4.1

- 17.87 m → 4 s.f
- 0.4730 Km → 4 s.f
- 17.9 sec → 3 s.f
- 0.473 → 3 s.f
- 18 ns → 2 s.f
- 0.47 Ω → 2 s.f
- $1.34 \times 10^2 \frac{m}{s}$ → 3 s.f
- 2.567×10^5 cm → 4 s.f
- 2.0×10^{10} J → 2 s.f
- 1.001 sec → 4 s.f
- 1.000 sec → 4 s.f
- 1 oz → 1 s.f
- 1000 Liters → 1 s.f
- 1001 cm^2 → 4 s.f

4.2

a) $231.3 + 5.8 \times 10^2$ ⇒ (You must write the both in scientific notation)

$(2.313 + 5.8) \times 10^2 = 8.113 \times 10^2 = \boxed{8.1 \times 10^2}$

(2.313: 3 decimal pt; 5.8: 1 decimal point)

b) $24.7 \times 2.7 \times 10^4 = 66.69 \times 10^4 = \boxed{67 \times 10^4}$

(24.7: 3 s.f; 2.7: 2 s.f)

c) ~~141.65~~ $217.0 - 141.65 = 75.35 = \boxed{75.4}$

(217.0: 1 decimal point; 141.65: 2 decimal point)

4.3

3.13 / 3.22 / 3.32 / 3.21 / 3.17 {By using calculator SD}

$\bar{h} \pm \sigma_m = (3.21 \pm 0.03)$ m

4.4

a) $\bar{L} = 87.414$ cm

b) Sample standard deviation $\sigma_5 = 0.24103 \sim \boxed{0.2 \text{ cm}}$

c) σ_m = uncertainty in the length $= \frac{\sigma_5}{\sqrt{7}} = \frac{0.24103}{\sqrt{7}}$

$\sigma_m = 0.0911 \sim \boxed{0.09 \text{ cm}}$

$\bar{L} \pm \sigma_m = (87.41 \pm 0.09)$ cm

[4.5] 9.87, 9.75, 9.63, 9.80, 9.72, 9.73, 9.78, 9.67, 9.81, 9.63

a) $\sigma_s = 0.07936$

$\bar{g} = 9.739 \frac{m}{s^2}$

$\sigma_m = 0.02509$

$\sigma_m \sim 0.03 \frac{m}{s^2}$

b) $\bar{g} \pm \sigma_m = (9.74 \pm 0.03) \frac{m}{s^2}$

c) $g_{true} = 9.81$

$D = |g_{exp} - g_{true}| = |9.81 - 9.74| = 0.07 > 0.06$

$2\Delta g = 2 \times 0.03 = 0.06$ not accepted

[4.6] a) $3.565 \pm 0.035 \rightarrow 3.56 \pm 0.04$

b) $4.02 \pm 0.02315 \rightarrow 4.02 \pm 0.02$

c) $1.75143 \pm 1 \rightarrow 2 \pm 1$

d)

e) $0.000,000,432 \pm 0.000,000,07 \rightarrow 0.00000043 \pm 0.00000007$

f) $2.362 \times 10^3 \pm 21 \rightarrow 2.362 \times 10^3 \pm 0.02 \times 10^3$

$(2.36 \pm 0.02) \times 10^3$

[4.7] a) $g = 10.4 \pm 1.1 \frac{m}{s^2}$, $g = 9.8 \frac{m}{s^2}$ [$2 \times 1.1 = 2.2$]

$D = |10.4 - 9.8| = 0.6 < 2.2$ accepted

b) $T = 2.5 \pm 0.2$ sec $T = 3.1$ sec [$2 \times 0.2 = 0.4$]

$D = |2.5 - 3.1| = 0.6 < 0.4$ accepted

c) Ignore it

4.8 $L = 8.27 \pm 0.05\ cm$, $W = 5.12 \pm 0.02\ cm$

$$A = LW = 8.27 \times 5.12 = 42.3424\ cm^2$$

$$\frac{\Delta A}{A} = \frac{\Delta L}{L} + \frac{\Delta W}{W} \Rightarrow \Delta A = A\left[\frac{\Delta L}{L} + \frac{\Delta W}{W}\right]$$

$$\Delta A = 42.3424\left[\frac{0.05}{8.27} + \frac{0.02}{5.12}\right]$$

$$\Delta A = 0.4214 = \underline{\underline{0.4\ cm^2}}$$

$$A = (42.3 \pm 0.4)\ cm^2$$

4.9 a) $a + b - c = R$

$$\Delta R = \Delta a + \Delta b + \Delta c$$

$\left\{ R = 5,\ \Delta R = 4 \quad R = 5 \pm 4 \right.$

b) $R = ct^2$, $\frac{\Delta R}{R} = \frac{\Delta c}{c} + 2\frac{\Delta t}{t}$

$$\Delta R = ct^2\left[\frac{\Delta c}{c} + \frac{\Delta t}{t}\right]$$

c) $R = \frac{mb}{t} \longrightarrow \frac{\Delta R}{R} = \frac{\Delta m}{m} + \frac{\Delta b}{b} + \frac{\Delta t}{t}$

$$\Delta R = \frac{mb}{t}\left[\frac{\Delta m}{m} + \frac{\Delta b}{b} + \frac{\Delta t}{t}\right]$$

d) $\ln\left(\frac{c}{a}\right) = R$ let $\frac{c}{a} = X \Rightarrow R = \ln X$, $\Delta R = \frac{\Delta X}{X}$

$$X = \frac{c}{a} \Rightarrow \frac{\Delta X}{X} = \frac{\Delta c}{c} + \frac{\Delta a}{a}$$

so $\Delta R = \frac{\Delta c}{c} + \frac{\Delta a}{a}$

e) $R = \exp\left(\frac{b}{ac}\right)$ "use general Rule" $\Rightarrow R = \exp\left[b a^{-1} c^{-1}\right]$

$$\Delta R = \left|\frac{\partial R}{\partial b}\right|\Delta b + \left|\frac{\partial R}{\partial a}\right|\Delta a + \left|\frac{\partial R}{\partial c}\right|\Delta c$$

$$\Delta R = \left(\frac{1}{ac}\Delta b + \frac{b}{a^2 c}\Delta a + \frac{b}{ac^2}\Delta c\right)\exp\left[\frac{b}{ac}\right]$$

4.10 $y = v_i t + \frac{1}{2} g t^2$

$v_i = (2.4 \pm 0.2)\ \frac{m}{s}$

$g = (9.80 \pm 0.02)\ \frac{m}{s^2}$

$t = (3.45 \pm 0.05)\ s$

a) $y \pm \Delta y$, $y = 66.60225$

$$y = (67 \pm 3)\,m$$

{ let $y = A + B$

$\Delta y = \Delta A + \Delta B$

$\Rightarrow A = v_i t$

$\Delta A = v_i \Delta t + t \Delta v_i$

$\Delta A = 0.81\ m$

$\Rightarrow B = \frac{1}{2} g t^2$ $\Rightarrow B = 58.3223$

$$\frac{\Delta B}{B} = \frac{\Delta g}{g} + 2\frac{\Delta t}{t}$$

$$\Delta B = 58.3223\left[\frac{0.02}{9.8} + \frac{(0.05)2}{3.45}\right]$$

$\Delta B = 1.8095\ m$

$\Delta y = \Delta A + \Delta B$

$= 0.81 + 1.8095 = 2.6\ m$

$\Delta y = 3\,m$

b) most Important effect on y's uncertainty?

$\Delta y = \Delta A + \Delta B = v_i \Delta t + t \Delta v_i + \frac{1}{2} t^2 \Delta g + g t \Delta t$

$\Delta y = t \Delta v_i + (v_i + gt)\Delta t + \frac{1}{2} t^2 \Delta g$

$= 0.69 + 1.8105 + 0.11903 = \underline{2.6\ m}$

(t) has the Important effect on y's uncertainty since the term that includes (Δt) is the largest term

• Least effect on y's uncertainty?

g — the term that includes Δg is the smallest one.