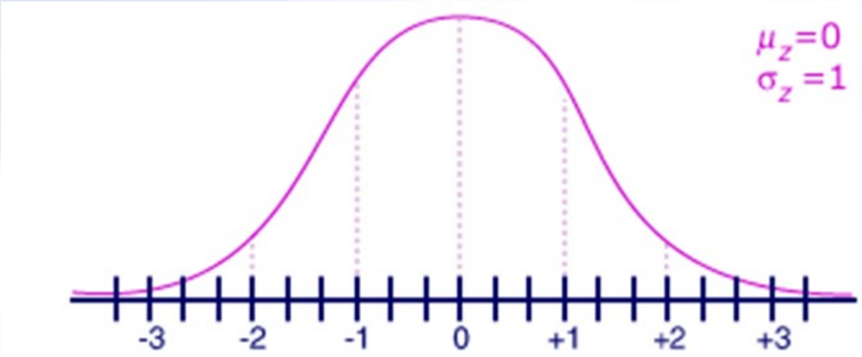
Bring Numerical Methods together

Why Use Numerical Methods?

Why Use Numerical Methods?

- To solve problems that cannot be solved exactly

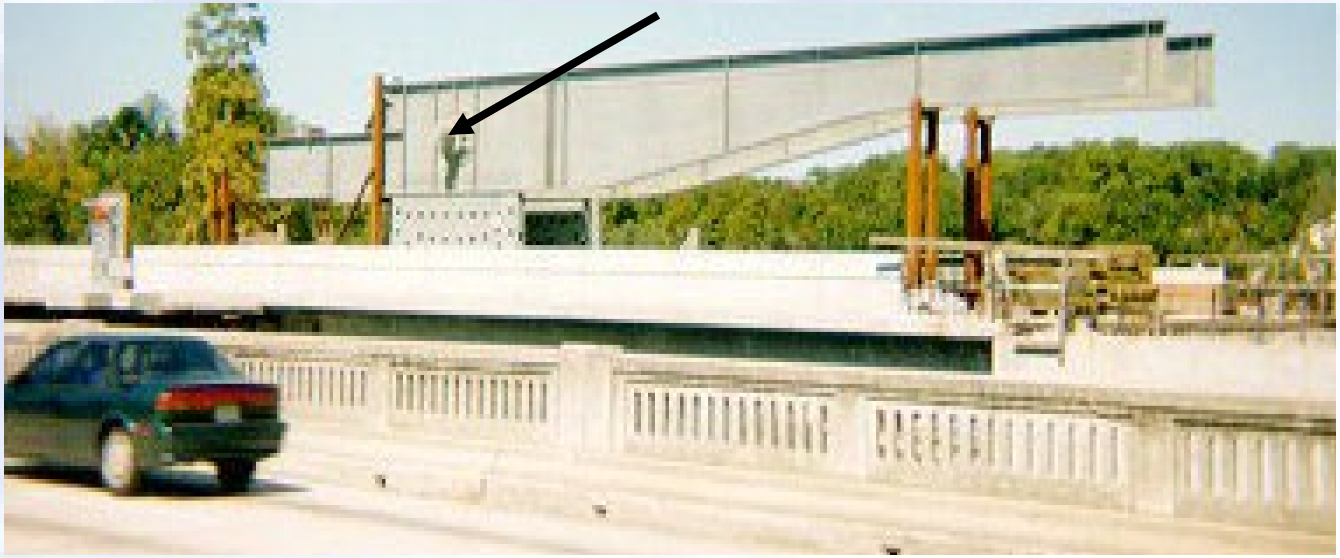
$$\frac{1}{\sqrt{2\pi}}\int_{-\infty}^{x} e^{-\frac{u^2}{2}}\,du$$



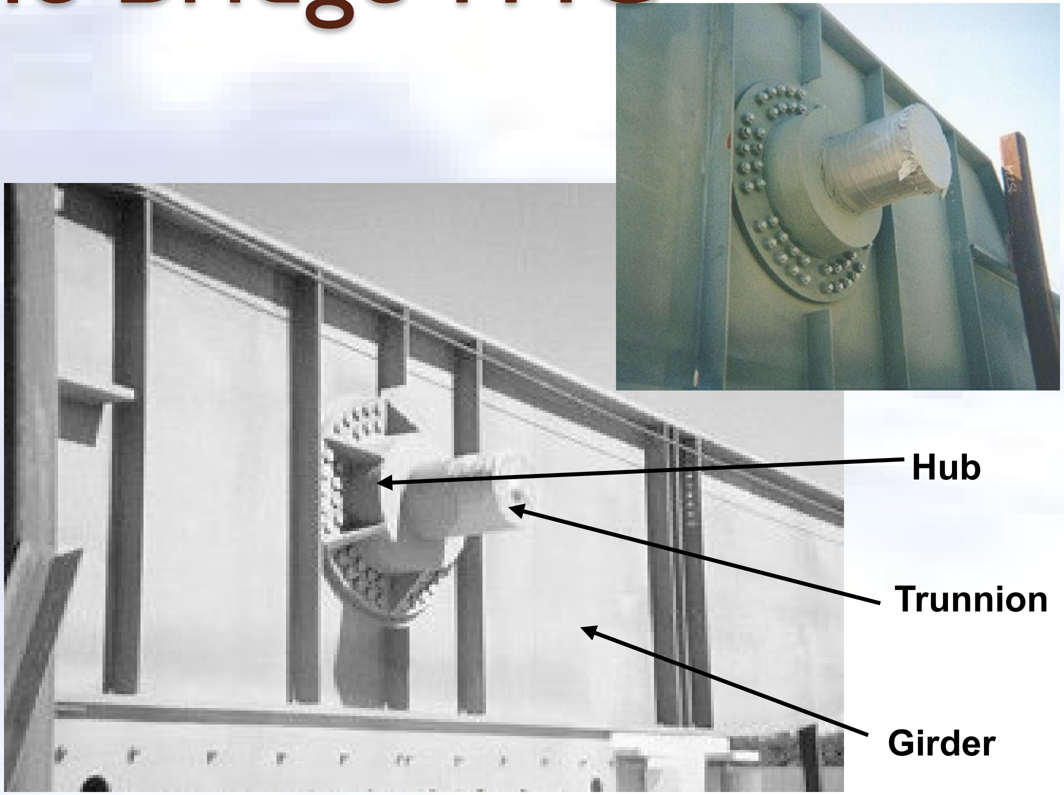
Why Use Numerical Methods?

- To solve problems that are intractable to solve exactly!

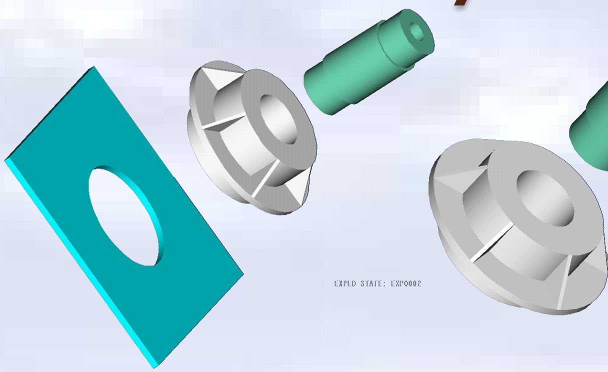
Bascule Bridge THG

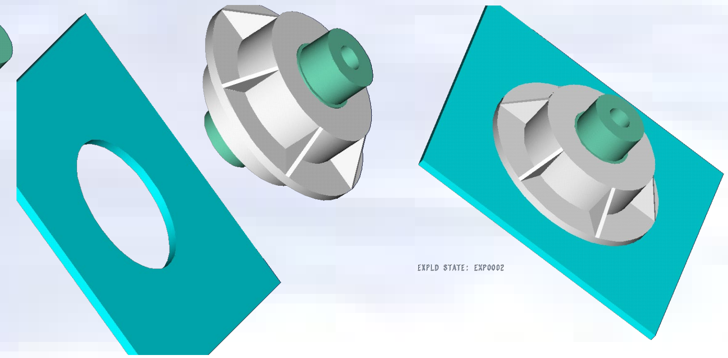


Bascule Bridge THG



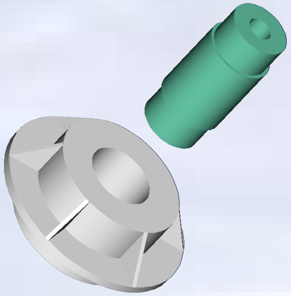
Trunnion-Hub-Girder Assembly Procedure





Step1.	Trunnion immersed in dry-ice/alcohol
Step2.	Trunnion warm-up in hub
Step3.	Trunnion-Hub immersed in dry-ice/alcohol
Step4.	Trunnion-Hub warm-up into girder

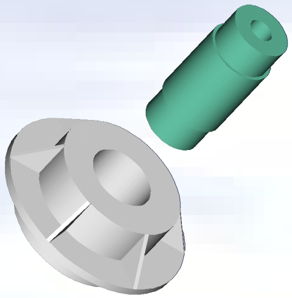
Problem



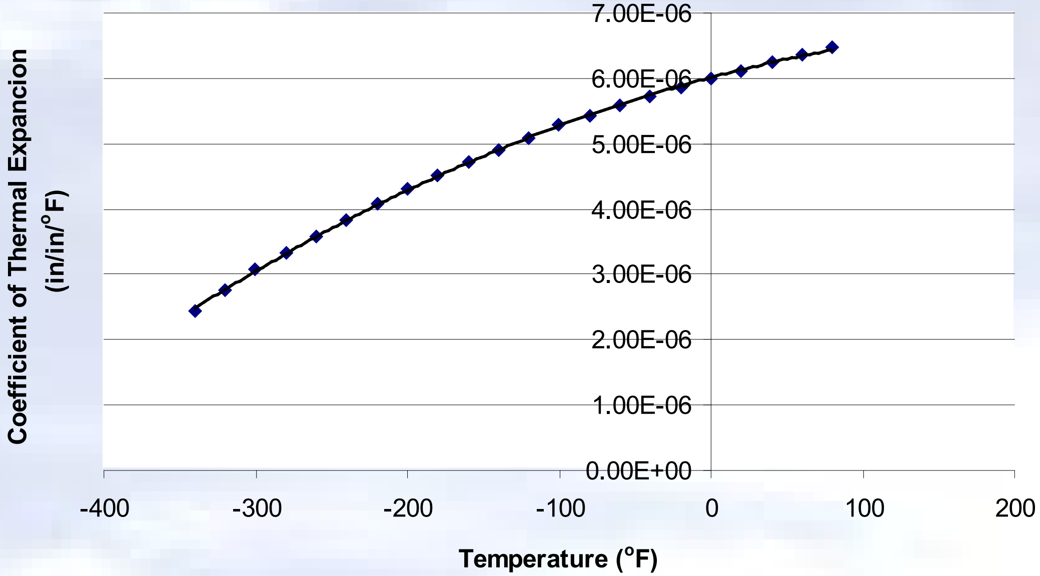
After Cooling, the Trunnion Got Stuck in Hub

Why did it get stuck?

Magnitude of contraction needed in the trunnion was 0.015″ or more. Did it contract enough?



What model should I use to calculate contraction of trunnion?



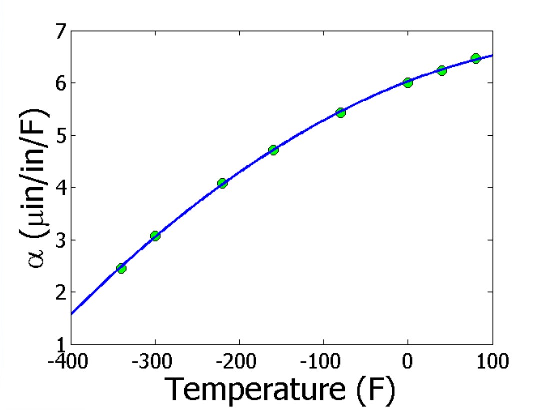
$$\Delta D = D\alpha\Delta T$$

$$\Delta D = D\int_{T_{room}}^{T_{fluid}} \alpha dT$$

Finding the fluid temperature to get enough contraction

$$\Delta D = D \int_{T_a}^{T_c} \alpha(T)\,dT$$

$T_a = 80^{o}F$
$T_c = ???^{o}F$
$D = 12.363''$
$\Delta D = -0.015''$



$$\alpha = -1.228 \times 10^{-5} T^2 + 6.195 \times 10^{-3} T + 6.015$$

$$-0.015 = 12.363 \int_{80}^{T_c} \left(-1.228 \times 10^{-5} T^2 + 6.195 \times 10^{-3} T + 6.015\right) dT$$

$$-0.015 = -5.059 \times 10^{-9} {T_c}^3 + 3.829 \times 10^{-6} {T_c}^2 + 7.435 \times 10^{-5} T_c - 6.166 \times 10^{-3}$$

$$f(T_c) = -5.059 \times 10^{-9} {T_c}^3 + 3.829 \times 10^{-6} {T_c}^2 + 7.435 \times 10^{-5} T_c + 8.834 \times 10^{-3} = 0$$

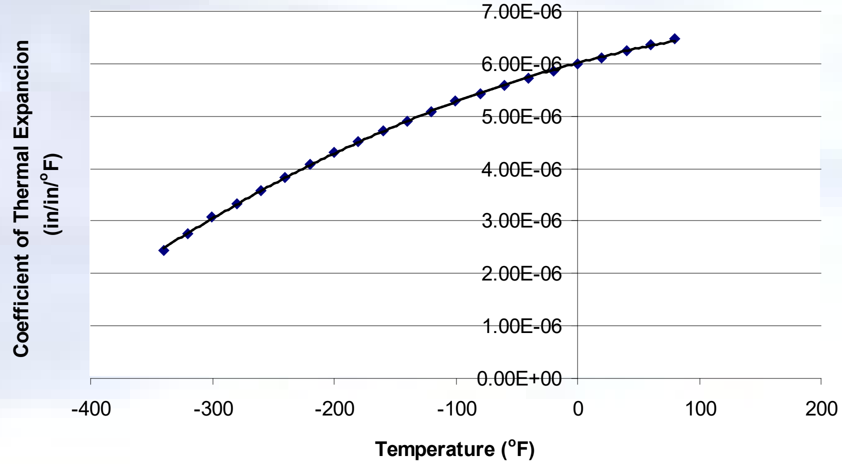
Finding the expression for thermal expansion coefficient

$$\Delta D = D \int_{T_{room}}^{T_{fluid}} \alpha dT$$

$$\alpha = a_0 + a_1 T + a_2 T^2$$

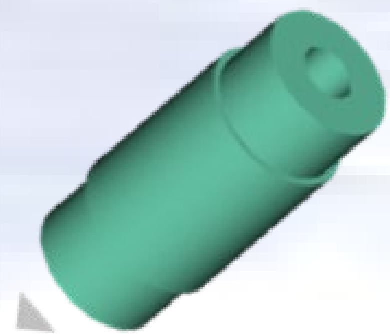
$$S_r = \sum_{i=1}^{n} \left(\alpha_i - \{a_0 + a_1 T_i + a_2 T_i^2\}\right)^2$$

$$\begin{bmatrix} n & \left(\sum_{i=1}^{n} T_i\right) & \left(\sum_{i=1}^{n} T_i^2\right) \\ \left(\sum_{i=1}^{n} T_i\right) & \left(\sum_{i=1}^{n} T_i^2\right) & \left(\sum_{i=1}^{n} T_i^3\right) \\ \left(\sum_{i=1}^{n} T_i^2\right) & \left(\sum_{i=1}^{n} T_i^3\right) & \left(\sum_{i=1}^{n} T_i^4\right) \end{bmatrix} \begin{bmatrix} a_0 \\ a_1 \\ a_2 \end{bmatrix} = \begin{bmatrix} \sum_{i=1}^{n} \alpha_i \\ \sum_{i=1}^{n} T_i \alpha_i \\ \sum_{i=1}^{n} T_i^2 \alpha_i \end{bmatrix}$$



$$\alpha = -1.2278 \times 10^{-11} T^2 + 6.1946 \times 10^{-9} T + 6.0150 \times 10^{-6}$$

What is the temperature of the trunnion after half an hour?



$$mc\frac{d\theta}{dt} = -hA(\theta - \theta_a), \quad \theta(0) = \theta_{room}$$

How long does it take a trunnion to cool down?

$$mc\frac{d\theta}{dt} = -hA(\theta - \theta_a),\ \theta(0) = \theta_{room}$$

What is the rate of change of heat stored in the cylinder?

$$mc\frac{d\theta}{dt} = -hA(\theta - \theta_a), \quad \theta(0) = \theta_{room}$$

Can you identify?

- We talked about 7 mathematical procedures in this course. Write them down.
- Now connect the problem just discussed to these 7 mathematical procedures on each of the previous slides.

THE END