## **Nonlinear Equations**

### Your nonlinearity confuses me

 $ax^5 + bx^4 + cx^3 + dx^2 + ex + f = 0$ 

tanh(x) = x

For the trunnion-hub problem discussed on first day of class where we were seeking contraction of 0.015", did the trunnion shrink enough when dipped in dry-ice/alcohol mixture?

- 1. Yes
- 2. No



### **Example – Mechanical Engineering**

Since the answer was a resounding NO, a logical question to ask would be:

If the temperature of -108°F is not enough for the contraction, what is?



### Finding The Temperature of the Fluid

$$\Delta D = D \int_{T_{\alpha}}^{T_{c}} \alpha(T) dT$$

$$T_{a} = 80^{\circ}F$$

$$T_{c} = ???^{\circ}F$$

$$D = 12.363"$$

$$\Delta D = -0.015"$$

$$\alpha(T) = 6.033 + 0.009696T$$

$$-0.015$$

$$= 12.363 \int_{T_{c}}^{T_{c}} (6.033 + 0.009696T) dT$$

$$-0.015 = 5.992 \times 10^{-8}T_{c}^{2} + 7.457 \times 10^{-5}T_{c} - 6.349 \times 10^{-3}$$

 $f(T_c) = 5.992 \times 10^{-8} T_c^2 + 7.457 \times 10^{-5} T_c + 8.651 \times 10^{-3} = 0$ 

### Finding The Temperature of the Fluid



$$\alpha = -1.228 \times 10^{-5}T^{2} + 6.195 \times 10^{-3}T + 6.015$$
  
$$-0.015 = 12.363 \int_{80}^{T_{c}} (-1.228 \times 10^{-5}T^{2} + 6.195 \times 10^{-3}T + 6.015)(1 \times 10^{-6}) dT$$
  
$$-0.015 = -5.059 \times 10^{-11}T_{c}^{-3} + 3.829 \times 10^{-8}T_{c}^{-2} + 7.435 \times 10^{-5}T_{c} - 6.166 \times 10^{-3}$$
  
$$F(T_{c}) = -5.059 \times 10^{-11}T_{c}^{-3} + 3.829 \times 10^{-8}T_{c}^{-2} + 7.435 \times 10^{-5}T_{c} + 8.834 \times 10^{-3} = 0$$

#### How tall can a vertical mast be

$$1 + \sum_{n=1}^{\infty} c_n \beta^n = 0$$
  

$$c_1 = -\frac{3}{8}$$
  

$$c_n = -\frac{3c_{n-1}}{4n(3n-1)}, n = 2,3,...$$
  

$$L = \left(\frac{9\beta EI}{4w}\right)^{\frac{1}{3}}$$

E = Young's modulus of elasticity, I = second moment of area, w = weight per unit length



Thanks to Markus Gjengaar for sharing their work on Unsplash.

#### Nonlinear Equations (Background)









"The problem of not knowing what we missed is that we believe we haven't missed anything" – Stephen Chew on Multitasking



http://nm.MathForCollege.com Numerical Methods for the STEM undergraduate