

## LESSON: ORDER OF OPERATIONS

**OBJECTIVES:** To make students understand the order of operations (PEMDAS) and to apply it to solve algebraic equations and simplify expressions.

**MATERIALS NEEDED:** Transparencies with Fast Food Menu and Shopping Spree, handouts #1, 2, and 3 with problems emphasizing order of operations; index cards for O-OOPS Game, overhead projector and markers.

### CONCEPT DEVELOPMENT:

Introduce the order of operations by using *Fast Food Menu* problem: A group of students goes to the local fast food restaurant. The menu is

Hamburgers	\$1.50
French Fries	\$1.00
Sodas	\$0.75

Have students decide how many of each to buy for a 5 person party. Make sure you choose different numbers for each item on the menu. Say, we'll buy 3 hamburgers, 4 French fries and 5 Sodas: 3H's, 4F's and 5S's.

Add up  $\$1.50 + \$1.00 + \$0.75$ . Then multiply by the number of total items, 12. THIS DOES NOT MAKE SENSE, because of the context of the problem.

Next, write out as  $3 \times 1.50 + 4 \times 1.00 + 5 \times .75$ , and then work from left to right. We get  $3 \times 1.50$  is 4.50; then add 4 to get 8.50; then multiply by 1 to get 8.50; then add 5 to get 13.50; then multiply by .75 to get 10.125, which does not make sense at all. (This problem illustrates that multiplication must come before addition, and we simply cannot work from left to right).

Now ask students what is the right way to solve the problem. At least few will say that we should multiply first and then add the results:  $3 \times 1.50 + 4 \times 1.00 + 5 \times .75 = 12.25$  That's right!

This problem also provides a good opportunity to introduce or reteach variables. The problem can be rewritten as an intermediate verbal mathematical expression:

Hamburgers  $\times 1.50$  + French fries  $\times 1.00$  + sodas  $\times .75$

Have students practice by replacing the variables in the expression, by making up different combinations of numbers.

**GROUP EXERCISE:** The groups of students use menu to come up with different combinations that will total \$10.

**EXPLORATORY ACTIVITY:** *Shopping Spree* (This scenario brings in parentheses and subtraction)

The local clothing store is having a 1-hour sale. The announcement says

Tee shirts regularly \$15; discounted \$5
Jeans regularly \$35; discounted \$10
Shoes regularly \$45; discounted \$15
<b>SPECIAL:</b>
If you spend exactly \$200, after the discount, in less than 60 minutes you get an extra \$15 off

Ask students how many T-shirts/jeans/ shoes do you grab? Ask students to give possible combinations:

Tee shirts: try 5          Jeans: try 3          Shoes: try 1

Ask how much you should pay:          The verbal expression will be: # of tee shirts \*price of 1 tee shirt + # of jeans\*price of 1 jeans + # of shoes\*price of 1 shoes

The mathematical model will be:  $5 \times (15 - 5) + 3 \times (35 - 10) + 1 \times (45 - 15)$ .

In the context of the problem you have shown that parentheses come first, then multiplication then addition.

Note: Writing the expression without parentheses and working from left to right simply does not make sense:  $5 \times 15 - 5 + 3 \times 35 - 10 + 1 \times 45 - 15$  !

The order of operation rules tells us to multiply first, before adding or subtracting. So this expression needs to be modified. We can simplify this expression by doing parentheses first, then multiplication and then addition:

$$5 \times (15 - 5) + 3 \times (35 - 10) + 1 \times (45 - 15) = 5 \times 10 + 3 \times 25 + 1 \times 30 = 50 + 75 + 30 = 155$$

For practice, have the groups of students try to come up with one or more combinations of items that will amount to exactly \$200.

How many different combinations will total \$200 for the shopping spree? Which group can find the most combinations totaling \$200?

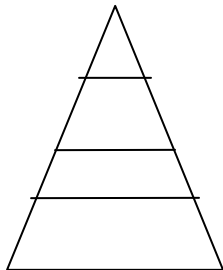
**GROUP EXERCISE:** Divide your class in groups of two or three students. Have each group make their own scenarios and let other groups try to find the “unknown” combinations.

Define for students the right order of operations- PEMDAS- parentheses, exponents, multiplication or division as they occur from left to right, and then addition or subtraction as they occur from left to right. There are few ways to memorize this rule:

1) Please Excuse My Dear Aunt Sally or

2) Purple Elephants May Destroy A School

You can also visualize it in the form of a pyramid.



Parentheses

Exponents

Multiplication or Division (as they occur from left to right)

Addition or Subtraction (as they occur from left to right)

A method that has been very successful for working with order of operations is PEMDAS table.

P	E	M	D	A	S

Draw a PEMDAS box for every problem. Check off the operation after it has been performed, or determined not part of the problem. For example,  $2 + 6(3 + 1)^2$ .

P	E	M	D	A	S
x					
P	E	M	D	A	S
x	x				
P	E	M	D	A	S
x	x	x			
P	E	M	D	A	S
x	x	x	-		
P	E	M	D	A	S
x	x	x	-	x	-

Practice solving the problems using PEMDAS table.

1)  $3 + (5 - 2)^3 - 12 =$

2)  $2(4 - 7)^2 - 3 \times 5 =$

3)  $(20 - 14) \times 3 - 4^2 + 7 \times 2 =$

### HANDS-ON ACTIVITY:

- 1) Distribute among the students handout #1: Please Excuse My Dear Aunt Sally. (10 min)
- 2) For advanced students you may try to use handouts #2 and #3 with more complicated problems.

**INTERACTION/LEARNING ACTIVITY:** Prepare the cards with blank space for students to create their own problems. For example,

$$\square \div \square \times \square + \square = \square$$

Tell your students that fractions can also be simplified or “cleaned up” by using PEMDAS. You have to clean-up the numerator and denominator separately before you can do the division.

For example,  $\frac{7-3}{4 \times 5} = \frac{4}{20} = \frac{1}{5}$

### **O-OOPS GAME! By Shirley Cousins**

Number of Players: 3-4 per group

Materials: Set of O-OOPS cards for each group, see attached handout.

Rules:

1. The dealer shuffles the cards and deals them all out. Each player matches the expression of numbers with correct value using the correct order of operations for the pairs in his hand. These pairs are placed face up on the table.
2. Play begins by each player passing 3 of the remaining cards to the player on his right. If this action results in new pairs being formed, each player adds these cards in front of him.
3. To begin the draw, the player to the left of the dealer draws a card from the hand of the player on his left. If the drawn card completes a pair, he plays the pair face up with the others. Otherwise, he keeps the card and the next player to his left draws from the player on his left.
4. Play continues until all the pairs are formed, leaving one player with the O-OOPS card. As a player's hand is depleted, he drops out of the game.