Introduction to Precision & Accuracy in Measurements

PHY406: A Physical Science Activity

Universiti Teknologi MARA
Fakulti Sains Gunaan

Name:_____ HP: _____ Lab # 1:

The goal of today's activity is to explore the concept of precision and accuracy in making and reporting direct and indirect measurements of physical and observable quantities.

At the end of the activity, students will be able to:

1. Use a ruler, vernier caliper and a micrometer to make measurements related to length of objects.
2. Compare the precision and accuracy obtained by the different measuring devices.
3. Use excel spreadsheet to perform error analysis and report on the accuracy and precision of direct and indirect measurements.

Background Information

Scientific research or investigations involve a string of activities that include making observations, defining the problems associated with the observation, reflecting on the problems, developing hypotheses (or eventually theories) governing the observed event and testing the hypotheses through experiments.

Science has and will discover and uncover laws and patterns of nature by answering questions related to natural events. Galileo suggested finding the answer by engaging and having dialogues with nature itself via investigations and experiments. Conducting experiments mean that you are systematically looking for patterns and behavior associated to the event.

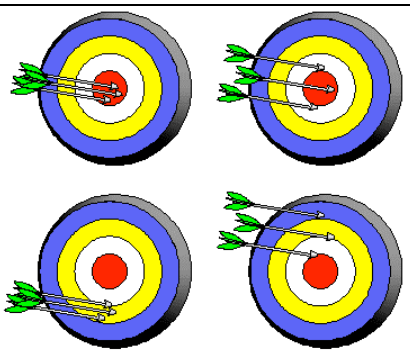
Performing investigations involve making measurements by using measuring devices. A meter rule, a vernier caliper and a micrometer are measuring devices which are commonly used in measuring quantities related to lengths. Other devices include weighing balance to measure the mass, clocks to measure time intervals, thermometers to measure temperature, and ammeters to measure electrical current.

When reading the values from each of this device, we try to report the "true" value but often times the "true" value will be limited by the precision and accuracy of the instrument.

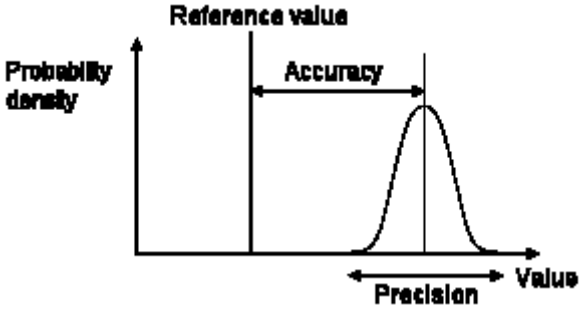
Precision is a measure of exactness and refers to the reliability of the instrument in giving us the same reading or value when we measure the same object at different times or when the measurement is made by other users. Our measurements are precise when our measured values do not scatter too much and have a small spread from the central measure (or standard & known values).

Accuracy is a measure of rightness and refers to how close our measured mean values are to the accepted or "true" value. For example, you are accurate in a target shooting when your shots are all bulls eye. The figure below depicts the meaning of precision and accuracy.

Precision vs. Accuracy

Accurate & Precise		Accurate but not precise
Precise but not accurate		Not accurate & not precise

In terms of data points which are represented on the graph below, precision refers to the spread or scatter from the measured values while accuracy is how close our measurement or mean values are from the accepted or true value.



The activities today will allow you to explore the concepts of accuracy and precision in making direct and indirect measurements. Direct measurements are obtained by reading the values directly from the measuring tools. Indirect measurements are the derived measurements and obtained by performing addition, subtraction, multiplication and division of direct measurements. This include taking the sum of lengths, subtracting two lengths, multiplying two lengths together and dividing lengths by time intervals (difference between two clock readings).

No measurement is accurate and no measurement device is precise. A measurement is valid if and only if it is both accurate and precise. There are always limitations and uncertainties due to systematic, human and random errors that occurred. A discussion of these types or errors and its effect on measurement will be the focus of today's investigation.

STUDENT ACTIVITIES

You need to predict the outcomes before you begin any activities. Predictions can be just a guess, any guesses based on gut feeling. Other times, predictions are used to develop a scientific explanation for a phenomenon that has never been tested experimentally. These kinds of predictions are called hypothesis. Your predictions throughout this course will be between a guess if someone had provided some form of explanation or reasoning to a phenomenon or it could as well be a hypothesis if the explanation is not part of a documented theory.

INVESTIGATION 1-WHICH MEASURING DEVICE IS MOST ACCURATE IN MEASURING LENGTH?

Prediction 1:

Predict which device will give you the most accurate measurement by ranking them from most accurate to least accurate. Give reasons for your prediction.

Activity 1:

Materials:

1 meter rule
1 vernier caliper
1 tape micrometer
Coins, beaker, A4 paper & your finger (still intact to your hand)

METHOD (This must be detailed out so that someone else can repeat what you did and confirm your findings)

Plan your investigation to record the thickness of a coin, a beaker, a piece of A4 paper and your own finger by using a ruler, a vernier caliper and a micrometer respectively. In addition, measure the length of your finger. In each case, record the most significant digit. Plan how you will record and present your raw and transformed data in EXCEL spreadsheet.

RESULTS

Determine the thickness of the
1. Coin & of an A4 paper,
2. area and volume of the coin, beaker and of the your finger

In addition, perform error analysis for both the direct (the accuracy & precision of directly measured properties) and indirect measurement (the accuracy and precision of derived properties). Use excel spreadsheet to tabulate your data and to perform indirect measurement (calculations). [Refer to additional reading materials provided on the Dr JJ's PHY406 Labs padlet wall or Dr JJ's PHY406 website.]

CONCLUSION

How does the data and the results help you in achieving your outcomes? Discuss and conclude.

Prediction 2:

Predict the accepted time of flight when dropping a tennis ball from a height of 5 meters until it hits the floor beneath. Give reasons for your prediction. Is the distance of 5 meters a reasonable height? Why or why not?

Activity 2:

Materials:

- ✓ 1 meter rule
- ✓ 1 stop watch
- ✓ 1 tennis ball
- ✓ long strings

METHOD (This must be detailed out so that someone else can repeat what you did and confirm your findings)

Plan your investigation to record the time taken for a tennis ball to fall a distance of 5 meters (or **a height you determined most appropriate**). I suggest you do this investigation outside the lab.

RESULTS

Determine the accepted speed of the ball upon colliding with the floor. Show examples on how the speed was determined. Perform error analysis for both the direct and indirect measurement s.

CONCLUSION

Discuss the accuracy and precision of your direct and indirect measurement.