UNIT 4

Construction-Related Math and Measurement

by Anne Meisenzahl and David Greene
Edited by Keisha Edwards
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Acknowledgements

*Working Hands, Working Minds* is a work in progress. The authors have experimented over the years with a variety of strategies for bringing education, community building, and societal issues into an occupational framework. We are eager to work with other teachers and learn from them as they experiment with new ways to engage, involve, and challenge young people who are working to create a better future for themselves and others. This curriculum is based upon our belief that meaningful learning is contextual, intuitive, and connected to community issues.

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Anne Meisenzahl, David Greene, and Keisha Edwards
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Dorothy Stoneman
President, YouthBuild USA
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Guide for Facilitators

What is YouthBuild and Who Participates?

YouthBuild is a highly successful and well-respected program for out-of-school young adults that places equal emphasis on community development, job training, career development, and education. The program is nationally recognized for its ability to enable young adults to create success for themselves while making a significant contribution to society. As of June 2000, there are approximately 145 YouthBuild programs operating in 43 states.

Started in 1978 as the Youth Action Program with support from the U.S. Department of Housing and Urban Development (HUD), YouthBuild provides young adults an immediately productive role in their community. As they engage in the development and renovation of low-income housing, they contribute to their communities, they learn about the responsibilities of work, they learn academic skills required for a high school diploma or a GED, they acquire job skills in the construction trades, and they learn skills of leadership and social action.

Is YouthBuild an alternative school? A charter school? An employability program for out-of-school youth? A social movement? A chance for “at-risk” young adults to learn the skills required for success? A state-of-the-art example of contextual learning? The essence of school-to-work? It’s all of the above, and more — everyone who has experienced YouthBuild will add to the above description. Every YouthBuild program creates its own flavor and personality. With support and technical assistance from the national YouthBuild USA staff, young adults across the country are using the construction of low-income housing as the context through which they learn the skills to be productive, independent, contributing, and satisfied members of their communities.

The HUD legislation defines YouthBuild students as follows:
• Participants must be between 16 and 24 years old.
• At least 75 percent must have dropped out of high school.
• At least 75 percent must be low income or from a low-income family.
• One hundred percent (100 percent) must have “educational needs.”
Working Hands, Working Minds is an integrated construction curriculum. It was designed for academic instructors and construction trainers to use collaboratively.

In all YouthBuild programs, learning is an active process that involves interpreting new information, connecting it in some way to one’s prior knowledge, and applying it appropriately. Traditional instruction focuses on discrete skills and isolated facts; it makes minimal connection to anything beyond the classroom or text. It does not advance authentic learning. Integrated and interdisciplinary curriculum, on the other hand, reflects real learning in the real world.

The YouthBuild Integrated Construction Curriculum, Working Hands, Working Minds, motivates students by engaging them in real-world problems and projects. Using the teacher as their guide, students investigate authentic community problems. They decide how they are going to proceed and what strategies to use. They develop the skills they need to take responsibility for their own learning. Students also share their individual talents and expertise as they work on projects as collaborative team members. They learn by talking over ideas with others, explaining their answers, and listening to other viewpoints.

In Working Hands, Working Minds, students explore topics and themes that are relevant and rich in possibilities. They are involved in activities that are practical and have clear value in a particular field. Instead of students showing what they know by taking a test that targets their weaknesses, they demonstrate their understanding in the context of meaningful activities that support their strengths and abilities.

Working Hands, Working Minds consists of the following five units:
1. Health and Safety
2. Housing and Community
3. Construction-Related Math and Measurement
4. Tools, Trades, and Technology in Construction
5. Teamwork and Leadership in Construction

It would be reasonable to ask why these five units were chosen to be the first phase of Working Hands, Working Minds. In many training programs, the two components — academics and construction — are separate and distinct from one another. Working Hands, Working Minds closes that gap. This curriculum is designed to help YouthBuild instructors and trainers integrate academics, construction, and leadership development. It fosters reading, writing, and mathematics learning through the context of construction; skill training is directly
linked to community responsibility and social analysis.

Each of the five units is an introduction, and only an introduction, to the topic. Each unit presents what we believe to be the essential ingredients of the topics, those ingredients that are essential to a YouthBuild student’s learning. In the future, we plan to produce an intermediate and an advanced version of every one of these units for those young adults who have an extended YouthBuild experience, at this time, however, it is important for the users of the curriculum to realize that these lessons represent a critical foundation and, we hope, a springboard for other related learning experiences.

We encourage program staff to use the curriculum as a recipe. Although Working Hands, Working Minds was developed by many people, it does not represent rigid operating instructions. Usually the first time you cook a recipe, you follow the directions. But the next time you cook the recipe, you might add one thing and take out another. Just as a good recipe is a guide for you to create the dish you want to serve your diners, this is a flexible curriculum with many opportunities to give it your own flavor and personality.

It is critical to remember that learning happens everywhere at YouthBuild — at the construction sites in the community, in the academic and vocational classrooms, during community meetings, and while doing community service. All of YouthBuild is education. Therefore, this curriculum is a vehicle for program staff to integrate what they teach, why they teach it, and how they teach it.

These five units of Working Hands, Working Minds do not teach the technical vocational skills of the construction trades, such as framing, masonry, finish carpentry, plumbing, etc. Rather, these units teach a set of transferable skills that are critical for and applicable in any of the construction trades. In fact, many of the skills taught in these units, such as teamwork, basic writing and communication, critical thinking, and problem solving, are transferable to careers in nearly any occupational area.
Working Hands, Working Minds: Blueprint for Success

Working Hands, Working Minds is a curriculum that reflects current research and practice related to contextual teaching and learning. What is contextual learning? In a contextual learning environment, textbooks, lectures, and traditional tests are no longer the primary teaching tools. Rather, they are supplemental to a learning process in which students apply and experience what is being taught by addressing real problems and needs associated with their roles and responsibilities as family members, citizens, students, and workers. In a YouthBuild program, students are at the center of their learning, and construction of low-income housing is the context.

According to current research there are six key elements of contextual learning (Owens, Tom; Dunham, Dan and Wang, Changhua, “Toward a Theory of Contextual Teaching and Learning,” Washington State Preservice Teacher Education Consortium for Contextual Teaching and Learning, 1999):

1. Meaningful learning
2. Application of knowledge
3. Higher order thinking
4. Standards-based
5. Cultures-focused
6. Authentic assessment

Related to those elements of contextual learning, the Working Hands, Working Minds blueprint has been drawn to:

• Engage youth in real conversation about issues relevant to their lives.
• Help youth articulate their dreams, goals, experiences, skills, and talents.
• Encourage youth to plan and participate in change in their own lives and their communities.
• Challenge youth to step out of their comfort zone and put themselves in the driver’s seat of their own learning.
• Push youth to think critically about program standards and employability standards as they assess their own strengths and weaknesses.
• Engage youth in hands-on activities with a meaningful balance of theory and practice in a safe environment.
• Engage youth in meaningful reflection about each lesson, thus teaching that reflection is a valuable process in our lives.

1 Reprinted with permission from the Northwest Regional Educational Laboratory.
• Instruct youth in the development of portfolios so they can document and articulate their knowledge and skills.
• Help youth make connections between the classroom, the worksite, and life beyond YouthBuild.
• Immerse youth in culturally relevant perspectives.

Just as the occupants of a building do not need to think about the architectural blueprints every day, YouthBuild staff do not need to recite these principles of contextual learning; however, in a program that operates without them, learning will not be meaningful.

Described below are some examples of how these principles play out in Working Hands, Working Minds.

Teaching from Real Life Experiences

Skills introduced in Working Hands, Working Minds are taught in the context of low-income housing construction. The skills are introduced in reference to real community and social problems that need to be solved, in conjunction with real tasks that need to be accomplished. For example, when students build a porch on a low-income apartment unit, the curriculum addresses the reading, writing, and math skills needed to accomplish that task. In a lesson that teaches about first aid and how to respond to emergencies, related reading, writing, and communication skills are emphasized. Specific academic skills are identified in the GED description later in this section.

As young people work in and contribute to their communities, they assume ownership and they invest into the community. Their work is real, their work is urgent, and their work is valued. It is through these real life experiences that YouthBuild young adults flourish and create their own success.

Fostering Teamwork

Teamwork skills are among the most critical for success in any job in any career; construction sites are a perfect context for teaching these skills. Teamwork and cooperation are embedded throughout the curriculum. Students working together in teams learn a fundamental lesson: we are stronger when we help each other and share our skills than if we ignore or compete against one another. As students learn group skills necessary for work, their communication skills are enhanced and they develop confidence in solving problems. They learn to trust each other and respect differences. They participate actively and learn to work both cooperatively and independently.
In this curriculum, many activities involve the use of small groups and teamwork. The following questions should be taken into consideration regarding the use of small groups:

• What are the reading and verbal abilities of students in the groups?
• How are students’ maturity levels similar and/or different regarding teamwork skills? How will you structure the activities to increase the skill levels of all the students?
• Will anyone feel left out or left behind? How will students be able to assist one another?
• How many students are in the class and how will small groups be structured?
• What are the group management issues?
• What skills do the instructors have?
• Will staff training be available, if needed?

Encouraging Problem Solving and Critical Thinking

Problem posing and problem solving are key components of Working Hands, Working Minds. All lessons incorporate opportunities for generating questions, solving problems, and reflecting on the process. Students are given opportunities to use their own experiences as a source of information on how to complete tasks and reach goals. The lessons in the curriculum are designed to facilitate critical analysis and reflection by creating opportunities for students to act on and experiment with the problems and solutions they have posed. The curriculum makes explicit the connection between these problems, community development, and the literacy skills needed to support reflection and action.

Developing Skills of Social Analysis

In Working Hands, Working Minds, the social realities of housing, community, and urban development are addressed through the construction and renovation of low-income housing. Students have opportunities to research and appraise related social issues and to develop strategies for creating change. By participating in the process of renovating buildings or constructing new homes, students are making important social contributions. In this curriculum, through research, reading, writing, and math activities, students become more conscious of their socially useful role.
The Importance of the General Equivalency Diploma (GED)

Obtaining either a high school diploma or a General Equivalency Diploma (GED) is an important goal for YouthBuild students. The GED examination certifies that a learner performs academically at a level that is equivalent to a high school education.

Although for many years the GED has been nationally recognized as an equivalent to the high school diploma, some people believe it does not represent equal rigor and preparation for postsecondary courses. Most of the studies comparing the outcomes of GED and high school graduates indicate that, although getting a GED does not offer the same set of comprehensive experiences that a high school education/diploma would provide, it does allow individuals to enter the job market and postsecondary education at similar rates. In other words, the GED definitely provides an avenue for young people to pursue job opportunities and postsecondary education.

YouthBuild students who are close to graduating from high school and lack only a few high school credits are encouraged to obtain their diploma either through partnership with the local school system or through the YouthBuild program itself. However, for many YouthBuild students, the GED provides the most efficient and reasonable pathway to high school competition. The GED is recognized by employers and postsecondary institutions as proof that the individual has achieved a level of competency that will benefit them on the job and in future educational endeavors.

The major academic and GED skills emphasized in the first five units of Working Hands, Working Minds include:

**Reading and Writing**
- Recognize and infer cause and effect
- Predict outcomes
- Apply information to new situations
- Recognize, recall, summarize, and express main ideas
- Recall detail
- Recognize sequence
- Organize ideas
- Write an essay
- Use the library, encyclopedia, table of contents, and index of a book
- Read and write poetry

**Math**
- Define standard units of measurement
- Convert length and time measurements
• Solve measurement problems
• Add, subtract, multiply, and divide numbers using inches, feet, and yards
• Use fractions and percentages to solve problems
• Use standard measurement tools, such as ruler, tape measure or yardstick
• Estimate and draft a budget
• Solve area problems using square foot and perimeter
• Explore angles and triangles as used in construction

The New GED Test to be used in 2002, will provide students with calculators during part of the Math Section of the Test. Students will be expected to be able to use these calculators effectively to answer questions. We recommend that staff access training and learning materials to facilitate the development of this new skill requirement for the General Equivalency Diploma.

These skills are interspersed throughout many of the lessons in all of the units. Students have multiple opportunities to practice using the skills both in the classroom and on the construction sites. As the students learn these skills in the context of doing construction, they understand that the skills are transferable to many other areas of their lives.

**Employability and Career Development**

YouthBuild helps young adults acquire the skills required to succeed in any job, in any industry, in any community. In 1991 the U.S. Department of Labor’s Secretary’s Commission on Achieving Necessary Skills (SCANS) gathered information from business owners, public employees, union officials, and workers in all types of jobs from entry level to top management. The conclusions were unanimous:

> “New workers must be creative and responsible problem solvers and have the skills and attitudes on which employers can build. Traditional jobs are changing and new jobs are created every day. High paying but unskilled jobs are disappearing. Employers and employees share the belief that all workplaces must ‘work smarter.’”

*(From *What Work Requires of Schools, A SCANS Report for AMERICA 2000, 1991)*

Most youth employment programs, as well as nearly every state education agency, have adopted the SCANS competencies as those skills that all people need to become productive, independent, contributing, and satisfied members of society. *Working Hands, Working Minds* consciously and directly addresses the following SCANS competencies and foundation skills:
- **Identify, organize, plan, and allocate resources**: time, money, material and facilities, and human resources
- **Work with others**: teamwork, teach others, serve clients and customers, leadership, and work with diversity
- **Acquire and use information**: find and assess information, organize and communicate information, and use computers to process information
- **Understand complex inter-relationships**: understand, improve and design systems, correct performance
- **Work with a variety of technologies**: apply technology to a task, maintain and troubleshoot equipment
- **Basic skills**: reading, writing, math, listening, speaking
- **Thinking skills**: creative thinking, decision making, problem solving, knowing how to learn, reasoning
- **Personal qualities**: responsibility, self-esteem, sociability, self-management, integrity/honesty

As YouthBuild students successfully complete the *Working Hands, Working Minds* lessons, they demonstrate increasingly high levels of achievement of the SCANS competencies that are critical to construction or any other industry they may choose to pursue. Through the learning activities and portfolio entries, YouthBuild students have many opportunities to document their skills for use on a resume, letter of application, or job interview.

In order to help students prepare for the realities of the world of work, many lessons involve visiting local workplaces, gathering information about career opportunities, and interviewing workers. Not only do these activities acquaint students with the literacy skills needed to do particular jobs, but they also learn about the physical environment, teamwork, and communication skills required by different jobs.

*Working Hands, Working Minds* is about career exploration. By researching the types of jobs available in the construction trades, students gain a broader understanding of the options available to them, and develop a realistic sense of what skills and training they will need for jobs that interest them.

**Assessment**

YouthBuild thrives in the new era of educational assessment. The traditional paper-and-pencil testing mode of assessment is losing prominence. A few notes about the “old methods” will add to our understanding of the new. It used to be that achievement tests were used to sort and separate learners into those who went on to college and those who didn’t. Traditionally, teachers
taught and students were tested to determine if they learned what they were supposed to; this created a wall between teachers and students. The '70s brought statewide testing, the '80s and '90s brought national standards and centralized assessments.

The more realistic theory of assessment is that testing alone is insufficient. Assessment must be used to inform the instructional process and the learning process, and the teacher and the student should use assessment information equally. Here are a few assumptions about authentic assessment:

• Meaningful learning and meaningful assessment go hand-in-hand; one won’t happen without the other.
• Good assessment comes from a clear vision of expected outcomes; the standards and criteria for excellence are clear and understood by both the learner and the instructor.
• Good assessment actively involves the learner; there is a conscious emphasis on reflection and ownership of learning.
• Assessment has many purposes, strategies, and products; it is multidimensional, much more than a test-at-the-end strategy.
• Assessment should not be a time-eater; it should save time. It should make the job of teaching easier and more effective.
• There is ongoing positive interaction between all learners, including the instructor.

The assessment process in Working Hands, Working Minds is as authentic as possible. It is based on the “use it or lose it” theory of knowledge. Every lesson in all five units ends with Creative Extensions and Project-Based Learning Activities so that students can demonstrate their understanding of what they have learned. Both of these components of the lessons are structured opportunities for students to apply what they have learned. Embedded in the lessons are numerous opportunities for both individual and group reflection.

The final lesson in each unit is a formal assessment of learning that measures young peoples’ ability to apply and personalize the information they have acquired. Assessment activities in each unit might include writing a response to a question such as, “How have your attitudes, beliefs, and ideas changed as a result of this unit?” Or students might complete a safety self-assessment and compare it to one completed by their construction trainer.

Throughout each unit, students collect work products/samples to put in a portfolio. As the culmination of the student’s work in the unit, the portfolio serves the following purposes:

• It is a student-centered assessment tool. Students make judgments about the quality of their work and learning and what needs to be improved.
• It enables teachers to review collected work and make judgments about students’ growth over time.
• It has the potential to boost students’ self-confidence about their skills because it offers a concrete illustration of these skills.
• It is a potential tool to help students “show what they know” to a prospective employer, internship host, or educational institution.

Although different YouthBuild programs make different uses of portfolios, in its simplest form a portfolio serves as an assessment tool for instructors, a self-assessment tool for students, and the raw material to use for a career presentation portfolio.

**Working Hands, Working Minds: The Foundation**

First, a note about learning readiness. Learning readiness is defined as the ability of a learner to engage in the instructional program with effective learning and study skill habits. YouthBuild students must be able to take notes, do homework, take examinations, read and digest material, write effective prose, problem solve, and think critically — all habits that are conducive to life-long learning. In addition, YouthBuild students need to learn how to ask questions, think about their learning, and assess how they are doing with the material that is presented to them. Study groups are often used to support effective learning and study habits.

*Working Hands, Working Minds* was conceived as a way to introduce individuals to the world of construction and its relationships to academic achievement, e.g., reading, writing, and mathematics. It provides classroom teachers, counselors, and construction managers with a set of lessons to integrate academics with construction skills. Because *Working Hands, Working Minds* requires YouthBuild students to learn and practice effective study skills, learning readiness is an important consideration when delivering the curriculum.

Learning readiness is a key to successfully completing the GED program, learning construction skills, and being prepared to enter the job market or post secondary education. *Working Hands, Working Minds* was designed to take this into consideration in both content and process.

*Working Hands, Working Minds* was designed to be easy to use, easy to adapt, and easy to integrate with other program curricula. Therefore, each unit has a similar format and each lesson has the same design. Described below is the structure of the units and the lessons in each unit.
Each unit has an overview, which includes:

- A brief summary of each lesson.
- A competency checklist that outlines the skills (both academic and construction) students should be able to perform upon successful completion of the lessons in the unit.
- A portfolio assessment checklist that outlines the materials students could include in their portfolios.

Each lesson in each unit uses the following format:

- **Aim:** The purpose of the lesson and what students will do/learn.
- **Key Terms and Concepts:** A list of vocabulary words that can be introduced in relation to specific lessons.
- **Time:** Approximately how long the lesson should take.
- **Things to Consider:** What an instructor might need to do or think about before starting to teach the lesson, such as how to present a sensitive topic, finding a guest speaker, arranging for access to computers for Internet research, or preparing for career interviews.
- **Materials, Tools and Resources:** A list of all the handouts and any materials that are needed to teach the lesson, such as flipchart paper, student journals, or newspapers.
- **Steps for Activities:** A lightly scripted step-by-step guide for the instructor.
- **Wrap-Up:** Reflection on the lesson, thinking about how to apply what was learned both to the YouthBuild program and to one’s personal life.
- **Creative Extensions:** Suggestions about ways to adapt certain activities in the lesson; ideas for embellishing the lesson; simple applications or ways to practice what was learned in the classroom.
- **Project-Based Learning Activities:** Ideas for extending the lesson with a group or individual project that requires students to take leadership to plan, carry out their activities, and reflect on what they did and learned. Projects should all have a community component in which students connect with other people or organizations; some have career connections. These activities are ideas for program staff to start from, not fully scripted guides for each project idea.
- **Handouts:** All handouts required to complete the lesson are at the end of the lesson; others are in the supplemental Tools and Resources section at the end of the unit.

Following the lessons in each unit are two final sections:

- **Tools and Resources** section lists print, Internet, and video resources that might be helpful for enrichment activities or for the facilitator.

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“We try to make our students feel okay about who they are. There was a time when it wasn’t okay to be Indian. There is a whole movement now to preserve our cultural identity, and our young people are becoming a part of that.”

DENNIS FOX, YOUTHBUILD FORT BERTHOLD, ND
• **Supplemental Handouts** suggest optional activities, creative extensions, and project-based learning activities.

  “We do vocational education on the site two mornings a week. We are in a room in a garage that is set up like a classroom. It has a desk, tables and a blackboard…I also teach vocational education in the classroom two sessions a week. We have a good blackboard, textbooks, and a VCR. We combine reading and writing, vocabulary development, demonstration, and hands-on practice…I’m also planning to deal with the history of construction careers, barriers to employment for women, real estate, financing and community development, because these topics make construction come alive, students can see the relevance of it.”

  Rebecca Etchison, YouthBuild Dayton

### Making the Curriculum Work for Your Program

*Working Hands, Working Minds* is appropriate for any program that strives to teach construction skills in the context of community development and social action.

The curriculum is applicable to any performance-based and competency-based education programs. It can be integrated into programs that use Individual Education Plans (IEPs) or Academic Development Plans (ADPs) in which students have individual plans geared to their particular learning needs. It can be used in conjunction with other curricula; it can supplement high school equivalency (GED) or high school diploma curricula. Programs can adapt the curriculum to meet their needs by selecting lessons relevant to their program’s competencies.

*Working Hands, Working Minds* is designed to be used by a team of staff (teachers, counselors, construction managers, and other instructional staff) working together to coordinate the learning process. Programs should make their own decisions about which lessons will be taught, who will teach which lessons of each unit, and which lessons will be taught as a team. Instructors should meet regularly to plan and debrief.

Groups might consider the following questions as they plan the use of the curriculum:

- Where will instruction take place?
- Who will teach which lessons?
- How will the program maximize the integration of worksite and classroom instruction?
- When will instructional staff meet to plan, coordinate instruction, and debrief?
How much of the time will be spent team-teaching and how much will be separate?

Depending on the staffing structure and the skills and background of the staff, programs can use *Working Hands, Working Minds* in numerous ways, ranging from a traditional approach (in which components remain distinct) to a fully integrated approach. Three of these approaches are described below.

1. **Separate but Equal Approach**

In this traditional model, academic teachers, worksite instructors, and vocational instructors work and teach separately, but reinforce each other’s separate domains and support each other’s work. Instructors and teachers choose separate lessons from the curriculum to teach in their distinct components, but do not actually teach together. Because of the shared theme of the lessons, students may, on their own, make the intellectual connection between them, but the connection is not overtly emphasized by the instructors.

2. **Content Exchange Approach**

In this approach, academic teachers and vocational instructors meet initially to discuss how to divide the lessons and when lessons might best be taught in order to support each other’s content area. They meet regularly to discuss how the curriculum can be expanded to demonstrate the interrelatedness of the content. For example, when students learn vocabulary, they use words related to construction; after learning how to frame a wall on the construction site, students might describe the process in a writing exercise in the classroom.

Vocational instructors might recommend creative extensions or project-based learning activities to be coordinated by the teacher; academic teachers might suggest materials and methods for teaching measurement skills on the worksite.

3. **Team Teaching Approach**

When “teaming,” worksite instructors, academic teachers, and vocational instructors work together to choose lessons, develop additional instructional materials, present material, and assess student progress. In this highly collaborative approach, instructors demonstrate to students the way in which their respective fields are related. The academic teacher might go to the worksite to teach the math skills needed to measure the perimeter of a lot to determine board feet of fencing needed, or to teach the reading skills needed to understand the directions for operating a power tool. Likewise, worksite and vocational instructors might go into the classroom to teach proper names and operating instructions of tools to be used on the construction site. Academic and vocational teachers decide which lessons can be taught together and with which activities they can assist each other.

“*I’m also planning to deal with the history of construction careers, barriers to employment for women, real estate, financing, and community development because these topics make construction come alive; students can see the relevance of it.*”

REBECCA ETCHEISON
YOUTHBUILD DAYTON
On a frequent basis, all of the instructional partners meet to assess the collaboration process and to discuss continuous improvement of the process.

**Using the Key Terms and Concepts**

At the beginning of each lesson you will find a list of vocabulary words from the lesson that may require clarification and dialogue. Listed here are a few ideas for teaching the key words and concepts.

- **Before each lesson, write the words on the board and ask students what they think the words mean.** Have a short group discussion to come to consensus on definition; if consensus is not reached, wait until the term or concept appears in the lesson and then revisit the discussion.

- **Before beginning the lesson, you could have students individually write down what they think the terms mean.** Then, at the end of the lesson, ask students to revisit their definitions and revise, as necessary. Give students a chance to compare their definitions and come to a common definition.

- **Students can compile glossaries of key terms** and continue to add words to it from each lesson. In addition to writing definitions, they could divide words into syllables to aid spelling, identify parts of speech, and use words in sentences.

- **Short quizzes** can be given at the end of a lesson so students can assess their own comprehension of the key terms and concepts.

- **A homework assignment** could be for students to teach one or more of the key terms or concepts to a family member or friend.

- **Using computers**, students can create YouthBuild dictionaries with definitions of the key terms and concepts.

The last lesson in each unit is a good time to briefly review the vocabulary from the unit and assess comprehension.

- **You could be traditional** and give a test.

- **You could be dramatic** and ask for a skit using some of the key terms.

- **You could be playful** and engage students in a charades or game activity.

- **You could be humorous** and let students draw cartoons with captions or write jokes using the vocabulary words.

**Creative Extensions**

Everyone teaches differently and all learners have their own unique interests and needs. We know that there is no “one right way” to teach, and the more teachers modify these lessons to make them their own, the more effective they will be. Therefore we have included two or three ideas for modifying or
enriching the lesson. These ideas are optional of course, and are meant to be short, creative, typically classroom-based extensions and modifications of the lesson. The overall purpose, however, is to offer students alternative strategies to learn and opportunities to apply what they learned in a wide variety of ways.

One simple example of a creative extension in the math unit is to have students write their own construction-related word problems using the skills they learned in the lesson. A more complex creative extension in the math unit has students explore how the architect Frank Lloyd Wright used angles and geometrical shapes to enhance the aesthetic beauty and functionality of his buildings. Many creative extensions are, in fact, applications of learning that can be used as an assessment of how well the students learned the subject matter.

While the overall purpose is application of knowledge gained, these creative extensions should also be motivating and personalized. For example, the one about Frank Lloyd Wright could be changed so that a student or group of students select their own architect to study. If you wanted to personalize or localize the project even further, you could focus on local architects.

The creative extensions are meant to be just that — creative activities that extend, embellish, or enrich the lesson.

**Project-Based Learning**

Every day more research appears on the rationale for, and the value of, project-based learning. It is a teaching and learning strategy that puts students “in the driver’s seat of their own learning.” YouthBuild is intrinsically conducive to project-based learning because of the very nature of the construction projects.

What is a project? Coupling the current research and practice on project-based learning with the YouthBuild philosophy, a good YouthBuild project is a cohesive set of learning activities with the following characteristics:

- A project is derived from an issue or idea that has authentic meaning for the student(s), the community, and the program.
- Rather than focusing on one subject area, projects are interdisciplinary and integrate a variety of content areas.
- A project takes more than a week to complete; it is a series of activities that hang together with a beginning, a middle, and an end.
- Students, teachers, and in many cases, community members, collaborate in the planning, execution, and assessment of the project.
- A project requires the use of both community and classroom resources.
- Projects require students to use critical thinking and problem-solving skills, and many of the GED skills and employability (SCANS) skills described earlier in this Guide for Facilitators.
• Projects encourage teamwork and leadership as students take on different roles and assist each other in the learning process.
• A project should ideally result in a product, presentation, portfolio, or demonstration of knowledge.
• Project-based learning demands that both students and teachers assume new roles.
• The teacher is the facilitator, not the leader.
• The teacher learns along with the students rather than being an expert.
• The teacher gives up some authority as the students demonstrate leadership.
• The teacher is a coach, cheerleader, and a model.
• The teacher must be patient, willing to let students make mistakes in a safe environment, and ready to support students through the bumps in the road.

One of the nicest pieces written recently on project-based learning is from a toolkit titled *Connected Learning Communities Toolkit for Reinventing High School* (Jobs for the Future) by Adria Steinberg of Jobs for the Future. Divided into six categories, the author identifies these criteria for designing projects:

**Authenticity**
- Project emanates from a problem or question that has meaning to the student.
- Problem or question is one that might actually be tackled by an adult at work or in the community.
- Students create or produce something that has personal and/or social value, beyond the school setting.

**Academic Rigor**
- Students acquire and apply knowledge central to one or more discipline or content area.
- Students use methods of inquiry central to one or more disciplines (e.g., to think like a scientist).
- Students develop higher-order thinking skills and habits of mind (e.g., searching for evidence, taking different perspectives).

**Applied Learning**
- Students solve a semi structured problem (e.g. designing a product, improving a system, or organizing an event) that is grounded in a context of life and work beyond the school walls.
- Students acquire and use competencies expected in high-performance work organizations (e.g., teamwork, problem solving).
- Work requires students to develop organizational and self-management skills.
Active Exploration

- Students spend significant amounts of time doing field-based work.
- Students engage in real investigations using a variety of methods, media, and sources.
- Students communicate what they learn through presentations.

Adult Connections

- Students meet and observe adults with relevant expertise and experience.
- Students work closely with at least one adult.
- Adults collaborate on the design and assessment of student work.

Assessment

- Students reflect regularly on their learning, using clear project criteria that they have helped to set.
- Adults from outside the classroom help students develop a sense of the real-world standards for this type of work.
- There are opportunities for regular assessment of student work through a range of methods, including exhibitions and portfolios.

The project-based learning activities at the end of each lesson are merely ideas; doing a project in its ideal form is no simple matter. As you begin to build on some of the project ideas in the lessons, it is good to start small, make it doable, and build in success for the participants.

Time

The time indication for each lesson is an estimation, not a statement of fact. The time it takes to complete each lesson is dependent on the following factors: the intent of the facilitator, past experiences of the students, interest of the students, how verbal and conversational the students are, and how your program is structured.

“All students don’t learn the same. Learning should be tailored around students so that it doesn’t force them to learn in one way. Learning should not be limited to the classroom. The whole world is a classroom. Take them out in the world and teach them.”

ROBERT BELL, YOUTHBUILD PHILADELPHIA
“Facilitate” means “to make easier.” Think about yourself as a facilitator — someone who helps people learn rather than someone who imposes learning upon them. Facilitating suggests the idea of a collaborative relationship between the instructor and students. A facilitator is a:

- Coach
- Listener
- Trainer
- Learner
- Manager of a group process

What follows are some good practices for facilitating, adapted from *Strengthening Mentoring Programs: The National Mentoring Center Training Curriculum* (Office of Juvenile Justice and Delinquency Prevention; Northwest Regional Education Laboratory, Public/Private Ventures, 2000).

### Before Each Lesson

**Know the curriculum thoroughly**

- As necessary, customize activities, handouts, and overheads so they best address characteristics of your program and your specific group of students.
- Think about how you will facilitate the session, and be prepared to make on-the-spot adjustments. If, for example, you find you need to spend more time on one activity, you might need to shorten another.

**Make your learning environment conducive to group interaction.**

- Avoid a traditional classroom set-up. Depending on the size of your group, have tables large enough for all the students to sit around, write and converse.
- If small groups are going to be meeting as part of the lesson, make sure the area is large enough so that small groups can meet without distracting each other.

**Have everything ready.**

- Copy handouts and prepare overheads.
- Gather any required materials and equipment: newsprint, markers, masking tape, an overhead projector (and extension cord, if necessary), and anything else you might need for the lesson.

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2 Reprinted with permission from the Northwest Regional Education Laboratory.
During Each Lesson

Create a comfortable learning environment.
- Create an atmosphere where participants are taken seriously and where they can also laugh. People are usually most open to new ideas when they are enjoying themselves and feel comfortable enough to risk making mistakes.

Pace the lesson appropriately.
- Encourage the exchange of ideas and information, while also keeping activities on track. Move things quickly enough to keep students from being bored, but slowly enough to make sure they absorb what is being discussed.
- Allow time throughout the session for students to ask questions and assist one another with seeking answers.

Model good listening, feedback, and problem-solving skills.
- Listen carefully and respectfully. Acknowledge what the young people say even if you don’t agree. People need to feel they are being listened to and their ideas and concerns are recognized as worthy contributions.
- Respond by guiding, not judging. Repeat and address key points.
- Help students develop collaborative problem-solving skills. Involve them in answering other participants’ question, and have them work together to arrive at solutions.

Think about how people learn best.
- Keep this point in mind: people remember about 20 percent of what they hear, 40 percent of what they hear and see, and 80 percent of what they discover for themselves.
- Use overheads and newsprint to help students see and remember. Newsprint is also a useful tool for group thinking and problem solving. Summarize major discussion points on newsprint. Post it on the walls around the room so you and your group can keep referring back to, and expanding upon, earlier ideas and contributions.
- Use the three effective strategies for facilitators — brainstorming, group work, and role plays — that are described below.
- Build in success. People learn best when they experience success frequently. Structure activities so students have a sense of accomplishment by the end.

Be yourself
- Know your limitations. If you don’t know the answer to a question, that’s okay. You don’t need to know all the answers. Learning is a collaborative process and you are a partner with your students in that endeavor.
- Maintain your sense of humor.

Math and Measurement
After Each Lesson

Get feedback from students.

• Prepare an evaluation form that asks for feedback on both the process and the content of the lesson. Distribute it at the end of the session, and ask students to complete it before they leave.

• Use their comments and opinions to plan and tailor your next lessons.

Reflect on what worked well and what did not.

• Don’t use the feedback forms to judge yourself. Instead, use the information to help you think through what went well from the students’ point of view, what you need to modify about the content, and what facilitation skills you should work on.

• Along with students’ feedback, give yourself feedback on the lesson. Think about the situations when students seemed involved, bored, stimulated, confused, angry, or amused. Based on your self-observations, make necessary adjustments in lesson content and your facilitation strategies.

Three Strategies for Effective Facilitation

While facilitating these lessons, you will want to take advantage of three important strategies: brainstorming, group work, and role plays.

1. Brainstorming

Brainstorming is an excellent way to generate ideas, and it is an effective technique for getting all students involved and contributing. This is especially true at the beginning of a lesson when you are trying to get everyone focused on the same subject.

When facilitating brainstorming activities, keep these points in mind:

• The purpose of brainstorming is to encourage all students to offer their thoughts and opinions in a nonjudgmental atmosphere.

• As students offer ideas, record them — all of them — on newsprint.

• Brainstorming is a free exchange of ideas on a topic; it is important to accept everyone’s contribution.

2. Group Work

During many activities, organizing the whole group into small groups of four to six students will encourage participation, involvement, and collaborative problem solving.
In some cases, assign, or have group members assign to themselves, these specific roles:

- **The leader** (like a facilitator) takes responsibility for helping the group complete its task. He or she helps group members work together and encourages everyone to participate in positive ways.
- **The recorder** writes down ideas from a brainstorming and anything else that needs to be recorded.
- **The reporter** presents the small group’s ideas and conclusions back to the whole group. Sometimes you might want to combine the recorder and reporter roles.

Make sure that over the course of several sessions student roles vary and that everyone has an opportunity to be the “leader.” Make sure participants understand that, whatever other roles they may have, everyone in the group works together to complete the group task. Everyone suggests ideas, gives opinions, agrees or disagrees with others, asks questions, and offers solutions.

### 3. Role plays

When preparing to facilitate role plays, keep these points in mind:

- Role plays are informal dramatizations through which students can try out ways they might handle a potential situation and increase their insight into someone else’s feelings, values, or attitudes.
- If the lesson includes suggested scenarios and characterizations for the role plays, you should modify these, where possible, to reflect actual situations that have arisen or are likely to arise in your particular program.
- Always allow time after the role plays for students to discuss their own and others’ “performances” and to talk about what they learned from the activity.
- Many people initially feel uncomfortable doing role plays. However, once they have some practice with them, they usually enjoy the experience and see that role plays can increase confidence, comfort, and self-esteem.

### What If Life Happens?

Nothing in life goes perfectly all the time, and facilitating an integrated curriculum is no exception. Despite all your planning and skillful facilitation, things can (and sometimes will) become unexpectedly challenging. Below are suggestions for handling some of those awkward situations.

**What if you notice that students’ eyes are glazing over?**

- Ask yourself if you’re talking too much without giving the students a chance to contribute. Get the participants engaged by structuring it so they have to do the thinking.
· Do a reality check. Are you addressing the needs students have presented?
· Do another reality check. Do you all need a break? Perhaps you could pass out Hershey’s Kisses!
· Inject some humor fast.

**What if you don’t have enough students for the small group work you have planned?**
· Use pairs instead.
· Change the activity to a whole group activity, and seat the group in a circle.

**What if there’s a heated discussion that is moving the group off track and taking up too much time?**
· First let students know that you value their interest and enthusiasm.
· You can say, “Let’s stay with this discussion for two more minutes.” Then, after two minutes, sum up what’s been said and move on.
· Refer back to the aim of the lesson and say “We need to move on so let’s have two or three final comments on the topic.”
· Let the students suggest an alternate time and process to pursue the discussion so you can move ahead with the lesson.

**What if you realize you’re going to run out of time before you’ve accomplished your goals?**
· One option is to move quickly through the rest of the lesson. Cover everything, even though the coverage will not be as deep.
· Another option is to stop the activities a little earlier than planned and have a longer wrap-up session where you talk about the topics you didn’t get to. Relate those topics to the lesson’s goals.

Finally, be flexible, be creative, be honest, be a learner, be ready for anything, and, most important of all, have fun with *Working Hands, Working Minds*. 
Special Note

Basic math skills are an integral part of daily life and critical to the construction trades. The lessons included in the Construction-Related Math and Measurement unit are not intended to be all-inclusive; rather, they can serve as a starting point for acquainting students with fundamental math skills needed on a construction site.

There are many aspects to the teaching of math. This unit is intended to supplement other math learning done in the classroom and on the site. In addition, practical math activities have been integrated into many of the other units.

The information on the following pages from the National Council of Teachers of Mathematics, outlines the key areas of mathematical thinking essential for success in the modern world, both in daily life and on the workplace. As often as possible, these key skills are reinforced in this and the other units of “Working Hands, Working Minds.”

Key Areas of Mathematical Thinking Essential for Success in the Modern World (National Council of Teachers of Mathematics)

Problem Solving

Learning to solve problems is the principal reason for studying mathematics. Problem solving is the process of applying previously-acquired knowledge to new and unfamiliar situations. Solving word problems in texts is one form of problem solving, but students also should be faced with nontextbook problems. Problem-solving strategies involve posing questions, analyzing situations, translating results, illustrating results, drawing diagrams, and using trial and error. In solving problems, students need to be able to apply the rules of logic necessary to arrive at valid conclusions. They must be able to determine which facts are relevant. They should be unfearful of arriving at tentative conclusions and they must be willing to subject these conclusions to scrutiny.

Applying Mathematics to Everyday Situations

The use of mathematics is interrelated with all computation activities. Students should be encouraged to take everyday situations, translate them into
mathematical expressions, solve the mathematics, and interpret the results in light of the initial situation.

**Alertness to the Reasonableness of Results**

Due to arithmetic errors or other mistakes, results of mathematical work are sometimes wrong. Students should learn to inspect all results and to check for reasonableness in terms of the original problem. With the increase in the use of calculating devices in society, this skill is essential.

**Estimation and Approximation**

Students should be able to carry out rapid approximate calculations by first rounding off numbers. They should acquire some simple techniques for estimating quantity, length, distance, weight, etc. It is also necessary to decide when a particular result is precise enough for the purpose at hand.

**Appropriate Computational Skills**

Students should gain facility with addition, subtraction, multiplication, and division with whole numbers and decimals. Today it must be recognized that long, complicated computations will usually be done with a calculator. However, knowledge of single-digit number facts is still essential and mental arithmetic is a valuable skill. It’s also practical when you are standing on scaffolding! Moreover, there are everyday situations, in which people must be able to recognize and compute fractions. Because consumers continually deal with many situations that involve percentage, the ability to recognize and use percents should also be developed and maintained.

**Geometry**

Students should learn the geometric concepts they will need to function effectively in the three-dimensional world. They should have knowledge of concepts such as point, line, plane, parallel, and perpendicular. They should know basic properties of simple geometric figures, particularly those properties that relate to measurement and problem-solving skills. They also must be able to recognize similarities and differences among objects.

**Measurement**

Minimally, students should be able to measure distance, weight, time, capacity, and temperature. Measurement of angles and calculations of simple areas and volumes are also essential. Students should be able to perform measurement in both metric and customary systems using the appropriate tools.
**Reading, Interpreting, and Constructing Tables, Charts, and Graphs**

Students should know how to read and draw conclusions from simple tables, maps, charts, and graphs. They should be able to condense numerical information into more manageable or meaningful terms by setting up simple tables, charts, and graphs.

**Using Mathematics to Predict**

Students should learn how elementary notions of probability are used to determine the likelihood of future events. They should learn to identify situations where immediate past experience does not affect the likelihood of future events. They should become familiar with how mathematics is used to help make predictions such as election forecasts.

**Computer Literacy**

It is important for all citizens to understand what computers can and cannot do. Students should be aware of the many uses of computers in society, such as their use in teaching, learning, financial transactions, and information storage and retrieval. The “mystique” surrounding computers is disturbing and can put persons with no understanding of computers at a disadvantage. The increasing use of computers by government, industry, and business demands an awareness of computer uses and limitations.
Suggested Teaching Approaches

Teaching math involves a great deal more than passing on a set of discrete skills. On the following pages, we suggest a variety of approaches that can be taken to enrich the experience of math learning in the YouthBuild classroom and on the worksite.

Consider Students’ Learning Styles and Needs

Students bring with them a variety of experiences, attitudes, and feelings about math. Getting to know students’ individual strengths and weaknesses, as well as their particular ways of working, will greatly enhance the instructor’s ability to assist students. Take some time to assess students’ skills as well as their learning styles. Some students learn best in small, cooperative group settings; some benefit from individual instruction and practice; some benefit greatly giving or getting peer tutoring; some work well in large groups. Most students will benefit from a mix of instructional styles.

Students can also use different learning modalities to demonstrate learning: include opportunities for students to show what they know by using portfolios, hands-on demonstrations, projects, reports, displays, as well as written tests.

Involve Students in Construction-math Problem Solving

As often as possible, involve students in the real life math problems that come up on the construction site. Instead of simply telling students that you are going to order tiles or plywood or studs, ask them to help you. In pairs or small groups, they can figure the materials needed or the cost. They can help figure additional materials needed to fix a mistake, or help you figure out how to alter formulas if needed. Problems that arise on the site present “teachable moments” when the opportunity is right to demonstrate in a powerful way how classroom learning relates pragmatically to the day-to-day operations of the site.

The worksite and the vocational classroom are ideal environments for teaching problem-solving skills. Real decisions need to be made on a regular basis, related to shortages of materials, errors in drawings, or inadequate workmanship. Use these occasions to help students identify the problem and brainstorm possible solutions. Model problem solving by discussing the issues aloud, in site and class meetings, and letting students discuss and analyze the solutions.
An important problem-solving skill involves the ability to prove to oneself that an answer is correct. Students need to understand that the teacher is not the only holder of “right” and “wrong” solutions. Students need opportunities to ask themselves whether their answers are correct and to figure out ways to be certain.

Instructors can foster problem-solving skill development in the following ways:

✩ Pose problems frequently and ask students to solve them

✩ Pose questions in a manner that stimulates creative thinking. Ask questions like:
  • What do we need to know to do this?
  • How are we going to do this?
  • Why are we going to do this?
  • What other tools could we use?
  • What other methods or techniques could we use?

✩ When introducing a problem, ask several questions to guide the process:
  • Are there any words you don't understand?
  • Can you retell the problem in your own words?
  • What information are you trying to find?

✩ Set up problems which have multiple answers to encourage creative thinking and the understanding that there is often more than one right answer.

✩ Encourage students to raise problems from their own experience for the class to solve.

✩ Ask students to make up original problems, involving concepts learned, for other students to solve.

✩ Ask students to test the reasonableness of answers by estimating.

✩ Provide a variety of problems at varying levels of difficulty.

✩ Encourage the use of concrete materials wherever feasible to help students visualize problems and verify solutions.

**Involve Students in Real-life Math Problem Solving**

Generate problems that are an integral part of the program. Students can actively participate in the solutions, in order to cultivate real-life problem-solving skills. For example, students can:

✩ Solve real classroom problems related to time scheduling, percentage of time allocated to different tasks and cost of materials. For example:
• How many days are left in the program?
• How many hours are left?
• What percentage of those hours is spent on math?
• How many books can we order with a certain budget?
• Based on this information, are we using our time and our money wisely?
• How might we use it differently?

✩ Assist the teachers in doing math-related tasks: calculating the percentage scores on tests, calculating percentage attendance, making graphs and charts depicting percentage or ratios in attendance, and lateness.

✩ Plan a meal to eat together: figuring costs of materials, purchasing food and calculating change, and using recipes (cut a recipe in half, increase recipe 2½ times).

✩ Go to a restaurant together: in both real and fictional situations, calculate the cost of a meal within a budget, tax, tip, change.

✩ Plan a trip together: students can figure time, schedules, costs, and most efficient route.

✩ Plan strategies for earning money as a group in order to buy something at year’s end, put on a party, or go on a trip. Students can investigate things to sell or services to perform in order to make money.

Teach Measurement Skills Up Front

Reading a tape measure is an essential skill on the building site and it should be taught at the beginning. Review and reinforce this skill until students have mastered it. Build opportunities for practice into the worksite schedule, so students will be reminded again and again of how the skill is used in construction. It is important to help students master this skill early on, so that they can feel a sense of accomplishment and production stays on schedule.

This unit includes strategies for teaching measurement intensively and systematically with opportunities for hands-on practice whenever possible. Students measure everything in sight: themselves, the windows, the doors, tables. They cut wood to size, build scale models, and make scale drawings. Advanced students can help beginners and provide tutoring if necessary.

Build from the Concrete to the Abstract

For many students, performing math operations is difficult because they do not understand the underlying concepts. They have not learned the connection between the abstract symbols of math and demonstrable concrete experience.
By having hands-on experience with the practical realities of math, the concept “sticks” better when you move to the symbolic level.

For example, when learning about area, students estimate the length and width of a room. In pairs, students then actually measure the floor. Students use floor tiles to lay out a section of the floor to find area. In this way, students “see” area, sometimes for the first time.

**Teach Estimation Skills**

The ability to “figure it out in your head” and make an educated guess about a math problem is as important as solving complex algebra problems or finding common denominators. There are many ways to arrive at solutions to math problems, and estimating a reasonable approximation of an answer is as valuable in many cases as an exact answer. Give students the opportunity to estimate their answers before solving problems on paper; this helps them become familiar with math relationships and concepts and teaches them to check their “exact” answers for reasonableness.

- Examples of estimation activities include:
  - Estimating how much of your pay check is spent on groceries
  - Estimating how long it will take to complete a job
  - Estimating how much money will be needed to take a trip
  - Estimating how much carpet is needed to cover a floor
  - Estimating how much money will be left over after making a purchase

**Teach a Variety of Math Skills Simultaneously**

One of the reasons that math is often so tedious and frustrating for adult learners is because they have never moved beyond basic skills. They have only been taught using the “linear” approach, in which one simple skill is built upon another and only after these are mastered do they become gradually more complex.

Introduce complex skills early in order to enhance student interest, build confidence, and show the interrelatedness of math concepts. For example, you can introduce a lesson on purchasing materials on the site by asking students how to figure sales tax. Break down the notion of percent to simple terms, explaining that they pay seven cents on every dollar. Show how this relationship can be written as a fraction (7/100), a decimal (.07) or a percent, (seven per every hundred: “cent” meaning “hundred”) and that these are all various forms of saying the same thing. Show students how to figure percents using simple problems. Students who have been stuck reviewing multiplication tables for years will be impressed to see that they can understand concepts that they once thought were insurmountable.
Use Calculators

The use of calculators is often perceived as a “crutch” or considered “cheating,” when in fact it can give beginning students access to complex math experiences they never thought possible. Combine practice with basic skills, like studying and memorizing multiplication tables, with opportunities to work out real problems using tools that enhance speed and accuracy. Calculators free students from the arduousness of doing long or routine figuring and enable them to work with the underlying concepts.

In order to stimulate math thinking, students can first estimate their answers, then figure with a calculator, then check with pencil and paper figuring. In this way, they develop important conceptual understanding and reinforce basic skills.

Play Math Games

Make math fun. Reinforce skill learning with cooperative games and games of team competition. Students often get caught up in the spirit of games and do not realize they are practicing important skills; the activity is lively, engaging, and not frustrating. Examples of math games include:

- Multiplication BINGO
- Construction-math problem jeopardy
- Matching games: matching fractions to their equivalents, fractions to decimals, symbols to words
- Team competition of mental math
- Team competition of drawing a picture involving measurement directions
- Estimating the number of jelly beans in a jar or other similar items in a container
Overview of Construction-Related Math and Measurement

The ability to measure and compute accurately are critical skills in construction. This unit consists of 18 lessons which address students’ fears and doubts about mathematics while teaching essential basic math skills.

- **Lesson 1 — The Uses of Math**
  Students discuss the practical applications of math in daily life.

- **Lesson 2 — Math Memories**
  Students examine their earliest memories and experiences with math in a short essay.

- **Lesson 3 — Math in Literature and Life**
  Students use poetic terms and concepts to explore ideas and feelings about math.

- **Lesson 4 — Measurement Skills Assessment**
  Students demonstrate their current measurement skills using a skills assessment.

- **Lesson 5 — The Standard Unit**
  Students explore the concept of “standard unit” by practicing measuring with and without standard units.

- **Lesson 6 — Standard Units and Conversion**
  Students identify occasions when measurement is used in daily life and become familiar with standard units of conversion.

- **Lesson 7 — Conversion BINGO**
  Students practice converting inches, feet, and yards by playing BINGO.

- **Lesson 8 — Measurement Conversion Scavenger Hunt**
  Students add, subtract, and multiply the heights and widths of various objects in order to practice measurement conversion.

- **Lesson 9 — Using a Ruler**
  Students review and practice measuring with a ruler in order to improve accuracy in construction projects.
• Lesson 10 — Fractions of an Inch
  Students practice identifying fractional parts on a ruler and measuring fractions of an inch.

• Lesson 11 — Fractions Operations

• Lesson 12 — Using Perimeter in Construction
  Students develop a formula for finding perimeter based on actual measurement of a room.

• Lesson 13 — Using Area in Construction
  Students find area through a discovery process and then practice finding area using a formula.

• Lesson 14 — Using Percentage

• Lesson 15 — Geometric Terms in Construction
  Students explore angles, triangles, and the Pythagorean theorem in construction.

• Lesson 16 — Getting Things Square: Tools that Create a Right Angle in Construction
  Students explain the origins of the theory for finding right angles and practice measuring and making right angles with various carpentry tools.

• Lesson 17 — Bringing It All Together: Designing an Entertainment Center
  Students design an entertainment center as a way to practice measurement and to understand how fractions and percentages are used in construction.

• Lesson 18 — Final Assessment: Portfolios
  The final assessment includes portfolio materials, student self-assessment, and culminating and measurement skills assessments.

**Competency Checklist**

Upon satisfactory completion of this unit, student will be able to:

- Brainstorm the many uses of math in daily life and in construction
- Write a group poem about math using simile and metaphor
- Write an essay on math memories
- Complete a measurement skills assessment
Measure with nonstandard units
Explain the reasons for standard measures
Brainstorm when measurement is used in daily life and construction and what kinds of things are measured
Use measurement tools to determine relationship between standard units
Define a “standard unit of measure”
Accurately convert inches to feet to yards
Add, subtract, multiply, and divide numbers involving feet and inches
Accurately measure and mark graduations of an inch
Add, subtract and multiply fractions and mixed numbers
Write fractional equivalents
Calculate percentages
Subtract a discount to find total
Add a sales tax to find total
Develop a formula for finding perimeter, based on discovery
Find perimeter of a rectangle
Find perimeter of a figure
Solve perimeter problems
Develop a formula for finding area, based on discovery
Define area
Define “square foot”
Define area of a rectangle
Solve area problems
Identify angles
Identify triangles
Use the Pythagorean theorem
Explore scale
Portfolio Assessment Checklist

Upon completion of the unit, students should have the following items in their portfolios:

☐ Math collage using newspapers and magazines (Lesson 1)
☐ Math memories essay (Lesson 2)
☐ Math simile and metaphor poem (Lesson 3)
☐ Conversion and measurement writing (Lesson 4)
☐ Journal reflection (Assessing Your Skills) (Lesson 4)
☐ Journal reflection (The Importance of Standard Measurements) (Lesson 5)
☐ Daily uses of measurement brainstorm (Lesson 6)
☐ Definition of standard measurement (Lesson 9)
☐ Perimeter formula (Lesson 12)
☐ Angles in construction journal entry (Angles and Construction) (Lesson 14)
☐ Square corner sketch and journal entry (Lesson 16)
☐ Entertainment center drawing to scale (Lesson 17)
☐ Expense estimate (Lesson 17)
☐ Budget draft (Lesson 17)
☐ Entertainment center thumbnail sketch (Lesson 17)
The Uses of Math

Aim

Students will discuss the many practical applications of math in daily life and in construction, in order to realize how much math they use on a daily basis. In this lesson, they will:

- Brainstorm the many uses of math in daily life and in construction
- Create a math collage using newspapers and magazines
Things to Consider

In this lesson, students are encouraged to brainstorm the many uses of math in daily life. In this way, students are reminded that math is not only a “school subject,” but also a practical skill. In addition, they will begin to feel less intimidated as they realize how much they already use math.

Materials, Tools, and Resources

- Variety of newspapers and magazines
- Scissors
- Glue
- Poster or tag board for each student

Key Terms

- Mathematics/mathematical
- Application
- Budget
- Estimate
- Calculate
Steps for Activity

1. Divide students into small groups and ask them to brainstorm the many ways they use math in everyday life. Encourage them to think about the math they have used in the last week or the last month. Have them record their responses, then report to the class. Write their examples on the board. Examples might include:
   - Reading a recipe
   - Doubling a recipe
   - Mixing baby formula
   - Making a purchase and receiving change
   - Counting change
   - Planning a budget
   - Calculating tax and tip in a restaurant
   - Going grocery shopping
   - Examining a paycheck for accuracy
   - Reading timetables for catching a bus
   - Calculating the distance between two places
   - Balancing a checkbook
   - Paying bills

2. In the same small groups, ask students to brainstorm the many ways math is used in construction. Encourage them to think about the math they have used on the site or have seen other workers use. Have them record their responses, and then report to the class. Write their examples on the board. Examples might include:
   - Measuring and cutting wood
   - Calculating how much plywood is needed to cover a floor
   - Calculating how many tiles are needed to cover a floor
   - Estimating the cost of a job
   - Estimating the time it will take to do a job
   - Calculating the amount of materials for a job
   - Mixing concrete
   - Checking for right angles
   - Ordering materials for a job
• Laying out rafters
• Calculating the length of bridging
• Determining the number of studs needed to frame a wall

3. Distribute a variety of newspapers and magazines to each group. Pass out the tag board, glue, and scissors. Instruct the students to find examples of math used in the newspapers and magazines and to create a collage that illustrates examples of the “everyday” math they brainstormed earlier. If possible, the collage should also show several examples of how they use “everyday” math in their own lives. Examples found in the newspapers and magazines might include stories or ads that contain numbers or math information. Ask students to explain on the back of their collage, in one or two paragraphs, why they selected the images that they did. Allow students 30–40 minutes to create their collages and write their reflection.

Wrap Up

Ask for volunteers to share their collages with the larger group. To help students reflect on the activity, ask questions like:

• Were the math images easy or difficult to find?
• In what publications did you find the most examples? Why might that be?
• Do you use math more often than you realized? Explain with examples.
• Earlier we brainstormed the uses of math in construction, but how have you used math in other work environments? Give examples. How might you use math in future work settings?
Creative Extensions

- Invite a community college math instructor who specializes in “developmental education” to share hints, tips, and strategies for overcoming math anxiety with your students.

- Invite a speaker to talk about the uses of math in their workplace. A construction worker, an architect, a city planner, a landscape designer, a building inspector can easily talk to students about using math in the job.
Project-Based Learning Activities

• Have students do a career exploration that focuses on uses of math and math theory in the workplace. After students research 6–8 different jobs, have them creatively present the various uses of math or math theory found in each of the jobs and the pay ranges for the various jobs. They should think beyond the basics of educational background or technical training needed to obtain the job. Jobs to explore might include musician, engineer, fast food worker, landscape technician, bricklayer, and general construction laborer.

• Students can explore how math plays a part in ALL aspects of our lives. How do math and art, or math and music, or math and the sciences intersect? Who works in those areas where math intersects with other aspects of our lives? Have students explore an “intersection,” do research, and creatively present their findings to the larger group.
In this lesson students will practice measuring fractions of an inch. Students will:

- Identify on a ruler the markings for halves, fourths, eighths, and sixteenths
- Accurately measure objects to the nearest 1/2", 1/4", and 1/8"
**Things to Consider**

*Here is an opportunity* for students who are shaky on basic math to relearn the concept of fractional parts and practice finding them on a ruler. This activity lends itself to measuring activities at the construction site, where objects frequently include a fractional measurement.

*If your students* need practice adding and subtracting fractions, see these handouts in Tools and Resources “Adding Fractions” and “Subtracting Fractions.”

**Materials, Tools, and Resources**

- Flipchart or blackboard
- Handout: Ruler Reference Sheet
- Handout: Measuring Fractions
- Handout: Equivalent Fractions of an Inch
- Handout: Measuring and Marking
- Handout: Measurement Symbols
- Handouts: The Inch; Object Measurement Worksheet: The Inch; Activities for Practice Measuring the Inch
- Handouts: The Half Inch; Object Measurement Worksheet: The Half Inch; Activities for Practice Measuring the Half Inch
- Handouts: Sixteenths of an Inch; Object Measurement Worksheet: Sixteenths of an Inch; Activities for Practice Measuring Sixteenths of an Inch
- Handouts: Eighths of an Inch; Object Measurement Worksheet: Eighths of an Inch; Activities for Practice Measuring Eighths of an Inch
- Handouts: Fourths of an Inch; Object Measurement Worksheet: Fourths of an Inch; Activities for Practice Measuring Fourths of an Inch
- Rulers for each student
- Tape measures for four groups
- A collection of eight numbered objects in different fractional lengths: nails, screws, pieces of wood, wire, tools
- Scissors for each student

**Key Terms**

- Fraction
- 1/2"
- 1/4"
- 1/8"
- 1/16"

**Time**

2 hours
**Steps for Activity**

1. Ask students how many of them have measured objects on the worksite to the nearest 1/2". What were the objects? Tell students that much of what they will measure in construction will include parts of inches — or fractions of inches. Being able to identify and measure objects to the smallest fraction will make their work accurate and clean.

2. Invite students to name all the fractional parts of an inch that they know. List these on the board.

3. Pass out the handout “Ruler Reference Sheet.” Explain that this activity will review reading a ruler as an introduction to practicing measuring fractions of an inch. Have students cut out the enlarged ruler.

4. Tell students to fold the sheet exactly in half and find the line that is halfway between the inch mark. Label this 1/2".

5. Have students fold the sheet in half again. What do we call the marks that fall on these new creases? (1/4" marks) What is another name for 1/2"?

6. Repeat folding for eighths and sixteenths.

7. Write the fractions below on the board and have students copy them down. Using their reference sheet, students can figure out and complete the equivalents.

   - 4/8" = 2/8" =
   - 2/16" = 14/16" =
   - 4/16" = 10/16" =
   - 1/2" = 3/4" =
   - 3/8" = 6/8" =

8. Pass out rulers and the handout “Measuring Fractions.” Spread out a collection of objects that have been numbered one through eight. Have students work individually or in pairs to measure the objects and complete their worksheets. Allow 10 minutes.

9. In whole group have students share and compare their answers. Did students come up with different numbers for the same object? Are these answers equivalent?
Wrap Up

1. Divide the class into four teams and give each a steel tape measure. Each team will measure the length, width, depth, and height of the tables in the room. (Or you can choose some other object for students to measure: windows, doors, etc.) Have team number one measure to the nearest 1/2". Team number two will measure to the nearest 1/4". Team number three will measure to the nearest 1/8" and team number four will measure to the nearest 1/16". Put some of your best measurers in the last group.

Have the groups compare their measurements when they are done. Using their rulers or the Ruler Reference Sheet, students should be able to determine correct equivalencies. Have students resolve disputes about accuracy by re-measuring objects as a class.

2. To help students reflect on this activity, ask students to do the following:
   (a) List the times on a job when an accurate measurement — marked to the nearest sixteenth — might be essential.
   (b) List other times when it might be better not to measure to the nearest sixteenth or when it might not matter.

Creative Extensions

- Challenge the students to draw a picture using only 1/2" lines or 1/4" lines.

- Tell students that scale is a measurement used in maps and blueprints that is proportionate to actual size. Have students draw simple rooms that are based on a scale using 1/4" = 1' or 1/2" = 1'.

- Play a measuring game. Break the students into teams and have them measure all surfaces of three or four objects on the site. They should carefully note the dimensions. These objects could be doors, windows, tables, or bookshelves. Teams then choose one of their objects and write its dimensions on a piece of paper. Each team exchanges dimensions but does not tell the other what the object is. The first team to find the object that matches the dimensions on its piece of paper wins.

Project-Based Learning Activities

- Students could go to a lumber yard and measure various sizes of lumber. They can make a chart of nominal and actual sizes of lumber. Have them research the history of the lumbering business. How is it that a 2 x 4 is really 1 1/2" x 3 1/2"? Encourage them to display this information as a resource for their own and other classes.

- Have students collect, label, and mount nails and wood screws on a portable display. They will need to be shown how to measure the length of wood screws. This display can be used during class as a reference.
Handout 1

Equivalent Fractions of the Inch

This is an enlarged “inch.”

Use an actual ruler to help you to label fractions and their equivalents.

Cut out the ruler reference sheet.

Fold the sheet exactly in half.
Find the line that is halfway between the “inch” marks. Label this: 1/2”.

Fold the sheet in half again. When the paper is unfolded, you will see that the folds now fall on the 1/4” marks. What is another name for 1/2”?

Refold the sheet again along the creases, then fold the paper again. Label the 1/8” mark, then 2/8”, then 3/8”, etc. What is another name for 2/8”?

Can you label all the 16th”s?

Use the reference sheet to figure out these equivalents:

4/8” =
2/16” =
4/16” =
1/2” =
3/8” =
2/8” =
14/16” =
10/16” =
3/4” =
6/8” =
Handout 2

Measuring Fractions

Measure the length of the numbered objects you have been given. Write the measurements in words first, and then in numbers and symbols.

Example: three inches = 3”.

Object #1 ____________________________
   a) words ____________________________
   b) number and symbol ____________________________

Object #2 ____________________________
   a) words ____________________________
   b) number and symbol ____________________________

Object #3 ____________________________
   a) words ____________________________
   b) number and symbol ____________________________

Object #4 ____________________________
   a) words ____________________________
   b) number and symbol ____________________________

Object #5 ____________________________
   a) words ____________________________
   b) number and symbol ____________________________

Object #6 ____________________________
   a) words ____________________________
   b) number and symbol ____________________________

Object #7 ____________________________
   a) words ____________________________
   b) number and symbol ____________________________

Object #8 ____________________________
   a) words ____________________________
   b) number and symbol ____________________________
Measuring and Marking

The folding wood rule is used for general measuring, especially where rigidity is needed, as in extending across wide openings in stairwells.

The steel tape rule is flexible. It is used to measure round as well as straight objects, and it is compact enough to fit into toolboxes and pockets easily.
Measurement Symbols

Measurement symbols are a short way to write “feet” and “inches.”
For feet, write this symbol after the number: '
Example: four feet = 4'
For inches, write this symbol after the number: '
Example: two inches = 2'

1. Write the measurements represented by the following symbols:
   a. 2' = ______________________
   b. 5' = ______________________
   c. 10' = ______________________
   d. 4" = ______________________
   e. 9" = ______________________
   f. 21" = ______________________
   g. 3'5" = ______________________
   h. 7'9" = ______________________

2. Write the following measurements, using numbers and symbols:
   a. twenty-two feet ________
   b. five inches ________
   c. seventeen inches ________
   d. twelve feet ________
   e. four feet, six inches ________
   f. ten feet, three inches ________
   g. sixteen feet, three inches ________
   h. five feet, nine inches ________
Every ruler is divided into inches.

Examine a ruler or tape measure to see how inches are written.

Line up the tape measure against the object you wish to measure. How many inches long are these objects?

Sometimes you need to measure to the “nearest inch.” Can you measure these objects to the “nearest inch?”

Sometimes you need to add objects of different lengths. Can you find the total length of these two objects?
Object Measurement Worksheet: The Inch

Measure the length of these objects to the nearest inch. Write the measurements in words first, and then in numbers and symbols. The first one is done for you.

Object (example) is: a piece of wood
(a) two inches
(b) 2"

Object #1 is: ________________________ Object #6 is: ________________________
(a) ________________________ (a) ________________________
(b) ________________________ (b) ________________________

Object #2 is: ________________________ Object #7 is: ________________________
(a) ________________________ (a) ________________________
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Object #3 is: ________________________ Object #8 is: ________________________
(a) ________________________ (a) ________________________
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Object #4 is: ________________________ Object #9 is: ________________________
(a) ________________________ (a) ________________________
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Object #5 is: ________________________ Object #10 is: ________________________
(a) ________________________ (a) ________________________
(b) ________________________ (b) ________________________
**Activities for Practice: The Inch**

Have students do the following activities for practicing measuring and marking the inch. Students can work individually for practice, then check each other’s work for accuracy. Or they can work in pairs or groups of three, each person doing a different part of the assignment.

- **Draw, on large paper, a scale drawing of the classroom, or a room on the worksite, or any room you choose. Measure the length and width of the room, then draw a picture of it, in which an inch is equal to one foot (1" = 1').**

- **Build a model of the classroom, a floor of the worksite, or any area you choose. Measure the length, width and height of the room or rooms, then cut pieces of the cardboard or posterboard to scale, where one inch is equal to one foot. (1"=1") Tape them together and display.**

- **Construct a cardboard box with the dimensions 4"x3"x2". Cut six pieces of cardboard or posterboard with the measurements:**
  - 2 pieces: 4"x3"
  - 2 pieces: 4"x2"
  - 2 pieces: 3"x2"

  Tape all the pieces together to form a three-dimensional box. If the sides are measured and cut accurately, they should fit together perfectly!

- **Construct a wooden pencil box with the dimensions 7"x3"x2". Cut five pieces of wood with the measurements:**
  - Bottom: 7"x3"
  - 2 end pieces: 3"x2"
  - 2 side pieces: 7"x3"

  Glue all the pieces together to form a box. If the sides are measured and cut accurately, they should fit together perfectly! Use the box to store pencils and erasers.

- **Measure the height of all the students in the room to the nearest inch. On a large pieces of newsprint (about seven feet long) make lines the same length as each student’s height and compare.**

- **Make a picture or design using lines that are varying lengths, marked in exact inches.**
Handout 7, cont’d.

- Try these measurement puzzles:
  - Cut three pieces of wood of any length, in exact inches, that measure a total of 17 inches.
  - Cut four pieces of wood of any length, in exact inches, that measure a total of 13 inches.
  - Cut five pieces of wood of any length, in exact inches, that measure a total of 18 inches.

Check for accuracy by asking another student to assemble them and measure the total length.
The Half-Inch

Every inch is divided into half-inches.

Examine a ruler or tape measure to see how half-inches are written.

Line up the tape measure against the object you wish to measure. How long are these objects?

Sometimes you need to add measurements that include half-inches.

How many half-inches are there in one inch?

Can you find the total length of these two objects?
Object Measurement Worksheet: The Half-Inch

Measure the length of these objects to the nearest half-inch. Write the measurements in words first, and then in numbers and symbols. The first one is done for you.

Object (example) is: *a piece of wood*
(a) *four and a half inches*
(b) *4 1/2”*

Object #1 is: ______________________          Object #6 is: ______________________
(a) ______________________            (a) ______________________
(b) ______________________            (b) ______________________

Object #2 is: ______________________          Object #7 is: ______________________
(a) ______________________            (a) ______________________
(b) ______________________            (b) ______________________

Object #3 is: ______________________          Object #8 is: ______________________
(a) ______________________            (a) ______________________
(b) ______________________            (b) ______________________

Object #4 is: ______________________          Object #9 is: ______________________
(a) ______________________            (a) ______________________
(b) ______________________            (b) ______________________

Object #5 is: ______________________          Object #10 is: ______________________
(a) ______________________            (a) ______________________
(b) ______________________            (b) ______________________
ACTIVITIES FOR PRACTICE: THE HALF-INCH

Have students do the following activities for practicing measuring and marking half-inches. Students can work individually for practice, then check each other’s work for accuracy. Or they can work in pairs or groups of three, each person doing a different part of the assignment.

• Construct a cardboard box with the dimensions: 4 1/2” x 3 1/2” x 2 1/2”. Cut six pieces of cardboard or posterboard with the measurements:
  2 pieces: 4 1/2” x 3 1/2”
  2 pieces: 4 1/2” x 2 1/2”
  2 pieces: 3 1/2” x 2 1/2”

Tape all the pieces together to form a three-dimensional box. If the sides are measured and cut accurately, they should fit together perfectly!

• Measure the height of all the students in the room to the nearest half-inch. On a large piece of newsprint (about seven feet long) make lines the same length as each student’s height and compare.

• Draw, on large paper, a scale drawing of the classroom, or a room on the worksite, or any area you choose. Measure the length, width and height of the room or rooms, then cut pieces of cardboard or posterboard to scale, where one half-inch is equal to one foot (1/2”=1’).

• Have students experiment with marking 16” on center. Give pairs of students each an eight foot long stud (which will serve as a mock bottom plate of a framed wall), a carpenter’s pencil, a tape measure and a quick square. Show students a picture of a framed wall. Ask them to figure out how to measure and mark out the bottom plate for wall studs to be placed sixteen inches apart, using the process of discovery, before correctly demonstrating the procedure. Give only this information:

  We’re going to prepare you to build a wall.

  The first thing you do when building a wall is lay out a bottom plate.

  The wall studs rest on the bottom plate.

  Even though we call these 2”x4”s, they are 1 1/2” wide.

  On each end you should place double studs for wall support.

  Otherwise, studs should be placed on the wall at a maximum distance of 16” on center, which means that from the center of one to the center of another is 16”.

  This is the same measurement if you measure from the left to the left, or from the right to the right.

  To mark where the wall studs should go, mark the bottom plate with two lines for each side of the wall stud and an x.
After students have experimented with this and displayed their marks, use a tape measure to demonstrate how to mark and measure correctly 16” on center.

• Practice marking 16” on center till students get it right. Add additional problems for review: put in a 30” window in the middle of the wall; put in a 36” window, etc. Give assorted addition problems in which students add 16” to an assortment of measures to practice marking 16” on center in various situations.
Sixteenths of an Inch

Every inch is divided into sixteenths.

Examine a ruler or tape measure to see how sixteenths of an inch are written.
Each whole inch is divided into sixteen equal parts.
Each part is called one-sixteenth (1/16).
Two-sixteenths are written this way: 2/16.
Three-sixteenths are written this way: 3/16.
How would you write five-sixteenths?
How would you write seven-sixteenths?
How would you write eight-sixteenths? Look at a ruler. What is another way to write this?
How would you write seven-sixteenths?
Line up the tape measure against the object you wish to measure. How many sixteenths of an inch long are these objects?
Object Measurement Worksheet: Sixteenths of an Inch

Measure the length of these objects to the nearest sixteenth of an inch. Write the measurements in words first, and then in numbers and symbols. The first one is done for you.

Object (example) is: a piece of wood
(a) three and five-sixteenths inches
(b) 3 5/16"

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Handout 13

Activities for Practice: Sixteenths of an Inch

Have students do the following activities for practicing measuring and marking sixteenths of an inch. Students can work individually for practice, then check each other’s work for accuracy. Or they can work in pairs or groups of three, each person doing a different part of the assignment.

- Tell students that they can always give a correct measurement even if they have not yet measured fractional equivalents. In other words, any measurement can be described in sixteenths. Give students lots of practice finding assorted measurements and then checking each other for accuracy.

- Measure the height of all the students in the room to the nearest sixteenth of an inch. On a large piece of newsprint (about seven feet long) make lines the same length as each student’s height and compare.

- Measure the length of the table students work on to the nearest sixteenth of an inch.

- Make a drawing using straight lines, each measured in sixteenths.

- Make a list of the times when an accurate measurement — marked to the nearest sixteenth — might be essential. List other times when it might be better to not measure to the nearest sixteenth, or when it might not matter.

- Make a series of lines measured in sixteenths. Look at the ruler; are there any other names for these measures? Are there equivalent fractions that can be used to express the same number?
LESSON TEN Fractions of an Inch

WORKING HANDS, WORKING MINDS

Handout 14

Eighths of an Inch

Every inch is divided into eighths.

\[
\begin{array}{cccccccc}
\hline
& & & & & & & & \\
1 & 2 & 3 & 4 & 5 & 6 \\
\hline
\end{array}
\]

An eighth of an inch is equal to two-sixteenths.
Two-eighths of an inch is equal to four-sixteenths.
Three-eighths of an inch is equal to how many sixteenths?
Four-eighths of an inch is equal to how many sixteenths?
How many sixteenths are in five eighths of an inch?
How many sixteenths are in six eighths of an inch?
How many sixteenths are in seven eighths of an inch?
Line up the tape measure against the object you wish to measure.
How long are these objects?

WORKING HANDS, WORKING MINDS
Object Measurement Worksheet: Eighths of an Inch

Measure the length of these objects to the nearest eighth of an inch. Write the measurements in words first, and then in numbers and symbols. The first one is done for you.

Object (example) is: a piece of wood
(a) four and one-eighth inches
(b) $4\frac{1}{8}$"

Object #1 is: 
(a) __________________________
(b) __________________________

Object #2 is: 
(a) __________________________
(b) __________________________

Object #3 is: 
(a) __________________________
(b) __________________________

Object #4 is: 
(a) __________________________
(b) __________________________

Object #5 is: 
(a) __________________________
(b) __________________________

Object #6 is: 
(a) __________________________
(b) __________________________

Object #7 is: 
(a) __________________________
(b) __________________________

Object #8 is: 
(a) __________________________
(b) __________________________

Object #9 is: 
(a) __________________________
(b) __________________________

Object #10 is: 
(a) __________________________
(b) __________________________
Activities for Practice: Eighths of an Inch

Have students do the following activities for practicing measuring and marking eighths of an inch. Students can work individually for practice, then check each other’s work for accuracy. Or they can work in pairs or groups of three, each person doing a different part of the assignment.

- Draw, on a large piece of paper, a scale drawing of the classroom, or a room on the worksite, or any room you choose. Measure the length and width of the room, then draw a picture of it, in which an inch is equal to one foot (1/8” = 1’). Tape them together and display.

- Construct a cardboard box with the dimensions 4 1/8” x 2 1/8”. Cut six pieces of cardboard or posterboard with the measurements:
  - 2 pieces: 4 1/8” x 3 1/8”
  - 2 pieces: 4 1/8” x 2 1/8”
  - 2 pieces: 3 1/8” x 2 1/8”

  Tape all the pieces together to form a three-dimensional box. If the sides are measured and cut accurately, they should fit together perfectly!
Fourths of an Inch

Every inch is divided into fourths of an inch, also called quarter-inches.

Examine a ruler or tape measure to see how fourths of an inch are written.

A fourth of an inch is equal to two-eighths.
A fourth of an inch is also equal to four-sixteenths.
Two-fourths of an inch is equal to one-half inch.
Two-fourths of an inch is equal to how many eighths?
Two-fourths of an inch is equal to how many sixteenths?
Three-fourths of an inch is equal to how many eighths?
Three-fourths of an inch is equal to how many sixteenths?

Line up the tape measure against the object you wish to measure.
How long are these objects?
Object Measurement Worksheet: Fourths of an Inch

Measure the length of these objects to the nearest fourth of an inch. Write the measurements in words first, and then in numbers and symbols. The first one is done for you.

Object (example) is: *a piece of wood*
(a) *two and one-fourth inches*
(b) *2 1/4"

Object #1 is: __________________________  Object #6 is: __________________________
(a) __________________________
(b) __________________________

Object #2 is: __________________________  Object #7 is: __________________________
(a) __________________________
(b) __________________________

Object #3 is: __________________________  Object #8 is: __________________________
(a) __________________________
(b) __________________________

Object #4 is: __________________________  Object #9 is: __________________________
(a) __________________________
(b) __________________________

Object #5 is: __________________________  Object #10 is: __________________________
(a) __________________________
(b) __________________________
Activities for Practice: Fourths of an Inch

Have students do the following activities for practicing measuring and marking fourths of an inch. Students can work individually for practice, then check each other’s work for accuracy. Or they can work in pairs or groups of three, each person doing a different part of the assignment.

- Draw, on a large piece of paper, a scale drawing of the classroom, or a room on the worksite, or any room you choose. Measure the length and width of the room, then draw a picture of it, in which one-fourth of an inch is equal to one foot (1/4" = 1’).

- Build a model of the classroom, a floor of the worksite, or any area you choose. Measure the length, width and height of the room or rooms, then cut pieces of cardboard or posterboard to scale, where one-fourth of an inch is equal to one foot (1/4"=1’). Tape them together and display.

- Construct a cardboard box with the dimensions 4 1/4” x 2 1/4”. Cut six pieces of cardboard or posterboard with the measurements:
  2 pieces: 4 1/4” x 3 1/4”
  2 pieces: 4 1/4” x 2 1/4”
  2 pieces: 3 1/4” x 2 1/4”
  Tape all the pieces together to form a three-dimensional box. If the sides are measured and cut accurately, they should fit together perfectly!

- Create a set of building blocks for children in which ten blocks are 2 1/4” wide and ten blocks are 4 3/4” wide. Each student should mark a stud for twenty blocks, and have another student and the instructor check for accuracy before cutting. Then have students use a hand saw to cut and sand paper to smooth.
Students practice various fractions operations as they relate to construction problems. In this lesson, they:

- Add, subtract, and multiply fractions and mixed numbers.
Things to Consider

The activity sheets included in this section are intended only to supplement the teaching of fractions. The resources described at the end of this unit are recommended for providing a thorough introduction to and extensive review of fractions operations.

Materials, Tools, and Resources

- Handout: Adding Common Fractions
- Handout: Subtracting Common Fractions
- Handout: Adding, Subtracting, Multiplying and Dividing Fractions and Mixed Numbers in Construction
Adding Common Fractions

The top number in a fraction is the number of parts and is known as the **numerator**. The bottom number is the whole that the parts come from. It is called the **denominator**.

\[
\begin{align*}
\text{Numerator} & \quad 3 \\
\text{Denominator} & \quad 4
\end{align*}
\]

The Basics of Adding Fractions

Adding fractions with the same bottom number, or denominator, is easy — you just add the top numbers and you’re on your way: \( \frac{1}{8} + \frac{2}{8} = \frac{3}{8} \).

Adding fractions with different bottom numbers requires a few more steps.

To add fractions, they must have the same denominator, known as the **common denominator**. This means you will need to raise at least one of the fractions to higher terms.

For example, to add \( \frac{3}{5} + \frac{4}{15} \) you must first convert the denominators to the **lowest common denominator** or **LCD**. The LCD is the lowest number that ALL the denominators you are currently adding will fit into EVENLY.

Here’s how you do it:

\[
\begin{align*}
\frac{3}{5} + \frac{4}{15} &= \\
\text{Step 1} & \\
\text{Since 5 divides evenly into 15, 15 is the LCD. Now your problem looks like this:} & \\
\frac{7}{15} + \frac{4}{15} &= \\
\text{Step 2} & \\
\text{Turn 3/5 into 15ths. Since 5 goes into 15 three times, you multiply the top number by three and end up with 9.} & \\
\frac{9}{15} + \frac{4}{15} &= \\
\text{Step 3} & \\
\text{Add the new fractions. Note that the denominator stays the same.} & \\
\frac{9}{15} + \frac{4}{15} &= \frac{13}{15}
\end{align*}
\]

Tips on finding the Lowest Common Denominator (LCD)

- Examine the fractions you are currently adding. If the largest denominator is a multiple of the smallest denominator, then the larger one is the LCD.
  Example: \( \frac{1}{6} + \frac{3}{12} \). In this problem, 6 divides evenly into 12, therefore 12 is the LCD. The problem would be written as \( \frac{2}{12} + \frac{3}{12} \).
• If both denominators are prime numbers, then the LCD is the product of the two primes. (A reminder: prime numbers are only divisible by 1 or themselves — examples of prime numbers are 2, 3, 5, 7, 11, 13, 17 and 19.)

Trial and Error:
• If all else fails, you can start with the larger denominator and multiply by 2, by 3, by 4, etc., until you find a number that the smaller denominator will evenly divide.

PRACTICE PROBLEMS
Add the following fractions:
1. 7/8 + 9/16 =
2. 1/16 + 3/32 =
3. 3/4 + 1/2 =
4. 1/3 + 3/4 =
5. 3/4 inch + 5/8 inch =
6. 1/2 hour + 2/8 hour + 1/3 hour =
7. How thick are three pieces of wood 3/4 inch, 5/8 inch and 1/3 inch?
8. 1/4 + 1/3 + 1/2 =
9. Calculate the thickness of a floor which combines two layers of underlayment 1/3 inch and 3/4 inch with oak tongue and groove 1/2 inch thick.
10. If a counter top consists of 2/3 inch particle board, 1/4 inch masonite and 5/8 inch maple how thick is it?
Subtracting Common Fractions

The Basics of Subtracting Fractions

Similar to adding fractions, you must find common denominators in order to subtract fractions. The numerators are subtracted, and the difference is indicated over the common denominator.

For example, to subtract 1/4 from 7/8, you convert 1/4 to 2/8.

\[
\frac{7}{8} - \frac{2}{8} = \frac{5}{8}
\]

Whole numbers can be converted into improper fractions to facilitate subtraction. To subtract 3/4 from 6, express the 6 as 24/4.

\[
\frac{24}{4} - \frac{3}{4} = \frac{21}{4}
\]

Then reduce your fraction so it is easier to read: \(21/4 = 5\frac{1}{4}\)

PRACTICE PROBLEMS

Subtract the following fractions:

1. 1/2 inch from 3/4 inch
2. 4/5 hour from 1 2/3 hours
3. 3/32 from 5/16
4. 1/3 gallon from 3/4 gallon
5. 15 1/2 board feet from 20 1/2 board feet
6. 2 1/4 inches from 5 1/32 inches
7. 8/32 from 5/8
8. The 1/8 inch Formica will be removed from a counter top measuring 2 5/32 inches. How thick will it be?
9. 1/2 inch must be removed from a 4 1/2 inch board. What will it measure?
10. A 3/4 inch board must have 2/32 inch planed from it. How thick will it be?
**Adding, Subtracting, Multiplying and Dividing Fractions and Mixed Numbers in Construction**

**Directions:** Complete the following problems.

**Addition**

1. In many detail drawings whole numbers and fractions must be added to obtain an overall dimension. What is the height of the bookshelf shown at the right?

2. What will be the total thickness of a wall allowing for 1/2" sheathing, a 3 1/2" stud, and 5/8" plaster?

3. Some boards are made of three plies stacked together. What is the total thickness of a board built of three plies 1/2", 1/4" and 7/16"?

**Subtraction**

4. A 12d nail is 3 1/4" long, and an 8d nail is 2 1/2" long. What is the difference in length?

5. What is the final thickness of a 3" piece of board after 1/8" has been planed off of both surfaces?
6. How much must a 7/8" board be planed in order to make it the required thickness of 3/4"?

**Multiplication and Division**

7. Because large, solid girders often warp or may contain decayed wood, it is often necessary to use built-up girders. What is the actual thickness of a girder built-up of three 2" x 8"s? (Remember to multiply actual rather than nominal thickness.)

8. Seven windows need to be painted. Each one requires 1/8 can of paint. How much paint will be used all together?

9. A flight of stairs has 12 risers, each 6 3/4" high. What is the total rise?

10. If 1/4" on a drawing represents 1'-0", how many inches on the drawing represent 21'-0"?

11. You are cutting 2x4's for braces that need to be 1 3/4 feet long. You have available 7 2x4's that are each 12 feet long. How many pieces can be cut from this available lumber? Do you have enough lumber to cut 45 braces, or will you have to get more?
12. A bathroom wall needs to be tiled. The tiles used are $4\frac{1}{4}$ inch squares. The wall space that needs to be covered is 7 feet by $4\frac{1}{2}$ feet. Approximate the number of tiles needed and try to calculate the exact number required to fill the space.

13. A piece of plywood (4 x 8 feet) is being cut into strips that are 4 feet long and 9 inches wide ($\frac{3}{4}$ of a foot). How many can be cut from 6 sheets of plywood?

14. A bricklayer can lay 10 blocks in $\frac{1}{3}$ of an hour. If she keeps working at this rate to finish the job, it will take her 67 hours. How many blocks will she have laid?

15. A scaffold is used which is rated to safely hold 300 pounds per square foot. Jose is placing cement blocks on top of each other in a 4 square foot area. Each block weighs $42\frac{3}{4}$ pounds. How many blocks can be pile before he reaches the safety limit?
Students will develop a formula for finding perimeter, based on actual measurement of a room. In this activity, they will:

- Develop a formula for finding perimeter
- Find perimeter of a rectangle
- Find perimeter of a figure
- Solve perimeter problems
Key Terms
- Perimeter
- Rectangle
- Equation
- Dimension
- Parallelogram
- Trapezoid

Materials, Tools, and Resources
- Tape measures, one for each group of three
- Several balls of colored yarn, one color for each group of three
- Masking tape
- Scissors
- Optional: Candy or small prizes for the winning team
- Handout: Finding Perimeter: Real Objects
- Handout: Finding Perimeter: Problems

Time
1 hour
LESSON TWELVE Using Perimeter in Construction

Steps for Activity

1. Divide the students into groups of three. Give them the following problem:
   - Suppose you were asked to put new baseboard (molding) around the base of the walls of this classroom. How would you know how much baseboard to buy?

   Discuss the students’ solutions. Write their suggestions on the board. Remind them to allow for doorways and cabinets, the measure of which will need to be added or subtracted.

2. Distribute paper, pencils, and the tape measures. Ask students to draw a picture of the room on the piece of paper, then use the tape measure to find the measurement of the baseboard they would need. Students should record their measurements on their drawing.

3. Once the groups have calculated the total amount of baseboard needed, have them write their total on the back of the sheet of paper. Using the yarn (a different color for each team) as molding, give each team the amount of “molding” that they calculated.

4. Have each team carefully tape their yarn around the room. When a team comes to a doorway they should cut the yarn and continue on the other side. The team who comes closest to the correct perimeter of the room wins.

5. Ask students to come together to discuss the process they used. Discuss their answers and review the process of measuring all sides of the room and subtracting for doors. Ask students to come up with a formula, or an equation, for finding perimeter. Encourage students to arrive at a simple expression that could express this explanation. Write student equations on the board or chart paper.

   Answers might include:
   - Add all four sides \((s + s + s + s) =\)
   - Add the length, then the width \((l + l + w + w) =\)
   - Multiply the width times two, and multiply the length times two, then add together \((2w + 2l) =\)

Wrap Up

1. Discuss the solutions as a class. Ask for volunteers to copy their drawings on the board.

To help students reflect on the activity, ask the following questions:

• What difficulties, if any, did you have working as a group to arrive at a solution?

• How has this activity influenced your understanding of the importance of math and measuring in construction?

• If you did not calculate the perimeter precisely, what might be the various reasons for the error?

• What could your team have done to better calculate the perimeter of the room?

• Now that we have discussed several formulas or equations for calculating perimeter, which one would you feel most comfortable using and why?

• If you were to explain to someone else how to find perimeter, how would you do so?

2. Ask students to write the best perimeter formula in their journals and explain why it is the one they would use.

Creative Extensions

• Label a number of objects in the classroom for which students can find perimeter. Distribute copies of the handout “Finding Perimeter: Real Objects,” on which you have identified those objects. Tell students that not all objects that have a perimeter are rectangles. Ask them to list other shapes that have perimeters, that might have to be measured, which are not rectangles. Answers might include triangles, parallelograms, and trapezoids.

• Tell students that perimeter can be found by adding all the sides. Ask students to work individually to complete the “Finding Perimeter: Real Objects” handout.
Project-Based Learning Activities

• Have students use their perimeter calculating skills to put weather stripping around windows and doors of the homes of the elderly or those with low incomes.

• Design and construct raised garden beds for a retirement center or for handicapped access in a community garden.

• Work with a local organization such as Habitat for Humanity, a daycare center, or a retirement center to construct a fence to enclose a playground or courtyard or create a “mock” proposal to construct the fence. Have students calculate the perimeter of the space to be enclosed, estimate the materials required, and figure the total cost of the project.

  **Sample “Budget”:**
  The play yard is 18 feet wide and 23 feet long.
  There are two openings, both four feet wide.
  How much fencing is needed for the play yard?
  Fencing costs $2.00 per foot.
  You charge your client $9.00 an hour for labor.
  You estimate the job will take four hours.
  What will be your total costs for this job?
Finding Perimeter: Real Objects

Find the perimeter of the following objects. First measure the length, then the width. Then use the following formula to write an equation. Solve the equation.

For rectangles: \(2(L) + 2(W) = \text{perimeter}\)

For nonrectangles: side + side + side + side + side = perimeter

1. **OBJECT A** is: this page
   
   **Its length is:** 11 inches. Its width is \(8\frac{1}{2}\) inches
   
   **Equation:** \(2(11) + 2(8\frac{1}{2}) = 22 + 17 = 39\) inches

2. **OBJECT B** is
   
   Its length is _________________. Its width is _________________.
   
   **Equation:** _________________.

3. **OBJECT C** is
   
   Its length is _________________. Its width is _________________.
   
   **Equation:** _________________.

4. **OBJECT D** is
   
   Its length is _________________. Its width is _________________.
   
   **Equation:** _________________.

5. **OBJECT E** is
   
   Its length is _________________. Its width is _________________.
   
   **Equation:** _________________.

Math and Measurement
6. OBJECT F is ____________________________
   Its length is ________________. Its width is ________________.
   Equation: ______________________________________

7. OBJECT G is ____________________________
   Its length is ________________. Its width is ________________.
   Equation: ______________________________________
Finding Perimeter: Problems

1. How much fence material must a landscaper use to surround an area that is in the shape of a square 18 yards on each side?

2. Allowing three feet for the door, how much baseboard would a carpenter need to enclose a square room that measures 12 feet on each wall?

3. Subtracting 2’ 11” inches for door space, how much baseboard would be needed to go around a rectangular room that measures 11’5” x 11’7”?

4. A store has windows in the shape of triangles. How much molding is needed to enclose four windows if a window measures 1’9” on each side?

5. A triangle has sides which each measure 10 inches. Allowing three extra inches for each corner, figure how much molding would be needed to enclose it.

6. How much fencing would be needed to enclose a garden that is shaped like a trapezoid if the sides measure 40 feet, 38 feet, 35 feet and 31 feet?
LESSON
13

Using Area in Construction

Aim

Students will find area through discovery, then practice finding area using a formula. In a series of activities they will:

- Develop a formula for finding area
- Define area
- Define square foot
- Define area of a rectangle
- Solve area problems
Time
1 hour

Things to Consider

Handout 2, “Practice with Area” needs to be done outside — for example, in a large parking lot or park.

Materials, Tools, and Resources

• Square foot tiles
• One-inch graph paper
• Sidewalk chalk
• Measuring tapes
• Handout: Finding Area
• Handout: Practice with Area
• Handout: You Are the Contractor: Finding Area in Construction I
• Handout: You Are the Contractor: Finding Area in Construction II
• Handout: You Are the Contractor: Finding Area in Construction III

Key Terms

• Area
• Square inch
• Square foot
• Formula
Steps for Activity

1. Hold up a square foot tile. Pass it around. Ask students:
   - If you needed to cover the surface of the classroom floor with square foot tiles, how would you figure out how many tiles you would need?

   Give students the opportunity to either call out answers or lay tiles on the floor to do an estimate.

   Lay five square foot tiles on the floor along a wall and show them that these are covering five square feet of space. Ask:
   - How many tiles would be needed to make one row covering the length of the wall?

2. Have students figure out the answer by laying out tiles or by measuring with a tape. Ask:
   - How many rows of square foot tiles would be needed to cover the floor?

   Have students figure the answer by laying out tiles or by measuring with a tape.

   Based on students’ calculations, draw a picture on the graph paper of a room with the measurements of the classroom. Ask them to guide you as you draw, by asking:
   - How many tiles should be represented as the length of the room?
   - How many rows are there?

3. Once you have made a drawing with measurements drawn to scale, each one-inch box depicting a square foot, ask students how they would figure out how many squares are in the picture. If they don’t suggest themselves, ask the students to count the number of squares.

   After they have finished counting, ask if there is another way they might discover how many square tiles there are in the picture. Show them that you can add the number in each row as many times as there are rows; write the number next to each row to show them how this could be done. Ask someone to add all of the numbers to see if the answer is the same as the one they got from counting.

   Ask them if there might be an easier way. They can then be shown, if they do not arrive at the answer themselves, that they can multiply the number of tiles by the number of rows. Thus they have arrived at a formula:

   \[ \text{Length} \times \text{Width} = \text{Area} \]

4. Have students complete the handouts “Finding Area” and “Practice with Area” (needs to be done outside) and share answers in class.
Wrap Up

Discuss the lesson as a class. To help students reflect on activities, ask questions like:

- What were the most difficult parts of the measurement activity? How did you overcome these challenges?
- If you were to explain to someone else how to find area, how would you do so?
- What is your image of a great mathematician? What stereotypes have you heard about people who are good at math?
- In the past, which cultures did you believe were responsible for great mathematical advancements? What do you know about the mathematical contributions of Native Indians, Africans, Asians, and women of other ethnic backgrounds?

Creative Extensions

- Have students use the internet or the library to research the mathematical and architectural contributions of cultures from around the world. Use a world map to pinpoint the parts of the world and the time period in which great math or architectural advancements were made. Discuss the findings and how they compare to “popular thought” (myths, stereotypes, negative or limiting images) on the subject.

- Break students into three teams and have each team work on one of the worksheets, “You are the Contractor: Finding Area in Construction.” Have teams discuss their strategies and team approach to the problem.
Project-Based Learning Activities

- Have students work with a local agency or school to roll out grass, lay sod or gravel, or pour concrete. Have students work to calculate the area and estimate the amount of materials needed.

- Invite a local quilting circle to discuss and teach quilting techniques and the many ways area is used in quilting. Have the students design and make a wall-size quilt that celebrates the YouthBuild experience. The quilt might be used to decorate the YouthBuild building or be donated to a local shelter or organization.

- Have students research the specific needs and requirements of various animals and then design and build shelters for them. These could include guinea pig cages, rabbit hutches, doghouses, or birdhouses.
Finding Area

Find the area of the following objects. First measure the length, then the width. Then use the following formula to write an equation. Solve the equation.

For rectangles: \((L) \times (W) = \text{area (in square units)}\)

For nonrectangles:

1. OBJECT A is: this page
   
   Its length is: 11 inches. Its width is: 8.5 inches.
   
   Equation: \(11 \times 8.5 = 93.5\) square inches.

2. OBJECT B is: 
   
   Its length is: . Its width is: .
   
   Equation: 

3. OBJECT C is: 
   
   Its length is: . Its width is: .
   
   Equation: 

4. OBJECT D is: 
   
   Its length is: . Its width is: .
   
   Equation: 

5. OBJECT E is: 
   
   Its length is: . Its width is: .
   
   Equation: 

6. OBJECT F is: 
   
   Its length is: . Its width is: .
   
   Equation: 

7. OBJECT G is: 
   
   Its length is: . Its width is: .
   
   Equation: 

Math and Measurement
Practice with Area

• Draw a rectangle (not to scale) with an area of 30 sq. ft., and a length of 10 ft. Label the sides.

• Draw a square with an area of 36 sq. ft. Label the sides.

• Draw a square with an area of 25 sq. ft. Label the sides.

• Draw two different rectangles, both with areas of 36 sq. ft, but with different lengths and widths.
You contract to install carpet in a living room.

- The room is 12 feet wide and 15 feet long.
- A closet in the room is three feet wide and three feet deep.

How many square yards of carpet are needed to cover the floor and closet? (1 sq. yd. = 9 sq. ft.)

- Carpet costs $7.59 per square yard.
- You charge your client $11.00 an hour for labor and delivery.
- You estimate the job will take four hours.

What will be your total costs for this job?
You Are the Contractor: Finding Area in Construction II

You contract to install tiles on a basement floor.

- The floor is 55 feet long and 22 feet wide.
- Tiles cost $2.00 a dozen.
- Glue costs $8.95 a gallon, and you estimate that you will need two gallons.
- You charge your client $9.00 an hour for labor and delivery.
- You estimate the job will take six hours.

How many square foot tiles will be needed to cover the floor?

What will be your total costs for this job?
You contract to lay plywood sub-flooring in two rooms in a new house.

- The living room measures 16' x 12'.
- The dining room measures 12' x 12'.
- Plywood is purchased in 4' x 8' sheets.
- Plywood costs $12.00 a sheet.
- You charge your client $11.00 an hour for labor.
- You estimate the job will take four hours.

How many sheets of plywood will you need?

What will be your total costs for this job?
Students calculate percent by figuring discounts and sales tax on purchases of lumber. In this lesson, they will:

- Write fractional equivalents
- Figure percent
- Subtract discount to find total
- Add sales tax to find total
Materials, Tools, and Resources

Handout: Figuring Discounts and Sales Tax
Handout: Using Percentage

Key Terms
- Percent
- Discount
- Tax
There are occasions in which you may need to first figure out the discount, then figure the sales tax on the total after that.

**Steps for Activity**

1. Write the words SIX PERCENT on the board. Ask the students:
   - What does this expression mean?
   - What are three ways this expression could be written?

   Discuss students’ responses. Depending on their answers, show them that six percent can be written as a fraction (6/100), a decimal (.06) or a percent (six per every hundred, “cent” meaning “hundred”), and that these are all various forms of saying the same thing.

   \[ 6\% = \frac{6}{100} = .06 \]

2. Distribute the handout, “Using Percentage.” Have students take turns reading it aloud as you discuss and explain. Show students that if 6% is written as a decimal fraction, you can calculate the percent of a number by multiplying. If you needed to figure out how much a 6% discount would be on a $20 purchase, for example, you would multiply 20.00 x .06. The answer would be $1.20. Since this is a discount, it needs to be subtracted from $20 to get the total. The total price would be $18.80.

   \[
   \begin{array}{ccc}
   \text{STEP ONE} & 20.00 & \text{STEP TWO} & 20.00 \\
   \times .06 & -1.20 & \text{STEP TWO} & 18.80 \\
   \text{1.20} & & \text{1.20} \\
   \end{array}
   \]

3. Show students that the same calculations are used to figure sales tax. If you need to figure 7% sales tax on a $30 purchase, you multiply 30.00 x .07. The answer would be $2.10. Since sales tax is additional money that needs to be paid, it needs to be added to $30 to get the total. The total price is $32.10.

   \[
   \begin{array}{ccc}
   \text{STEP ONE} & 30.00 & \text{STEP TWO} & 30.00 \\
   \times .07 & + 2.10 & \text{STEP TWO} & 32.10 \\
   \text{2.10} & & \text{2.10} \\
   \end{array}
   \]

Explain to students that there are occasions in which you may need to first figure out the discount, then figure the sales tax on the total after that discount. If you needed to figure a 5% discount on a $50 purchase, then add an 8% sales tax to that figure, you could do it like this:

\[
\begin{array}{ccc}
\text{STEP ONE} & 50.00 & \text{STEP TWO} & 50.00 \\
\times .05 & -2.50 & \text{STEP TWO} & 47.50 \\
\text{2.50} & & \text{2.50} \\
\end{array}
\]

\[
\begin{array}{ccc}
\text{STEP THREE} & 47.50 & \text{STEP FOUR} & 47.50 \\
\times .08 & + 3.80 & \text{STEP FOUR} & 51.30 \\
\text{3.80} & & \text{3.80} \\
\end{array}
\]

**Working Hands, Working Minds**
4. Distribute the handout, “Figuring Discounts and Sales Tax” and ask students to work individually to calculate the percents, then either add or subtract to get totals. Ask them to compare their answers with those of another student, and check for accuracy if their answers differ.

**Wrap Up**

Ask students to write in their journals for five minutes in answer to the following question:

How often do you think you have used percents without realizing it?
### Figuring Discounts and Sales Tax

**Material Estimate Sheet**

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Type of Material</th>
<th>Price/Unit</th>
<th>Total Units</th>
<th>Cost</th>
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</thead>
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<tr>
<td>30</td>
<td>1x2x10'</td>
<td>$.40/ft.</td>
<td>200'</td>
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**Materials Total**

6% Discount

**Subtotal**

8% Sales Tax

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<tr>
<th>Quantity</th>
<th>Type of Material</th>
<th>Price/Unit</th>
<th>Total Units</th>
<th>Cost</th>
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<td>$.26/ft.</td>
<td>100'</td>
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**Materials Total**

6% Discount

**Subtotal**

8% Sales Tax

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Type of Material</th>
<th>Price/Unit</th>
<th>Total Units</th>
<th>Cost</th>
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<td>$.48/ft.</td>
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**Materials Total**

6% Discount

**Subtotal**

8% Sales Tax
Using Percentage

What are three ways to write the expression six-percent? Six percent can be written as a fraction (6/100), a decimal (.06) or a percent, (six per every hundred: “cent” meaning “hundred”) and that these are all various forms of saying the same thing.

\[ 6\% = \frac{6}{100} = .06 \]

If six percent is written as a decimal fraction (.06), you can calculate the percent of a number by multiplying. If you need to figure how much a 6% discount would be on a $20 purchase, for example, you would multiply 20.00 x .06. The answer would be $1.20. Since this is a discount, it needs to be subtracted from $20, to get the total. The total price would be $18.80.

1. 20.00  
   \[ \times .06 \]
   1.20

2. 20.00  
   \[ \times .06 \]
   -1.20

   \[ 1.20 \]

   $18.80

If you need to figure 7% sales tax on a $30 purchase, you multiply 30.00 x .07. The answer would be $2.10. Since sales tax is additional money that needs to be paid, it needs to be added to $20, to get the total. The total price would be $32.10.

1. 30.00  
   \[ \times .07 \]
   2.10

2. 30.00  
   \[ \times .07 \]
   +2.10

   \[ 2.10 \]

   $32.10

There are occasions in which you may need to first figure out the discount, then figure the sales tax on the total after that discount. If you needed to figure a 5% discount on a $50 purchase, then add an 8% sales tax to that figure, you could do it like this:

1. 50.00  
   \[ \times .05 \]
   2.50

2. 50.00  
   \[ \times .05 \]
   -2.50

   \[ 2.50 \]

3. 47.50  
   \[ \times .08 \]
   3.80

   \[ 47.50 \]

4. 47.50  
   \[ \times .08 \]
   +3.80

   \[ 3.80 \]

   51.30

Try this:
1. What would be the total price of a $40 item after a discount of 25%?

2. What would be the total price of a $60 item discounted 9%?

3. What is the total cost of a $35 item after adding 7% sales tax?
Students will explore how angles, triangles, and the Pythagorean Theorem relate to construction. In this activity, they will:

- Identify the origins of angles
- Identify how angles are used in construction and record brainstorm in journal
- Use the Pythagorean Theorem
Things to Consider

In this lesson students will explore geometric concepts and terms that may be unfamiliar. If your students have “Geometry Anxiety” think about ways that you can help them overcome their preconceived thoughts and feelings about the difficulty of geometry.

Materials, Tools, and Resources

- Slab of clay or cork tiles
- Wooden pegs (or Popsicle sticks, wooden skewers, or twigs of wood)
- Cord and string
- Rulers (enough for a team of students)
- Scissors (enough for a team of students)
- Protractors (enough for each student or team of students)
- Student journals
- Handout: The Measurement of an Angle

Key Terms

- Geometry
- Angle
- Theorem
- Protractor
- Square
- Pythagorean theorem
- Hypotenuse
- Right angle
- Parallel
- Perpendicular
- Vertical
- Horizontal
- Framing square
LESSON FIFTEEN  Geometric Terms in Construction

Steps for Activity

1. Tell students that in this lesson they will explore how angles, triangles, and the Pythagorean rule relate to construction. Ask students how many of them have heard of the Pythagorean theorem or rule. Explain to students that Pythagoras was a Greek scholar who discovered that in right triangles, the squares of the lengths of the two shorter sides added together equals the square of the length of the longest side (formula: $a^2 + b^2 = c^2$).

2. Ask students to brainstorm the ways they see or use angles at the construction site. To help students “see” the angles in a constructed area, ask them to look around the room and envision the various construction sites they have worked at. Have students record the brainstorm in their journals. Your list may include things like:
   - Corners of doors, cabinets, windows, or where the floor meets the wall
   - Various tools: try, combination, or rafter square
   - Where two walls come together

   Lead a discussion with students about the importance of getting things “square” at the construction site. You might ask students: Why is it essential in construction to make sure your cuts are “square” or at a right angle? Answers should include:
   - Pieces don’t fit correctly unless the angles are right.
   - Pieces that don’t fit correctly weaken the structure.
   - It creates a professional look.

3. Have the students break into teams of three or four. Each team of students will need string, scissors, pegs (Popsicle sticks, wooden skewers, twigs of equal diameter, etc.), a ruler, a framing square, and their journals. (You may work outside on soft ground, or inside, using a corkboard or a slab of clay.) Have each team do the following:
   - Mark a long, straight line by stretching a piece of cord between two pegs.
   - To each peg, tie an equal length of string, more than half as long as the cord.
   - Keep the strings stretched tight and move the ends around to draw arcs. The arcs will cross each other at two points.
   - Draw a straight line between the two points to create a right angle to the line. (Check your right angle with a framing square.)
   - Sketch what you have just done in your journal.
To help students reflect on the activity, ask questions like:

- Did this activity help you understand the importance of right angles in construction? How?
- What did you find difficult about this activity? What did you find fun?
- When do you think you might use this method in construction?

4. Pass out the “Measurement of an Angle” worksheet and protractors to each student. Go over the handout with the students by putting the following on the flipchart or overhead:

- Angles are measured in units called degrees.
- The symbol for degrees is °
- Seventy degrees would be written as 70°

Ask students questions like:

- How would you write one hundred and five degrees? Thirty-seven degrees? Eight degrees? (If time permits, have students come up and demonstrate on the board.)

Tell students that angles can be thought of as the measurement of the opening of the two sides. Degrees can be thought of as part of a circle and that a circle contains 360 degrees.

Ask students questions like:

- How else might you describe angles?
- Where else do you see the unit of measurement in degrees?
- Do you ever use the word degree in your daily language? If so, how?

Ask students to look at their protractors. Show students how to read them. Ask students to create angles of varying degrees with the protractor.

5. Ask students to complete the five problems on the “Measurement of an Angle” worksheet. After all students have completed the worksheet, go over the answers as a large group.
Wrap Up

To help students reflect on the activity, ask questions or provide prompts like:

• What is the most interesting thing that you have learned about the use of geometry in construction?

• How do you think the understanding of Pythagoras’ theorem changed the world of architecture and construction in his time?

• Discuss the ways a roofer might use geometry.

• Make a list of the tools that you learned about and used during this activity, and then explain their use in construction.

Creative Extensions

• Check out the activity sheet on triangles in the Tools and Resources section. Students can use this worksheet to practice recognition of the hypotenuse and different types of triangles and practice using the Pythagorean theorem.

• Have students explore triangles (and other geometric shapes) in architecture. Use the internet and/or books and magazines as resources to get students thinking about “shape usage” in architecture. Then have the class take a walk through the neighborhood to look for examples of shape usage in the neighborhood’s buildings. Ask each student to make a sketch of their favorite, then come back to the classroom to share and discuss findings.
**Project-Based Learning Activities**

- Have students brainstorm possible new homeless shelter designs and/or new systems for running shelters to alleviate current problems. Project tasks could include: designing new blueprints for shelters, seeking out cost effective ways for shelters to have individual rooms or sleeping areas, and presenting the students’ ideas to the city council.

- Challenge students to design and draw buildings of the future based on their predictions of human needs, habits, and the environmental conditions. What geometric shapes can students incorporate into their designs?
The Measurement of an Angle

• Angles are measured in units called degrees.

• The symbol for degrees is °

• The symbol for angle is <

• Seventy degrees would be written as 70°.

• Angles can be thought of as the measurement of the opening of the two sides.

• Degrees can be thought of as part of a circle.

• A circle contains 360°.

• Squares also have 360°. There are four 90° angles in a square, so added together that makes 360°.

• Triangles have 180°; i.e., the sum of their three angles always equals 180°.
Parallel Lines

Parallel means two lines that are the same distance apart at all points — WHEREVER YOU MEASURE THEM.

Line a is parallel to line b.

c is parallel to d
and e
and f
and g
and h.

Stairs are parallel to each other.

Lines do not have to be straight to be parallel. Even the borders of a winding road are parallel if they are the same distance apart at all points.

How many parallel lines can you find in your classroom?
Practice with Parallel

1. Is line A parallel to line B? Why or why not?

2. Line A is parallel to _____ and _____.
   Line B is parallel to _____.
   Line F is parallel to _____.
   Is line D parallel to line C? _________

3. Line Q is parallel to _____ and _____ and _____.
   Line R is parallel to______.
   How many lines is S parallel to?
   _______________________

4. Draw a line that is parallel to line X.
5. Draw a line that is parallel to line Y.
6. Draw a line that is parallel to line Z.
**Handout 4**

**Horizontal Lines**

*Horizontal* means STRAIGHT ACROSS and PARALLEL with the Earth’s “horizon.”

Line $B$ is a horizontal line. Line $Y$ is a horizontal line.

The HORIZON is the line where the EARTH and SKY meet.

If a jar of water is placed on an uneven or unlevel surface, the water will still be level with the earth’s horizon — TRY IT.
Practice with Horizontal

1. Which lines in the drawing above are horizontal?

2. How many horizontal lines can you find in this framed wall?
Level

If an object or a surface is level, it is a TRUE HORIZONTAL. It is parallel to the earth’s surface.

![Diagram of level with water]  

Because water always settles level to the earth’s surface, water is used in tools to help determine if the surface is level.

A water level is used to find two or more points over a long distance. The water level is a pliable, clear plastic tube approximately 5/8” to 3/4” in diameter. The length varies from 15 to 100 feet. The plastic tube is usually filled with a clear liquid.

The spirit level is an important testing tool. Spirit levels come in many different sizes. The smallest is about three inches in length, and the longest is nine feet long. Levels can be constructed of wood, aluminum, magnesium or iron.

A carpenter’s level is the most commonly used level. It can be laid against both vertical and horizontal surfaces. It contains from one to six bubbles encased in a long frame. Two marks are painted on the tubes to mark the center. When the bubble is centered between these marks, the tube is level, or parallel, to the earth.
Vertical Lines

Vertical means STRAIGHT UP and DOWN — the opposite of the horizontal.

Line $A$ is a vertical line.  

1. What parts of this framed wall are vertical?

2. Draw a vertical line that is 1" long.

3. Draw a vertical line that is 1/2" long.

4. Draw a vertical line that is 1 1/2" long.
Plumb

If a line is **plumb**, it is a TRUE VERTICAL. It is straight up and down.

A **plumb bob** is used to find the VERTICAL TRUENESS of a line.

A plumb bob and a level are often used together.

**Try It:**

Use a plumb bob to test the **vertical trueness** of a line. Check it with a level. When would using a plumb bob be more feasible than using a level?
Square

A square corner is formed when a true vertical and a true horizontal meet to form a right angle.

Label the vertical line with the letter V.

Label the horizontal line with the letter H.

Put an S in the square corner.

How many square corners can you find in this framed wall? Label each one with a box.
A circle is 360° (360 degrees) around.

Half a circle is 180°.

One-fourth of a circle is 90°.

A 90° angle is formed when a vertical line and a horizontal line meet at a square corner.
A 90° angle is also called a **right angle**.

How many 90° angles are in this window?
How many right angles can you find?

How many 90° angles are in this ladder?
How many right angles can you find?

Draw a line which forms a right angle to line B.

Draw a line which forms a 90° angle to line A.
**Perpendicular Lines**

When two lines meet to form a right angle or a square corner, they are **perpendicular** to each other.

In this drawing, how many sets of perpendicular lines can you find?

How many examples of perpendicular lines can you find in your classroom?

Are lines A and B perpendicular to each other? Why or why not?

Draw a line that is perpendicular to line X.
Handout 12

Practice with terms

Which lines are parallel to line A?
Which lines are perpendicular to line A?
Which lines are parallel to line E?
Which lines are perpendicular to line E?
Which lines are vertical?
Which lines are horizontal?
Which lines form a right angle to line B?
Which lines form a right angle to line D?
Which lines form a 90° angle with line J?
Which lines are parallel to line C?

Draw a box in the square corner of each right angle you can find. Angle HI is done for you.
ACROSS
2. Describes two lines which meet to form a right angle
3. Top
7. On the other side
9. Even with the earth’s surface
10. A true vertical
11. Straight up and down; the opposite of horizontal

DOWN
1. Forming a right angle
4. Even with the surface
5. A true horizontal
6. Another word for a ninety-degree angle
8. Describes two lines that are the same distance apart at all points

DOWN: 1. square; 4. flush; 5. level; 6. right; 8. parallel.
LESSON 16

Getting Things Square: Tools that Create a Right Angle in Construction

Aim

Students will explain the origins of the theory for finding right angles and find right angles using various carpenters’ tools. In this series of activities, they will:

- Identify carpentry tools that create right and other angles
- Practice determining the squareness of a corner
- Practice making right angles with various carpentry tools
This lesson is meant to follow Lesson 15 — Geometric Terms in Construction. Students should be prepared to use their journal reflections from that lesson.

**Materials, Tools, and Resources**

- Try squares (1 for every 3-4 students)
- Adjustable squares (1 for every 3-4 students)
- Rafter squares (1 for every 3-4 students)
- T bevels (1 for every 3-4 students)
- Rulers (enough for each student to have one)
- Larger pieces of wood scraps
- Masking tape
- String
- Handout: Getting Things Square
- Handout: Determining the Squareness of a Corner
- Student journals

**Key Terms**

- Acute
- Obtuse
- Isosceles triangle
- Try square
- Adjustable square
- Rafter square
- T bevel

**Time**

1 hour
Steps for Activity

1. Tell students that in this lesson they will become familiar with and use carpentry tools that were designed to help make measuring angles easier. Begin with a review of the terms and concepts of right angles, degrees, and the Pythagorean rule. (If you did the previous lesson, have students review their journal entries.) Ask questions like:
   - What is a right angle? Who can draw one?
   - Where do we see right angles in construction?
   - Why is it important to be able to accurately measure a right angle?
   - In terms of creating an angle, what is a degree?
   - How many degrees are in a circle?
   - How many degrees are in a right angle?
   - What is the Pythagorean rule?
   - How can the Pythagorean rule be helpful to you at the construction site?

2. Ask students to get into teams of three or four. (Make sure that each team of students has one try square, adjustable square, rafter square, T bevel, and several scrap pieces of wood.) Ask the students to look at the tools. Tell them that they will be working in teams to explore and use these tools. Lead a discussion with the students about the tools. Ask:
   - Can anyone identify (or name) any of these tools?
   - Does anyone know what the various tools are used for?
   - Pick them up and touch them. How might they be used?

3. Pass out “Getting Things Square.” Go over the handout with students, demonstrating how each tool is used.
   Ask students to complete the “try these” exercises as a team, making sure that everyone in the group has an opportunity to use each of the tools. When students have completed the activity, lead a discussion about the various ways they might use the tools at the construction site.

4. Tell students that there are other ways to check the accuracy of an angle. Pass out “Determining the Squareness of a Corner.” Go over the handout with the students.

5. Give each team of students measuring devices (yardsticks, tape measures, and rulers), tape, and string. Make sure students have their journal with them. Assign each team a corner in the room or building and ask them to find out if the corner is square and if the line is perpendicular to the wall. Ask them to record the process in their journals.
LESSON SIXTEEN  Getting Things Square: Tools that Create a Right Angle in Construction

Wrap Up

1. When students have completed the activity have them share their findings with the larger group.

2. To help them reflect on the lesson, ask the following questions like:
   - Do you feel more comfortable using the try square, adjustable square, rafter square, or T bevel?
   - How do you feel about your ability to measure right angles?
   - What happens if you can’t or don’t accurately measure on the worksite?
   - Will you have opportunities to practice measuring angles at the worksite? How can you make sure that you’ll have an opportunity to practice?
   - Today you went through a process of “checking your work” (or in this case someone else’s work when you checked the corners of the room for accurate right angles). Do you think that “checking the work” is an important task on the worksite? Why or why not?
   - What are other times in your life when it might be important to check your work?
   - In what other jobs might you need to be able to accurately measure angles?

Creative Extensions

- Have students research the ways that societies throughout history have worked to ensure that their structures were square and safe. What types of tools have been used to accomplish this? Are there times in history where major advancements were made in the understanding of mathematical concepts, tool manufacturing, or architectural methods? Where did these advances take place? How were they influenced by other historical events?

- Explore the work of Frank Lloyd Wright. How did he use angles and geometrical shapes to enhance the aesthetic beauty and functionality of his structures? Why is he considered by many to be the greatest American architect of the 20th century?
Project-Based Learning Activities

- Have students work with a neighborhood association to design and construct a community garden. Projects might include creating a blueprint or detailed sketch of the project, putting up a fence, designing and building an arbor, benches, or chairs.

- Build a playhouse for a local daycare or pre-school program. Students can design the house, estimate costs, build the structure, and paint and decorate the playhouse.

- Work with a disabled community member, a retirement center, or a group home for the mentally disabled to design and build a wheelchair ramp to improve access for all individuals.

- Find a collection of old picture frames at a thrift store. Let students take them apart and measure the angles of the miter joints. Give students a miter box and let them experiment with making their own frames.
Getting Things Square

It is essential in construction to get things square (that is, at right angles.) Pieces don’t fit correctly unless the angles are right. Pieces that don’t fit right weaken the structure.

Squares are essential carpenter’s tools that are used to measure and check angles (mainly right angles). To use a square, lay it against a joint you’re making to see if it is a true right angle, or lay one leg of the square against an edge, and the other leg of the square will give you the perpendicular to that edge, for marking square cuts, etc.

Try Square
A try square is a steel blade 6” to 12” long attached at a right angle to a thick, squared-off wood or metal handle.

Adjustable Square
An adjustable square is a try square with a 12” sliding blade that marks right angles on one side of the handle and 45 degree angles on the other.

Rafter Square
A rafter square is a flat steel square. One leg is called the tongue, and is sixteen inches long. One leg is called the blade, and it is twenty-four inches long. It is used to measure inside or outside squares.

T Bevel
A T bevel has an adjustable angle. The blade pivots on the handle and can be locked in any position. It can be used to transfer any angle from one place to another. This can be used to line up repeat angles and cuts. With this tool, you can set an angle you have and copy it. This is used for rafters, cross braces, etc.
Try these

- Test the square of the edges of your wood scraps and other surfaces in the classroom.
- Draw lines perpendicular to the edge of a piece of wood for cutting.
- Use it to place a wood scrap perpendicular to another wood scrap.
- Check the squareness of a bookcase in your classroom that’s been there for a while to see if the weight of the books has changed the angle of the shelves to the walls.
- Check the right angles of the walls and floor in the room.
- With a T bevel, check the angle by lining it up with the existing angle of a piece of scrap wood you’ve just set to mark another piece of wood to match the angle of the first piece.
Determining the Squareness of a Corner

In any true rectangle, the two diagonals are equal in length.

If you lay out lines AB and BC perpendicular to the walls, and you find AC and BD are not equal, you'll know that at least two of the corners are NOT square. Either you laid the lines out wrong, or more likely, the room corner is not square.

Another way to check if two lines are perpendicular is to set a 3-4-5 triangle on them. Any triangle with sides in that proportion (3-4-5) is a right triangle, with the 3 and 4 side perpendicular.

Try this:
1. Measure 4' along the bottom of a baseboard from a doorway opening, and mark that point.
2. Then measure 3' up the inside of the doorway and mark that point.
3. Now check to see if the distance between the two points is 5'. If it is, then a right angle is formed by the juncture of the door and the floor.
LESSON 17

Bringing It All Together: Designing an Entertainment Center

**Aim**

In this lesson students will work in teams to design an entertainment center to practice measurement and see how fractions and percentage have meaning in construction. In this lesson students will:

- Collaboratively design a functional piece of furniture
- Draw their designs to scale
- Estimate and authenticate expenses
- Draft a budget
- Convert the budget into terms of fractions and percentages
- Present findings to the class
**Things to Consider**

This lesson was designed to take place over several class periods. There are several “natural” breaks in the lesson:

1. Students talk about the purpose of the activity, create thumbnail sketches of their ideal entertainment centers, create a final group design and reflect on the process (1 hour).
2. Students create scale drawings (45 minutes).
3. Students estimate costs and expenses for building their entertainment center, call around for estimates on materials, and complete budget work sheet reflection (1 hour).
4. Students creatively present findings to the large group and reflect on activity (1 hour or more, depending on number of students and creativity of presentations).

This lesson was designed to be done with students in teams of three or four; however, the lesson can be modified as an individual activity.

**Time**

Several class periods

**Materials, Tools, and Resources**

- Rulers for each student
- Graph paper
- Beginning carpentry books
- Furniture ads from the newspaper
- Building materials ads from the newspaper
- White paper
- Phone books and telephones
- Handout: Budgeting Costs/Estimating Costs
- Handout: Budget Reflection
- Student journals

**Key Terms**

- Fraction
- Percentage
- Scale
- Estimation
- Budget
- Cost
- Thumbnail sketch
- Scale drawing
Tell students that in this lesson they will work in teams to design an entertainment center. Through this activity they will experience how measuring, fractions, percentages, and other math all relate to construction.

Ask students to think for a minute about what belongings they have at home that would go in an entertainment center. Have them brainstorm a list of things they would or could use a new entertainment center for. Examples might include: books, photo frames, sports trophies, TV, VCR, stereo, or music collections.

Based on this, ask students to describe various ways the entertainment center could be configured to hold those things most efficiently. Ask for volunteers to create quick sketches of their ideas (or other student’s ideas) on flipchart paper or the blackboard.

Ask students to take a few minutes to create a “thumbnail sketch” of their ideal entertainment center in their journal. Have them respond through sketches and words to the following:

How would your ideal entertainment center be configured? Would it be tall or short, wide or narrow? Would it have shelves or doors? What other features might it have? How would you use it?

Get students into teams of three or four. Team students who have different, but complementary skills, strengths, and interests. (Skills used in this lesson include drawing, oral communication, basic math, and measurement conversion.) Tell students that they will be working in their teams for the rest of the lesson, but at times they will be asked to complete individual work assignments.

Explain to each team that it is now their job to incorporate their individual needs and wants and come up with one entertainment center design that will satisfy everyone in the group. Someone in each group needs to create a sketch of their group-designed entertainment center complete with height and width measurements for the various parts of the entertainment center. The team will also need to be prepared to share the “rationale” behind the design features.

Tell students that they will need to present their final design idea to the larger group. Allow students to use the furniture ads and carpentry books to give them design ideas. (Give at least 20 minutes for the students to complete this activity.)

Have each team share with the larger group their design and the reasons why they selected the various features. After students share, help them to reflect on the activity by asking questions like:

- How well did your team work together? Was everyone able to share his or her perspective?

Skills used in this lesson include drawing, oral communication, basic math, and measurement conversion.
• Was it difficult to let go of a design feature that you really wanted incorporated? How did you deal with that?

• What do you think is the best feature of your entertainment center?

• Do you think it would be difficult to actually construct your entertainment center? (Is your design simple or complex?)

• What techniques would you use to construct it? What tools would you need?

• What math skills do you need to get your entertainment center from a sketch to a finished product? Give examples.

4. Tell students that they are now going to work individually to create a “scale” drawing of their entertainment center using the dimensions the group came up with in the previous activity.

Lead a discussion with the group about the meaning of drawing something “to scale,” and decide what scale the group will draw in. (Example: 1 inch on the graph paper = 1 foot of the entertainment center.) For a more challenging activity, allow each student to select the scale they want to draw in.

Distribute graph paper and rulers to each student. Ask students to draw to scale the front and one side of their entertainment center. Discuss the importance of accurate measurements in construction. Brainstorm with the class the possible consequences of not measuring accurately. Your list might include:

• Unsafe structures

• Pieces that don’t fit together

• Loss of money from having to redo jobs

• Slows the process if work needs to be checked often

Allow students ample time to complete their scale drawings. (Even though you want each student to complete their own scale drawing, it might be helpful for students to complete this activity in their teams so they can help one another with the activity.)

When students are done with their drawings, let them present them to the large group, using the following questions as a guide:

• Are you pleased with the way your drawing turned out? Why or why not?

• If you had to do this activity again, is there anything you would change about your process, e.g., getting started, or converting measurements.

• What made the activity challenging? What made it fun?

• What did you learn from the process?

• How might you use the skills you just practiced at the construction site in your life away from YouthBuild?
5. Ask students to join their teams again. Pass out the builder’s supplies ads (taken from the newspaper) and the “Estimating Costs” handout to each group. Lead a discussion with the group about estimating the cost of building their entertainment center. Ask students:

- How much do you think it will cost you to build your entertainment center?
- What type of wood will you use? How much wood do you think it will take?
- What other materials and supplies do you need (nails, sandpaper, screws, knobs, etc.)? How much of each material do you need?
- What type of finish will your entertainment center have (paint, stain or varnish)? How much will you need?

Ask students to use the “Estimating Cost” worksheet and work in their teams to brainstorm a list of the materials and supplies they would need to build their entertainment center. If possible, have students use the builder’s supplies ads to estimate how much it is going to cost to build their entertainment center. Tell students that when they are done with their estimations they will actually call different building supply places to get estimates on materials.

6. When the teams have completed the estimation of materials, supplies, and expenses, pass out the “Budget Worksheet” handout to each group. Tell each team that they will be calling building supply centers to get quotes for the materials they would need to build their entertainment center.

Go over the “Budget Worksheet” handout with the students, and if necessary help the groups assign tasks to each group member. Tell students that they will need to use the phonebooks to find three building supply centers to call and get quotes for the materials. To help students get focused on the task at hand, ask the following questions:

- How are phonebooks organized (the Yellow Pages, the White Pages)?
- If you do not know the names of any building supply centers, where in the phonebook would you find advertisements for a variety of supply stores?
- If you know the name of the store you want to call, where can you look to find the number?
- When you call, how should you introduce yourself?
- What questions will you ask to find out the information that you are seeking?
- How can you help to ensure that you will get a positive response from the person on the other end of the line?
- How can we ensure that we are not all calling the same places?

Depending on the experience level of the students, you may want to allow time for telephone role plays.
7. Have students complete the “Budget Reflection” worksheet and convert findings into fractions and percentages. Discuss the students’ answers. To help students reflect, ask questions like:

- What centers did you find to be the cheapest? Did different groups find deals on materials at different places?
- Were your estimates close to your findings? Were you surprised by the actual costs? Why?
- What changes could you make to your design to bring down the cost of your project?

**Wrap Up**

1. Have students creatively present findings to the large group.

2. To help students reflect on the lesson, ask the following questions:

- Were you surprised at the cost of materials for your entertainment center? How might you cut costs? Or if you had a little extra money, how would you choose to improve the entertainment center?
- Who had the most “reasonably” priced entertainment center? Why might that have been (size, materials used, sale on materials)?
- What skills did you practice in this lesson? Was there any time you had to step out of your “comfort zone” and wear a different hat? How did that make you feel?
- How will you use the skills you practiced in this lesson at the construction site? In the classroom? At home?
- You did a lot in this lesson: designing, estimating, budgeting, converting measurements and numbers, gathering and presenting information, and participating on a team. Was there anything in particular you really enjoyed doing? If so, what jobs exist where you can practice similar skills?
LESSON SEVENTEEN  Bringing It All Together: Designing an Entertainment Center

Creative Extensions

• After students have completed their sketches, scale drawings, and estimates take them to a builders supply center to get the actual costs of materials. Ask the store manager to take students on a tour of the business and talk about “all aspects” of the building supply business (what they do there, what jobs are available at the business, who primary customers are, and how much volume they do).

• Have students experiment with marking 16" on center. Give pairs of students each an eight-foot long stud (which will serve as a mock bottom plate of a framed wall), a carpenter’s pencil, a tape measure, and a quick square.) Show students a picture of a framed wall. Ask them to figure out how to measure and mark out the bottom plate for wall studs to be placed 16 inches apart, using the process of discovery, before correctly demonstrating the procedure. Give only this information:

We are now going to build a wall. The first thing to do when building a wall is lay out a bottom plate. The wall studs rest on the bottom plate. Even though we call these 2”x4”s, they are 1 1/2” wide.

On each end you should place double studs for wall support. Otherwise, studs should be placed on the wall at a maximum distance of 16" on center, which means that from the center of one to the center of another is 16”. This is the same measurement if you measure from the left to the left, or from the right to the right.

To mark where the wall studs should go, mark the bottom plate with two lines for each side of the wall stud and an X.

After students have experimented with this and displayed their marks, use a tape measure to demonstrate how to mark and measure correctly 16" on center. Practice marking 16" on center until the students do it correctly. Add additional problems for review: put in a 30" window in the middle of the wall; put in a 36" window, etc. Give assorted addition problems in which students add 16" to an assortment of measures to practice marking 16" on center in various situations.

• Have students research alternative construction materials: What are the environmentally-sound options for building materials? For instance, students could research options for putting in a “wood” floor. Options might include: wood, bamboo, or tile. How do the costs compare? What is the cost to the environment? How quickly and easily can these resources be renewed? Compare performance, aesthetic value, and functionality.
Project-Based Learning Activities

- Create a set of building blocks for children in which 10 blocks are $2\frac{1}{4}''$ wide and ten blocks are $4\frac{3}{4}''$ wide. Each student should mark a stud for 20 blocks, and have another student and the instructor check for accuracy before cutting. Then have them use a hand saw to cut and sandpaper to smooth. Students can paint or decorate the blocks and donate them to a local childcare center.

- Students can design their ideal desk or other type of workstation following the same type of procedure as used for the entertainment center.
Handout 1

Budget Reflection

1. List your three bid totals here:
   Bid Total #1
   Bid Total #2
   Bid Total #3

2. What is the difference between the highest bid and the lowest bid?

3. Your lowest bid is what percentage less than your highest bid?

4. If the manager of the store with the highest bid were to offer you a 10% discount on all materials, would the discount make that store the most economical for this project? With the 10% discount, how much would your new total be?

5. If the manager of the store with the highest bid were to offer to cut your cost by 1/5, how much would you save? Would this discount make this store the most economical for this project?

6. There is a sales tax of 7% on the materials you want to purchase. Add this cost to each of your bids. What are your total costs at each of the stores with the sales tax added on?
   Bid Total #1 + 7% Sales tax =
   Bid Total #2 + 7% Sales tax =
   Bid Total #3 + 7% Sales tax =

7. a) What item on your material list costs the most? What percentage of your total costs is this item?
   b) Estimate what fraction of your total costs is spent on this item
   c) What could you do to lower the cost of this material?

8. Draw a pie chart showing the breakdown of cost for each material.

9. If you were to travel to all three supply centers or stores, purchasing the lowest priced materials at each store, would you save money on your total cost? How much?

10. Choose one of the above problems and write a paragraph explaining all the steps you went through to find your answer (use back of sheet if necessary).
# Handout 2

## Budgeting Costs

<table>
<thead>
<tr>
<th>Material needed</th>
<th>Number needed</th>
<th>Store #1 Price per item</th>
<th>Store #1 Total cost</th>
<th>Store #2 Price per item</th>
<th>Store #2 Total cost</th>
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**Totals:**

## Estimating Costs

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**Total:**
Facilitator Resource: Budget Reflection

1. What is the difference between the highest bid and the lowest bid? You can explain this to your group as a simple subtraction problem.
   \[ \text{The difference} = \text{highest bid} - \text{lowest bid} \]

2. Your lowest bid is what percentage less than your highest bid?
   Tell your students that they can use their answer to the last problem to help answer this one. The percentage less = the difference (between highest and lowest bid) divided by the highest bid. This will come out as a decimal number that can be translated into a percentage.

3. If the manager of the store with the highest bid were to offer you a 10% discount on all materials, would the discount make that store the most economical for this project? With the 10% discount, how much would your new total be?
   Since the highest bid less 10% is equivalent to 0.9 times the highest bid, you can give your students the following formula: \((0.90 \times \text{highest bid}) - \text{lowest bid}\). If the resulting number is greater than zero, the discount did not make the store the most economical. If the resulting number is less than zero, then the discount did make it the cheapest. And if the resulting number is zero, than the discount made it equal in cost to the lowest bid.
   With the 10% discount, the new total is \(0.90 \times \text{(original) highest bid}\).

4. If the manager of the store with the highest bid were to offer to cut your cost by \(\frac{1}{5}\), how much would you save? Would this discount make this store the most economical for this project? How much would you save?
   To help your students calculate this, they can use the formula:
   \[ \text{Amount saved} = \left(\frac{1}{5}\right) \times \text{highest bid}. \]
   At this point, if desired, you can review multiplying with fractions. Will this discount make this store the cheapest? Since the bid with a \(\frac{1}{5}\) discount is \(\left(\frac{4}{5}\right) \times \text{highest bid}\), to answer this question your group may use the formula: \((\left(\frac{4}{5}\right) \times \text{highest bid}) - \text{lowest bid}\). Again, you can explain to the class that if the resulting number is greater than zero, the discount did not make the store the most economical, while if the resulting number is less than zero, then the reduction did make it the most economical. And if the resulting number just is zero, then the discount made it the same price as the lowest bid.

5a. What item on your material list cost the most? What percentage of your total costs is this item?
   To calculate this percentage, you may give them this formula:
   \[ \text{Percentage of total costs} = \frac{\text{cost of (most expensive) item}}{\text{total cost}}. \]
   This number can then be converted into a percentage.
5b. Estimate what fraction of your total costs is spent on this item. There are various ways you can have your students do this.

They can convert the percentage of total costs they calculated for the last problem and convert that into a fraction. Thus the fraction would be whatever the percentage was divided by 100, and they could reduce from there.

Or you could suggest to them the following: the fraction of total costs spent on this item = cost of item/total costs, and they can reduce that fraction.
Math Memories

Aim

Students will describe some of their earliest memories of math as well as their math experiences, in order to explore their fears, successes, and difficulties. In this lesson, they will:

- Discuss the math “messages” they received as students and reflect on how those messages made them feel
- Write an essay about their math memories
Things to Consider

Many students come into the YouthBuild classroom with fears and memories of failure related to mathematics. They are often reluctant to do math or feel that they “can’t.” By giving them the opportunity to talk and write about their experiences with math, these fears may lessen, and they may reaffirm some of their successes. Since you will be asking students to discuss a topic that may be sensitive for them, think about ways to make the classroom and discussion “safe” and supportive.

How can you use the achievements of minority, female, working class, or learning disabled persons to help your students connect with math? How might you use the biographies of Benjamin Banneker, Skip (Clarence A.) Ellis, Albert Einstein, or Mae C. Jemison to enrich this lesson?

Materials, Tools, and Resources

- Handout: Math Memories

Key Terms

- “Everyday” math skills
Steps for Activity

1. Tell students that in this lesson they will be exploring their feelings and experiences around math. Lead a discussion with the students about their math experiences by asking questions such as the following:
   - Think back to elementary, middle, and high school. What messages did you get about math in school? (Examples might include: math is for boys, if you like math you're a nerd, etc.)
   - How did those messages make you feel about yourself? How did you feel about your ability to learn math?
   - Can you describe positive memories about math?
   - When was learning math fun? What made it fun?
   - If you are turned off by math, at what age did that happen? Why?
   - How many years, months, or days has it been since you took a math class? Describe the class. What did you like and dislike about it?
   - How many weeks, days, or minutes has it been since you used math? Give examples.

2. Tell students that the messages we get about math — whom it’s for and whom it’s not for — and the negative experiences we may have had with math can be very powerful. But if we are aware of the messages and understand how our experiences make us feel about ourselves, we can begin to “unlearn” the negative things we were taught about our aptitude and ability to do math. Having a strong knowledge base in math is important because math is more than just adding and subtracting and numbers; math is also about exploring relationships between things, identifying patterns, and knowing how to solve complex problems.

3. Tell students they are going to continue to explore their feelings about math through essay writing. Distribute the handout “Math Memories.” Ask students to write a brief essay in which they describe their experiences with math. Have them tell of their earliest memories of learning math and what they liked and didn’t like. Ask them to describe what has been hard and what has been easy and to tell the ways they have used math in daily life. Also ask students to list the construction-related math skills that they think they possess.
1. Ask volunteers to share their writing aloud. After several students have shared, help students reflect on the lesson by asking questions like:

   • Did you learn anything new about yourself and math today?
   • What kinds of math do you like to do?
   • How do you learn math best?
   • How might schools teach math better?
   • How are your “everyday” math skills (budgeting your paycheck, adding up items in a grocery store, making correct change, measuring items for a recipe)?
   • If you are weak in a certain area of math, what strategies have you developed to compensate for it?

2. Have the students find a creative way to share their writing with the larger community. They can create a bulletin board, submit writings to an existing student publication, or create and publish a special newsletter on math student experiences and writing.
**Creative Extensions**

- Follow this lesson with a fun “interdisciplinary” math activity. Here are several examples to get you started:

  Explore the connections between math and art. Through the work of MC Escher, students can create their own patterns, optical art, or tessellation.

  How do math and science connect? What about doing an experiment where students have to measure liquids and solids precisely to get a correct outcome?

  Encourage students to create “industrial” art with pulleys, levers, or inclines (physics).

  Bake cookies or a cake by doubling a recipe.

- Follow this lesson with fun math puzzles or brainteasers. See games and brainteasers in the Tools and Resources section of this unit. The following resources can lead you to further puzzles/brainteasers:*

  *Brain Games: Ready to Use Activities That Make Thinking Fun*, Jack Umstatter; The Center for Applied Research in Education; www.phdirect.com


*These resources were available at date of this publication.
Project-Based Learning Activities

- Have students research the contributions that other cultures have made to the field of mathematics. What did the Mayans, ancient Egyptians, and people from Timbuktu know about math and math theory before “Western” culture took such a foothold? How can students creatively present their findings to the larger community?

- Have students research the contributions that minorities have made to the field of mathematics. How can they creatively present their findings to the larger community?

- Students can create a “Math Is for You!” campaign to implement at a local elementary or middle school. What organizations or tools already exist to promote math for minorities, girls, and those who are poor? How can you modify existing tools or create new ones that will have meaning in your community? Your public awareness campaign might consist of posters, a comic book, t-shirts, bumper stickers, buttons, public speaking in classrooms, a “workshop” on how to overcome math messages and fears, or a career awareness campaign about how math is used at various workplaces. How will you celebrate and evaluate the success of your project? You may wish to consult the following resources:


  * Biographies of Women Mathematical Scientists and History of Women in Mathematical Sciences, Publications: http://www.darkwing.uoregon.edu/~wmnmath/Publications/Bibliographies/bio.html

  * Annotated Bibliography of Books Related to Gender Equity in Math and Science. http://quest.arc.nasa.gov/women/resources/annbib.html
Mathematicians of the African Diaspora,
http://www.math.buffalo.edu/mad/mad0.html

Multicultural Perspectives in Mathematics Education,
http://jwilson.coe.uga.edu/DEPT/Multicultural/MathEd.html

History of Black Women in the Mathematical Sciences,
http://www.math.buffalo.edu/mad/wohist.html

*The above websites and links were available at the time of publication
1. Write a brief essay in which you describe your experiences with math. Tell your earliest memories of learning math. What did you like? What didn’t you like? Describe what has been hard and what has been easy and the ways you have used math in daily life. Continue on the back of the page if necessary.

2. List the construction-related math skills you possess:
   1. 
   2. 
   3. 
   4. 
   5. 
   6. 
   7. 
   8. 
   9. 
   10. 
LESSON 3

Math in Literature and Life

Aim

Students explore math in contemporary literature and language and use poetic terms and concepts as a tool for exploring ideas and feelings about math. In this lesson students:

- Brainstorm how math “lingo” colors daily language
- Read a poem about math
- Write a group poem about math using simile and metaphor
Materials, Tools, and Resources

- Handout: “Arithmetic,” by Carl Sandburg

Key Terms

- Simile
- Metaphor
- Idiom

Time

1 hour
LESSON THREE  Math in Literature and Life

Steps for Activity

1. Tell students that in this lesson they are going to explore the influence of math on literature and language. Put the following idioms, or sayings, on the board:
   - “The buck stops here”
   - “Put two and two together”
   - “Five o’clock shadow”
   - “Give me the 4-1-1”

Ask students to translate what each idiom means.

Ask students to think about other math or measurement sayings or terms they use or have heard. As a group, brainstorm a list of math and measurement-related idioms or terms. Your list might include:
   - At the eleventh hour
   - Drop a dime
   - C-note
   - Ace
   - A grand
   - Two bits
   - Don’t count your chickens before they hatch
   - I can count on you
   - Just a stone’s throw away
   - A drop in the bucket
   - I’m doing the countdown
   - Rule of thumb
   - Dressed to the nines
   - At odds with something
   - A dime a dozen
   - Count me in

Ask students to translate the idioms or terms they came up with. Tell students that mathematical concepts and “math language” have a great influence on the way we speak and the way we think about things in this world. Tell students that they are now going to explore ways math has influenced literature, particularly poetry.

2. Distribute the poem “Arithmetic.” Read it aloud with the class and discuss the colorful and descriptive language that each uses to show how math affects us. If necessary, use the following discussion prompts:
• Did you relate to any of the poems? Which ones and why?
• Can you think of how your world would change if mathematics didn’t exist?
• If you were to write your own poem about mathematics, what would you focus on? How could you creatively express the ways that you use math in your life?

Form students into small groups of three to four. Ask each group to complete two statements starting with the phrase “Math is...” Tell them one of the statements should be a simile (the comparison of one thing to something else). Examples of similes:
• Math is like a puzzle because it feels good to find the missing piece.
• Math is like an egg you have to crack before you cook.

The other statement should be a metaphor (the comparison of two things as if one of them really was that thing). Examples of metaphors:
• Math is a car you can’t drive until you find the key.
• Math is a present you haven’t opened yet.
• Math is an amazing maze.

Wrap Up

1. Ask each group to share its statements. Then arrange them together to create a group poem. Ask for volunteers to copy the poem onto poster board. Post it, display it on a bulletin board, or publish it in a program newsletter.

2. To help students reflect on the activity, ask questions like:
• Would you consider the metaphors and similes that you came up with to be positive or negative? How do you think that your feelings about math influenced the connections that you made during this activity?
• Were you surprised by any of the metaphors and similes that others came up with? Which ones and why?
• Were you surprised by how many idioms the group came up with? Can you imagine a day of conversation without using idioms? Why do you think we use idioms? What purpose do they serve?
• How would it feel to be a non-native speaker and have a conversation with a native speaker whose language was full of idioms?
• How can we explore the roots of the idioms we recalled?
• How might these idioms relate to the culture and uses of mathematics of the time?
Creative Extensions

- Instead of creating a group math poem, have each student write a poem of his or her own.

- As a group, brainstorm a list of children’s songs that have to do with numbers, math, or measurement. Brainstorm creative ways teachers might use the list or songs in their classroom. Create a resource guide that contains the titles of the songs (or the actual words to each song) and activities. Share the guide with teachers in your neighborhood elementary schools. Some titles to get started are:
  
  The Black Snowman (Mendez 1989) New York: Scholastic Hardcover
  Sweet Clara and the Freedom Quilt (Hopkinson, D. 1993) New York: Knopf
  Women and Numbers: Lives of Women Mathematicians (Perl, Teri 1993)
  San Carlos, CA: Wide World/Tetra

Project-Based Learning Activities

- Students can research and collect other math poems (and/or children’s books and songs). Take a math period to compare findings as a class. Have students compile the poems and share them with the community. Resources:

  Math and Children’s Literature Site:
  http://www.carolhurst.com/subjects/math/math.html


- Students can create a rap about math for a younger audience. Steps to get started:

  Share some examples of math raps with the group. A good resource is the Schoolhouse Rock website:
  (http://genxtvland.simplenet.com/SchoolHouseRock) Here you can find an audio of the various Schoolhouse Rock "raps," as well as ordering information for Schoolhouse Rock CDs sung by contemporary music artists.

  Ask students: What math idea or concept will you highlight in your rap? How will you express these ideas? Who will be your target audience (Elementary kids or older youth)? Will you record the rap? If so, what technology will you use: audio, video, or computer technology? Could you create a website to share your rap(s) with the world?

- Who said there were no math superheroes in this world? Students can write and publish a children’s story or comic book about how we all use math in life. Distribute the book at schools and community centers throughout the neighborhood.

*The websites above were available at times of publication.
Arithmetic is where numbers fly like pigeons in and out of your head.

Arithmetic tells you how many you lose or win if you know how many you had before you lost or won.

Arithmetic is seven eleven all good children go to heaven — or five six bundle of sticks.

Arithmetic is numbers you squeeze from your head to your hand to your pencil to your paper till you get the right answer.

Arithmetic is where the answer is right and everything is nice and you can look out of the window and see the blue sky — or the answer is wrong and you have to start all over and try again and see how it comes out this time.

If you take a number and double it and double it again and then double it a few more times, the number gets bigger and bigger and goes higher and higher and only arithmetic can tell you what the number is when you decide to quit doubling.

Arithmetic is where you have to multiply — and you carry the multiplication table in your head and hope you won’t lose it.

If you have two animal crackers, one good and one bad, and you eat one and a striped zebra with streaks all over him eats the other, how many animal crackers will you have if somebody offers you five six seven and you say No no no and you say Nay nay nay and you say Nix nix nix.

If you asked your mother for one fried egg for breakfast and she gives you two fried eggs and you eat both of them, who is better in arithmetic, you or your mother?

Students will demonstrate their current measurement skills, using a measurement skill assessment tool. This lesson gives instructors the opportunity to assess student knowledge of standard units of measurement and ability to measure accurately. Instructors can then use the knowledge to better plan instruction. In this lesson, students will:

- Demonstrate present knowledge and skills related to conversion and measurement through a written assessment
- Reflect on the assessment in their journal
**Things to Consider**

*Some of your students* may be anxious about taking tests. Take a few minutes at the beginning of the lesson to explain that this assessment is simply an opportunity for you to assess their skills with math and measurement so you can better plan lessons and activities. Tell students that the assessment is also for them. They can use the results to set math-related goals such as developing better test-taking strategies, brushing up on old skills, or learning new skills. Let them know that they will be taking a similar assessment at the end of this unit (or at the end of a given time period; for example, at the end of the trimester) and that these assessments are a good way for them to measure and document their own growth.

*For the second part* of the assessment students will need to move around and measure objects in the room. The objects should be labeled in advance (Object A, B, C, etc.) to correspond with measurement questions 11–16.

*Since this is a skills assessment,* students will not be completing Creative Extensions or Project-Based Learning Activities. The lesson ends with Wrap Up.

**Materials, Tools, and Resources**

- Handout: Measurement Skills Assessment
- Measuring devices, such as rulers, tapes measures, and yard sticks (enough for each pair of students to have a measuring device)
- Optional: calculators for each pair of students

**Key Terms**

- Ruler
- Tape measure
- Measure/measurement
- Standard unit
- Conversion
- Assessment

**Time**

Allow students to complete the assessment at their own pace. Allow approximately one hour (some students may need additional time).
**Steps for Activity**

1. Tell students that they are going to work in pairs to assess their conversion and ruler measurement skills so that you can gear your teaching to their needs and skill levels. Pair students who will work together well and who will have an opportunity to teach and learn from one another. Distribute the “Measurement Skills Assessment” handout to each student.

2. Make sure each team has a measuring device (and, if you choose, a calculator). Tell students to take their time with the assessment and that most of the assessment is “hands on” — they will be using real objects and measuring devices to show what they know about measurement and conversion.

   Tell students that the assessment asks for the solution to the problem, but they will also need to share how they got the answer. There is plenty of room on the assessment for students to show how they found the solution to the problem. If you allow calculators, students also need to check their work using the “long” method.

   If you believe your students need it, do one or two of the sample problems with the whole group to get them started. For example, you might pose a measurement conversion question to the students, such as how many inches are in two feet, and then ask: What are the various ways you could find the answer using the tools we have available?

3. Allow ample time for students to finish the assessment. Then, score the assessments, take any personal notes you may want for further reference, and put the scores in the students’ portfolios. Use this information to plan instruction. Choose from the lessons that follow to determine which lessons are appropriate for the whole group, and which lessons are for individuals who need skills reinforcement. Determine which students are knowledgeable of which skills so they can tutor or assist others.
Wrap Up

1. To help students reflect after taking the assessment, ask questions like:
   - How did it work to complete the assessment as a team? Give examples of things that went well and things that could be improved for next time.
   - Did you have fun? Why or why not?
   - How would the assessment have been different if you had to complete it by yourself?
   - What did you find to be your strong areas?
   - What did you find to be weak areas? How might you develop those skills more?

2. Tell students that you would like for them to take a few additional minutes to reflect on the assessment in their journals. Write the following prompts on the chalkboard or overhead:
   - What is hard and what is easy for you about taking a test or assessment?
   - What are some of your memories of tests and assessments you’ve done in the past?
   - Set one or two goals for yourself around math. State the goal. What do you need to do to accomplish your goal(s)? By when? How will you measure and celebrate success?

Ask students to write for 10 minutes or so.
Measurement Skills Assessment

Name _______________________________ Date ________________

“Show” your work as necessary.

1. How many inches are in one foot?

2. How many feet are in one yard?

3. How many inches are in one yard?

4. How many inches are in:
   Six feet? ____________________ Three feet? ____________________
   Two feet? __________________ Two yards? ____________________

5. How many feet are in:
   48 inches? _________________ 60 inches? _________________
   84 inches? _________________ 21 yards? _________________

6. One piece of wood is 6 feet, 2 inches long, another is 3 feet, 11 inches long, and another is 5 feet, 6 inches long.
   What is the total length of all three pieces? ____________________________

7. Sixty inches and 24 inches are how many feet? ____________________________

8. Two feet and three feet and 12 feet are how many inches? ____________________________

9. Add these measurements:
   a.) 3 feet
       10 feet 4 inches
       2 feet 7 inches
   + 4 feet 8 inches
   b.) 6 inches
       5 feet 3 inches
       2 feet
   + 6 feet 5 inches

10. What does this mean? Write the measurement in words.
   3’ 4” ____________________________

Working Hands, Working Minds
This section of the test involves the measurement of actual objects. Using either a rule or a tape measure, measure the length of each object and write it on the line.

11. Object A ________________ Length: __________________
12. Object B ________________ Length: __________________
13. Object C ________________ Length: __________________
14. Object D ________________ Length: __________________
15. Object E ________________ Length: __________________
16. Object F ________________ Length: __________________

17–23 Draw lines of the following length. (Bonus: Find something in the room that is of each approximate length)
17. 2 inches
18. 1 and 1/2 inches
19. 4 and 1/4 inches
20. 2 and 5/8 inches
21. 2 and 1/8 inches
22. 3 and 3/4 inches
23. 4 and 3/16 inches

Congratulations!
You have just finished your math and measurement assessment!
Students will list occasions when measurement is used in daily life and they become familiar with using standard units of conversion. In this lesson, they will:

- Brainstorm when measurement is used in daily life and construction, and the kinds of things that are measured, recording these uses in their journals
- Use measurement tools to determine relationships between standard units
**Time**

1 hour

**Things to Consider**

*You will need* enough table space for students to spread out and use the measuring utensils.

**Materials, Tools, and Resources**

- Calendar
- Measuring cup
- Rice or water
- Clock
- Measuring spoons
- Scale
- Dictionaries
- Measuring tape
- Yardstick
- Gallon milk container
- Metric stick
- Math books
- Quart milk carton
- Handout: Figure it Out
- Handout: Standard Units of Measure
- Student journals

**Key Terms**

- Yard
- Foot
- Centimeter
- Inch
Steps for Activity

1. As a class, brainstorm the uses of measurement in daily life. Ask students:
   - When do we measure? What kinds of things are measured?
   Ask students to record the brainstorm in their journal. The list may include some of the following categories:
   - Baking/cooking: ingredients, weight, liquid
   - Sewing: length of fabric
   - Buying clothes: size of body, size of clothes
   - Driving, travel: speed, distance, amount of gas, oil
   - Furnishing a house: size of furniture
   - Health/medical: body weight, blood pressure, heart rate
   - Time: age
   - Salary: dollars per hour, per week, per year
   Brainstorm the kinds of measurement that are used in construction. Ask students to record the brainstorm in their journal. Your list may include:
   - Cutting: length of studs
   - Laying floors: area of floor
   - Painting a wall: size of the wall, amount of paint
   - Framing: finding 16” o.c.

2. Put the various measuring utensils on a table that is accessible to the class. Tell students that you will be asking them to figure out how some measurements relate to each other by using the measuring tools. Divide the students into groups of three. Distribute the “Figure It Out” handout to each team. Ask students to work together to find the answers, using the measurement tools and any other references in the room.
   After the students have worked to complete the worksheet, review the answers together. Have students demonstrate the answers where necessary.
LESSON SIX  Standard Units and Conversion

Wrap Up

1. Distribute the handout, “Standard Units of Measure.” Read and review it as a group. Compare the standard units to the answers they arrived at during the exercise.

2. To help students reflect on the activity, ask questions like:
   • Was the activity fun? Did you learn anything new?
   • How did you work together as a team?
   • Did your measurements come out correctly? If not, why might that be?

Lead a discussion with students about the importance of measurement. To facilitate this discussion ask questions like:
   • Do you use measurement often? At home? At school? On the worksite? Give examples.
   • Is the ability to measure things correctly an important skill to have? Why or why not?
   • When are times in your life that you might need to convert from one unit of measure to another?
   • If you need to, what are some creative ways to polish up on your measuring skills?

Creative Extensions

• Have students find a website on the Internet or bring in a reference book that helps them calculate how much the students would weigh on different planets.

• Have students make “No Bake” cookies. See recipe in the Tools and Resources section.

Project-Based Learning Activities

• Have students take a walk around the block or to a specific destination in the community (neighborhood market, post office, or park). Ask them to take their journals and to describe their walk in measurement terms. (Example: Go four oak trees, three houses, and a vacant lot; take a left; walk 12 paces and a fire hydrant; stop. You’re at the community center.) When they get back to the classroom, either individually or in groups, have students create a map or poem based on their observations.

• Make a community quilt out of fabric or paper. See the handout in the Tools and Resources section for instructions.
Figure it Out!

**Directions:** Using the measurement tools available to you, as well as any reference materials in the room, work with your team to find the answers to the following questions.

1. How many cups are in a quart?  
2. How many cups are in a gallon?  
3. How many pints are in a quart?  
4. How many quarts are in a gallon?  
5. How many teaspoons are in a tablespoon?  
6. How many ounces are in a pound?  
7. How many minutes are in an hour?  
8. How many hours are in a day?  
9. How many days are in a week?  
10. How many months are in a year?  
11. How many days are in a year?  
12. How many inches are in a foot?  
13. How many feet are in a yard?  
14. How many inches are in a yard?
Standard Units of Measure

The following table lists common measurements and what they are equal to in other units. Abbreviations for units of measure are written in parentheses.

Measures of Length
1 foot (ft.) = 12 inches (in.)
1 yard (yd.) = 36 inches (in.)
1 yard (yd.) = 3 feet (ft.)
1 mile (mi.) = 5,280 feet (ft.)
1 mile (mi.) = 1,760 yards (yds.)

Liquid Measures
1 pint (pt.) = 16 ounces (oz.)
1 pint (pt.) = 2 cups (c.)
1 quart (qt.) = 2 pints (pts.)
1 gallon (gal.) = 4 quarts (qts.)

Measures of Time
1 minute (min.) = 60 seconds (sec.)
1 hour (hr.) = 60 minutes (min.)
1 day = 24 hours (hrs.)
1 week (wk.) = 7 days
1 year (yr.) = 365 days
1 decade = 10 years (yrs.)
1 century = 100 years (yrs.)

Measures of Weight
1 pound (lb.) = 16 ounces (oz.)
1 ton (T.) = 2,000 pounds (lbs.)
Students will play BINGO in order to review standard units and practice measurement conversion involving feet, inches and yards. In this lesson, they will:

- Accurately convert inches to feet to yards
**Things to Consider**

**Plan ahead** for this activity by photocopying and cutting up enough BINGO cards so that each pair of students can have at least two cards each.

**Materials, Tools, and Resources**

- Tape measures
- Rulers
- Yardsticks
- Handout: Converting Inches, Feet, and Yards
- BINGO cards, enough copies for each pair of students to have two or more
- Conversion BINGO problems checklist
- Small prizes
Steps for Activity

1. Tell students that in this lesson, they will be working on their conversion skills by playing BINGO. Review with the group the relationship between feet, inches, and yards by asking students the following questions and then working through several examples on flipchart paper or the chalkboard:
   - How do you determine how many inches there are in a number of feet? (Answer: multiply by 12. Example: 6 feet x 12 = 72 inches)
   - How do you determine how many feet there are in a number of inches? (Answer: divide by 12. Example: 72 inches / 12 = 6 feet)
   - How do you determine how many feet there are in a number of yards? (Answer: multiply by three. Example: 10 yards x 3 = 30 feet)
   - How do you determine how many yards there are in a number of feet? (Answer: divide by three. Example: 30 feet / 3 = 10 yards)

2. Pass out handout “Converting Inches, Feet, and Yards.” Give students 15 minutes to complete, then discuss the answers as a group.

3. For the BINGO game, pair students so that their skill levels are such that they might help each other. Give each pair two or more BINGO cards.

   Ask students to assist each other in their pairs as you read off conversion word problems from the “Conversion BINGO problems checklist.” (For initial review, read the problems in order. For a more challenging game, read the problems in random order.)

   Tell students to try to find the answer on their cards, and that if they find it, they should cross it off the card. The first pair that gets five in a row says BINGO. Have the winners read off their answers to make sure that they have correctly marked their BINGO cards.
Wrap Up

1. Give a small prize to the winners, and then have students switch cards and play again. Have students take turns as “callers,” reading off the problems and then checking the winners’ cards.

2. Help students to reflect on the activity by asking questions like:
   - Was the BINGO fun?
   - Did you find doing the conversions difficult? Were there some problems that were easier for you than others? Why?
   - Besides the construction industry, what other professions might require you to convert inches to feet or yards and visa versa?

Creative Extensions

- Have students create new conversion problems and bingo cards for future games. Have students check one another’s work for accuracy.

- Find other games for students to play that teach math concepts, such as dominoes, Monopoly, Mancala, Backgammon, Yahtzee, or card games.

Project-Based Learning Activities

- What games teach math concepts? Have students research various math games and create a resources list for the classroom or teachers in the community. How might students find games to review? Their own experience, the Internet, a trip to your local game or toy store, or interviewing math teachers in the community are all great possibilities. Have students write a paragraph or two about each game that describes the game, how to play it, the math concepts it addresses, and the age for which it is appropriate. Students might even choose to rate each game on a scale of 1–10 as to its usefulness for teaching a particular math concept. Games to get you started include: Dominoes, Monopoly, Mancala, Backgammon, Yahtzee, and various card games.

- Have students create math games for the class or a younger audience.

- Have students research “cool” tools, resources, and websites for kids who hate math or have difficulty with math.
In your life, and especially on the construction site, you will need to know how to quickly convert measurements.

**Finding Inches from Feet**

How do you find out how many inches there are in a number of feet? **Multiply by 12** (the number of inches in one foot).

Example: 4 feet x 12 = 48 inches. There are 48 inches in four feet.

Convert feet to inches:

1. 7 feet equals ______ inches
2. 3 feet equals ______ inches
3. 19 feet equals ______ inches
4. 24 feet equals ______ inches
5. 47 feet equals ______ inches

**Finding Feet from Inches**

How do you find out how many feet there are in a number of inches? **Divide by 12** (the number of inches in one foot).

Example: 24 inches divided by 12 = 2 feet. There are two feet in 24 inches.

Convert inches to feet:

1. 48 inches equals _____ feet
2. 36 inches equals _____ feet
3. 12 inches equals _____ feet
4. 63 inches equals _____ feet _____ inches
5. 32 inches equals _____ feet _____ inches
Finding Feet from Yards
How do you find how many feet are in a number of yards? **Multiply by three** (the number of feet in a yard).

Example: 6 yards x 3 = 18 feet. There are 18 feet in six yards.

Convert yards to feet:
1. 2 yards equals _____ feet
2. 36 yards equals _____ feet
3. 15 yards equals _____ feet
4. 5 yards equals _____ feet
5. 42 yards equals _____ feet

Finding Yards from Feet
How do you find how many yards are in a number of feet? **Divide by three** (the number of feet in a yard).

Example: 12 feet ÷ 3 = 4 yards. There are four yards in 12 feet.

Convert feet to yards:
1. 33 feet equals _____ yards
2. 24 feet equals _____ yards
3. 3 feet equals _____ yards
4. 93 feet equals _____ yards
5. 15 feet equals _____ yards
### Conversion BINGO Problems Checklist

Caller should read off conversion word problems, asking pairs to find the answers on their BINGO cards. (For initial review, read the problems in order. For a more challenging game, read the problems in random order).

- **Inches in 1 foot**
- **Inches in 2 feet**
- **Inches in 2\(\frac{1}{2}\) feet**
- **Inches in 3\(\frac{1}{2}\) feet**
- **Inches in 4 feet**
- **Inches in 5 feet**
- **Inches in 5\(\frac{1}{2}\) feet**
- **Inches in 7 feet**
- **Inches in 11 feet**
- **Inches in 12 feet**
- **Inches in one yard**
- **Inches in 2 yards**
- **Inches in 3 yards**
- **Inches in 6 yards**
- **Feet in 24 inches**
- **Feet in 48 inches**
- **Feet in 60 inches**
- **Feet in 84 inches**
- **Feet in 96 inches**
- **Feet in 108 inches**
- **Feet in one yard**
- **Feet in 6 yards**
- **Feet in 21 yards**
- **Yards in 36 inches**
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Math and Measurement
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Math and Measurement
Lesson
8

Measurement Conversion Scavenger Hunt

Aim

Students will add, subtract, and multiply the heights and widths of various objects in the room in order to practice measuring and measurement conversion. In this lesson they will:

- Define “standard unit of measure” in their journals
- Add, subtract, multiply, and divide numbers involving feet and inches
- Accurately convert inches to feet and/or yards
Scavenger Time

1 hour

Key Terms

• Scavenger

Materials, Tools, and Resources

• Handout: Measurement Conversion Scavenger Hunt
• Handout: Conversion in Construction
• Yardsticks or tape measures (enough so that each pair of students can have one)
• Optional: Calculators (for students to check work)
Steps for Activity

1. Ask students to address the following questions for five minutes in their journals:
   - Describe everything you know about “standard units of measure.” Draw diagrams or pictures if necessary.
   - Give examples of how you have used standard units of measure at home and at the construction site in the last week.

2. Explain to students that there are many times when they will need to add, subtract, multiply, or divide measurements on the construction site and convert measurements from inches to feet or yards and vice versa. Tell students that in order to practice measurement conversion they will measure objects in the room and then add, subtract, multiply, or divide those measurements.

3. Divide students into pairs or groups. Distribute the handouts “Measurement Conversion Scavenger Hunt,” and “Conversion in Construction.” Review the directions for “Scavenger Hunt,” and complete the example with the students. Allow students to work in pairs to first complete the scavenger hunt and then the “Conversion in Construction” worksheet. Allow students to check their work with calculators if you have calculators available.
Wrap Up

1. Discuss the solutions as a class. Ask for several students to demonstrate (on the chalkboard or flipchart) how they solved the problems from the “Measurement Conversion Scavenger Hunt” and “Conversion in Construction” worksheets.

2. To help students reflect on the activity, ask the following questions:
   - Has anyone recently had to add, subtract, multiply, or divide measurements on the construction site? Give examples.
   - Has anyone had to convert measurements from inches to feet or yards on the construction site? Give examples.
   - What are other occasions when you might use these skills on the construction site? At home?

Creative Extensions

- Create a math riddle that the students can solve, then have them create their own riddles.

- Have students create their own word problems using the skills they have developed in this activity.

- Have students investigate to find the most common/favored measurement unit used by architects and constructors. Have students look at blueprints and original construction of the building. Is there a noticeable preference? If so, why do you think it is preferred?

Project-Based Learning Activities

- To give students practice in measurement and measurement conversion, have them make birdhouses, toolboxes, mailboxes, puzzles, math manipulatives, or other small woodworking projects that can be completed in a short period of time. Have students reflect on their measurement success of the project. If appropriate, have students donate their finished products to a local school or charitable group.

- Have students volunteer at a local middle school or learning center to help tutor younger kids in math.
**Measurement Conversion: Scavenger Hunt**

You will need to add, subtract, multiply, and divide measurements on the worksite. With your partner, find the following measurements around your classroom and work through the problems. Use scratch paper to record your “work.” See the example below for how to convert inches to feet.

**Example:** Measure the length of two tables in the room. Add the two measurements together. What is the total?

\[(\text{L. table } \#1) = 6 \text{ feet, 4 inches} \]
\[+ (\text{L. table } \#2) = 3 \text{ feet, 9 inches} \]
\[9 \text{ feet, 13 inches} \]

Simplify: 10 feet, 1 inch

1. Find the height of two doors in the room. Add the two heights together.

2. What is the length of a table plus the height of a chair?

3. Measure four sides around a window. Add the total of all four sides.

4. Measure the total height of a bookshelf. Measure the height of the tallest book on the shelf. Subtract the height of the book from the height of the bookshelf.

5. Find the height of a door in the room. Measure your or your partner’s height. Subtract your (or your partner’s) height from the height of the door.

6. Multiply the width of a door frame by its height. (Bonus: What have you just found?)

7. Find the width of a desk or table. Multiply the measurement by three.

8. Estimate the area of the ceiling. Measure the floor area that reflects that of the ceiling and check your answer for accuracy. (How do you measure the floor area? Remember that width \( \times \) length = area)

9. Tape off a large rectangular area on the floor. Divide both sides by 1/3.

10. Measure your foot. Measure the length of the room. How many steps would it take you to move from one corner of the room to another? Measure your partner’s foot. How many steps would it take him or her to travel the same distance?
Conversion in Construction

1. A carpenter wants to cut an 8 foot 9-inch pipe into five equal pieces. How long should he cut each piece?

2. A contractor is asked to build a table that requires six 2" x 6" boards, each board measuring 6'9". What is the total length of 2" x 6" boards needed?

3. A mason plans to lay out 25 decorative bricks on a walkway. Each brick is 14" long. If the bricks are placed end-to-end in a straight line, how long will the walkway be?

4. A carpenter needs to cut a 3' 6" piece of wood from a stud that is 8' long. How long would the remaining piece be?

5. A tile setter needs to lay a line of 6" tiles along a wall that is 6 yards long. How many tiles will be needed?

6. A carpenter needs to cut a 4' 8" section from a piece of plywood that is two yards long. How long would the remaining piece be?
LESSON 9

Using a Ruler

Aim

Students will review and practice measuring with a ruler in order to improve accuracy in construction projects. At the same time, they will be introduced to the concept of scale. In this lesson students will:

• Understand that measuring is an essential skill in construction
• List consequences of inaccurate measuring
• Identify situations where measuring is used
• Name and identify the inch as the standard unit of measurement on a ruler
• Measure and record the length of objects
• Practice adding and subtracting whole numbers
• Explore changing scale
Things to Consider

This is a good lesson to introduce or reinforce measuring skills, especially for your students who did poorly on the “Measurement Skills Assessment” or with the estimating and measuring in “The Standard Unit.”

The measuring activities in this lesson use whole numbers. For students who need more practice with adding and subtracting whole numbers, please see the following worksheets in the Tools and Resources section of this unit:

“Adding Whole Numbers”
“Subtracting Whole Numbers”

Materials, Tools, and Resources

- Flipchart or blackboard
- Rulers for each student
- Handout: Measuring Inches
- Large sheets of drawing paper
- A bowl full of small objects 1”, 2” and 3” long: screws, nails, and keys, etc.
- Different pieces of wood measuring under one foot, cut to whole inches

Key Terms

- Ruler
- Standard unit of measurement
- Inch
- Scale
**Steps for Activity**

1. Tell students that in this lesson they will practice using a ruler because accurate measurement is such an essential skill in construction. Write key terms and concepts on the board and tell students to listen for these in the lesson. Do they know what each term means?

2. Ask students to brainstorm with you the possible consequences of not measuring accurately, i.e. crooked steps and doors or pieces that don’t fit together; unsafe structures; wasted materials; or loss of money from having to redo a job.

3. Pass out rulers. Explain to students that a ruler is a number line and that the space between each number is the same. That space between each number is call a unit of measurement.

4. Ask students what the standard unit of measurement is on a ruler. Have students point to the inch markings on their rulers.

5. With their rulers in front of them, ask students to answer the following questions:
   - How many inches are there on a ruler?
   - If you start at 0 and move to 6, how many inches have you moved on the ruler?
   - If you start at 7 and move to the number 2, how many inches have you moved?
   - If you start at 4 and move to the number 12, how many inches have you moved?

6. Pass out the student handout “Measuring Inches” and have students complete the handout in pairs or individually. Allow 10 minutes for this activity.

7. In the whole group, have students compare their answers.

8. Explain to students — without going into too much detail at this time — that when we talk about scale we mean the proportion or relationship between two sets of dimensions, such as a drawing and a real object. Tell students they will continue to practice measuring with a ruler, but now we are adding the concept of scale.
9. Pass out a large sheet of drawing paper and a small object to each student. Give students the following directions and write key points on the board:

- You are going to draw a small object up to five times bigger than it is. You will be changing its scale and you'll need your ruler to do this. Each time you enlarge, write the length in inches under your drawing.
- To begin, draw your object on a piece of paper exactly the size it is. Measure the length of your object and write that measurement next to your drawing.
- Next enlarge your drawing two times. If your object is two inches long in real life, when you make it two times bigger, how many more inches will you need to add?
- The enlargement will go like this:
  - For an object three times bigger, you will need $2" + 2" + 2" = 6"$ long.
  - For an object four times bigger, you will need $2" + 2" + 2" + 2" = 8"$
  - For an object five times bigger, you will need how many $2"$?
- You will be adding inches each time. You can multiply the length of your object by how many times you are enlarging it because multiplication is just a faster way to add.
- Be sure to label each drawing by writing down the length of the object. Then write down the scale: two times, three times, etc.

10. Ask students to share their drawings with the class. Which scale was the hardest to do and why? Can students name an application for scale? Where have they seen this kind of sizing up and down before?
LESSON NINE  Using a Ruler

Wrap Up

1. To determine how well students can use a ruler to measure inches, hold up various lengths of wood (cut to whole inches) and ask students to guess the lengths. Pick different students to check the real length by using a ruler. Note any students who still need help with measuring inches and give them further practice and/or reteaching.

2. Put the following questions on the board and ask students to respond in writing:
   - Where and when might you use a ruler at home or on the construction site? Name specific projects.
   - What have you measured on the worksite so far?
   - List any situations where you think a 12-inch ruler would not be the right tool to give you the measurements you need.
   - What else could you use to get the measurements you are looking for?

Give students 10 minutes to respond in their journals and then share their responses.

Creative Extensions

- Give students this writing prompt: In the 1950s there was a great movie about a shrinking man who ends up being terrorized by his own cat. Imagine you have been zapped by an alien microbe that causes you to begin shrinking. Draw a picture of a seven-inch person and write about what life at that height would be like.

Then draw a one-inch person. At this height things would change even more drastically. Write about the hazards and problems of everyday living: eating, sleeping, finding clothes, moving about. Or maybe you can think of some benefits in being a one inch person.

- Have students try these measurement puzzles:
  
  Cut three pieces of wood of any length, in exact inches, that measure a total of 17 inches.

  Cut four pieces of wood of any length, in exact inches, that measure a total of 13 inches.

  Cut five pieces of wood of any length, in exact inches, that measure a total of 18 inches.

  Check for accuracy by asking another student to assemble them and measure the total length.
Project-Based Learning Activities

• Have students study simple floor plans of homes. (Many home building magazines have these.) Challenge students to design and draw their own simple house plan for a one-inch person. The scale would be one to one. How much space would the inch person need and what, if any, special design modifications would he or she require? Students should write in measurements for every room in inches.

• Students can create a math mobile: pieces of wood cut to various whole-inch lengths and widths hung from a wood frame. The wood pieces could be cut in any shapes, but encourage students to use a variety of sizes.

• Students can construct a wooden pencil box with the dimensions 7” x 3” x 2”. They will need to cut five pieces of wood with the following measurements
  
  Bottom: 7” x 3
  End pieces (2): 3” x 2”
  Side pieces (2): 7” x 3”

  Glue all the pieces together to form a box. If the sides are measured and cut accurately, they should fit together perfectly. Boxes can be decorated with paints or varnished. Use boxes to store pencils and erasers.
Measuring Inches

Every ruler is divided into inches. Examine a ruler or tape measure to see how inches are written. Line up the tape measure against the objects you wish to measure. How many inches long are the objects below?

Write the measurement in words first and then write the number and the inch symbol (two slash marks). The first one is done for you.

1. a) two inches b) 2"

2. a) b)

3. a) b)

4. a) b)

5. Sometimes you need to add objects of different lengths. Can you find the total length of these two objects?

6. What is the total length of these two added together?
Sometimes you need to know how many inches are left after you have subtracted or cut off pieces from an object. Measure the object below and write how many inches are left after you remove two inches.

How many inches are left after you cut off one inch from this piece of wood?

a)  

b)  

a)  

b)  

Math and Measurement
Selected Readings

*Math Ace*, Magic Quest, 125 University Ave., Palo Alto, CA, 94301.

Computer software program that provides a good review of basic skills in game format. Addition, subtraction, fractions, decimals, beginning algebra, and geometry are all covered. A tutorial is included.


This course focuses on four complex areas of planning (reading plans, ordering materials, laying out and cutting materials, cost estimating) that carpenters must master to work effectively in their trade. Subjects covered include: lumber sizes, framing a wall, reading a plan, furring and paneling, preparing an order, board feet, graph paper layout, molding, preparing a cutting list, sheathing, siding, surface area, calculating square, laying out and cutting, figuring door clearance, rafters: determining line length, materials estimate: prices, figuring labor costs, preparing a materials estimate, and estimating the complete job.


Basic mathematics, volume and area measurements, everyday problems in the building trades. Clear, full of word problems and relevant examples.


Full of strategies, activities and games designed for parents to teach children mathematics, but appropriate for supplementing classroom instruction as well.

This workbook is full of job-related activities which demonstrate the wide variety of ways math is used in the work world.


This collection of biographies of women mathematicians includes personal histories, accounts of discrimination, experiments, and discovery activities. Accessible, interesting stories designed to help young women and men both realize the number of options available to them.


This text uses computing problems common to the carpentry trade to teach mathematics. At the same time that students are practicing computation, they are learning the terminology used in the field of carpentry. The text contains many good story problems that reflect real-world situations.


*The Exploratorium Guide to Scale and Structure*, Barry Kluger-Bell, Heinemann, 361 Hanover Street, Portsmouth, NH 03801-3912.


*Applied Mathematics, Unit 1, Learning Problem-solving Techniques*
*Applied Mathematics, Unit 2, Estimating Answers*
*Applied Mathematics, Unit 7, Working with Shapes in Two Dimensions*
*Applied Mathematics, Unit 13, Precision, Accuracy, and Tolerance*
All from: Center for Occupational Research and Development, 601 C Lake Air Drive, Waco, TX 76710.


Video


This video illustrates the ways in which math can be taught in a hands-on, relevant way to adult students. A teacher interacts with the class to demonstrate the teaching of percents, fractions and area. Excellent training resource for teachers.

“Children and Math,” (27 min.) 1/2" VHS, $25.00; 3/4" U-MATIC, $35.00, available from: Salvadori Center on the Built Environment, City College of New York, Harris Hall, Room 202, Convent Avenue at 138th Street, New York, NY 10031.

A video of a panel discussion on teaching math using innovative and hands-on activities.

Websites:

Please note: the following websites were available as of January 2001, but may no longer be operational.


http://www.girlsinc.org

A resource for materials on “Operation Smart”, dedicated to raising the confidence of girls in the fields of science, math, and technology. Provides a set curriculum.

http://math.usask.ca

This site provides various math problems and summaries of basic concepts. Covers algebra, geometry, trigonometry, exponential and logarithmic functions, and math theory.

http://www.edu4kids.com/math.html

An excellent interactive website for running basic drills of addition, multiplication, subtraction and division in games and flashcards. Various levels of complexity.
http://forum.swarthmore.edu/teachers/element
This site has simple games and projects for basic math skills. Primarily useful for teachers.

http://coolmath.com
“An amusement park of mathematics.” This site includes areas like “How to Succeed in Math” and an interesting section on “Careers in Math” which includes profiles of math-related careers and even devotes some space to the women of NASA.

http://mthwww.uwc.edu

http://hoxie.org
Math humor in various formats: jokes, riddles, comics, etc.

http://www.youngmath.org
Geared towards youth, this is a good site for pulling kids into math without boring them.

The United States Department of Education’s official website, with numerous resources for parents and teachers on how to get over “math phobia.”

http://sosmath.com
An interactive website designed to help kids understand math. The site offers help for doing homework, preparing for tests and getting ready for math classes.

http://MTL.math.uinc.edu
This Math Teachers Link website links high school math teachers and lower level college professors from around the United States together in order to share curriculum and questions.

http://www.cne.gmu.edu
This Math Index site acts as a dictionary with examples for any math term or formula.

http://pumas.jpl.nasa.gov
The On-Line Journal of Math and Science is a collection of one page examples of how math subjects taught in high school and college can be utilized in everyday settings.

http://eduplace.com
The Mathematics Center was designed to provide students, teachers, and parents math problems and games for specific, but common, math difficulties.
**General Supplemental Material**

**Handout 1**

**Mancala Math Game**

This activity can easily be broken into two one-hour lessons. In the first have students make their Mancala games. In the second lesson let them play and reflect on the experience.

**Materials, Tools, and Resources**

1. egg carton for each student
2. paper cups for each student
3. plastic bag for each student
4. 24 beans, marbles, small rocks, or other similar items for each student (for game pieces)
5. Scissors
6. Tape

**Background**

Tell students that they will be learning to play a game called Mancala, which is thought to have originated in Africa and has been played in many parts of the world for at least 3,000 years.

Ask for a show of hands of people who have played Mancala before. If you have experienced students in the group, let them share their experiences with, or reactions to, the game. You might also have students explain Mancala’s rules when it is time to play.

Each student will need an egg carton, two paper cups, 24 game pieces (beans, rocks, marbles), scissors, and tape.

Instruct students to cut off the lid of the egg carton and discard it. The egg compartments will be the “wells” or “pits” for the “stones” or game pieces.

Next, give each student two paper cups. Have students cut the top off of the cups, making them about the height of the egg carton. Using tape, attach one cup to each end of the carton. These are the “mancalas” and will be used to hold “captured” stones.

At this point, students can use paint to decorate their game board. Explain to the students that the six egg compartments or “wells” on each side of the carton go with the cup or “mancala” on the right end of the carton. When painting the game board, students might choose to make this distinction. Remember, if you do paint, the game boards will need time to dry.
Make sure that each student has 24 game pieces (beans, rocks, marbles). Students can paint these pieces in any colors they like.

Pass out a copy of the handout “Mancala Rules” to students and read them aloud. Pair students and give them time to play one or more games.

**Mancala Rules**

**Object:** Be the player with the most pieces or “stones” in your Mancala.

**Setup:** Each player has 24 “stones.” Place four stones in each of your six “wells” or “pits.” The “Mancalas” or cups are left empty at the start of the game.

**How to Play**

Decide who will go first. This player takes all of the stones from any well on his or her side of the board. Moving counter-clockwise the player drops one stone into each bin that he or she comes to (including the opponent’s wells) until all of the stones are gone. This is known as “sowing.” If the player comes to his own Mancala he drops a stone into it, but players DO NOT drop a stone into the opponent’s Mancala.

If the player’s last stone lands in his or her own Mancala, he or she gets to go again. It is possible to move many times on one turn if you strategize to drop your last stone in your Mancala. Otherwise, it is the opponent’s turn.

**Capturing Pieces**

If the last stone that a player drops lands into an empty well on his or her side of the board, he or she captures any of the opponent’s stones in the well directly across from his or hers. When pieces are captured, they go into the Mancala of the player who captured them, along with the stone that was responsible for the capture. After a capture, it is the opponent’s turn.

The game ends when all six wells on one side of the board are empty. At this point, all of the remaining stones on the other side are moved into the Mancala owned by that side’s player.

The player that ends the game is not necessarily the winner, the player with the most stones wins.
MORDIN’S MAZE

A knight, far from home and seeking shelter in a storm, happened upon what appeared to be an abandoned castle. In reality it was the abode of Mordin the Sorcerer. The knight was received and provided with food and drink containing a potion that rendered him senseless.

When his head cleared, the knight found that he was in a room in the depths of the castle. Since no other option presented itself, the knight was determined to successfully negotiate the maze.

The First Choice
The knight approached two doors at the end of the room and read these signs:

A. Only one of these signs is false.
B. This is the door you should go through.

Which door should be opened?

The Second Choice
Having selected the right door, the knight passed into a second room and found two doors from which to choose. Each contained a sign, as follows:

A. These signs are both false.
B. This is the way to go.

Which door is the correct one?

The Third Choice
Again the knight went through the correct door and entered another room, this time containing a choice of three doors, with these signs:

A. Exactly two of these are false.
B. This is the door to go through.
C. Enter the next room through this door.

Which door should be chosen?

The Fourth Choice
Having made the right selection, the knight continued through the maze, and encountered a choice of three doors, with these signs:

A. Do not go through door C.
B. At least one of these signs is false.
C. If door A is not the one to go through, then door B is.

Which is the right choice?
The Fifth Choice
Proceeding correctly into the fifth room, the knight perceived three doors. He read their signs, as follows:
A. These signs are all false.
B. At least one of these signs is false.
C. This is the correct door to open.
Which door leads to the next choice?

The Sixth Choice
Once again, the knight selected the correct door and entered the sixth room, which contained three doors, with these signs:
A. No fewer than two of these signs are false.
B. None of these signs are false.
C. Go through either this door or the door with the sign that is true.
Which door is the one to go through?

The Seventh Choice
After taking a deep breath, the knight chose one of the doors and entered the seventh room. He observed four doors, as follows:
A. Do not go through door C.
B. Go this way.
C. This is not the door to go through.
D. Door B is not.
Which door should the knight select?

The Eighth Choice
Having successfully passed the first seven decisions, the knight entered the eighth and final room of the maze. He found three doors, with these signs:
A. This is not the door to go through unless the sign on the adjacent door is true.
B. Exactly two of these signs are false.
C. This is the door to open unless the sign on the adjacent door is false.

The knight entered the correct door, which opened into a wooded area near the entrance to the castle, where he found his faithful horse awaiting him.
What door was opened?
Handout 3, cont’d.

MORDIN’S MAZE SOLUTION

The first choice: Door A
The second choice: Door B
The third choice: Door A
The fourth choice: Door C
The fifth choice: Door C
The sixth choice: Door B
The seventh choice: Door C
The eighth choice: Door B

Math Riddle: Facilitator Guide


2. Using this as your code, write a message for the students to decode, for instance, the location of a special treat or a punch line to a joke. Here’s an example:

“Under the desk”

might be written as:

```
  2 4 9 1 0 6 8 1 9 1 3 7
```

3. Create a series of problems where the students can add, subtract, or multiply measurements that will help them break the code. Each question should be connected to one letter in the encoded message.

   **Sample Problem:**
   Complete this problem to find the numerical code for the letter “N”:
   A carpenter has eight, six inch tiles. If she lays them out in a line along a wall, how many feet will the tiles cover?
   Answer: 48 inches = four feet
   The Letter “N” = 4

4. After students have solved the riddle, have them create their own codes and secret messages.
Supplemental Resources
Lesson 7 — Standard Units and Conversion

Handout 1

No Bake Fruit Balls

2 tablespoons butter or margarine
1 1/2 cups chopped dried fruit (dates, raisins, cherries, or apricots)
1 cup confectioner’s sugar
2 beaten eggs
1/4 teaspoon salt
2 1/2 cups crispy rice cereal
1/2 cup chopped walnuts
1 teaspoon vanilla extract
2 cups (approx.) shredded coconut

Using a double boiler, heat butter, chopped dates, confectioner’s sugar, eggs and salt. Stir constantly. Remove from heat and cool.

Add crispy rice cereal, chopped walnuts, and vanilla. Mix well and form into small balls. Roll in coconut. Keep refrigerated until eaten.

Makes two dozen

Adapted from the following website:
http://www.cookierecipe.com/az/NoBakeDB.asp
No Bake Cookies

Tasty no-bake cookies made with oatmeal, peanut butter and cocoa.

1 1/4 cups white sugar
1/2 cup milk
1/2 cup butter or margarine
4 tablespoons cocoa
1/2 cup crunchy peanut butter
3 cups quick cooking oats
1 teaspoon vanilla extract

Directions:
1. Boil together sugar, milk, butter, and cocoa for 1 1/2 minutes. (Start timing when mixture reaches a full rolling boil. This is the trick to successful cookies. If you boil too long the cookies will be dry and crumbly. If you don't boil long enough, cookies won't form properly.)

2. Remove from heat and add peanut butter, oats and vanilla. Stir until well blended. Drop by teaspoonfuls onto wax paper. Let cool until hardened.

Makes 3 dozen

Adapted from the following website:
http://www.cookierecipe.com/az/NoBakeDB.asp
Community Quilt Project

Make a community quilt out of fabric or paper. In order for a quilt to be successful, it needs to be accurate. Like in any construction, before you begin working with the materials, you must have a plan. A quilt, which is divided into squares called quilt blocks, can be made by first creating an individual square. On a piece of paper draw a square that is 8” x 8”. (The blocks can be made smaller or larger as preferences vary, but a quilt is much easier to complete when working with even numbers.)

Step 1:

After this grid has been created, your imagination is free to run wild. Most quilt patterns are created using squares and triangles, although more ambitious projects will include semi-circles. Start with something simple.

Once your pattern has been set on a grid, color it in. Once complete, copy this grid onto another sheet of paper. This piece of paper will be your sample.

Cut the sample into all the specific shapes you will need. According to the colors chosen, cut all the quilt pieces and lay them out according to your original design. Then proceed to glue them to a “base square” or background piece of paper. Once complete, you will have one quilt block.

Experiment with different shapes and patterns. The complexity of a quilt goes as far as the creator’s mind.
Supplemental Resources
Lesson 9 — Using a Ruler

Handout 1

Adding Whole Numbers: Review Problems

Add the following quantities:

1. $86
   17
   3
   78
   +
   59
   204 square inches
   799 square inches
   392 square inches
   +
   1,987 square inches

2. 175 gallons
   45 gallons
   5 gallons
   243 gallons
   +
   113 gallons
   5,330
   1,700
   406
   +
   2,009

3. 95 feet
   12 feet
   62 feet
   14 feet
   +
   45 feet
   1,701
   501
   3,423
   +
   4,977

4. 175 plywood sheets
   188 plywood sheets
   275 plywood sheets
   137 plywood sheets
   +
   421 plywood sheets
   1,125
   34
   125
   3,675
   +
   2,098

5. 1,809 board feet
   756 board feet
   479 board feet
   4,503 board feet
   +
   3,987 board feet
10. On Monday, a contractor purchased 4,650 board feet of cedar siding and on Friday he purchased an additional 3,905 board feet. What was his total board feet purchase for that week?

11. Two deliveries of 1,850, 8’ pieces of green fir 2x4’s and one delivery of 1,735 pieces were made to the job site. How many total pieces were delivered?

12. The contractor’s bills for a recent job are: $82 for hardware, $1495 for wood, $195 for paint, and $432 for finishing materials. In addition he paid two carpenters $465 each for the job. What did the job cost him?

13. The roofer has calculated that three new houses will need a total of 6,725 square feet of asphalt shingles. Each house also has a garage attached requiring 325 square feet of shingles per garage. How many square feet of shingles will be necessary to complete all three houses and garages?
Handout 2

Subtracting Whole Numbers: Review Problems

Subtract the following quantities:

1. 454 feet – 36 feet
2. 4,527 yards – 679 yards
3. 6,453 – 1,764
4. 89,000 board feet – 26,983 board feet
5. 2,493 joists – 387 joists
6. $33,781 – 12,457
7. 14,893 square feet – 2,365 square feet
8. $56,920 – 3,663
9. 13,361 – 9,396

10. At a house construction site, the builder has calculated that he needs an additional 17,86 pieces of ten-inch joist materials. He already has 487 on the job. How many additional pieces will he need?
11. The lumber yard has 561,500 board feet of green fir 2x4's. Two local contractors will buy 236,000 and 308,000 board feet today. How many board feet will be left on the yard?

12. A contractor has been hired to finish a baseboard job that has 3,675 linear feet completed. Including the finished work, the entire job will require 6,893 linear feet. How many additional linear feet of baseboard material will the contractor need to buy?

13. The new warehouse floor will require 5,874 square feet of underlayment and the total count in the contractor’s stock is 2,345 square feet. How many additional square feet will be needed for the job?

14. A truck has arrived at the building site with 5,780 4’x8’ plywood sheets. At the start of the day, 10,000 sheets were loaded on the truck. The truck made one delivery earlier in the day. How many sheets were off-loaded at the first delivery?
Supplemental Resources
Lesson 15 — Geometric Terms in Construction

Handout 1

Triangles — What Do We Know About Triangles?

• The length of a side is dependent on the lengths of the other two sides.
• The triangle’s three angles always add up to 180 degrees. For example, if one angle is 25 degrees, and another is 60 degrees, the third angle has to be 95 degrees.
• The longest side is called the hypotenuse.
• Triangles can be acute, obtuse, or right. A triangle is acute if its largest angle is less than 90 degrees. It is obtuse if there is an angle greater than ninety degrees. A right triangle has one angle that is exactly 90 degrees.

Above are some triangles of different types. For each triangle, circle the hypotenuse and write what type of triangle it is.

a. __________________________

b. __________________________

c. __________________________

d. __________________________

e. __________________________

f. __________________________

g. __________________________
You can also:

• Measure the lengths of the sides of each triangle.

• For the right triangles use the Pythagorean theorem to calculate the length of one of the sides, and then measure the side to check your work.

• Practice measuring angles using a protractor. After you measure each angle record the number of degrees it is. Do all three angles of each triangle add up to 180 degrees?