RACING TO THE FUTURE™
MATH LESSON #4 WORKSHEET
HOW TO ESTIMATE SPEED

In this worksheet you will learn about how to estimate the speed of your slot car using the rear tire size, gear ratio and the RPM of the motor. By using this information we can estimate the speed in feet per second.

How To Spec Your Car's Speed.

When preparing your car to race, it is good to have an idea of how fast it is going to run. You can do that before you even put it on the track! You only need to get a few bits of information and you can estimate how many feet per second your car will run.

You will need the following information:

1.) What is the RPM (Revolutions per Minute) rating of the motor/ armature.
You can get that from the manufacturer of the car or armature. If you are buying a performance armature for your car, the vendor can tell you what the RPM rating for that particular armature will be.

2.) What is the circumference of the rear tires? (The measurement around the outside of the tire.)

3.) What is the gear ratio you are running?

4.) How many seconds are in a minute?

5.) How many inches are in a foot?

We will use this information and some conversion equations to figure out how many feet per second a car will run in the example below.

John is wanting to make his car faster, but is not certain how fast it is currently running. He recently read on the Racing to the Future website that his slot car motor ran at 15,000 RPM (revolutions per minute) at full power. He also measured around his rear tires to get the circumference length. His rear tires measured 1.25 inches. This means each time his rear tires rotate one complete time, his car will move forward 1.25 inches. This is true for the circumference of the rear tires on any car. John was using the stock gears on his car. The crown gear was a 25 tooth gear, the pinion gear was a 7 tooth gear. So let's see what information John has on hand.

John's Car:
Motor/Armature's RPM = 15,000
Rear Tire Circumference = 1.25 Inches
Crown Gear = 25t
Pinion Gear = 7t

We can figure out how many feet per second John's car will run with this and little bit of additional information.

First we need to figure out the gear ratio. We do that by dividing the number of teeth on the crown gear, by the number of teeth on the pinion gear.

25 ÷ 7 = 3.57 = Gear Ratio

So by knowing the gear ratio, we know that every time the motor (where the pinion gear is attached) turns 3.57 times, the rear axle (where the crown gear is attached) and rear wheels turn 1 time. We'll set this number to side and work on the motor/armature next.

We need to convert the motor's RPM (revolutions per minute) to RPS or Revolutions Per Second. There are 60 seconds in a minute, so we divide the number of RPMs by 60 to turn it into RPS. John's motor/armature runs at 15,000 RPM, here's how to figure the RPS:

15,000 ÷ 60 = 250 RPS (Revolutions Per Second)

Now we can take the gear ratio number and the RPS number and figure out how many times the rear wheel turns completely in 1 second. We do that by taking the RPS number and dividing it by the gear ratio number.

250 ÷ 3.57 = 70.02 (The number of times the rear wheel turns completely in 1 second)

Now we need to know how many inches of track the car will travel in that one second.. We can do that by taking the number of times the rear wheel turns in 1 second and multiply that by the rear wheel's circumference. John's rear wheels are 1.25 inches in circumference.

70.02 X 1.25 = 87.525 Inches Per Second

So John's car runs 87.525 inches per second. Next we will figure out how many feet per second that is. There are 12 inches in a foot. So we can take the Inches per Second number and divide that by 12. That will give us Feet Per Second.

87.525 ÷ 12 = 7.29 Feet Per Second

So John has now figured out his car will run 7.29 Feet Per Second.

So how does all of this math help us make our cars faster? By knowing this information, we can figure out how changes effect the car's speed. So in our next example we will show you how changing a gear will make the car faster or slower. By doing this before you get your parts installed, you will know what things will improve or slow down your car.

When we last saw John he knew his car was running at 7.29 feet per second. John wants his car to go faster, so he thought a gear change might do just that. His car has a 7 tooth pinion gear (7t) and a 25 tooth crown gear (25t). John wants to buy a different crown gear but wants to know which size would be better, before he buys it. He can do that by following the steps we did above and change the gear ratio numbers to see which works best. John thinks if he uses a 22 tooth crown gear (22t) that would make his car faster. Let's see.

John's Car With a 22t Crown Gear:
Motor/Armature's RPM = 15,000
Rear Tire Circumference = 1.25 Inches
Crown Gear = 22t
Pinion Gear = 7t

First we need to figure out the gear ratio again. We do that by dividing the number of teeth on the crown gear, by the number of teeth on the pinion gear.

22 ÷ 7 = 3.14 = Gear Ratio

Now John's car turns the motor 3.14 times and the rear axle and rear wheels turn 1 time. We'll set this number to side and work on the motor/armature next.

We need to convert the motor's RPM (revolutions per minute) to RPS or Revolutions Per Second. There are 60 seconds in a minute, so we divide the number of RPM by 60 to turn it into RPS. John's motor/armature runs at 15,000 RPM, here's how to figure the RPS:

15,000 ÷ 60 = 250 RPS (Revolutions Per Second)

Now we can take the gear ratio number and the RPS number and figure out how many times the rear wheel turns completely in 1 second. We do that by taking the RPS number and dividing it by the gear ratio number.

250 ÷ 3.14 = 79.61 (The number of times the rear wheel turns completely in 1 second)

Now we need to know how many inches of track the car will travel in that one second.. We can do that by taking the number of times the rear wheel turns in 1 second and multiply that by the rear wheel's circumference. John's rear wheels are 1.25 inches in circumference.

79.61 X 1.25 = 99.52 Inches Per Second

So John's car now runs 99.52 inches per second. Next we will figure out how many feet per second that is. There are 12 inches in a foot. So we can take the Inches per Second number and divide that by 12. That will give us Feet Per Second.

87.525 ÷ 12 = 8.29 Feet Per Second

So John has now figured out his car will run 8.29 Feet Per Second with the gear change. That's an improvement of 1 foot per second by just changing the crown gear.

There are many things you can test using the information above. You can try different tire sizes, pinion gears, crown gears and even different motors (by their RPM rating). By using the math first, you can focus on specific parts and have a better idea how those will change the performance of the car.

<u>One Note To Think About</u>

Some changes will look good on paper, but not show so well on the track. That is because we are not considering other factors that might effect the car, like friction, weight or rotational weight. Bigger tires will make the car faster, but once they get too big, the motor has a harder time rotating the larger, heavier tire. That will actually slow the car down some. The same can happen with gear ratios. You can make the car faster by reducing the gear ratio, but like the larger tires, once you get the ratio too low, the motor will have a harder time turning the gears. That can be figured out with a bit of physics and we will learn all about that, when we cover torque and power in another lesson.

How Fast Are the Cars ?

Jessica is trying to figure out how fast her cars will be if she changes the rear tires to a larger size. She has the following information:

Motor/Armature's RPM = 18,000
Rear Tire Circumference = .75 Inches
Crown Gear = 25t
Pinion Gear = 7t

1.) Using the number above, how many feet per second will her car run?

2.) If Jessica changes the rear tires to 1 inch in circumference, how many feet per second will her car run? How much faster or slower did the change make the car?

3.) After changing the tires, Jessica thinks a new pinion gear will speed her car up. If she changes her pinion gear to an 8 tooth pinion gear (8t) how many feet per second will her car run after the change? Did the car go faster or slower?

Answer Key

1.) Step 1: Figure the Gear Ratio

Number of teeth on the Crown Gear ÷ Number of teeth on the pinion gear = Gear ratio

25 ÷ 7 = 3.57

Step 2: Change the motor's RPM to RPS

RPM rating of the motor ÷ Number of seconds in a minute = Revolutions Per Second

18,000 ÷ 60 = 300 RPS

Step 3: Figure the number of turns the rear wheel makes in 1 second

RPS rating of motor ÷ Gear ratio = Number of turns rear wheel makes per second

300 ÷ 3.57 = 84.03

Step 4: How many inches does the car travel in 1 second (Inches per Second)

Number of turns the rear wheel makes per second Multiplied by the Rear tire circumference = Inches per second the car travels

84.03 X 1 = 84.03

Step 5: How Many Feet per Second does the car travel

Inches per Second the car travels ÷ the number of inches in a foot = Feet per second the car travels

84.03 ÷ 12 = 5.25 Feet per Second

Answer to Question #1 is 5.25. Feet per Second

2.) Step 1: Figure the Gear Ratio

Number of teeth on the Crown Gear ÷ Number of teeth on the pinion gear = Gear ratio

25 ÷ 7 = 3.57

Step 2: Change the motor's RPM to RPS

RPM rating of the motor ÷ Number of seconds in a minute = Revolutions Per Second

18,000 ÷ 60 = 300 RPS

Step 3: Figure the number of turns the rear wheel makes in 1 second

RPS rating of motor ÷ Gear ratio = Number of turns rear wheel makes per second

300 ÷ 3.57 = 84.03

Step 4: How many inches does the car travel in 1 second (Inches per Second)

Number of turns the rear wheel makes per second Multiplied by the Rear tire circumference = Inches per second the car travels

84.03 X 1 = 84.03

Step 5: How Many Feet per Second does the car travel

Inches per Second the car travels ÷ the number of inches in a foot = Feet per second the car travels

84.03 ÷ 12 = 7.00 Feet per Second

Answer to Question #2 is 7.00 Feet per Second. The car traveled 1.75 Feet per Second faster.

Answer Key

3.) Step 1: Figure the Gear Ratio

Number of teeth on the Crown Gear ÷ Number of teeth on the pinion gear = Gear ratio

25 ÷ 8 = 3.125

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Step 2: Change the motor's RPM to RPS

RPM rating of the motor ÷ Number of seconds in a minute = Revolutions Per Second

18,000 ÷ 60 = 300 RPS

Step 3: Figure the number of turns the rear wheel makes in 1 second

RPS rating of motor ÷ Gear ratio = Number of turns rear wheel makes per second

300 ÷ 3.125 = 96

Step 4: How many inches does the car travel in 1 second (Inches per Second)

Number of turns the rear wheel makes per second Multiplied by the Rear tire circumference = Inches per second the car travels

96 X 1 = 96

Step 5: How Many Feet per Second does the car travel

Inches per Second the car travels ÷ the number of inches in a foot = Feet per second the car travels

96 ÷ 12 = 8.00 Feet per Second

Answer to Question #3 is 8.00 Feet per Second. The car traveled 1 Foot per Second faster.