Integrating Discrete Functions

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Integrating Discrete Functions

Spline Method

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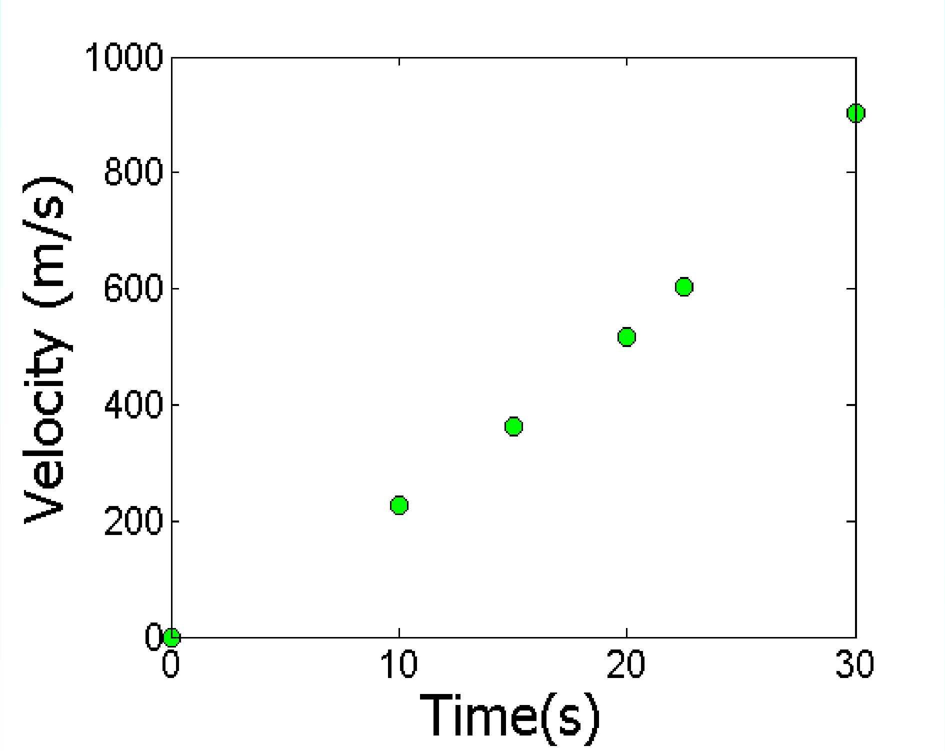
Problem Statement

The upward velocity of a rocket is given as a function of time. Using quadratic splines, find the distance covered between t=11 and t=16 seconds.

t	v(t)
s	m/s
0	0
10	227.04
15	362.78
20	517.35
22.5	602.97
30	901.67

Data and Plot

t	v(t)
s	m/s
0	0
10	227.04
15	362.78
20	517.35
22.5	602.97
30	901.67



Solution

$$v(t) = a_1 t^2 + b_1 t + c_1, \qquad 0 \le t \le 10$$
$$= a_2 t^2 + b_2 t + c_2, \qquad 10 \le t \le 15$$
$$= a_3 t^2 + b_3 t + c_3, \qquad 15 \le t \le 20$$
$$= a_4 t^2 + b_4 t + c_4, \qquad 20 \le t \le 22.5$$
$$= a_5 t^2 + b_5 t + c_5, \qquad 22.5 \le t \le 30$$

Distance from Velocity Profile

$$
\begin{aligned}
v(t) &= 22.704t, & 0 \le t \le 10 \\
&= 0.8888t^2 + 4.928t + 88.88, & 10 \le t \le 15 \\
&= -0.1356t^2 + 35.66t - 141.61, & 15 \le t \le 20 \\
&= 1.6048t^2 - 33.956t + 554.55, & 20 \le t \le 22.5 \\
&= 0.20889t^2 + 28.86t - 152.13, & 22.5 \le t \le 30
\end{aligned}
$$

$$S(16) - S(11) = \int_{11}^{16} v(t)\,dt$$

Distance from Velocity Profile

$$v(t) = 0.8888t^2 + 4.928t + 88.88, \quad 10 \le t \le 15$$
$$= -0.1356t^2 + 35.66t - 141.61, \quad 15 \le t \le 20$$

$$S(16) - S(11) = \int_{11}^{16} v(t)dt = \int_{11}^{15} v(t)dt + \int_{15}^{16} v(t)dt$$

$$= \int_{11}^{15} (0.8888t^2 + 4.928t + 88.88)dt$$

$$+ \int_{15}^{16} (-0.1356t^2 + 35.66t - 141.61)dt$$

$$= 1595.9 \text{ m}$$

END

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Integrating Discrete Functions

Regression Method

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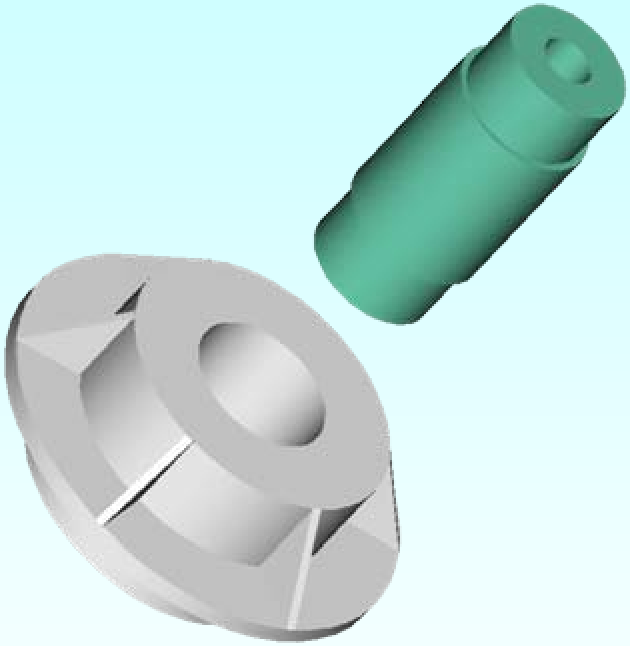
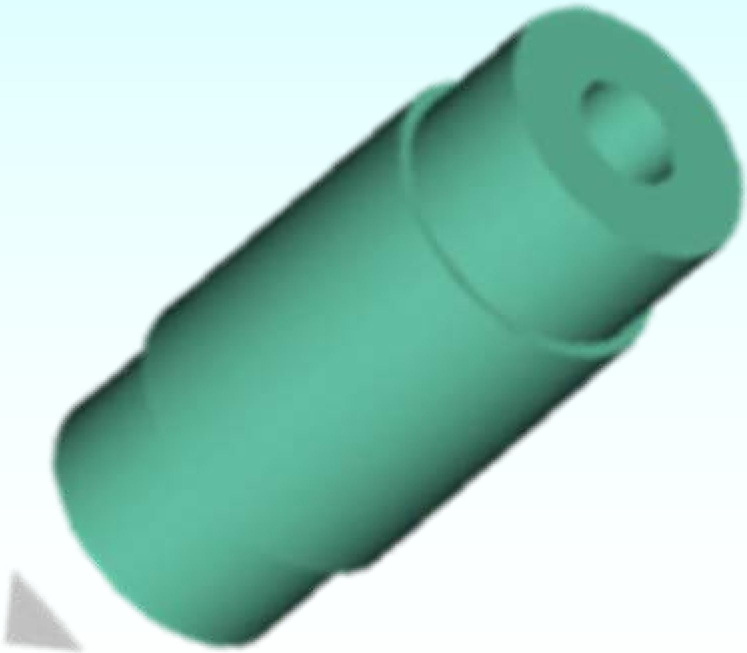
Trunnion Shrink Fit into Hub



Is the Contraction Enough?

Magnitude of contraction needed in the trunnion was 0.015” or more.



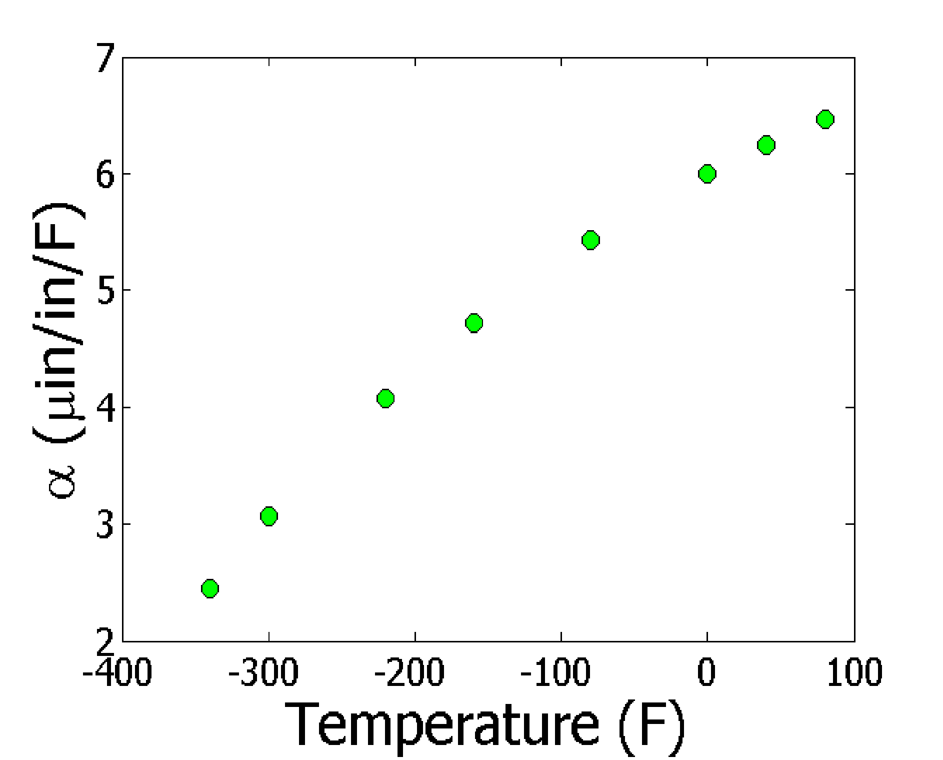
How do we find the contraction?

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

$T_a = 80^oF$
$T_c = -108^oF$
$D = 12.363"$

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

Regression Model



T(°F)	α (μin/in/°F)
-340	2.45
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-160	4.72
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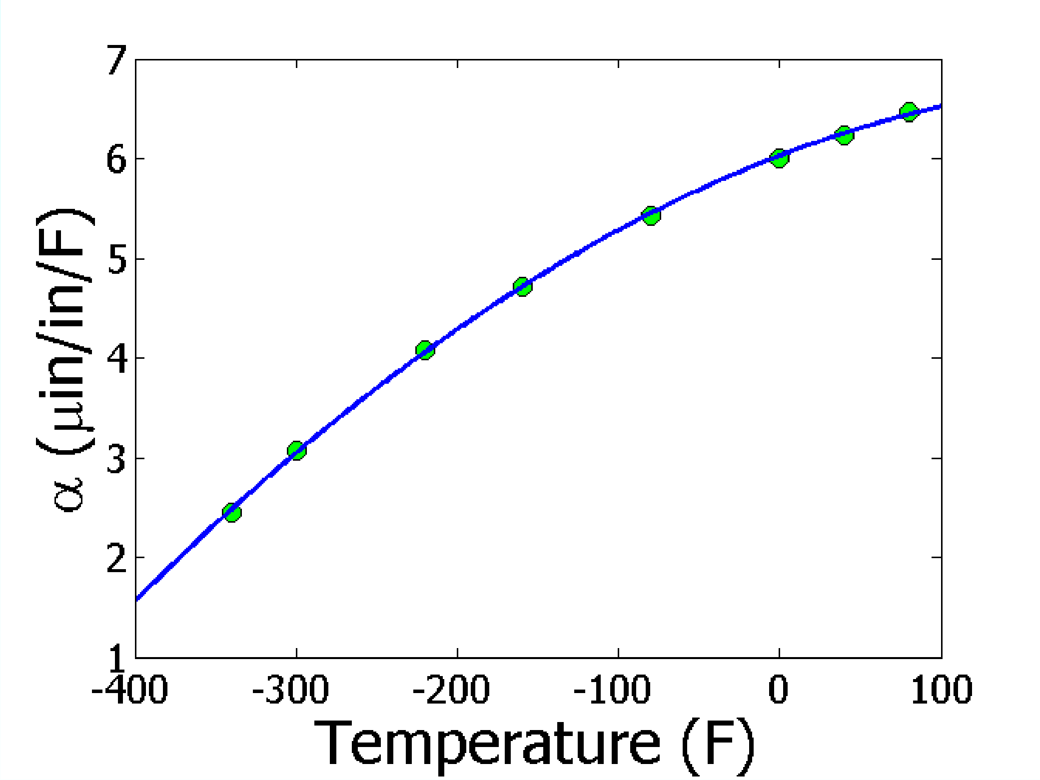
40	6.24
80	6.47

Estimating the Contraction



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

Calculating the contraction

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

$$\alpha = -1.2278 \times 10^{-5} T^2 + 6.1946 \times 10^{-3} T + 6.0150$$

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

$$= 12.363 \int_{80}^{-108} (-1.2278 \times 10^{-5} T^2 + 6.1946 \times 10^{-3} T + 6.0150) \times 10^{-6} dT$$

$$= -0.0137''$$

Magnitude of contraction needed in the trunnion was 0.015” or more.

THE END