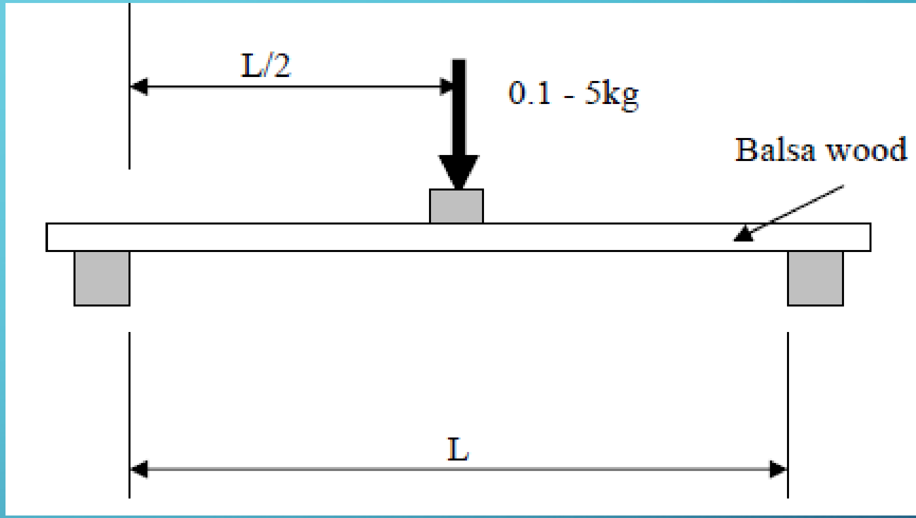
ENGG102 Fundamentals of Engineering Mechanics

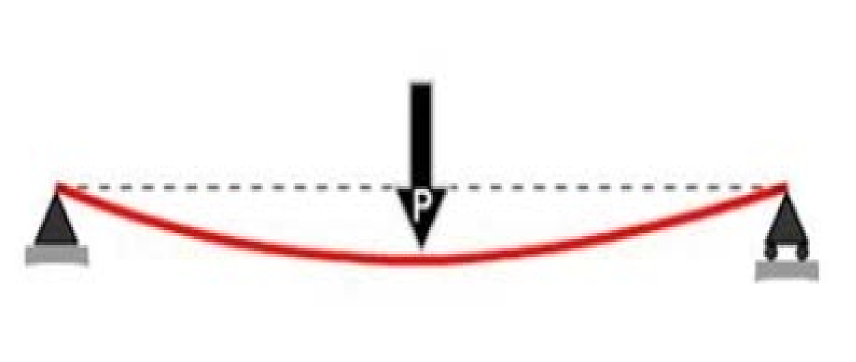
VISIONARY / PASSIONATE / DYNAMIC
CONNECT:
UNIVERSITY OF WOLLONGONG

UOWD
University of Wollongong in Dubai

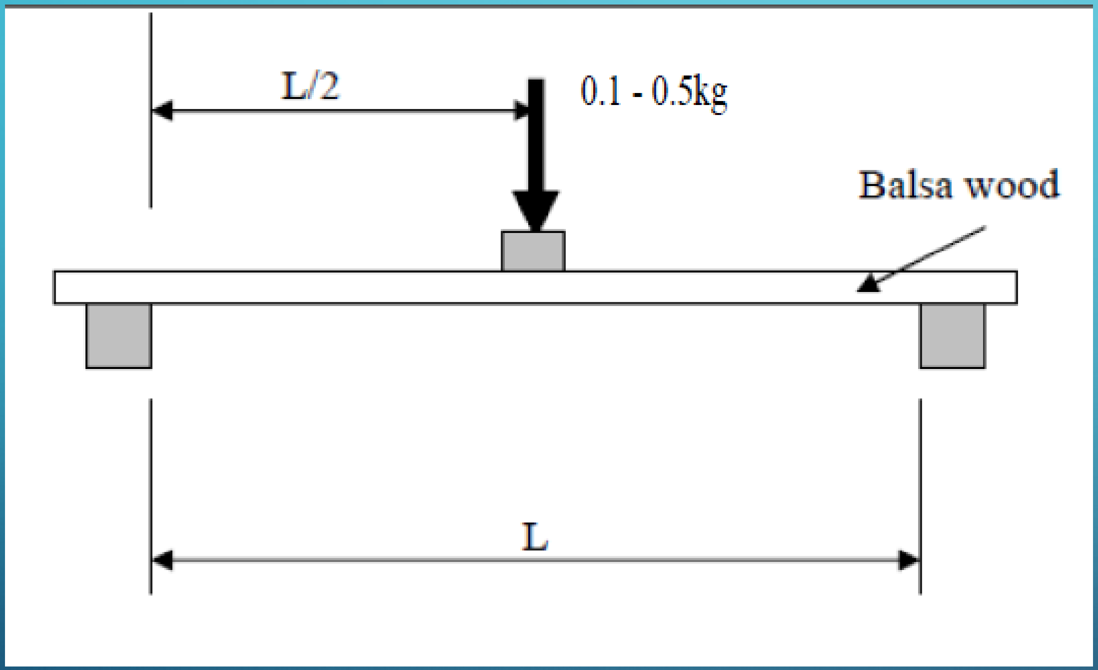
Deflection in a beam

- You have performed experiments in lab on such a beam.
- The design of beam requires knowledge of Statics, Moment of Inertia of the beam and material properties like Modulus of Elasticity.





- To find out Modulus of Elasticity, you performed an experiment where you apply load and find out deflection under that load. Plot a graph between these two and viola! You have the Modulus of Elasticity.



$$\delta = PL^3/48EI$$

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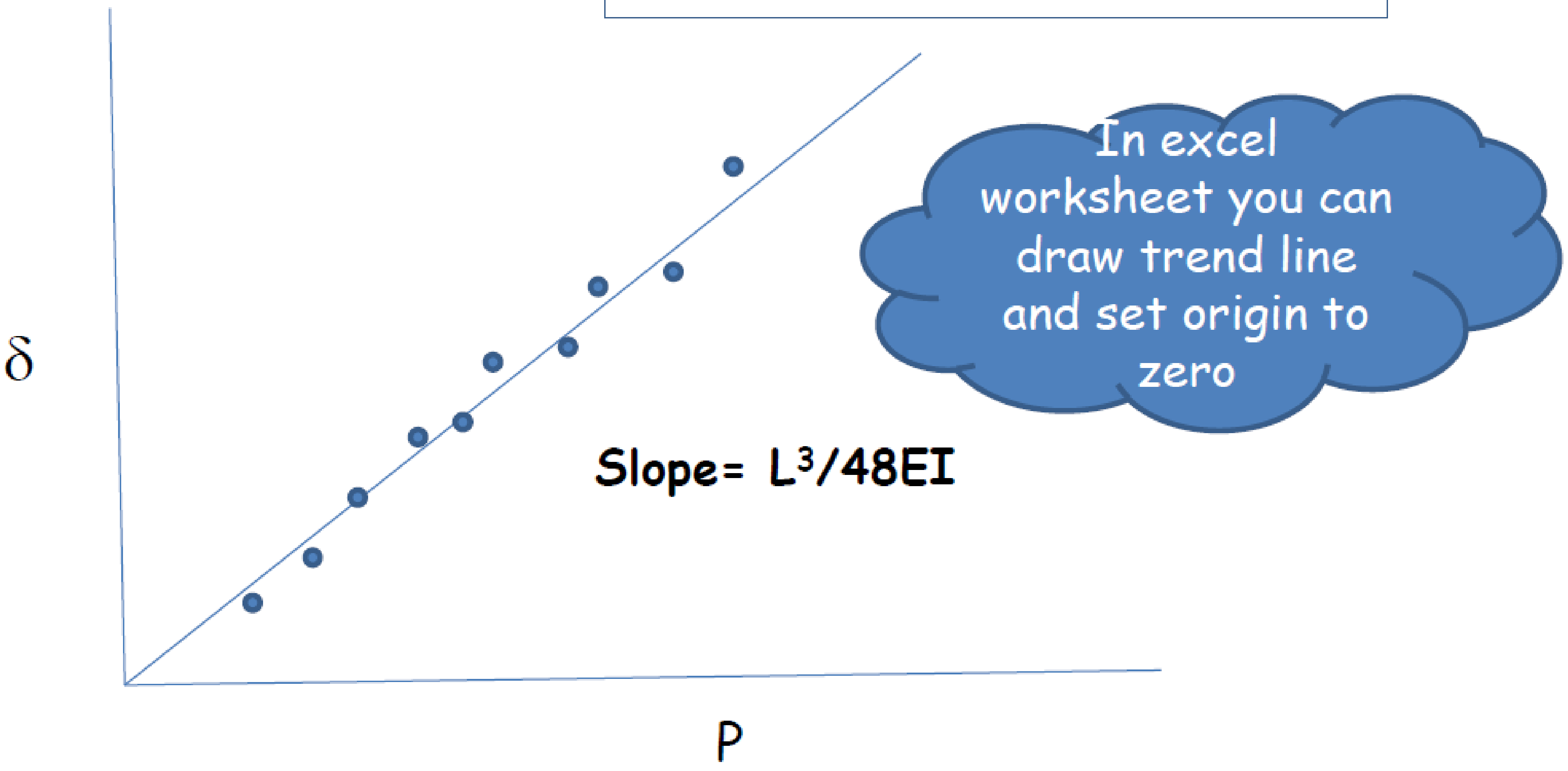

Understanding the brief (1B)

- Main criterion – carry central load with acceptable deflection (1.5mm to 6.5mm)
- Optimize – minimum volume of balsa
- Your beam design will be sighted by the tutor in week 6!

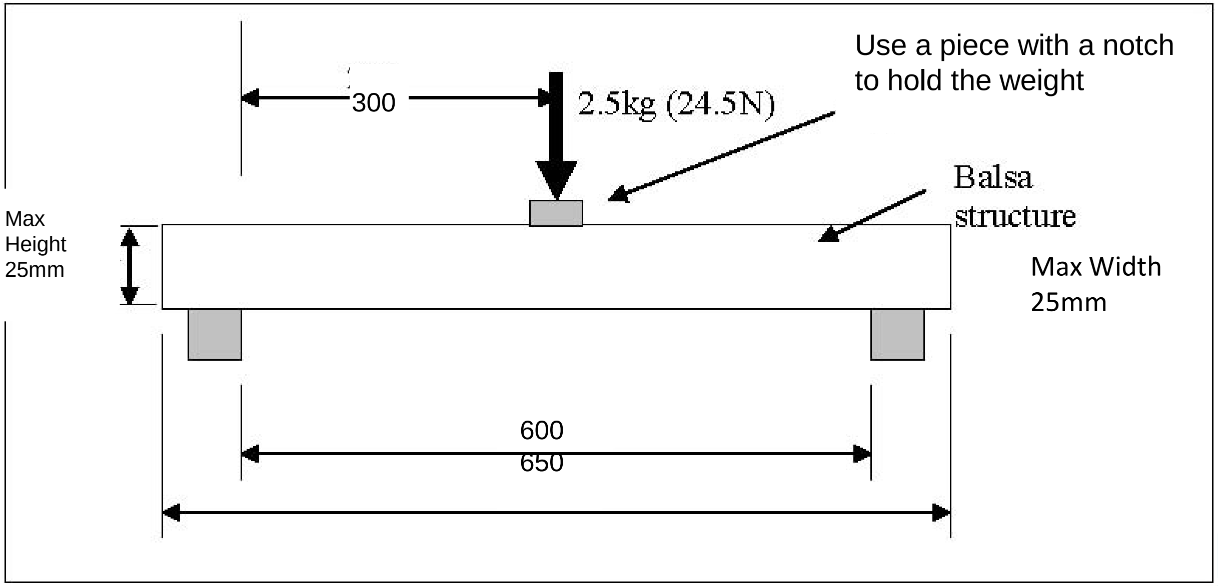

Figure 1: Side View of Beam

$\delta = (PL^3/48EI)$ mm

- The load P is prescribed
- The length L is also prescribed
- 48 is a number
- E is Young's Modulus for balsa. The material has been prescribed (but has a range of E values)
- The second moment of area depends on the shape of the beam – **this is our only variable to control**
- If we increase I we will decrease δ.

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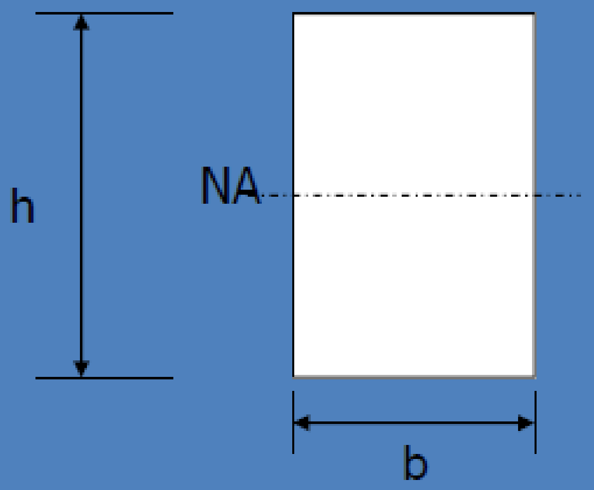
Second moment of area
–Simple Rectangle cross section



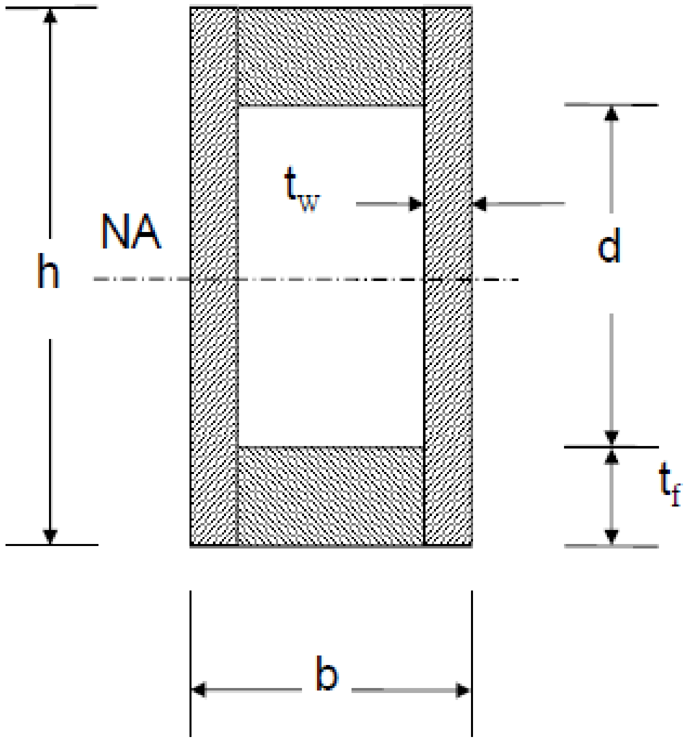
$$I = \frac{bh^3}{12}$$

$\delta = (PL^3/48EI)$

Second moment or area is always measured about a datum line.
In this case it was derived about the centroidal line which is also called the NEUTRAL AXIS (NA)

What about compound shapes

- The box is a rectangle of size b x d minus the inner rectangle
- Both rectangles must have the same centroid line Centre of Area or Neutral Axis(NA)

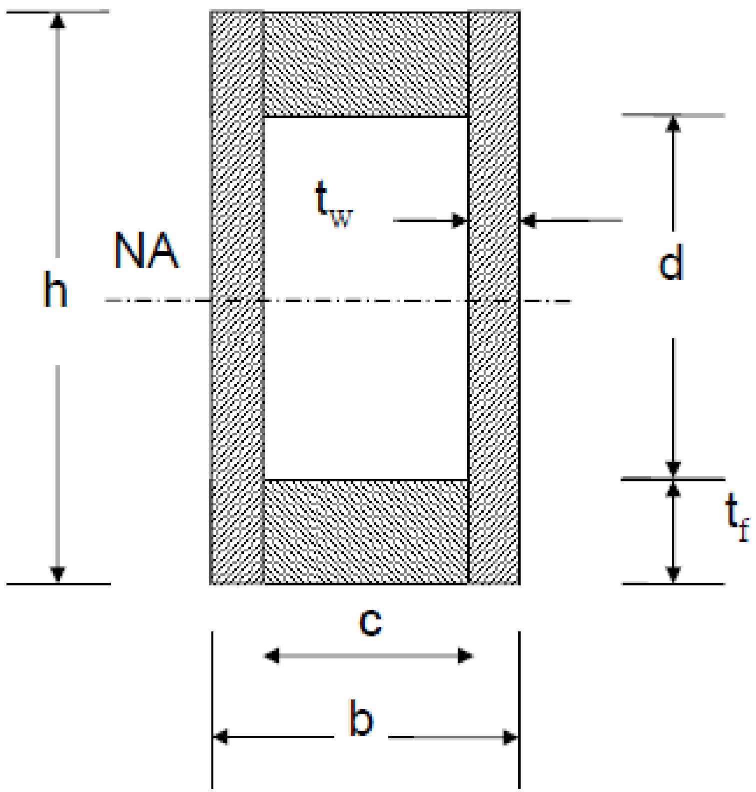


Shapes based on rectangles

- Rectangles all have **same centroidal axis**
- This is also called the Neutral axis (NA)

$$I = I_{gross} - I_{void}$$

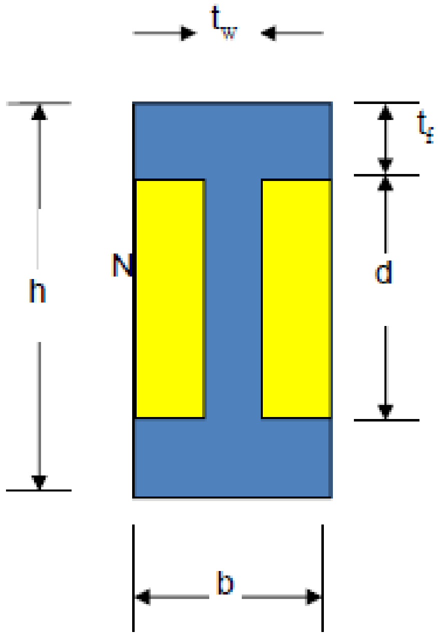
$$I = \frac{1}{12}\left(bh^3 - cd^3\right)$$

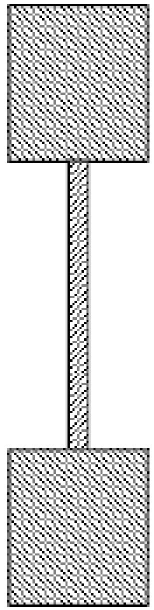


$c = b - 2t_w$ and $d = h = 2t_f$

I shaped section

- This is a rectangle minus two smaller ones



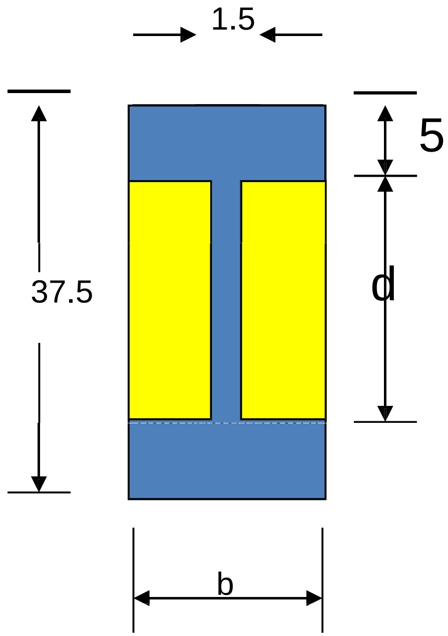


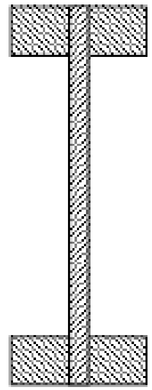
All shapes must have same NA

$$I = I_{gross} - I_{voids}$$

I shaped section Example

- Fabricate I shape out of Four 5 mm x 5 mm and one piece 37.5 mm x 1.5mm
- 5x5 stuck to side of 37.5x1.5
- d = 37.5 – (2x5) = 27.5 mm
- b = 2x5+1.5 = 11.5 mm
- void d = 27.5 mm, b_v = 5 mm

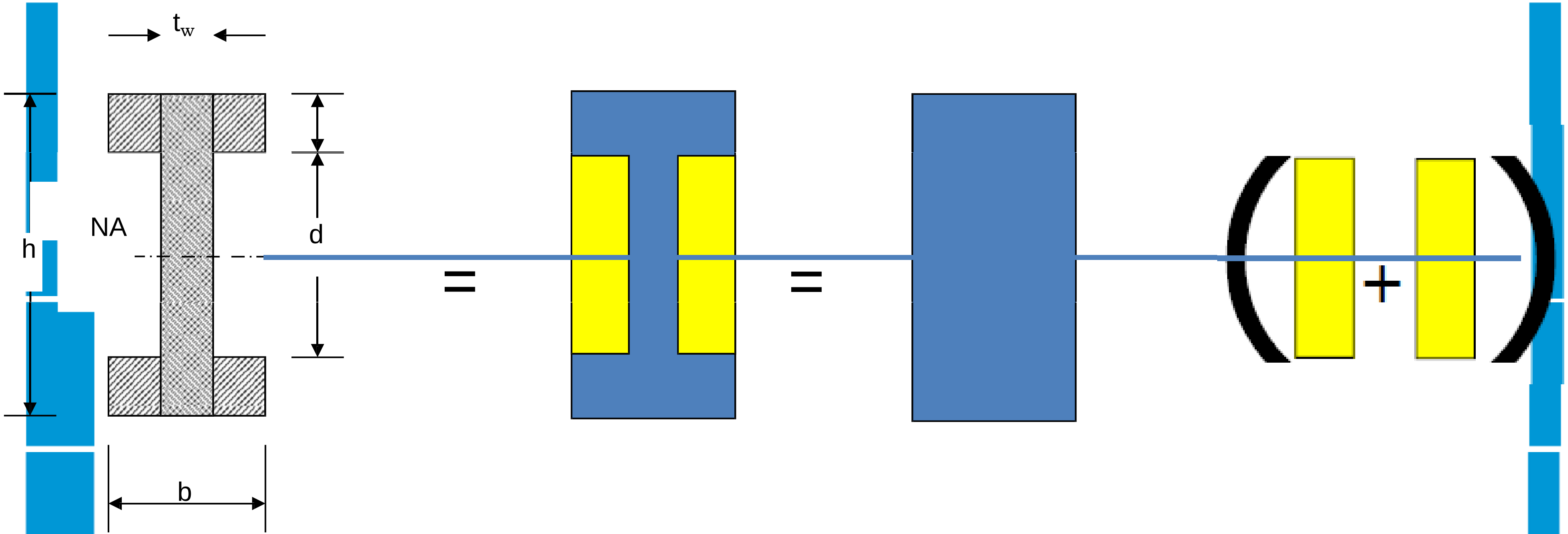




- $I_{gross} = (1/12)*11.5*37.5^3$
- $I_{voids} = 2*[(1/12)*5*27.5^3]$
- I = 50537-17331

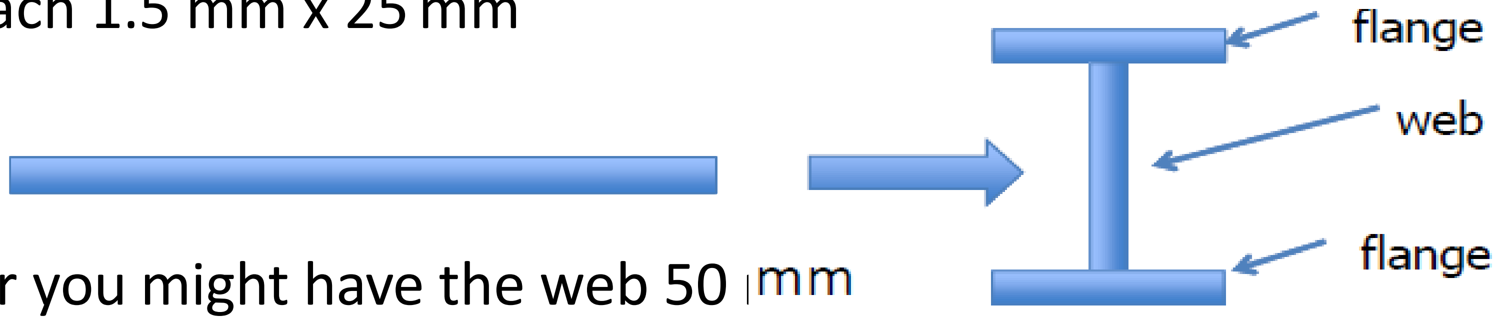
$$I \qquad I_{gross} \qquad I_{voids}$$

What does it mean that all areas have the same centroidal axis?



Each shape is symmetrical about the central horizontal axis

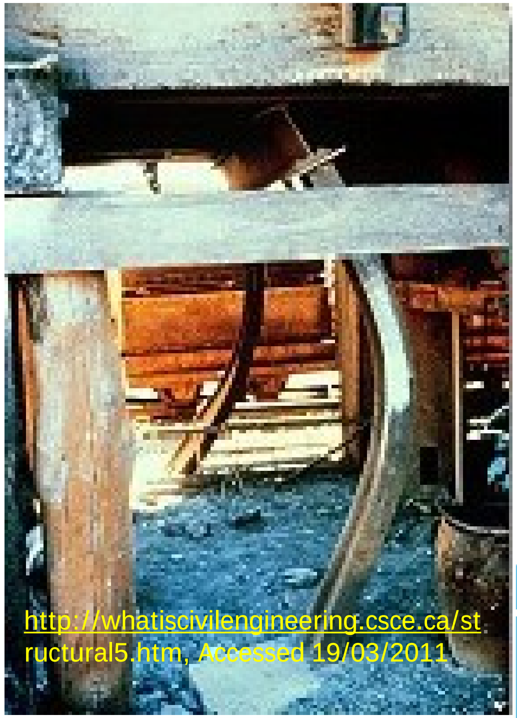
- From 1 sheet of balsa with a cross section of 1.5 mm x 75 mm and length L, what is the maximum value of Second moment of area that can be achieved?
- E.g. you might make an I shaped beam from three pieces each 1.5 mm x 25 mm



- Or you might have the web 50 mm and each flange 12.5 mm

Stability issues

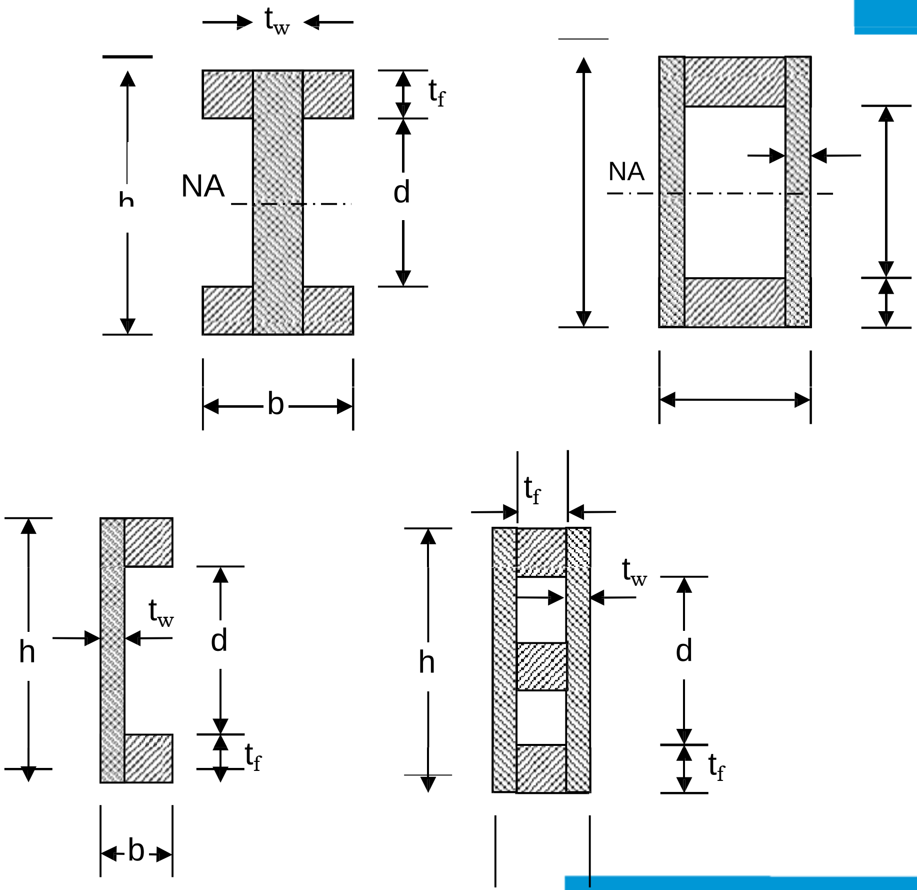
- Will your beam buckle instead of deflecting?
- Limit h/t_w ratios about <25



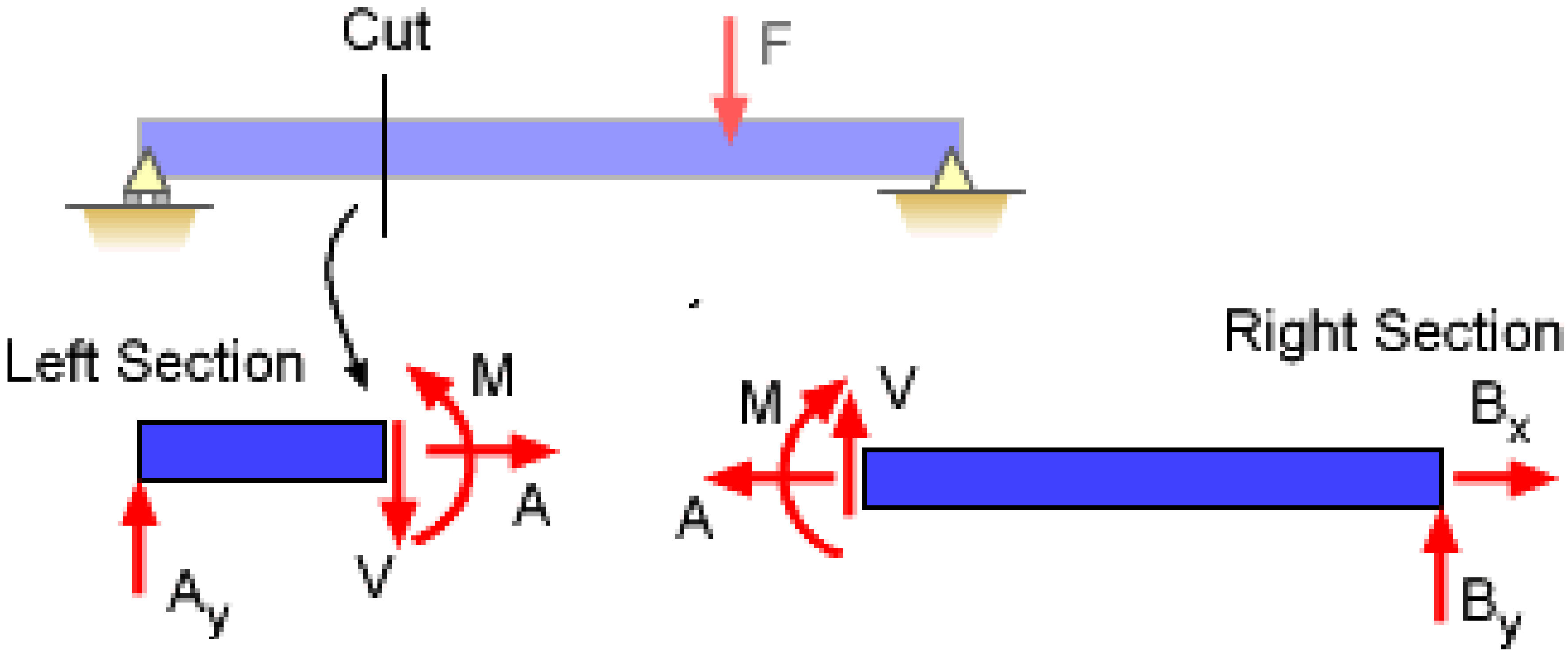
Range of shapes

- I shapes made from thin web with 4 or 2 rectangular pieces
- C shapes and box shapes
- Plain rectangles may also work

- More details in the Project 1B spec.



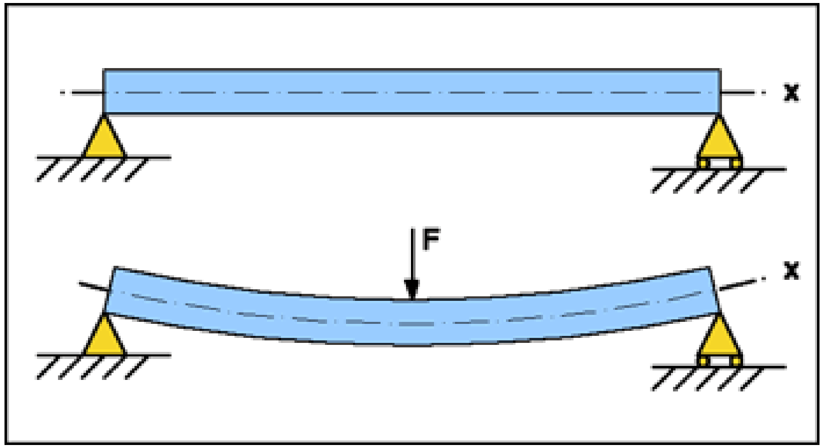
Internal forces in Beam in general



Q. Where will the Balsa Beam break?
A. Where stress is maximum. Most like bending stress.

Q. Where the bending stress is maximum?
A. Where bending moment is maximum (bending moment is type of internal force)

Q. How to find out location of maximum bending moment?
A. Use equilibrium equations and find out the maximum bending moment.



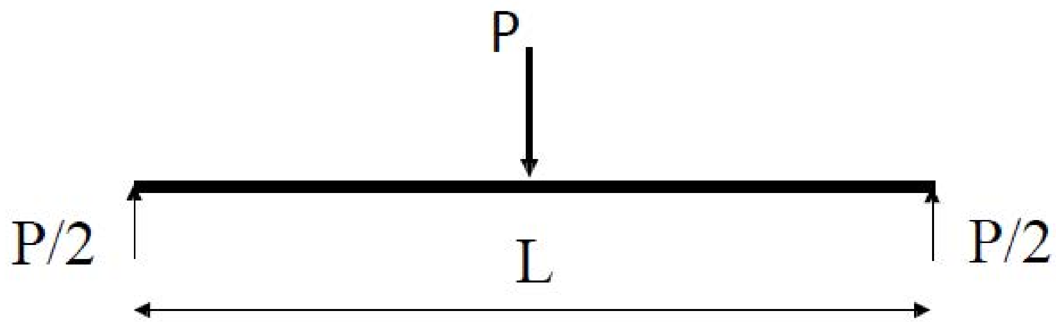
Use equilibrium equations and find out the maximum bending moment in the beam.

Hint: It will occur at midspan.

YOUR Beam: stress and strength

FAST FORWARD TO SECOND YEAR ENGG251

- Maximum tensile stress allowed in BALSA is for you to find
- In this case the beam will break (mostly) because it is bending
- In that case stress on the bottom fibres in the middle will be $\sigma_{\max} = M_{\max} h / (2I)$
- Where the maximum moment is $M_{\max} = PL/4$



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