

P1.1 - Uncertainty –

Any measurement or value in Physics will have an uncertainty. Here’s how to estimate that uncertainty:

- Measuring with a ruler: The uncertainty is \pm half the smallest division on the ruler. If you measure something that is 12.4 cm long with a ruler that has mm divisions, then your uncertainty is $\pm .5$ mm or $\pm .05$ cm so you would say $12.4 \pm .05$ cm
- Using a digital readout: The uncertainty is \pm the last digit. If you have an ammeter that reads 1.56 Amps, it would be $1.56 \pm .01$ Amps.
- Multiple trials of something with random error: You could say that it is the average, \pm range/2. If you did 3 trials for the rocket lab, and a rocket stayed up in the air for 5.23, 5.25, 5.12, and 5.36 seconds, you could say that it is 5.24 (the average) \pm 0.12 (the range/2, i.e. (5.36-5.12)/2).

Directions: The answers are on the side. (Uncertainties should be rounded to 1 or 2 sig figs, and the number of decimal places in the answer should not exceed the limit of the uncertainty)

1. Adding or subtracting – the uncertainty of a sum or difference is the sum of the uncertainties

25.2 ± 0.7	13.1 ± 0.2	23.12 ± 0.01	24 ± 2	21.3 ± 0.5
6.87 ± 0.03	<u>$+ 12.1 \pm 0.5$</u>	<u>$- 16.25 \pm 0.02$</u>	<u>$+ 127 \pm 5$</u>	<u>$- 21.1 \pm 0.1$</u>
151 ± 7				
$0.2 \pm .6??$				

2. Multiplying and/or dividing – if $y = ab/c$, then $\Delta y/y = \Delta a/a + \Delta b/b + \Delta c/c$ (Δ reads uncertainty of) Round uncertainty to two sig figs.

31.6 ± 3.8	5.10 ± 0.2	3.12 ± 0.05	484 ± 2	137 ± 9
3.59 ± 0.15	<u>$\times 6.20 \pm 0.5$</u>	<u>$\times 1.15 \pm 0.03$</u>	<u>$\div 12.0 \pm 1$</u>	<u>$\div 1.78 \pm 0.05$</u>
40.3 ± 3.5				
77.0 ± 7.2				

(These are easy - % uncertainties are fractional uncertainties, so just add the %)

- 12% 0. What is the percent uncertainty of the area of a rectangle if the length is uncertain by 5%, and the width by 7%
- 9% 1. What is the percent uncertainty of the volume of a cube if the sides each have a percent uncertainty of 3%?
- 15% 2. A sphere has a radius with an uncertainty of 5%, what is the percent uncertainty of the volume?

3. Powers – if $y = a^n$, then $\Delta y/y = |n\Delta a/a|$ (Δ reads uncertainty of) Round uncertainty to two sig figs.

$(12.6 \pm 1.2)^2$	$(3.4 \pm .1)^3$	$\sqrt{(16 \pm 3)}$	$\sqrt[3]{(343 \pm 31)}$
$159 \pm 30.$	39.3 ± 3.5	$4.00 \pm .38?$	7.00 ± 0.21

Word problems (the test isn't like these : -)

- 21.2 ± 1.3 m/s 0. A car goes $45 \pm .5$ m in 2.12 ± 0.11 seconds. What is the speed of the car, and what is the uncertainty of the speed?
- $14.7 \pm .8$ m²
.77? 1. What is the area (with uncertainty) in square meters of a rectangular room that measures 3.5 x 4.2 m where both measurements have an uncertainty of .1 m?
- 140.4 ± 6.0 cm 2. A staircase has 12 steps, each one being $11.7 \pm .5$ cm high. What is the total height of the staircase with uncertainty? (Add twelve together...)
- 1.2 ± 1.3 cm
Yes 3. One board is $24.1 \pm .5$ cm long, and another is $25.3 \pm .8$ cm long. How much longer is the second than the first? Could the first possibly be longer?
- 452.4 ± 7.5 cm² 4. What is the area (with uncertainty) of a circle that is 12.0 cm $\pm .1$ cm in radius? (area = πr^2 so that is $\pi r \times r$)
- 589 ± 68 cc 5. A sphere has a radius of $5.2 \pm .2$ cm. What is its volume in cubic centimeters? ($V = 4/3\pi r^3$)