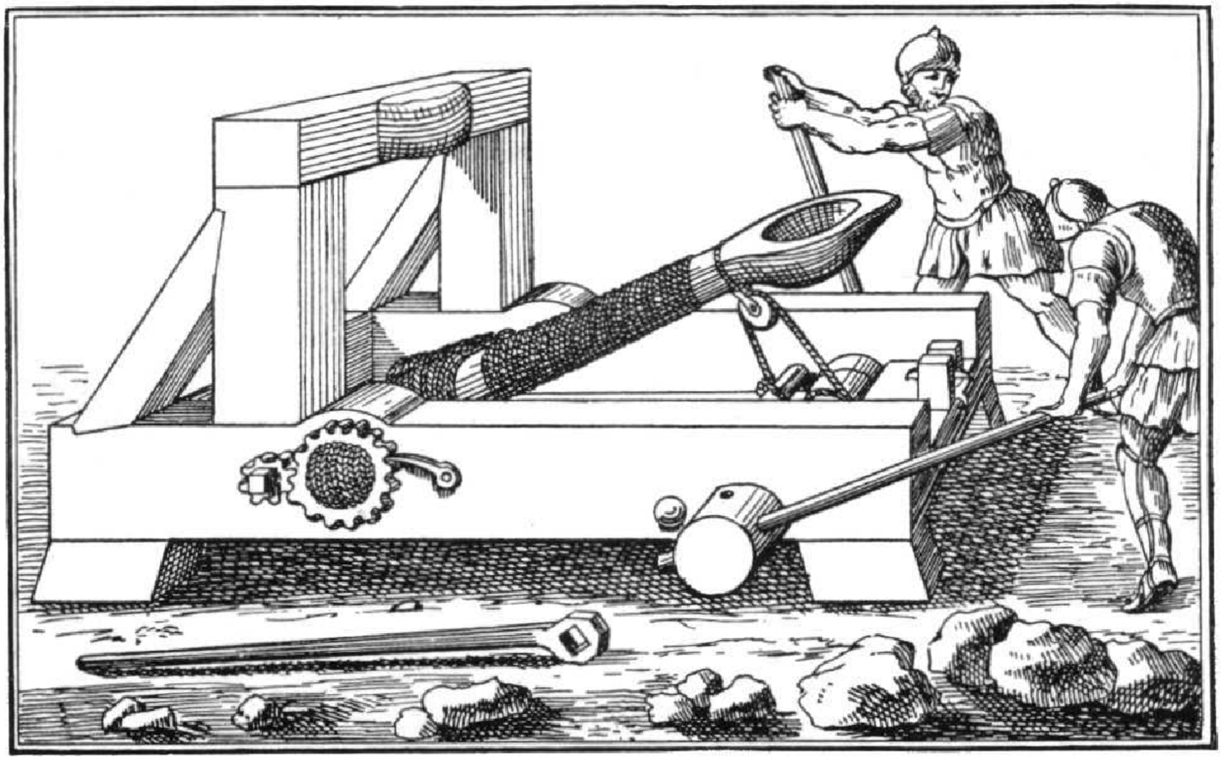

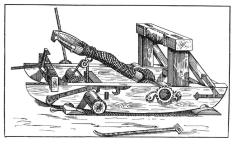

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ASSIGNMENT - 3.

STRUCTURAL ENGINEERING COMPONENT
DESIGN AGAINST FAILURE UNDER *STATIC* ACTIONS

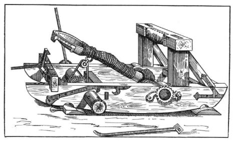
The following tasks have been based on the lecture by Mr. Kishore Khanna on designing against structural Failure under static loads. Complete the following **individually, copying will be dealt with severely.**

Notes:

1. Excel spreadsheets graphs to be created for Q1, Q2 and Q3 and evaluated by end of 2 hour class.
2. The print of this word document with **graphs (with Name and Roll No in text box)** and **hand written conclusion, name and roll number on every page**, stapled together, is to be submitted in next Tutorial class (if it is a holiday, then as instructed).
3. Do not leave this assignment until the last minute to find you have some IT issue.

   Despite this list, try and enjoy the assignment and try to think around the subject as much as possible and take from it any tips that you might use with your own Catapult.

Marking Scheme:Assignment 3 (10 Marks) =10%
Evaluation at end of 2 Hours Tutorial: 5
Evaluation from printout submission:5



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TUTORIAL CLASS EVALUATION Q1-Q3. **[5 Marks]**

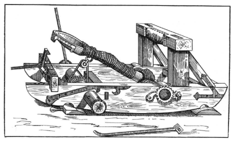
Q1 From experiments, you measured experimentally the bending stress at failure of a timber beam (**Calculate in Excel sheet the Average Stress at failure for the experiments**). (**Evaluated on laptop, use format below**)

	Measured				**Calculated**				
Exp	Span	Width	Depth	Failure load	Failure Force	M=PL/4	y=d/2	I=bd^3/12	Strength σ
No	L mm	b mm	d mm	mass Kg	P N	Nmm	mm	mm^4	MPa(N/mm^2)
1	300	9.65	4.88	6.30	61.781895	4633.642	2.44	93.45564	120.9781061
2	300	9.80	5.26	5.35	52.4655775	3934.918	2.63	118.8508	87.07418282
3	300	9.70	5.30	5.50	53.936575	4045.243	2.65	120.3422	89.07839951
4	300	10.00	5.10	4.25	41.6782625	3125.87	2.55	110.5425	72.10772059
5	300	9.99	5.06	4.70	46.091255	3456.844	2.53	107.8539	81.08948186
6	300	9.99	5.06	6.70	65.704555	4927.842	2.53	107.8539	115.5956443
Av	300	9.855	5.11	5.47	53.60968667	4020.727	2.555	109.8165	94.32058921

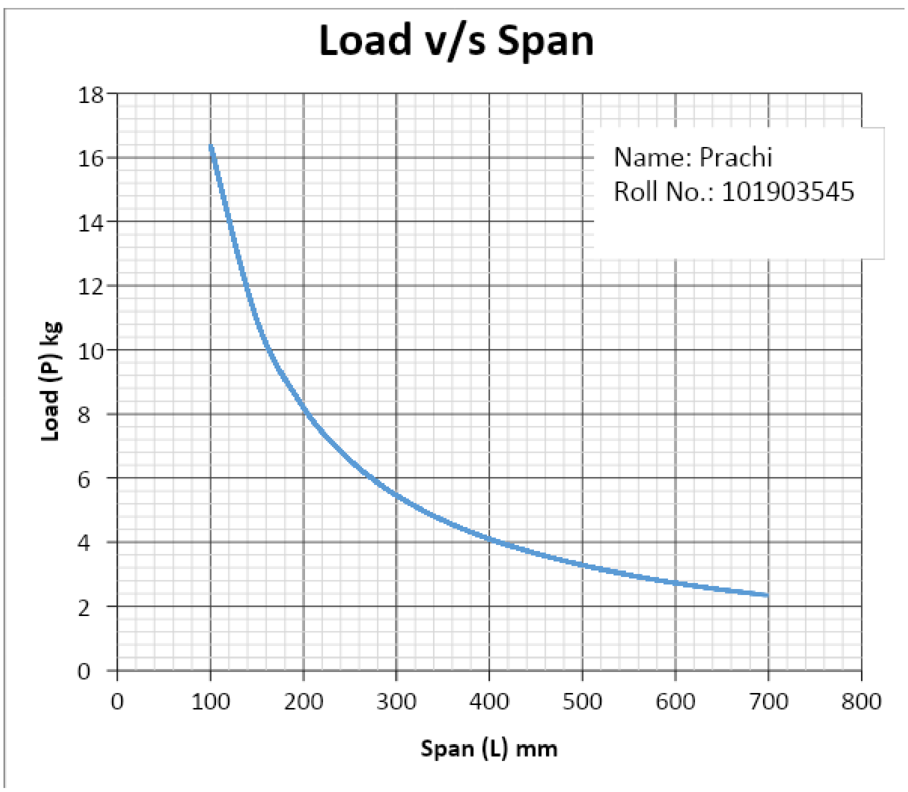
Q2 Using the average strength of wood from Q1 calculate the theoretical variation in failure load, P, when the span of the beam is varied over the range from 100-700mm, for the same dimensions inQ1, and **draw a plot** of the relationship. (**Evaluated on laptop**)

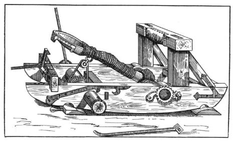
(Insert the **Excel graph in format given below**).

L mm	P (N)	P (kg)
100	160.8291	16.4
150	107.2194	10.93333
200	80.41454	8.200001
250	64.33163	6.560001
300	53.60969	5.466667



	45.9511	4.68571
350	7	5
	40.2072	4.10000
400	7	1
		3.64444
450	35.7398	5
	32.1658	
500	2	3.28
	29.2416	2.98181
550	5	9
	26.8048	2.73333
600	5	4
	24.7429	2.52307
650	4	7
	22.9755	2.34285
700	8	7





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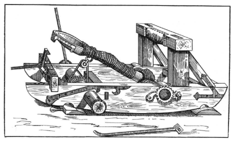
Q3 Using the average strength of wood from Q1 calculate the theoretical variation in failure load, P, when the cross sectional dimensions of the beam are varied over the range from square of 4-10 mm (for the same span as was used in Q1 and **draw a plot** of the relationship(**<u>Evaluated on laptop</u>**)

(Insert the **Excel graph in format given below**).

b=d	P(N)	P(kg)
4	13.41448	1.367897
4.5	19.09992	1.94765
5	26.20016	2.671673
5.5	34.87242	3.555997
6	45.27388	4.616651
6.5	57.56176	5.869666
7	71.89325	7.331071
7.5	88.42555	9.016897
8	107.3159	10.94317
8.5	128.7214	13.12593
9	152.7994	15.5812
9.5	179.7069	18.32501
10	209.6013	21.37339



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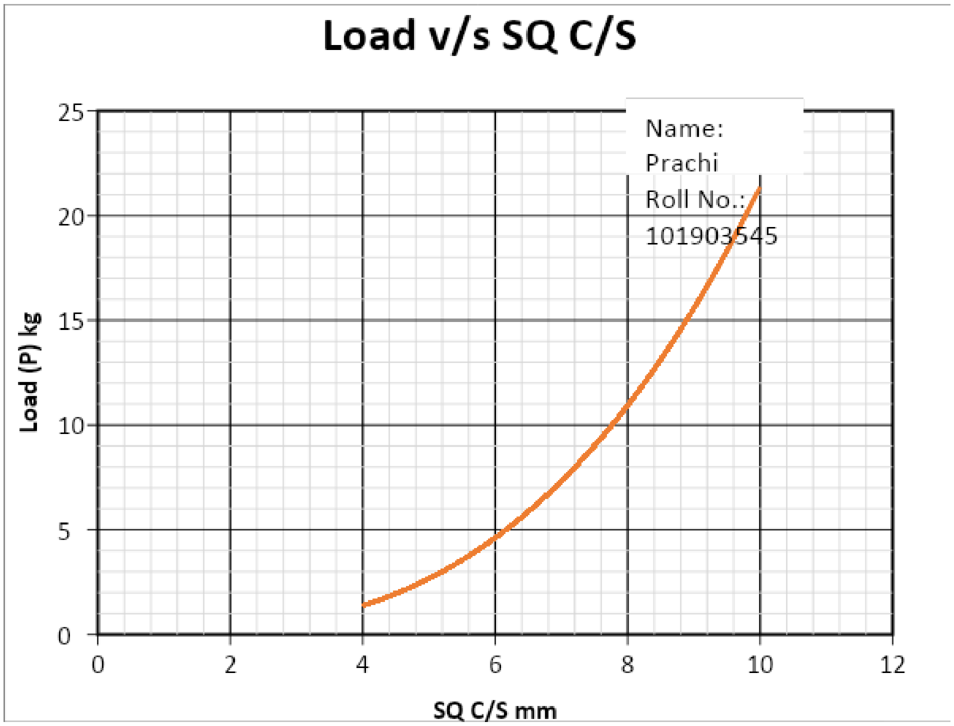

Q4 For Q1. Assuming the square cross section of 6mm and a span of L=200 mm calculate **theoretically** the failure stress (strength) for a simply supported beam which fails due to a 5kg weight. _______________________________.

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Q4 $A = 6 \times 6 = 36\ mm^2$

$D = 6\ mm$ $\quad y = 3\ mm$

$L = 200\ mm$

Failure load = 5 kg

$P = 5 \times 9.81 = 49.05\ N$

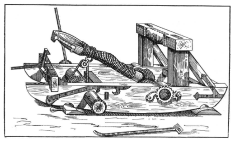
$M = \frac{PL}{4} = \frac{9810}{4} = 2452.5\ Nmm$

$I = \frac{D^4}{12} = \frac{6 \times 6 \times 6 \times 6}{12}$

$= 108\ mm^4$

$\sigma = \frac{My}{I} = \frac{2452.5 \times 3}{108}$

$= 68.125\ N/mm^2$



Q5 A second beam of dimensions 9x9 mm and span L=500 mm was tested and found to fail at 7kg. Theoretically, what value should it have failed at? Explain any discrepancy in your result if there is one. What do you learn from this?

Q5 $A = 9 \times 9 = 81\ mm^2$

$D = 9\ mm$ $L = 500\ mm$

$y = 4.5\ mm$ $\sigma = 95.06\ N/mm^2$

Faliure Load = 7 kg

$I = \frac{D^4}{12} = \frac{9^4}{12} \approx 92.39\ N$

Practical Faliure Load $= \frac{P}{9.81}$

$= 9.42\ kg$

We learnt that theoritical value should not be used straight away.

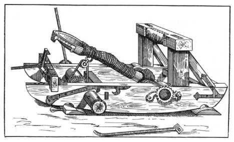
Q6 What do you observe from the plot of Q2?

Q6 With increase in span load the bearing capacity of simply supported beams decreases.

Q7 What do you observe from the plot of Q3?

Q7 Bearing capacity of beam decreases with increase in cross section.

Q8 **Now let us address the Catapult.** Assume the length of the throwing arm of the Catapult is 240 mm from the axis of rotation to the D-ring. Select the optimum diameter and so that the arm does not fail in bending under static loading. The worst case of static loading is when the arm is fully pulled back and ready to release. You should use a peak static force of 120N in your



calculation. Note! The end conditions of the arm are different to those in class experiments, i.e. it is not simply supported! Refer to notes handout to determine which equation is appropriate for this cantilevered condition. Is the diameter of the throwing arm of 28 mm adequate? Comment.

Q8

$L = 240\ mm$ $\quad \sigma = 99.32\ N/mm^2$

$P = 120N$ $\quad I = \pi d^4/64$

$$\sigma = \frac{My}{I} = \frac{32PL}{\pi d^3}$$

$$d = \sqrt[3]{\frac{32PL}{\sigma \pi}}$$

$$= \sqrt[3]{\frac{32 \times 120 \times 240}{\pi \times 95.06}}$$

$$= 14.56\ mm.$$

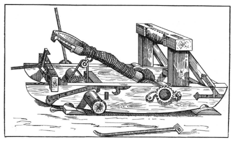
Q9

For the conditions in Q8:

a. Can the nylon cable holding the main arm in place, when cocked, resist the force without breaking?What is the FOS? You may assume that the axial failure stress of the cable is 65MPa (i.e. N/mm^2) and that the cable has a circular cross section of diameter 2.4mm.

---

b. The other end of the cable is attached to a timber dowel 20.5 mm diameter which is held in double shear by the base of the Catapult. Design the minimum diameter of dowel that is required to resist this force without it failing in shear. You may assume the shear stress capacity of the dowel is 15MPa. What is the FOS of the dowel of your Catapult?



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Q9. Axial failure stress = 65 NPa
d = 2.4 mm
Shear stress = $\frac{\text{force}}{\text{area}}$
Failure load = 120 W

$\sigma' = \frac{P}{\pi d^4} = \frac{120 \times 4}{3.14 \times 2.4 \times 2.4}$

$\sigma' = 26.54\ N/mm^2$

$FUS = \frac{65}{26.54} = 2.449$

Yes.

Q10 Using the library and /or the internet for referencing, compare the strength of timber in bending with a variety of other available materials. Produce a table of the relevant properties and comment on their suitability for use as the main arm in a Catapult. You will use this information as well as the analysis techniques above to help you redesign/optimise the throwing arm.

Sr No	Material	Strength in Bending	Comment
1.	Plastic		
2.	Acrylic		
3.	Glass		
4.	Aluminium		
5.	Stainless Steel		

Note!! The end conditions are different in Q1-Q7 (simply supported) from that of the Catapult (cantilever) in Q8 onwards. The equation for the bending stress will therefore be different!

Q10

Sr. No.	Material	strength in Bending	Comment
1	Plastic	80 MPa	Not suitable.
2.	Acrylic	69 MPa	Not suitable
3.	Glass	71 MPa	Can be easily broken
4.	Aluminium	150 MPa	Can be used due to higher strength.
5.	Stainless steel	210 MPa	Totally Appropriate