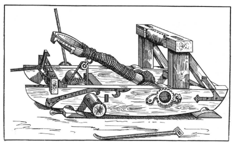


NAME: Prachi Singhroha Roll No: 101903545 Group: 2CO21

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

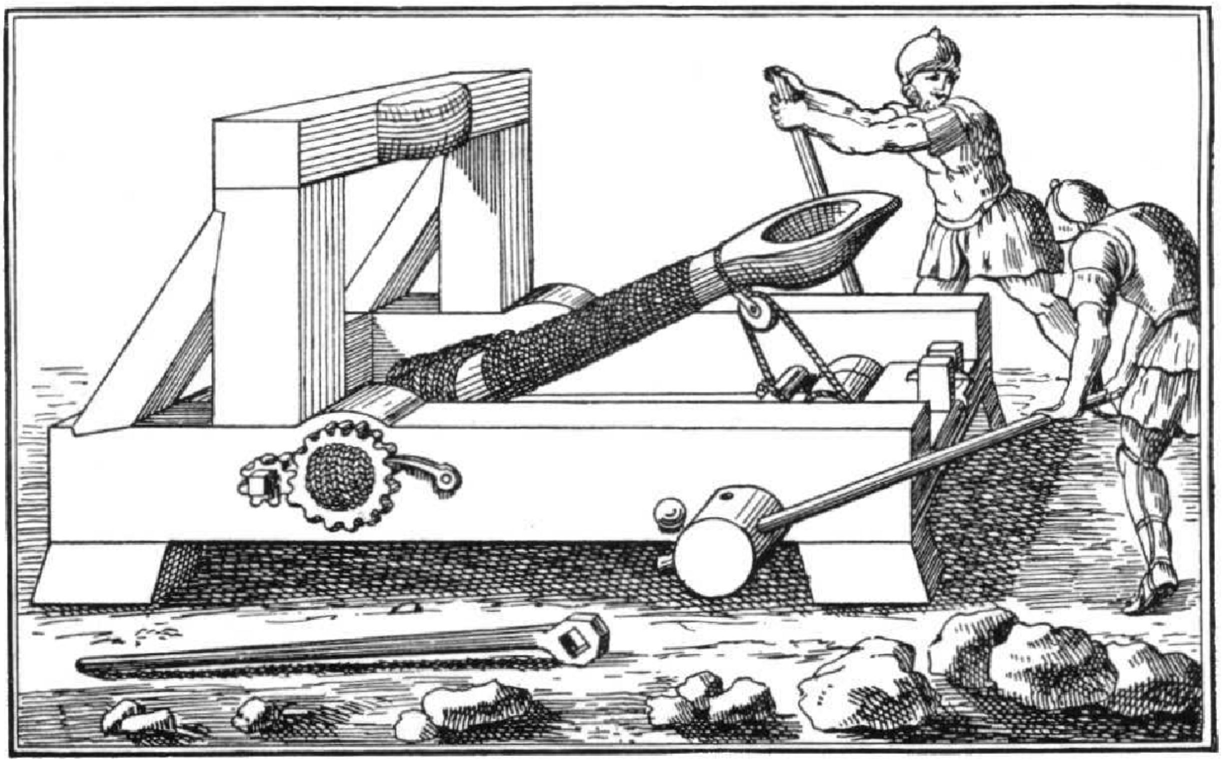
THAPAR INSTITUTE
OF ENGINEERING & TECHNOLOGY
(Deemed to be University)

MECHANICAL ENGINEERING DEPARTMENT

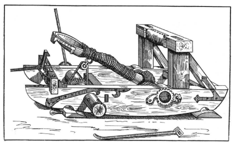
Thapar Institute of Engineering and Technology, Patiala

ASSIGNMENT - 4.
DESIGN AGAINST FAILURE UNDER DYNAMIC ACTIONS

UTA013 Engineering Design Project-I



(Reference: Roger P West, TCD course 1E13)



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ASSIGNMENT - 4.

STRUCTURAL ENGINEERING COMPONENT

DESIGN AGAINST FAILURE UNDER *DYNAMIC* ACTIONS

The following tasks have been based on the lecture by Dr. T K Bera on designing against structural failure under *dynamic* loads. Complete the following **individually, copying will be dealt with severely.**

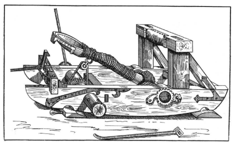
Notes:

1. Excel spreadsheet to be created for Q1, Q2 (a) 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). Submit your documents on time. No extensions will be granted.

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.

When you have built your own mangonel, with your own choice of rotating arm, L2 part (ie spoon: material, diameter and length) and having measured the rotational velocity on impact using the electronic component of this project, then the procedures in Assignments 3 and 4 should allow you to make a reasonable prediction as to whether your chosen arm is likely to fail statically when fully loaded or dynamically when the missile is released. It would clearly be desirable to avoid an unexpected structural failure of any part during the competition!

Marking Scheme:Assignment 4 (10Marks) =10%
Evaluation at end of 2 Hours Tutorial: 5 Marks
Evaluation from printout submission:5 Marks



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<u>TUTORIAL CLASS EVALUATION</u> Q1-Q3.
[5 Marks]

Q1. A dowel of 0.006mdiameter (d), a beam span of 0.3m, fails at a static failure load of 47N. Calculate the static failure stressin Excel sheet.

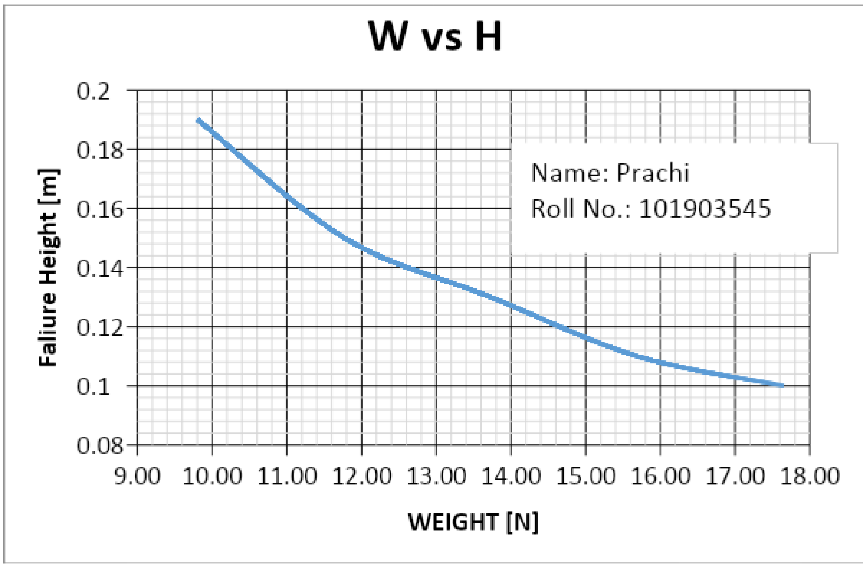
(Evaluated at the end of the Tutorial class)

Measured			Calculated			Actual strength
Span	Dia	Failure Force	M=PL/4	y=d/2	I=πd^4/64	σ=y*M/I
L mm	d mm	P N	Nmm	mm	mm^4	MPa(N/mm^2)
300.00	6.00	47.00	3525.00	3.00	63.62	166.23

Q2. (a) A series of dynamic tests were performed where weights of different magnitude were dropped onto the dowel span from different heights. The following table was produced;

Weight (N)	Height Failure (m)	Strike Velocity m/s
9.81	0.19	1.93
11.77	0.15	1.72
13.73	0.13	1.60
15.69	0.11	1.47
17.65	0.10	1.40

Insert a plot of weight against drop height to failure for the impact experiment.

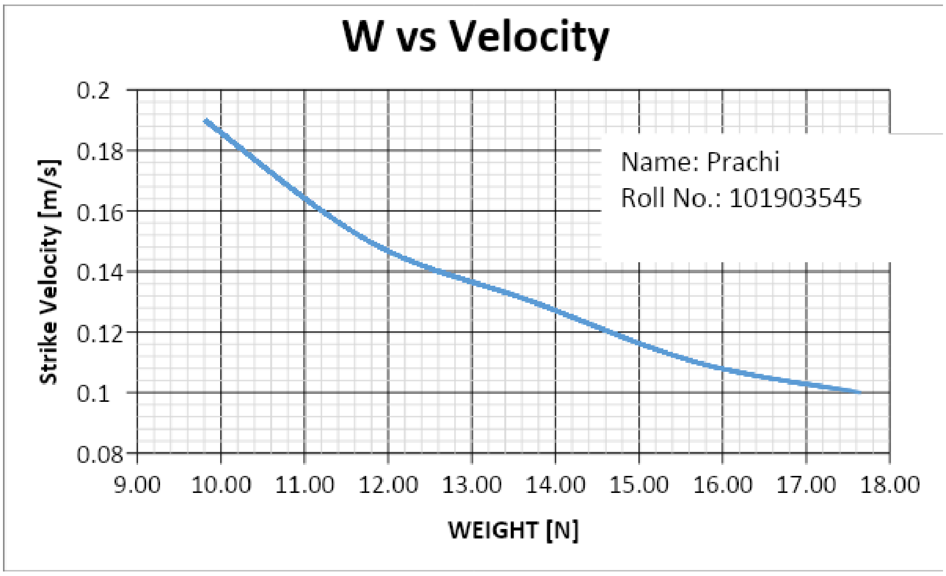


(Table and Plot Evaluated at the end of the Tutorial class)

(b) Comment on the shape of the plot and the magnitude of the values to failure when compared to the static failure load.

Q2) b) With the increase in loads and decrease in height, the graph shows linear decrement. This implies the fact that when the force or load reaches a particular height upon constant increment it leads to breaking of wooden static.

Q3. (a) From the tabulated the theoretical velocity on impact for the masses dropped from their respective heights from Q2 produce a plot.



(Plot Evaluated at the end of the Tutorial class)

(b) Comment on this plot in comparison with the plot in Q2 above.

Q3) b) Both the graphs show decrement upon increase in load and decrease in both height and velocity but the shape of graph is different because V is directly porportional to $\sqrt{H}$

Q4. Using *Scenario 4: Case 1* from the lecture 3 and 4supplementary notes, assuming a Dynamic Magnification Factor of 2, calculate the approximate maximum dynamic force that might be applied to the beam of Q1 inducing a stress equal to the static failure stress.

Q4) DMf = 2

$F_\sigma = 47$ N

$DMF = \frac{F_d}{F_\sigma}$

$\Rightarrow F_d = DMF \times F_\sigma$

$= 47 \times 2$

$= 94$ N

Q5. Using *Scenario 4: Case 2* in the lecture 3 and 4supplementary notes, calculate the mass density, γ, (in units of kg/m^3) of the timber dowel beam, the mass per unit length, **m**., (in kg/m) and the load per unit length, ω, (in N/m). The mass of the dowel was measured to be m=4.7g, 6mm diameter and the total length equal to L=0.3m

[3]

NAME: Prachi Singhroha Roll No: 101903545 Group: 2CO21

PAGE No

Q5 $m = 4.7\,g$ $L = 0.3\,m.$

$d = 6\,mm$

$$\text{mass density} = \frac{m}{\frac{\pi d^2}{4} \times l}$$

$$= \frac{4.7 \times 10^{-3} \times 4}{\pi (6 \times 10^{-3})^2 \times 0.3}$$

$$= \frac{18.8 \times 10^{-3}}{0.3 \times \pi \times 36}$$

$$= 554.09\,kg/m^3$$

$$\text{mass per unit length} = \frac{4.7 \times 10^{-3}\,kg}{0.3}$$

$$= 15.67 \times 10^{-3}\,kg/m$$

$$\text{load / unit length} = 0.0156 \times 9.81$$

$$= 0.1537\,N/m$$

Q6. Using this value for **m**, and selecting an overhang for the arm of 0.2m (see Figure 3(b) in the lecture notes and slide 7 of lecture), calculate the theoretical deflection of this cantilever of length L_2, 6mm diameter, under a static point load equivalent to its own weight when in fully cocked state of the Mangonel arm. The value of the Young's modulus of elasticity, E, can be assumed from the lecture notes.

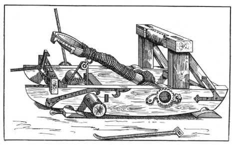
Q6) $$\delta_b = \frac{P \times l^2}{3 \times E \times I} = \frac{mg \times L \times L^3}{3 \times E \times I}$$

$$\text{where } I = \frac{\pi d^4}{64} = \frac{\pi (6 \times 10^{-3})^4}{64} = 63.617 \times 10^{-12}$$

$$\delta_b = \frac{mg \times L \times L^3}{3 \times E \times I} = \frac{1.56 \times 10^{-12} \times 9.8 \times (0.2)^4}{3 \times 10^{10} \times 63.617 \times 10^{-12}}$$

$$\delta_b = 644.2 \times 10^{-6} \times 0.2$$

$$= 128.856 \times 10^{-6}$$



NAME: Prachi Singhroha Roll No: 101903545 Group: 2CO21

Q7. Due to the dynamic effect of a rotating cantilever, assumed equivalent to a drop height of h, calculate the Dynamic Magnification Factor for a variety of realistic impact velocities, using equation (4) in the lecture supplementary notes. You should use here the impact velocities of Q2.

δstatic = 1.28 * 10^-3

Weight of L2= mass/length x 9.81 x length
= 15.67 x 9.81 x 0.2
= 30.738

Height h (m)	**Velocity m/s**	DMF
0.19	1.93	55.50
0.15	1.72	49.42
0.13	1.60	46.08
0.11	1.47	42.47
0.10	1.40	40.54

Q8. Takethe velocity corresponding to the drop height of 0.25m (giving rise to a corresponding DMF) and check that this velocity on impact will not cause the cantilever of L_2=0.2m to fail, taking failure stress from Q1, remembering that the dynamic stress can be approximated to $\sigma_{dynamic} = \sigma_{static}$ x DMF, where $\sigma_{static}$is from last equation in lecture notes.

NAME: Prachi Singhroha Roll No: 101903545 Group: 2CO21

Q3) height = 0.25 m. $v = \sqrt{2gh}$
$L_2 = 0.2$ m. $= 2.21$ m/s

$$\sigma_{static} = \frac{16 \omega L_2^2}{\pi d^3}$$

$$= \frac{16 \times 53.58 \times 10^{-3} \times (0.2)^2}{3.14 \times (6 \times 10^{-3})^3}$$

$$= \frac{98.29 \times 10^{-3}}{678.24 \times 10^{-9}}$$

$$\sigma_s = 1.449 \times 10^5 \text{ N/m}^2$$

$$DMF = 1 + \sqrt{1 + \frac{2h}{\delta_s}}$$

$$\delta_s = 0.1231 \times 10^{-3}$$

$$DMF = 1 + \sqrt{1 + \frac{0.5}{0.1231 \times 10^{-3}}}$$

$$= 1 + \sqrt{1 + 4.0617 \times 10^3}$$

$$= 1 + 63.7$$

$$= 64.7$$

$$\sigma_d = DMF \times \sigma_s$$

$$= 64.7 \times 1.449 \times 10^5$$

$$= 93.7 \times 10^5 \text{ N/m}^2$$

$$= 9.37 \times 10^6 \text{ N/m}^2$$

Faliure Stress = 166.2285×10^6 N/m^2
which is ~~ta~~ greater than σ_d,

$\therefore$ it can be concluded that beam will not fail.