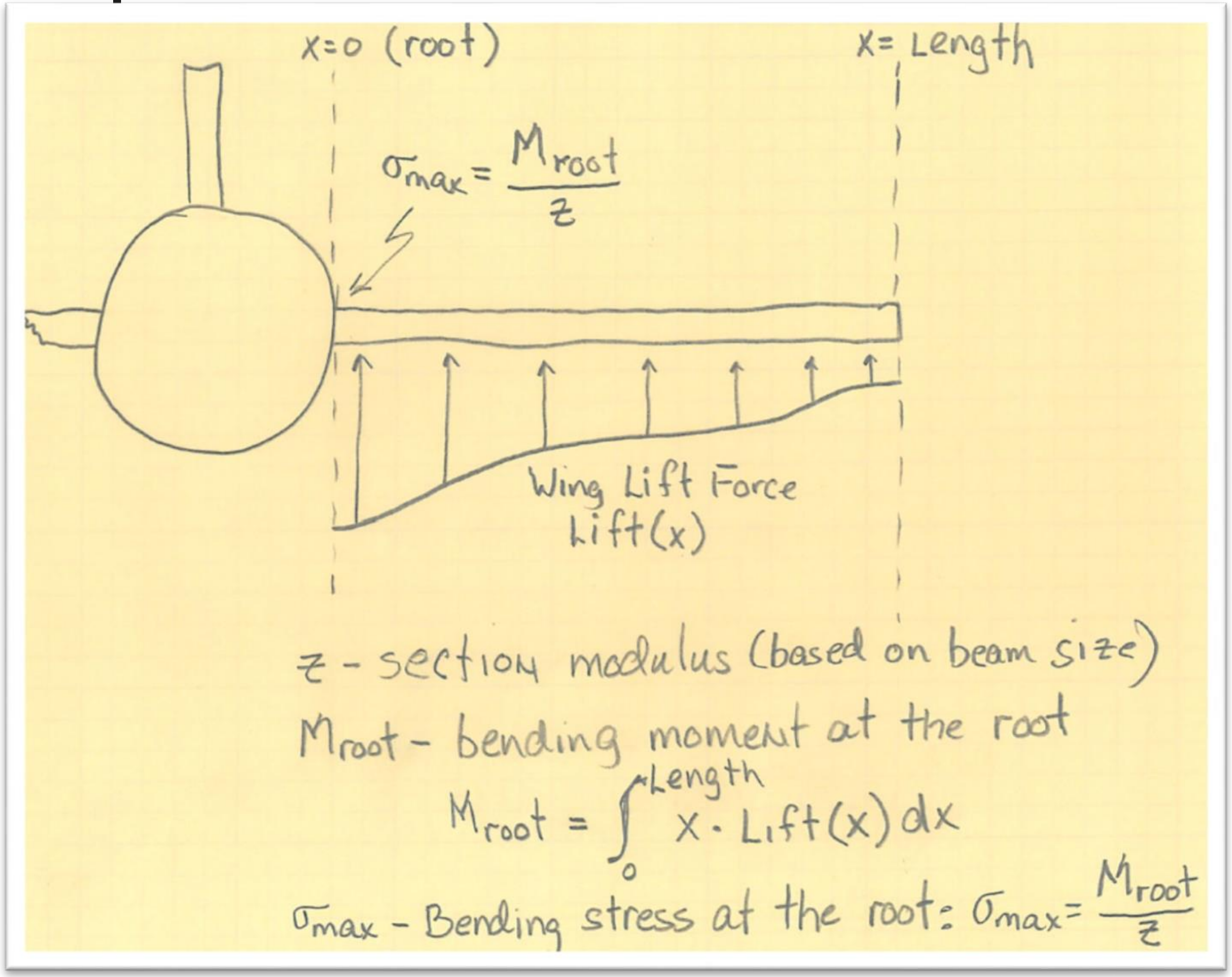
Computer Methods (MAE 3403)

Engineering examples using root finding and integral

Airplane design

- One aspect: choose the size of the wing spar (main structural beam) so that the wing is strong enough to survive the forces imposed on it.

Simplified calculation of stress



The figure shows that for a given lift force function (Lift(x)), wing length (Length) and wing spar section modulus (z), the maximum stress in the wing (σ_{max}) can be calculated.

Analysis & Design

- Stress analysis problem:
  - Knowing the loads and the geometry, calculate the stress.

- Wing spar design problem:
  - Choose the spar section modulus (z) so that
    σ_{max} = design stress
  - The design stress is the maximum safe wing stress, generally based on material properties and factors of safety.

A specific problem

- Lift(x) = 1.5 * cos(x / Length)
- The wing length is: Length = 320
- Calculate the max stress σ_{max} given z
  - σ_{max} : integration of x*Lift(x) from 0 to Length, divided by z
- Design the wing spar given a design stress σ_{max} and return the required z
  - Inverse process: requires root finding

Compute the following

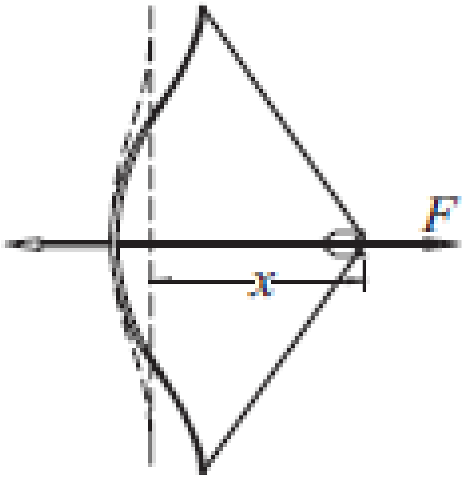
- Calculate the stress for a value of z = 3.5.
- Calculate the stress for a value of z = 1.5.
- Calculate the section modulus needed if the design stress is 25000.

Integration problem

The following table gives the pull F of the bow as a function of the draw x. If the bow is drawn 0.5m, determine the speed of the 0.075-kg arrow when it leaves the bow.

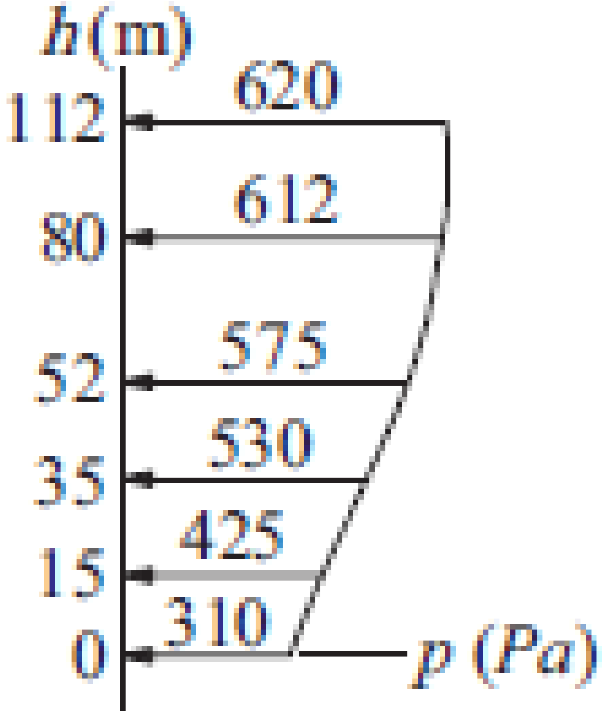
Hint: The kinetic energy of the arrow equals the work done in drawing the bow; that is,

$$mv^2/2 = \int_0^{0.5\text{m}} F\,dx.$$



x (m)	0.00	0.05	0.10	0.15	0.20	0.25
F (N)	0	37	71	104	134	161
x (m)	0.30	0.35	0.40	0.45	0.50	
F (N)	185	207	225	239	250	

Another problem



The pressure of wind was measured at various heights on a vertical wall, as shown on the diagram. Find the height of the pressure center, which is defined as

$$\bar{h} = \frac{\int_0^{112\text{ m}} h\, p(h)\, dh}{\int_0^{112\text{ m}} p(h)\, dh}$$