Lesson 22

# Applications of Expressions

## Goals

- Determine which order for applying multiple coupons gives the better discount and explain (orally and in writing) the reasoning.
- Justify (orally, in writing, and using other representations) that two different sequences of calculations give the same result.

## Learning Targets

I can write algebraic expressions to understand and justify a choice between two options.

## Lesson Narrative

In this culminating lesson, students look at several real-world situations that can be represented by an expression with a variable. First, students write expressions to represent two different methods for performing a real-world calculation. They use the expressions to show why the two methods are equivalent. Then students are presented with two different coupons to a store (a 20% off coupon and a $30 off coupon). They apply their understanding of expressions, equations, and inequalities to decide in which order the coupons should be applied to save more money on a purchase. As students write expressions to represent and compare the different discounts, they are reasoning abstractly and quantitatively.

## Student Learning Goals

Let's use expressions to solve problems.

### Access for Students with Diverse Abilities

- Engagement (Activity 1)
- Representation (Activity 2)
- Action and Expression (Warm-up)

### Access for Multilingual Learners

- MLR8 (Warm-up)
- Compare and Connect (Activity 1)

### Instructional Routines

- Math Talk
- MLR7: Compare and Connect
- MLR8: Discussion Supports
- Notice and Wonder

## Lesson Timeline

| 5 min | 15 min | 15 min | 10 min |
|---|---|---|---|
| Warm-up | Activity 1 | Activity 2 | Lesson Synthesis |

**Instructional Routines**

**Math Talk**

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**Instructional Routines**

**MLR8: Discussion Supports**

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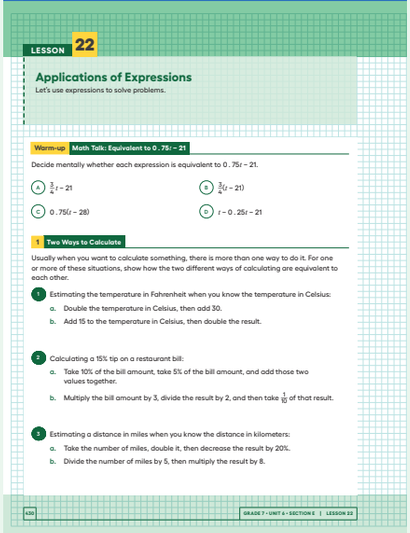
**Access for Students with Diverse Abilities (Warm-up, Task Statement)**

**Action and Expression: Internalize Executive Functions.**
To support working memory, provide students with access to sticky notes or mini whiteboards.

*Supports accessibility for: Memory, Organization*

**Student Workbook**



LESSON 22

Applications of Expressions

Let's use expressions to solve problems.

Warm-up Math Talk: Equivalent to 0.75t − 21

Decide mentally whether each expression is equivalent to 0.75t − 21.

A. $\frac{3}{4}t - 21$

B. $\frac{3}{4}(t - 21)$

C. $0.75(t - 28)$

D. $t - 0.25t - 21$

1 Two Ways to Calculate

Usually when you want to calculate something, there is more than one way to do it. For one or more of these situations, show how the two different ways of calculating are equivalent to each other.

1. Estimating the temperature in Fahrenheit when you know the temperature in Celsius:
   a. Double the temperature in Celsius, then add 30.
   b. Add 15 to the temperature in Celsius, then double the result.

2. Calculating a 15% tip on a restaurant bill:
   a. Take 10% of the bill amount, take 5% of the bill amount, and add those two values together.
   b. Multiply the bill amount by 3, divide the result by 2, and then take $\frac{1}{10}$ of that result.

3. Estimating a distance in miles when you know the distance in kilometers:
   a. Take the number of miles, double it, then decrease the result by 20%.
   b. Divide the number of miles by 5, then multiply the result by 8.

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## Warm-up

## Math Talk: Equivalent to $0.75t - 21$

5 min

### Activity Narrative

This *Math Talk* focuses on rewriting expressions in different, equivalent ways. It encourages students to think about relevant terminology and to rely on the distributive property to mentally solve problems. The strategy elicited here will be helpful later in the lesson when students show that two different ways of calculating are equivalent.

In explaining how they know whether expressions are equivalent, students need to be precise in their word choice and use of language.

### Launch

Tell students to close their books or devices (or to keep them closed). Reveal one problem at a time. For each problem:

- Give students quiet think time, and ask them to give a signal when they have an answer and a strategy.
- Invite students to share their strategies, and record and display their responses for all to see.
- Use the questions in the *Activity Synthesis* to involve more students in the conversation before moving to the next problem.

Keep all previous problems and work displayed throughout the talk.

### Student Task Statement

Decide mentally whether each expression is equivalent to $0.75t - 21$.

**A.** $\frac{3}{4}t - 21$

Yes

Sample reasoning: $\frac{3}{4}t - 21$ is equivalent to $0.75t - 21$ because $0.75 = \frac{3}{4}$.

**B.** $\frac{3}{4}(t - 21)$

No

Sample reasoning: $\frac{3}{4}(t - 21)$ is not equivalent to $0.75t - 21$ because by the distributive property, it is equivalent to $\frac{3}{4}t - 15.75$.

**C.** $0.75(t - 28)$

Yes

Sample reasoning: $0.75(t - 28)$ is equivalent to $0.75t - 21$ because of the distributive property.

**D.** $t - 0.25t - 21$

Yes

Sample reasoning: $t - 0.25t - 21$ is equivalent to $0.75t - 21$ because if you combine $t - 0.25t$, you get $0.75t$.

### Activity Synthesis

To involve more students in the conversation, consider asking:

- *"Who can restate _____'s reasoning in a different way?"*
- *"Did anyone use the same strategy but would explain it differently?"*
- *"Did anyone solve the problem in a different way?"*
- *"Does anyone want to add on to _____'s strategy?"*
- *"Do you agree or disagree? Why?"*
- *"What connections to previous problems do you see?"*

## Activity 1
## Two Ways to Calculate

15 min

### Activity Narrative

In this activity, students show that two different ways of calculating something are equivalent. For example, $2T + 30$ and $2(T + 15)$ are equivalent ways of estimating a temperature in Fahrenheit when you know $T$, the temperature in Celsius.

The calculations are presented with words, so it's advantageous to express them with algebraic expressions to reason abstractly and quantitatively.

Students may find other ways of explaining why the calculation methods are equivalent, but the *Activity Synthesis* should highlight explaining why two expressions that use a variable are equivalent.

Monitor for students or groups who:

- Substitute sample values into the calculations to see if they get the same numerical result.
- Write pseudo-expressions like "double $C$ + 30" or "10% of $b$ + 5% of $b$."
- Write expressions with variables.
- Use plain-language descriptions of properties and moves like "switch" and "smush."
- Name properties and moves like "distributive property," "combine like terms," and "commutative property."

### Launch

Select work from students with different strategies, such as those described in the *Activity Narrative*, to share later.

#### Access for Multilingual Learners (Warm-up, Synthesis)

**MLR8: Discussion Supports.**
Display sentence frames to support students when they explain their strategy. For example, "First, I _____ because ..." or "I noticed _____ so I ..." Some students may benefit from the opportunity to rehearse what they will say with a partner before they share with the whole class.

*Advances: Speaking, Representing*

#### Instructional Routines

**MLR7: Compare and Connect**

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#### Access for Multilingual Learners (Activity 1, Synthesis)

This activity uses the *Compare and Connect* math language routine to advance representing and conversing as students use mathematically precise language in discussion.

#### Access for Students with Diverse Abilities (Activity 1, Task Statement)

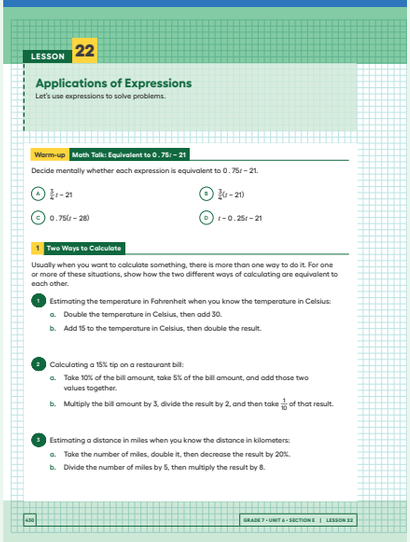
**Engagement: Internalize Self Regulation.**
Chunk this task into more manageable parts to differentiate the degree of difficulty or complexity. Invite students to choose and respond to just one or two of the three questions. The three situations are presented in order of increasing complexity.

*Supports accessibility for: Organization, Attention*

### Building on Student Thinking

For students who have trouble getting started, ask them to first calculate using a few specific values. For example, calculate the temperature in degrees Fahrenheit if the temperature in Celsius is 0 degrees, 5 degrees, and 10 degrees, and then use the same operations to write an expression for $x$ degrees. Another option would be to provide a bank of expressions for students to choose from, rather than asking them to generate the expressions.

### Student Workbook



LESSON 22

Applications of Expressions

Let's use expressions to solve problems.

Warm-up Math Talk: Equivalent to 0.75r − 21

Decide mentally whether each expression is equivalent to 0.75r − 21.

A $\frac{3}{4}r - 21$

B $\frac{3}{4}(r - 21)$

C $0.75(r - 28)$

D $r - 0.25r - 21$

1 Two Ways to Calculate

Usually when you want to calculate something, there is more than one way to do it. For one or more of these situations, show how the two different ways of calculating are equivalent to each other.

1. Estimating the temperature in Fahrenheit when you know the temperature in Celsius:
   a. Double the temperature in Celsius, then add 30.
   b. Add 15 to the temperature in Celsius, then double the result.
2. Calculating a 15% tip on a restaurant bill:
   a. Take 10% of the bill amount, take 5% of the bill amount, and add those two values together.
   b. Multiply the bill amount by 3, divide the result by 2, and then take $\frac{1}{10}$ of that result.
3. Estimating a distance in miles when you know the distance in kilometers:
   a. Take the number of miles, double it, then decrease the result by 20%.
   b. Divide the number of miles by 5, then multiply the result by 8.

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### Student Task Statement

Usually when you want to calculate something, there is more than one way to do it. For one or more of these situations, show how the two different ways of calculating are equivalent to each other.

1. Estimating the temperature in Fahrenheit when you know the temperature in Celsius:
   a. Double the temperature in Celsius, then add 30.

      If $c$ represents the temperature in Celsius, this way of calculating can be expressed with $2c + 30$.

   b. Add 15 to the temperature in Celsius, then double the result.

      This way of calculating can be represented with $2(c + 15)$, which is equivalent to $2c + 30$ because of the distributive property.

2. Calculating a 15% tip on a restaurant bill:
   a. Take 10% of the bill amount, take 5% of the bill amount, and add those two values together.

      If $b$ represents the bill amount, this way of calculating can be expressed with $0.1b + 0.05b$, which is equivalent to $0.15b$ by combining like terms.

   b. Multiply the bill amount by 3, divide the result by 2, and then take $\frac{1}{10}$ of that result.

      This way of calculating can be represented with $\frac{3b}{2} \cdot \frac{1}{10}$. This is equivalent to $1.5b \cdot 0.1$ because $\frac{3}{2} = 1.5$ and $\frac{1}{10} = 0.1$. This is equivalent to $0.1 \cdot 1.5b$ because multiplication is commutative, and it's also equivalent to $0.15b$ because $0.1 \cdot 1.5 = 0.15$.

3. Estimating a distance in miles when you know the distance in kilometers:
   a. Take the number of miles, double it, then decrease the result by 20%.

      If $m$ represents the distance in miles, this way of calculating can be expressed with $0.8(2m)$, and then $1.6m$ after multiplying. Alternatively, it can be expressed with $2m - 0.2(2m)$, which is equivalent to $1.6m$ after multiplying to get $2m - 0.4m$ and then combining like terms.

   b. Divide the number of miles by 5, then multiply the result by 8.

      This way of calculating can be expressed with $\frac{m}{5} \cdot 8$, which is equivalent to $0.2m \cdot 8$ because $\frac{1}{5} = 0.2$. After rearranging and multiplying, this is also equivalent to $1.6m$.

### Activity Synthesis

The goal of this discussion is to help students understand why situations can be represented by expressions with variables, and to identify properties that indicate two expressions are equal.

Display 2–3 approaches from previously selected students for all to see. Use *Compare and Connect* to help students compare, contrast, and connect the different representations. Here are some questions for discussion:

- *"How are the expressions the same? How are they different?"*
- *"Did anyone solve the problem the same way, but would explain it differently?"*
- *"How does the distributive property/combining like terms show up in each method?"*
- *"How do these different representations show the same information?"*

## Activity 2
## Which Way?

15 min

### Activity Narrative

In this activity, students use expressions with a variable to represent applying coupons in different orders. By analyzing these expressions, students learn that no matter how much we spend, we always pay $6 less if the 20% off coupon is applied first.

Monitor for how students are approaching the problem. If, once students have an answer, they have not written expressions with a variable to show the best way to apply the coupons, consider asking them to try writing an expression using a variable to represent the purchase amount.

Students may notice that if we spend less than $30, the store probably won't let us take $30 off. This is a possible constraint, and students who include this constraint are engaging in aspects of mathematical modeling.

### Launch

Tell students to close their books or devices (or to keep them closed). Display the two coupons for all to see.

Give students 1 minute of quiet think time and ask them to be prepared to share at least one thing they notice and one thing they wonder. Record and display their responses without editing or commentary. If possible, record the relevant reasoning on or near the images.

Things students may notice:

- There are two coupons to the same store.
- One coupon is for 20% off, and one coupon is for $30 off.

Things students may wonder:

- Can you use both coupons on the same purchase?
- Do the coupons expire?
- Is there a minimum or maximum amount you have to spend?

If no students wonder about using both coupons for one purchase, ask,

💬 *"What if you could use both coupons on the same purchase? Does it matter in what order you use them?"*

Tell students to open their books or devices and answer the questions.

**Instructional Routines**

**Notice and Wonder**

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### Access for Students with Diverse Abilities (Activity 2, Task Statement)

**Representation: Access for Perception.**
Provide appropriate reading accommodations and supports to ensure student access to written directions, word problems, and other text-based content.

*Supports accessibility for: Language*

### Student Workbook


2 Which Way?




You have two coupons to the same store: one for 20% off and one for $30 off. The cashier will let you use them both, and will let you decide in which order to use them.

- Mai says that it doesn't matter in which order you use them. You will get the same discount either way.
- Jada says that you should apply the 20% off coupon first, and then the $30 off coupon.
- Han says that you should apply the $30 off coupon first, and then the 20% off coupon.
- Kiran says that it depends on how much you are spending.

Do you agree with any of them? Explain your reasoning.

Learning Targets
+ I can write algebraic expressions to understand and justify a choice between two options.

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### Building on Student Thinking

If students have trouble getting started, suggest that they calculate which order is better for some specific purchase amounts.

### Student Task Statement



You have two coupons to the same store: one for 20% off and one for $30 off. The cashier will let you use them both, and will let you decide in which order to use them.

- Mai says that it doesn't matter in which order you use them. You will get the same discount either way.
- Jada says that you should apply the 20% off coupon first, and then the $30 off coupon.
- Han says that you should apply the $30 off coupon first, and then the 20% off coupon.
- Kiran says that it depends on how much you are spending.
- Do you agree with any of them? Explain your reasoning.

It is always better to use the 20% off coupon first

Sample reasoning:

- Let $x$ represent the amount of the purchase.
- 20% off is $0.8x$. $30 off that is $0.8x - 30$.
- $30 off is $x - 30$. 20% off that is $0.8(x - 30)$. By the distributive property, this is equivalent to $0.8x - 24$.
- Comparing $0.8x - 30$ to $0.8x - 24$, shows the resulting cost will always be $6 less if you use the 20% off coupon first.

## Activity Synthesis

The purpose of this discussion is to compare expressions to help students understand why the bill will always be $6 less if we use the 20% off coupon first.

If any students only computed their resulting cost using a specific dollar amount, ask them to present their solution first. For example, on a $100 purchase, this might look like:

- 20% off is $80. Then $30 off of $80 is $50.
- $30 off is $70. Then 20% off of $70 is $56.

So, if your purchase was $100, it's better to apply the 20% off coupon first. What about other purchase amounts? (If students tried other purchase amounts, consider also having them demonstrate. It is helpful if students see a few different examples that always result in a $6 difference.)

Select a student to present who wrote an expression using a variable for the purchase amount. If no students did so, demonstrate this approach. (See *Student Response*.)