



COMMUTER MATCH & MATH

Lesson Concepts: After matching various vehicles to their gas mileage, students will calculate the gallons of gasoline needed to travel 100 miles and the amount of carbon dioxide produced. Students will participate in a commuter activity that applies what they learned, and they must decide how to reduce the use of gasoline thereby reducing carbon dioxide emissions.

Learning Objectives — Students will be able to:

- Match various vehicles with their fuel economy and relate that to carbon dioxide production.
- Calculate the gallons of gasoline needed for the various vehicles to travel 100 miles and the carbon dioxide that is produced.
- Examine gallons per person and pounds of carbon dioxide produced per person for various vehicles.
- Apply what they learned to the Commuter activity.
- Decide what to do to increase fuel economy and reduce carbon dioxide production (rideshare, live close to work.)

Link to Air-The Search for One Clean Breath from Executive Producer Barbara L. Page

Motor vehicles cause about 33% of CO₂ emissions nationwide. In California, it's even more—about 41%. In this lesson, we explore the relationship between motor vehicles and greenhouse gases.



Materials

- Match & Math Day handouts
- Copies of vehicle cards and chance cards
- Large bag of jellybeans or dry beans, enough for 40 per student
- Three signs (Hometown, Center City, and Distantville)

Advanced Preparation

Match & Math Day: Make copies of the *Match and Math Activity* handout, one per student.

Commuter Activity Day: If your classroom is small you will need to play in a larger room or outside. Copy the two vehicle pages and cut along the lines so each cut rectangle has the information about a particular vehicle. Copy the chance cards and cut along the lines. Place the Hometown sign where the students will start the card. Count out 100 paces and place the Center City sign so it is visible. Count an additional 100 paces from Center City and place the Distantville sign so it is visible.

Time and Student Grouping

Two to three class periods; groups of two to three students

Grade Level: 6-12

California Science Standards

Grade 6, 6.a. Students know the utility of energy sources is determined by factors that are involved in converting these sources to useful forms and the consequences of the conversion process.

HS Earth Science 7.b. Students know the global carbon cycle: the different physical and chemical forms of carbon in the atmosphere, oceans, biomass, fossil fuels, and the movement of carbon among these reservoirs.

HS Life Science 6b. Students know how to analyze changes in an ecosystem resulting from changes in climate, human activity, introduction to nonnative species, or changes in population size.

HS Life Science 6d. Students know how water, carbon, and nitrogen cycle between abiotic resources and organic matter in the ecosystem and how oxygen cycles through photosynthesis and respiration.

California History Social Science Standards

Grade 9-12, 11.11. Students analyze the major social problems and domestic policy issues in contemporary American society.

National Science Standards

Grade 5-8 Science & Technology Content Standard E

Grade 9-12 Science & Technology Content Standard E

National Geography Standards

Grades 5-8, 14.3. How human actions modify the physical environment.

Education and the Environment Initiative Educational Principles and Concepts

Principle IV: The exchange of matter between natural systems and human societies affects the long-term functioning of both. As a basis for understanding this principle:

Concept a. Students need to know that the effects of human activities on natural systems are directly related to the quantities of resources consumed and to the quantity and characteristics of the resulting byproducts.

Concept b. Students need to know that the byproducts of human activity are not readily prevented from entering natural systems and may be beneficial, neutral, or detrimental in their effect.

Vocabulary

All WD—all wheel drive

Compact—small automobile

Coupe—two door automobile

High performance vehicle—car designed with specific performance capabilities above normal

MPG—miles per gallon

Sedan—four door automobile

Sub compact—smaller than a compact

SUV—sport utility vehicle

2WD—two wheel drive

4WD—four wheel drive

Teacher Background

Many things contribute to air pollution and the production of greenhouse gas emissions. In Ventura County, CA, transportation contributes more than half of the air pollution and greenhouse gas emissions. It is hard to determine the amount of air pollution that is produced by each vehicle because it depends on the type of engine and how well it is maintained. Fortunately, it is easy to determine the amount of greenhouse gas that is released by each vehicle. When gas is burned in the engine, oxygen atoms attach to carbon atoms from the gasoline to produce carbon dioxide. For each gallon of gasoline, which weighs 5.8-6.5 pounds, 19.42 pounds of carbon dioxide are produced. For a quick computation, one average mile of travel equals about one pound of carbon dioxide. When we breathe in oxygen, we produce carbon dioxide. A person produces about 2.3 pounds of carbon dioxide each day.

Procedure

Day 1:

Match and Math

1. Discuss how transportation produces more than half of the air pollution and greenhouse gases produced in Ventura County and 20-30% of the air pollution and greenhouse gases produced in the world. The amount of air pollution that a particular vehicle produces depends on the type of engine and how well it is maintained. However, it is easy to determine how much carbon dioxide (a greenhouse gas) a vehicle produces. For each gallon of gasoline that is burned, 19.42 pounds of carbon dioxide is released into the atmosphere. Students should ask how gasoline, which weighs 5.8-6.5 pounds, could produce 19.42 pounds of carbon dioxide when it is burned. As gasoline is burned in the vehicle engine, oxygen atoms from the air attach to the carbon atoms from the gasoline to produce carbon dioxide, hence the increase of weight. See the teacher tips for a kinesthetic and visual demonstration.
2. Give each student the *Match and Math Activity*. In groups, the students should match the vehicle with the miles per gallon. To avoid favoring any manufacturer or type of vehicle, general categories of vehicles are given. The number of passengers is based on comfortable seating and miles per gallon are an average of several vehicles.
3. Review the answers with the students. The correct answers can be put on the board or overhead.
Note: Students are guessing on this section so it should not be graded.
4. On the board, illustrate how to do the calculations for the *Match and Math Table*, depending on students' math levels.
5. Have the students do the calculations.
6. Assign the *Match and Math Questions* as homework.

Teacher Tips

For a kinesthetic experience, bring in an item that is about six pounds to represent one gallon of gasoline and one that weighs about 20 pounds to represent the CO₂ produced by one gallon of gasoline. For a visual, hold up a gallon sized container and compare it to 158.4 cubic feet (4484.5 liters) space (use meter sticks to construct a square with sides that are 5.4 feet) to show 19.42 times that amount.

Day 2:

1. Give each student a vehicle card. Have the students determine the pounds of carbon dioxide produced by their vehicle to travel 200 miles. Give each student 10 jellybeans or dry beans to represent 10 gallons of gasoline.
2. Using their vehicle card, have the students line up in order of MPG.
3. We will assume that one trip to Center City and back, 200 miles, is a week's worth of trips to work. Tell the students they are to "drive" their vehicles to work in Center City. Each step represents one mile when they walk toward Center City, which is 100 steps away. When they have gone enough steps to represent a gallon of gasoline used by their vehicle, they need to get rid of a jellybean or dry bean (eat or place in pocket).
4. Have students predict if their vehicle will be able to make the complete trip with ten gallons of gasoline.
5. **Round 1:** Have the students walk to Center City and back. When they have gone far enough to burn a gallon of gasoline, they must get rid of a gallon of gasoline. They must stop walking and stay where they are if they run out of gasoline.
6. Afterwards, have the students determine how many pounds of carbon dioxide they produced during the trip. They can also predict how many pounds of carbon dioxide they produced in one year, multiply by 52.
7. Discuss the results (amount of gasoline used, amount of gasoline left, and carbon dioxide produced) with the students. Also discuss the traffic (crowding) everyone encountered. Students can (eat) any extra gallons of gasoline.
8. **Round 2:** (Optional) Give the students 10 gallons of gasoline again and make predictions if they were to drive to Distantville and back. Have the students begin walking to Distantville and back. Again, once they have gone far enough to burn a gallon of gasoline they need to get rid of it. They must stop walking if they run out of gasoline. Repeat Steps 6 and 7.
9. **Round 3:** Issue 10 more gallons of gasoline. Challenge students to figure out a way to go as far as they can with their 10 gallons of gasoline. They can't purchase a new vehicle and they can't put more people in the car than is safe. If they decide to rideshare with someone, they can combine their gasoline. Riders give their 10 gallons of gasoline to the driver. If there was any left over gasoline after the trip, the gallons of gasoline should be divided up among the number of people in the vehicle.
10. Have students determine the amount of carbon dioxide not produced as a result of ridesharing. Subtract this amount of carbon dioxide from the amount that would have been produced from all of the vehicles if they had been driven separately to determine their emission reduction. To determine the carbon dioxide produced per person, divide the amount of carbon dioxide produced on the trip by the number of people in the vehicle. Groups must use data to prove their savings.
11. Discuss the results (amount of gasoline used and saved, and the amount of carbon dioxide produced and saved) with the students. Also discuss the traffic (crowding) everyone encountered.
12. Let each student select a chance card. Have the students read their Chance Card out loud to the rest of the class. Give students time to decide what to do based on their chance cards, while saving gasoline and producing less carbon dioxide.
13. Assign the Commuter Questions for homework.

Closure: Have students complete a quick write explaining what they learned from this lesson.

Assessment:

Match and Math Activity, Match and Math Table, Match and Math Questions, Commuter Questions

Extension:

More rounds of the commuter activity could be played and other variables could be introduced to the commuter activity. Students may even generate some of these variables.

Homework:

Match and Math Day: Assign the Match and Math Questions.

Commuter Activity Day: Assign the Commuter Question.

Resources:

Ventura County Air Pollution Control District: <http://www.vcapcd.org>

California Air Resources Board: <http://www.arb.ca.gov>

Related Web Sites:

USA Environmental Protection Agency: <http://www.epa.gov/OMS/index.htm>

Drive Clean: <http://driveclean.ca.gov>

Union of Concerned Scientists: http://www.ucsusa.org/clean_vehicles

Live Neutral: <http://www.liveneutral.org>

Pew Center: http://www.pewclimate.org/global-warming-basics/climate_change_101

Wikipedia: http://en.wikipedia.org/wiki/File:Greenhouse_Gas_by_Sector.png

Match and Math Activity

You will be doing several activities today. Follow the steps below.

1. Use the Match and Math table to match the following vehicle type to gas mileage.
2. Then fill out the table calculating the gallons of gasoline for 100 miles, pounds of CO_2 for 100 miles, average pounds of CO_2 for one year or 10,000 miles, gallons of gasoline per passenger for 100 miles, and pounds of CO_2 per passenger for 100 miles.
3. Answer the Match and Math Questions in complete sentences.

Vehicle Type and Number of Passengers		Miles per Gallon
Super sub compact	2	9
Sub compact	4	9
Coupe (2 door)	4	10
Sporty Coupe (2 door)	4	12
Small Sedan (4 door)	4	15
Large Luxury Sedan (4 door)	6	16
Small SUV	4	16
Large Luxury SUV	7	18
Small Sports Car	2	19
High Performance Sports Car	2	19
Small 4WD	2	19
4WD	5	25
Mini Van	7	25
Extended Van	13	27
Hybrid Car	4	33
Hybrid All WD	4	45

To avoid favoring any manufacturer or type of vehicle, general categories of vehicles are given. The number of passengers is based on comfortable seating and miles per gallon are an average.

Match & Math Table

Vehicle Type	Number of Passengers	Average Miles Per Gallon (for this activity)	Gallons of Gas for 100 Miles	Pounds of CO ₂ for 100 Miles	Average Pounds of CO ₂ for One Year or 10,000 Miles	Gallons of Gasoline Per Passenger for 100 Miles	Pounds of CO ₂ Per Passenger for 100 Miles
Super sub compact	2	33					
Sub compact	4	27					
Coupe (2 door)	4	25					
Sporty Coupe (2 door)	4	15					
Small Sedan (4 door)	4	19					
Large Luxury Sedan (4 door)	6	12					
Small SUV	4	19					
Large Luxury SUV	7	10					
Small Sports Car	2	18					
High Performance Sports Car	2	9					
Small 4WD	2	19					
4WD	5	16					
Mini Van	7	16					
Extended Van	13	9					
Hybrid Car	4	45					
Hybrid All WD	4	25					

Match and Math Questions

1. List the vehicles in order of pounds of carbon dioxide produced per 100 miles.
2. Explain the relationship between the miles per gallon and the pounds of carbon dioxide produced.
3. Most people drive an average of 10,000 to 20,000 miles each year. That means they are making about 100 to 200 trips of 100 miles each year. What are some ways to reduce the amount of carbon dioxide that is being released into the environment from vehicles?
4. List three advantages of ridesharing.
5. Which vehicle is best for you (or your parents) to drive? Why?
6. Producing a new vehicle produces a lot of carbon dioxide. It is easier on the environment to drive an older vehicle as long as it runs efficiently. If you were going to purchase a vehicle, what would you buy and why?
7. High performance vehicles, sporty cars, or luxury SUVs are expensive and can produce a lot of emissions. What is your feeling about this?
8. What have you learned from doing this activity?

Vehicle Cards

<p>Small SUV 4 passengers 19 mpg</p>	<p>Midsize SUV 4 passengers 17 mpg</p>	<p>Full Size SUV 7 passengers 14 mpg</p>
<p>Full Sized Luxury SUV 7 passengers 10 mpg</p>	<p>Super Sub Compact 2 passengers 33 mpg</p>	<p>Sub Compact 4 passengers 27 mpg</p>
<p>Coupe (2 door) 4 passengers 25 mpg</p>	<p>Sporty Coupe (2 door) 4 passengers 15 mpg</p>	<p>Luxury Coupe (2 door) 4 passengers 17 mpg</p>
<p>Small Sedan (4 door) 4 passengers 19 mpg</p>	<p>Midsize Sedan (4 door) 5 passengers 17 mpg</p>	<p>Full Size Sedan (4 door) 6 passengers 12 mpg</p>
<p>Midsize Luxury Sedan (4 door) 5 passengers 16 mpg</p>	<p>Full Size Luxury Sedan (4 door) 6 passengers 12 mpg</p>	<p>Super Luxury Sedan (4 door) 6 passengers 10 mpg</p>
<p>Small Sports Car 2 passengers 18 mpg</p>	<p>Large Sports Car 2 passengers 14 mpg</p>	<p>High Performance Sports Car 2 passengers 9 mpg</p>
<p>Small 4WD 2 passengers 19 mpg</p>	<p>4 WD 5 passengers 16 mpg</p>	<p>Large 4 WD 5 passengers 13 mpg</p>
<p>Small Wagon 4 passengers 19 mpg</p>	<p>Large Wagon 5 passengers 16 mpg</p>	<p>Mini Van 7 passengers 16 mpg</p>

Vehicle Cards

<p>Van 9 passengers 14 mpg</p>	<p>Extended Van 13 passengers 9 mpg</p>	<p>Small 2 WD Pickup 2 passengers 19 mpg</p>
<p>Small 4 WD Pickup 2 passengers 16 mpg</p>	<p>1/2 Ton Truck 5 passengers 14 mpg</p>	<p>3/4 Ton Truck 5 passengers 10 mpg</p>
<p>1 Ton Pickup 5 passengers 9 mpg</p>	<p>Hybrid Sedan 4 passengers 45 mpg</p>	<p>Hybrid All Wheel Drive 4 passengers 25 mpg</p>
<p>1960's Muscle Car 5 passengers 7 mpg</p>	<p>1970's Muscle Car 5 passengers 9 mpg</p>	<p>1950's Finned Car 6 passengers 8 mpg</p>
<p>Limousine 8 passengers 10 mpg</p>		
<p>Small Scooter 1 passenger 95 mpg</p>	<p>Big Scooter 1 passenger 53 mpg</p>	<p>Small Motorcycle 1 passenger 45 mpg</p>
<p>Large Motorcycle 2 passengers 36 mpg</p>	<p>Cruiser Motorcycle 2 passengers 34 mpg</p>	<p>Touring Motorcycle 2 passengers 32 mpg</p>

Chance Cards

<p>Your vehicle didn't pass the smog inspection. It is off the road.</p>	<p>Your vehicle didn't pass the smog inspection. It is off the road.</p>	<p>You forgot to put oil in the engine and it burned up. Your vehicle is off the road.</p>
<p>You forgot to put oil in the engine and it burned up. Your vehicle is off the road.</p>	<p>You have a new job and it is in Distantville.</p>	<p>You have a new job and it is in Distantville.</p>
<p>You just moved to Center City and bought a bicycle.</p>	<p>You just moved to Center City and bought a bicycle.</p>	<p>Your vehicle just got repossessed. Your vehicle is off of the road.</p>
<p>Your vehicle just got repossessed. Your vehicle is off of the road.</p>	<p>You just got promoted but you have to work in Distantville.</p>	<p>You just got promoted but you have to work in Distantville.</p>
<p>You had to buy tires for your vehicle. As a result, you only have \$5.00 for gasoline.</p>	<p>You had to buy tires for your vehicle. As a result, you only have \$5.00 for gasoline.</p>	<p>You just got a tune up and improved your gas mileage by two miles per gallon.</p>
<p>You just got a tune up and improved your gas mileage by 2 miles per gallon.</p>	<p>Your vehicle needs a tune up and your gas mileage has dropped by 2 miles per gallon.</p>	<p>Your vehicle needs a tune up and your mileage has dropped by 2 miles per gallon.</p>
<p>You put air in your tires and improved your gas mileage by 1 mile per gallon.</p>	<p>You put air in your tires and improved your gas mileage by 1 mile per gallon.</p>	<p>You broke your right leg and you can't drive your vehicle.</p>
<p>You broke your right leg and you can't drive your vehicle.</p>	<p>You move in with your parents in Distantville but work in Center City.</p>	<p>You move in with your parents in Distantville but work in Center City.</p>

Chance Cards

Distantville has cheaper rent so you moved there but work in Center City.	Distantville has cheaper rent so you moved there but work in Center City.	Your office closed but you keep your job. It is now in Distantville.
Your office closed but you keep your job. It is now in Distantville.	Someone ran into your vehicle and it is totaled. It is off of the road.	Someone ran into your vehicle and it is totaled. It is off of the road.
You return to college. Tuition is high. As a result, you only have \$5.00 for gas.	You return to college. Tuition is high. As a result, you only have \$5.00 for gas.	Your tires don't have enough air. Your gas mileage has dropped by 1 mile per gallon.
Your tires don't have enough air. Your gas mileage has dropped by 1 mile per gallon.	You saved your money and you can buy any vehicle you want. Select one.	You saved your money and you can buy any vehicle you want. Select one.
You modified your engine for racing and your mileage drops 5 miles per gallon.	You modified your engine for racing and your mileage drops 5 miles per gallon.	You inherited \$100,000! Decide what you want to do. New vehicle, move, etc.

Commuter Questions

After the commuter activity, answer the following questions in complete sentences.

1. What vehicle did you get? In reality, would you own this vehicle? Explain your answer.
2. What are the advantages and disadvantages of having this vehicle?
3. How did you save gas and the production of carbon dioxide in round three? How much carbon dioxide did you save?
4. What are the advantages and disadvantages of ride sharing?
5. What Chance Card did you receive? How did you feel about it?
6. What did you do as a result of your Chance Card?
7. Which Chance Card would you have preferred? Explain your answer.
8. Was this exercise realistic? Explain your answer.
9. How could you help reduce the production of carbon dioxide from passenger vehicles?
10. What new concepts did you learn from doing this exercise?

Match and Math Answer Key

Vehicle Type and Number of Passengers		Miles per Gallon
Super sub compact	2	33
Sub compact	4	27
Coupe (2 door)	4	25
Sporty Coupe (2 door)	4	15
Small Sedan (4 door)	4	19
Large Luxury Sedan (4 door)	6	12
Small SUV	4	19
Large Luxury SUV	7	10
Small Sports Car	2	18
High Performance Sports Car	2	9
Small 4WD	2	19
4WD	5	16
Mini Van	7	16
Extended Van	13	9
Hybrid Car	4	45

Match and Math Table Answer Key

Vehicle Type	Number of Passengers	Miles Per Gallon	Gallons of Gas for 100 Miles	Pounds of CO ₂ for 100 Miles	Average Pounds of CO ₂ for one year (10,000 Miles)	Gallons of Gas Per Passenger for 100 Miles	Pounds of CO ₂ Per Passenger for 100 Miles
Super sub compact	2	33	100 miles/ 33 mpg equals 3.03	3.03 Gal x 19.42 lbs equals 58.84	58.84 lbs x 100 equals 5,884	3.03/ 2 passengers equals 1.52	58.84/ 2 passengers equals 29.42
Sub compact	4	27	3.70	71.85	7,185	0.93	17.96
Coupe (2 door)	4	25	4	77.68	7,768	1.00	19.42
Sporty Coupe (2 door)	4	15	6.67	129.53	12,953	1.67	32.38
Small Sedan (4 door)	4	19	5.26	102.00	10,200	1.32	25.50
Large Luxury Sedan (4 door)	6	12	8.33	161.77	16,177	1.39	26.96
Small SUV	4	19	5.26	102.00	10,200	1.32	25.50
Large Luxury SUV	7	10	10	194.20	19,420	1.43	27.74
Small Sports Car	2	18	5.56	107.98	10,798	2.78	53.99
High Performance Sports Car	2	9	11.11	215.76	21,576	5.56	107.88
Small 4WD	2	19	5.26	102.00	10,200	2.63	51.00
4WD	5	16	6.25	121.38	12,138	1.23	24.28
Mini Van	7	16	6.25	121.38	12,138	0.89	17.34
Extended Van	13	9	11.11	215.76	21,576	0.85	16.60
Hybrid Car	4	45	2.22	43.11	4,311	0.56	10.78
Hybrid All WD	4	25	4.00	77.68	7,768	1.00	19.42