ECEN321: Engineering Statistics Assignment 4 Submission

Daniel Eisen: 300447549

May 5, 2020

Measurement Error

1. (Navidi 3.1.2)

It is not possible to tell which thermometer is more accurate, as the mean value of both measurements is equidistant from the true value.

- (a) The first thermometer covers the range 16.2 to 16.6 and the second thermometer covers 16.7 to 16.9. Thus the first thermometer shows greater accuracy.
- (b) The second thermometer as a lower uncertainty, there is the more precise measurement.
- 2. (Navidi 3.1.8)
 - (a) Uncertainty = $s = \pm 0.6$ (b) Bias = 26.18



3. (Navidi 3.2.2)

$$\sigma_X = \frac{\sigma}{\sqrt{N}}$$

$$N = (\frac{\sigma}{\sigma_X})^2 = (\frac{1.5}{0.5})^2 = 9$$

4. (Navidi 3.2.6)
$$C = \frac{20.00 - 19.90}{2} = 0.05$$

$$\sigma_C = \sigma_{\frac{h+p}{2}} = \sqrt{\frac{1}{4}0.01^2 + \frac{1}{4}0.02^2} = 0.01118$$

Uncertainties for Functions of One Measurement

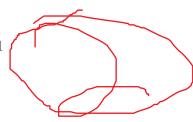
5. (Navidi 3.3.4) $T = 300 \pm 0.4$

$$V = 20.04\sqrt{T} = 347.102982$$

$$\frac{dV}{dR} = \frac{10.02}{\sqrt{T}}$$

$$\sigma_V \approx \left| \frac{10.02}{\sqrt{T}} \right| \cdot \sigma_T = \left| \frac{10.02}{\sqrt{300}} \right| 0.4 = 0.231401987891$$

$$V = 347.1 \pm 0.23 \ m/s$$



Uncertainties for Functions of Several Measurements

6. (Navidi 3.4.2) $V = \frac{\pi}{3}r^2h$, $r = 5.00 \pm 0.02$ cm, $h = 6.00 \pm 0.01$ cm

(a)
$$V = \frac{\pi}{3}25.6 = 157.079633$$

 $\frac{\delta V}{\delta r} = \frac{2\pi}{6}rh, \quad \frac{\delta V}{\delta h} = \frac{\pi}{3}r^2$
 $\sigma_V = \sqrt{(\frac{\pi}{6}rh)^2\sigma_r^2 + (\frac{\pi}{3}r^2)^2\sigma_h^2} = \sigma_V = \sqrt{(\frac{\pi}{6}5.6)^20.02^2 + (\frac{\pi}{3}25)^20.01^2} = 1.28361817673$
 $V = 157 \pm 1.28 \ cm^3$

- (b) $\sqrt{(\frac{\pi}{6}5 \cdot 6)^2 0.01^2 + (\frac{\pi}{3}25)^2 0.01^2} = 0.680678408278$ $\sqrt{(\frac{\pi}{6}5 \cdot 6)^2 0.02^2 + (\frac{\pi}{3}25)^2 0.005^2} = 1.26343635931$ \therefore reducing r to 0.01
- 7. (Navidi 3.4.14) $R = kl/d^2, \ l = 14.0 \pm 0.1 \ cm, \ d = 4.4 \pm 0.1 \ cm$

(a)
$$R = 14/4.4^2k = \frac{16k}{19.36}$$

 $\frac{\delta R}{\delta l} = k/d^2 = k/4.4^2 = \frac{k}{19.36}$
 $\frac{\delta R}{\delta d} = -2kl/d^3 = \frac{-28k}{85.184}$
 $\sigma_R = \sqrt{(\frac{k}{19.36})^2 0.1^2 + (\frac{-28k}{85.184})^2 0.1^2} = 0.03327k$
 $R = \frac{16k}{19.36} \pm 0.033\Omega$

(b)
$$\sigma_l = 0.05 \rightarrow \sigma_R = 0.0329k$$

 $\sigma_d = 0.05 \rightarrow \sigma_R = 0.0172k$
 \therefore reducing d's uncertainty