NIST Metric Recipes:

Measure. Mix. Learn.

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Cover: Lloyd Bekele bakes chocolate chip cookies. Credit: NIST

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Summary

Audience

Formal and Informal Educators, Parents and Families.

Keywords

Bake, classroom, cook, food, gram, mass, measure, metric system, recipe, STEAM.

Subjects

Biology, Chemistry, Earth Science, Engineering, Environmental Science, Life Science, Mathematics, Physical Science, Physics, and STEAM.

Activity Includes

Instructions, printable recipe cards, templates, and supporting classroom resources.

- **Recipe Times: 30 to 90 minutes**

Education Standards

This activity is designed to the Next Generation Science Standards (NGSS), Common Core State Standards (CCSS) for Mathematics and English Language Arts **(Resources).**

Abstract

Cooking and baking using a kitchen scale are fun ways to build metric system abilities and apply measurement techniques. This recipe series is ideal for both new and experienced chefs **(Figure 1)**.

Transform your K-12 classroom or home kitchen into a hands-on culinary laboratory by swapping volume cups for a digital scale. Explore this metric recipe series, hands-on activities, printable worksheets, and videos to build and reinforce interdisciplinary math, science, engineering, art, and mathematics (STEAM) skills. Apply the metric system in daily life to build confidence, develop proportional reasoning, and practice measurement techniques. Companion resources are available on the *NIST Metric Kitchen* website.

Figure 1. Child baking with parent. Credit: Adobe Stock

Activity	Delivery Method	Grade Level			
		K to 2nd	3rd to 5th	6th to 8th	9th+
Facilitator Guided	Classroom		✓	✓	✓
Family Guided	Home	✓	✓	✓	✓

Introduction

Metric system measurements simplify cooking and baking. In professional kitchens, recipes are formulas.

- **Using grams instead of volume to measure ingredients makes a recipe reliable, repeatable, and efficient.**
- **Metric measurements reduce errors, improve cooking, and baking consistency.**
- **Metric recipes are easy to scale up or down.**

Measure. Mix. Learn.

Many important skills are developed through metric cooking and baking. Hands-on culinary measurements build math skills, confidence, independence, and responsibility. They also help learners understand place value and problem solve. Cooking and baking activities help students discover the importance of measurements and see how math and science are used in daily life **(Figure 2)**.

The *NIST Metric Kitchen* is an online companion resource based on this publication that includes a recipe gallery and culinary measurement guidance for classroom and home use[1].

The *NIST Metric Kitchen* offers practical benefits for educators, parents, and young learners by connecting academic concepts with a meaningful, everyday experience. These activities energize students' understanding of the International System of Unites (SI, commonly known as the metric system) by helping them recall key unit relationships and apply them in a practical setting. As ingredients are measured, students strengthen their understanding of place value and proportional reasoning. Working with recipes allows learners to see how scaling a recipe up or down relies on proportional relationships—doubling, halving, or adjusting ingredient quantities while maintaining the integrity of the original culinary formula. Through these experiences, students recognize how mathematical ideas connect directly to everyday culinary tasks. Turn cooking into an engaging opportunity to practice math, science, and creativity.

Figure 2. Tanna Nguyen, bakes banana bread. Credit: NIST

For educators, metric cooking provides a highly engaging way to teach math and science concepts through hands-on learning. Measuring ingredients, converting units with the metric system, and scaling recipes reinforce topics such as place value, proportional reasoning, estimation, and problem solving. Teachers can also integrate discussions about accuracy, tools, and processes, helping learners justify why certain measurement methods—such as using a kitchen scale instead of a volume cup—may produce more reliable results.

Cooking naturally involves observation, sequencing, and experimentation. It supports interdisciplinary learning across mathematics, science, and life skills while encouraging collaboration and inquiry in the classroom.

Figure 3. Young girl prepares a metric recipe with a family member. Credit: Adobe Stock

For parents and families, metric cooking turns everyday cooking at home into an opportunity for informal learning. Families can use the companion resources and videos from the *NIST Metric Kitchen* to follow recipes together, practice measuring ingredients, and talk about how recipes change when they are scaled up or down. This shared experience helps parents reinforce classroom concepts in a relaxed environment while building confidence in the ability to apply math and science in real-life situations. Cooking encourages family participation in learning and promotes independence as children begin to take more responsibility for measuring, mixing, and preparing food **(Figure 3)**.

For young learners, metric cooking makes abstract ideas more concrete and memorable. Handling ingredients, reading measurements, and observing how quantities affect a recipe help students recognize the purpose behind numbers and units. Learners gain confidence as they practice problem solving—figuring out how much of an ingredient is needed, adjusting quantities, or deciding which tools to use. At the same time, they develop practical life skills such as following directions, organizing steps, and working safely in the kitchen. By combining creativity, experimentation, and teamwork, metric cooking helps build curiosity and a deeper understanding of how math and science are used in daily life **(Figure 4)**.

Figure 4. Young boy using kitchen scale to measure ingredients in grams. Credit: Adobe Stock

Learning Objectives

The culinary arts are a fun hands-on way to learn how to apply the International System of Units (SI), commonly known as the metric system.

- **Students prepare recipes using mass, length, area, volume, time, and temperature measurements.**

Measurement Skills

Using SI prefixes[2] during recipe preparation helps students interpret measurements in small and large quantities, and understand how measurements change scale, such as grams (g) or kilograms (kg). Learners build familiarity with SI writing[3] style, such as including a space between a number and unit symbol (e.g., 100 g, not 100g) and capitalization rules (e.g., kg, °C, mL).

Students will learn to interpret written instructions, complete steps in a necessary sequence, troubleshoot mistakes, and build confidence as they observe how precise measurements lead to successful results. As students prepare ingredients using the culinary practice of *mise en place*, they also practice planning and organization, which are important skills in both the laboratory, field, and kitchen.

Measuring ingredients by mass using a digital kitchen scale will help students understand why mass is more accurate for cooking and baking. Reading and interpreting an oven thermometer can translate to other temperature laboratory and field data collection activities. Students develop fine motor skills and coordination as they practice selecting appropriate cooking tools, opening containers, mixing, pouring without spilling, counting, and weighing.

Request a Free SI Teacher Kit

Email the NIST Metric Program:

TheSI@nist.gov

Include your name, school, subject, grade level, phone number, and U.S. mailing address.

Participants will be able to:

- **LIST** and **INTERPRET** SI measurement units used in a recipe.
- **INTERPRET** a metric recipe.
- **DESCRIBE** the relationship between grams and kilograms.
- **MEASURE** ingredients accurately.
- **DEVELOP** a metric version of a recipe.
- **CRITIQUE** a poorly converted recipe.
- **EXPLAIN** how doubling or halving affects the recipe quantities.

Visit the *NIST Metric Kitchen* website for resources.

STEAM Activities

Completing a *NIST Metric Kitchen Recipes* is an opportunity to practice important STEAM skills, including culinary math and accurate measurement techniques.

- **Students use a digital kitchen scale, organize, plan, and prepare ingredients, select tools, collect data, and reflect on how preparation improves scientific and culinary outcomes.**
- **Students use ratio and rate reasoning to solve real-world problems.**
- **Students plan like a scientist, engineer, and chef.**

Mise en Place (Preparation)

Introduce the culinary technique of *mise en place* used by chefs to prepare all equipment and ingredients before preparing a recipe **(Figure 5)**.

Objective: Students will measure several ingredients, taring between each measurement, then mix the ingredients, record each measurement in a table, and verify that all ingredients are ready **(*Mise en Place* Worksheet** and ***Mise en Place* Answer Key)**.

NGSS Alignment:

Science and Engineering Practices

- Planning and carrying out investigations.
- Using mathematics and computational thinking.
- Analyzing and interpreting data.

Crosscutting Concepts

- Cause and effect.
- Systems and system models.

Students review a simple metric recipe and predict:

- How will organizing and measuring individual ingredients first, before combining them, impact accuracy and time.
- How will measuring ingredients sequentially in one bowl impact accuracy and time.

Figure 5. Baking ingredients and tools. Credit: Adobe Stock

Activity A: Students complete the ***Mise en Place* Worksheet** and evaluate the *NIST Metric Kitchen* **Cocoa Mix Recipe**, sequence the recipe tasks, and reflect on the benefits and use of *mise en place* in the cooking process.

Activity B: Students compare and contrast recipe preparation with and without *mise en place*. Divided the class into two teams.

Scenario 1: Students tare the scale and measure each ingredient (grams) in a bowl and record each measurement in a data table. Do not mix ingredients. Students verify all ingredients are ready.

Scenario 2: Students measure several ingredients in the same bowl, taring between each measurement, then mix the ingredients.

Students will:

- Calculate the total time for each scenario.
- Measure accurately.
- Identify mistakes or errors with and without *mise en place.*

Figure 6. NIST Metric Kitchen Cocoa Mix. Credit: Adobe Stock

Figure 7. NIST Metric Kitchen Chocolate Chip Cookies. Credit: Adobe Stock

How Sweet

Objective: Students will compute unit rates (e.g., grams of sugar per 1 serving) and compare ratios across recipes. **(How Sweet Worksheet,** and **How Sweet Answer Key** and **Figure 6)**.

Common Core State Standards (Mathematics) Alignment:

- Use ratio and rate reasoning to solve real-world problems.
- Discuss rates, such as grams of sugar per serving size.

Activity A: Students will evaluate 3 metric recipes with different amounts of sugar and servings. Determine the grams of sugar per serving. Record the data (Worksheet). Rank the recipes from highest to lowest sugar.

Activity B: Students will answer the following: If the daily recommended value for added sugars is 50 g per day (based on a 2 000 calorie daily diet), how many servings per day could be eaten without exceeding the recommended amount?

Extension

Graph the ratio data (number of servings vs. sugar) for the 4 recipes.

- x-axis (horizontal): Number of servings.
- y-axis (vertical): Sugar (grams).

Scale Up a Recipe

Objective: Students will apply ratios and proportional reasoning to scale up the metric chocolate chip cookie recipe **(Scaling a Recipe Worksheet** and **Scaling a Recipe Answer Key** and **Figure 7)**.

NGSS Alignment:

Science and Engineering Practices

- Use mathematics and computational thinking.

Crosscutting Concepts

- Scale, proportion, and quantity.

Design and Test a Simple Structure

Objective: Students will design, construct, and test a gingerbread house to improve structural strength. See data tables **(Gingerbread House Template)**.

NGSS Alignment:

Science and Engineering Practices

- Design solutions and construct explanations.

Disciplinary Core Idea: ETS1.B

- Develop possible solutions.

Crosscutting Concepts

- Structure and function.

Discussion Prompts (Think-Pair-Share):

Objective:

After this discussion activity, learners will:

- Explain their thinking using math.
- Correctly use science vocabulary when speaking.
- Support ideas with evidence.

Conduct small group discussions using these prompts and rubric **(Table 1** and **Vocabulary)**.

Ask questions and define problems:

- Why do professional bakers prefer using mass (grams) instead of volume (milliliters).
- Why is it important to tare a kitchen scale before adding ingredients **(Resources - Measurement Process).**

Plan and carry out investigations:

- What variables can affect measurements when cooking (e.g., tools, environment, human error or technique).
- How do two bakers following the same recipe get different results.
- How could you redesign a recipe to make it easier to repeat.

Use mathematics and computational thinking:

- How does converting between grams and kilograms help when measuring large recipe ingredient quantities.
- Why is consistency important in both baking and scientific experiments.

Engage in argument from evidence:

- Compare and contrast collecting data in a science laboratory and measuring ingredients when cooking.
- Describe how doubling (or halving) a recipe demonstrates ratios and proportions.

Obtain, evaluate, and communicate information:

- What STEAM skills are used when following a recipe step-by-step.
- Describe what careers use measurement skills similar to those in cooking and baking.

Discussion Rubric				
Criteria	**4 Exceeds Expectations**	**3 Meets Expectations**	**2 Developing**	**1 Beginning**
Use of STEAM Vocabulary	Uses multiple vocabulary words correctly (e.g., mass, ratio, accuracy) and explains them clearly	Uses at least one vocabulary word correctly	Uses vocabulary incorrectly or unclearly	Does not use STEAM vocabulary
Math & Computational Thinking	Clearly explains calculations, patterns, or models using numbers, equations, or steps	Shows correct math reasoning or logical steps	Attempts math reasoning but includes errors or gaps	Does not show math reasoning
Evidence & Reasoning	Supports ideas with clear evidence from cooking activities or data	Gives a reason or example to support an idea	Gives an opinion with limited support	Gives an opinion with no support
Clarity of Explanation	Ideas are organized, detailed, and easy to understand	Ideas are clear and mostly complete	Ideas are somewhat unclear or incomplete	Ideas are confusing or off-topic
Participation & Listening	Actively participates, listens respectfully, and builds on others' ideas	Participates and listens respectfully	Participates inconsistently or needs reminders	Does not participate or disrupts discussion

Table 1: Discussion Rubric Table.

Educational Standards

Using metric system measurements is a key skill. *NIST Metric Kitchen Recipes* encourage procedural sequencing and precision. Cooking activities provide reasoning opportunities in measurement, ratio, and data interpretation skills similar to those in cooking and baking.

Figure 8. Gingerbread house panel. Credit: Adobe Stock

Next Generation Science Standards (NGSS)[4]	
[https://nap.nationalacademies.org/read/13165/chapter/7#52]	
Science and Engineering Practices	
Using Mathematics and Computational Thinking	Apply mathematics and computational thinking by comparing measurements and converting units when scaling up recipe batches to increase yield.
Planning and Carrying Out Investigations	Plan and carry out investigations, such as ingredient measurement and adjusting quantities or cook times.
Obtaining, Evaluating, and Communicating Information	Obtain, evaluate, and communicate information by reading and interpreting a recipe and writing a description of the results.
Crosscutting Concepts	
Scale, Proportion, and Quantity	Compare ingredient quantities relative to yield.
Systems and System Models	Use a recipe as a system with inputs (ingredients) and outputs (prepared food).
Disciplinary Core Ideas	
This activity offers supplemental connections to: • Matter and its interactions. Observe how ingredients change when mixed and heated. • Energy. Thermal energy transfer from oven to food (heat effect).	

Figure 9. Piping bags with colored icing. Credit: Adobe Stock

Figure 10. Family cleaning before cooking. Credit: Adobe Stock

Common Core State Standards (CCSS) - Mathematics[5]	
[https://www.thecorestandards.org/Math/Practice/MP5/]	
Instructional Level	**Measurement and Data** [https://www.thecorestandards.org/Math/Content/MD/]
Grade 5	**5.MD.A.1.** Convert among different-sized standard measurement units within a given measurement system.
Grade 6	**6.RP.A.3.** Use ratio and rate reasoning to solve real-world problems. • Use appropriate tools strategically and use precision to measure mass in grams using a digital kitchen scale and degrees Celsius using a thermometer. • Interpret kitchen scale readouts. • Describe how the tare process removes a container's mass. • Compute, compare, and evaluate ingredient quantity relationships (e.g. grams of sugar vs. flour). • Discuss rates, such as grams per cookie. • Represent data by comparing batch variations in a chart. • Discuss why consistent measurement units matter in daily life and STEAM applications. • Evaluate problems and persevere in solving measurement challenges.

Common Core State Standards (CCSS) - English Language Arts (ELA)
Reading comprehension is supported during procedural recipe card interpretation. Writing and communication is supported through documenting and reflecting on recipe results. [https://www.thecorestandards.org/ELA-Literacy/W]

Figure 11. Angie Tehrani, baking brownies. Credit: NIST

Figure 12. Family measuring ingredients. Credit: Adobe Stock

Background

Hands-on activities are an easy way to motivate students to learn, build self-confidence, and transfer SI measurement skills to new situations.

- **Interpreting a recipe is similar to solving a science, technology, engineering, arts, and mathematics (STEAM) problem.**
- **Students must carefully read the recipe, understand the quantities and units, accurately measure ingredients, and evaluate the impact of error and variation on the quality of the resulting dish.**

SI Basics

Familiarity with the elements and structure of the International System of Units (SI) prepares students to successfully make measurements in STEAM applications. The SI is made up of several elements, including the defining constants[6], base units[2], derived units, and prefixes[2]. Together, these elements help measure in a clear, simple, and consistent way. The major SI elements are illustrated in this model[7,8] **(Figure 13 and Figure 14)**.

Figure 13. SI logo with seven defining constants and seven base units[9]. Credit: BIPM

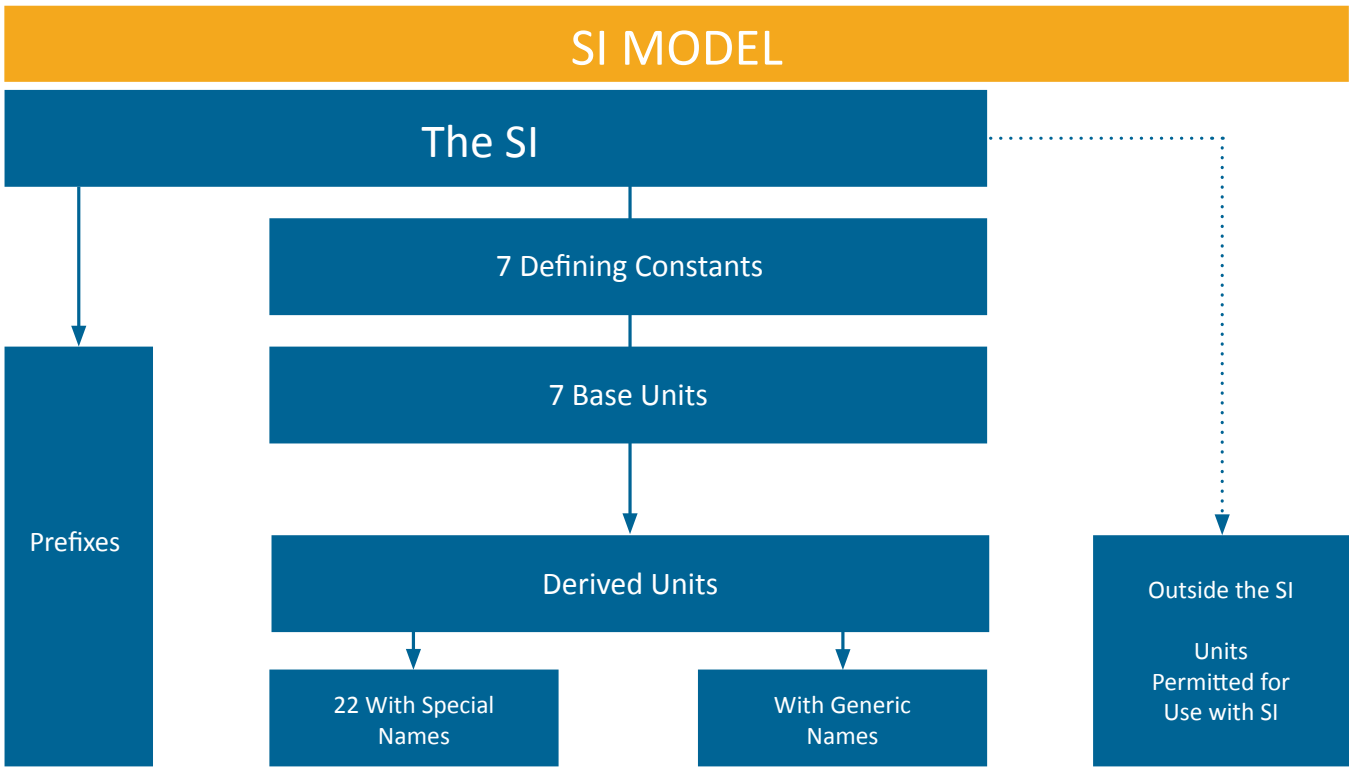


Figure 14. A graphical model of the International System of Units (SI), adapted from NIST TN 938.2. Credit: NIST

- Seven **defining constants**: the cesium hyperfine splitting frequency (ΔV_{Cs}), speed of light in vacuum (c), the Planck constant (h), elementary charge (e) (i.e., the charge on a proton), Boltzmann constant (k), Avogadro constant (N_A), and luminous efficacy of a specified monochromatic source (K_{cd}). More information on the defining constants is available on the *NIST website*[10].
- Seven **SI base units**: the meter (m), second (s), mole (mole), ampere (A), kelvin (K), candela (cd), and kilogram (kg). The seven base units of the SI are used to define 22 derived units with special names and symbols (**Figure 13**)[11].
- Twenty-two **derived units with special names**, defined as products of powers of the base units **(Figure 15)**.
- Together the base units and derived units with special names (29 units) form the **core set of SI units**. All other SI units are combinations of some of these 29 units. Any of the base units and derived units with special names can be constructed directly from the seven defining constants. Derived units with **generic names** reflect their mathematical derivation, such as area (m^2), volume (m^3), velocity (m/s), and acceleration (m/s^2).
- Twenty-four **prefixes** ranging from 10^{30} to 10^{-30}, are currently recognized for use. Values of quantities are expressed using Arabic symbols for numbers paired with a unit symbol, often with a prefix symbol that modifies unit magnitude.

Learn more about the SI in NIST Special Publication 330, **SP 811,** and explore the *NIST webpage*[12].

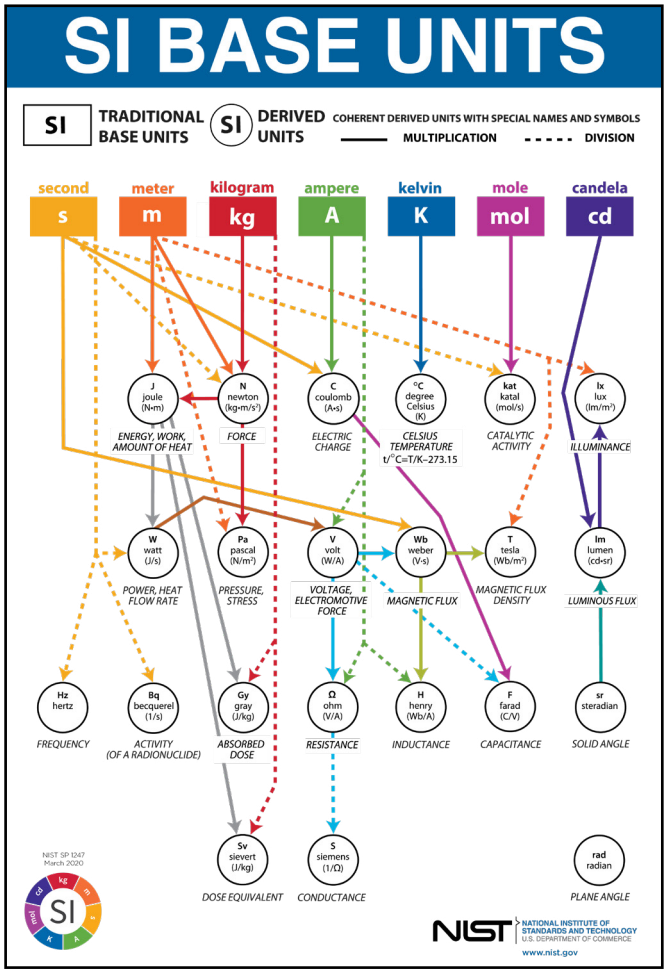


Figure 15. SI Base Units Relationships Poster, a colorful diagram illustrating the relationships between the SI derived units with special names and symbols and the seven traditional base units[6]. Credit: NIST

SI units are used in cooking and baking like mass, volume, length, time, and temperature — measurements that are common in daily life[12]. When you drink a 500 mL bottle of water, run a 100 m track and field sprint, or read a garden thermometer in °C, you're using the metric system. Baking is a real-world application of scale, proportion, and quantity.

The SI is built on base 10. Measurement units can be increased or decreased by powers of ten using SI prefixes, allowing students to visualize scale as they transition between very small and large measurements. SI relationships are proportional. If a recipe ingredient quantity is divided by 1 000 to convert grams to kilograms, the proportional relationship is consistent. See Common Prefixes for Culinary Applications **(Table 2)**. For example, 250 g/1 000 = 0.25 kg. A recipe may use 250 g of flour. Doubling 250 g to 500 g, or 0.5 kg, is quick "mental math."

Recognizing multiplicative relationships is an important scientific practice. Understanding scale is essential for explaining phenomena.

Common Prefixes

NAME	SYMBOL	FACTOR	QUANTITY
kilo	k	10^3	1 000 one thousand
centi	c	10^{-2}	0.01 one hundredth
milli	m	10^{-3}	0.001 one thousandth

Table 2. Common Prefixes for Culinary Applications. A comprehensive list of SI Prefixes are available online NIST Metric (SI) Prefixes[15].

Common Measurement Units for Culinary Applications

Mass[13]

- 1 gram (g) = 1 000 milligrams (mg)
- 1 kilogram (kg) = 1 000 grams (g)

Length[14]

- 10 millimeters (mm) = 1 centimeter (cm)
- 10 centimeters (cm) = 1 decimeter (dm) = 100 millimeters (mm)
- 10 decimeters (dm) = 1 meter (m) = 1 000 millimeters (mm)

Area[15]

- 100 square millimeters (mm^2) = 1 square centimeter (cm^2)
- 100 square centimeters (cm^2) = 1 square decimeter (dm^2)

Volume[16]

- 1 milliliters (mL) = 1 000 cubic millimeters (mm^3) = 1 cubic centimeter (cm^3)
- 1 deciliter (dL) = 100 milliliters (mL)
- 1 liter (L) = 1 000 milliliters (mL) = 1 000 cubic centimeters (cm^3) = 1 cubic decimeter (dm^3)

Time[17]

- 60 seconds (s) = 1 minute (min) = 1 hour (h)

Temperature[18]

- 1 °C = 274.15 K

TIP

This manuscript uses the SI writing style practice of separating digits into groups of three, counting from the decimal marker towards the left and right, by the use of a thin, fixed (nonbreaking) space[3].

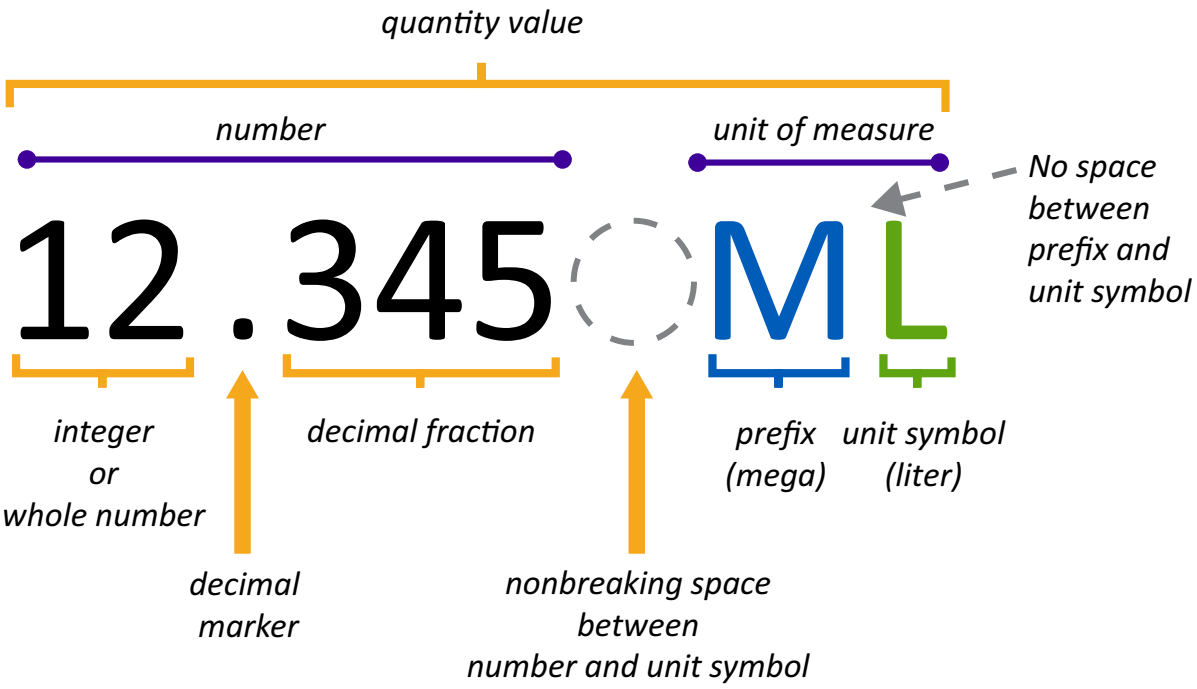


Figure 16. SI writing conventions are applied to a quantity value, which includes a number and unit of measure. Credit: NIST

Writing with the SI

A benefit of the SI is that written technical information is effectively communicated, transcending the variations of language – including spelling and pronunciation. Arabic numerals describe the quantity. A quantity is then paired with a unit symbol, often with a prefix symbol that modifies unit magnitude[3].

Write Like a Scientist, Technologist, Engineer, and Mathematician

SI writing style is an essential literacy skill used by STEAM professionals and the public to interpret, evaluate, synthesize, communicate, and apply measurement information. For STEAM professionals, SI skills are necessary to plan investigations, collect and document research data observations, analyze results, clearly communicate, share research, gain new information by interpreting the findings of others, develop technological solutions to improve the quality of life, design and build critical infrastructure, and develop new products for the marketplace. Using SI writing style helps prevent miscommunication, misinterpretation of data, and calculation errors. SI writing style is also important for consumers who will interpret and use quantities to make daily life decisions.

Learning new concepts requires building new vocabulary in context **(Resources - Vocabulary)**. Using metric recipes provides an opportunity for learners to apply, practice, and reinforce writing quantity values, unit symbols, prefixes and capitalization rules frequently within a short period of time.

Communicating Results

SI writing conventions are important to ensure the comprehension of quantitative information and understandability of quantity values. A quantity is a property that often consists of an Arabic number paired with a unit of measure. For example, megaliter (ML) is made up of the prefix “mega” (M) and unit “liter” (L) **(Figure 16)**. When used in a sentence, “megaliter” becomes one word without a space between the prefix and unit symbol.

Figure 17. Measurements are used in daily life while baking, interpreting nutrition labels, determining the outside temperature, and sewing. Credit: Adobe Stock

Similarly, the prefix symbol and the unit symbol are written without any space between the symbols to form a single symbol.

SI unit symbols are the same in every language. Because word spelling varies among different languages, abbreviations may also vary. For this reason, abbreviations are not used in technical communications **(Table 3)**. For example, the permitted unit symbol for the second is s, but the unacceptable abbreviation sec should not be used.

SI Symbols		
UNIT	**SYMBOL (permitted)**	**ABBREVIATION (unacceptable)**
second	s	sec
grams	g	gms
cubic centimeter	cm^3	cc

Table 3. Use SI symbols. Do not use abbreviations.

Using the SI

For use in daily life, participants need to learn about ten units and get used to a few new temperatures. There are some metric units with which learners are likely already familiar. Where might participants observe SI measurements in daily life? Use of SI measurements includes areas such as media reports (e.g., military deployments using kilometers), time (second), electric current (ampere, volt, ohm, and watt), track and field, cycling, international sports competitions (meter, gram, and second), package labeling (especially beverages), healthcare (blood pressure, cholesterol levels, glucose measurements, prescription and over-the-counter medicines, and dietary supplement dosages (mL, µg, and cm^3), automotive (meter, ampere, and candela), and other consumer products (liter, and gram) **(Figure 17)**.

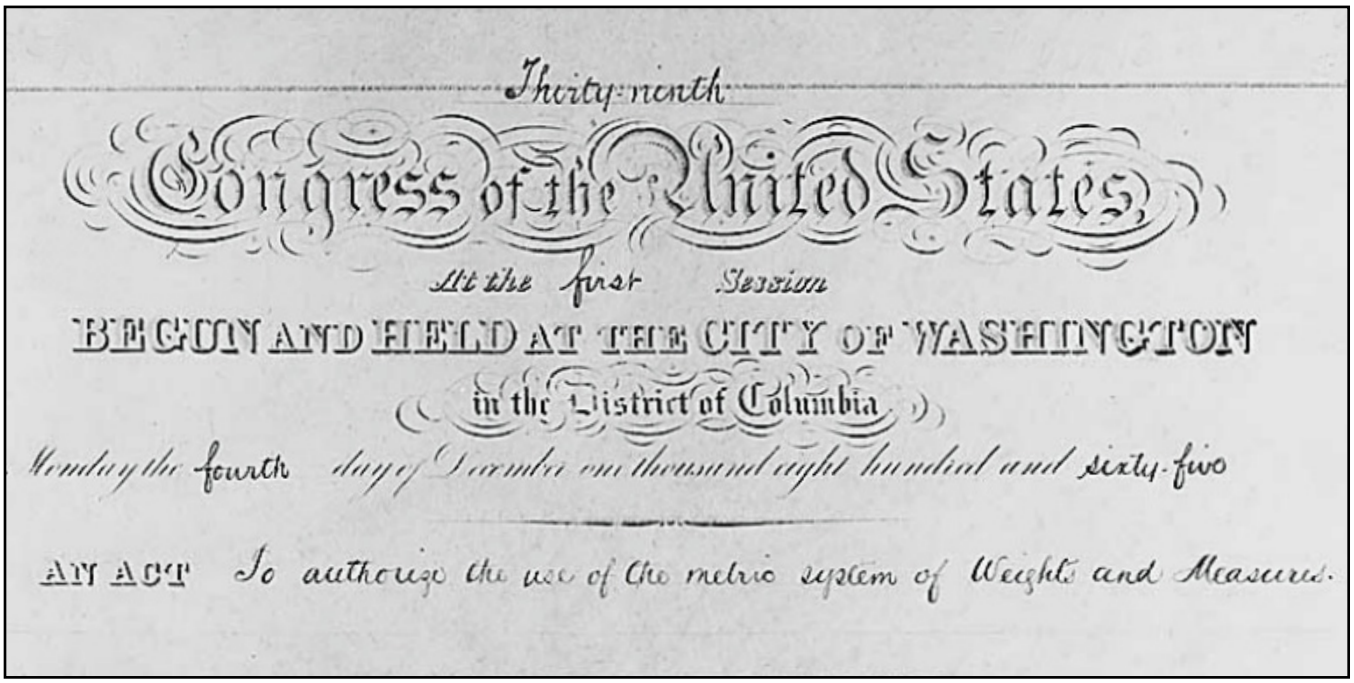

Thirty-ninth
Congress of the United States
At the first Session
BEGUN AND HELD AT THE CITY OF WASHINGTON
in the District of Columbia
Monday the fourth day of December one thousand eight hundred and sixty-five
AN ACT To authorize the use of the metric system of Weights and Measures.

Figure 18. Metric Act of 1866, also known as the Kasson Act[19]. Credit: National Archives

U.S. consumers are becoming more familiar with grams and milligrams through information provided on mandatory nutritional labeling. Advertising, coupons, and consumer product packaging are increasingly found using metric units exclusively. U.S. currency and coinage are designed according to metric system design specifications.

Because of the importance of the SI as an international standard, its use in product design, manufacturing, marketing, and labeling is essential for U.S. industry's success in the global marketplace. The NIST Metric Program encourages the use of the SI in all facets of education, including honing of worker skills.

U.S. Metrication

What countries have not adopted the SI? Many mistakenly think of countries like the United States, Liberia, and Myanmar (Burma). Some are surprised to learn that all countries have adopted the SI, including the U.S.; metric system use is either mandatory or permissible. The U.S. has a long history using the metric system, including being one of the original 17 countries that signed the Treaty of the Meter in 1875, which is now celebrated as **World Metrology Day** (May 20th)[20]. It has been legal to use the metric system in the U.S. since 1866. The SI later became the preferred system of weights and measures for U.S. trade and commerce in 1988 **(Figure 18)**.

Becoming metric is not a one-time event that has either happened or not. It is a process that happens over time. Every international economy is positioned somewhere along a transition continuum represented by various stages of the metric transition journey. In nearly all countries, people often use traditional units, at least in colloquial expressions. Processes and legacy infrastructure designed with U.S. customary measurement practices often continue to be maintained and supported until the product life cycle ends or it is no longer fit for purpose. For instance, municipal utility infrastructure requires maintenance over many years and replacement represents considerable financial investment. More information about U.S. metrication can be found in the NIST blog, *Busting Myths about the Metric System*[21].

Techniques and Tools

Practice measurement processes and culinary technique reasoning while reinforcing the value of careful observation and accurate data collection.

- **Compare the precision of kitchen scales with traditional volume measures and consider if equipment is fit for purpose.**
- **Weigh ingredients, evaluate measurement accuracy, and discuss technique choices.**

Preparation

The concept of *mise en place* is used to gather all ingredients and equipment before undertaking a recipe.

When introducing a new cook or baker, adults must observe and evaluate their skills before permitting independent kitchen work. Before beginning any recipe, collaborate to identify, discuss, and avoid kitchen hazards, such as adopting food hygiene best practices, using a sharp knife, and safely applying heat using an oven. Adults must closely supervise inexperienced chefs.

Selecting and Using Equipment

- Use each equipment, as designed, to achieve the best measurement result and recipe outcome.
- Thermometers are invaluable **kitchen equipment** when cooking, grilling, baking, and making candy. A simple method to evaluate a cooking thermometer is to prepare a vessel of boiling water (100 °C, sea level), then read and record the displayed temperature. Calculate the difference. Make temperature adjustments according to the difference (e.g., add or subtract degrees as needed) and/or adapt cooking times, as needed **(Figure 19)**.
- Measuring ingredients by mass (weight) using an appropriate **kitchen scale** is a best practice to improve recipe accuracy, rather than measuring ingredients by volume using fluid or dry measuring cups.

Figure 19. Kitchen equipment. Credit: Adobe Stock

- Using dry measuring cup (designed to measure the volume of dry commodities like sugar) instead of using a fluid measuring cup (designed to measure the volume of liquid commodities like water) is a common way of introducing measurement errors into the cooking process.

Recipes

Cooking and baking using a kitchen scale is a fun way to build metric system abilities and apply measurement techniques.

- **This recipe card collection is ideal for both new and experienced Chefs.**
- **Use the *NIST Metric Kitchen Recipes* to measure ingredients with a kitchen scale, follow a procedural sequence, and analyze the results.**
- **Review scientific and mathematical practices such as measurement precision, ratios, and proportional reasoning.**

Savory and Sweet

Each metric recipe describes the tools, equipment, ingredients, and directions needed to prepare the dish. The estimated yield, preparation, and cooking times are also provided.

Prepare the activity materials, ingredients, and other resources before the activity begins.

Safety Considerations

Adults will closely supervise, observe, and evaluate learners' skills before permitting independent kitchen work. Prior to undertaking a recipe, collaborate to identify, discuss and avoid kitchen hazards, such as safely applying heat using an oven and adopting food hygiene best practices. Review the safety considerations before beginning any cooking activity (printable **Safety Tips** card).

Tools and Equipment

The metric recipes use a **Kitchen Scale**, **Cookware**, oven thermometer (°C), utensils, and other equipment. Scissors are used to cut the Gingerbread House templates. A metric ruler is used to construct and evaluate Gingerbread House panels.

Printing Instructions

Figure 20. NIST Metric Kitchen Recipes, Special Publication 1290. Credit: NIST

Print the appropriate materials based on the planned classroom or home activity. The digital file (PDF) includes 12 recipe cards, activity ideas, templates, and supporting resources. Prepare the **Recipe Cards** and supplemental resources, like the **Measurement Process**, **Vocabulary**, **Safety Tips**, and **QR Codes** cards before the activity (e.g., 1 per student or pair). Use U.S. office size card stock 215.9 mm x 279.4 mm (8.5 in x 11 in) for individual recipe cards to print single-sided in portrait orientation and scale fit to page. Resource cards may be printed double-sided on paper or cardstock. Lamination may be used for easy cleaning and classroom reuse. Store classroom sets in envelopes for easy distribution **(Figure 20** and **Figure 21)**.

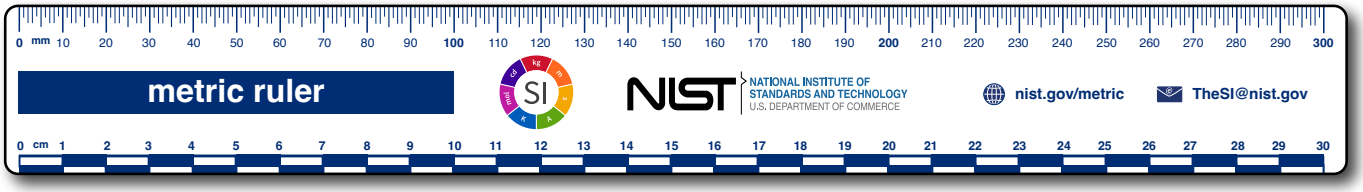


Figure 21. NIST Metric Ruler, Special Publication 376. Credit: NIST

Figure 22. Macaroni and Cheese, Honey Dijon Salad Dressing, and Salad. Credit: Adobe Stock

Macaroni and Cheese

YIELD: 8 SERVINGS **PREP TIME: 30 MINUTES** **COOKING TIME: 15 MINUTES**

Tools

- ☐ Spoon & Whisk
- ☐ Mixing Bowl (1)
- ☐ Large Saucepan (1)
- ☐ Medium Saucepan (1)
- ☐ Pitcher
- ☐ Colander
- ☐ Kitchen Scale
- ☐ Glass Baking Dish

Ingredients

- ☐ 370 g Cheddar Cheese (shredded)
- ☐ 110 g Parmesan Cheese (shredded)
- ☐ Water
- ☐ 10 g Salt
- ☐ 450 g Elbow Pasta (dry)
- ☐ 110 g Unsalted Butter
- ☐ 60 g All-Purpose Flour
- ☐ 1 000 g Whole Milk
- ☐ 1 g Paprika
- ☐ 1 g Pepper

Directions

1. Preheat the oven to 175 °C and grease baking dish.
2. Grate the cheeses and mix them together, then divide into 2 equal portions.
3. Cook the pasta in water and salt according to the manufacturer instructions. Drain the pasta and set aside.
4. Melt the butter in the medium saucepan on medium heat. Sprinkle in the flour. Whisk until combined.
5. Measure the milk in a small pitcher. Slowly pour half into the butter-flour mixture and whisk until smooth. Repeat with the remaining milk. Constantly whisk sauce until thickened. Remove from heat.
6. Slowly add half of the cheese mixture. Whisk until smooth.
7. Add the cheese sauce to the drained pasta. Stir until blended. Transfer half the pasta mixture to the baking dish. Top with the remaining cheese mixture.
8. Bake for 15 minutes until bubbling and light golden brown. Garnish with paprika and pepper.
9. Rest the hot dish before serving. Enjoy!

Figure 23. Macaroni and Cheese. Credit: Adobe Stock

Salad

YIELD: 6 SERVINGS **PREP TIME: 20 MINUTES**

Tools

- ☐ Spoon & Knife
- ☐ Cutting Board
- ☐ Colander
- ☐ Large Mixing Bowl (1)
- ☐ Kitchen Scale

Ingredients

- ☐ 280 g Corn (canned, drained)
- ☐ 250 g Black Beans (canned, drained)
- ☐ 170 g Black Olives (canned, pitted)
- ☐ 130 g Tomato (chopped)
- ☐ 300 g Cucumber (medium, chopped)
- ☐ 150 g Bell Pepper (medium, chopped)
- ☐ 100 g Onions (optional, chopped)
- ☐ Honey Dijon Salad Dressing
- ☐ 250 g Tortilla Chips (optional, regular retail bag)

Directions

1. Drain the canned ingredients using a colander.
2. Measure the corn.
3. Measure the black beans.
4. Measure the olives.
5. Wash the fresh vegetables. Remove pepper seeds. Chop vegetables into 13 mm to 25 mm pieces.
6. Measure the tomato.
7. Measure the cucumber.
8. Measure the bell pepper.
9. Measure the onion (if using).
10. Mix the ingredients.
11. Prepare and pour the **Honey Dijon Salad Dressing (Figure 20)** over the salad and gently stir until coated.
12. Crush tortilla chips (if using) and combine with salad right before serving. Gently stir so the chips stay crunchy.
13. Scoop the salad into bowls and serve. Enjoy!

Figure 24. Salad. Credit: Adobe Stock

Honey Dijon Salad Dressing

YIELD: 275 g **PREP TIME: 10 MINUTES**

Tools

- Whisk, Spoon, & Spatula
- Medium Mixing Bowl (1)
- Pepper Grinder
- Glass Jar or Bottle
- Kitchen Scale

Ingredients

- ☐ 60 g Balsamic Vinegar
- ☐ 160 g Extra Virgin Olive Oil
- ☐ 15 g Dijon Mustard
- ☐ 40 g Honey
- ☐ 2 g Salt
- ☐ 1 g Ground Black Pepper

Directions

1. Measure the balsamic vinegar.
2. Slowly measure the olive oil.
3. Measure the Dijon mustard.
4. Measure the honey.
5. Measure the salt.
6. Measure the pepper.
7. Whisk the ingredients together until well blended and the dressing looks creamy and even.
8. Store refrigerated in a clean glass jar or bottle with a tight lid for up to 7 days.
9. Before serving, take out of the refrigerator 10 minutes before serving. Shake well.
10. Apply the dressing to the salad according to your preference. Enjoy!

Figure 25. Honey Dijon Salad Dressing. Credit: Adobe Stock

Figure 26. Brownies, Chocolate Chip Cookies, and Gingerbread Houses. Credit: Adobe Stock

Apple Crisp

YIELD: 6 SERVINGS **PREP TIME: 30 MINUTES** **TIME: 60 MINUTES**

Tools

- Whisk, Spatula, Knife, & Fork
- Large Mixing Bowls (2)
- Kitchen Scale
- Glass Baking Dish (20 cm x 20 cm)

Ingredients

- ☐ 6 Apples (peel, core and slice)
- ☐ 25 g Granulated Sugar
- ☐ 5 g Cinnamon Powder (divide in half)
- ☐ 5 g Vanilla Extract
- ☐ 5 g Lemon Juice
- ☐ 100 g Old Fashioned Oats
- ☐ 140 g Light Brown Sugar
- ☐ 100 g All-Purpose Flour
- ☐ 5 g Salt
- ☐ 110 g Unsalted Butter (cold, diced)

Directions

1. Preheat oven to 180 °C.
2. Prepare a greased baking dish.
3. Measure all ingredients.
4. Combine the apples, sugar, half of the cinnamon powder, vanilla, and lemon juice in a mixing bowl.
5. Transfer the apple mixture to the baking dish.
6. In a separate bowl, use a fork to combine oats, sugar, flour, salt, remaining cinnamon powder, and cut diced butter into dry ingredients until mixture resembles coarse crumbs for the topping mixture.
7. Spread the topping mixture evenly on top of the apple mixture.
8. Place the baking dish on the middle rack of the preheated oven, and bake for 60 minutes.
9. Serve warm or cool. Enjoy!

Figure 27. Apple Crisp. Credit: Adobe Stock

Banana Bread

YIELD: 10 SERVINGS **PREP TIME: 15 MINUTES** **COOKING TIME: 60 MINUTES**

Tools

- Spatula & Fork
- Large Mixing Bowls (2)
- Kitchen Scale
- Metal Loaf Pan (23 cm x 13 cm)
- Toothpick (1)

Ingredients

Wet Ingredients:

- ☐ 225 g Bananas (ripe)
- ☐ Eggs (2 large)
- ☐ 100 g Vegetable Oil
- ☐ 55 g Whole Milk
- ☐ 5 g Vanilla Extract

Dry Ingredients:

- ☐ 260 g All-Purpose Flour
- ☐ 200 g Sugar
- ☐ 6 g Baking Soda
- ☐ 3 g Salt

Toppings:

- ☐ 100 g Chocolate Chips (optional)
- ☐ 100 g Walnuts (optional)

Directions

1. Preheat oven to 180 °C.
2. Measure all ingredients.
3. Mash bananas in a bowl.
4. Combine mashed bananas and other wet ingredients together in the same bowl.
5. Mix all dry ingredients together in a separate bowl.
6. Mix the dry mixture into the wet mixture until just combined.
7. Fold in chocolate chips and/or walnuts before pouring into the pan.
8. Pour mixture into a greased loaf pan.
9. Place the pan on the middle rack of the preheated oven and bake for about 60 minutes or until a toothpick inserted into the bread comes out clean.
10. Enjoy!

Watch the Video

Figure 28. Banana Bread. Credit: Adobe Stock

Brownies

YIELD: 9 BROWNIES **PREP TIME: 15 MINUTES** **COOKING TIME: 20 MINUTES**

Tools

- Whisk, Spatula, & Spoon
- Large Mixing Bowl (1)
- Kitchen Scale
- Metal Baking Pan (20 cm x 20 cm)
- Toothpick (1)

Ingredients

- ☐ 250 g Granulated Sugar
- ☐ 120 g All-Purpose Flour
- ☐ 60 g Unsweetened Cocoa Powder
- ☐ 2 g Baking Powder
- ☐ 3 g Salt
- ☐ 140 g Vegetable Oil
- ☐ 5 g Vanilla Extract
- ☐ Eggs (3 large)
- ☐ 150 g Chocolate Chips

Directions

1. Preheat the oven to 170 °C.
2. Combine sugar, flour, unsweetened cocoa powder, baking powder, and salt together in mixing bowl.
3. Mix in the vegetable oil, vanilla extract, and eggs.
4. Add the wet mixture to the dry ingredients until combined.
5. Fold the chocolate chips into the batter.
6. To avoid sticking, spray the metal pan with oil or place parchment paper in the pan.
7. Pour the brownie batter into the pan.
8. Place the pan on the middle rack of the preheated oven and bake for 20 minutes.
9. Remove from the oven. Brownies are done when a toothpick inserted in the center comes out clean.
10. Let the brownies rest for 10 minutes.
11. Enjoy!

Watch the Video

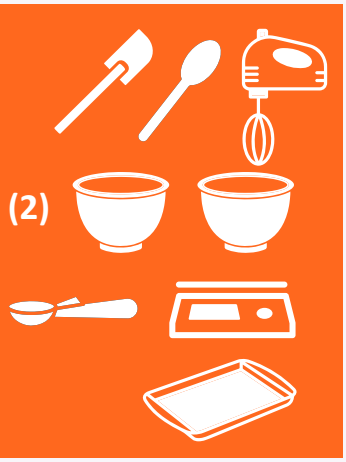
Figure 29. Brownie. Credit: Adobe Stock

Chocolate Chip Cookies

YIELD: 24 COOKIES **PREP TIME: 20 MINUTES** **COOKING TIME: 10 MINUTES**

Tools

- Spatula, Spoon, or Hand/Stand Mixer
- Large Mixing Bowls (2)
- Cookie Scoop
- Kitchen Scale
- Metal Sheet Pan (46 cm x 33 cm)



Ingredients

- ☐ 360 g All-Purpose Flour
- ☐ 5 g Baking Soda
- ☐ 5 g Salt
- ☐ 230 g Unsalted Butter (softened)
- ☐ 200 g Granulated Sugar
- ☐ 200 g Light Brown Sugar
- ☐ 5 g Vanilla Extract
- ☐ Eggs (2 large)
- ☐ 350 g Chocolate Chips/Chunks

Directions

1. Preheat oven to 180 °C.
2. Combine the flour, baking soda, and salt then set aside.
3. In a separate bowl, combine the butter, sugars, vanilla, and eggs until light and fluffy.
4. Gradually add dry mixture to the wet mixture and combine well.
5. Fold in chocolate chips/chunks.
6. Spoon dough from the mixing bowl onto a sheet pan using a cookie scoop (or spoon). Allow sufficient space between each cookie for spreading to occur during the baking process.
7. Place the pan into the preheated oven on the middle rack and bake for about 10 minutes.
8. Cookies are done when the edges are lightly browned.
9. Serve warm or cold. Enjoy!

Watch the Video

Figure 30. Chocolate Chip Cookies. Credit: Adobe Stock

Cocoa Mix

YIELD: 14 SERVINGS **PREP TIME: 5 MINUTES**

Tools

- ■ Whisk & Spoon
- ■ Large Mixing Bowl (1)
- ■ Small Mixing Bowl (1)
- ■ Kitchen Scale
- ■ Resealable Plastic Bags (snack-size)
- ■ Permanent Marker

Ingredients

Dry Ingredients:

- ☐ 160 g Nonfat Dry Milk Powder
- ☐ 240 g Powdered (Confectioners') Sugar
- ☐ 80 g Unsweetened Cocoa Powder
- ☐ 3 g Salt
- ☐ Mini Marshmallows (optional)

Directions

1. Measure the nonfat dry powdered milk.
2. Measure the powdered sugar.
3. Measure the cocoa powder.
4. Measure the salt.
5. Whisk together until well blended.
6. Write the instructions on 14 resealable plastic bags: "Add cocoa mix to a ceramic mug. Add 240 g hot water or hot milk. Stir to combine."
7. In a small bowl, measure 34 g hot cocoa mix.
8. Add to a resealable plastic bag.
9. Add several marshmallows to the bag (optional) and seal.
10. Package the remaining cocoa mix.
11. Prepare the cocoa mix according to the instructions. Enjoy!

Figure 31. Cocoa with marshmallows. Credit: Adobe Stock

Ginger Cookies

YIELD: 36 to 40 COOKIES **PREP TIME: 90 MINUTES** **COOKING TIME: 10 MINUTES**

Tools

- Whisk, Spoon, or Cookie Scoop
- Large Mixing Bowls (3)
- Kitchen Scale
- Metal Sheet Pan (46 cm x 33 cm)

Ingredients

- ☐ 450 g All-Purpose Flour
- ☐ 5 g Baking Soda
- ☐ 10 g Ground Ginger
- ☐ 8 g Ground Cinnamon
- ☐ 2 g Ground Cloves
- ☐ 2 g Ground Nutmeg
- ☐ 2 g Salt
- ☐ 120 g Unsalted Butter (cold, diced)
- ☐ 150 g Dark Brown Sugar
- ☐ 160 g Molasses
- ☐ Egg (1 large)

Directions

1. Preheat oven to 160 °C.
2. Combine the flour, baking soda, spices, salt and then set aside.
3. In a separate bowl, mix the butter and sugar until light and fluffy.
4. In the third bowl, measure and add the molasses. Beat in the egg.
5. Mix the molasses-egg mixture into the butter-sugar mixture. Pour into the dry ingredients and stir until mixed. Cover the dough.
6. Chill the dough for 30 to 45 minutes.
7. Spoon dough from the mixing bowl onto a sheet pan using a spoon or cookie scoop. Allow sufficient space between each cookie for spreading to occur during the baking process.
8. Place the pan into the preheated oven on the middle rack and bake for about 10 to 12 minutes. Edges should feel firm, but not soft.
9. Serve warm or cold. Enjoy!

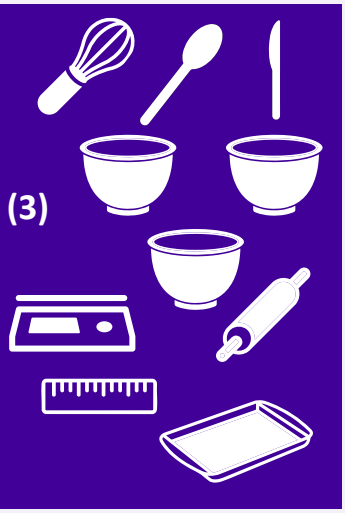
Figure 32. Ginger Cookies. Credit: Adobe Stock

Gingerbread House

YIELD: 1 GINGERBREAD HOUSE **PREP TIME: 90 MINUTES** **COOKING TIME: 12 MINUTES**

Tools

- Whisk, Spoon, & Knife
- Large Mixing Bowls (3)
- Rolling Pin
- Kitchen Scale
- Metric Ruler
- Metal Sheet Pan (46 cm x 33 cm)



Ingredients

- ☐ 450 g All-Purpose Flour
- ☐ 5 g Baking Soda
- ☐ 10 g Ground Ginger
- ☐ 8 g Ground Cinnamon
- ☐ 2 g Ground Cloves
- ☐ 2 g Ground Nutmeg
- ☐ 2 g Salt
- ☐ 120 g Unsalted Butter (cold, cubed)
- ☐ 150 g Dark Brown Sugar
- ☐ 160 g Molasses
- ☐ Egg (1 large)

Directions

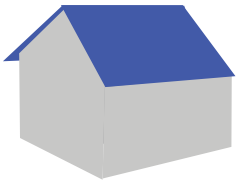
1. Preheat oven to 160 °C.
2. Combine the flour, baking soda, spices, salt and then set aside.
3. In a separate bowl, mix the butter and sugar until light and fluffy.
4. In the third bowl, measure and add the molasses. Beat in the egg.
5. Mix the molasses-egg mixture into the butter-sugar mixture. Pour into the dry ingredients and stir until mixed. Cover the dough.
6. Chill the dough for 30 to 45 minutes.
7. Roll dough to 8 mm thick for house panels. Cut the panels with a knife using a metric ruler as a straight edge **(Figure 17)**. Place panels onto a sheet pan with sufficient space between each panel for spreading to occur during baking.
8. Place the pan into preheated oven on the middle rack. Bake for 12 to 15 minutes. Edges should feel firm, but not soft.
9. Let panels sit overnight for maximum strength. Handle panels carefully to avoid breakage.

Figure 33. Gingerbread House. Credit: Adobe Stock

Gingerbread House Template

YIELD: 1 GINGERBREAD HOUSE ASSEMBLY AND DECORATION TIME: 90 MINUTES

Print the template on cardstock and cut before the activity. Use baked and cooled gingerbread panels.



ROOF PANELS
Prepare 2

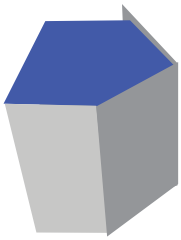
10. Assemble walls and roof.

- Pipe icing along the house walls edges where walls meet, then press pieces together. Use props to support the walls as they dry.
- Pipe the roof icing along the top edges of the walls and gently place the roof pieces. Let it dry completely before decorating.
- Use icing to pipe details, windows, doors, and to attach candies like gumdrops, jellies, sours, sprinkles, and hard candy. Enjoy!

TIPS

- **Use cans or jars to prop walls as they dry.**
- **Let panels set 10 minutes before adding the roof.**

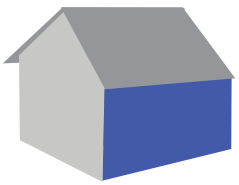
FRONT & BACK WALL PANELS
Prepare 2



Gingerbread House Template

YIELD: 1 GINGERBREAD HOUSE **ASSEMBLY AND DECORATION TIME: 90 MINUTES**

Print the template on cardstock and cut before the activity. Use baked and cooled gingerbread panels.



SIDE WALL PANELS
Prepare 2

Tools

- ☐ Kitchen Scale
- ☐ Metric Ruler

Figure 34. Request a free NIST Metric Ruler, Special Publication 376[22]. Credit: NIST

Measure

Record the mass, thickness and surface area of one baked panel in the data tables below.

Area of rectangle[23]:
length × width

Area of triangle[23]:
(0.5) × base × perpendicular height

Roof Panel

Mass (g)	Thickness (mm)	Area (cm²)

Front Wall Panel

(**Hint:** area = square + triangle)

Mass (g)	Thickness (mm)	Area (cm²)

Side Wall Panel

Mass (g)	Thickness (mm)	Area (cm²)

Evaluate

Record and compare data with another classmate or family member.

Mass (g)	Thickness (mm)	Area (cm²)

Icing

YIELD: 36 to 40 COOKIES OR 1 GINGERBREAD HOUSE **PREP TIME: 30 MINUTES**

Tools

- ☐ Spatula, Whisk & Spoon
- ☐ Large Mixing Bowl (1)
- ☐ Scissors
- ☐ Zip-top plastic bag or piping bag

Royal Icing

Ingredients

- ☐ 450 g Confectioners' Sugar
- ☐ 15 g Egg White Powder*
- ☐ 60 g to 75 g Water (room temperature)
- ☐ 5 g Lemon Juice (optional)
- ☐ Food Coloring (optional)

*Egg white powder is pasteurized and safer than raw egg whites.

Directions

1. Measure the powdered sugar.
2. Measure and add the egg white powder.
3. Measure and add the water.
4. Measure and add the lemon juice.
5. Whisk until thick and smooth. The texture should hold stiff peaks. Adjust with water to thin or sugar to thicken, as needed.
6. Add food coloring one drop at a time. Mix well after each drop until the color is even. Record how many drops of each color is used.
7. Add icing to the bag with a spatula. Use for decorating cookies or gingerbread houses.
8. Icing sets in 10 to 15 minutes and will harden in about 2 hours.

Simple Icing (Egg-Free)

Ingredients

- ☐ 500 g Confectioners' Sugar
- ☐ 80 g to 90 g Water
- ☐ 10 g Corn Syrup
- ☐ Food Coloring (optional)

Directions

1. Measure the powdered sugar.
2. Measure and add the water.
3. Measure and add the corn syrup.
4. Mix into a thick paste. Adjust with water to thin or sugar to thicken, as needed.
5. Add food coloring one drop at a time. Mix well after each drop until the color is even. Record how many drops of each color is used.
6. Add icing to the bag with a spatula. Use for decorating cookies or gingerbread houses.
7. Icing will harden to the touch in about 6 hours. Allow icing to harden overnight before stacking cookies.
8. Enjoy!

Figure 35: Preparing colored icing. Credit: Adobe Stock

Icing Color Tips

YIELD: 36 to 40 COOKIES OR 1 GINGERBREAD HOUSE **PREP TIME: 30 MINUTES**

Primary Colors

Primary colors: Red, Yellow, and Blue.

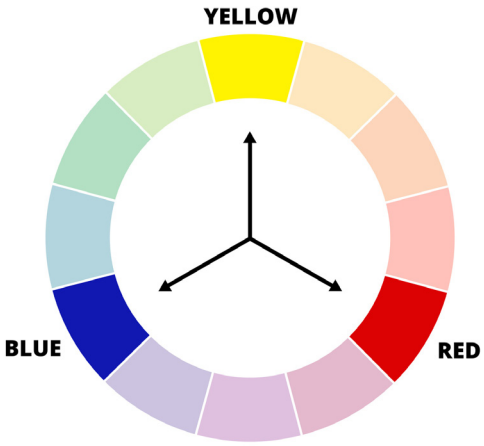


Figure 36. Primary color wheel. Credit: Adobe Stock

Secondary Colors

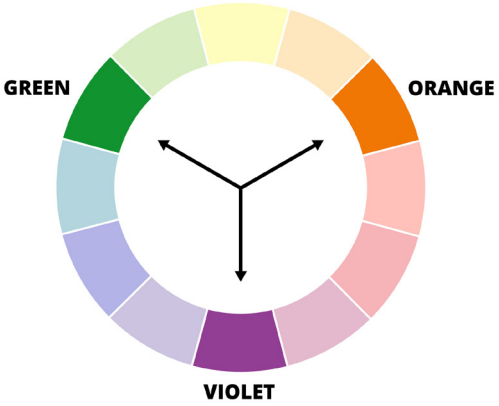


Figure 37. Secondary color wheel. Credit: Adobe Stock

TIPS

- **Add more white icing if color is too dark.**
- **Use zip-top or piping bags with a small corner cut to apply the icing.**

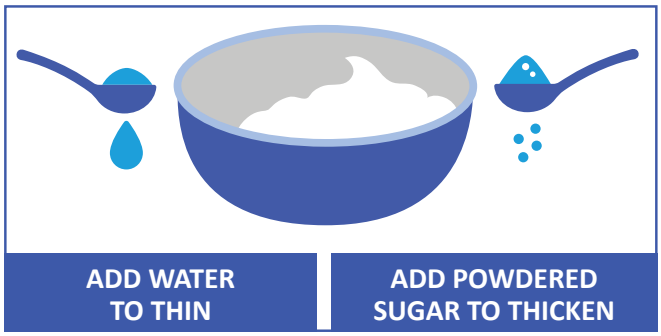


Figure 38. Adjust the icing consistency by adding water or powdered sugar as needed. Credit: NIST/K. Dill

Desired Color	Mix Approximate Food Coloring Mixtures
Orange	Red + Yellow
Green	Blue + Yellow
Purple	Red + Blue
Brown	Red + Yellow + tiny Blue
Dark Brown	Brown + extra Red
Tan	Brown + extra White icing
Gray	Blue + tiny Red + tiny Yellow
Black	Blue + Red + Yellow (very small amounts)
Light Pink	Red + lots of White
Light Blue	Blue + lots of White
Mint Green	Green + extra White
Lavender	Purple + extra White

Figure 39. Add small drops of food color in a bowl. Stir well to completely blend the icing. Credit: NIST/K. Dill

Pumpkin Pie

YIELD: 10 SERVINGS **PREP TIME: 90 MINUTES** **COOKING TIME: 60 MINUTES**

Tools

- Knife, Spatula, & Spoon
- Mixing Bowls (1)
- Kitchen Scale
- Baking Pan (20 cm x 20 cm)
- Blender/Food Processor
- Glass Pie Plate (23 cm)

Ingredients

- ☐ 500 g Sugar or Pie Pumpkin, Cooked and Pureed
- ☐ 1 Classic Pastry Crust (ready-made uncooked)
- ☐ Eggs (2 large)
- ☐ 100 g Sugar
- ☐ 50 g Brown Sugar
- ☐ 350 g Evaporated Milk
- ☐ 5 g Cinnamon
- ☐ 2.5 g Salt
- ☐ 2.5 g Ginger
- ☐ 1 g Nutmeg
- ☐ 0.5 g Cloves
- ☐ 2 cm Water

Directions

Roast the Pumpkin

1. Preheat oven to 160 °C.
2. Cut pumpkin in half and spoon out the seeds.
3. Bake halves flesh side down on baking pan in 1 cm to 2 cm of water for about 1 hour or until soft.
4. Allow to cool, then spoon out the meat and puree.

Bake the Pie

5. Preheat oven to 220 °C.
6. Line a pie plate (23 cm) with the pie crust.
7. Mix all ingredients until well blended and pour into pie shell.
8. Bake for 15 minutes, then reduce heat to 180 °C and bake for another 45 minutes. Pie is done when a knife inserted in the middle comes out clean.
9. Enjoy!

Figure 40. Pumpkin Pie. Credit: Adobe Stock

Waffles

YIELD: 10 WAFFLES **PREP TIME: 20 MINUTES** **COOKING TIME: 30 MINUTES**

Tools

- Whisk, Spatula, & Spoon
- Large Mixing Bowls (2)
- Kitchen Scale
- Waffle Iron

Ingredients

- ☐ 250 g All-Purpose Flour
- ☐ 15 g White Sugar
- ☐ 8 g Baking Powder
- ☐ 3 g Baking Soda
- ☐ 3 g Salt
- ☐ Eggs (4 large)
- ☐ 250 g Milk
- ☐ 250 g Plain Yogurt
- ☐ 80 g Unsalted Butter (melted)
- ☐ 5 g Vanilla Extract
- ☐ Vegetable Oil

Directions

1. Combine flour, sugar, baking powder, baking soda, and salt together in a bowl.
2. Beat the eggs in a bowl. Add milk, yogurt, melted butter, and vanilla and combine.
3. Add the dry mixture to the wet mixture until combined.
4. Preheat the waffle iron and test temperature (see appliance instructions).
5. To avoid sticking, prepare the waffle iron using oil, as needed before each waffle.
6. Gently spoon the batter mixture at the center of the waffle iron and avoid overfilling the iron (batter rises and spreads during cooking).
7. Close the waffle iron lid and fully cook each waffle (see appliance instructions).
8. Serve hot with toppings, such as mixed fruit, butter, whipped cream, maple syrup, or powdered sugar.
9. Enjoy!

Figure 41. Waffle topped with fruit and cream.
Credit: Adobe Stock

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Name: Class/Date:

Resources – *Mise en Place* Worksheet

Tools

- ☐ Recipe Card
- ☐ Whisk & Spoon
- ☐ Mixing Bowls (2)
- ☐ Kitchen Scale
- ☐ Resealable Plastic Bags
- ☐ Permanent Marker

Instructions: Use *mise en place* to prepare the *NIST Metric Kitchen* **Cocoa Mix Recipe**.

Activity A: Record the ingredients, quantities, and tool/equipment needed in the data table.

Ingredient	Recipe Quantity	Tool/Equipment Needed
Nonfat Dry Milk Powder	160 g	Cocoa Mix Recipe Card

Activity A1. Sequence the Steps: Put these steps in the correct order (number them 1–8).

_____ Start cooking

_____ Prepare workspace

_____ Cleanup workspace

_____ Preheat oven

_____ Safety check

_____ Gather tools and ingredients

_____ Measure ingredients

_____ Read recipe

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Name: Class/Date:

Resources – *Mise en Place* Worksheet

Activity B. Divide the class into two teams. Students will compare and contrast recipe preparation with and without *mise en place*.

Scenario 1

Students tare the scale and measure **each ingredient (grams) in a bowl** and record each measurement in a data table. **Ingredients are not mixed.**

Measured Quantities	Time
Nonfat Dry Milk Powder	160 g

Scenario 2

Students measure several ingredients **in the same bowl**, taring between each measurement. **Ingredients are mixed.**

Measured Quantities	Time
Nonfat Dry Milk Powder	160 g

Activity B1. Reflection. Answer the following:

Mise en place means:
One benefit of *mise en place* is:
Why is *mise en place* important in cooking?
What could happen if you do NOT use *mise en place*?

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Name: Class/Date:

Resources – How Sweet Worksheet

Tools

- ☐ Recipe Card
- ☐ Calculator
- ☐ Pen

Instructions: Use ratio and rate reasoning with the ***NIST Metric Kitchen Recipes.***

Activity A: Evaluate four metric recipes with different amounts of sugar and servings. Determine the grams of sugar per serving. Review the recipe. Record the data, calculate the sugar per serving, and rank the recipes from highest to lowest sugar in the table below.

Example Calculation: Total Sugar = 165 g Number of Servings = 6
Total Sugar per Serving: 165 g ÷ 6 Servings = 27.5 g per Serving

Activity B: If the daily recommended value for added sugars is 50 g per day (based on a 2 000 calorie daily diet), how many servings per day could be eaten of each recipe **without exceeding** the recommended amount? Record your answer in the table below. Circle the highest sugar per serving.

Recipe Name	Total Sugar (g)	Number of Servings	Sugar (g) per Serving	Rank Highest (1) to Lowest (4)	Servings per Day
Apple Crisp	165 g	6	27.5 g		
Cocoa Drink					
Brownies					
Chocolate Chip Cookies					

What does “grams per serving” mean mathematically?
How would you determine if one recipe is sweeter than another?
Is the same number of servings necessary to compare multiple recipes?
Where else do you see ‘per serving’ in daily life?
What happens to the sugar rate when we double the recipe?

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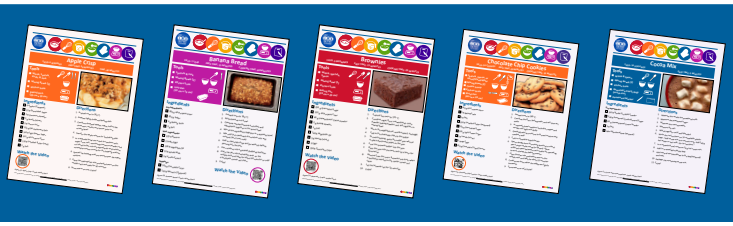
Name: Class/Date:

Resources – How Sweet Worksheet

Tools

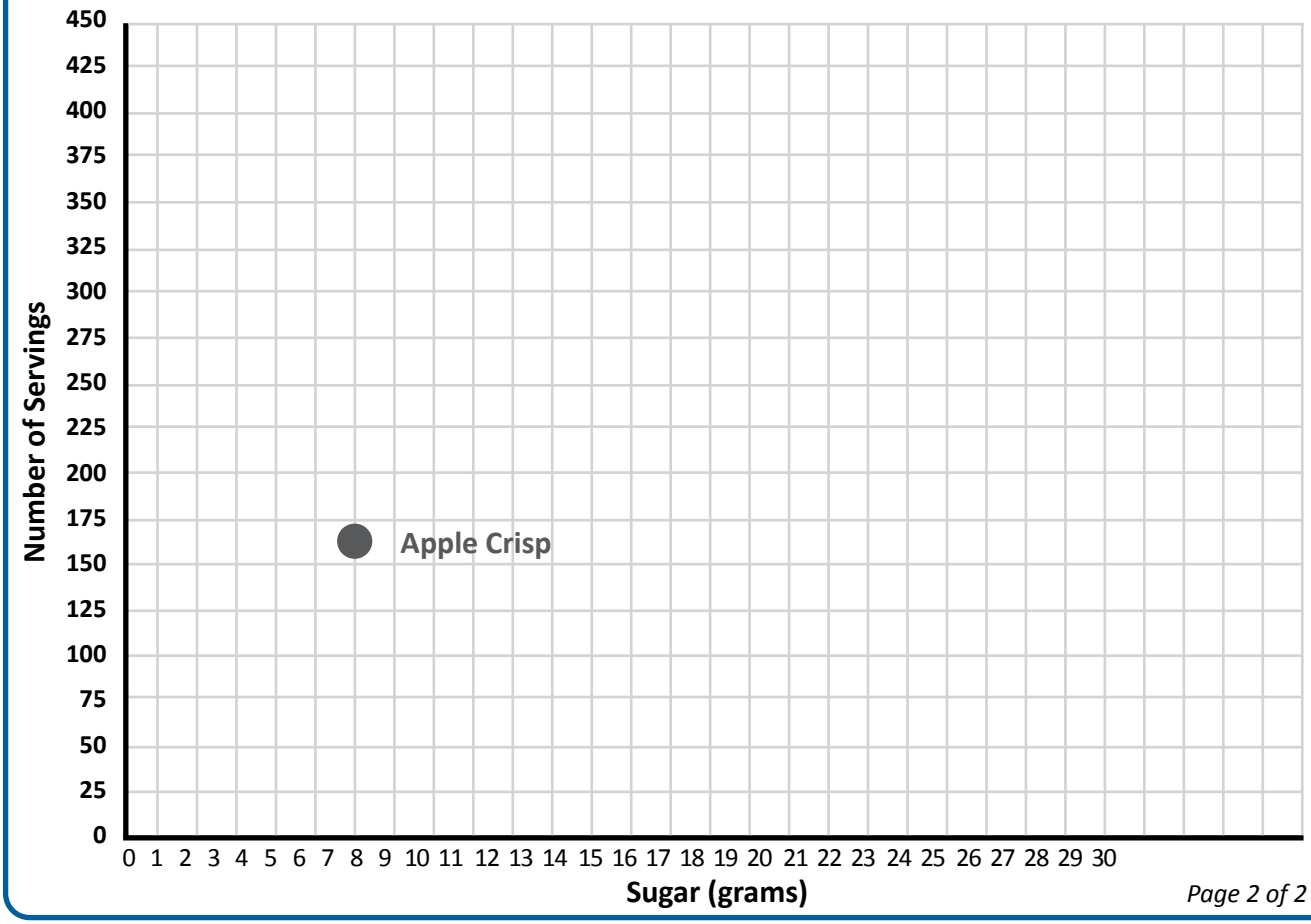
- ☐ Recipe Cards
- ☐ Pen



Extension. Graph the ratio data (number of servings vs. sugar) using these additional **NIST Metric Kitchen** recipes: *Apple Crisp, Banana Bread, Brownies, Chocolate Chip Cookies, and Cocoa Mix Recipes*. Each recipe is one data point.

Recipe Name	Total Sugar (g)	Number of Servings
Apple Crisp	165 g	6

*Excluding chocolate chips.



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Name: Class/Date:

Resources – Scaling a Recipe Worksheet

Tools

- ☐ Recipe Card
- ☐ Calculator
- ☐ Pen

Instructions: The *NIST Metric Kitchen* **Chocolate Cookie Recipe** makes 24 chocolate chip cookies, but your class needs 48 cookies for a birthday celebration. Use ratios and proportional reasoning to scale the new ingredient quantities.

1. Identify the scaling factor.

Original number of cookies =	
Desired number of cookies =	
Formula: Desired quantity ÷ original quantity = scaling factor **Show your calculation:** **Scaling Factor =**	

2. Record the original ingredients and quantities in the data table. Apply the scaling factor and use to calculate the new ingredient quantities.

Ingredient	Original Ingredient Quantities	Scaling Factor	New Ingredient Quantities
Example	360 g	2	720 g

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Name: **Class/Date:**

Resources – Scaling a Recipe Worksheet

3. Compare the original recipe to the new recipe and answer the following questions.

a. What is the ratio of the new batch size to the original batch size?	
b. How did the amount of each ingredient change?	
c. If 72 cookies are needed for the celebration, what is the scaling factor? **Formula:** Desired quantity ÷ original quantity = scaling factor **Show your calculation:** **Scaling Factor =**	
d. If you wanted 12 cookies instead of 24, what would the scaling factor be?	
e. Why is proportional reasoning important when cooking or baking?	

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Name: Class/Date:

Resources – *Mise en Place* Answer Key

Tools

- ☐ Recipe Card
- ☐ Whisk & Spoon
- ☐ Mixing Bowls (2)
- ☐ Kitchen Scale
- ☐ Resealable Plastic Bags
- ☐ Permanent Marker

Instructions: Use *mise en place* to prepare the *NIST Metric Kitchen* **Cocoa Mix Recipe**.

Activity A. Record the ingredients, quantities, and tool/equipment needed in the data table.

Ingredient	Recipe Quantity	Tool/Equipment Needed
Nonfat Dry Milk Powder	160 g	Cocoa Mix Recipe Card Kitchen scale Bowls Spoon Whisk Plastic bag Marker
Powdered sugar	240 g	
Unsweetened cocoa powder	80 g	
Salt	3 g	
Mini Marshmallows	3	

Activity A1. Sequence the Steps: Put these steps in the correct order (number them 1–8).

- 7 Start cooking
- 3 Prepare workspace
- 8 Cleanup workspace
- 5 Preheat oven
- 2 Safety check
- 4 Gather tools and ingredients
- 6 Measure ingredients
- 1 Read recipe

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Name: Class/Date:

Resources – *Mise en Place* Answer Key

Activity B. Divide the class into two teams. Students will compare and contrast recipe preparation with and without *mise en place*.

Scenario 1

Students tare the scale and measure **each ingredient (grams) in a bowl** and record each measurement in a data table. **Ingredients are not mixed.**

Measured Quantities	Time
Nonfat Dry Milk Powder	160 g

Scenario 2

Students measure several ingredients **in the same bowl**, taring between each measurement. **Ingredients are mixed.**

Measured Quantities	Time
Nonfat Dry Milk Powder	160 g

Activity B1. Reflection. Answer the following:

Mise en place means: **To put in place.**
One benefit of *mise en place* is: **Organization. Efficiency.**
Why is *mise en place* important in cooking? **The practice ensures all ingredients and equipment are ready and available.**
What could happen if you do NOT use *mise en place*? **It is possible to forget an ingredient or equipment.**

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Name: **Class/Date:**

Resources – How Sweet Answer Key

Tools

- ☐ Recipe Card
- ☐ Calculator
- ☐ Pen

Instructions: Use ratio and rate reasoning with the ***NIST Metric Kitchen Recipes.***

Activity A: Evaluate four metric recipes with different amounts of sugar and servings. Determine the grams of sugar per serving. Review the recipe. Record the data, calculate the sugar per serving, and rank the recipes from highest to lowest sugar in the table below.

Example Calculation: Total Sugar = 165 g Number of Servings = 6
Total Sugar per Serving: 165 g ÷ 6 Servings = 27.5 g per Serving

Activity B: If the daily recommended value for added sugars is 50 g per day (based on a 2 000 calorie daily diet), how many servings per day could be eaten of each recipe **without exceeding** the recommended amount? Record your answer in the table below. Circle the highest sugar per serving.

Recipe Name	Total Sugar (g)	Number of Servings	Sugar (g) per Serving	Rank Highest (1) to Lowest (4)	Servings per Day
Apple Crisp	165 g	6	27.5 g	2	1
Cocoa Mix	240 g	14	17.14 g	3	2
Brownies	250 g	9	27.7 g	1	1
Chocolate Chip Cookies	400 g	24	16.67 g	4	3

What does “grams per serving” mean mathematically? **Find the rate by dividing total sugar by the number of servings.**
How would you determine if one recipe is sweeter than another? **Calculate the rate (grams of sugar per serving) for each recipe. The recipe with the highest grams per serving is sweeter.**
Is the same number of servings necessary to compare multiple recipes? **No. Compare multiple recipes by finding the unit rate (per 1 serving) for each recipe**
Where else do you see ‘per serving’ in daily life? **Nutrition labels, Drinks, Snacks**
What happens to the sugar rate when we double the recipe? **The ratio remains the same. Both the sugar and the servings are doubled, so the grams per serving (the ratio) does not change.**

Circle the brownies (the sweetest or highest sugar per serving)

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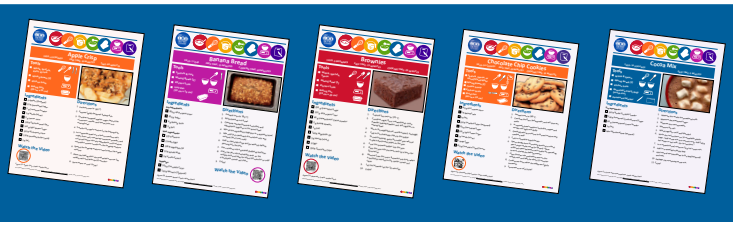
Name: Class/Date:

Resources – How Sweet Answer Key

Tools

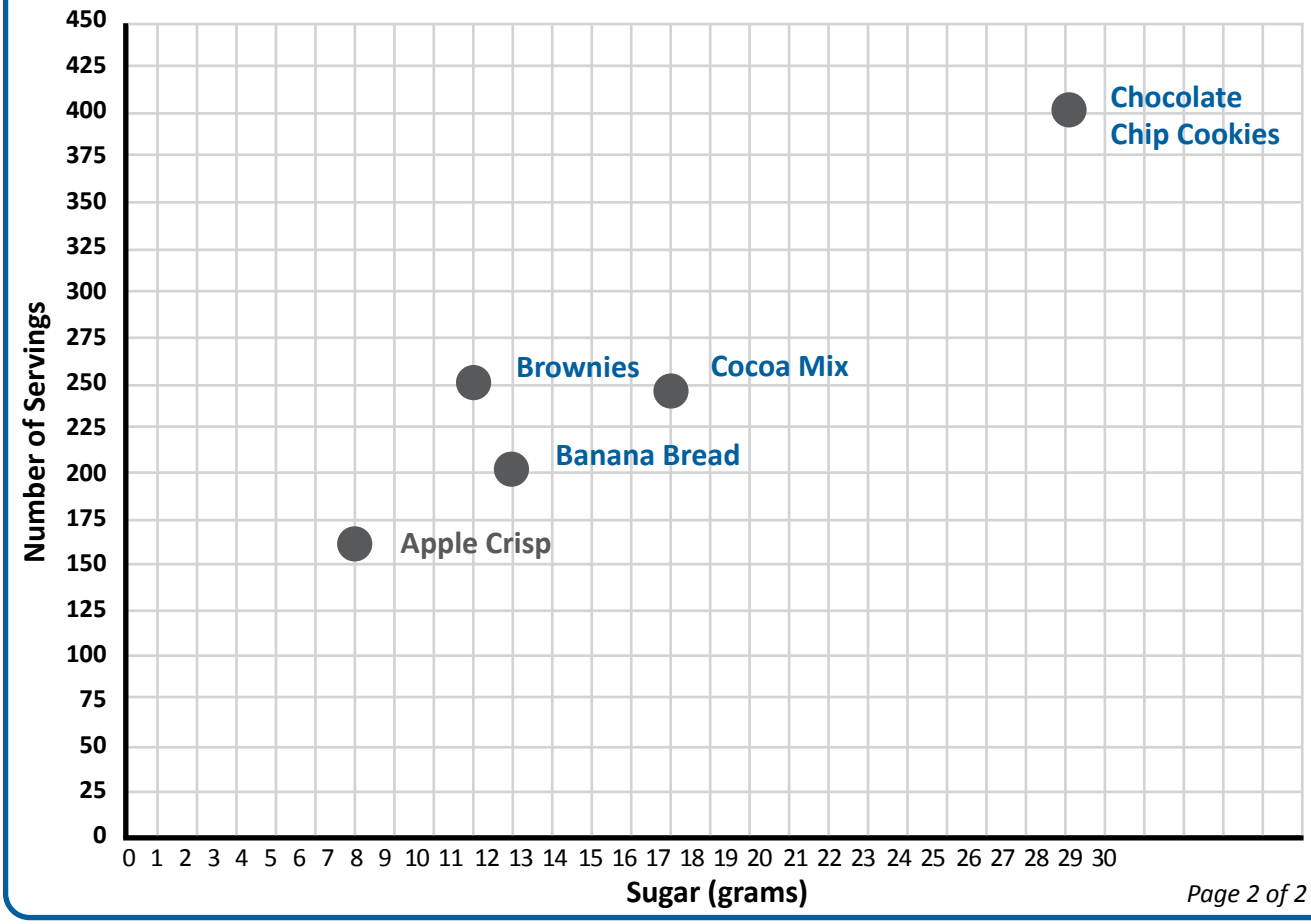
☐ Recipe Cards ☐ Pen



Extension. Graph the ratio data (number of servings vs. sugar) using these additional **NIST Metric Kitchen** recipes: *Apple Crisp, Banana Bread, Brownies, Chocolate Chip Cookies, and Cocoa Mix Recipes*. Each recipe is one data point.

Recipe Name	Total Sugar (g)	Number of Servings
Apple Crisp	165 g	6
Banana Bread	200 g	10
Brownies*	250 g	9
Chocolate Chip Cookies*	400 g	24
Cocoa Mix	240 g	14

*Excluding chocolate chips.



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Name: Class/Date:

Resources – Scaling a Recipe Answer Key

- ☐ Recipe Card
- ☐ Calculator
- ☐ Pen

Instructions: The *NIST Metric Kitchen* **Chocolate Cookie Recipe** makes 24 chocolate chip cookies, but your class needs 48 cookies for a birthday celebration. Use ratios and proportional reasoning to scale the new ingredient quantities.

1. Identify the scaling factor.

Original number of cookies =	**24**
Desired number of cookies =	**48**
Formula: Desired quantity ÷ original quantity = scaling factor **Show your calculation:** **48 / 24 = 2 The scaling factor is 2 (double the recipe).** **Scaling Factor = 2**	

2. Record the original ingredients and quantities in the data table. Apply the scaling factor and use to calculate the new ingredient quantities.

Ingredient	Original Ingredient Quantities	Scaling Factor	New Ingredient Quantities
All-Purpose Flour	360 g	2	720 g
Baking Soda	5 g	2	10 g
Salt	5 g	2	10 g
Unsalted Butter	230 g	2	460 g
Granulated Sugar	200 g	2	400 g
Brown Sugar	200 g	2	400 g
Vanilla Extract	10 g	2	20 g
Eggs	2	2	4
Chocolate Chips	350 g	2	700 g

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Name: Class/Date:

Resources – Scaling a Recipe Answer Key

3. Compare the original recipe to the new recipe and answer the following questions.

a. What is the ratio of the new batch size to the original batch size?	**2:1**
b. How did the amount of each ingredient change? **Each ingredient was doubled because the scaling factor is 2.**	
c. If 72 cookies are needed for the celebration, what is the scaling factor? **Formula:** Desired quantity ÷ original quantity = scaling factor **Show your calculation:** **72/24 = 3** **Scaling Factor = 3**	
d. If you wanted 12 cookies instead of 24, what would the scaling factor be? **12/24 = 0.5** **The scaling factor is 0.5, half the recipe.**	
e. Why is proportional reasoning important when cooking or baking? **It's an easy way to increase or decrease (scale up or down) a recipe while maintaining the original formulation.**	

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Resources - Kitchen Scale

Kitchen Scale (gram, kilogram)

- A digital kitchen scale is recommended to measure recipe ingredients in grams (or kilogram for large batches).
- Cooking and baking with a metric kitchen scale provides several benefits including:
  - **Accuracy**. Measuring ingredients by weight rather than volume is more precise and consistent, ensuring repeatable results. Recipes turn out the same way each time they are prepared.
  - **Time-saving.** Measuring ingredients with a kitchen scale is faster and more efficient than measuring by volume, especially when dealing with small quantities or sticky ingredients like honey or molasses. Chefs may easily tare the scale to zero after adding each ingredient, without having to clean multiple measuring cups or spoons.
  - **Better Results.** Using a metric kitchen scale helps achieve better baking results. Baking is not only an art, but a science that requires precise measurements. Even a slight variation in ingredient quantities can affect the texture and taste of baked goods. A kitchen scale helps the chef ensure that the right amount of each ingredient is added, resulting in a perfect product.
  - **Versatility.** A metric kitchen scale can be used for a variety of tasks, including measuring ingredients of cooking and baking. It can also be used to weigh portions of food for portion control and healthy eating.

Kitchen scales measuring ingredients. Credit: Adobe Stock

  - **Cost-effective.** Using a metric kitchen scale can help save money by reducing food waste. When chefs measure ingredients accurately, they are less likely to overuse or under use ingredients, which can lead to spoiled or inedible food. This can help make the most of grocery purchases and reduce overall food expenses.

TIPS

- **A 5 kg scale capacity is a common home kitchen choice.**
- **Do not mix ingredients while the bowl is placed on the scale.**
- **Place the bowl on a stable surface to mix.**

Resources - Measurement Process

STEP 1

Press the “on” button.

STEP 2

Put an empty bowl on the scale.

The display number increases.

STEP 3

Press the “tare” or “zero” button.

The display reads “0 g.”

STEP 4

Slowly add the first ingredient.

Stop when the recipe quantity is displayed.

Carefully remove some if you added too much.

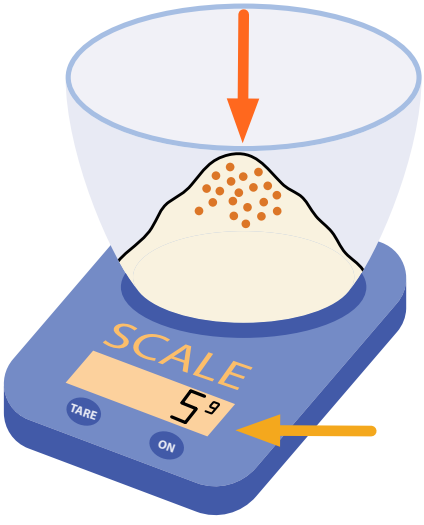
STEP 5

Press the “tare” or “zero” button.

The display reads “0 g.”

The first ingredient remains in the bowl.

STEP 6



Slowly add the second ingredient.

Stop when you reach the correct quantity.

Repeat the process, according to the recipe.

Use the tare button to zero out the kitchen scale display during the measurement process. Credit: NIST/K. Dill

Resources - Culinary Temperature

Oven Temperature		
(approximate equivalencies)		
Description*	Temperature (°C)	Temperature (°F)
Cool	90 °C	200 °F
Very Slow	120 °C	250 °F
Slow	150 °C to 160 °C	300 °F to 325 °F
Moderately Slow	160 °C to 180 °C	325 °F to 350 °F
Moderate	180 °C to 190 °C	350 °F to 375 °F
Moderately Hot	190 °C to 200 °C	375 °F to 400 °F
Hot	200 °C to 230 °C	400 °F to 450 °F
Very Hot	230 °C to 260 °C	450 °F to 500 °F

*These legacy culinary descriptions are provided as a guide for preparing heirloom and vintage recipes, translating the terms into modern oven temperature equivalents. The *NIST Metric Kitchen* provides additional cooking and baking measurement resources[3].

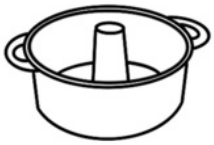
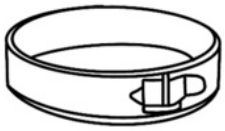
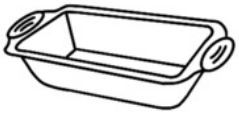
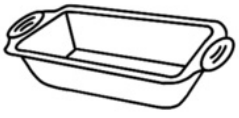
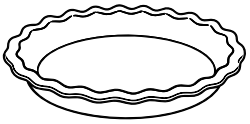
Cook using a kitchen thermometer. Credit: Adobe Stock

Student measuring ingredients on a kitchen scale. Credit: Adobe Stock

Resources - Cookware

Estimate Cookware Volume

A quick method to measure the capacity of a baking dish is to use a kitchen scale in grams. Place the empty bakeware on the kitchen scale. Tare the scale to zero. Fill the bakeware up to the rim with tap water (don't fill over the edge). Read the displayed weight to determine the pan volume. Remember, the density of water is about 1 g per mL. Example: If your full baking dish holds 1 000 g of water, then your baking dish volume is about 1 000 mL or 1 L. Cookware is available in nominal sizes.

Common Cookware		Measurement Dimensions	Approximate Volume
	**Rectangle**	18 cm x 28 cm	3 L
		23 cm x 33 cm	3.5 L
	**Square**	20 cm x 20 cm	2 L
		23 cm x 23 cm	2.5 L
	**Round**	20 cm	1.2 L
		23 cm	1.5 L
	**Springform**	23 cm	2.5 L
		27 cm	3 L
	**Loaf Pan**	20 cm x 10 cm	1.5 L
	**Loaf Pan (Deep)**	23 x 13 cm	2 L
	**Pie Plate**	23 cm	1.25 L

Cookware Volume Illustration. Credit: NIST/D. Jagoda and NIST/K. Dill

Resources - Vocabulary

Accuracy – How close a measured value is to the true value.

Area – The size of a surface. The amount of space inside the boundary of a flat shape or the surface of an object. Measured in square units.

Bake – Cook by dry heat, usually in the oven.

Batch – A group of food made at the same time.

Batter – A mixture containing flour and liquid, thin enough to pour.

Beat – To mix rapidly in order to make a mixture smooth and light by incorporating as much air as possible.

Blend – Incorporate two or more ingredients thoroughly.

Boiling Point (Water) – The specific temperature (at sea level) where water changes from a liquid into a gas (steam).

Capacity – The maximum amount that an object can contain, measured in cubic units.

Chop (Medium) – Cut solids into 13 mm to 25 mm pieces with a sharp knife or other chopping device. Pieces can be irregular, but size should be reasonably uniform.

Consistency – How thick, thin, or uniform a mixture is.

Cut – Incorporate cold butter into a dry mixture to create a crumbly texture.

Data – Information collected from a measurement process.

Degree Celsius – A temperature measurement unit.

Diced – To cut into small uniform pieces about 1 cm x 1 cm x 1 cm.

Student measuring ingredients on a kitchen scale. Credit: Adobe Stock

Fold – Incorporate a delicate substance, such as whipped cream or beaten egg whites, into another substance of different weight in a way that minimizes loss of volume. Cut down through mixture with spoon, whisk, or fork; go across bottom of bowl, up and over, close to surface. The process is repeated, while slowing rotating the bowl, until the ingredients are thoroughly blended.

Freezing Point (Water) – The specific temperature (0 °C) where liquid water turns into solid ice.

Greased – Apply a thin layer of butter, shortening or vegetable oil to the surface of a pan to prevent food from sticking.

Ingredient – A food item used to make a recipe.

International System of Units – A measurement system abbreviated SI (from the French Le Système International d'Unités). Also known as the metric system of measurement.

Resources - Vocabulary

Length – Measurement of the distance between two points measured in meters.

Liter – A volume measurement unit.

Magnitude – Size or extent of an object.

Mass – The amount of matter in an object measured in grams.

Measure – To determine the dimension, quantity, or capacity.

Meter – A length measurement unit.

Metrology – The science of measurement.

Mise en place – A French culinary technique meaning "to put in place" that refers to the practice of preparing and organizing all equipment and ingredients before preparing a recipe.

Mixture – Two or more ingredients combined together.

Proportion – The relationship between ingredient amounts in a recipe.

Precision – How close a series of repeated measurements are to one another.

Puree – To mash foods until smooth by hand, by rubbing through a sieve or food mill, or by whirling in a blender or food processor. A puree should be completely smooth.

Quantity – A measurable amount, characteristic, or property of an object or collection of objects.

Recipe – A set of instructions for making food.

Scale (Kitchen) – A device used to accurately measure the weight of solid and liquid recipe ingredients and other food.

Baking mat. Credit: Adobe Stock

Stir – To mix ingredients with a circular motion until well blended or of uniform consistency.

Tare – To reset a scale to zero.

Thermometer (Kitchen) – A device that measures temperature measured in degree Celsius.

Toss – To combine ingredients with a lifting motion.

Volume – The measurement of the amount of space occupied inside the three-dimensional space, measured in cubic units.

Weight – How heavy something is because of gravity.

Whip – To beat rapidly to incorporate air and produce expansion, as in heavy cream or egg whites.

Yield – The amount of food made from a recipe.

Resources - Safety Tips

PREP

Read the recipe.

Start with a clean counter and tools.

Wash hands before and after handling food.

SAFETY CHECK

Have an adult present when using the oven, stove, or sharp tools.

Discuss allergy info (eggs, gluten, dairy).

Tie back long hair.

Roll up long sleeves.

COOKING

Carefully handle cooking tools.

Use caution around hot surfaces.

Use oven mitts.

CLEANUP

Cool hot tools before washing.

Clean as you go to keep the area safe.

Wipe up spills immediately to prevent slipping.

Put dirty tools in the sink.

Follow safety tips in the kitchen to prevent injury, avoid fire hazards, and prevent foodborne illness. Credit: NIST/K. Dill

STAY SAFE AND HAVE FUN

Resources - NIST QR Codes

SI Units

SI Prefixes

Writing with the SI

National Metric Week
(10 October)

Metric Program

Metric Training Program
(Professional Development)

Calendar of Events

NIST Education

Video[24]

Banana Bread Recipe
Tanna Nguyen, Intern

Video[25]

Brownies Recipe
Angie Tehrani, Intern

Video[26]

Chocolate Chip Cookies Recipe
Lloyd Bekele, Intern

Website

The End

NIST Metric Kitchen videos. Credit: NIST