Compare Costs of Gas-Only and Hybrid Cars

Grade 6

45 Min.

or

LESSON OBJECTIVE Students will use algebraic expressions to reason about costs of gas-only and hybrid cars.

LANGUAGE OBJECTIVES Students will use comparative and mathematical language to compare costs in real-world problems involving algebraic expressions.

PREREQUISITE SKILLS Students write and evaluate algebraic expressions.

Teachers can use the Imagine Math Standards Report and the Benchmark Performance Level Report to evaluate student readiness to complete this task.

COLLEGE AND CAREER READINESS STANDARDS FOR MATHEMATICS 6.NS.C.6.C

CCSS MATH	TEKS MATH	QSC
6.EE.A.2, 6.NS.C.6.C	6.4.D, 6.11	247, 274, 1031

Teacher Preparation

LESSON OVERVIEW Students write and evaluate algebraic expressions to compare total costs for gas-only and hybrid cars over 5 years. They use graphing to check their answers.

MATERIALS
- Base-10 blocks
- Vocabulary Knowledge Rating Sheet

Understand Science Background

In this task, students use algebraic expressions to model how gasoline prices affect the cost of gas-only and hybrid cars. Gas-only cars are traditional vehicles that run solely on gasoline fuel. Hybrid cars, on the other hand, use energy from an electric battery in addition to gasoline, so they can travel greater distances than gas-only cars with the same amount of gasoline. The premise of this Application Task is that hybrid cars will be more economical to own when gas prices are high and the time of ownership is more than a few years.

This premise is confirmed by auto industry analysis. For example, when gas is $3.50 per gallon, the cost savings of driving 12,000 miles per year in a hybrid car that gets 48 miles per gallon compared to driving the same distance in a similar gas-only car that gets 33 miles per gallon is $398 per year. When gas prices are $2.50 per gallon, annual savings are only $284. If the price of the hybrid car is $7,500 greater than the gas-only car, it would take more than 18 years to break even at $3.50 per gallon and more than 26 years to break even at $2.50 per gallon.

Teacher Tip: Collaborate with science, literacy, and history teachers to explore opportunities to expand cross-curricular experiences for students.

Although this task focuses on gas-only and hybrid cars, electric cars that run solely on energy from electric batteries are also rapidly gaining popularity due to technological advances. Predictions suggest that if gasoline prices increase, 1 in 6 cars sold globally will be electric by 2025.

Because gasoline prices have such a direct effect on the total cost of ownership, simple algebraic expressions with one variable representing factors such as gasoline cost per gallon or number of years of driving a car can be powerful tools for "What if?" analysis, which involves systematically changing variable values to model different constraints. The use of spreadsheets and other computer tools has made algebra-based analysis more accessible.

It is important, however, to point out that analysis based on one-variable algebraic expressions may oversimplify real-world problems. The car situation is a case in point, as there are other criteria, such as aesthetics and environmental impact, that affect decisions on the type of car that is purchased.

Pre-Task Class Activities

Engage in Discussion

Engage students in a discussion using their prior knowledge of and personal experiences with algebraic expressions. Guide the discussion toward how creating algebraic expressions can help people quickly calculate or estimate quantities to help students understand the **Essential Question**. Direct students to use the **Supporting Words** and **Comparative Language** on student pages 2 and 3 during their conversations. You may also use sentence stems to support your students' language usage in context.

Possible Discussion Topics

1. Discuss what makes a car environmentally friendly, including fuel efficiency, emissions, and pollution from manufacturing and batteries.
   - An environmentally friendly car _____.
2. In pairs, have students discuss what happens when the price of gas increases or decreases.
3. Have students think of a variable that affects an outcome in their daily life. Have students use this variable to write algebraic expressions that model the situations.
   - If gas prices increase, _____.
   - If gas prices decrease, _____.
4. Find, share, and discuss examples of real-world situations that can be modeled with algebraic expressions.
   - If _____ increases, then _____.
   - If _____ decreases, then _____.

Examples of Situations Where Algebraic Expressions Can Be Used as a Model
The effect of gasoline prices on car choices, consumer spending, and summer vacation plans.
The effect of food costs on family budgets, restaurant prices, and school lunch options.

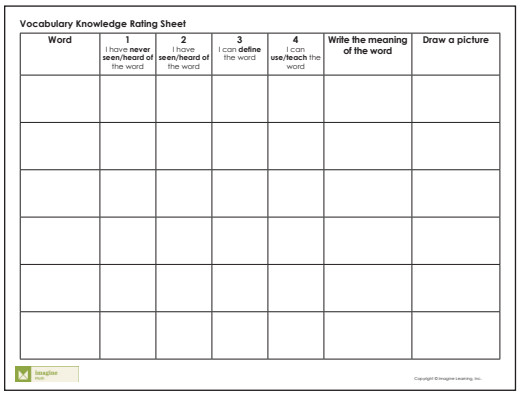
5. Use the **Understand Science Background** to explain the relationship between gas prices and car costs.
   - Cars that _____ are economical.
   - Cars that _____ are more economical.
   - Cars that _____ are most economical.

Review Vocabulary

Based on your students' language needs, use these activities to provide additional vocabulary support. Students should be prepared to meet the **Language Objective**.

Vocabulary Knowledge Rating Sheet

Ask students to choose four words from the **Supporting Words** and **Major Words** to write on a Vocabulary Knowledge Rating Sheet. Have students self-assess their knowledge of the words using the ratings 1–4 as shown on the sheet. Ask students to write what they think the word means in their own words. Then have them draw a picture of the word on their rating sheet.



Vocabulary Knowledge Rating Sheet

Word	1 I have never seen/heard of the word	2 I have seen/heard of the word	3 I can define the word	4 I can use/teach the word	Write the meaning of the word	Draw a picture

Cognates

Cognates are words from two different languages that share a common language origin. As a result, cognates often look or sound similar. The table shows some English and Spanish cognates from this lesson's vocabulary words. Cognates may similarly exist for other languages.

English	Spanish
algebraic expression	*expresión algebraica*
battery	*batería*
coefficient	*coeficiente*
constant term	*término constante*
economical	*económico*
electricity	*electricidad*
gasoline	*gasolina*
variable	*variable*

Additional Vocabulary Words

Every class has its own language needs. Based on your students' proficiency, you may wish to review some of the **Additional Words** used in this lesson. It may also be helpful to allow students to look up definitions of the **Supporting Words** and **Major Words** in their native languages.

ADDITIONAL WORDS

cost: an amount of money to be paid in exchange for an item or service

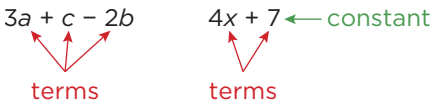
fuel: a material that produces heat or power by burning

gas mileage: the number of miles a vehicle can travel using a given amount of gasoline

power: a source of energy, often electrical

recharging station: a facility, often located on a street or in a parking lot, that provides electrical power, with a connection that electric vehicles can be plugged into to have their batteries recharged

term: each part of an expression between operation symbols



Review Math Concepts

Depending on the needs of the students, use these teaching strategies to review and verify students' ability to write and evaluate algebraic expressions. Throughout the math review, maintain focus on the **Essential Question**.

Jigsaw

Organize groups of 4 to 6 students. Students will work together to model the total cost of a field trip using algebraic expressions, with the variable in each expression representing cost per student. Groups should define the problem they are solving and write algebraic expressions for their models as well as analysis of their results. (Sample response: A class of 25 students has raised $500 for a field trip. They can rent 1 bus for $125 or 4 vans for $50 each. They use algebraic expressions to model costs per student for activities $10 and up, and the total cost including transportation.) Encourage groups to use tables to display results and to discuss their models using cloze sentences as necessary.

- The total cost for activities at x dollars per student is _____.
- The total cost including transportation is _____.
- We can spend $_____ **more** per student on activities if we _____.

Group members should work together to define the problem, write algebraic expressions, evaluate expressions, and analyze results. Upon completion, create new groups, mixing the original groups as much as possible with others. Instruct each group member to present their models with algebraic expressions and respond to questions from their new group members.

Algebraic Expressions

Using one of the student-created models from the **Jigsaw** activity or the Vocabulary Knowledge Rating Sheet, guide the whole class through creating an algebraic expression to model a real-world situation. Solicit student interaction to use the model to compare costs. Your completed models should resemble those in the **Sample Plan** and in **section B** in the lesson. Allow this model to remain on display throughout the task for student reference. A table with algebraic expressions for the **Jigsaw** sample response is presented here.

Activities Cost per Student ($) ($x$)	**Total Field Trip Cost ($)**	
	Bus $125 + 25x$	Vans $200 + 25x$
10	375	450
11	400	475
12	425	500
13	450	525
14	475	550
15	500	575

Given the $500 limit, the cost of activities can only be as high as $12 per student if vans are rented. With a bus, the cost can be as high as $15 per student, or $3 **more** per student.

The Application Task

Application Tasks are Performance Tasks where students apply their conceptual understanding and use procedural skills to solve a real-world problem. Application Tasks provide students the opportunity to demonstrate understanding and proficiency in multiple ways. Use the following ideas and modifications to ensure that students clearly understand the purpose, context, and constraints of the task. As students become more familiar with Application Tasks, less guidance may be needed.

Introduce the Essential Question

Direct students to the **Essential Question** on page 1. In this task, students will use algebraic expressions to solve real-world problems.

Make sure that students understand that the real-world problems in the **Essential Question** refer to the **Goal** of using algebraic expressions to reason about costs of gas-only and hybrid cars.

Analyze Instructions and Background

You may wish to provide support for students by reading and analyzing the instructions and background.

First, ask students to individually read the instructions beginning with "Hybrid cars have. . ." ***for context only***. Students will share with a partner their answer to the questions "What is the situation?" and "What do we need to find?" Note that these questions clarify the **Essential Question**: How can you use algebraic expressions to solve real-world problems? Provide the sentence stems below for additional language support. Circulate the room and assess student responses, providing appropriate feedback.

- This activity has to do with _____.
- I need to find _____.

Continue the class discussion as students read the remainder of page 1 and the **Background** information on page 2. Ask students to read the pages either independently or in groups and then answer the **Think about It** question. After reviewing these pages, students should be able to understand the **Goal** of using algebraic expressions to reason about costs of gas-only and hybrid cars.

Now, ask students to read or scan the first two pages again, this time ***for mathematical content***. Ask students to work with a partner to answer the questions "What numbers appear in the problem?" and "What do those numbers represent (including the units)?" Ask students to share their answers aloud. Provide appropriate feedback.

- Some numbers I will work with are _____, _____, and _____.
- These numbers represent _____ and are measured in _____, which means _____.

Then ask students to pay close attention to the constraints: "What limitations are given in the problem?" Students should also be able to answer "How does the **Sample Plan** meet the conditions set by the constraints?"

- One constraint is that _____ must be _____.
- The **Sample Plan** meets the constraints because _____.

Walk Through the Sample Plan

The **Sample Plan** on page 1 provides students with a worked solution to the task. While reviewing the **Sample Plan** with your class, elicit participation as much as possible. You may also need to clarify the information in the images and tables on pages 1 and 2.

The **Essential Question** asks us to use algebraic expressions to solve a real-world problem. Specifically, we need to reason about cost of ownership of gas-only and hybrid cars. Consequently, the **Sample Plan** begins by having students select two of the cars shown on page 1: one gas-only car and one hybrid car. In the Sample Plan, the gas-only car is Car 1, which has a price of $20,500 and a mileage rate of 20 miles per gallon, and the hybrid car is Car 4, which has a price of $24,000 and a mileage rate of 40 miles per gallon. Students will compare costs for the two cars over 5 years for gas prices of $2 per gallon and $4 per gallon.

In preparation for making comparisons, students complete the table in **section A** to help them write algebraic expressions for the cost of gas over x years for each of the five mileage rates of the cars on page 1, for gas prices of $2 and $4 per gallon. The following table is an abbreviated version of that table, for gas priced at $2 per gallon.

MPG	Cost per Mile ($) $2/gal ÷ MPG	Cost per Year ($) 15,000 × Cost per Mile	Cost After *x* Years ($)
20	2 ÷ 20 = 0.10	1,500	1,500*x*
25	2 ÷ 25 = 0.08	1,200	1,200*x*
40	2 ÷ 40 = 0.05	750	750*x*
50	2 ÷ 50 = 0.04	600	600*x*
80	2 ÷ 80 = 0.025	375	375*x*

The first step in completing the table is to find the cost of gas per mile for each mileage rate, which is $2 divided by the miles per gallon, shown in the second column. Look at the mileage rates for the two cars in the **Sample Plan**: 20 MPG and 40 MPG. At 20 MPG, the cost of gas is $0.10 per mile; at 40 MPG, the cost is $0.05 per mile.

The next step is to find the yearly cost of gas for an annual mileage of 15,000 miles, which is 15,000 multiplied by the cost per mile, shown in the third column. At 20 MPG, the yearly cost of gas is $1,500; at 40 MPG, the yearly cost is $750.

Finally, students use the costs per year to write algebraic expressions for the cost of gas after *x* years: yearly cost multiplied by *x*. At 20 MPG, the expression is 1,500*x*; at 40 MPG, the expression is 750*x*. Expressions for the cost of gas after *x* years at $4 per gallon are found in a similar manner, resulting in the expression 3,000*x* for 20 MPG and 1,500*x* for 40 MPG.

To compare total costs or cost of ownership, we need to include the cost of the car itself in each expression. Look at the table showing total cost for gas priced at $2 per gallon.

Years (*x*)	Total Cost with Gas @ $2/gal	
	Gas-Only Car $\underline{20{,}500} + \underline{1{,}500}x$	Hybrid Car $\underline{24{,}000} + \underline{750}x$
0	20,500	24,000
1	22,000	24,750
2	23,500	25,500
3	25,000	26,250
4	26,500	27,000
5	28,000	27,750

The expression for total cost after *x* years is the sum of the price of the car plus the cost of gas after *x* years. The expression for the total cost of the gas-only car after *x* years is 20,500 + 1,500*x*. Starting at *x* = 0, when the car has just been purchased and no years have passed, we substitute 0 for *x* in 20,500 + 1,500*x*: 20,500 + 1,500(0) = 20,500 + 0 = 20,500. This makes sense because the total cost of the car when it is new is $20,500 because gas costs have not yet accrued.

Next, we look at the result after 1 year has passed, where *x* = 1. Now the total cost is the initial price of the car, which is $20,500, plus 1 year of gas costs, which is $1,500. Substituting 1 for *x* in 20,500 + 1,500*x* gives that total: 20,500 + 1,500(1) = 20,500 + 1,500 = 22,000. We complete the table for both gas-only and hybrid cars, for 0 to 5 years.

Our last step is to determine when it becomes more economical to buy the hybrid car. In our model, this occurs when the total cost of the hybrid car becomes less than the total cost of the gas-only car. Looking at the previous table, we see that the total cost of the hybrid car is still more in year 4, but the total cost becomes less in year 5. Therefore, we can say that by year 5, it is more economical to buy the hybrid car. However, remind students that this total cost does not include electricity for charging the battery.

The same process is followed in the table below to find total costs when gas is $4 per gallon.

Years (*x*)	Total Cost with Gas @ $4/gal	
	Gas-Only Car $\underline{20{,}500} + \underline{3{,}000}x$	Hybrid Car $\underline{24{,}000} + \underline{1{,}500}x$
0	20,500	24,000
1	23,500	25,500
2	26,500	27,000
3	29,500	28,500
4	32,500	30,000
5	35,500	31,500

When gas is priced at $4 per gallon, the cost of the hybrid becomes less than the cost of the gas-only car sooner, between years 2 and 3. This supports the argument that higher gas prices make hybrid cars more economical.

Of course, a model based on a single-variable algebraic expression oversimplifies the situation. There are additional variables that contribute to the total cost of either car (see the **Watch Out: Common Misconceptions** section for a further discussion). Nevertheless, this single-variable algebraic model reaches a conclusion similar to the industry analysis described in the **Background** section. We have answered the **Essential Question**: How can you use algebraic expressions to solve real-world problems? This section of our task is complete!

Introduce Section A

Help students understand that the purpose of **section A** is to complete a table to calculate the cost of gas per mile at gas prices of $2 and $4 per gallon, as well as the cost of gas per year at a rate of 15,000 miles per year. They use these calculations to write expressions for the cost of gas after x years.

Modifications: Students who need help with calculations involving decimals may benefit from modeling problems with base-10 blocks, using hundred blocks for ones, ten blocks for tenths, and unit blocks for hundredths. If you are not using this task as an individual assessment, you could allow students to work in pairs on **section A**. Also consider discussing student responses as a class or in small targeted groups before continuing to **section B**. The **Talk about It** prompt on page 3, which asks about alternative problem-solving strategies, could lead to a productive and informative class discussion.

Introduce Section B

Help students understand that the purpose of **section B** is to complete two plans in which they complete tables comparing total costs for one gas-only car and one hybrid car after x years, for $x = 0$ to $x = 5$.

Modifications: Students who have difficulty completing **section B** may benefit from using addition and subtraction to see that the differences between values in adjacent rows are constant as x increases by 1. If you are not using this task as an individual assessment, consider asking students to make their tables on separate sheets of paper that you can later post around the room or in the hallway. You could also have a few students present their tables while the remainder of the class asks questions and provides constructive criticism.

Introduce Section C

Help students understand that the purpose of **section C** is to summarize results in a table by determining when it becomes more economical to buy a hybrid car than a gas-only car. They then connect their work to the overarching concept addressed in the **Essential Question** by explaining how their algebraic expression helps them reason about the total cost of ownership (purchase price of the car and cost of gas over time) of gas-only and hybrid cars.

Students should use the **Comparative Language** as well as **Supporting Words** and **Major Words** in their responses.

Modifications: If students struggle to understand why the hybrid car becomes more economical after a different time period, guide them through the sample table and compare the price for each car year by year.

Introduce Section D

Help students understand that the purpose of **section D** is to use graphs to check their solutions from their tables in the previous sections for reasonableness.

Modifications: Reinforce visual understanding by helping students analyze and use the graph to see the relationship between total costs for gas-only cars and hybrid cars over time. Explain that each point on the lines represents the price of the car after a specific number of years and that each line represents a different relationship: the total cost of the gas-only car over time and the total cost of the hybrid car over time. Remind students of their results from the previous section and ask them if they can recognize their conclusions in the graph.

Watch Out: Common Misconceptions

When writing an expression for total cost, students might include a variable in both terms of the expression. Explain that the cost of buying the car is a one-time expense, which makes it a constant term. On the other hand, the total cost for gas increases at a constant rate each year, so that term is a product of the rate and a variable representing number of years. Point out that although there are other recurring car costs such as repair and maintenance, total costs are being modeled only for the initial price of the car plus annual gas costs and does not include the cost of electricity for charging a battery or the cost for replacement of a battery.

Students may think they can only use graphs to check their work if they can graph ordered pairs at exact locations. Explain that graphs can also be used to visualize relationships in a more general way. Ask students to look at the **Sample Plan** for the $2 gas price. The total cost for the hybrid car is greater than the total cost for the gas-only car when $x = 0$, but when $x = 5$ the total cost for the hybrid car is less. By graphing each pair of points and connecting them with a line, students can verify that the hybrid car becomes more economical before 5 years have passed.

Sample Rubric

Score	Criteria
3	Students accurately complete the table of gas costs, including expressions, in **section A**. In **section B**, they create tables for two different plans and accurately explain their reasoning. Their answers in **sections C** and **D** accurately apply math concepts. Students use comparative language in their explanations, along with mathematical language.
2	Students complete the table of gas costs, including expressions, in **section A** with one error at most, and in **section B** they create mostly accurate tables for two plans and explain their reasoning with minor errors. Their answers in **sections C** and **D** apply math concepts with no more than one or two minor errors. Students use comparative language in their explanations, along with mathematical language.
1	Students complete the table of gas costs, including expressions, in **section A** with at least 50% accuracy, and in **section B** they create tables and explain their reasoning with at least 50% accuracy. Their answers in **sections C** and **D** are mostly inaccurate statements and demonstrate a limited understanding of math concepts. Students use mathematical language in their explanations, but they do not use comparative language.
0	Students present a very limited or rudimentary response to the assignment. They complete the table of gas costs, including expressions, in **section A** with less than 50% accuracy. They create tables and explain their reasoning in **section B** with less than 50% accuracy, and include very general or incomplete answers in **sections C** and **D**. Students do not use comparative language in their explanations, and they do not use mathematical language.

STEM Activity Suggestions

STEM OBJECTIVE Compare gas-only, hybrid, and electric vehicles based on evidence.

NGSS SCIENCE	SCIENCE AND ENGINEERING PRACTICE	MATHEMATICAL PRACTICE
NGSS MS-ETS1-2	SEP7	MP2

1. **Build Background** Over the past decade, hybrid and electric vehicles have been increasing in popularity. This rise in popularity may be due to the combination of many factors that are considered when a person is looking to purchase a car: initial cost, age of the car, city and highway gas mileage rates, cost of gas, comfort, convenience, distances that people drive, and environmental impacts.

   In the past, consumers who wanted to purchase a car that was economically friendly were often unpleasantly surprised by the high cost of hybrid cars that would produce a lesser amount of carbon emissions. However, these extremely high initial costs are becoming a thing of the past as manufacturers and government agencies around the world have worked together to reduce initial costs.

   There are additional factors to consider when purchasing a hybrid car though. Generally, most hybrid cars cost more to repair, have less power because of their smaller internal combustion engines, and their batteries have a high cost for replacement and are often inconvenient to recharge, taking 1 to 12 hours to recharge. Conversely, hybrid cars save on fuel, have higher gas mileage, have a higher resale value, and are more environmentally friendly, with reduced carbon dioxide emissions.

2. **Introduce the STEM Activity** In this activity, students will create a rating chart comparing gas-only, hybrid, and electric cars using five criteria of their choice. For each criterion, each vehicle type will be rated using a scale such as 1 to 5 stars. Criteria can include economic considerations (initial cost of the car, gasoline cost, electricity costs, replacement battery costs), environmental impact, convenience (battery charging time and locations), vehicle performance, vehicle appearance, and owner satisfaction. Comparisons for at least two criteria should be based on evidence over time and use algebraic expressions to represent changes for a variable number of years, miles, or other quantity. Rating charts should be created on poster boards or using technology with projection capability so that they can be displayed to the class. Students should be prepared to justify their ratings by providing additional evidence from their research.

3. **Guide Teams** Encourage students to investigate both the advantages and disadvantages of hybrid and gas-only vehicles. Point out that they can apply strategies used in the Application Task as they create their comparison charts.
   - The impact of hybrid cars includes the environmental and human costs associated with obtaining materials such as lithium and cobalt, used to manufacture the batteries. Recycling of batteries is also a consideration.
   - Driving habits can also affect performance and fuel efficiency of vehicles. In the Application Task, students made calculations based on average driving distances of 15,000 miles per year. For this activity, they may want to use algebraic expressions to represent varying annual driving distances.

4. **Assess Results** Evaluate how students use the evidence from their research in their rating systems (**NGSS MS-ETS1-2, SEP7**). Check that students have used algebraic expressions correctly and that they have provided reasonable and precise interpretations of their results (**MP2**).

MIT study
http://news.mit.edu/2016/study-finds-low-emissions-vehicles-less-expensive-overall-0927

Effect of gas prices on popularity of alternative-energy vehicles
http://www.roadandtrack.com/car-culture/buying-maintenance/a31723/why-hybrids-and-electric-vehicle-sales-are-rising/

Environmental impact of hybrid and electric cars
https://phys.org/news/2006-01-hybrid-cars-pros-cons.html

Student Page Masters

APPLICATION TASK | **Compare Costs of Gas-Only and Hybrid Cars**

Name: _____

Goal
Use algebraic expressions to reason about costs of gas-only and hybrid cars.

Language Objective
Use comparative and mathematical language to compare costs in real-world problems involving algebraic expressions.

Why Use Algebraic Expressions to Represent Costs?
You can change the value of the variable to show costs after different numbers of years.

Essential Question **How can you use algebraic expressions to solve real-world problems?**

Hybrid cars have better gas mileage than **gasoline** cars. However, the price of a hybrid car is usually more than a **gas-only car**. In this task, you will develop two plans to determine when it becomes more **economical** to buy a hybrid car than a gas-only car, after accounting for the cost of gas.

Constraints:

- Cars are driven 15,000 miles per year.
- Compare gas prices of $2 and $4 per gallon.

Car 1	Price: $20,500	Car 4	Price: $24,000
Type: Gas-only	MPG 20	Type: Hybrid	MPG 40
Car 2	Price: $17,000	Car 5	Price: $23,000
Type: Gas-only	MPG 25	Type: Hybrid	MPG 50
Car 3	Price: $18,000	Car 6	Price: $22,000
Type: Gas-only	MPG 25	Type: Hybrid	MPG 80

Hybrid cars use both **electricity** and gasoline as a power source.

MPG represents **m**iles **p**er **g**allon of gas.

MPG shown is for combined city MPG and highway MPG.

SAMPLE PLAN

Gas-only car: 1
Price: $20,500

Years (x)	Total Cost with Gas @ $2/gal	
	Gas-Only Car 20,500 + 1,500x	Hybrid Car 24,000 + 750x
0	20,500	24,000
1	22,000	24,750
2	23,500	25,500
3	25,000	26,250
4	26,500	27,000
5	28,000	27,750

Hybrid car: 4
Price: $24,000

Years (x)	Total Cost with Gas @ $4/gal	
	Gas-Only Car 20,500 + 3,000x	Hybrid Car 24,000 + 1,500x
0	20,500	24,000
1	23,500	25,500
2	26,500	27,000
3	29,500	28,500
4	32,500	30,000
5	35,500	31,500

Price of Gas	When does it become more economical to buy the hybrid car?
$2/gal	By year 5
$4/gal	By year 3

Did You Know? **Electric vehicles, including hybrid cars, have additional costs that include the cost of electricity to charge the battery and the cost of replacing the battery after 8 to 10 years.**

Background

Name: _____

Cars must receive some type of fuel or power to run. Two types of cars that use different power sources are hybrid cars and gas-only cars. A gas-only car is a car that is powered by gasoline only. A hybrid car uses gasoline as well as electricity from a **battery**.

A hybrid car generally has better gas mileage, miles per gallon, than cars that use gas only. Over short distances, hybrid cars can even run entirely on electricity from a battery, using no gas at all. Although hybrid cars are more expensive to purchase than gas-only cars, the total cost of ownership (purchase price plus total cost of gas) for hybrid cars can be more economical than gas-only cars, over a number of years, due to lower total gas costs.

However, there are additional costs associated with hybrid cars. This includes the battery replacement cost after 10 years, which can amount to thousands of dollars, and the cost of electricity used by plug-in hybrid cars for charging the battery each year.

For plug-in hybrid cars, there is also a convenience factor of the time it takes to recharge the battery and the hassle of finding a recharging station if a home charging station is not readily available. The number of charging stations is rapidly growing though, and many are now free.

Think about It How are hybrid cars similar to gas-only cars? How are they different? Use comparative language in your explanation.

A hybrid car and a gas-only car are similar because they both use gasoline as a power source and need to refuel. One difference between the cars is that a hybrid car can also be powered by electricity while a gas-only car cannot.

ACADEMIC VOCABULARY

Supporting Words

battery: a container that stores and converts energy into electric energy to be used as a power source

economical: operating at a good value, with little waste of money or by saving money

electricity: the flow of electrical power or charge that can be used to power machines or other devices

gasoline: a refined natural liquid that is used to power engines such as those found in cars

gas-only car: a car that is powered by gasoline only

hybrid car: a car that is powered by more than one power source, such as a gasoline engine and an electric motor

A | Understand

Name: _____

Solve a similar problem Complete the table to find the total gas cost when the gas price is $2 per gallon and when the price is $4 per gallon.

First, use the data on page 1 to find the cost of gas per mile and the cost of gas per year at a rate of 15,000 miles per year. Then write expressions for the cost of gas after x years. Some values are entered for you.

MPG	Cost per Mile ($) $/gal ÷ MPG		Cost per Year ($) 15,000 × Cost per Mile		Cost After *x* Years ($)	
	$2/gal	$4/gal	$2/gal	$4/gal	$2/gal	$4/gal
20	2 ÷ 20 = 0.10	4 ÷ 20 = 0.20	1,500	3,000	1,500x	3,000x
25	2 ÷ 25 = 0.08	4 ÷ 25 = 0.16	1,200	2,400	1,200x	2,400x
40	2 ÷ 40 = 0.05	4 ÷ 40 = 0.10	750	1,500	750x	1,500x
50	2 ÷ 50 = 0.04	4 ÷ 50 = 0.08	600	1,200	600x	1,200x
80	2 ÷ 80 = 0.025	4 ÷ 80 = 0.05	375	750	375x	750x

Think about It Use the vocabulary from page 4 to complete the sentence.

The total cost of gas for a car over a period of time can be modeled with an algebraic expression.

Explain your reasoning.

Sample answer: In the table, the total cost of gas for a car for a number of years was found by multiplying the cost of gas per year and the number of years, which is represented with a variable. Altogether, this product is an algebraic expression.

Explain It How can you write an **algebraic expression** for the total cost to buy a gas-only or hybrid car **and** the cost of the gas it uses after x years?

Sample answer: An algebraic expression can be written with two terms. The first term is a constant term that represents the price to buy the car. Then add a second term that represents the cost of gas for that car after x years.

Talk about It Talk about how to solve this problem with a partner. Discuss how the sample solution in ***section A*** meets the requirements of the task. Is there another way that you could solve the problem?

COMPARATIVE LANGUAGE

When comparing the choice of a hybrid or gas-only car, use comparative words like the following to justify your choice.

Adjectives

economical	more economical	most economical
good	better	best
low	lower	lowest
many	more	most

Adverbs

efficiently	more efficiently	most efficiently
fast	faster	fastest
little	less	least
well	better	best

B | Organize

Name: _____

In each plan, compare one gas-only car and one hybrid car shown on page 1.

Constraints

- Use information from ***section A*** to write expressions for the total cost of the car and gas after *x* years.
- Find total costs over 5 years at gas prices of $2 and $4 per gallon when a car is driven 15,000 miles per year.

Plan 1

Gas-only car: 2
Price: $17,000

Hybrid car: 5
Price: $23,000

Years (*x*)	Total Cost with Gas @ $2/gal		Years (*x*)	Total Cost with Gas @ $4/gal	
	Gas-Only Car 17,000 + 1,200*x*	Hybrid Car 23,000 + 600*x*		Gas-Only Car 17,000 + 2,400*x*	Hybrid Car 23,000 + 1,200*x*
0	17,000	23,000	0	17,000	23,000
1	18,200	23,600	1	19,400	24,200
2	19,400	24,200	2	21,800	25,400
3	20,600	24,800	3	24,200	26,600
4	21,800	25,400	4	26,600	27,800
5	23,000	26,000	5	29,000	29,000

Plan 2

Gas-only car: 3
Price: $18,000

Hybrid car: 6
Price: $22,000

Years (*x*)	Total Cost with Gas @ $2/gal		Years (*x*)	Total Cost with Gas @ $4/gal	
	Gas-Only Car 18,000 + 1,200*x*	Hybrid Car 22,000 + 375*x*		Gas-Only Car 18,000 + 2,400*x*	Hybrid Car 22,000 + 750*x*
0	18,000	22,000	0	18,000	22,000
1	19,200	22,375	1	20,400	22,750
2	20,400	22,750	2	22,800	23,500
3	21,600	23,125	3	25,200	24,250
4	22,800	23,500	4	27,600	25,000
5	24,000	23,875	5	30,000	25,750

Explain It In general, when does it become more economical to buy a hybrid car instead of a gas-only car?

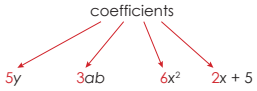
Sample answer: It becomes more economical to buy a hybrid car when the total cost of ownership for the gas-only car becomes greater than the total cost for the hybrid car.

MATHEMATICAL LANGUAGE

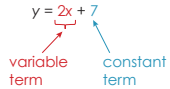
Major Words

algebraic expression: an expression, which may include numbers, variables, and operators, that contains at least one variable

coefficient: the numerical factor in a term of an algebraic expression



constant term: a term in an expression or equation that has a value that cannot change



variable: a letter or symbol used in equations, expressions, and inequalities that represents a number

Name: _____

C | Solve

Complete the table for each of your plans. Then compare the plans.

Plan	Price of Gas	When does it become more economical to buy the hybrid car?
1	$2/gal	After more than 5 years
	$4/gal	After 5 years
2	$2/gal	By year 5
	$4/gal	By year 3

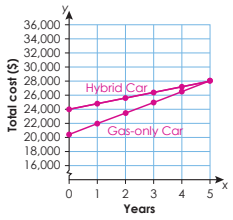
Explain It Using which plan is it more economical to buy a hybrid car?

Sample answer: It is more economical using plan 2 because the total cost of ownership for a hybrid car becomes less by the 5th year when gas is $2 per gallon and by the 3rd year when gas is $4 per gallon. Using plan 1, it only becomes more economical to buy a hybrid car after the 5th year when gas is $4 per gallon.

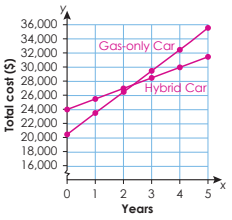
D | Check

You can check your solutions in ***section C*** by graphing. First, complete the graphs for the Sample Plan. Then, graph your own plans.

Gas $2/gal



Gas $4/gal



Explain It What will the graph for the Sample Plan look like if the work is correct? Explain.

Sample answer: The two lines will intersect between 4 and 5 years when the cost of gas is $2 per gallon, and the two lines will intersect between 2 and 3 years when the cost of gas is $4 per gallon.

CONNECT TO SCIENCE

Gas prices affect the total cost of ownership of a car over time.

How does an increase in gasoline prices affect the decision to buy a hybrid car rather than a gas-only car?

Sample answer: As gas prices increase, it becomes more economical to buy a hybrid car. It will cost less to operate a hybrid car that uses less gasoline to travel the same distance. However, this does not include the cost of electricity for the battery, nor does it include the cost of a new battery every 8–10 years.

How does annual driving mileage affect the relationship between car type and gasoline costs?

Sample answer: If you drive more miles annually, the total gas costs will be less with a hybrid than with a gas-only car.

Extend Find the total cost of ownership for both cars in each plan over a 10-year period instead of just 5 years. How do you think comparing costs over a longer period of time will affect the decision to buy a hybrid car rather than a gas-only car?

Sample answer: As the number of years increases, the total cost of a hybrid car will increase at a slower rate than the total cost of a gas-only car. However, the replacement cost of a battery may also need to be considered.

imagine Math

Compare Costs of Gas-Only and Hybrid Cars
Expressions and Equations | Grade 6

