Experiment with MET™

Printable Experiment Cards

Classroom & Homeschool Handout Series

Ages 6–9 (Explorer) **Ages 10–14 (Technician)** **Ages 15–18 (Metrologist)**

4 MODES · 45 EXPERIMENTS · 3 AGE LEVELS

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⚠ SAFETY FIRST — READ BEFORE YOU BEGIN

This page must be reviewed with all students before conducting any experiment

Science is one of the greatest adventures in human experience — and like all great adventures, it demands respect, preparation, and awareness. Safety is not a box to check before the fun begins. **Safety is the first measurement a scientist makes.**

Before beginning any experiment in this collection, educators and students must review the following guidelines together. Every experiment card includes a specific PPE and safety callout — always read it before setting up materials or touching any equipment.

Personal Protective Equipment (PPE)

Required PPE is listed on every experiment card. The following are standard across all age groups unless the card states otherwise:

Safety Glasses
Required for all experiments involving liquids, heat, or materials. When in doubt — wear them.

Gloves
Chemical-resistant for liquid experiments; heat-resistant for all thermal experiments.

Lab Apron
Worn over clothing during any experiment with water, chemicals, or messy materials.

Closed-Toe Shoes
Required whenever instruments, weights, or equipment could be dropped or fall.

Hair Tied Back
Required whenever a hot plate, heating element, or rotating equipment is present.

No Food or Drink
Never permitted in any science or laboratory workspace — no exceptions.

Clean Workspace
Clear all clutter before starting. Wipe down surfaces after every experiment.

Supervision Requirements by Age Group

Ages 6–9 · Explorer Level
ADULT SUPERVISION REQUIRED at all times — no exceptions. All hot water, sharp tools, and chemical materials must be handled exclusively by the supervising adult. Students observe and record; adults handle hazards.

Ages 10–14 · Technician Level
Adult present and aware of the experiment at all times. Students may operate instruments independently under supervision. Adults must control all heating equipment, open flames, and chemical preparation.

Ages 15–18 · Metrologist Level
Follow your school or laboratory safety policy. Read the full experiment procedure before beginning. When in doubt about any safety question — stop and ask your instructor first. Never improvise.

General Laboratory Rules

- Follow all procedure steps in written order — never skip or improvise a step.
- Read the full experiment card before setting up any materials.
- Report any spill, broken glass, or injury to the supervising adult immediately.
- Keep your workspace clean and organised throughout the entire experiment.
- Wash hands thoroughly with soap and water after every experiment.
- Return all materials and instruments to their proper storage when finished.
- Record ALL data honestly — never change, erase, or delete a measurement result.

📐 Data Integrity — The Metrologist's Code of Honour

In a professional calibration laboratory, data integrity is treated with the same seriousness as physical safety. These rules are simple, absolute, and non-negotiable:

- Record what you actually measured — not what you expected or hoped to see.
- Never erase a measurement error. Draw a single line through it, write the correction beside it, and initial with the date.
- Never alter, delete, or fabricate data. In an accredited laboratory, falsified data is grounds for losing accreditation and carries legal consequences.
- If something goes wrong during an experiment, note it in your record. Honest documentation of errors is how science improves.
- Every number must have a unit. A measurement without a unit is not a measurement — it is a guess.

Concept Mode

Explore the big ideas behind measurement — from basic units to uncertainty and traceability

Ages 6–9 (Explorer) · Ages 10–14 (Technician) · Ages 15–18 (Metrologist)

Ages 6–9 · Explorer Level | CONCEPT MODE

My Body Is a Ruler!

20 min · Individual · Home / Classroom

SAFETY & PPE REQUIRED

No special PPE required. Wash hands before and after any science activity.

OBJECTIVE

Discover why we need standard measurement units by comparing body measurements to a ruler.

MATERIALS

- Ruler or tape measure
- String or yarn
- Pencil & paper
- A friend or family member

STEPS

1. Stretch your hand wide (pinky to thumb). Cut a piece of string that length — that is your personal "hand span."
2. Use your hand span string to measure your desk or table. Count how many "hand spans" it is.
3. Now use a real ruler or tape measure to measure the same desk in centimetres.
4. Ask your partner to measure the desk with their hand span. Is their number the same as yours?
5. Write down both numbers. Draw a picture of your results!

WHY IT MATTERS

Your hand span is different from your friend's! Long ago, kings used their own feet and arms as "units" — and trades went wrong all the time. This is exactly why the world invented the metric system: one agreed-upon standard for everyone.

Ages 6–9 · Explorer Level | CONCEPT MODE

Hot, Warm, or Cold? — The Thermometer Test

⏱ 25 min · Pairs · Home / Classroom

SAFETY & PPE REQUIRED
Safety glasses required. Adult must handle all hot water — students must NOT touch warm water without adult supervision.

OBJECTIVE

Learn that our senses are NOT reliable measurement tools, and that thermometers give us trustworthy numbers.

MATERIALS

- 3 bowls
- Cold water (with ice cubes)
- Room temperature water
- Warm water (adult prepares — NOT hot)
- Thermometer
- Paper to record results

STEPS

6. Ask an adult to prepare three bowls: cold, room temperature, and warm water.
7. Carefully put one finger in each bowl for 3 seconds. Write down: cold / warm / hot.
8. Now use the thermometer to measure the actual temperature of each bowl.
9. Did your body guess the right order? Were the numbers surprising?
10. Try this: put your hand in the cold bowl for 10 seconds. Then move it to the room-temp bowl. How does it feel now?

WHY IT MATTERS
Our skin can be fooled by contrast! Doctors, cooks, and scientists cannot rely on feelings — they need a calibrated thermometer that gives the same reading every time, for everyone.

Ages 6–9 · Explorer Level | CONCEPT MODE

The Great Balance Challenge

⏱ 30 min · Groups of 2–3 · Home / Classroom

SAFETY & PPE REQUIRED
Wash hands before and after. Adult supervision required throughout.

OBJECTIVE

Explore mass and weight by building a simple balance and comparing everyday objects.

MATERIALS

- Ruler or wooden dowel (30 cm)
- String
- 2 small paper cups
- Pencil to balance on
- Various small objects (coins, erasers, paper clips, small fruit)

STEPS

11. Tie a string cup to each end of the ruler. Balance the ruler on a pencil or finger at the centre.
12. Place a coin in one cup. What happens? Add items to the other cup until it balances again.
13. Record your results: "1 eraser = ___ paper clips."
14. Now use a kitchen scale to find the weight in grams of each object. Did your balance match?

WHY IT MATTERS
Your homemade balance compares masses — but the kitchen scale gives a number in grams. In science, we need numbers, not just "heavier" or "lighter." Every scale in a store or laboratory is calibrated against a standard weight to ensure accuracy.

Ages 6–9 · Explorer Level | CONCEPT MODE

Volume Race — How Much Does It Hold?

⏱ 20 min · Individual · Home / Classroom

SAFETY & PPE REQUIRED
Waterproof apron recommended. Work over a sink or tray. Wipe up spills immediately to prevent slipping.

OBJECTIVE

Understand volume by measuring how much liquid different containers hold.

MATERIALS

- Measuring cup (with mL or cups markings)
- 3–5 different-shaped containers (bottle, jar, wide bowl, tall glass)
- Water
- Tray to catch spills

STEPS

15. Before measuring: guess which container holds the most water. Write it down.
16. Fill each container with water, then pour into the measuring cup to find its volume.
17. Record: "The tall jar holds ___ mL."
18. Did the tallest container hold the most? Were you surprised?
19. BONUS: Is 1 cup of water the same as 237 mL? Pour and check!

WHY IT MATTERS
Shape is deceiving! A tall, thin container might hold less than a short, wide one. This is why bottles and cans must list their volume in millilitres (mL) — so you know exactly what you're buying, no matter the shape.

Ages 6–9 · Explorer Level | CONCEPT MODE

Watch Me Grow! — 7-Day Plant Measurement

⏱ 15 min/day × 7 days · Individual · Home

SAFETY & PPE REQUIRED
Wash hands after handling soil. Wear an apron. Keep soil away from eyes.

OBJECTIVE

Practice consistent, repeated measurement by tracking a growing plant each day.

MATERIALS

- Bean or radish seeds
- Small cup with potting soil
- Ruler (mm scale)
- Notebook to record daily measurements
- Pencil to mark the soil surface

STEPS

20. Plant your seed and write "Day 0" in your notebook.
21. Each morning, use the ruler to measure the sprout height from soil to tip in millimetres.
22. Record: "Day 3: Height = ___ mm." Draw a small sketch each day.
23. After 7 days, make a bar chart of your data. Which day grew the most?
24. Compare your results with a classmate's plant. Why might they be different?

WHY IT MATTERS
Scientists use repeated, consistent measurement to track change over time. If you measure in a different spot each day, your data is wrong! This is why real labs always measure at the same conditions — and document everything.

Ages 10–14 · Technician Level | CONCEPT MODE

Pendulum Laws — How Length Changes Everything

45 min · Pairs · Classroom / Home

SAFETY & PPE REQUIRED
Safety glasses required. Tie back hair. Keep clear of swinging weight. Adult should be aware of experiment.

OBJECTIVE

Discover how pendulum length determines period (swing time) and practice timing measurements with statistical analysis.

MATERIALS

- String (at least 1 metre)
- Small weight (fishing sinker, washer, or bag of coins)
- Ruler or measuring tape
- Stopwatch or phone timer
- Tape to mark the swing start

STEPS

25. Attach the weight to the string. Set string length to 25 cm. Secure the top to a shelf edge.
26. Pull the weight 10 cm to the side and release. Time 10 complete swings. Divide by 10 = period.
27. Repeat 3 times and calculate the average. Record all values.
28. Now change string length to 50 cm and 100 cm. Repeat measurements for each.
29. Plot length vs. period on a graph. What pattern do you see?

WHY IT MATTERS
Notice that your three timing trials are NOT identical — that variation is measurement uncertainty! Scientists always repeat measurements and calculate averages to reduce uncertainty. Pendulums were used in the first accurate clocks — precision timing drove navigation and trade for centuries.

Ages 10–14 · Technician Level | CONCEPT MODE

Density Tower — When Liquids Refuse to Mix

40 min · Groups of 2–3 · Home / Classroom

SAFETY & PPE REQUIRED
Safety glasses, gloves, and apron required. Do NOT drink any liquids used in this experiment.

OBJECTIVE
Calculate the density of different liquids and discover how density explains layering.

MATERIALS
- Honey, corn syrup, dish soap, water, vegetable oil, rubbing alcohol
- Measuring cylinder or graduated cup (100 mL)
- Kitchen scale
- Tall clear glass or cylinder
- Food colouring (to tint water and alcohol)

STEPS
30. Measure exactly 50 mL of each liquid. Weigh each separately on the scale (in grams).
31. Calculate density: Density = Mass (g) ÷ Volume (mL). Record in a table.
32. In the tall glass, slowly pour liquids from most dense to least dense (honey first, alcohol last). Pour down the side gently.
33. Observe the layers. Do they match your calculated density order?
34. Gently drop a small object (grape, ice cube, coin) and observe where it floats.

WHY IT MATTERS
Density (g/mL) is a calculated measurement using two direct measurements — mass and volume. Both instruments must be accurate and calibrated for your density calculation to be correct. Density measurements are used in fuel testing, medical labs, and food manufacturing every day.

Ages 10–14 · Technician Level | CONCEPT MODE

Thermal Expansion — Does Metal Really Grow?

50 min · Pairs · Classroom

SAFETY & PPE REQUIRED
Safety glasses, heat-resistant gloves, and apron required. ADULT SUPERVISION REQUIRED for hot water. Never leave heating water unattended.

OBJECTIVE

Measure how a metal rod or pipe changes length when heated and calculate the change per degree Celsius.

MATERIALS

- Metal rod or pipe (~30 cm) — copper pipe works well
- Digital caliper or precise ruler
- Hot water (adult pours) and cold water
- Thermometer
- Small dial indicator (optional but educational)

STEPS

35. Measure the exact length of the metal rod at room temperature. Record in mm.
36. Record the room temperature with a thermometer.
37. Place the rod in hot water (adult handles this). After 3 minutes, carefully measure the length again.
38. Record the water temperature. Calculate: Change in length = Hot length − Cold length.
39. Repeat with different metals if available. Which expands more?

WHY IT MATTERS
This is why bridge builders leave expansion gaps, why thermometers work, and why precision measurements must always record temperature! In calibration laboratories, temperature is controlled to ±0.1°C because thermal expansion can add measurement error.

Ages 10–14 · Technician Level | CONCEPT MODE

Parallax Error — Your Eye Is Lying to You

⏱ 30 min · Individual · Home / Classroom

SAFETY & PPE REQUIRED
No special PPE needed. Work at a stable table.

OBJECTIVE

Demonstrate parallax error — how the angle of your eye when reading a scale changes your measurement result.

MATERIALS

- Clear graduated cylinder or glass with a marked scale
- Water
- Ruler
- Pencil and paper
- Camera or phone (optional)

STEPS

40. Fill the graduated cylinder to approximately 50 mL.
41. Read the volume while looking DOWN at an angle. Record the value.
42. Read the volume with your eyes LEVEL with the liquid surface (at the meniscus). Record.
43. Read the volume while looking UP from below. Record.
44. Compare all three readings. Calculate the maximum error introduced by viewing angle.

WHY IT MATTERS
The correct reading is always eye-level at the bottom of the meniscus. Parallax error is a systematic error — it shifts your reading in one direction consistently. Calibration technicians are trained to always read instruments from a direct, perpendicular angle to eliminate this error.

Ages 10–14 · Technician Level | CONCEPT MODE

How Fast Is Sound? — Echo Timing Experiment

⏱ 45 min · Groups of 3 · Outdoors

SAFETY & PPE REQUIRED
Closed-toe shoes required for outdoor activity. Sun protection if needed. Use the buddy system outdoors at all times.

OBJECTIVE

Estimate the speed of sound by measuring the time delay between a clap and its echo.

MATERIALS

- Measuring tape (long — 50+ metres)
- Two blocks of wood (to clap together)
- Stopwatch
- A large wall or building as an echo surface
- Calculator

STEPS

45. Measure exactly 100 m from a large wall. Mark your spot.
46. Clap the wood blocks and listen for the echo. Start timing when you clap, stop when you hear the echo.
47. Repeat 10 times. Record all times. Calculate the average.
48. Speed = Distance ÷ Time. Sound travels there and back, so total distance = 200 m.
49. Compare your calculated speed to the known value (343 m/s at 20°C). Calculate your percentage error.

WHY IT MATTERS
Your reaction time adds measurement uncertainty! Trained metrologists use calibrated timing equipment with microsecond accuracy. This experiment shows why repeated trials and averaging reduce uncertainty — a core principle from the NIST GUM document.

Ages 15–18 · Metrologist Level | CONCEPT MODE

Uncertainty Revealed — 20-Trial Statistical Analysis

⏱ 60 min · Individual · Lab / Classroom

SAFETY & PPE REQUIRED
Safety glasses, lab coat or apron, and closed-toe shoes required. No food or drink in the lab.

OBJECTIVE

Conduct Type A uncertainty evaluation by making 20 repeated measurements of a single object and applying GUM statistics.

MATERIALS

- Digital calipers (0.01 mm resolution)
- Small metal cylinder or coin
- Calculator or spreadsheet
- Measurement record sheet

STEPS

50. Measure the diameter of the object 20 times. Remove and replace it between each measurement.
51. Record all 20 values. Calculate the mean ($\bar{x}$) and standard deviation (s).
52. Calculate the Type A standard uncertainty: $u_A = s \div \sqrt{n}$ (where $n = 20$).
53. Identify the resolution contribution (Type B): $u_B = \text{resolution} \div (2 \times \sqrt{3})$.
54. Calculate combined uncertainty: $u_c = \sqrt{u_A^2 + u_B^2}$. State expanded uncertainty $U = 2 \times u_c$.
55. Plot your 20 measurements on a histogram. Does it look like a normal distribution?

WHY IT MATTERS
This is the NIST GUM (JCGM 100:2008) Type A evaluation. The GUM is the international standard that all calibration laboratories follow. Every measurement result on a real calibration certificate includes an uncertainty stated just like you calculated here: $U = k \times u_c$ at 95% confidence.

Ages 15–18 · Metrologist Level | CONCEPT MODE

Caliper Precision Study — Vernier vs Digital

⏱ 55 min · Pairs · Lab / Classroom

SAFETY & PPE REQUIRED
Safety glasses and apron required. Wear gloves when handling sharp-edged metal parts. Keep caliper jaws away from face.

OBJECTIVE

Compare the repeatability and accuracy of a Vernier caliper vs. a digital caliper on the same reference object.

MATERIALS

- Vernier caliper (0.02 mm resolution)
- Digital caliper (0.01 mm resolution)
- Gauge block or machined bolt (reference object)
- Measurement log sheet
- Spreadsheet or calculator

STEPS

56. Measure the same object 10 times with the Vernier caliper. Record all values.
57. Measure the same object 10 times with the digital caliper. Record all values.
58. Calculate mean and standard deviation for each instrument.
59. Calculate Type A uncertainty for each set. Compare repeatability (s) of the two instruments.
60. If a certified reference value is available, calculate bias = mean − reference value.
61. Write a brief report: "Which instrument has better repeatability? Which has less bias? Why?"

WHY IT MATTERS
This is how calibration technicians perform instrument comparisons. Repeatability (s) tells you about random variation; bias tells you about systematic error. ISO/IEC 17025 requires laboratories to evaluate both and document them in their uncertainty budgets.

Ages 15–18 · Metrologist Level | CONCEPT MODE

Repeatability vs Reproducibility — Gauge R&R Study

⏱ 75 min · Groups of 3 · Lab / Classroom

SAFETY & PPE REQUIRED
Safety glasses and apron required. Closed-toe shoes. No food or drink in lab area.

OBJECTIVE

Conduct a simplified Gauge R&R study to separate operator-to-operator variation from instrument variation.

MATERIALS

- One digital scale (0.01 g resolution)
- 5 different small objects labelled A–E
- 3 "operators" (team members)
- Data collection sheet
- Calculator or spreadsheet

STEPS

62. Each operator measures all 5 objects 3 times each (without seeing the others' results).
63. Record in a table: Operator × Part × Trial = measurement value.
64. Calculate repeatability: average standard deviation within each operator's measurements.
65. Calculate reproducibility: variation in operator averages for the same part.
66. Calculate total Gauge R&R = $\sqrt{(\text{repeatability}^2 + \text{reproducibility}^2)}$.
67. Discuss: What percentage of variation is from the instrument vs the operators?

WHY IT MATTERS
In manufacturing quality control, Gauge R&R determines if a measurement system is adequate. ISO/IEC 17025 and AIAG MSA guidelines require that measurement system variation be less than 10% of the total process tolerance.

Ages 15–18 · Metrologist Level | CONCEPT MODE

Thermometer Comparison — Bias & Correction

⏱ 60 min · Pairs · Lab / Classroom

SAFETY & PPE REQUIRED
Safety glasses, heat-resistant gloves, and apron required. Careful handling of boiling and ice water. Adult supervision for heating equipment.

OBJECTIVE

Compare the accuracy of a consumer thermometer against two known reference points (ice bath = 0°C, boiling water ≈ 100°C) and calculate instrument bias.

MATERIALS

- Consumer digital thermometer (unit under test)
- NIST-traceable thermometer (reference, if available) OR ice bath and boiling water reference points
- Ice and water bath
- Boiling water setup (adult handles heating)
- Stopwatch, data log

STEPS

68. Prepare a proper ice bath (crushed ice + water in equilibrium = 0.0°C reference).
69. Measure the ice bath temperature 5 times with your thermometer. Record each reading.
70. Calculate mean reading at 0°C. Bias at 0°C = mean − 0.0°C.
71. Repeat at the boiling water point (adult handles). Record 5 readings.
72. Calculate bias at 100°C. Plot bias vs temperature — is your thermometer linear?
73. Write a calibration correction factor for each reference point.

WHY IT MATTERS
This is the basic principle behind a multi-point calibration — something every calibration lab performs on temperature equipment. The ice point (0°C) and steam point (100°C) are well-defined physical references traceable through the ITS-90 temperature scale.

Ages 15–18 · Metrologist Level | CONCEPT MODE

Building a Calibration Curve — Multi-Point Scale Test

75 min · Individual · Lab / Classroom

SAFETY & PPE REQUIRED
Safety glasses and apron required. Closed-toe shoes. Handle certified weights carefully — do not drop on feet.

OBJECTIVE

Evaluate the linearity of a digital scale by testing at multiple points across its range and plotting a calibration curve.

MATERIALS

- Digital kitchen scale (0.1 g or 1 g resolution)
- Set of known reference weights: 10 g, 20 g, 50 g, 100 g, 200 g, 500 g
- Spreadsheet or graph paper
- Calculator

STEPS

74. Zero the scale. Place each reference weight and record the scale reading. Measure each weight 3 times.
75. Create a data table: Reference Value vs. Scale Reading vs. Error (Reading − Reference).
76. Plot scale reading (Y axis) vs. reference value (X axis). This is your calibration curve.
77. Draw the ideal 1:1 line. Any deviation from this line is your linearity error.
78. Calculate the maximum linearity error as a percentage of full scale.
79. Determine: Does this scale meet a ±1% specification? Would it pass ISO 17025 requirements?

WHY IT MATTERS
Every calibration laboratory plots calibration curves to document how instruments perform across their full range. The NIST GUM and ISO/IEC 17025 require that linearity be evaluated and included in the uncertainty budget for any instrument used in accredited calibration work.

Problems Mode

Hands-on experiments with data collection, calculations, and real measurement math

Ages 6–9 (Explorer) · Ages 10–14 (Technician) · Ages 15–18 (Metrologist)

Ages 6–9 · Explorer Level | PROBLEMS MODE

Fruity Mass Lab — How Many Grapes = One Apple?

25 min · Individual · Home / Classroom

SAFETY & PPE REQUIRED
Wash hands before and after. Do not eat any fruit during the experiment.

OBJECTIVE

Learn to use a scale and write measurement results with proper units (grams).

MATERIALS

- Kitchen scale
- 1 apple, 1 banana, grapes, and 3 other fruits
- Pencil and paper

STEPS

80. Weigh each fruit one at a time. Write: "Apple = ___ grams."
81. Guess: How many grapes weigh the same as one apple? Write your guess.
82. Count out grapes and weigh them in groups of 5 until you match the apple's mass.
83. Write your answer: "1 apple = ___ grapes (by mass)."
84. Which fruit is heaviest? Make a list from heaviest to lightest.

WHY IT MATTERS
Every grocery store scale must be certified and calibrated so you pay for the weight of the food, not the container. Weights & Measures inspectors test grocery scales regularly using certified reference weights.

Ages 6–9 · Explorer Level | PROBLEMS MODE

The Great Jump-Off — Measuring Distance

⏱ 30 min · Groups of 3 · Outdoors / Gym

SAFETY & PPE REQUIRED
Closed-toe athletic shoes required. Clear the landing zone — no obstacles! Adult supervision outdoors.

OBJECTIVE
Practice measuring distance in centimetres and compare jump distances using a data table.

MATERIALS
- Measuring tape or long ruler
- Masking tape to mark the start line
- Chalk or markers to mark landing spots
- Data recording sheet

STEPS
85. Mark a clear start line with tape. Each person jumps 3 times from a standing position.
86. Mark each landing with chalk. Measure from the start line to the mark in centimetres.
87. Record all 3 jumps for each person. Calculate the average jump distance.
88. Make a bar chart comparing the average jump of each person.
89. Challenge: Does jumping with arms help? Test and measure to find out!

WHY IT MATTERS
The Olympic long jump is measured to the nearest centimetre — and the tape measure used must be certified! In 2004, a single centimetre separated first and second place in the Olympic long jump final. Accurate measurement determines who wins.

Ages 6–9 · Explorer Level | PROBLEMS MODE

Paper Airplane Flight Time

⏱ 35 min · Groups of 2 · Home / Classroom

SAFETY & PPE REQUIRED
Do not aim paper airplanes at faces or eyes. Clear the flight path before each launch.

OBJECTIVE

Measure and compare flight times and distances to find the best paper airplane design.

MATERIALS

- Paper (different types/weights)
- Stopwatch or phone timer
- Measuring tape
- Ruler for folding
- Data sheet

STEPS

90. Fold 3 different airplane designs. Label them A, B, C.
91. Launch each airplane 5 times from the same spot and same height. Time each flight.
92. Measure the landing distance for each flight.
93. Record all data. Calculate the average time and average distance for each design.
94. Which design has the longest average flight time? Which goes farthest?

WHY IT MATTERS
Aircraft engineers measure flight performance with very precise instruments to develop safe, efficient planes. Averages from repeated trials reduce the effect of random variation — this is the foundation of statistical measurement analysis.

Ages 6–9 · Explorer Level | PROBLEMS MODE

Hot vs Cold — Which Melts Ice Faster?

⏱ 40 min · Groups of 2 · Home / Classroom

SAFETY & PPE REQUIRED
Safety glasses required. Adult handles warm water. Wipe up spills immediately to prevent slipping.

OBJECTIVE
Measure how quickly ice melts in different temperature water and record time in a data table.

MATERIALS
- 6 identical ice cubes
- 3 cups of water: cold (5°C), room temp (20°C), warm (40°C) — adult prepares warm
- Thermometer
- Stopwatch

STEPS
95. Record the temperature of each cup of water with the thermometer.
96. Place 2 ice cubes in each cup at exactly the same time. Start the stopwatch.
97. Every 2 minutes, note whether ice is still present (yes/no).
98. Record the time when each cup's ice is completely melted.
99. Make a chart: "Cup temperature vs time to melt."

WHY IT MATTERS
The relationship between temperature and melting rate is used in food safety, medicine storage, and ice management in hospitals. Every measurement here requires a calibrated thermometer — temperature is one of the most critical quantities in science and engineering.

Ages 6–9 · Explorer Level | PROBLEMS MODE

Measure the Room — Unit Conversion Challenge

⏱ 30 min · Individual · Home / Classroom

SAFETY & PPE REQUIRED
Be aware of furniture edges and corners when measuring. Move carefully around the room.

OBJECTIVE

Measure room dimensions and practise converting between centimetres, metres, and feet.

MATERIALS

- Measuring tape (metric + imperial if possible)
- Paper and pencil
- Calculator

STEPS

100. Measure the length and width of your room in centimetres.
101. Convert to metres: divide by 100. Convert to feet: multiply metres by 3.281.
102. Calculate the area: Length × Width in m^2. Record the answer.
103. Measure 3 pieces of furniture in cm, then convert to mm and to inches.
104. Create a conversion table: your measurements in cm, mm, m, and inches.

WHY IT MATTERS
In 1999, a NASA spacecraft was lost because engineers mixed imperial and metric units. The $327 million Mars Climate Orbiter burned up because one team used feet and another used metres. Unit conversion errors have real, catastrophic consequences.

Ages 10–14 · Technician Level | PROBLEMS MODE

Toy Car Velocity Lab — Speed Calculations

⏱ 45 min · Pairs · Home / Classroom

SAFETY & PPE REQUIRED

Closed-toe shoes required. Keep the test track clear of people during car runs. Tape down the ramp securely before testing.

OBJECTIVE

Calculate average velocity (v = d/t) for a toy car at different ramp heights and analyse how angle affects speed.

MATERIALS

- Toy car or marble
- Ramp (a plank of wood or cardboard)
- Books to prop at different heights
- Measuring tape
- Stopwatch (or high-speed phone camera)
- Ruler

STEPS

105. Set up the ramp at height 1 (e.g., 5 cm). Mark start and finish lines exactly 1 m apart.
106. Release the car 5 times. Time each run. Record all times.
107. Calculate average time. Calculate velocity: v = 1 m ÷ average time.
108. Repeat for heights: 10 cm, 15 cm, 20 cm.
109. Plot height vs velocity on a graph. Calculate percentage increase in speed per cm of height.

WHY IT MATTERS

Velocity is a derived measurement — it depends on the accuracy of BOTH your distance and time measurements. Any error in either propagates into your velocity result. This is exactly why engineers specify uncertainty in derived quantities using the law of error propagation.

Ages 10–14 · Technician Level | PROBLEMS MODE

Reaction Time — Statistics of a Biological Measurement

⏱ 40 min · Groups of 4 · Home / Classroom

SAFETY & PPE REQUIRED
No special PPE for this experiment. Ensure the dropped ruler cannot hit any person. Keep clear during drops.

OBJECTIVE

Measure human reaction time using the ruler drop test and analyse results statistically to find mean, standard deviation, and uncertainty.

MATERIALS

- 30 cm ruler with millimetre markings
- Conversion chart: distance fallen (mm) to time (ms)
- Data table for 20 trials per person
- Calculator or spreadsheet

STEPS

110. One person holds the ruler at the top. The "catcher" places thumb and finger at the 0 cm mark without touching.
111. Drop without warning. Catcher grabs as fast as possible. Record distance fallen (mm).
112. Use the formula: $t = \sqrt{2d/g}$ where d = distance in metres, $g = 9.81\ m/s^2$. Or use a conversion chart.
113. Repeat 20 times. Record all values in ms. Calculate mean and standard deviation.
114. Calculate Type A uncertainty: $u = s/\sqrt{n}$. State result as: "Reaction time = mean ± U ms (k=2)."

WHY IT MATTERS
Human reaction time is a biological measurement with natural variability. This variability is why calibration technicians use instruments instead of their senses — instruments have known, documented uncertainty. This experiment demonstrates why Type A statistical analysis exists.

Ages 10–14 · Technician Level | PROBLEMS MODE

Density Detective — Identify Mystery Objects

⏱ 50 min · Groups of 3 · Classroom / Lab

SAFETY & PPE REQUIRED

Safety glasses, gloves, and apron required. Handle metal objects carefully — sharp edges possible. Do not taste or touch unknown materials directly.

OBJECTIVE

Identify mystery metal cylinders using only density calculations compared to a reference table.

MATERIALS

- 5 small cylinders of different metals (labelled A–E, not identified)
- Digital scale (0.01 g resolution)
- Graduated cylinder (water displacement method)
- Density reference table (Al 2.7, Fe 7.9, Cu 8.9, Zn 7.1, Pb 11.3 g/cm³)

STEPS

115. Weigh each cylinder on the scale. Record mass in grams (3 measurements each, take average).
116. Measure volume using water displacement: fill graduated cylinder to 30 mL, lower metal in, record new level. Volume = change in mL = cm³.
117. Calculate density = mass ÷ volume for each object.
118. Compare to the reference table. Identify each metal A–E.
119. Calculate percentage error: |calculated − reference| ÷ reference × 100.

WHY IT MATTERS

Density is used to authenticate precious metals, detect counterfeit gold coins, and verify pharmaceutical ingredient purity. The accuracy of your identification depends entirely on the accuracy of your scale and graduated cylinder — both require regular calibration.

Ages 10–14 · Technician Level | PROBLEMS MODE

Heating Rate Calculation — Degrees Per Minute

⏱ 50 min · Pairs · Classroom / Lab

SAFETY & PPE REQUIRED
Safety glasses, heat-resistant gloves, and apron required. ADULT handles all heating equipment. Never leave heating water unattended.

OBJECTIVE

Measure the heating rate of water (°C per minute) and compare it for 100 mL vs 250 mL of water.

MATERIALS

- Hot plate or microwave (adult operates)
- Thermometer (digital, not mercury)
- 2 beakers: 100 mL and 250 mL water
- Stopwatch
- Graph paper or spreadsheet

STEPS

120. Record starting temperature of 100 mL water. Begin heating (adult at controls).
121. Every 60 seconds, record temperature. Continue until 70°C or 10 minutes. Turn off heat.
122. Repeat for 250 mL. Plot both heating curves on the same graph (time vs temperature).
123. Calculate average heating rate: $\Delta T \div \Delta t$ (°C per minute) for each.
124. Why does less water heat faster? Write your scientific explanation.

WHY IT MATTERS
Heating rates are critical in pharmaceutical manufacturing, food processing, and materials science. Calibrated thermometers and precise time measurements ensure that drugs are sterilised properly and foods are processed safely.

Ages 10–14 · Technician Level | PROBLEMS MODE

Irregular Area — Measuring What You Cannot Calculate

⏱ 45 min · Individual · Home / Classroom

SAFETY & PPE REQUIRED
Be careful with scissors if used for cutting paper templates. Adult should supervise cutting activities.

OBJECTIVE

Use two methods to measure the area of an irregular shape and compare accuracy.

MATERIALS

- Irregular-shaped object (leaf, hand outline, irregular cutout)
- Graph paper (1 mm grid)
- Ruler
- Pencil
- Calculator

STEPS

125. Trace the object onto graph paper. Count every complete square inside the outline. Then count partial squares (estimate as half).
126. Total area = complete squares + (partial squares × 0.5), in mm^2.
127. Method 2: Measure the longest length and widest width. Calculate bounding rectangle area.
128. Estimate the shape fills approximately what percentage of the rectangle? Calculate "percentage fill" × rectangle area.
129. Compare both methods. Which do you think is more accurate? Calculate the percentage difference.

WHY IT MATTERS
Measuring irregular shapes is common in medicine (organ surface area), engineering (circuit board layout), and environmental science (land area mapping). GIS software, laser scanners, and CMMs all apply more sophisticated versions of what you just did — with documented measurement uncertainty.

Ages 15–18 · Metrologist Level | PROBLEMS MODE

Build a Complete Uncertainty Budget

⏱ 75 min · Individual · Lab / Classroom

SAFETY & PPE REQUIRED
Safety glasses and apron required. Closed-toe shoes. Handle calibrated weights carefully — do not drop.

OBJECTIVE

Construct a complete GUM-compliant uncertainty budget for a mass measurement using a digital scale.

MATERIALS

- Digital scale (resolution 0.01 g)
- Reference weight (certified, 50 g)
- Small object to measure (coin or washer)
- Spreadsheet

STEPS

130. Source 1 — Repeatability (Type A): Weigh the coin 10 times. Calculate s and $u_A = s/\sqrt{10}$.
131. Source 2 — Resolution (Type B): $u_{Res} = 0.01 \text{ g} \div (2\sqrt{3}) = 0.00289$ g.
132. Source 3 — Reference standard (Type B): Use certificate uncertainty ÷ k (from certificate).
133. Combined: $u_c = \sqrt{u_A^2 + u_{Res}^2 + u_{Std}^2}$.
134. Expanded: $U = 2 \times u_c$ (k=2, ~95% confidence). State result: "Mass = x.xx g ± U g (k=2)."
135. Create a full uncertainty budget table showing each source, type, distribution, divisor, standard uncertainty, and contribution.

WHY IT MATTERS
This is the exact format required by ISO/IEC 17025:2017 clause 7.6 for all accredited calibration laboratories. Every calibration certificate ever issued was produced using a budget just like this one.

Ages 15–18 · Metrologist Level | PROBLEMS MODE

TUR Workshop — Test Uncertainty Ratio Calculations

⏱ 60 min · Individual · Classroom

SAFETY & PPE REQUIRED

This is a calculation experiment. Work at a clean, organised desk. Double-check all arithmetic before concluding.

OBJECTIVE

Calculate TUR for multiple measurement scenarios and determine whether ANSI/NCSL Z540.3 requirements are satisfied.

MATERIALS

- Calculator or spreadsheet
- Scenario worksheet (see steps)
- ANSI/NCSL Z540.3 reference (or MetTutor for document review)

STEPS

136. TUR = Instrument Tolerance ÷ Calibration Standard Expanded Uncertainty (k=2).
137. Scenario A: Pressure gauge tolerance ±0.5 PSI; standard uncertainty ±0.05 PSI (k=2). Calculate TUR.
138. Scenario B: Thermometer tolerance ±0.5°C; calibrator expanded uncertainty ±0.2°C (k=2). Calculate TUR.
139. Scenario C: Voltage meter tolerance ±0.010 V; reference expanded uncertainty ±0.003 V (k=2). Calculate TUR.
140. For each scenario: Does TUR ≥ 4:1? If not, what actions does Z540.3 require?
141. BONUS: Design a scenario where TUR barely meets 4:1. What standard uncertainty is needed?

WHY IT MATTERS

TUR is the fundamental metric used to select calibration standards. A 4:1 TUR means your reference is 4× more accurate than what you're calibrating. Without this ratio, false pass/fail decisions happen — and products that should fail get shipped. ANSI/NCSL Z540.3 governs this in US calibration labs.

Ages 15–18 · Metrologist Level | **PROBLEMS MODE**

Error Propagation — Combined Measurement Uncertainty

⏱ 60 min · Individual · Classroom / Lab

SAFETY & PPE REQUIRED
Safety glasses and closed-toe shoes when in lab areas. Calculation sections can be done at your desk.

OBJECTIVE

Calculate the uncertainty of a derived quantity (density) using the GUM law of propagation of uncertainty.

MATERIALS

- Digital calipers, ruler, scale
- Small rectangular block
- Calculator
- Spreadsheet (recommended)

STEPS

142. Measure length (L), width (W), and height (H) of the block 5 times each. Calculate mean and standard deviation for each.
143. Calculate volume: $V = L \times W \times H$. Calculate u(V) using: $[u(V)/V]^2 = [u(L)/L]^2 + [u(W)/W]^2 + [u(H)/H]^2$.
144. Weigh the block 5 times. Calculate mean mass M and u(M).
145. Calculate density: $\rho = M/V$. Propagate uncertainty: $[u(\rho)/\rho]^2 = [u(M)/M]^2 + [u(V)/V]^2$.
146. State final result: "Density = $\rho \pm U(\rho)$ g/cm³ (k=2, 95% confidence)."

WHY IT MATTERS
This is Section 5 of the GUM (JCGM 100:2008) — the international standard for uncertainty evaluation. Every time a derived quantity is calculated (speed, density, force, power), the uncertainty of each input measurement must be combined using this law.

Ages 15–18 · Metrologist Level | PROBLEMS MODE

Linearity Analysis — When Instruments Lie

⏱ 75 min · Pairs · Lab / Classroom

SAFETY & PPE REQUIRED

Safety glasses and apron required. Handle calibrated weights carefully. Store safely after use.

OBJECTIVE

Evaluate the linearity of a spring scale or force gauge by measuring across its full range and calculating the maximum linearity error.

MATERIALS

- Spring scale (0–5 N) or kitchen scale (0–1000 g)
- Set of certified reference weights spanning the full range
- Graph paper or spreadsheet
- Calculator

STEPS

147. Apply reference weights at 10 evenly spaced points across the instrument range.
148. Record scale reading at each point (3 readings per point, take average).
149. Create a table: Reference Value | Scale Reading | Error (Reading − Reference).
150. Plot scale reading vs reference. Draw the ideal 1:1 line. Calculate deviation from ideal at each point.
151. Maximum linearity error = largest absolute error ÷ full-scale range × 100%.
152. Does this instrument meet a ±1% of full scale linearity specification?

WHY IT MATTERS

Instrument specifications state accuracy as "±X% full scale" or "±X% reading." The only way to verify this claim is with a multi-point calibration across the full range. This is a required element of every calibration laboratory's quality system under ISO/IEC 17025.

Ages 15–18 · Metrologist Level | PROBLEMS MODE

Guard Band Determination — Protecting Against False Decisions

⏱ 60 min · Individual · Classroom

SAFETY & PPE REQUIRED
Calculation experiment. Use an organised desk and double-check all arithmetic before concluding pass/fail.

OBJECTIVE

Apply ILAC G8 guard band methodology to determine tightened acceptance limits that protect against false acceptance risk.

MATERIALS

- Calculator
- Three calibration scenarios (see steps)
- ILAC G8 or ANSI/NCSL Z540.3 reference

STEPS

153. Scenario A: Instrument tolerance ±1.000 mm. Calibration uncertainty U = 0.200 mm (k=2). Guard band: g = U = 0.200 mm. Acceptance limits = ±(1.000 − 0.200) = ±0.800 mm.
154. Scenario B: Voltage meter tolerance ±0.050 V. U = 0.010 V (k=2). Apply same method. State new acceptance limits.
155. For each scenario: A measurement reads 0.850 mm — does it PASS or FAIL with and without the guard band?
156. Calculate: What TUR would eliminate the need for a guard band? (Hint: TUR ≥ 4:1).
157. Write a brief explanation of why guard banding protects end-users of the calibrated instrument.

WHY IT MATTERS
Guard bands are required by ILAC G8 and ANSI/NCSL Z540.3 when the calibration uncertainty is significant compared to the tolerance. Without guard bands, instruments that are borderline out-of-tolerance get falsely passed — potentially causing product defects, safety hazards, or failed audits.

Documents Mode

Create real lab records, reports, calibration documents, and measurement procedures

Ages 6–9 (Explorer) · Ages 10–14 (Technician) · Ages 15–18 (Metrologist)

Ages 6–9 · Explorer Level | DOCUMENTS MODE

My Measurement Journal

10 min/day × 5 days · Individual · Home

SAFETY & PPE REQUIRED

Wash hands before writing. Handle any measured objects carefully — report anything sharp or hot to an adult before touching.

OBJECTIVE

Keep a personal measurement journal for 5 days, recording something new you measure each day with the correct units.

MATERIALS

- Notebook or stapled paper booklet
- Pencil or pen
- Ruler, measuring cup, kitchen scale, thermometer
- Stickers or coloured pencils to decorate

STEPS

158. Write today's date at the top of each page. This is a scientific habit!
159. Day 1: Measure your height. Day 2: Measure the temperature at breakfast. Day 3: Weigh your backpack.
160. Day 4: Measure how much water you drink. Day 5: Measure your hand and foot length.
161. Write: "I measured ___ and the result was ___ [units]."
162. Add a drawing of the measuring tool you used each day.

WHY IT MATTERS

Every scientist keeps a laboratory notebook. In real labs, notebooks are legal documents — they prove when a discovery was made. Marie Curie's notebooks are still so radioactive from her experiments that they're kept in lead-lined boxes! Documentation is part of science forever.

Ages 6–9 · Explorer Level | DOCUMENTS MODE

Daily Weather Station Reporter

⏱ 10 min/day × 7 days · Individual · Home / Outdoors

SAFETY & PPE REQUIRED

Sun protection and appropriate clothing when going outdoors. Never go outside during a storm to measure. Ask an adult.

OBJECTIVE

Create a 7-day weather measurement record using temperature and observation, just like a real weather station.

MATERIALS

- Outdoor thermometer (or indoor/outdoor digital)
- Paper weather log sheet (draw your own!)
- Pencil
- Ruler (to measure any rainfall in a cup)

STEPS

163. Each morning at the same time, check the outdoor temperature. Record: "Date · Time · Temperature · Weather."
164. Draw a weather symbol: sunny, cloudy, rainy, stormy.
165. If it rains, put a cup outside and measure how many mm of water collected.
166. After 7 days, find: highest temp, lowest temp, and average temperature.
167. Draw a simple line graph of temperature over the week.

WHY IT MATTERS

Weather stations around the world collect temperature data at the exact same time every day using calibrated thermometers. This data is used to study climate change, forecast storms, and plan farming — and it all starts with a record exactly like yours.

Ages 6–9 · Explorer Level | DOCUMENTS MODE

School Supply Measurement Survey

⏱ 30 min · Individual · Home / Classroom

SAFETY & PPE REQUIRED
Be careful with sharp pencils and scissors. Handle items gently.

OBJECTIVE
Measure and document all your school supplies in a proper data table, with units and neat organisation.

MATERIALS
- Ruler (cm and mm)
- Kitchen scale
- Your school supplies (pencils, eraser, notebooks, scissors, etc.)
- Pencil and a blank table drawn on paper

STEPS
168. Draw a table with columns: "Object | Length (cm) | Width (cm) | Mass (g) | Notes."
169. Measure each school supply. Write clearly in each box of the table.
170. Find: the longest item, the heaviest item, the lightest item.
171. Write a sentence at the bottom: "The heaviest thing in my pencil case is ___."
172. Share your table with a classmate. Did they get the same measurements?

WHY IT MATTERS
A data table is the most important document in science. Real laboratories record every measurement in organised tables — and those tables are reviewed by auditors to make sure the lab is measuring correctly. A neat, complete data table is a sign of a professional scientist.

Ages 6–9 · Explorer Level | DOCUMENTS MODE

My Measurement Dictionary

⏱ 30 min initial + ongoing · Individual · Home / Classroom

SAFETY & PPE REQUIRED
No special PPE needed for this document project.

OBJECTIVE

Create a personal illustrated measurement vocabulary book with at least 10 words, their definitions, and a drawing of each concept.

MATERIALS

- Small blank booklet or folded paper
- Pencil and coloured pencils
- Ruler, thermometer, or scale for reference drawings

STEPS

173. Create one page per word. Start with: Length, Mass, Temperature, Volume, and Time.
174. For each word: write the word, what it measures, the SI unit, and a tool that measures it.
175. Draw a picture of the measurement tool next to each entry.
176. Add 5 more words you discover while experimenting: Accuracy, Standard, Calibration, Uncertainty, Units.
177. Add a new word every week as you learn more about measurement science!

WHY IT MATTERS
Professional metrologists use the VIM (International Vocabulary of Metrology) — a global dictionary that ensures every measurement term means exactly the same thing in every country. Creating your own vocabulary book is the same idea: clear, agreed-upon language prevents misunderstandings in science.

Ages 10–14 · Technician Level | DOCUMENTS MODE

Create a Calibration Record

⏱ 45 min · Individual · Home / Classroom

SAFETY & PPE REQUIRED

Safety glasses when handling any measuring instruments. Handle certified weights with clean hands or gloves.

OBJECTIVE

Create a properly formatted calibration record for a kitchen scale by performing a basic check against known reference weights.

MATERIALS

- Kitchen scale
- Known reference weights (US nickels weigh exactly 5.000 g each)
- Printed or hand-drawn calibration record form
- Calculator

STEPS

178. Create your calibration record header: Instrument Name, Serial/ID, Date, Operator, Location, Environmental Conditions (room temperature).
179. List your reference weights with their "certified" values. (5 US nickels × 5.000 g each = 25.000 g).
180. Weigh each reference weight 3 times. Record all readings in a table.
181. Calculate: Average reading, Error (Average − Reference), Pass/Fail against ±1% tolerance.
182. Write a conclusion: "This instrument passes/fails calibration. Next calibration due: [date + 1 year]."
183. Sign and date the bottom of the record.

WHY IT MATTERS

This is the core document produced by every ISO/IEC 17025 accredited calibration laboratory. The calibration record proves that a measurement was performed, documents who did it, and provides traceability. Without this record, a measurement has no scientific or legal standing.

Ages 10–14 · Technician Level | DOCUMENTS MODE

Professional Temperature Log Sheet

⏱ 15 min/day × 5 days · Individual · Home / Classroom

SAFETY & PPE REQUIRED
Safety glasses when handling measurement instruments. Adult must handle any hot liquids used for calibration checks.

OBJECTIVE

Create and maintain a professional temperature monitoring log for a refrigerator or room, formatted to meet food safety and lab standards.

MATERIALS

- Digital thermometer
- Pre-formatted temperature log (create with columns: Date | Time | Location | Reading °C | In Range? | Operator | Notes)
- Acceptable range definition (e.g., refrigerator: 2–8°C)

STEPS

184. Design your temperature log form with all required columns.
185. At the same time each morning, measure and record the temperature of the refrigerator (or classroom).
186. Check: Is the reading within the acceptable range? Mark Y (Yes) or N (No).
187. If the reading is out of range, write an "Action Taken" note.
188. After 5 days, calculate the average temperature and the range (max − min).
189. Write a summary: "Was the temperature consistently within the required range? What factors caused variation?"

WHY IT MATTERS
Hospitals, pharmaceutical warehouses, and food companies maintain continuous temperature logs on every storage unit. Vaccines that are stored too warm become ineffective. Every reading must be documented, and every out-of-range event triggers an investigation.

Ages 10–14 · Technician Level | DOCUMENTS MODE

Write a Complete Lab Report

⏱ 60 min · Individual · Home / Classroom

SAFETY & PPE REQUIRED
Review the PPE requirements from your original experiment — any hazards present during the work should be described in the Safety section of your report.

OBJECTIVE

Write a complete, professional-format lab report for one of your Concept or Problems Mode experiments.

MATERIALS

- Your experiment notes and data
- Your formatted data table
- Graph of your results
- Word processor or pen and paper

STEPS

190. TITLE: Experiment name, your name, date, and partner name.
191. OBJECTIVE: One sentence — what question does this experiment answer?
192. MATERIALS & SAFETY: List all materials used. Note all PPE worn and safety precautions taken.
193. PROCEDURE: Numbered steps, past tense. "The pendulum was set to 25 cm…"
194. DATA: Your formatted data table with units and calculated statistics.
195. ANALYSIS: Graphs, calculations, and observations. Include sources of uncertainty.
196. CONCLUSION: What did you find? Did it match your prediction? What would you do differently?

WHY IT MATTERS
A lab report transforms raw data into scientific knowledge. In research, peer review, and accreditation, the lab report is examined to verify that the work was done correctly and safely. A good lab report from today is practice for university-level scientific writing and real career documents.

Ages 10–14 · Technician Level | DOCUMENTS MODE

Standards Scavenger Hunt

⏱ 45 min · Individual or pairs · Home / Classroom

SAFETY & PPE REQUIRED
No special PPE needed. Handle any physical products (food labels, medicine bottles) with clean hands.

OBJECTIVE

Find real-world examples of measurement standards, traceability statements, and calibration requirements in everyday products and documents.

MATERIALS

- 5 food labels from the kitchen
- 1 medicine bottle label
- 1 electrical appliance label
- Any calibration certificate or inspection sticker you can find
- Paper to record findings

STEPS

197. Look at a food nutrition label. Find: the mass/volume of contents. Who guarantees this measurement?
198. On a medicine bottle: find the dosage measurement. What standard requires this accuracy?
199. On an electrical appliance: find the voltage and wattage ratings. Why must these be accurate?
200. If you find a calibration sticker (on a scale, meter, or instrument): record the calibration date, who performed it, and due date.
201. Create a document: "Measurement Standards in My Home" — list all examples found with their measurements and units.

WHY IT MATTERS
Measurement standards are everywhere — they are simply invisible until you know how to look. Every quantity printed on a food label, medicine bottle, or appliance was verified by a calibrated instrument, traced to a national standard, and documented in a record.

Ages 15–18 · Metrologist Level | DOCUMENTS MODE

Write a Measurement Procedure (ISO 17025 Style)

⏱ 75 min · Individual · Classroom

SAFETY & PPE REQUIRED

Document the PPE requirements explicitly in Section 4 of your procedure — this is a mandatory element of any ISO 17025 laboratory procedure.

OBJECTIVE

Write a formal measurement procedure for one of your experiments in the structure required by ISO/IEC 17025:2017 clause 7.2.

MATERIALS

- Word processor
- Your experiment notes for reference
- ISO/IEC 17025:2017 clause 7.2 for reference (ask MET for details)

STEPS

202. HEADER: Procedure Title, Document ID, Version Number, Effective Date, Prepared By, Approved By.
203. SECTION 1 — Scope: What is measured, measurement range, and applicable instruments.
204. SECTION 2 — Reference Documents: List relevant standards (NIST GUM, ISO 17025, VIM, etc.).
205. SECTION 3 — Equipment Required: Instruments and their required specifications/uncertainties.
206. SECTION 4 — Safety and PPE: All hazards identified and PPE required. This section is MANDATORY.
207. SECTION 5 — Environmental Conditions: Required temperature, humidity, vibration limits.
208. SECTION 6 — Procedure Steps: Numbered, unambiguous steps any trained technician could follow.
209. SECTION 7 — Uncertainty Statement: Brief statement of measurement uncertainty achievable.
210. SECTION 8 — Records Required: What must be documented and where it is stored.

WHY IT MATTERS

ISO/IEC 17025 clause 7.2 requires that all calibration work be performed using documented, validated procedures. A procedure protects everyone: it ensures the measurement is done correctly every time, protects the operator's safety, and provides legal evidence of proper practice.

Ages 15–18 · Metrologist Level | DOCUMENTS MODE

Write a Formal Traceability Statement

⏱ 60 min · Individual · Classroom

SAFETY & PPE REQUIRED
No special PPE for this documentation project. Handle any physical instruments carefully when referencing them.

OBJECTIVE

Document a complete metrological traceability chain for one of your measurement instruments, from your instrument back to an SI unit definition.

MATERIALS

- Your digital caliper or thermometer
- Any available calibration certificate for the instrument
- Reference: VIM definition 2.41 (Metrological Traceability)

STEPS

211. Start with your instrument. Document: Name, Model, Serial Number, Resolution, Last Calibration Date.
212. Identify who calibrated it and what reference standard was used.
213. Identify who calibrated THAT reference standard (the calibration lab's certificate).
214. Continue up the chain: Lab standard → National standard (NIST) → SI definition of the unit.
215. Draw a traceability chain diagram showing each link with uncertainty values at each level.
216. Write the formal statement: "The [instrument] is traceable to [SI unit] through [lab name] under [accreditation body], with expanded uncertainty U = [value] at k=2."

WHY IT MATTERS
This statement appears on every ISO/IEC 17025 calibration certificate. A2LA P102 and ILAC P-14 both specify exactly what a traceability statement must contain. Without this documented chain, a calibration certificate is not considered legally or scientifically valid.

Ages 15–18 · Metrologist Level | DOCUMENTS MODE

Write a GUM-Compliant Uncertainty Statement

⏱ 75 min · Individual · Classroom / Lab

SAFETY & PPE REQUIRED
Safety glasses and apron required if any physical measurements are performed to gather data for this statement.

OBJECTIVE

Write a complete, publication-quality measurement uncertainty statement for your 20-trial experiment, formatted to NIST GUM and ISO/IEC 17025 requirements.

MATERIALS

- Data from your Type A uncertainty experiment
- Spreadsheet
- NIST GUM Section 5 for format reference (ask MET!)

STEPS

217. Write the measurement model: $y = f(x_1, x_2, ...)$ — describe what you are measuring and all input quantities.
218. Create the full uncertainty budget table with columns: Source | Symbol | Value | Type | Distribution | Divisor | Standard Uncertainty | Sensitivity Coefficient | Contribution.
219. Calculate combined standard uncertainty uc using root-sum-squares.
220. State expanded uncertainty U = k × uc, where k=2 for ~95% confidence level.
221. Write the formal result: "y = [value] ± [U] [units] (expanded uncertainty, k=2, ~95% confidence level)".
222. Add a footnote explaining what "k=2" means and how it was determined.

WHY IT MATTERS
This is the exact format required by ISO/IEC 17025:2017 and NIST GUM for all reported measurement results. When a calibration laboratory issues a certificate, this statement must appear. Auditors from A2LA, NVLAP, and other accreditation bodies review this statement for compliance with ILAC P-14.

Ages 15–18 · Metrologist Level | DOCUMENTS MODE

Create a Mock Calibration Certificate

⏱ 90 min · Individual · Classroom / Lab

SAFETY & PPE REQUIRED

Safety glasses and apron when performing the physical calibration. Document PPE usage on the certificate itself.

OBJECTIVE

Produce a complete mock calibration certificate for your kitchen scale, formatted to A2LA P102 and ILAC P-14 requirements.

MATERIALS

- Calibration data from your Calibration Curve experiment
- Uncertainty budget from your Uncertainty Budget experiment
- Word processor or spreadsheet for layout
- A2LA P102 or ILAC P-14 reference (available in MetTutor)

STEPS

223. CERTIFICATE HEADER: Certificate number, issue date, page number, lab name ("MET Student Calibration Lab"), accreditation statement (note: mock, not accredited).
224. CUSTOMER & INSTRUMENT INFO: Customer name, instrument description, model, serial number, asset ID, received date, completion date.
225. CALIBRATION PROCEDURE: Reference the procedure name you wrote in the Measurement Procedure project.
226. ENVIRONMENTAL CONDITIONS: Temperature and humidity recorded during calibration.
227. RESULTS TABLE: Reference values, observed values, errors, pass/fail against tolerance.
228. UNCERTAINTY STATEMENT: Paste your GUM-compliant uncertainty statement here.
229. TRACEABILITY STATEMENT: Paste your formal traceability statement here.
230. AUTHORIZATIONS: "Calibrated by: [your name] · Reviewed by: [teacher] · Date: ___"
231. Add a prominent watermark: "PRACTICE CERTIFICATE — NOT FOR COMMERCIAL USE."

WHY IT MATTERS

A calibration certificate is the final output of a calibration laboratory's work. It is a legally binding document that carries liability for the issuing lab. ISO/IEC 17025 clause 7.8, A2LA P102, and ILAC P-14 all specify exactly what must appear on a certificate.

