Introduction to Computational Physics

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Introduction

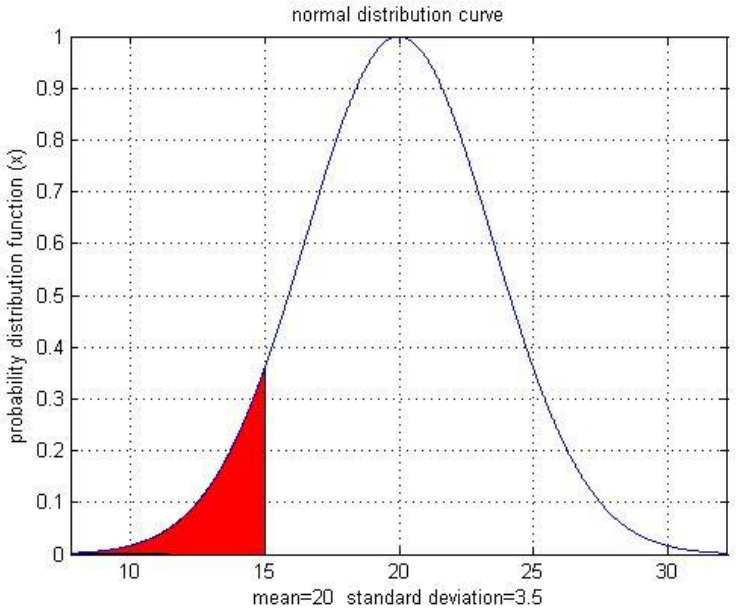
My advice

- *If you don't let a teacher know at what level you are by asking a question, or revealing your ignorance you will not learn or grow.*
- *You can't pretend for long, for you will eventually be found out. Admission of ignorance is often the first step in our education.*
  - *Steven Covey—Seven Habits of Highly Effective People*

Why use Numerical Methods?

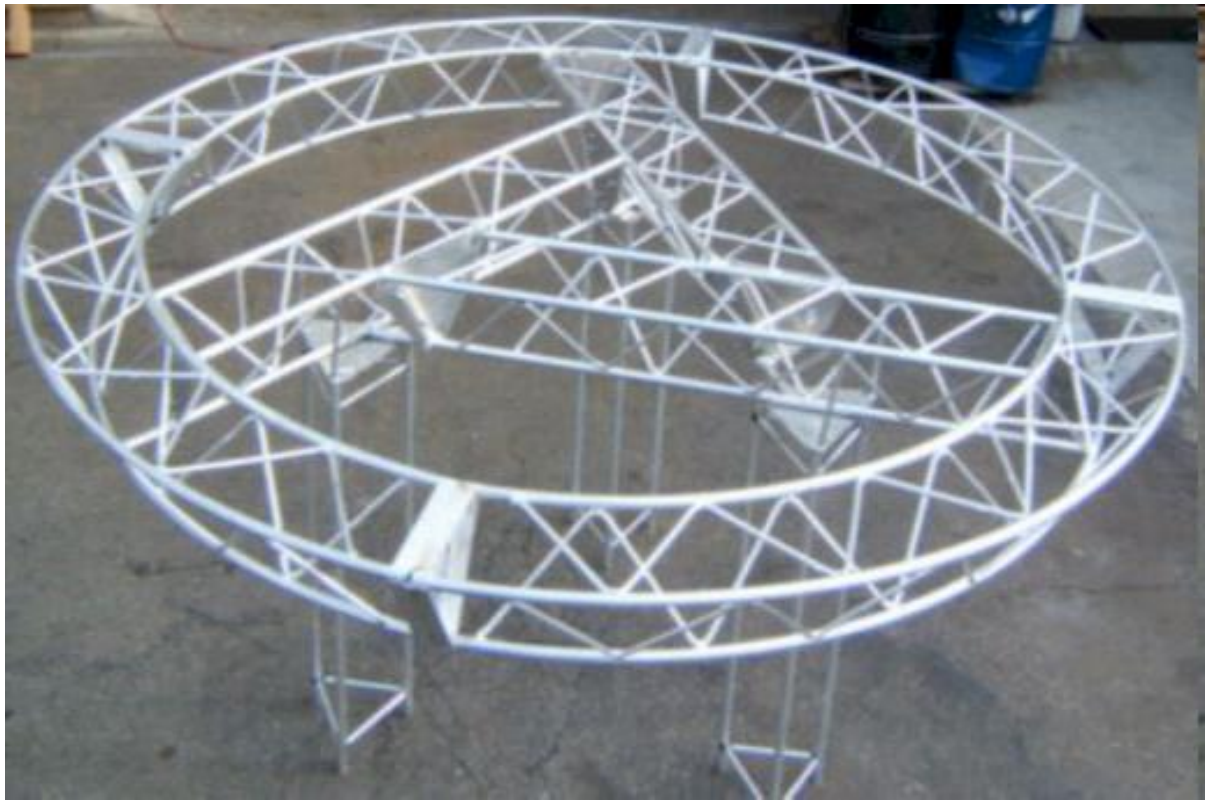
- To solve problems that cannot be solved exactly

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

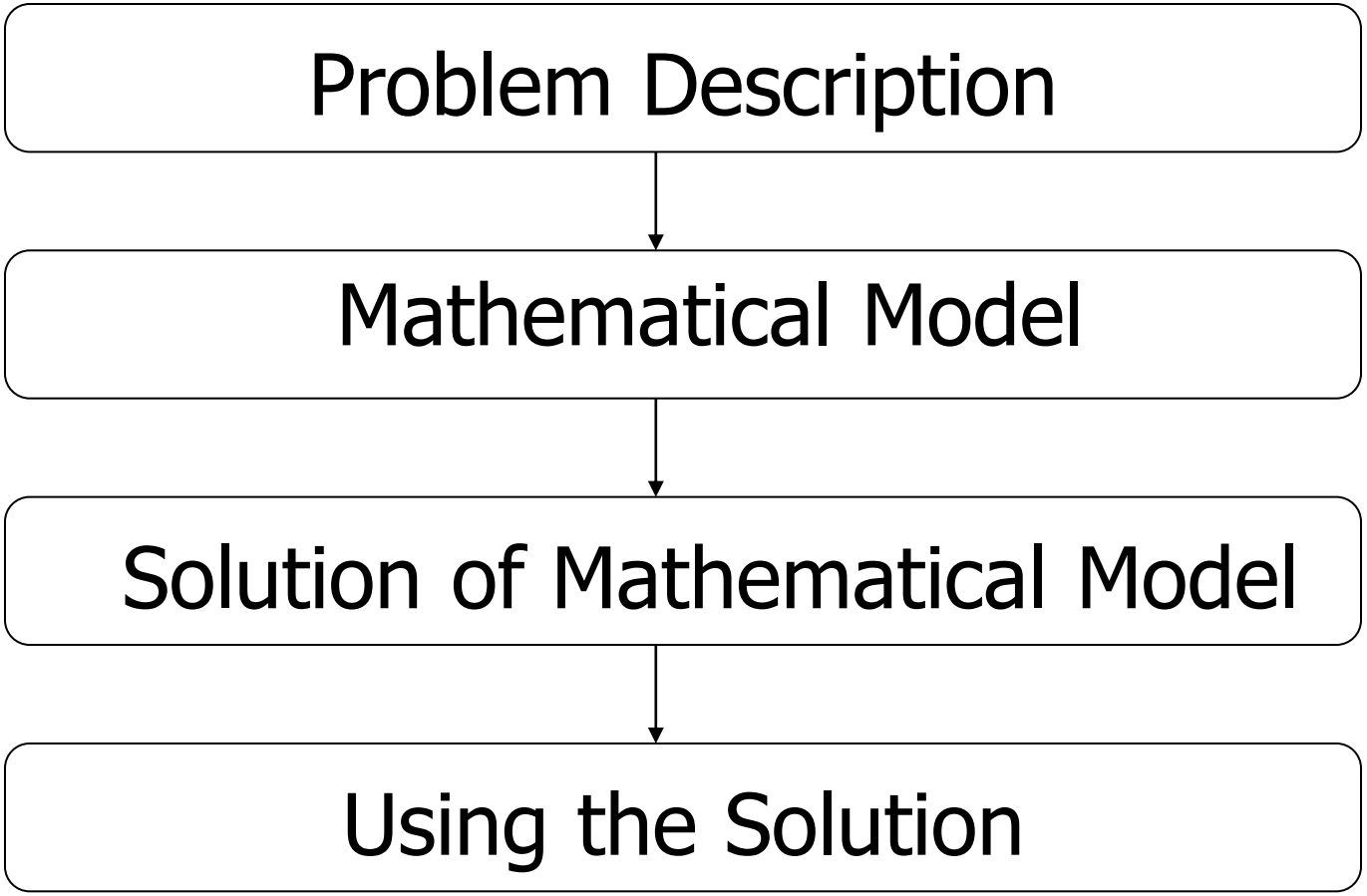


Why use Numerical Methods?

- To solve problems that are intractable!



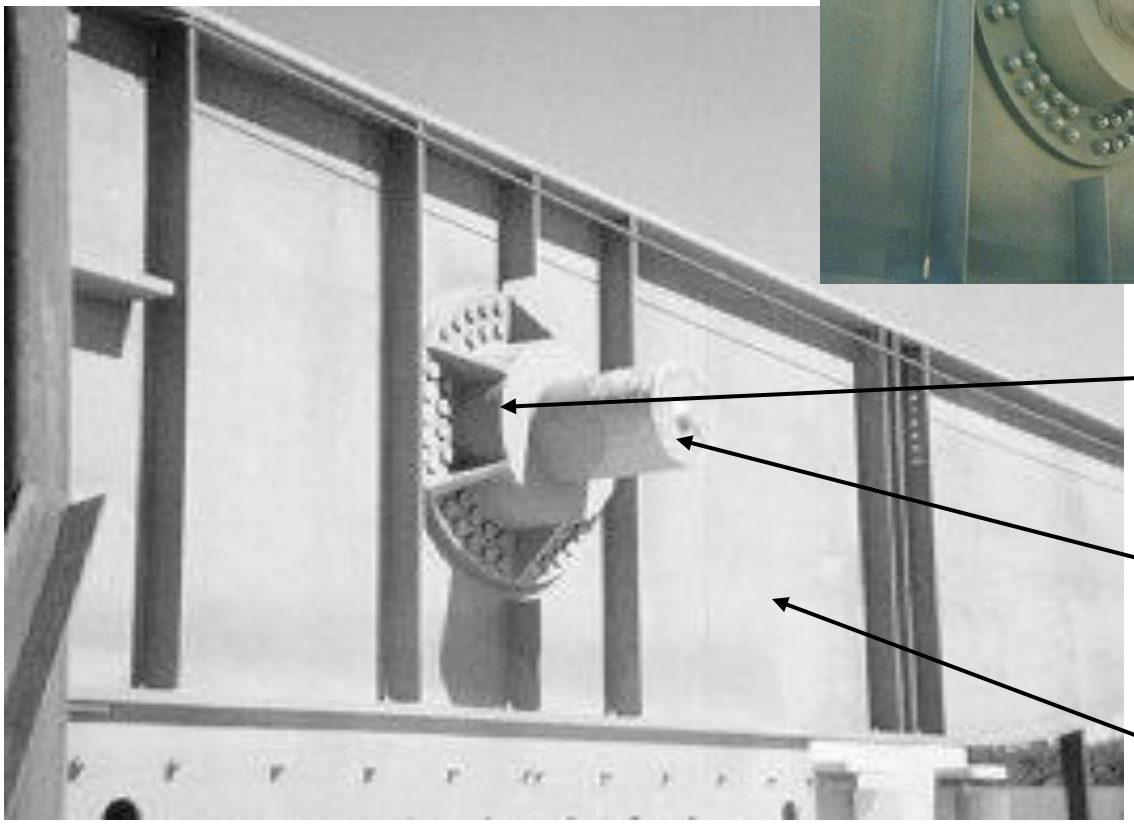
How do we solve a problem?



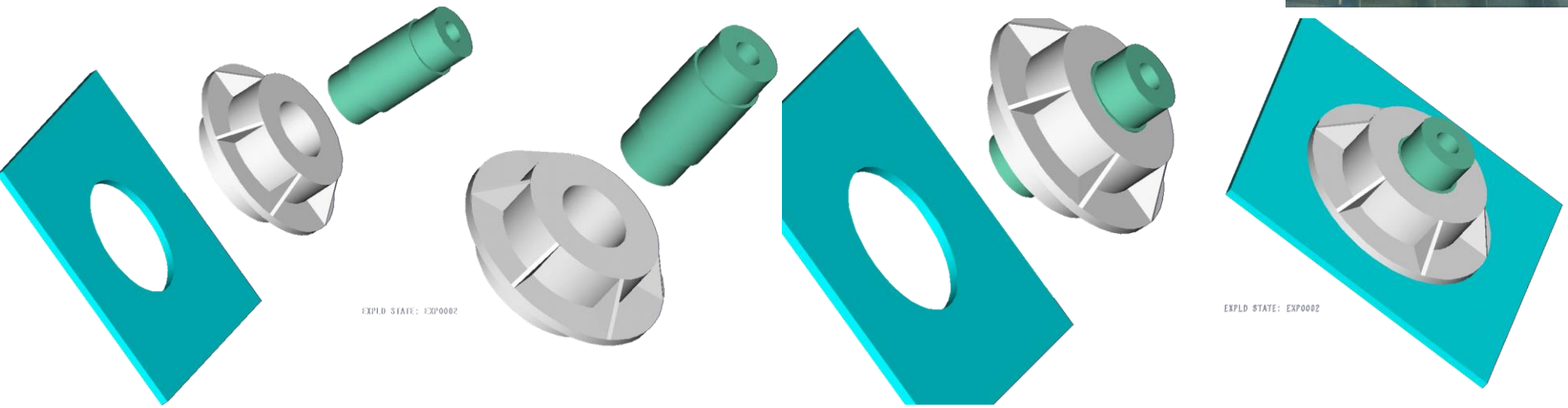
Example of Solving a Problem

Bascule Bridge THG

Bascule Bridge THG



Trunnion-Hub-Girder Assembly Procedure



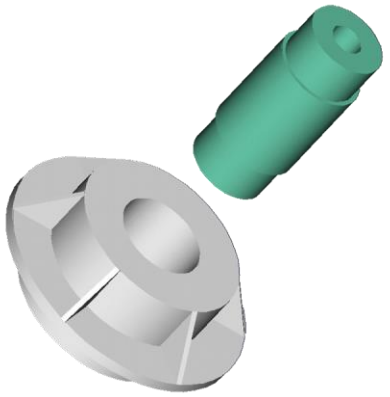
Step1. Trunnion immersed in dry-ice/alcohol

Step2. Trunnion warm-up in hub

Step3. Trunnion-Hub immersed in dry-ice/alcohol

Step4. Trunnion-Hub warm-up into girder

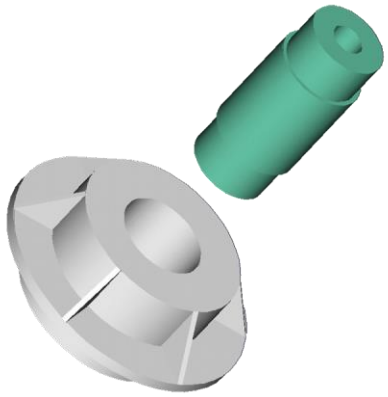
Problem



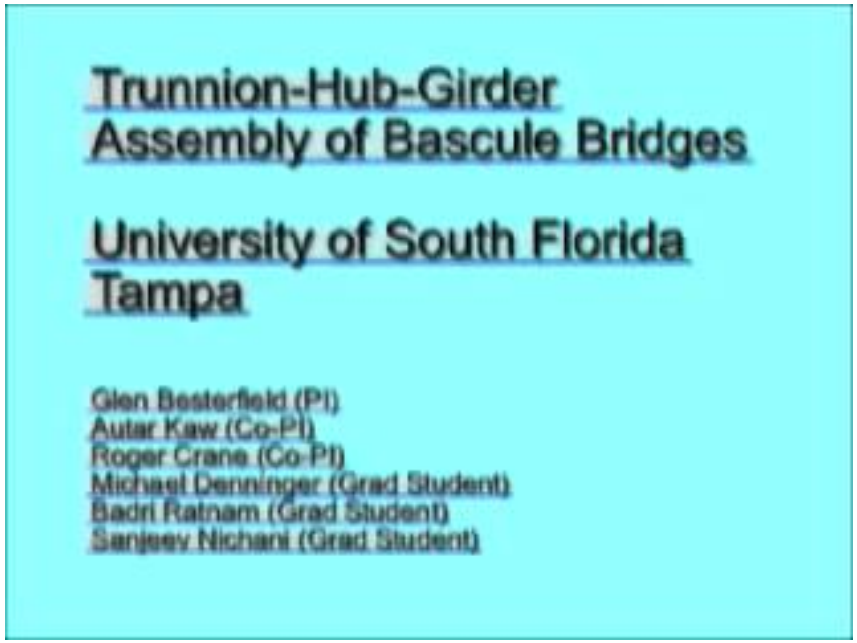
After Cooling, the Trunnion Got Stuck in Hub

Why did it get stuck?

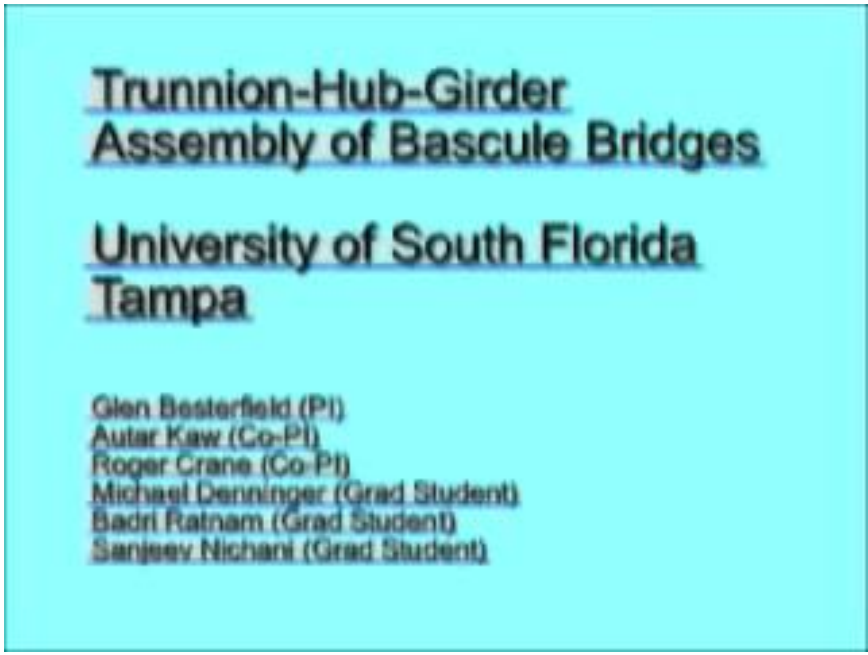
Magnitude of contraction needed in the trunnion was 0.015” or more. Did it contract enough?



Video of Assembly Process



Unplugged Version



VH1 Version

Consultant calculations

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

$$D = 12.363''$$

$$\alpha = 6.47 \times 10^{-6} in / in /^{o} F$$

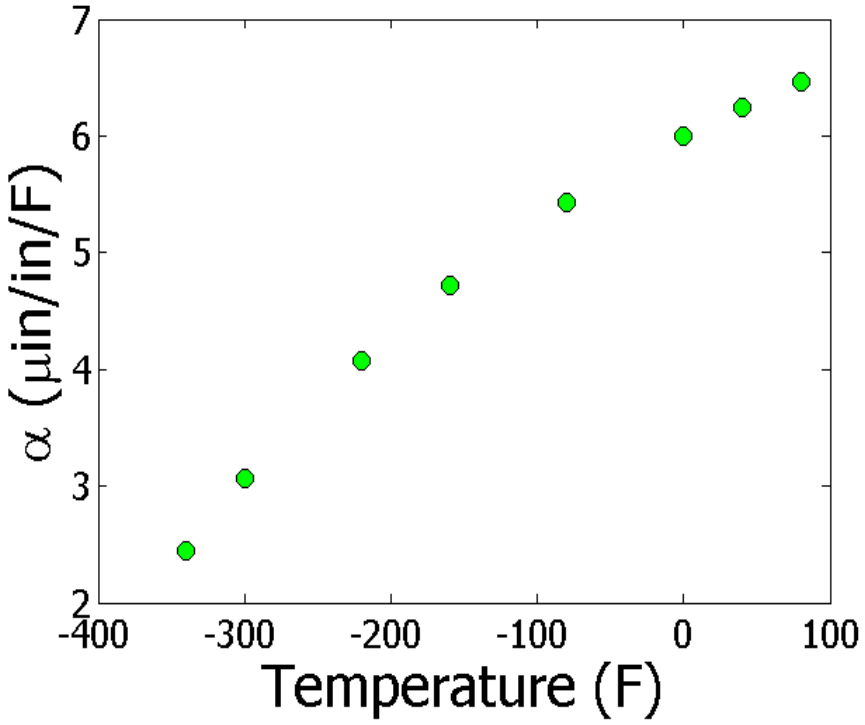
$$\Delta T = -108 - 80 = -188^{o} F$$

$$\Delta D = (12.363)(6.47 \times 10^{-6})(-188)$$

$$= -0.01504''$$

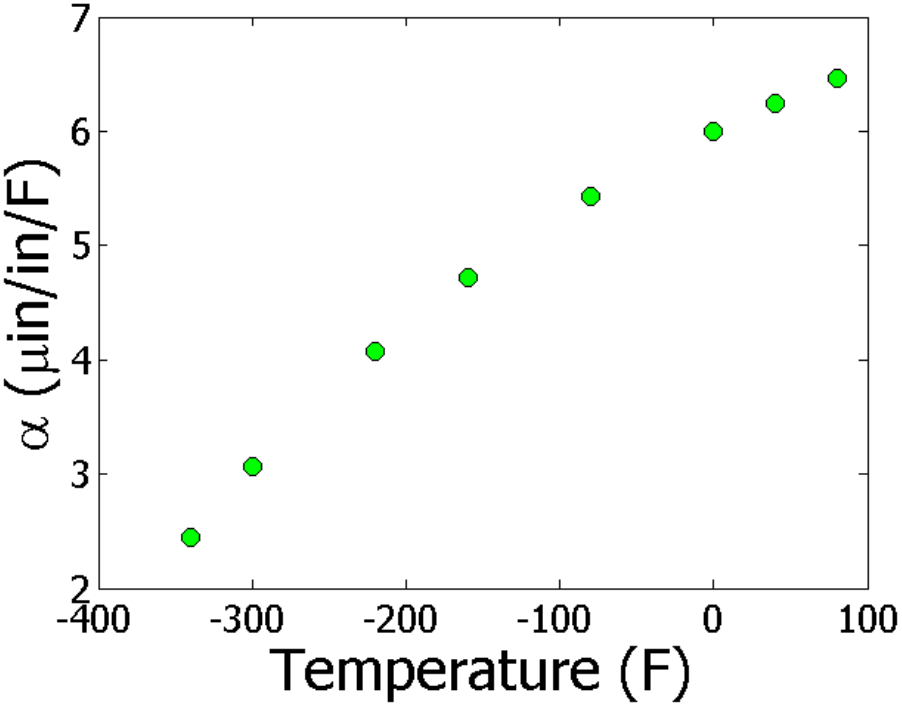
Is the formula used correct?

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



T(°F)	α (μin/in/°F)
-340	2.45
-300	3.07
-220	4.08
-160	4.72
-80	5.43
0	6.00
40	6.24
80	6.47

The Correct Model Would Account for Varying Thermal Expansion Coefficient

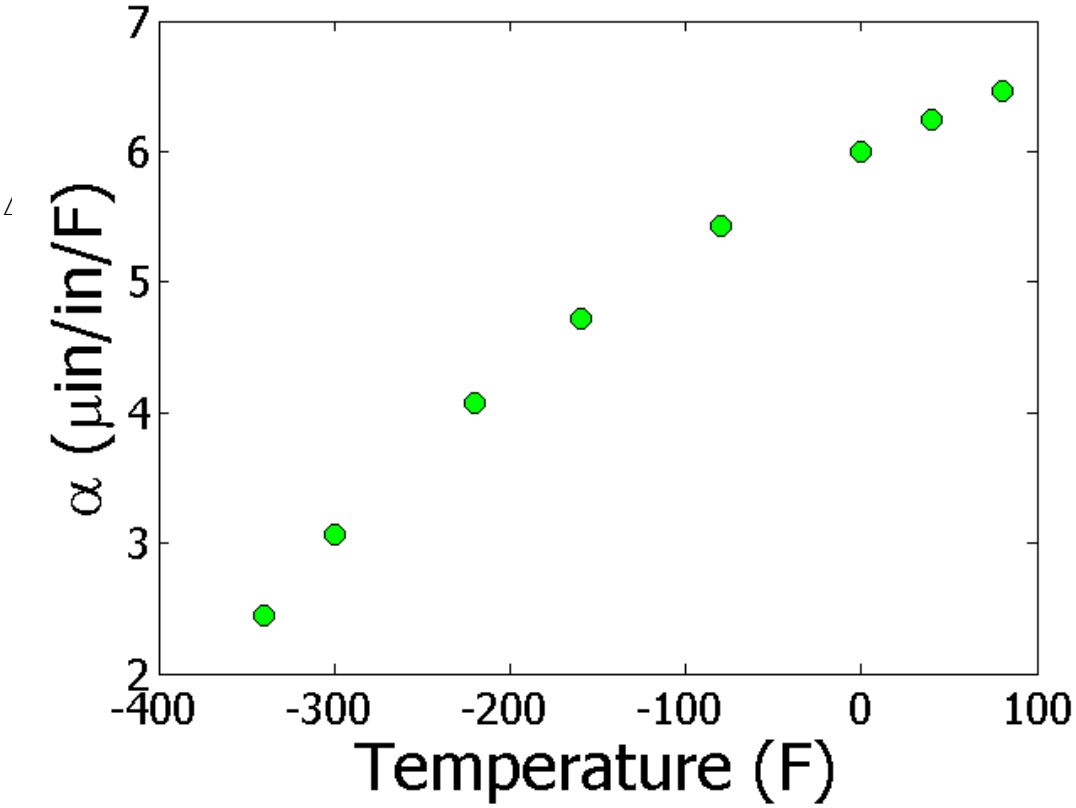


$$\Delta D = D\int_{T_a}^{T_c} \alpha(T)dT$$

Can You Roughly Estimate the Contraction?

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

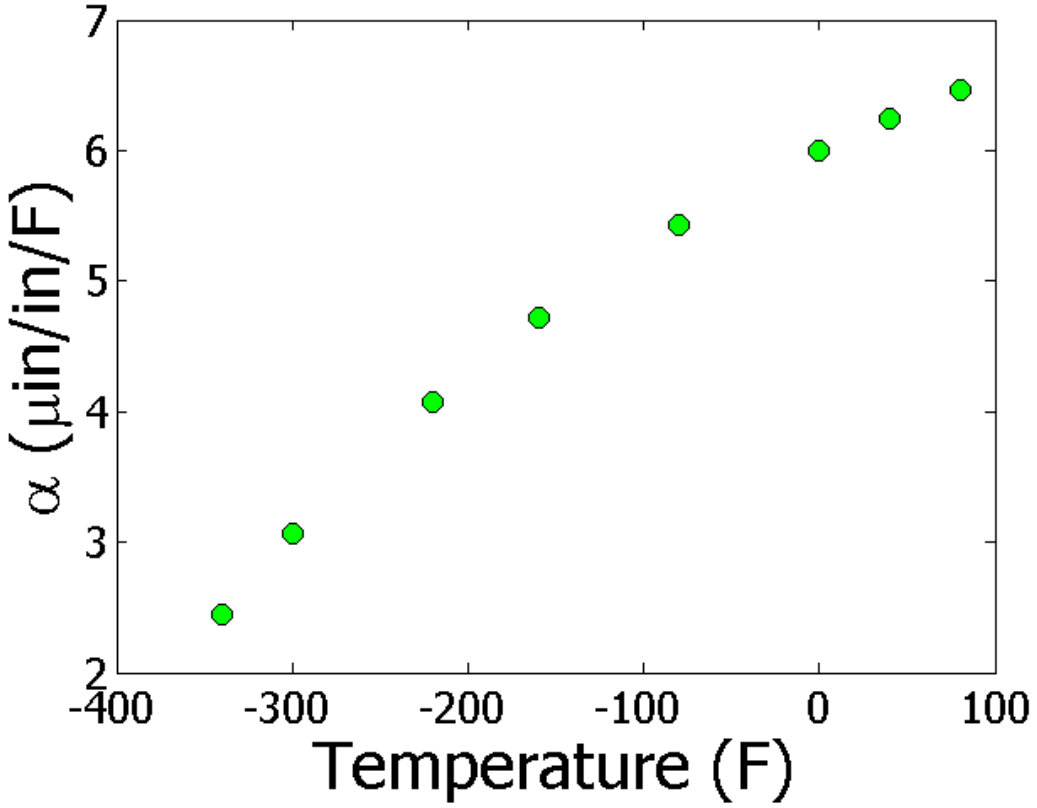
T_a=80°F; T_c=-108°F; D=12.363”



Can You Find a Better Estimate for the Contraction?

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

$T_a = 80^{o}\text{F}$
$T_c = -108^{o}\text{F}$
$D = 12.363"$

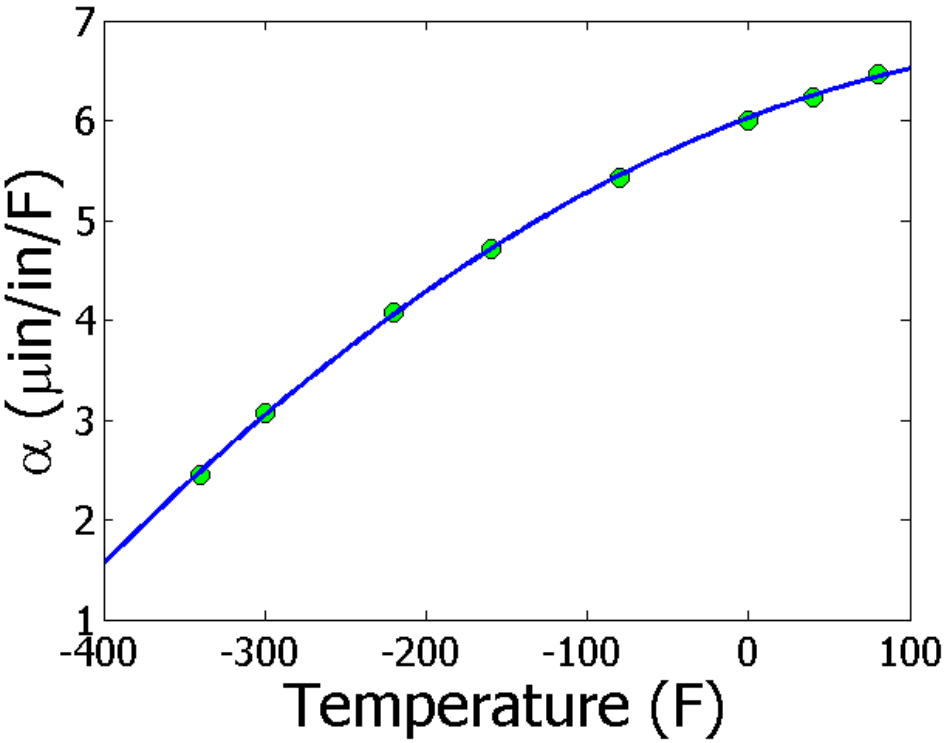


Estimating Contraction Accurately

Change in diameter (ΔD) by cooling it in dry ice/alcohol is given by

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

$$T_a = 80^{o}\text{F}$$
$$T_c = -108^{o}\text{F}$$
$$D = 12.363''$$



$$\alpha = -1.2278\times10^{-5}T^{2} + 6.1946\times10^{-3}T + 6.0150$$

$$\Delta D = -0.0137''$$

So what is the solution to the problem?

One solution is to immerse the trunnion in liquid nitrogen which has a boiling point of -321^{o}F as opposed to the dry-ice/alcohol temperature of -108^{o}F.

$$\Delta D = -0.0244''$$

Revisiting steps to solve a problem

1) Problem Statement: Trunnion got stuck in the hub.

2) Modeling: Developed a new model

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

3) Solution: 1) Used trapezoidal rule OR b) Used regression and integration.

4) Implementation: Cool the trunnion in liquid nitrogen.

THE END