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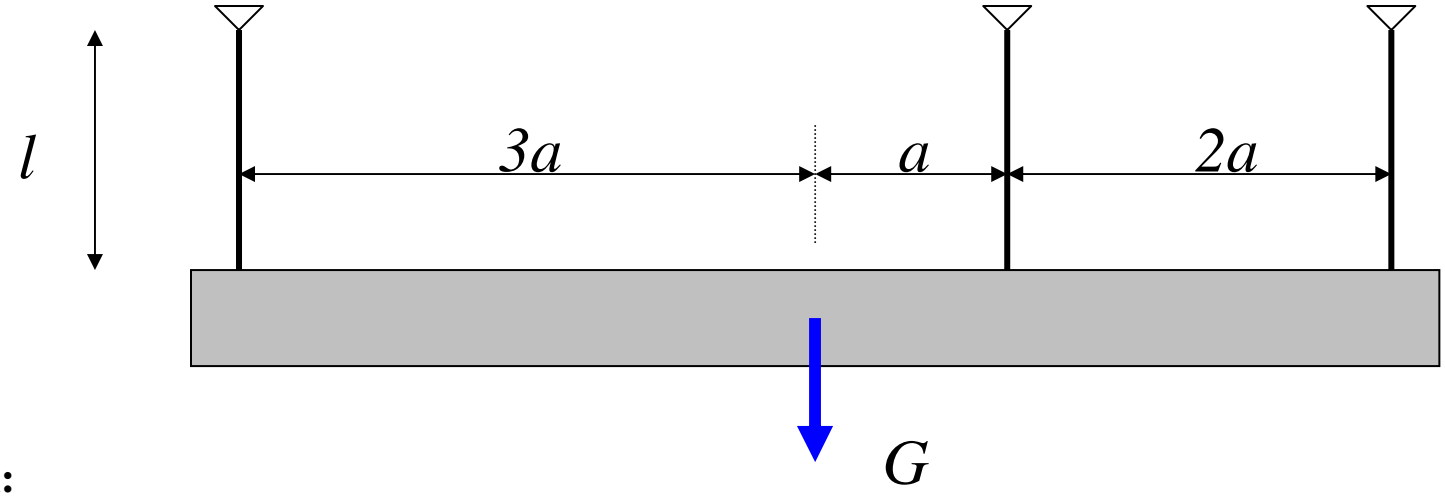
ASSIGNMENT 1

ELASTIC versus PLASTIC ANALYSIS

STRUCTURE IN TENSION



Given:

- Cross sectional area of each cable : A=100 mm^2 , length l=0,5 m, a=0,5 m
- Yield stress of the cable material : f_y = 235 N/mm^2
- Youngs modulus of the cable material : E=2,1*10^5 N/mm^2

Questions:

- Find the value of ***G*** for first occurrence of the yield stress (elastic limit)
- Find the failure load of ***G***

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ANSWER : ELASTIC LIMIT

Analysis:

- *three* unknown cable forces
- *two* equilibrium conditions which can be used ($\Sigma V=0$, $\Sigma T=0$)

Static undeterminate structure to the degree of one

Solution strategy: Force Method

- Chose a static redundant(force in one of the calbles)
- Reduce the structure to a static determinate system
- Setup the compatibility demand which belongs to the redundant force
- Solve the unknown
- Find the maximum cable force which is not allowed to exceed the elastic limit N_p

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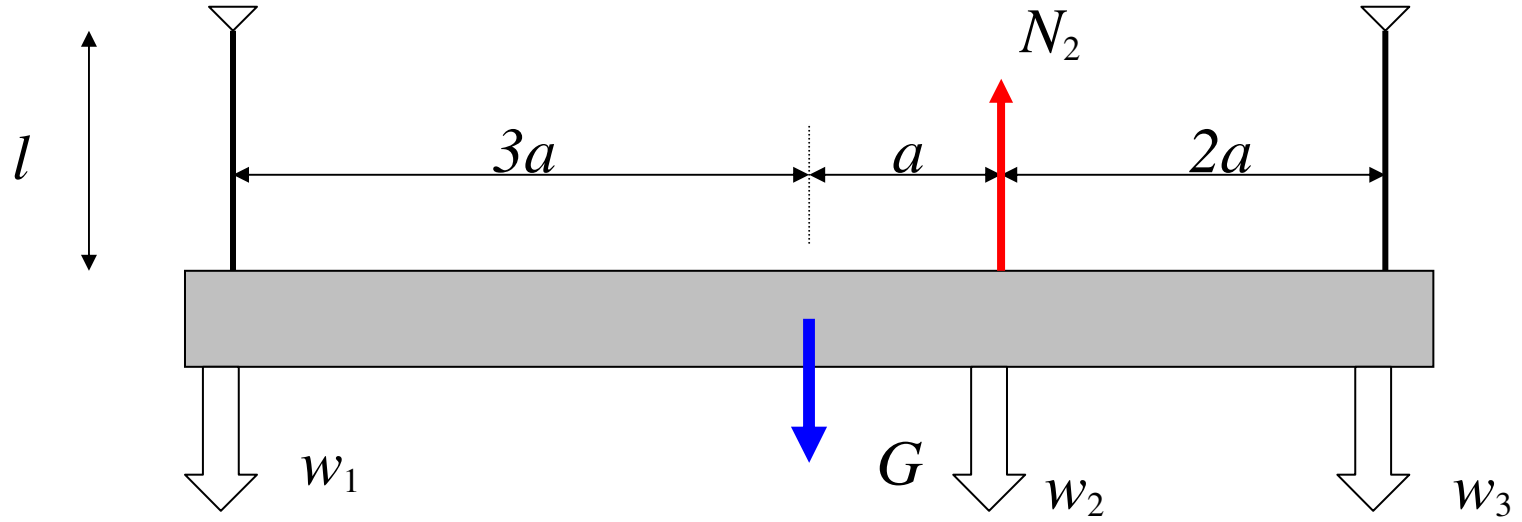
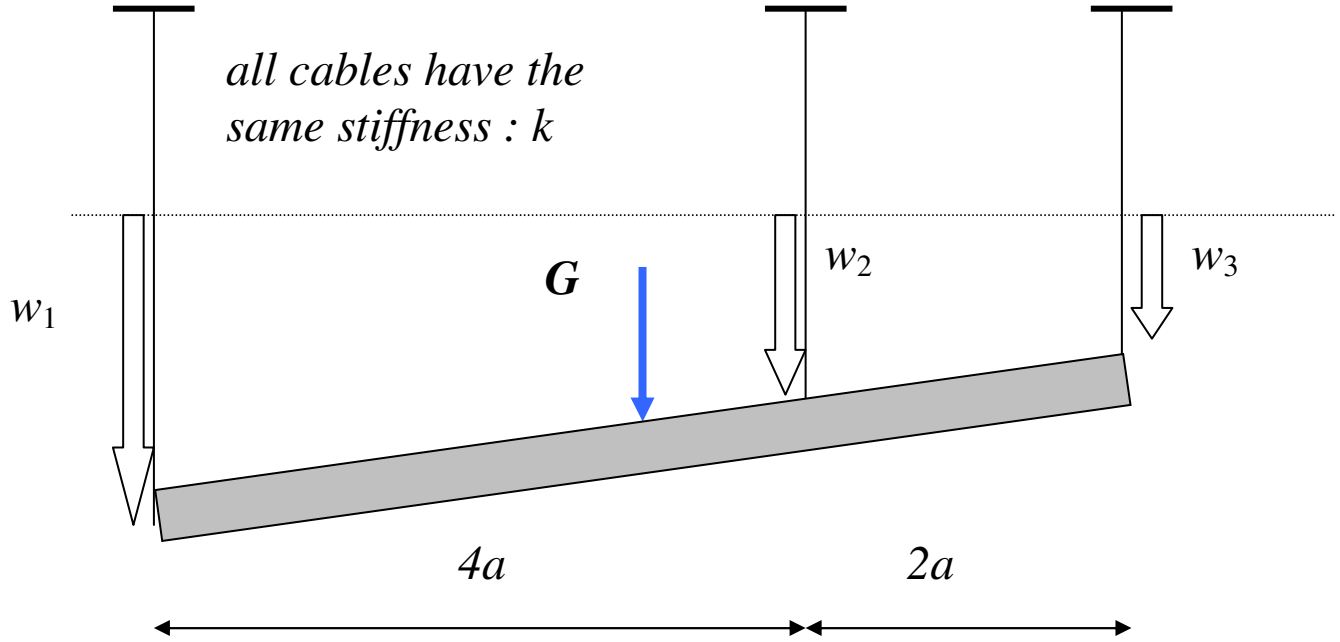
STATIC DETERMINATE PRINCIPAL SYSTEM WITH STATIC REDUNDANT



$$stiffness\ of\ the\ cable: \quad k = \frac{EA}{l}$$

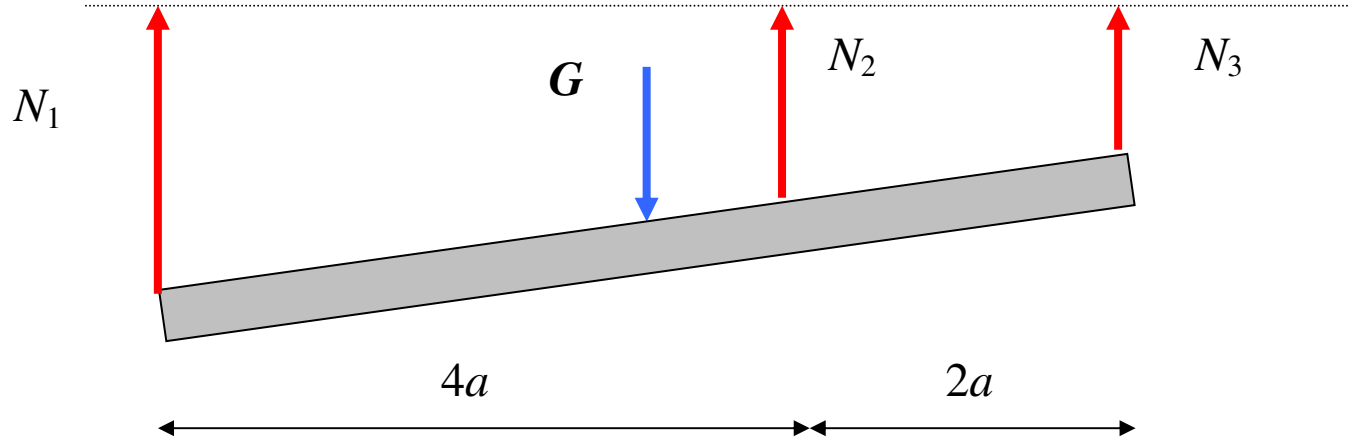
COMPATIBILITY CONDITION



$$w_2 = w_1 - \left(\frac{w_1 - w_3}{6a} \right) \cdot 4a$$

$$w_2 = \tfrac{1}{3}(w_1 + 2w_3) \quad \Rightarrow \quad N_2 = kw_2 = \tfrac{1}{3}k(w_1 + 2w_3) = \tfrac{1}{3}N_1 + \tfrac{2}{3}N_3$$

RESULTING SYSTEM OF EQUATIONS



$$N_1 + N_2 + N_3 = G$$
$$N_1 \cdot 3a - N_2 \cdot a - N_3 \cdot 3a = 0 \quad \Rightarrow \quad \begin{bmatrix} 1 & 1 & 1 \\ 3 & -1 & -3 \\ 1 & -3 & 2 \end{bmatrix} \begin{Bmatrix} N_1 \\ N_2 \\ N_3 \end{Bmatrix} = \begin{Bmatrix} G \\ 0 \\ 0 \end{Bmatrix}$$
$$N_1 - 3N_2 + 2N_3 = 0$$

$$N_p = A \cdot f_y = 23{,}5 \times 10^3 \ N$$
$$N_p = 23{,}5 \ kN$$

$$N_1 = \tfrac{11}{28} G \quad ; \quad N_2 = \tfrac{9}{28} G \quad ; \quad N_3 = \tfrac{8}{28} G$$

$$G_e = \tfrac{28}{11} \cdot N_p = 59{,}8 \ kN$$

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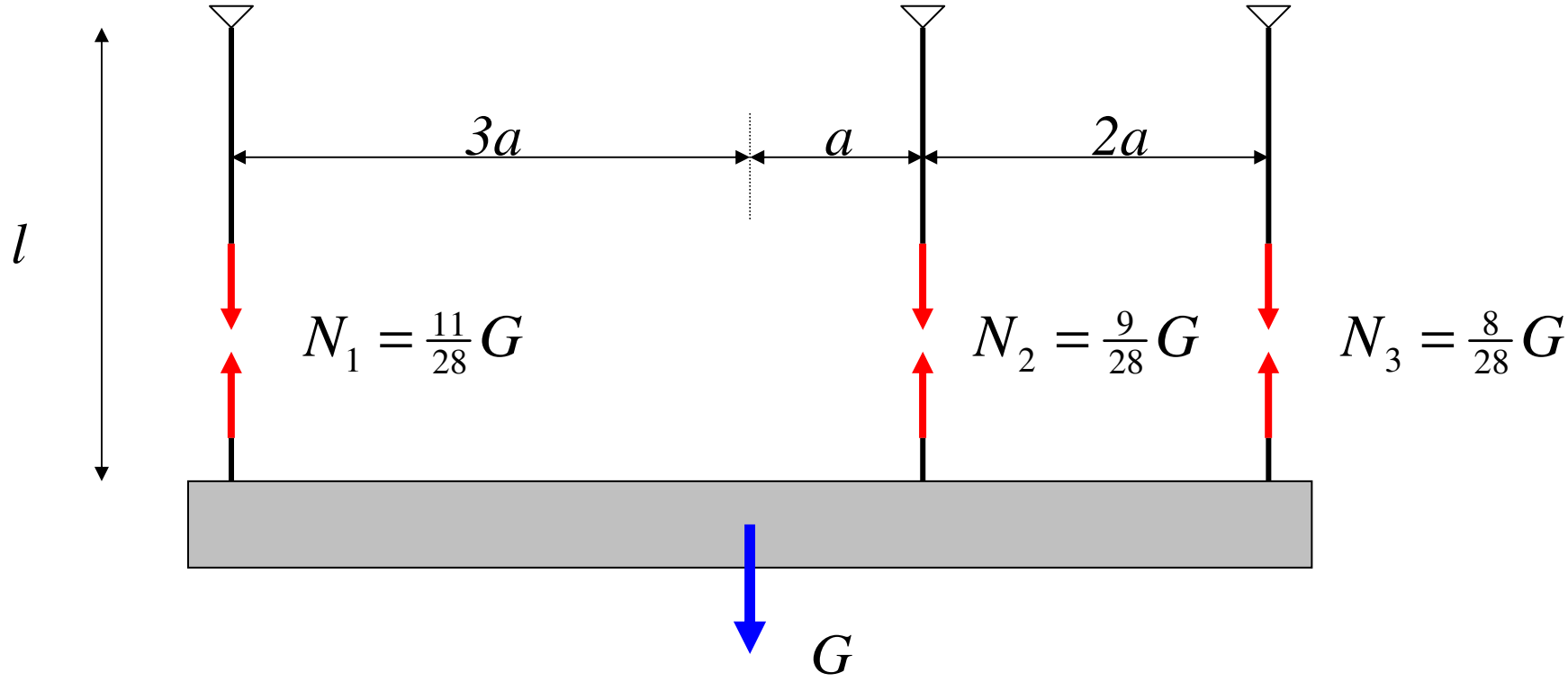
ELASTIC CABLE FORCE DISTRIBUTION



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ANSWER : FAILURE LOAD

Analysis:

- *failure* occurs if an additional load can not be taken by the structure, end of load capacity
- *two* cables which will yield results in a mechanism therefore failure occurs when the second cable starts to yield

Solution strategy :

- Incremental method or
- Direct method based upon failure mechanism

(this is shown in class)