



One Less Mile Traveled.....

Objectives:

This lesson is designed to increase the awareness and understanding of air quality due to mobile source emissions and actions individuals can take to reduce these emissions.

The target audience for this program is the beginning or high school driver. If we influence these young drivers now, their actions could have a great effect on the environment and establish a lifetime of smart, environmentally sound driving habits.

When confronted with the facts of air quality due to mobile source emissions, along with financial implications, the student will recognize and implement various commuter choice strategies or (Transportation Demand Management (TDM)) to reduce traffic congestion and improve air quality.

The best fit into our existing science curriculum is varied. Currently, at the high school level, we teach environmental concepts in Ecology, Florida Science, Chemistry, Biology, Environmental Science and Advanced Placement Environmental Science. Several courses already have a “bulky “ curriculum and time to teach new topics is limited, but there still exists many avenues to insert these important concepts into the curriculum¹. Health classes and driver’s education classes may also find this lesson useful. Two lessons will be created. One lesson is for the Ecology curriculum and one for the Chemistry curriculum.

Background:

For many teenagers in high school, the ability to drive is a sign of liberation, a declaration of their maturity. This declaration is not cheap. Costs to the teenager, the parent, society and the environment are steep. Since young adults are going to drive and we can’t change that, we should concentrate on things that we can change.

At present in the United States:

- Motor vehicles are responsible for up to half of the ozone-forming volatile organic compounds and nitrogen oxides.
- Motor vehicles release more than 50 percent of the hazardous air pollutants.
- Motor vehicles release up to 90 percent of the carbon monoxide found in urban air.

¹ County Curriculum Guides by Subject Area

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Automobiles are a major source of air pollution in most areas. As our roads become more congested, our quality of life, the land we live on, and the air we breathe need to be protected.

Everyone in the country has an important part to play. Here are some suggestions:

- Use Public Transportation
- Carpool with Other Students
- Use a Skateboard
- Ride the School Bus
- Walk
- Ride a Bicycle
- Explore possibilities for other commuter choice alternatives²

Here are some driving tips for students (and their parents!):

1. Organize your trips. Driving fewer miles will help reduce air pollution.
2. Participate in a carpool and use public transportation: this reduces the number of cars on the road and the number of miles driven.
3. Get regular engine tune-ups and car maintenance checks.
4. Make sure your tires are properly inflated and your wheels aligned.
5. Consider buying fuel-efficient cars.

Skill(s)/Technique(s) developed:

The student will become aware of their effect on air quality and the environment through a series of exercises that have them:

1. Log their vehicle miles traveled.
2. Use the World Wide Web to gather data for calculations.
3. Calculate their financial cost per mile to operate a car.
4. Calculate the cost of the environmental impact of cars
5. Develop strategies for reducing driving costs.

² See Commuter Choice Toolbox
http://www.cutr.eng.usf/tm/comm_choice/css/comm_choice_5.htm

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Materials:

This lesson can be successfully completed with access to an automobile or information about driving habits and type of vehicle from friends, family members, etc. The use of a computer with Internet connection, a calculator and the forms provided by this lesson.

Requirements from the students:

The student will fill in and complete the following lesson.

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Ecology Lesson

The United States Environmental Protection Agency (EPA)³ states that transportation consumes 25 percent of the total energy used in the US. Cars are a major form of transportation for most people including teenagers. Car engines emit many different pollutants. (See Table 1) These pollutants contribute to the quality of air that we breath.

Table 1- Major pollutants in our air		
Pollutant	Sources	Health effects
Carbon monoxide CO	Motor vehicles, burning of fossil fuels.	Blood absorbs CO more readily than oxygen, reducing the amount of oxygen being carried throughout the body. Can produce tiredness, headaches and even death. People with heart problems are particularly at risk
Sulfur dioxide SO₂	Coal and oil burning power stations, mineral ore processing and chemical manufacture. Auto exhaust emission.	Attacks the throat and lungs. People with breathing problems can suffer severe illness
Nitrogen oxides NO_x	Fuel combustion by motor vehicles and other forms of transportation.	Affects the throat and lungs.
Volatile organic Compounds VOC	Motor vehicles, fuel combustion, solvent use.	Some VOCs cause eye and skin irritation, headaches or nausea, while some are classed as carcinogens
Ozone O₃	Formed from nitrogen oxides and hydrocarbons in sunny conditions. These chemicals are released by motor vehicles and industry.	Ozone attacks the tissue of the throat and lungs and irritates the eyes.
Lead Pb	Exhaust gases from motor vehicles that use leaded fuel, smelters.	Particles containing lead in the air can enter the lungs. The lead can then be absorbed into the blood stream. Over a period of time, lead can affect the nervous system and the body's ability to produce blood.
Particulates	Motor vehicles, burning plant materials, brushfires.	May cause breathing difficulties and worsen respiratory diseases. Some particles contain cancer-producing materials.
Carbon dioxide CO₂	Motor vehicles and all forms of combustion, respiration.	Has been linked to global warming and ozone depletion.

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Ecology Lesson- Part 1

³ <http://www.epa.gov/>

Air pollution is the contamination the air we breathe by the substances above. Automobiles contribute heavily to air pollution. Ask not what your environment can do for you, but what you can do for your environment.

The Clean Air Act (CAA) of 1970 started a vigorous campaign to maintain healthy air by controlling pollution. The amendments to the CAA in 1990 intensified national efforts to reduce air pollution in the United States. The CAA created many guidelines that auto manufacturers, industries, etc had to follow to improve public health, preserve property, and benefit the environment.

Lesson One: The student will look up “The Clean Air Act of 1970” and the amended CAA of 1990 and do following: List three changes that came about due to the regulations of The Clean Air Act.

- 1.
- 2.
- 3.

Should laws concerning the environment be regulated by the Federal Government or by local and state governments? Why?

*One
Eco*

How does your car stack up? This section will take several weeks of data collection and seeking out information. Most of this work should be done out of class during the student's free time. Using the chart below, fill in your mileage. This is also known as vehicle miles traveled (VMT).



One Less Mile Traveled... – “Awareness”

My personal VMT (Vehicle Miles Traveled) Log!

Date	Miles traveled	Date	Miles traveled
	Total		Total
Date	Miles traveled	Date	Miles traveled
	Total		Total

The total VMT for the month of _____ was _____ miles.
 On the average I drive _____ miles per day.

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Ecology Lesson- Part 3



What does it cost to drive your car?

Figuring your costs (Cost per mile)

1. Operating Costs- this is based on your miles traveled
 - a. gas, oil
 - b. repair and maintenance
 - c. tires
2. Ownership Costs- these occur regardless of the miles traveled
 - a. finance charges
 - b. depreciation
 - c. insurance
 - d. licenses, taxes and regulations

1. Operating Costs Calculations: An outline of how to calculate your cost to operate your car.

a. Gas and Oil

Calculation of Miles Per Gallon (MPG)- do this for one month!

Gallons Purchased	Cost	Odometer Reading

Total Gallons = _____ *Total Cost* = \$ _____ *Total Miles* = _____

To calculate the MPG divide *Total Miles* by *Total Gallons*

Your average MPG = _____

To calculate your cost per mile for gas divide *Total Cost* by *Total Miles*

Your cost per mile for gas = \$ _____

Calculation of Oil + Filter cost per mile- (recommendation 3000 miles or 3 months)

Date of Oil and Filter change	Cost	Odometer Reading

Total Cost = \$ _____ *Total Miles* = _____

You may have to record this data over several months (or use your best estimate).

To calculate your cost per mile for oil divide the Cost by Total Miles

Your cost per mile for oil = \$ _____

Your cost per mile for gas and oil (add gas and oil) = \$ _____

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Figuring your costs

b. Repair and Maintenance

Take an average of your repair costs over several months and divide by your miles. This includes routine work done plus any needed repairs.

Your maintenance cost = \$ _____. Total miles traveled = _____

Your cost for maintenance and repair per mile = \$ _____

c. Tires

This is how much it costs to purchase and maintain the tires on your car. This includes the purchase of tires only, not special rims, etc. (add to value of your car in Depreciation) or to fix the tires (Repair and Maintenance). You may use manufacturers suggested mileage for the tires you purchase.

2. Ownership Costs and Calculations: an outline of what is cost to own your car

a. Finance Charges

This is the cost of financing the purchase of your car. If you paid cash the charge is \$ 0. If you borrowed money to buy your car, this would be the interest or use this formula:

Loan amount \$ _____ + interest \$ _____ ÷ years of loan = \$ _____ yr.

b. Depreciation

The depreciation of your car is the difference between what you pay for the car and what you could sell it for. You can find the value of your car from Kelly Blue Book www.kbb.com. Subtract the projected trade in value from your purchase price and divide by the total miles driven since you owned the car.

Cost of your car when purchased \$ _____

Taxes paid (6.75%) of purchase price \$ _____

Value of your car now (Blue Book Value) \$ _____

Total miles drive since purchase _____ miles

Your cost for depreciation per mile is \$ _____

c. Insurance

This can be very expensive and is based on your age, sex, driving and academic record. Your insurance bill is usually in three parts: Liability (bodily injury and property damage), Personal Injury Protection (PIP) and Physical Damage (PD)(comprehensive-your car and collision-others car). There may be other charges such as uninsured motorists.

What is your total cost of insurance per month \$ _____. To figure your cost per mile, divide the Costs per month with the average miles traveled in a month*.

d. License, Taxes and Registration Fee⁴

This is the cost of your tag and registration (charged when your bought the car)

There is a one-time charge of \$100 to register a new car plus the cost of your license**

What did it cost for you license, taxes and registration per year? \$ _____

Now calculate how much this cost per mile. Total cost per year divided by 12 to get the cost per month, and then divide by total miles traveled.

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⁴ <http://www.hsmv.state.fl.us/dmv/faqmotor.html>

Your cost for registration and license per mile = \$ _____

Now we are ready to calculate the total cost per mile to own and operate your car! Enter the values from above and total your Operating Cost and your Ownership Cost in the chart below.

Operating Cost	Cost \$
Gas, Oil	
Repair and Maintenance	
Tires	
Operating Cost Total	
Ownership Cost	
Finance Charges	
Depreciation	
Insurance	
License, Taxes, Registration	
Ownership Cost Total	

Total cost per mile to operate your car \$ _____/mile

Look at the value that you just calculated and compare to the national average. According to The American Automobile Association (AAA)⁵ it costs between \$0.45.1 and \$0.62.3 per mile to drive your car. How does your cost stack up?

Let's calculate the cost to operate your car for 1 year. Take your average mileage for 1 month (_____ miles) x (12 months) x \$_____ (your cost per mile from above) = \$ _____
This is how much it costs you to operate your car for one year!

Total cost to drive for one year \$ _____

Part 3: Evaluation and TDM or What can you do?

Now that you are aware of the effects of driving an automobile on environmental air quality and that your car is very expensive to operate, what are some things that **YOU** can do to drive down your cost and help save the environment. The strategies to reduce vehicle miles traveled plus other secondary effects such as reduction of emissions, energy conservation and financial savings and congestion are called Transportation Demand Management (TDM) programs.

After a class discussion on ways to contribute to the improvement of air quality, complete the following assignment.

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⁵ http://aaasouth.com/acs_news/Driveco2.asp

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Teaching Suggestion:

Cut out one-inch squares and number them sequentially from 1 to total number of students in the class. Have each student select a square. Tell them that the even numbers between 2 and 10 are *pro* TDM and that the odd numbers between 1 and 9 are *con* TDM. All numbers above 10 are in the jury. They have two days to gather their data and prepare their arguments for a debate on the pros and cons of TDM programs.

An alternative assignment for students (absentees): Write a 300-word paper on various ways to reduce automobile emissions, and how they would implement these methods by considering the costs and sacrifices of each.

Useful Links:

http://onelesscarbellevue.org/sub/com_costcalc.shtml

<http://www.airhead.org/Calculator/>

<http://globalwarming.enviroweb.org/games/yourscore/yourscore2.html>

<http://www.environmentaldefense.org/system/template/page/focus.cfm?focus=3>

<http://www.epa.gov/otaq/transp/commuter>

<http://www.nsc.org/ehc/mse.htm>

http://www.epa.gov/teachers/curriculum_resources.htm

<http://www.epa.gov/OMSWWW/quiz/quiz-env.htm>

<http://www.nsc.org/ehc.htm>

cost calculator
shows auto emissions
CO₂ emissions
tailpipe tally
CMAQ (Air Quality)
driving habits
teacher lessons
environmental quiz

Cleaner Cars A-Teaching Module

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One Less Mile Traveled....

Chemistry Lesson

To be an informed (and healthy) citizen you should be aware of the air that you breathe. You should know the what pollutants are present, how they got there, why they are harmful to your health and what can be done to make the air safer.

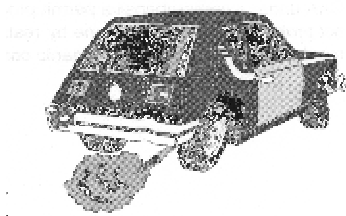
The air that you breathe consists of five basic substances. Nitrogen, oxygen, carbon dioxide, argon and water are all gases that you breathe in from the air around you every minute of your life.

Table 1: The Air We Breathe

Component of Air	Relative Abundance
Nitrogen	78.00 %
Oxygen	21.00 %
Carbon Dioxide	0.03 %
Argon	0.90 %
Water Vapor	0.07 % (varies)

The air that we breathe also includes pollutants. Toxic pollutants like carbon monoxide, sulfur and nitrogen oxides and ozone. These are very common in urban areas where most of us live and attend school. For the most part these substances are formed by chemical reactions involving fossil fuels that are used in factories, power plants and automobiles.

Technology and governmental regulations have resulted in reduction of many of these pollutants, but everyday more cars are purchased and the total numbers of automobiles is increasing at an alarming rate and we are also driving more. Driving contributes to air pollution and smog, exacerbating respiratory problems and obscuring scenic vistas. Vehicles also produce greenhouse gases that contribute to global warming. By taking a few simple steps, motorists can make travel lighter on the environment and lighter on the budget.⁶



This chemistry experiment accompanies *One Less Mile Traveled....*

⁶ <http://www.environmentaldefense.org/article.cfm?ContentID=2062>

More Than Just Hot Air

This is an experiment in detecting the components in automobile exhaust emissions, primarily carbons dioxide.

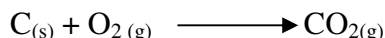
Introduction:

Combustion or burning is the rapid combination of oxygen with another material. For example, the burning of sulfur and hydrogen produces sulfur dioxide (SO₂) and water vapor (H₂O).

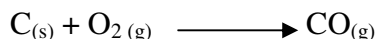
Combustion is a major type of chemical reaction. A **chemical reaction** is a process by which substances (reactants) are transformed into different substances (products). This is best represented in the form of a chemical equation:



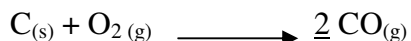
In another example, charcoal (carbon) is burned in air to produce carbon dioxide. The subscripts (s), (g), and (l) stand for the state of the substance (solid, gas, liquid). This is the equation for burning charcoal:



In the above equation you notice that matter is conserved. This means that the number and kinds of atoms on each side of the equation are equal. This is called **conservation of matter** and the result is a "balanced" chemical equation. During a chemical reaction, chemical changes occur and this may change the products. For example, if the amount of oxygen is limited in the above chemical reaction, **incomplete combustion** will occur. This is the equation for incomplete combustion of charcoal:

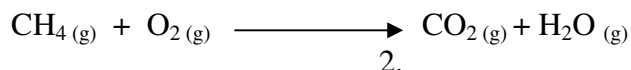


You will notice that the number of atoms on each side is not equal. This means that the equation needs to be balanced to make both sides the same.



The equation is now balanced and the number of atoms on each side of the equation is the same.

The burning of petroleum in automobiles is a **combustion reaction**. Many fuels, including those found in petroleum, are **hydrocarbons**. Hydrocarbons contain the elements hydrogen and carbon in varied proportions. When a hydrocarbon burns completely, all of the carbon combines with the oxygen to form carbon dioxide and all of the hydrogen combines with oxygen to form water. The complete combustion of methane gas (CH₄) is shown:



More Than Just Hot Air – An Experiment

Review Questions:

1. *What are the reactants in the equation for the combustion of methane?*
2. *What are the products?*
3. *Is matter conserved?*
4. *If not, show the balance the equation in the space below.*

Purpose:

The students will recognize the characteristics of complete and incomplete combustion reactions, demonstrate the ability to balance chemical reactions, correctly perform various laboratory techniques and apply the knowledge gained in discussing the effect of automobile emissions on the quality of the air we breathe.

Materials:

Collecting apparatus

- 6 “ plastic funnel
- 2 - feet of $\frac{3}{8}$ ” plastic Nagalene hose
- 1- # 8 two hole stopper
- 3- # 8 no hole stoppers
- 1- 18” pc. $\frac{3}{8}$ ” hollow glass tubing
- 1- 12” pc. $\frac{1}{4}$ ” hollow glass tubing
- 4- 250 mL wide mouth gas collecting bottles

Chemicals

- bromothymol blue (btb) indicator solution- 250 mL
- 0.05 N NaOH solution – 200 mL with dropper bottle

Procedure:

In this lab you are collecting gas emissions from three sources: humans, automobiles, and the laboratory. You will collect these gases by bubbling them in water. Then the partially dissolved gases will be tested using indicator solution to determine the difference, if any, in the amount of dissolved gases.

1. Assemble the collection apparatus (see diagram)
2. Pour 200 mL of distilled water in each of the four gas collecting bottles and stopper with the #8 no-hole stoppers.
3. Assemble the collection apparatus.
4. Collect your exhaled air by removing the funnel, placing the collection apparatus on bottle #1 and exhaling strongly for five seconds into the bottle. Replace the original stopper and label the bottle “exhaled air”.

3.

More Than Just Hot Air – An experiment

- Proceed outside to the automobile. Replace the funnel on the collecting apparatus. While the car is **NOT** running, practice placing the funnel over the exhaust pipe of the auto (cars with a single, flat exhaust pipe work best). Be sure that the funnel makes a good seal. Start the car with the parking break on and the transmission in Park (neutral for standard transmissions). Remove the stopper from bottle #2 and attach the collection apparatus securely. Be sure that you have on you safety goggles, lab coat, thermal gloves and mask at this point. Carefully place the funnel over the exhaust and collect gas from the auto for exactly 5 seconds. Place the original stopper back on the collection bottle and label the bottle "auto exhaust".
- Return to the lab and attach the hose of the apparatus to the carbon dioxide container and collect gas for 5 seconds from the container. Label the bottle "pure CO₂".
- The fourth bottle of water should remain untouched. This is your control.
- Place all four of the gas collecting bottles on the lab table and one at a time, open then and add 5 mL of bromothymol blue indicator solution. Replace the stopper and shake well. *Record* the color of each samples in the data table.
- You are now going to add the 0.05 N NaOH dropwise to each of the solutions, noting the number of drops and recording this value in the data table. *Caution:* NaOH is a strong base. Avoid contact with the skin and be sure that you have on you safety goggles and lab coat.

Data:

Data table:

	contents	color with indicator	# drops to change color
Bottle # 1	exhaled air	_____	_____
Bottle # 2	car exhaust	_____	_____
Bottle # 3	pure CO ₂	_____	_____
Bottle # 4	control	_____	_____

Questions:

- How does your data compare with others in the class?
- Why do you think that there was a color change?
- Which of the bottles needed the most drops of NaOH to elicit a color change? Which bottle took the least to change?
- One of the most widely used hydrocarbons in automobiles is *gasoline*. Gasoline is a mixture of many **organic compounds**

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(compounds that contain the element carbon). One of the compounds in gasoline is *octane*, C_8H_{18} . If a sufficient supply of oxygen is available, the combustion reaction in the automobile would be: _____.

(write the unbalanced chemical equation for the combustion of octane)

- Using your knowledge of balancing chemical equations, balance the above combustion reaction.

-
- If there was not enough oxygen, incomplete combustion would occur. Write the balanced chemical equation for the incomplete combustion of octane.

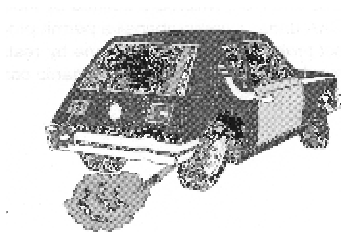
- Carbon dioxide (CO_2) is relatively harmless to humans while Carbon monoxide(CO) is not. What are some of the harmful effects of exposure to CO ?

Conclusion:

The modern high performance automobile, capable of operating at high speeds and with fast acceleration, is a source of carbon monoxide and some incomplete fragments of gasoline molecules. There is either insufficient oxygen present or insufficient time in the cylinders for all of the hydrocarbons to be burned to carbon dioxide and water.

Compare and contrast several engineering breakthroughs of the automobile industry that helped eliminate this incomplete combustion and why new cars pollute less than old cars.

The automobile is currently the source of the nation's most serious air pollutants, NO_x and O_3 . Make a list of things you can that YOU can do to reduce pollution and improve air quality. Think hard, the bigger your list the more you are aware of what YOU can do.



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