# 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 ± 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 ± .5 mm or ± .05 cm so you would say 12.4 ± .05 cm
* Using a digital readout: The uncertainty is ± the last digit. If you have an ammeter that reads 1.56 Amps, it would be 1.56 ± .01 Amps.
* Multiple trials of something with random error: You could say that it is the average, ± 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) ± 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

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| --- | --- | --- | --- | --- |
| 25.2 ± 0.7 | 13.1 ± 0.2 | 23.12 ± 0.01 | 24 ± 2 | 21.3 ± 0.5 |
| 6.87 ± 0.03 | + 12.1 ± 0.5 | - 16.25 ± 0.02 | + 127 ± 5 | - 21.1 ± 0.1 |
| 151 ± 7 |  |  |  |  |
| 0.2 ± .6?? |  |  |  |  |

**2. Multiplying and/or dividing** – if y = ab/c, then Δy/y = Δa/a + Δb/b + Δc/c (Δ reads uncertainty of) Round uncertainty to two sig figs.

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| --- | --- | --- | --- | --- |
| 31.6 ± 3.8 | 5.10 ± 0.2 | 3.12 ± 0.05 | 484 ± 2 | 137 ± 9 |
| 3.59 ± 0.15 | x 6.20 ± 0.5 | x 1.15 ± 0.03 | ÷12.0 ± 1 | ÷ 1.78 ± 0.05 |
| 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 = an, then Δy/y = |nΔa/a| (Δ reads uncertainty of) Round uncertainty to two sig figs.

|  |  |  |  |
| --- | --- | --- | --- |
| (12.6 ± 1.2)2 | (3.4 ± .1)3 | √(16 ± 3) | 3√(343 ± 31) |
| 159 ± 30. | 39.3 ± 3.5 | 4.00 ± .38? | 7.00 ± 0.21 |

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

|  |  |
| --- | --- |
| 21.2 ± 1.3 m/s | 0. A car goes 45 ± .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 ± .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 ± .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 ± .5 cm long, and another is 25.3 ± .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 ± .1 cm in radius? (area = πr2 so that is πxrxr) |
| 589 ± 68 cc | 5. A sphere has a radius of 5.2 ± .2 cm. What is its volume in cubic centimeters?  (V = 4/3πr3) |