The FUTURES Channel

MOVIE GUIDE

MOVIE NUMBER 1012

Bicycle Design

The Movie:

Making bicycles that are strong enough for stunts requires the right combination of triangles and circles. Featured: Forrest Yelverton, designer, GT bikes; Jorge Valencia, Factory Manager, GT Bikes. *(Movie length: 2:32)*

Background:

An Olympic athlete can run a mile in under 4 minutes, which translates to around 15 miles an hour. Is there a way to take the same energy source—the human body—and get it up to a speed of 30 miles an hour for several days in a row? There is—it's called a bicycle.

More than just a quick way to get from here to there, the bicycle is also the most efficient form of transportation we have, converting fuel to motion with an energy efficiency far better than that of an automobile. Bicycles are also zero-pollution vehicles, and quite inexpensive to own and maintain.

For all their advantages, bicycles are not the vehicle of choice for most people's morning commute. But they are very popular for recreation and sports, and come special-built for anything from bouncing over rocky terrain to speeding through European villages in the *Tour de France*. All of which calls for quite a bit of design, engineering, and manufacturing skill.

Curriculum Connections:

Measurement (speed), Decimals 1

One athlete posted the following speeds on each leg of a bicycle race route. What was her average speed for the entire course?

Leg	Speed (mph)	Distance (mi.)
1	26.3	7.8
2	28.5	5.6
3	31.4	4.9
4	22.4	2.4
5	25.6	9.2

Fractions 2

Suppose that the costs for parts for manufacturing a bicycle were as given in this table. Does the frame cost more or less than 2/5 of the total cost of parts?

Wheels	$18.00
Frame	$35.00
Seat, pedals, handlebars	$12.00
Gears and chain	$25.00

Ratios 3

Bicycles must be both strong and light, so the materials that they are made of must also have those qualities. This chart compares the strengths and weights of several metal tubes of identical size and shape but different compositions. (Strength is measured as how many pounds the tube can support without being bent out of shape.) Fill out the third column of the chart, the strength to weight ratio.

Strength of tube (amount of weight supported, in pounds)	Weight of tube (pounds)	Strength to weight ratio
560	4.3	
672	4.7	
320	2.5	
480	3.5	
870	6.3	

Ratios, Circles 4

Pedal gear

Rear wheel gear

In this diagram, the pedal gear has a diameter of 4 inches, and the rear wheel gear has a diameter of 7 inches. The tires on this bicycle have a diameter of 25 inches. How far will the bicycle move when the rider turns the pedals one complete revolution?

Ratios, Geometry (circles) 5

In a certain ten-speed bicycle, the gear diameters are as indicated.

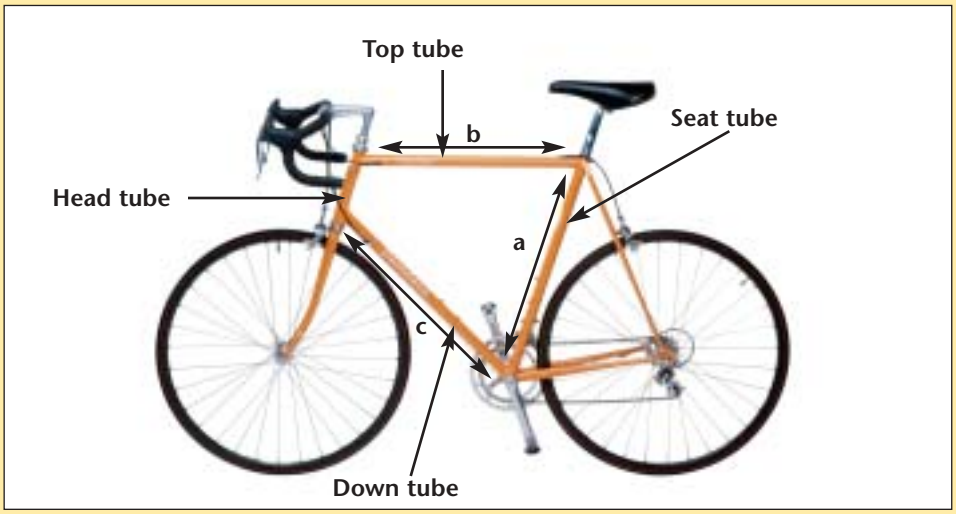
Pedal gear:	**Rear wheel gear:**
1) 2.5"	A) 3.75"
2) 3.75"	B) 5"
	C) 7"
	D) 8"
	E) 10"

a) For which combination of gears will it take four rotations of the pedals to give one rotation of the rear wheel? For which combination will 2 rotations of the pedals yield a little more than one rotation of the rear wheel?

b) With pedal gear 2 and rear wheel gear D engaged, how fast will the bicycle be going if the rider is turning the pedals at 80 revolutions per minute and the wheel diameter is 25 inches?

Measurement, Ratios, Angles 6

This picture of a bicycle frame is 1/15 the scale of the actual bicycle. Find these dimensions for the actual bicycle: ***a, b, c,*** angle between seat tube and top tube, angle between seat tube and down tube.



Ratios, Geometry (angles) 7

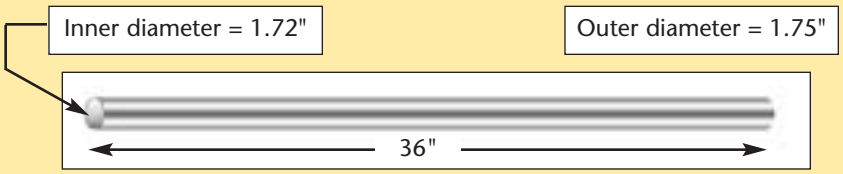
Solve these problems by drawing:

a) If the top tube for the bicycle pictured above were lengthened by 6 inches, how much longer would the down tube have to be so that the seat tube to top tube angle didn't change?

b) Modify the frame so that the seat tube is exactly vertical without changing the length of the top tube or seat tube.

Cylinders, Measurement (density), Decimals 8

a) What is the volume of steel used in this tube?



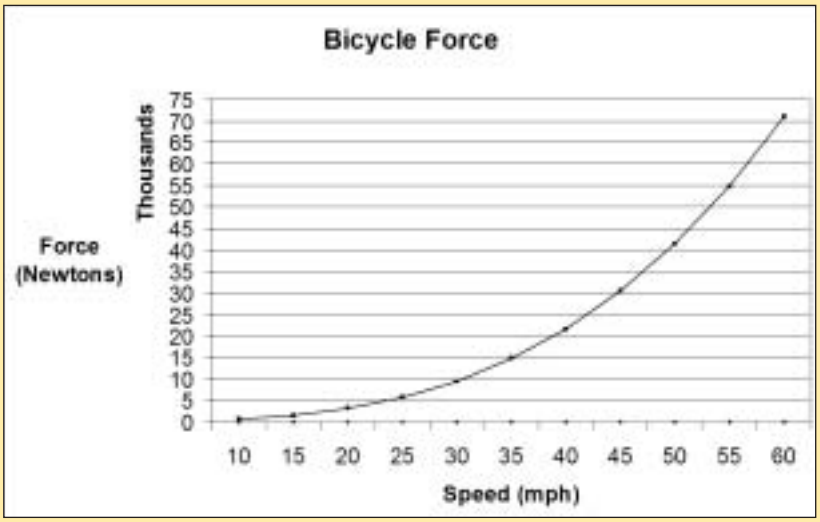
b) If the density of the steel is .283 pounds per cubic inch, what is the weight of the tube?

c) Titanium has a density of 0.160 pounds per cubic inch. What would the tube weigh if it were made of titanium?

d) If the tube had an inner diameter of 1.45 inches and the same thickness, what would be the volume of steel required to make it? What would it weigh?

Algebra (functions) 9

The forward motion of a bicycle on level ground is opposed by the resistance of the ground to the motion of the wheels (rolling resistance) and the resistance of the air to the motion of the rider and bicycle (wind resistance). This graph shows how the force required to keep a bicycle moving is related to the speed of the bicycle for a typical rider.



a) For what speed is the force required about three times as great as it is at 30 miles per hour?

b) Approximately how many times as much force is required at 60 miles per hour than is required at 20 miles per hour?

Algebra (simultaneous equations) 10

The formula for the relationship between force and speed shown in the graph above is this:

$$F = aS + bS^2$$

(F = force, S = speed)

Using two points on the graph to give you two sets of values for ***F*** and ***S***, find ***a*** and ***b***.

If you enjoyed this Futures Channel Movie, you will probably also like these:

Maglev Trains, #1004	Gliding on a wave of electromagnetic force, a maglev (magnetic levitation) train could travel at 300 miles per hour or faster.
Roller Coasters, #1008	Designing safe roller coasters requires an understanding of forces.
The Pterodactyl Flies Again, #1002	A young aeronautical designer creates a flying replica of a prehistoric dinosaur.