ECEN321 : Engineering Statistics
Assignment 4 Submission

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Measurement Error

1. (Navidi 3.1.2)
   (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 $= 26.18$

Linear Combinations of Measurements

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) $T = 300 \pm 0.4$
   $V = 20.04\sqrt{T} = 347.102982$
   $\frac{dV}{dR} = \frac{10.02}{\sqrt{T}}$
   $\sigma_V \approx \left|\frac{10.02}{\sqrt{T}}\right| \cdot \sigma_T = \left|\frac{10.02}{\sqrt{300}}\right| \cdot 0.4 = 0.231401987891$

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

Uncertainties for Functions of Several Measurements

6. (Navidi 3.4.2) $V = \frac{\pi}{3}r^2h,\;\; r = 5.00\pm0.02\ cm,\;\; h = 6.00\pm0.01\ cm$

   (a) $V = \frac{\pi}{3}25{\cdot}6 = 157.079633$
   $\frac{\delta V}{\delta r} = \frac{2\pi}{6}rh,\;\; \frac{\delta V}{\delta h} = \frac{\pi}{3}r^2$
   $\sigma_V = \sqrt{(\frac{\pi}{6}rh)^2\sigma_r^2 + (\frac{\pi}{3}r^2)^2\sigma_h^2} = \sigma_V = \sqrt{(\frac{\pi}{6}5{\cdot}6)^2 0.02^2 + (\frac{\pi}{3}25)^2 0.01^2} = 1.28361817673$

   $V = 157\pm1.28\ cm^3$

   (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) $R = kl/d^2,\; l = 14.0\pm0.1\ cm,\; d = 4.4\pm0.1\ cm$

   (a) $R = 14/4.4^2k = \frac{16k}{19.36}$
   $\frac{\delta R}{\delta l} = k/d^2 = k/4.4^2 = \frac{k}{19.36}$
   $\frac{\delta R}{\delta d} = -2kl/d^3 = \frac{-28k}{85.184}$
   $\sigma_R = \sqrt{(\frac{k}{19.36})^2 0.1^2 + (\frac{-28k}{85.184})^2 0.1^2} = 0.03327k$

   $R = \frac{16k}{19.36}\pm0.033\Omega$

   (b) $\sigma_l = 0.05 \rightarrow \sigma_R = 0.0329k$
   $\sigma_d = 0.05 \rightarrow \sigma_R = 0.0172k$
   $\therefore$ reducing d's uncertainty