1.2 Propagating uncertainties

1. 0.08 ± 0.02 m

2. Speed $= \frac{\text{distance}}{\text{time}} = \frac{3000}{400} = 7.5 \text{ m.s}^{-1}$

% uncertainty in distance $= \frac{100}{3000} \times 100 = 3.3\%$

% uncertainty in time $= \frac{10}{400} \times 100 = 2.5\%$

We are dividing, so we add % $\longrightarrow 3.3\% + 2.5\% = 5.8\%$

5.8% of $7.5 \text{ (m.s}^{-1}\text{)} = \frac{5.8}{100} \times 7.5 = 0.435$

Average speed $= \underline{7.5 \pm 0.4} \text{ m.s}^{-1}$

3. Area = Length × width $= 7.10 \times 3.45 = 24.495 \text{ m}^2$

% uncertainty in length $= \frac{0.05}{7.10} \times 100 = 0.7\%$

% uncertainty in width $= \frac{0.05}{3.45} \times 100 = 1.4\%$

} Add %, so uncert in area $= 0.7 + 1.4 = 2.1\%$

2.1% of $24.495 = \frac{2.1}{100} \times 24.495 = 0.51$

So area $= 24.5 \pm 0.5 \text{ m}^2$, he needs to buy $\underline{25} \text{ m}^2$

4. Volume $= 20.0 \times 10.0 \times 1.8 = 360 \text{ cm}^3$

% uncert in length $= \frac{0.2}{20} \times 100 = 1\%$

% uncert in width $= \frac{0.2}{10.0} \times 100 = 2\%$

% uncert in height $= \frac{0.2}{1.8} \times 100 = 11.1\%$

} Add % uncerts, $1 + 2 + 11.1 = 14.1\%$

14.1% of $360 = 50.76$

$\therefore$ Volume $= \underline{360 \pm 50} \text{ cm}^3$

5. $E_K = \frac{1}{2}mv^2 = \frac{1}{2} \times 1.80 \times 8.2^2 = 60.516$

% uncert in mass $= \frac{0.01}{1.80} \times 100 = 0.56\%$

% uncert in velocity $= \frac{0.2}{8.2} \times 100 = 2.4\%$ ← "Used" twice ($v^2 = v \times v$)

Total uncert $= 0.56\% + 2.4\% + 2.4\% = 5.36\%$

5.36% of $60.516 = \frac{5.36}{100} \times 60.516 = 3.24$

$\boxed{E_K = 61 \pm 3 \text{ J}}$

P.T.O

6. $a = \frac{2h}{t^2} = \frac{2 \times 5.25}{(1.14)^2} = 8.079 \ m.s^{-2}$

% uncert in height $= \frac{0.15}{5.25} \times 100 = 2.9\%$

% uncert in time $= \frac{0.06}{1.14} \times 100 = 5.3\%$ ← Used twice ($t^2 = t \times t$)

Total uncertainty $= 2.9\% + 5.3\% + 5.3\% = 13.5\%$

13.5% of $8.079 = 1.09$

$a = 8 \pm 1 \ m.s^{-2}$

7. Not good accuracy as the result is not near the real value ($9.81 \ m.s^{-2}$). This is probably due to air resistance (c). It's not too bad though!!

8. Reduce air resistance (d)