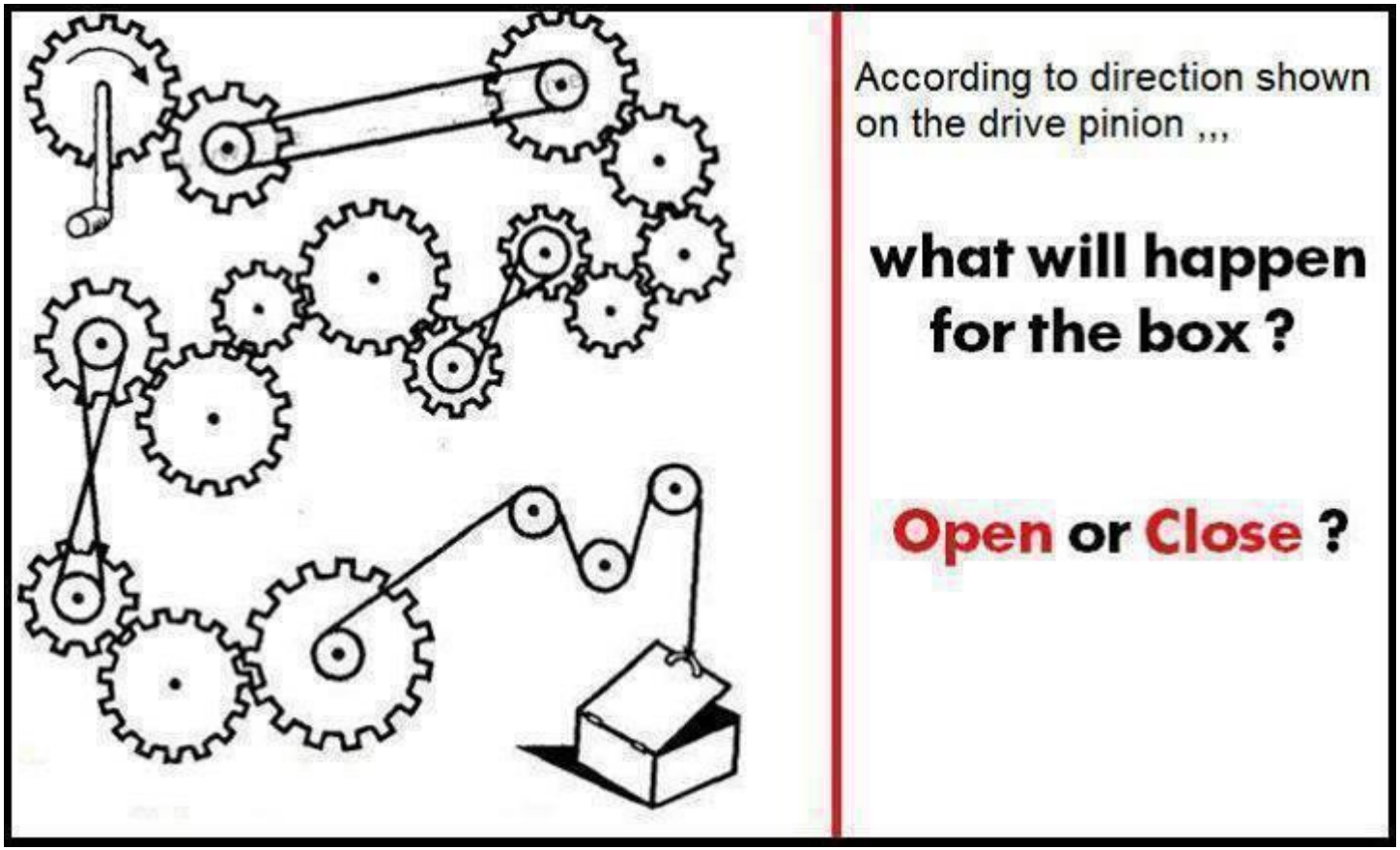
Calculating speeds and gearing

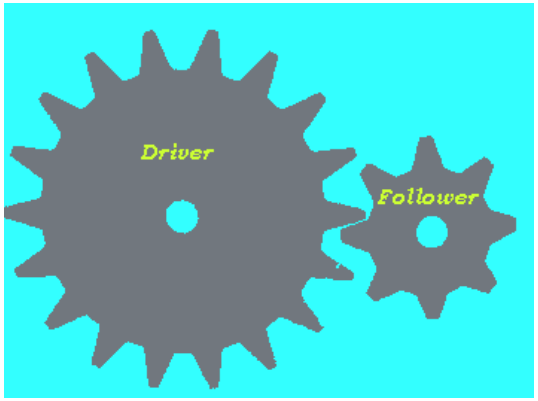


Gear Trains

Gear trains allow you to change the speed or force at which axles rotate or the direction of rotation. There are times when the RPM (revolutions per minute) a motor runs at is not appropriate for the task it is to complete.

Lets apply this;

If I have a gear attached to a motor (DRIVER) with 20 teeth and it is connected to another gear (FOLLOWER) with 5 teeth, I have a gear ratio of 1:4



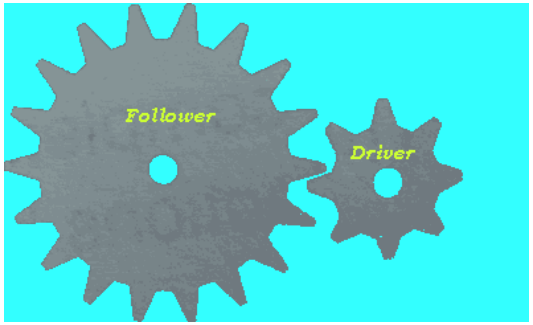
$$\frac{\text{\# teeth follower}}{\text{\#teeth driver}} \qquad \frac{5}{20} = \frac{1}{4} = 1:4$$

For every 1 time the big gear goes around, the smaller gear goes around 4 times

Gears Trains Continued

On the flip side, If I have a gear attached to a motor (DRIVER) with 5 teeth and it is connected to another gear (FOLLOWER) with 20 teeth, I have a gear ratio of 5:1

$$\frac{\text{\# teeth follower}}{\text{\#teeth driver}} \qquad \frac{20}{5} = \frac{5}{1} = 5:1$$

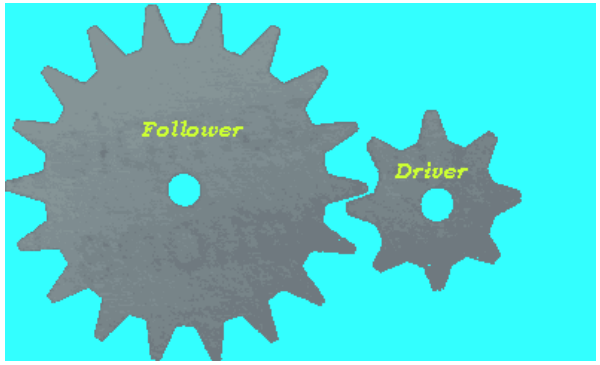


For every 5 time the little gear goes around, the bigger gear goes around 1 times.

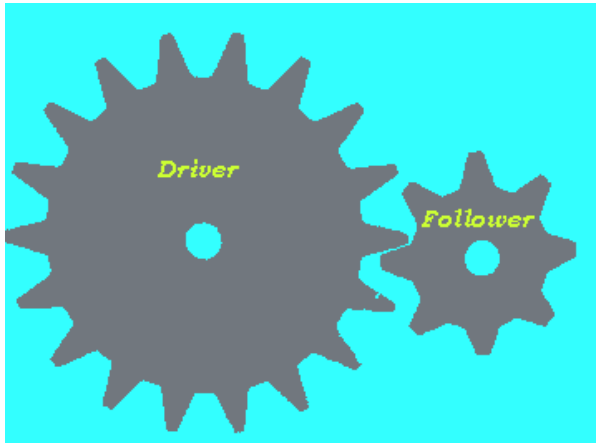
Gears Continued

To sum up a simple gear train;

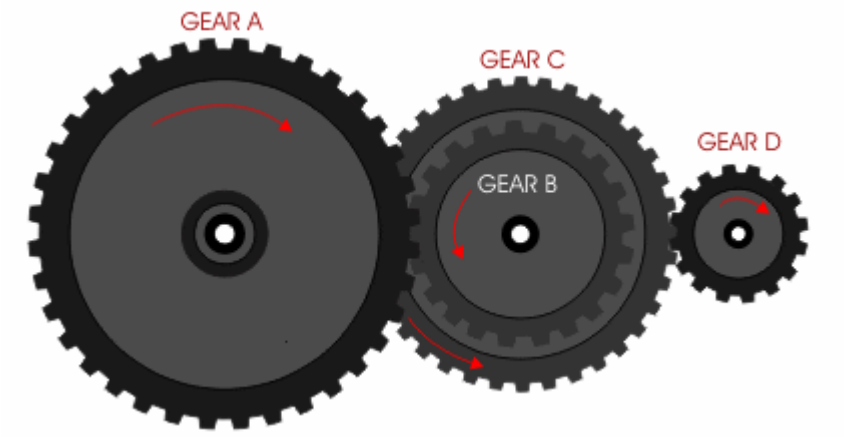
- IF the driver gear has less teeth then the follower gear, then the speed of the follower is **SLOWER**.



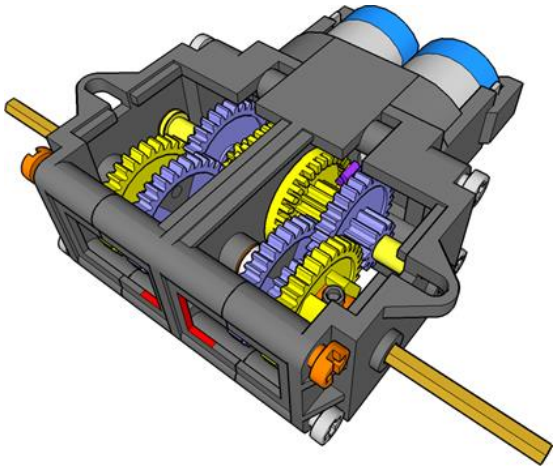
- IF the driver gear has more teeth then the follower gear, then the speed of the follower is **FASTER**.



Compound Gear Trains



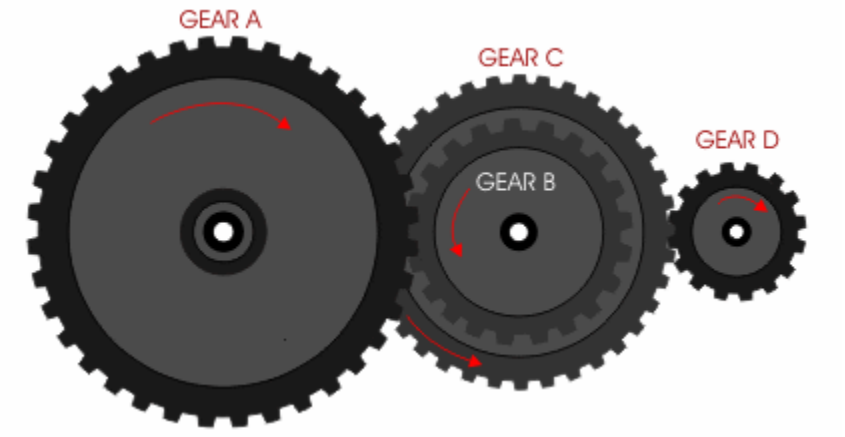
A compound gear train consists of two gear trains (gear A/B and gear C/D) that are joined together. Notice how gears B and C are joined together on the same shaft. By doing this, you can configure different gear ratios.



Note: you can get a much higher or lower gear ratio with COMPOUND GEAR TRAINS!!!!

Compound Gear Trains

In the example to the right;
Gear A has 40 teeth
Gear B has 20 teeth
Gear C has 30 teeth
Gear D has 15 teeth



Gear Train A/B has a ratio of 1:2

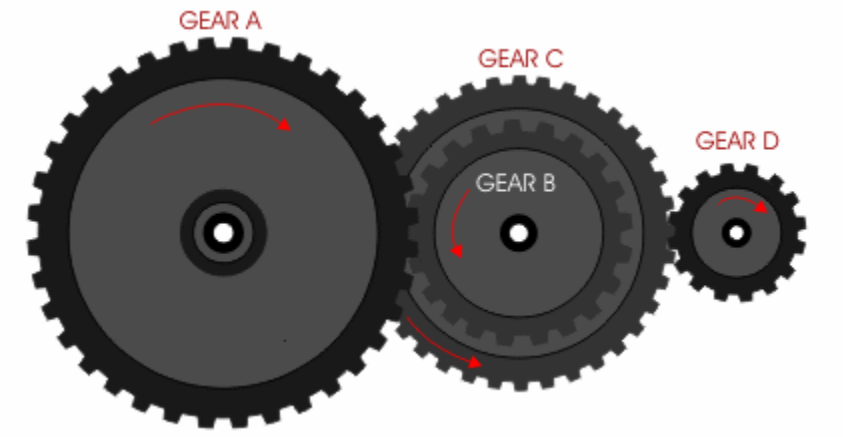
$$\frac{\text{\# teeth follower (B)}}{\text{\#teeth driver (A)}} \quad \frac{20}{40} = \frac{1}{2}$$

Gear Train C/D has a ratio of 1:2

$$\frac{\text{\# teeth follower}}{\text{\#teeth driver}} \quad \frac{15}{30} = \frac{1}{2}$$

Compound Gear Trains

You now have the 2 gear ratios figured out. To find the **final** gear ratio you simply multiply the ratios together;



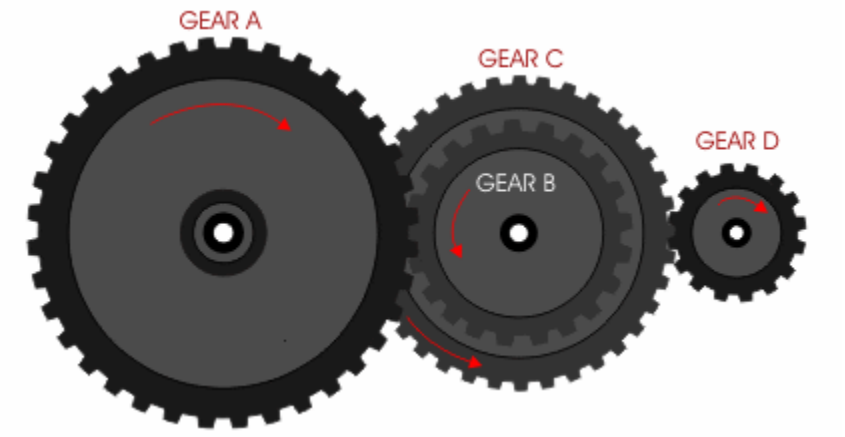
$$\text{Gear Ratio} = \frac{\#\text{ teeth on gear B}}{\#\text{ teeth on gear A}} \times \frac{\#\text{ teeth on gear D}}{\#\text{ teeth on gear C}}$$

$$\text{Gear Ratio} = \frac{20}{40} \times \frac{15}{30} = 1/4$$

The final gear ratio is 1:4 which means for every **ONE** time **gear A** goes around, **gear B** goes around 4 times

Compound Gear Trains

In the example to the right, if;
Gear A has 10 teeth
Gear B has 50 teeth
Gear C has 20 teeth
Gear D has 80 teeth



What is the gear ratio?

$$\text{Gear Ratio} = \frac{\text{\# teeth on gear B}}{\text{\# teeth on gear A}} \times \frac{\text{\# teeth on gear D}}{\text{\# teeth on gear C}}$$

$$\text{Gear Ratio} = \frac{50}{10} \times \frac{80}{20} = 20/1 \text{ or } 20:1$$

Calculating the Speed of a vehicle

There are times you may want to know how fast a vehicle is moving or more importantly how fast it WILL move before building it. Using some simple math you can calculate this factor before you start building a robot.

If a VexIQ motor runs at 120 rpm (revolutions per minute) @100% and I have a wheel diameter of 63.7mm, how far will I travel in 1 minute?

Circumference of wheel (πd)

C = 3.14 * 63.7mm
C = 200.12mm

Distance travelled in ONE minute?

Dist = rpm x Circumference
Dist = 120rpm * 200.12mm = 24014mm/min

In Meters/minute?

Dist = mm travelled in a minute / 1000mm
Dist = 24014mm/1000mm = 24m/min

In Meters/Second?

Dist = 24m/minute
Dist = $\frac{\text{24m/min}}{\text{60s}}$ = .4m/s (example on court)

In km/h

Speed (km/h) = 24m/min / 1000m = .024km/m
= .024km/min * 60min
= 1.44km/hour

Calculating the Speed a vehicle Continued (with gearing)

A Vex motor runs at 120 rpm (revolutions per minute) and I have a wheel diameter of 63.7mm, how fast am I travelling in m/sec, IF there is a gear ration to 5:1?

FIRST, Find RPM at wheels

$$\frac{motor\ RPM}{Gear\ Ratio} = \frac{120rpm}{\frac{5}{1}} = 120rpm * \frac{1}{5} = 24\text{rpm}$$

Circumference of wheel (πd)

C = 3.14 * 63.7mm = 200.12mm

Distance travelled in ONE minute?

RPM * circumference
24rpm * 200.12mm = 4802.88mm/min

Convert to m/sec

4802.88mm/1000mm 4.803m/min
= 4.803m/min ÷ 60 seconds
= .08m/sec

Alternately – If you already know the speed the wheel is going in m/s (previous slide .4m/s), then simply divide the speed by the gear ratio

$$\frac{wheel\ speed\ m/s}{Gear\ Ratio} = \frac{.4m/s}{\frac{5}{1}} = .4m/s * \frac{1}{5} = \textbf{.08m/s}$$

Calculating the Speed a vehicle Continued (with gearing)

A Vex motor runs at 120 rpm (revolutions per minute) and I still have a wheel diameter of 63.7mm, how fast am I travelling in m/sec, IF there is a gear ration to 1:15?

$$\frac{\textbf{\textit{wheel speed m/s}}}{\textbf{\textit{Gear Ratio}}} = \frac{.4m/s}{\frac{1}{15}} = .4m/s * \frac{15}{1} = 6m/s$$

Speed (km/h) **= 6m/s * 60 seconds = 360m/min**
= 360m/1000m = .36km/m
= .36km *60min
= 21.6km/h

Is there enough Torque in the motors to do this though???

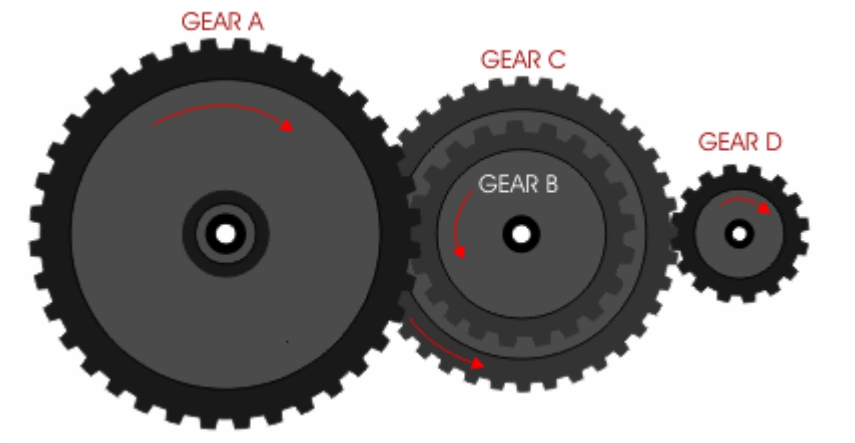
Gear Ratio Lab #1

You and ONE partner are to build a compound gear box as a lab. The gear box will consist of a single driver motor and a wheel as the output

Equipment:

- A single motor as the driver
- 2 - 12 tooth gears (**driver gear A** and gear C)
- 1 - 36 tooth gear (gear B)
- 1 - 60 tooth gear (gear D)
- A single small vex wheel as the output
- Any other vex parts for structural building

(Marks are given for build quality)



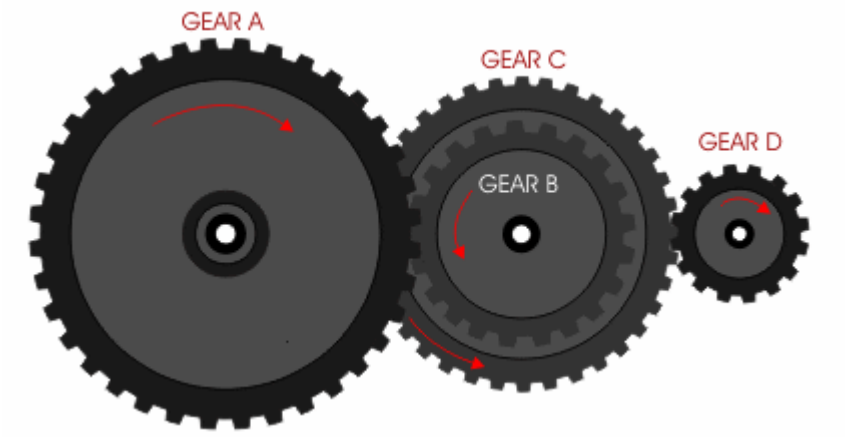
Procedure:

1. Calculate the gear ratio on paper. What is it?
2. How far should it travel in 1minute?
3. How fast is it going in m/sec?
4. Build the lab
5. Prove to the teacher that it works and show the math

Marking	
Correct math	/2
Works and quality	/3
Total	/5

Gear Ratio Lab #2

You and the same partner are to build another compound gear box as a lab. This time the gear ratio will be **1:75**



Equipment:

- A single 120RPM Vex motor as the driver
- A single small Vex wheel as the output
- Several gears of various sizes
- Any other vex parts for structural building

(Marks are given for build quality)

Procedure:

1. Which gears did you use (Driver A, B, C, D, E,F), ?
2. How far would it go in 1 minute
3. How fast is it travelling in Km/h?
4. Build the lab
5. Prove to the teacher that it works and show the math

Marking	
Correct math	/2
Works and quality	/3
Total	/5

Mechanical/Gear/Force Assignment

- Build a robot that can **PUSH** as much weight as possible
- The robot must not exceed 10” wide x 10” long x 5” tall
- You are limited to 2motors & 4 wheels
- The robot must **NOT** move slower than 1cm per second. (.01m/s)
- Motors are 120rpm