The FUTURES Channel®

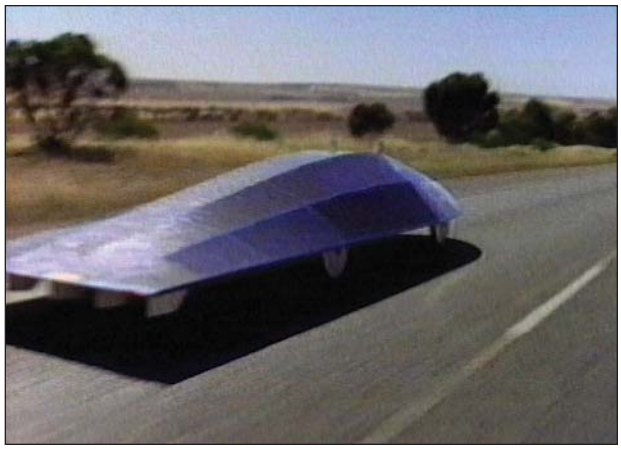
MOVIE GUIDE

MOVIE NUMBER 1001

Solar Powered Cars

The Movie:

Using the energy it takes to run a hair dryer, this solar-powered car travels 200 miles at speeds of 50 to 65 mph. Featured: Raymond Landis, Professor, Cal State L.A.; Derrick Hamilton, Student, Cal State L.A.; Kitty Rodden, Student, Cal State L.A. *(Movie length: 3:35)*



Background:

Though it's unlikely that we will be driving solar-powered cars to work in the near future, the solar car races that occur in the U.S. and around the world provide context and motivation for the development of new energy and transportation technologies that are already finding their way into commercial vehicles. To be competitive, entries must use efficient, lightweight solar cells, a body design that minimizes air resistance, highly efficient motors and drive trains, bodies made of high-tech composite materials which provide great strength for low mass, and high-efficiency, low-weight batteries.

Curriculum Connections:

Fractions 1

The top of one solar car has an area of 3-3/4 square meters. Solar cells cover 3-1/3 square meters of that area. How much area is not covered by solar cells?

Fractions, Measurement (speed) 2

A solar car gets the most energy from the sun when it is directly overhead. Unless the car uses batteries to store the energy, that is also the time it can go the fastest.

a) What fraction of its top speed is this car going at the times shown in this chart? The first answer is given.

Time	Speed (in miles per hour)	Fraction of top speed
9 A.M.	55	55/80 = 11/16
10 A.M.	65	
11 A.M.	75	
12 A.M.	80	
1 P.M.	72	
2 P.M.	66	
3 P.M.	56	

b) At which times is the car going faster than 9/10 of its top speed?

Decimals, Percents 3

The top surface of a solar-powered car has an area of 2.45 square meters. Solar cells cover a rectangular area on the roof which is 0.8 meters x 2.0 meters. What percent of the roof is covered with solar cells?

Decimals

4

When you build a car or other machine, it is important that all of the parts be the right size, so they fit together. A part can be only a little bigger, or a little smaller, than the size it is supposed to be.

For example, an axle might be required to have a diameter of 3.370 inches, *plus or minus* 0.015 inches. This means that the diameter must be no smaller than 3.355 inches (3.370 - 0.015) and no larger than 3.385 inches (3.370 + 0.015).

Find the missing information for these parts:

Part	Size	Plus or Minus	Largest allowed size	Smallest allowed size
Gear	Diameter = 0.450 in.	0.013 in.	?	?
Windshield	Height = 22.95 in.	0.08 in.	?	?
Motor Support	Length = 38.40 in.	?	38.52 in.	38.38 in.
Axle	Length = ? in.	0.18 in.	?	85.22 in.

Percents

5

The bodies of solar cars are usually made of special materials, called *composites* because they are a mixture of simpler materials. Suppose you need 25 pounds of composite material to make a car body. Use the information in these two charts to compute the total cost of the materials for composite "A" and composite "B".

Component	% in Composite "A"	% in Composite "B"
Carbon Filters	20%	25%
Fiberglass	50%	60%
Kevlar	30%	15%

Material	Cost per pound
Carbon Filters	$200
Fiberglass	$50
Kevlar	$500

Percents, Ratios

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When energy is changed from one form to another, only some of the energy is changed into the type of energy wanted. The rest is changed to heat or some other form. For example, when sunlight strikes a solar cell, the cell might convert only 15% of the sun's energy into electricity and the rest is reflected away or turns into heat energy.

The ratio of "desired energy out" to "energy in" is called *efficiency.*

Suppose that for a certain solar car, the solar cells convert sunlight to electricity with an efficiency of 20%, and the motor and drive train convert that electricity into the motion of turning the wheels with an efficiency of 54%. What is the overall efficiency for the conversion of the energy of sunlight into the energy of the turning of the wheels?

Ratios

9

Suppose that, for a certain solar car, the motor rotates once for every 2.6 revolutions of the wheels (after the car has reached its top speed). If the wheels will revolve 16,000 times in the course of a race, how many rotations of the motor will occur?

Measurement (speed)

10

In a trial run, a solar-powered car traveled 2.5 miles in 3 minutes. Convert this to miles per hour, then to kilometers per hour.

Ratios

6

Suppose you purchase 150 solar cells, but when you test 20 of them, you find that 3 are bad. If that ratio held true for the remainder of the cells, how many of the 150 solar cells would you expect to be bad?

Percents, Ratios

7

A certain type of solar cell costs $10 each, and converts 17% of the solar energy that strikes it into electrical energy. Another cell costs 10% more than the first one, but converts 21% of the solar energy that strikes it into electrical energy. Which cell gives the most energy per dollar spent?

Hint: Assume that 100 units of solar energy strike both cells, and find the ratio of "electrical energy out" to "cost" for each cell.

Measurement (speed)

11

A solar car ran a race from 9:00 A.M. until 4:00 P.M. During the first two hours, when the sun was not overhead, the car averaged 54 miles per hour. During the next two hours, with the sun nearly directly overhead, the car averaged 68 miles per hour. If the total length of the race is 390 miles, what speed would the car have to average in the last three hours in order to complete the course before 4:00 P.M.?

Measurement (length, area) 12

Determine the total surface area of the roof, hood and trunk of an actual car.

Measurement (weight, mass) 13

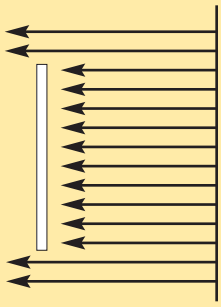
A certain type of solar cell weighs 4.55 ounces. How many such cells would weigh 80 pounds?

Geometry (polygons, circles) 14

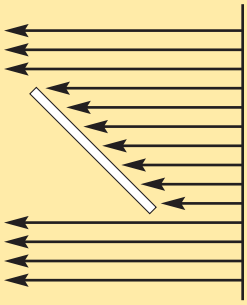
A designer wants to have 1.5 square meters of solar cells on the roof of his car. If the cells are arranged in a rectangular pattern, what could its dimensions be? A trapezoidal pattern? A triangular pattern? A circular pattern?

Geometry (angles) 15

Use a simple paper-and-pencil model to show how the intensity of sunlight that falls on a surface depends on the angle at which the light strikes the surface:



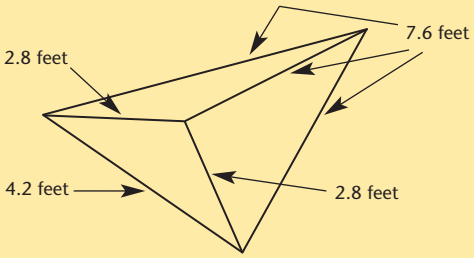
When the surface is perpendicuar to the rays, it intercepts 10 of them.

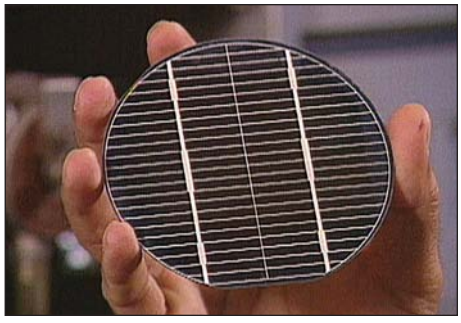


When the surface is at 45° to the rays, it intercepts 7 of them.

Geometry (solid figures) 18

This solar car body design is a triangular pyramid. What is its surface area?





Geometry (circles) 16

Suppose you purchase a batch of circular solar cells, each 10 cm in diameter. What's the best way to arrange them so that you get the maximum number in a rectangular area, and how many cells could you pack into a rectangular area of dimensions 1 m x 1.45 m?

Geometry (circles) 17

The wheels chosen for a solar-powered car have a diameter of 28 inches. These are special wheels and should be lubricated every 100,000 revolutions. Will lubrication be required during a race that lasts 200 miles?

Probability 19

Suppose your solar car has batteries that allow it to run for two days without sunlight. If you live in an area which is overcast one day out of three in November, what is the probability that you will have three straight days with no sun during that month? (Assume that the weather each day does not depend on what the weather was the day before.)

Statistics 20

Solar cells do not last forever. This chart shows the time-to-failure for 10 solar cells. Find the mean, range, mode and median, and explain why the median and mode are higher than the average.

Cell #	Time-to-failure (nearest thousand hours)
1	12,000
2	12,000
3	1,000
4	12,000
5	13,000
6	14,000
7	1,000
8	15,000
9	13,000
10	16,000

Algebra (variables) 21

- Amount of surface area covered by solar cells
- Amount of solar energy that is collected
- Amount of energy stored in the battery
- How much power is supplied by the engine
- Amount of wind resistance
- The top speed of the car
- Rate of acceleration of the car
- Weight of the car
- Amount of friction
- Angle of the sun in the sky

Algebra (patterns, relations and functions) 22

- The amount of solar energy collected is a function of the amount of surface area covered by solar cells.
- The top speed of the car is a function of how much power is supplied by the engine. It is also a function of the amount of wind resistance, the amount of friction, and the weight of the car.
- The amount of power that can be supplied by the engine will depend on how much energy is in the batteries and the amount of solar energy that is collected.
- The amount of electricity generated by a solar cell depends on the angle at which light strikes it.
- The maximum velocity that a solar-powered car can achieve *(v)* is related to the number of solar cells on it *(n)* by this equation:

$$v = k \cdot \sqrt[3]{n}$$ where k is a constant.

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