8258 Prospect Dr., Kewaskum, WI 53040

Phone : 262-689-9184

Email:christine@ammeinc.com

TEACHER NOTES for ALGEBRA LAB:

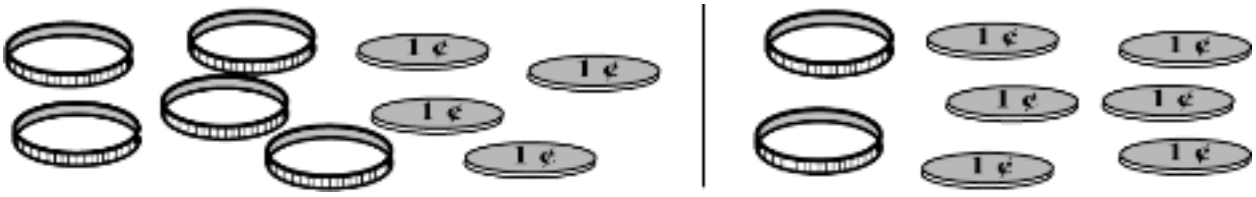
6-Lab B **Hang in There** 1 day

• This lab is **the most powerful way we have experienced to introduce solving of equations** for students who have almost no experience in solving equations. **In only one class period, virtually every student will be able to solve equations** with variables on both sides, such as 3b + 5 = 7b + 1.

• This lab is designed to help the right-brained, visual learners *see* that algebra is not abstract, but rather very logical. We use the age-old concept that equations are just like balance beams. Each pair of students will start with two "algebra cups." Each of the cups has pennies and another type of object, such as paper clips, clothes pins, or washers in them. (Since the objects in each cup *vary*, we mention that they will be called the *variables*, but since there will always be pennies in every cup, we call them the *constants*. Since pennies are used as the constants in all stations, if students find two pennies in a cup, they are to write + 2, not +2P.) They are told that contents of both cups weigh the same and their job is to determine the weight of one of the objects in terms of pennies.

How to introduce the lab

The day of the lab you will want to show at least two examples of how the *game* will be played. Take a pair of cups, tell the students that they both weigh the same, and empty them into two separate piles under a Elmo/document camera. Let's say that you have **milk caps and pennies in them**.

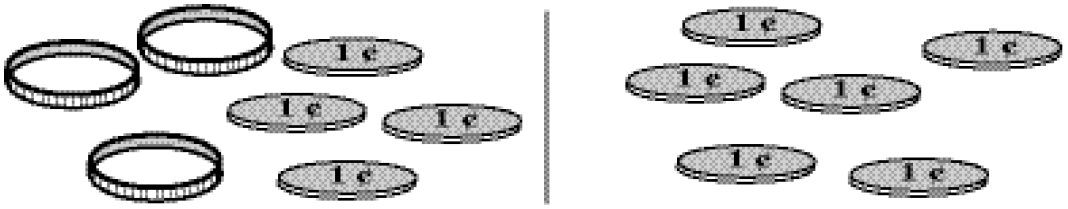


Ask if someone if they can tell the "weight" of a single milk cap. Since there will be many items on the overhead, it probably will be too complicated for most students to see the answer. Slide the items towards the top of the screen and start by writing the equation in the middle of the overhead.

5C + 4 = 2C + 6

Ask someone to tell you how to make the problem simpler. The answer will be something like, "Take away two milk caps from both piles."

Do that, but **before you do anything else, write what you have done algebraically.**



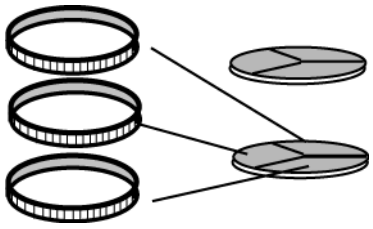
Note we first copy the previous equation. **5C + 4** - 2C = **2C + 6** - 2C

Students clearly see the next equation has to be: 3C + 4 = 6

• Next after someone tells you to take away 4 pennies from each pile, and you show the algebra, the items will look like this picture below.

(Note we copied the last equation.) **3C + 4** - 4 = 6 - 4

3C = 2



• We mentioned that this lab also allows you to help students understand fractions, as all our answers are fractional. Spread out the three caps and trace around the two pennies on the overhead. Divide each penny on the overhead into thirds, perhaps color-coding the thirds. Then each cap gets one-third from each penny.

To show that we divided each side into three piles, we first copy the previous equation again and then we showed algebraically that we divided each side into 3 parts.

$$\frac{3C}{3} = \frac{2}{3}$$

So clearly: $1C = 2/3$

• To run the lab, we assign partners. Place all the containers on a table and have one of the partners pick one pair of cups to run that station. (I make a few extra pairs of cups.) After they are done with their station, make sure they use their equation to reset the station as they found it. (We usually write the original equations on the cups so they get reset correctly.) Then they just trade their cups in for another set.

• **WARNING**: **An absolute key for success is to make sure students write their algebraic step immediately after they move a set of items** on the desk. As students are running the lab, your job will be to walk around and make sure everyone is doing that.

• Sometimes they get caught up in finding the answer, they forget their goal is to use algebra to explain what they did. The only students this lab doesn't work for are the ones who move all of the objects first and then try to write the algebra.

How to set up cups:

• **Included, on the flash drive, is a list of the equations we used for our cups and you can just duplicate them, but if you wish to start from scratch, here are detailed steps for how to set up stations.** Before you read how to set up the stations, you should probably look at several of the problems on page 1 and 2 of the lab to make the following explanations more clear.

• Start with two empty cups. Put **several** objects (Always more than one because the algebra steps are set up so they have to **divide to find the answer**.) such as 3 plastic spoons in one and enough pennies in the other cup to "sort of" balance their weight. In all actuality, it is not important that they really balance; we have found it really does not make a difference to the students. For example, they might end up with 4 bolts in one cup and six pennies in the other one. **We also find this lab is a great visual way to teach fractions,** so we always make sure the "answer" is not an integer.

• Let us say you have 2 spoons balanced with 9 pennies. (We use the 9 pennies as constants and students are not to label them or write them as 9P.) Now make the "equation", which is $2S = 9$, a little tougher. For example, you could put 3 more spoons and 4 more pennies in each cup. This gives you a final equation of $5S + 4 = 3S + 13$. Keep a list of your equations.

• It is wise to **put numbers on the cups and write the final equations on each cup** so if a team makes a mistake resetting a station, the next team can fix the error before they start. Since this is virtually their first look at solving equations, we do not want any students to be frustrated with cups, which were not set up properly.

• It takes a little time to set this lab up for the first time, but once done, we store all the cups in a plastic tub. Then when we get them out the next year, they are already set up.

• **At the end of these teacher notes is a list of equations and objects that we use.**

• We usually have students do page 1 and 2 of the lab the day before as homework. This introduces them to the concept of the lab. We do not explain very much, but do ask them to try their best since it is a short assignment.

Supplies Needed **Each set of cups for one team of two students needs:** two plastic cups, about 10-15 pennies, and sets of uniform objects to weigh (4 to 8 objects per station) pencils, bolts, washers, etc. (We found out the hard way not to use marbles because they roll off the desk.)

Unit 6 Algebra Lab B with cups

Cups have one variable and all have pennies as the constants.

Cup#	Object	Equation	Answer
1	Bolts	8B + 4 = 4B + 9	1B = $1\ ^{1}/_{4}$
2	Clothespins	4C + 5 = 2C + 10	1C = $2\ ^{1}/_{2}$
3	Wire nuts	4W + 4 = 1W + 9	1W = $1\ ^{2}/_{3}$
4	Beads	7B + 5 = 3B + 12	1B = $1\ ^{3}/_{4}$
5	Lag bolts	4L + 5 = 1L + 7	1L = $^{2}/_{3}$
6	Plastic spoons	5S + 7 = 3S + 12	1S = $2\ ^{1}/_{2}$
7	Lag bolts	4L + 3 = 2L + 10	1L = $3\ ^{1}/_{2}$
8	Wooden beads	8B + 4 = 5B + 9	1B = $1\ ^{2}/_{3}$
9	Clothespins	1C + 10 = 3C + 3	1C = $3\ ^{1}/_{2}$
10	Plastic forks	5F + 3 = 2F + 10	1F = $2\ ^{1}/_{3}$
11	Washers	8W + 4 = 2W + 6	1W = $^{1}/_{3}$
12	Wire nuts	5W + 6 = 2W + 11	1W = $1\ ^{2}/_{3}$
13	Washers	5W + 2 = 1W + 9	1W = $1\ ^{3}/_{4}$
14	Bolts	5B + 3 = 1B + 12	1B = $2\ ^{1}/_{4}$
15	Nails	6N + 5 = 3N + 7	1N = $^{2}/_{3}$
16	Cubes	7C + 6 = 4C + 8	1C = $^{2}/_{3}$

8-Lab C **Twice the Fun** 1 day

• This is a great lab to show the visual or hands-on learners that algebra does not have to be abstract. It is logical and easy to understand. This lab is very similar to 6-Lab B, but the difference this time is that students are going to work with equations containing two variables **and** a constant. **Their goal is to learn how to solve for one variable in terms of the others** to prepare them for the algebra review in which they use substitution to solve a system of equations.

• A team of two students will select one pair of cups which have two different types of objects, the variables, and also some pennies which represent constants. Since pennies are used as the constants in all the stations, if students find two pennies in a cup, they are to write + 2, not +2P. Before you start to set up the stations, you may wish to **read problem #5** so you get an idea of how the stations in the lab should be set up. They are told the cups weigh the same and they are to determine the weight of one of the objects in terms of both pennies and the second objects.

• Each team of two sit side-by-side and will pick up one of the many pairs of containers from the front of the room. After they finish that station, they reset it using their original equation, replace the containers and pick up another. **Again, we suggest that you number each pair of cups and also write the equation on each cup.** That way if a team returns the cups, but with the objects mixed up, the next team will not be frustrated. **You must also write on the cups which object they are to solve for.**

• It's an easy lab to run, but **it will take some time** to set up the cups. We try to use interesting objects and the students respond positively. For example, we used cups with toothpicks and Q-tips, small nails and cubic centimeters, lag bolts and insulators, whatever we could find at home or school. Remember, **all** the cups will have some pennies in them.

• **At the end of these teacher notes is a handout of equations and objects that we use.**

• Again we assign page 1 and 2 of the lab for homework the night before the lab. The day of the lab you will want to show at least two examples of how the "game" will be played. Take a pair of cups (see example on the next page) and tell the students they both weigh the same. Empty them into two separate piles on an overhead projector. Ask if someone can tell the “weight” of one of the objects you selected. Since there will be many items on the overhead, it will be too complicated for most students to see the answer. Slide the items towards the top of the screen and start by writing the equation on the middle of the overhead.

Ask someone to tell you how to make the problem easier to solve. The answer will be something like, “Take away two milk caps from both piles.” Do that, but **before you do anything else, write what you have done algebraically.**

Here's the algebra for an equation regarding milk carton **Caps, Erasers** and pennies.

$$5C + 4E + 2 = 2C + 6E + 5$$

$$\mathbf{5C + 4E + 2} - 2C = \mathbf{2C + 6E + 5} - 2C$$ *(Notice we copy the first equation before subtracting.)*

$$3C + 4E + 2 = 6E + 5$$

Then students may tell you to take away 4 erasers from both sides.

$\mathbf{3C + 4E + 2} - 4E$	=	$\mathbf{6E + 5} - 4E$	which gives
$3C + 2$	=	$2E + 5$	and after taking away 5 pennies, you get
$\mathbf{3C + 2} - 2$	=	$\mathbf{2E + 5} - 2$	turning into
$3C$	=	$2E + 3$	or…

To find the weight of a cap, spread them out and start by matching a penny up with each one. Since there are two erasers and three caps, you will have to help students see they need to divide the erasers in thirds. (We find that it helps at this time to take the erasers off the overhead and just draw them in so you can show them divided into thirds.) Then it's easy for them to see one milk cap pairs up with $^2/_3$ of an eraser plus one penny.

$$\frac{\mathbf{3C}}{3} = \frac{\mathbf{2E + 3}}{3}$$

So $1\,C = {}^2/_3\,E$

To set the stations up, start with two empty cups, then:

I. Put two types of items and pennies in cups to **form a "good" ending equation**.

Here are some examples:

Bolts and clothespins while solving for bolts:	$2B = 1C + 3$	(The 3 is 3 pennies.)
Pencils and washers, solving for pencils:	$3P = 7W + 3$	
Paper clips and small nails:	$4P = 2N + 4$	

a) Notice all will **require division** to find the final answer. The lab is set up that way. They have fractions in the answers, but usually halves, thirds or quarters. You probably don't want problems which have somewhat difficult final answers, such as: $7V = 9P + 11$

b) On each cup, you **must** write its number, the equation, and the variable they'll solve for.

c) Notice the pennies always end up on the opposite side of the equation from the variable they are solving for. (You don't want students to try to use negative pennies when solving. It would make the lab abstract again. They will have the opportunity to use negative numbers when they do the worksheets.)

d) It isn't important that the cups actually balance, just that they look somewhat close in weight.

II. Once you have the "starting equation" in the cups, you'll **make the equation more challenging** to solve by adding items, both variables and pennies, to both sides. For example, if you started with 4 Bolts = 2 Washers + 8 you could add 3 bolts, 2 washers, and 4 pennies to both cups. This would give a final equation of 7B + 2W + 4 = 4W + 3B + 12

III. When grading, you only need to be sure they understand what steps you require. It is easy to grade, although you could check your key to see if their "answer" is correct.

• WARNING: An absolute key for success is to make sure students **write their algebraic step immediately after they move a set of items** on the desk. As students are running the lab, walk around and make sure everyone is doing that. Sometimes they get caught up in finding the answer, and they forget their goal is to use algebra to explain what they did. The only students this lab doesn't work for are the ones who move all of the objects first and then try to write the algebra.

Supplies Needed **Each set of cups for one team of two students needs:** two plastic cups. pairs of uniform objects, 4 to 8 objects per station, perhaps plastic spoons, new pencils, small bolts, washers, Q-tips, paper clips, clothespins, plastic cubes, nails; actually any uniform objects work well, although don't use marbles because they will roll off the desk.

Key for Unit 8 - Lab B with cups

Cup #	Objects	Equation	Solutions
1	*People* & Washers	2P + 3W + 5 = 5P + 1W +3	$P = {}^{2}/_{3}W + {}^{2}/_{3}$
2	*Washers* & Bolts	1B + 6W + 3 = 5B + 4W + 7	W = 2B + 2
3	*Hickory Nuts* & Wire Nuts	3H + 5W + 6 = 7H + 3W + 2	H = ½ W + 1
4	*Toothpicks* & Q-tips	2Q + 3T + 5 = 1T + 4Q + 9	T = 1Q + 2
5	*L-Brackets* & Washers	6L + 2W + 2 = 2L +5W + 6	L = ¾ W + 1
6	*People* & Washers	6P + 1W + 2 = 3P + 5W + 4	$P = 1{}^{1}/_{3}W + {}^{2}/_{3}$
7	*Nails* & Washers	4N + 5W + 4 = 1N + 15W + 6	$N = 3{}^{1}/_{3}W + {}^{2}/_{3}$
8	*Lag Bolts* & Caps	4L + 1C + 4 = 6C + 1L + 8	$L = 1{}^{2}/_{3}W + 1\ {}^{1}/_{3}$
9	*Bolts* & Washers	1B + 4W + 7 = 4B + 2W + 3	$B = {}^{2}/_{3}\ W + 1{}^{1}/_{3}$
10	*People* & Nails	3P + 9N + 5 = 6P + 7N + 3	$P = {}^{2}/_{3}\ N + {}^{2}/_{3}$
11	*Pulleys* & Bolts	1P + 6B + 5 = 3P + 2B + 2	P = 2 B + 1 ½
12	*Toothpicks* & brads	2T + 14B + 3 = 4T + 5B + 2	T = 4½ B + ½
13	*People* & Q-tips	3P + 1Q + 5 = 1P + 4Q + 9	P = 1½ Q + 2
14	*Nails* & Bolts	4B + 3N + 5 = 1B + 5N + 1	N = 1½ B + 2
15	*Washers* & Small bolts	4W + 1B + 4 = 1W + 3B + 5	$W = {}^{2}/_{3}\ B + {}^{1}/_{3}$
16	*Big Washers* & Little washers	4B + 6L + 2 = 2B + 9L + 6	B = 1½ L + 2
17	*Washers* & Paper Clips	4C + 7W + 3 = 6C + 4W + 7	$W = {}^{2}/_{3}\ C + 1{}^{1}/_{3}$
Demo	Washers & Hickory nut	3H + 4W + 1 = 6H + 1W +5	$W = 1\ H + 1{}^{1}/_{3}$

8-11 **Teaching Aid – Introduction to Substitution** 15-20 minutes

• This single-page document of four glasses balanced on a scale (shown with the objects we use) can be used to introduce handout 8-12. We use it on a white board, or as a transparency, to help students understand the concept of substitution. We use: 3L + 3 = P + 4 and L + 4 = P.

We chose L-Brackets and People as our variables, and placed them so they appear to be in the cups. Then, we asked students to determine the weight, in pennies, of one L-Bracket. (Of course, use any objects you have available. Be sure to write on top, which object's weight students are to find.)

• Most students will not be able to determine the answer by just observing. As you ask for suggestions on how to solve this puzzle, someone may suggest that the bottom two glasses tells us that one person weighs the same as one L-Bracket and four pennies. Therefore you can replace the person in the top right glass with one L-Bracket and four pennies. After that it will be easy to determine the weight of an L-Bracket because the top equation will be 3L + 3 = 1L + 8. (Take one L-Bracket from each side of the top two glasses, then take three pennies from each glass and it's easy to see that each L-Bracket must weigh 2 ½ pennies.) This simple demonstration should allow students to more easily understand the concept of substitution that they will learn in handout 8-12.

8-13 **Sticky Subs** **½** day

• This short activity will give students the opportunity to be sure they understand the concept of substitution. It holds six relatively simple substitutions, but offers a way for students to physically make substitutions. Each student will need **six small pieces of sticky labels;** each piece only have to be at about ¼" tall and about ½" long. We use mailing labels (no particular size) and then cut them to size with a paper cutter. Colored or white sticky labels this size are available at Walmart in the stationary section.

• We usually start number one with the class to help them understand the directions. For example, in number 1 they would circle the "T' in the **right** equation. Then on the sticky label, they would write "2R." Since the "2R" on their label is equivalent to "T," he or she would be able to paste it on top of the "T" in the **left** equation.

• Then it would be easy to finish solving the new equation: 2 •R + 3•R = 60 and from there solve the system of equations. While not all systems will be as easy to solve as problem number 1, most are quite basic. Our main goal is just to help move the concept of substitution to their long-term memory. You may also wonder why we have typed the equations on the worksheet. We found we needed to in order to make sure they had room to be able to paste their label without covering more than they should.

Supplies needed for each student:

6 pieces of mailing labels - at least ¼" tall and about ½" long

You can use a paper cutter to reduce the size of most mailing labels.