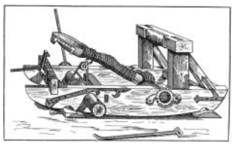
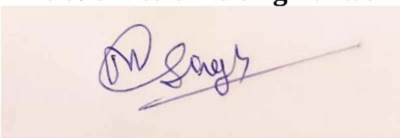


NAME: Meharamt Singh Roll No: 102003241 Group: 2CO10

This submission is original work and no part is plagiarized (signed)



Date) 19.10.2021

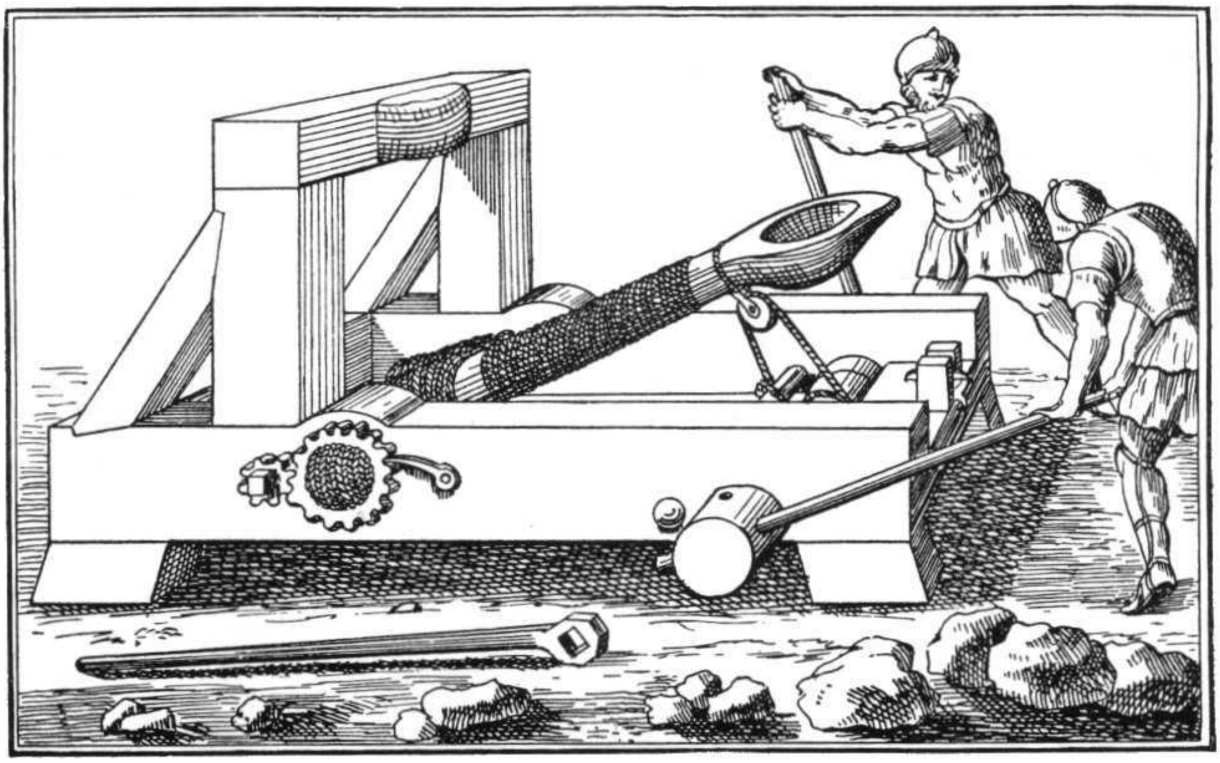
THAPAR INSTITUTE
OF ENGINEERING & TECHNOLOGY
(Deemed to be University)

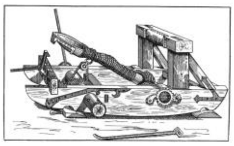
MECHANICAL ENGINEERING DEPARTMENT

Thapar Institute of Engineering and Technology, Patiala

ASSIGNMENT - 4.
DESIGN AGAINST FAILURE UNDER DYNAMIC ACTIONS

UTA016 Engineering Design Project-I





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ASSIGNMENT - 4.
STRUCTURAL ENGINEERING COMPONENT
DESIGN AGAINST FAILURE UNDER *DYNAMIC* ACTIONS

Complete the following **individually, copying will be dealt with severely.**

Instructions:

1. Data to be used for excel spreadsheets graphs to be created for Q2 and Q3 is (will be provided by the respective lab instructors):

Mass (kg)	Weight (N)	Height Failure (m)

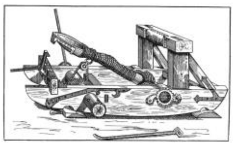
2. **Excel spreadsheets graphs to be created for Q1 and Q2 will evaluated by end of tutorial class**. Remaining questions is to be submitted before next tutorial class (if it is a holiday, then as instructed).

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 (i.e. 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 3 (5 Marks)

1. **Evaluation at end of Tutorial: 2.5**
2. **Evaluation from printout submission:2.5**



NAME: Meharamt Singh   Roll No: 102003241   Group: 2CO10

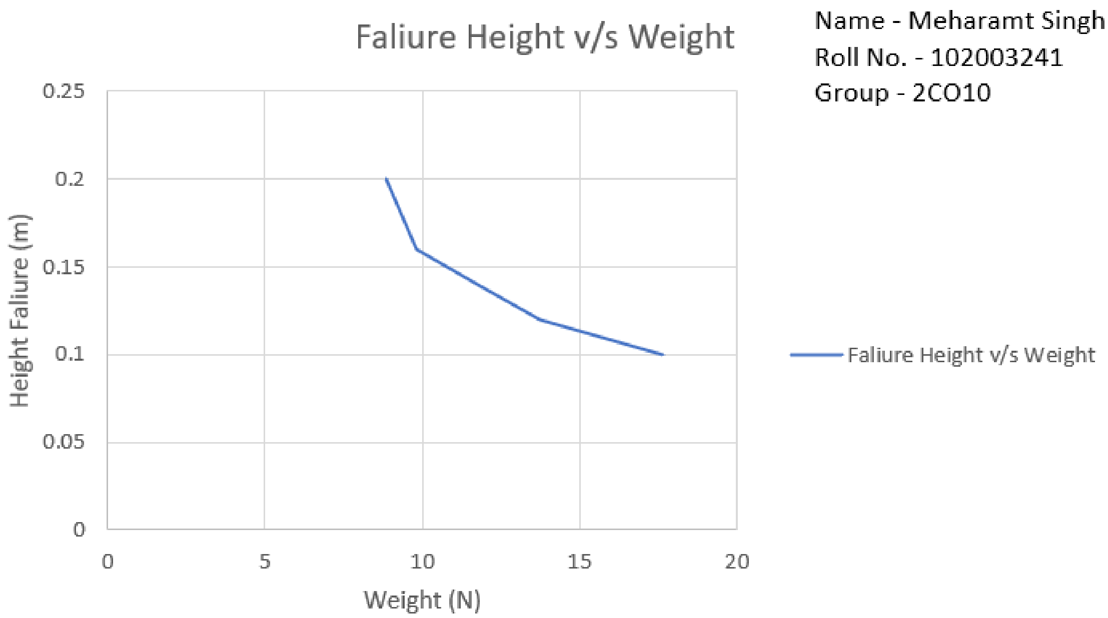
Q1. A dowel of 0.006 m diameter (d), a beam span of 0.3 m, fails at a static failure load of 47 N. Calculate the static failure stress in Excel sheet.

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	6	47	3525	3	63.585	166.3128096

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;

Mass (kg)	**Weight (N)**	**Height Failure (m)**	**Strike Velocity m/s**
0.9	8.829	0.2	1.980909
1	9.81	0.16	1.771779
1.2	11.772	0.14	1.657347
1.4	13.734	0.12	1.534405
1.8	17.658	0.1	1.400714

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

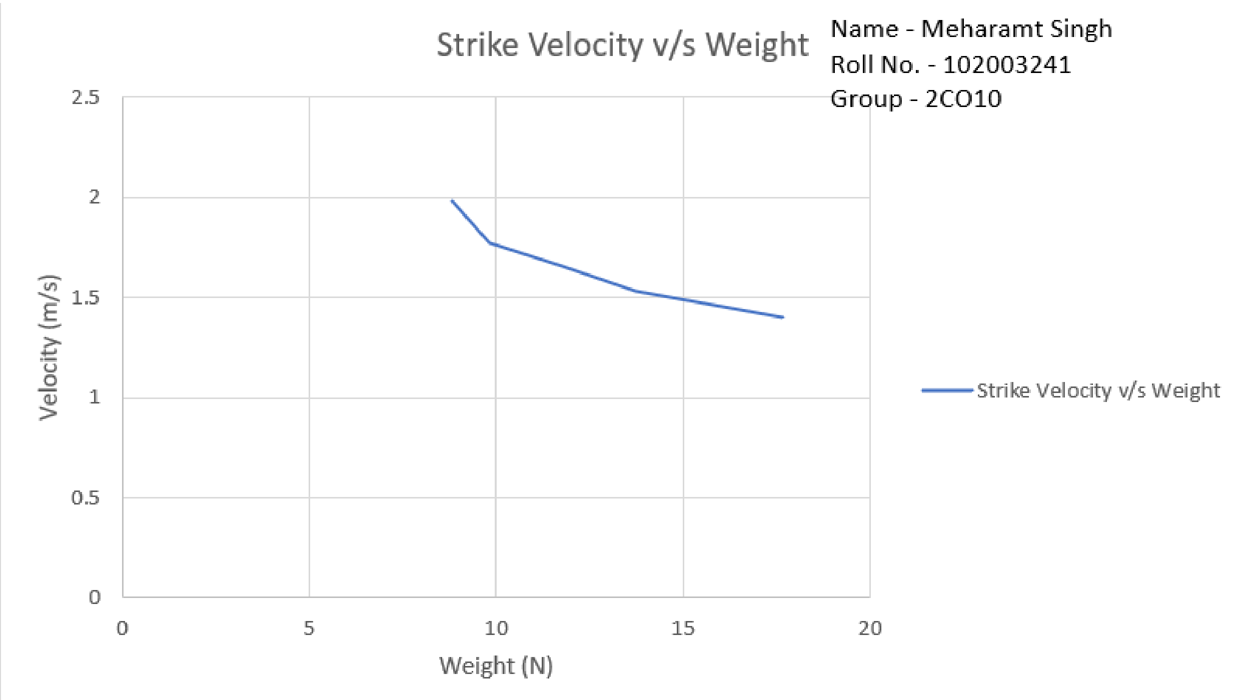


(Table and Plot Evaluated at the end of the Tutorial class)

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

2 (b) From the graph, it can be observed that height failure decreases with increase in weight & as compared to dynamic load the dowel span was able to withstand large failure load. in static condition

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



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

3 (b) In question 3 graph, we observe that the strike velocity is inversely proportional to the weight and in Q2 graph we saw that the failure height is inversely proportional to the weight. This proves that height is directly proportional to strike velocity.

Q4. Using *Scenario 4: Case 1* from the lecture 3 and 4 supplementary 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.

(4) given, static force (P) acc. to Q1 = 47N.

$$DMF = \frac{\text{dynamic force}}{\text{static force}} = 2$$

$\Rightarrow$ Dynamic force $= 2 \times 47$

$= 94\ N$

Q5. Using *Scenario 4: Case 2* in the lecture 3 and 4 supplementary 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

(5) given, $m = 4.7 \times 10^{-3}$ kg $\quad l = 0.3$ m $\quad d = 6 \times 10^{-3}$ m

$$\text{Mass density } (\gamma) = \frac{\text{mass}}{\text{Volume}} = \frac{\text{mass}}{\text{area} \times \text{length}} = \frac{4.7 \times 10^{-3} \times 4}{\pi \times (0.006)^2 \times 0.3}$$

$[\gamma = 554.094\ kg/m^3]$

$$\text{Mass per unit length} = \frac{m}{L} = \frac{4.7 \times 10^{-3}}{0.3}$$

$= 0.015667\ kg/m$

$m = [1.5667 \times 10^{-2}\ kg/m]$

$$\text{load per unit length } (\omega) = \frac{P}{L} \text{ (static load)}$$

$$= \frac{4.7 \times 10^{-3} \times 9.81}{0.3}$$

$= 0.15369\ N/m$

$[\omega = 15.369 \times 10^{-2}\ N/m]$

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, 6 mm diameter, under a static point load equivalent to its own weight when in fully locked state of the Mangonel arm. The value of the Young's modulus of elasticity, E, can be assumed from the lecture notes.

⑥ $m = 1.5667 \times 10^{-2}$ kg $\quad L_2 = 0.2$ m $\quad E = 10^{10}$ N/m

$d = 6$ mm $= 6 \times 10^{-3}$ m

static deflection (δ_{static}) $= \frac{P_0}{K}$

$P_0 = mgl$, $\quad K = \frac{3EI}{L_2^3}$, $\quad I = \frac{\pi d^4}{64}$

$P_0 = 1.5667 \times 10^{-2} \times 9.81 \times 0.2 = \underline{3.074 \times 10^{-2}\ N}$

$I = \frac{\pi \times (6 \times 10^{-3})^4}{64} = 6.3617 \times 10^{-11}\ m^4$

Putting values

$\delta_{static} = \frac{3.074 \times 10^{-2} \times (0.2)^3}{3 \times 10^{10} \times 6.3617 \times 10^{-11}} = \underline{1.2885 \times 10^{-4}\ m}$

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.

⑦ $\delta_{static} = 1.2885 \times 10^{-4}$

weight of $L_2 = 15.369 \times 10^{-2} \times 0.2 = 3.0738 \times 10^{-2}$ N

$= 0.030738$ N $\quad DMF = 1 + \sqrt{1 + \frac{2h}{\delta_{static}}}$

Height (m)	Velocity (m/s)	DMF
0.2	1.980	56.7259
0.16	1.772	50.8446
0.14	1.657	47.6289
0.12	1.534	44.1698
0.1	1.400	40.4106

Q8. Take the 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 $\sigma_{dynamic} = \sigma_{static} \times DMF$, where σ_{static} is from last equation in lecture notes.

(8) $h = 0.25m$

$l = 0.2m$

$\delta_{static} = 1.2885 \times 10^{-4}$

velocity $= \sqrt{2gh}$

$= \sqrt{2 \times 9.81 \times 0.25} = 2.214$ m/s

$DMF = 1 + \sqrt{1 + \dfrac{2 \times 0.25}{\delta_{static}}} = 63.352$

$\sigma_{static} = \dfrac{16 WL_2^3}{\pi d^3}$

$= \dfrac{16 \times 0.15309 \times (0.2)^3}{3.14 \times (6 \times 10^{-3})^3}$

$= 1.4495 \times 10^5$ N/m²

$\sigma_{dynamic} = \sigma_{static} \times DMF$

$= 1.4495 \times 10^5 \times 63.352$

$= 9.18294 \times 10^6$ N/m²

$\sigma_{dynamic} = 9.1824$ MPa

Failure stress $= 166.228$ MPa

$\sigma_{failure} > \sigma_{dynamic}$

Hence, the cantilever will not break for the velocity of 2.214 m/s