

1 | linear approximations

1.1 | cube root

1.1.1 | approximation

$$(1+x)^{\frac{1}{3}} \rightarrow \frac{1}{3}(1+x)^{-\frac{2}{3}}$$

at $x = 0$ is

$$\frac{1}{3}(1+0)^{-\frac{2}{3}} = \frac{1}{3}$$

so the linear approximation is

$$y \approx m(x-0) + f(0) = \frac{1}{3}x + 1$$

1.1.2 | estimations

| value | estimate |
|-------|----------|
| 0.05 | 1.016666 |
| -0.25 | 0.916666 |

These will be overestimates because the graph is concave down in this region.

1.2 | sin(x)

1.2.1 | approximation

$$y \approx \left. \frac{d}{dx} \sin x \right|_0 (x-0) + \sin 0 = x$$

1.2.2 | estimates

| value | estimate |
|-------|----------|
| -0.1 | -0.1 |
| 0.1 | 0.1 |

The first estimate will be an underestimate because $\sin x$ is concave up in that region. The opposite is true for the second estimate.

1.3 | unknown function (only some points known)

1.3.1 | approximation

$$y \approx \left. \frac{d}{dx} f(x) \right|_c (x-c) + f(c)$$

plugging in $c = 1$,

$$y \approx 5(x-1) - 4$$

1.3.2 | estimations

| value | estimate |
|-------|----------|
| 1.2 | -3 |

This will be an underestimate because the second derivative is positive and the graph is thus concave up.

2 | differentials

For a function $y = f(x)$, dy and dx are differentials and the relationship is $dy = f'(x)dx = \frac{L(a+\Delta a) - L(a)}{\Delta x} dx$.

For a function written $f(x) = (\text{something})$, the differentials are df and dx and the relationship is the same: $df = f'(x)dx$.

2.1 | cube error

2.1.1 | differential

$$\begin{aligned} df &= f'(x)dx \\ &= 3x^2 dx \end{aligned}$$

2.1.2 | volume error

If I understand the use of differentials correctly, then x is the measured value (2) and dx is the uncertainty (delta x), or 0.2ft. Then, the change in the volume (change in function or df) would be $3(2)^2(0.2) = 2.4$

2.1.3 | max error for some ϵ

$$\begin{aligned} df &\approx 3x^2 dx \\ dx &\approx \frac{df}{3x^2} \\ \left[\right. &\approx \frac{1}{3(2)^2} \quad \left. \right] \\ &\approx \frac{1}{12} \text{ ft} = 1 \text{ in} \end{aligned}$$

2.2 | sphere measuring

$$\begin{aligned} f(r) &= \frac{4}{3}\pi r^3 \\ \left[\right. &\frac{df}{dr} = 4\pi r^2 \quad \left. \right] \\ df &= 4\pi r^2(dr) \\ &= 4\pi (2)^2(0.05) = \pm 88.4\pi \text{ cm}^3 \end{aligned}$$