# ==Lab report investigating the density of an unknown solution==

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## ==Objectives==

1. To investigate the density of an unknown solution and compare with the literature value.
2. To calculate the uncertainties of measurements in this investigation.

## ==Data analysis==

### ==Raw data==

1. The measured mass of the empty plastic beaker is with the absolute uncertainty of > [[empty.jpg]]
2. The measured volume of the unknown solution is with the uncertainty of
3. The three trials of measured mass of unknown solution with plastic beaker are , and with the absolute uncertainty of > [[t1.jpg]] > Trial 1: > [[t2.jpg]] > Trial 2: > > [[t3.jpg]] > Trial 3:

| RAW Data | Measured value |
| --- | --- |
| Measured mass of empty beaker |  |
| Measured volume of unknown solution |  |

| RAW Data | Trial 1 | Trial 2 | Trial 3 |
| --- | --- | --- | --- |
| Measured mass of unknown solution with beaker |  |  |  |

### ==Processed data==

1. The mass of unknown solution for three trials can be calculated by the formula (), where is the measured mass of solution with beaker and is the measured volume of unknown beaker: , and with the absolute uncertainty of
2. The mean mass of solution from the three trials can be calculated by the formula ($ $):
3. The density of solution can be calculated by the formula ($\rm{\frac{M\_{mean}}{V}}$), where $\rm{M\_{mean}}$ is the mean mass calculated in step 2, and $\rm{V}$ is the measured volume of solution:
4. The percentage uncertainty of mass of solution can be calculated by the formula ($\frac{\rm{Absolute\ uncertainty} }{\rm{M\_{mean}}} \times 100\%$), where $\rm{M\_{mean}}$ is the mean mass calculated in step 2:
5. The percentage uncertainty of volume of solution can be calculated by the formula ($\frac{\rm{Absolute\ uncertainty} }{\rm{V}} \times 100\%$), where $\rm{V}$ is the measured volume of solution:
6. Therefore, the percentage uncertainty of density of solution can be calculated by the formula ($\rm{\%U\_1 + \%U\_2}$), where $\rm{\%U\_1}$ is the percentage uncertainty of mass of solution calculated in step 3, and $\rm{\%U\_2}$ is the percentage uncertainty of volume of solution:
7. And the absolute uncertainty of density can be calculated by the formula ($\rm{\%U} \cdot \rm{D}$), where $\rm{\%U}$ is the percentage uncertainty of density of solution calculated in step 6, and $\rm{D}$ is the density calculated in step 3:
8. ==Therefore, the density of the unknown liquid with absolute uncertainty is .==

| PROCESSED Data | Trial 1 | Trial 2 | Trial 3 | Mean |
| --- | --- | --- | --- | --- |
| Mass of solution (3dp) |  |  |  |  |

| PROCESSED Data | Calculated value |
| --- | --- |
| Density of solution (3sf) |  |
| Percentage uncertainty of mass of solution (1sf) |  |
| Percentage uncertainty of volume of solution (1sf) |  |
| Percentage uncertainty of density of solution (3dp) |  |
| Absolute uncertainty of density of solution (3sf) |  |
| Density of solution with absolute uncertainty (3dp) |  |

## ==Evaluation==

### ==Comparison of experimental value with literature value==

The literature value of the unknown liquid is , while the experimental value of the unknown liquid is . The highest possible experimental value after accounting the uncertainty is , which is still less than the literature value.

### ==Discussion on random error and level of precision==

The difference between experimental value and literature value can be caused by random error and level of precision. Random error might be caused by: 1. change in room temperature when taking different trials of the mass of liquid 2. liquid evaporating when between taking different readings Random error cannot be avoided but can be minimized by taking more reading and taking the mean value. By increasing the number of trials from 3 to 5, we can increase the accountability of the mean value and also remove data that are outliers from the set of measured values by performing the ‘Q Test’. The level of precision can be increased by using more precise apparatus/instruments, such as using a volumetric flask to measure the volume of unknown liquid instead of measuring cylinder. The improvement of precision can allow the experimental value to be closer to the literature value.

### ==Discussion on systematic error and how it influence the data==

Systematic error are caused by flawed experimental design or poorly calibrated apparatus, and can cause the experimental data to be always higher or always lower than the literature value when taking multiple trials of the experiment, therefore increasing number of trials of the experiment will not decrease the systematic error. By ensuring that the apparatus is well-calibrated or follow the experiment steps that the literature value is based on may decrease the risk of having systematic error.