Worksheet 3: Critical Thinking and Uncertainty/Error
Week 10

When scientists talk about the “error” in a measurement, they actually mean “uncertainty” – how certain they are that the value is precisely the value quoted (you might be more familiar with the expression “margin of error”). Quoting a measurement’s uncertainty gives an indication of how well the value is known. It’s not only considered a good thing in science to quote your uncertainty - it’s essential. In this worksheet, you will explore the concept of uncertainty in measurements and statistics.

1. (2 points) If I tell you that one measurement has an uncertainty of 0.4 and another has an uncertainty of 0.8, I haven’t given you enough information to infer which measurement is more accurate. The useful quantity is the relative or percent uncertainty. If my measurements are 5.2 ± 0.4 and 17.3 ± 0.8, my first measurement has a 7.7% uncertainty, and my second has a 4.6% uncertainty. The second measurement is more accurate.

In the following, circle the choice with the lower uncertainty.

a) 1 cup ± 1 tablespoon
   1 gallon ± 1 tablespoon

b) 1 AU ± 10² km
   1 km ± 1 cm

c) 5 hours ± 15 minutes
   1 day ± 3 hours

d) (538.9 ± 0.3) kg
   (395.2 ± 0.5) kg
2. (8 points) Two companies conduct polls on the same topic. Their data is listed below:

<table>
<thead>
<tr>
<th></th>
<th>% of participants who approve</th>
<th>% of participants who disapprove</th>
<th># of participants</th>
<th>Error (# of participants)</th>
<th>Error (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Company A</td>
<td>39.9</td>
<td>61.4</td>
<td>64</td>
<td>8</td>
<td>14</td>
</tr>
<tr>
<td>Company B</td>
<td>46.7</td>
<td>53.3</td>
<td>1000.</td>
<td>31.6</td>
<td>3.2</td>
</tr>
</tbody>
</table>

a) Which poll has a **lower** uncertainty?

b) Which poll is more accurate?

The uncertainty indicates the reasonable range of values for the measurement. For example, if I tell you that \( v = (5\pm2) \text{ m/s} \), I’m saying that the velocity falls somewhere within the range of 3 to 7 m/s. I’m indicating that I’m pretty sure that the velocity is neither 2 m/s nor 7.5 m/s, but I’m not saying that it’s definitely 5 m/s.

c) What is the reasonable range of “% of participants who approve” for Company A?

   Between _______ and _______

d) What is the reasonable range of “% of participants who disapprove” for Company A?

   Between _______ and _______

e) Can Company A definitively claim that its poll shows that more people disapprove than approve?

   f) What is the reasonable range of “% of participants who approve” for Company A?

   Between _______ and _______

g) What is the reasonable range of “% of participants who disapprove” for Company A?

   Between _______ and _______

   h) Can Company B definitively claim that its poll shows that more people disapprove than approve?