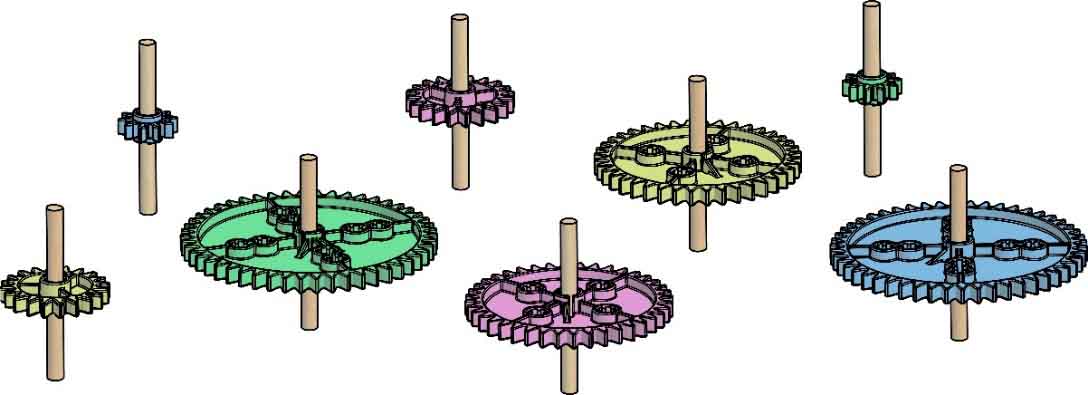
Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Date: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_



Make sure you built your Tinker Set with the [**Set-Up Guide**](https://teachergeek.org/gears_set_up_guide.docx). Find all our documents, including the [**Classroom Overview**](https://teachergeek.org/gears_overview.docx), at [**teachergeek.com/gears**](https://teachergeek.com/gears)

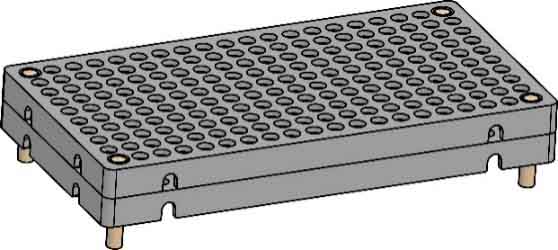


**Two** – 20 Tooth

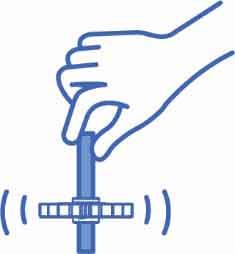
**Two** – 40 Tooth

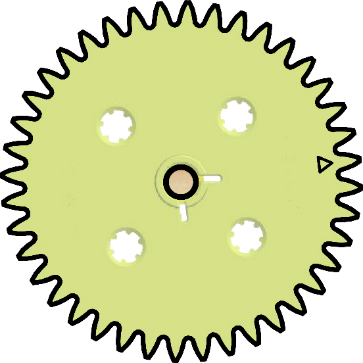
**Two** – 10 Tooth

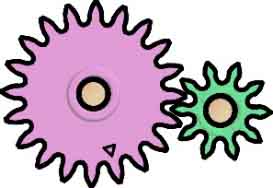
**Two** – 50 Tooth



Base







**Tooth**

**Meshed Teeth**



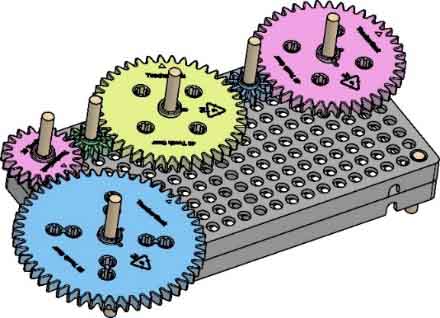
A **gear** is a wheel with **teeth**.   
The teeth **mesh** (connect) with other gears, to make them turn together.

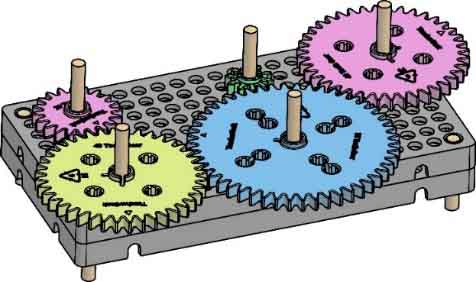
**Output Gear:**   
The gear that gets powered (turned   
by the other gear).

**Input Gear**:   
The gear that   
is powered   
(turned by you).



Place gears into the **base**, so they mesh. Give a spin   
and see what happens. Try different combinations!





**►**

**Be Careful:**   
If your gears are too close, or too far apart, they won’t mesh.



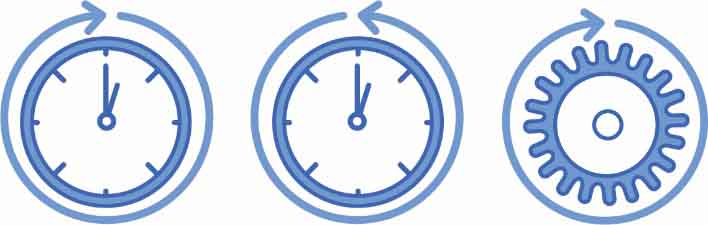
**Page 1**

**►**

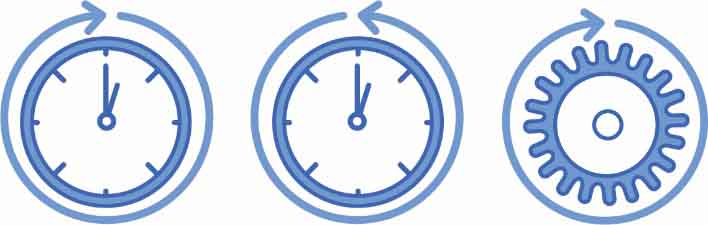
**Clockwise (CW)**

**Counterclockwise (CCW)**

**A Clock’s Rotation:**  
The minute hand on   
a clock makes one revolution every minute.

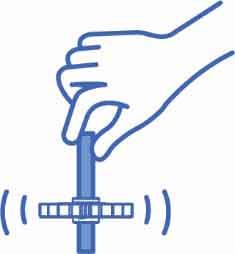


**Revolution:**   
one full rotation



**►**

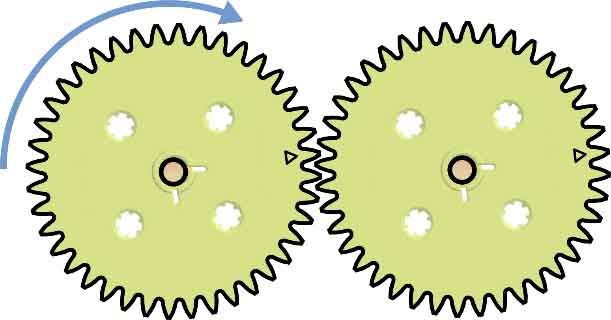
**►**





**Mesh** (connect) two 40-Tooth gears together on the base plate.   
 Using the dowel, spin **Gear A** clockwise (direction of the arrow) one   
**revolution**. Draw an arrow around **Gear** **B** to show the direction of **rotation** (turn).





**A**

**B**

**Input  
Revolutions**

Complete for meshed gears **A** & **B**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Gear** | **# of Teeth** | **Rotation Direction** | **# of**  **Revolutions** | **Revolutions’**  **Ratio** |
| **A Input** | 40 | **CW** | 1 |  |
| **B Output** | 40 |  |  |

**Output  
Revolutions**

**►**

A **ratio** is a comparison of two values (numbers).   
Which values are you comparing? \_\_\_\_\_\_\_\_\_\_\_\_  
 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Which **direction** did the output gear rotate?

Clockwise Counter Clockwise

40-Tooth

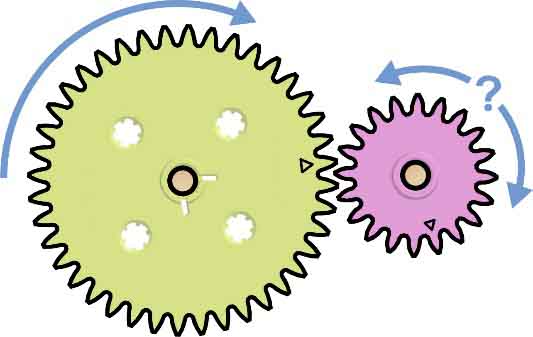
**►**





Swap your output for a 20-Tooth gear and spin **Gear C** clockwise one revolution.

Complete for meshed gears **C** & **D**



**C**

**D**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Gear** | **# of Teeth** | **Rotation Direction** | **# of**  **Revolutions** | **Revolutions’**  **Ratio** |
| **C Input** | 40 | **CW** | 1 |  |
| **D Output** | 20 |  |  |

20-Tooth

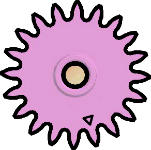
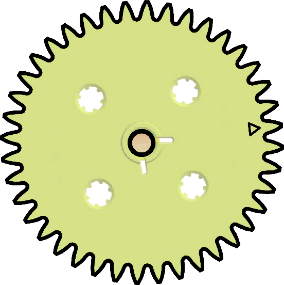
How did changing the **output gear** size affect   
the revolutions’ ratio? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**►**

**2**



Now, spin **Gear C** counter clockwise one full revolution.   
 Draw an around **Gear D** to show the direction of rotation.



**C**

**D**



Complete for meshed gears **C** & **D**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Gear** | **# of Teeth** | **Rotation Direction** | **# of**  **Revolutions** | **Revolutions’**  **Ratio** |
| **C Input** | 40 | **CCW** | 1 |  |
| **D Output** | 20 |  |  |

Did changing the **direction of rotation** affect   
the revolutions’ ratio? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**►**

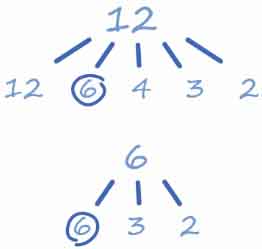
****

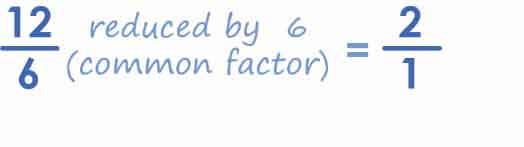
****

Find the **common factor**that’sdivisiblebetween the **input** and **output** numbers.

**►**

Many ratios can   
be written with smaller numbers – this is called **reducing**, or simplifying.

****

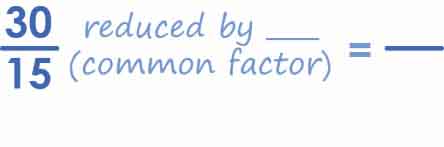
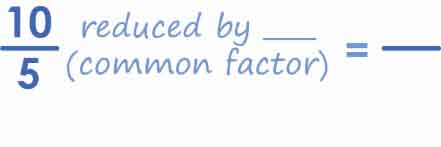
****

****

Reduce both values. Divide each by the same   
**common factor** (number).

**►**

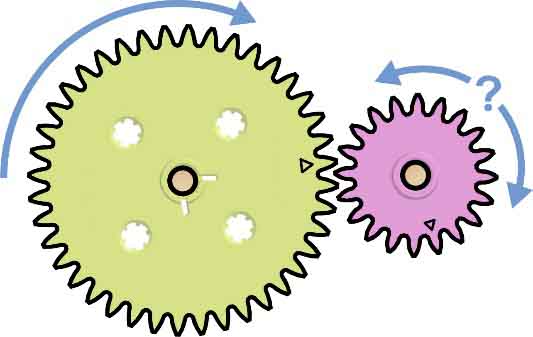
**Reduced  
Ratio**

****

Reduce these  
 ratios on your own:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Gear** | **# of Teeth** | **Rotation Direction** | **# of**  **Revolutions** | **Revolutions’**  **Ratio** | **Reduced Ratio** |
| **C Input** | 40 | **CW** | 6 |  |  |
| **D Output** | 20 |  |  |





**C**

**D**

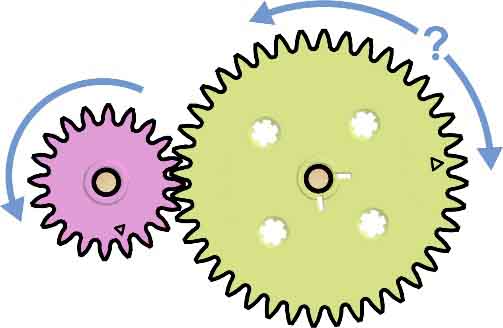
Complete for meshed gears **C** & **D**

**Reduce   
to a Fraction**

**3**

****

Switch your 20-Tooth and 40-Tooth gears. Using a dowel,   
 spin **Gear E** (now the **input**) clockwise.



**E**

**F**

Complete for meshed gears **E** & **F**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Gear** | **# of Teeth** | **Rotation Direction** | **# of**  **Revolutions** | **Revolutions’**  **Ratio** | **Reduced Ratio** |
| **E**  **Input** | 20 | **CW** | 6 |  |  |
| **F Output** | 40  **Inverse from before** |  |  |

How did switching input and output gear size affect the revolutions’ ratio? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**►**

****



**Teeth** allow gears to mesh and indicate gear **size**. Look at the **tooth ratio** of your   
 meshed gears. *How does it compare to the revolutions’ ratio?* \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_



**Reduce the tooth ratio values:**  
40**/**40 tooth reduces to: \_\_\_\_ **/** \_\_\_\_

40**/**20 tooth reduces to: \_\_\_\_ **/** \_\_\_\_

20**/**40 tooth reduces to: \_\_\_\_ **/** \_\_\_\_

**►**

**Predict for other gear combinations:**  
10**/**50 tooth reduces to: \_\_\_\_ **/** \_\_\_\_

50**/**20 tooth reduces to: \_\_\_\_ **/** \_\_\_\_

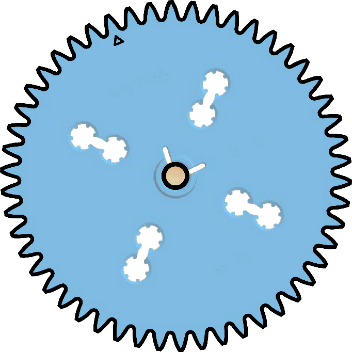
10**/**40 tooth reduces to: \_\_\_\_ **/** \_\_\_\_

**►**



Comparing the number of **teeth** in one gear to another is called **gear ratio.**  
 Spin the 10-Tooth and 50-Tooth gear combination on the base.   
 **Reduce** and then compare the results to your above predictions.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Gear** | **# of Teeth** | **Rotation Direction** | **# of**  **Revolutions** | **Revolutions’**  **Ratio** | **Reduced Ratio** |
| **A Input** | 10 | **CW** | 12 |  |  |
| **B Output** | 50 |  |  |





**A**

**B**

Was the reduced ratio the same as the tooth ratio?  
 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**►**

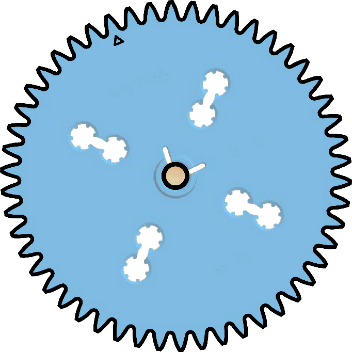
**4**

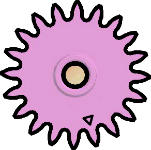


Now, spin the 50-Tooth and 20-Tooth gear combination on the base.   
 **Reduce** and then compare the results to your above predictions.



|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Gear** | **# of Teeth** | **Rotation Direction** | **# of**  **Revolutions** | **Revolutions’**  **Ratio** | **Reduced Ratio** |
| **C Input** | 50 | **CCW** | 12 |  |  |
| **D Output** | 20 |  |  |





**C**

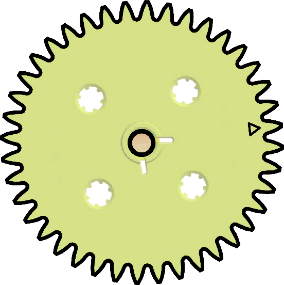
**D**

Was the reduced ratio the same as the tooth ratio?  
 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**►**



Now, spin the 10-Tooth and 40-Tooth gear combination on the base.   
 **Reduce** and then compare the results to your above predictions.



|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Gear** | **# of Teeth** | **Rotation Direction** | **# of**  **Revolutions** | **Revolutions’**  **Ratio** | **Reduced Ratio** |
| **E Input** | 10 | **CW** | 12 |  |  |
| **F Output** | 40 |  |  |



**F**

**E**

**►**

Was the reduced ratio the same as the tooth ratio?  
 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_





**Denominator  
(Bottom)**

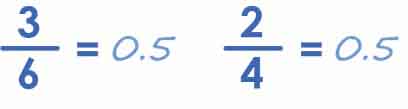
**Numerator  
(Top)**

A **proportion** is an equation   
showing that two ratios are **equal**.

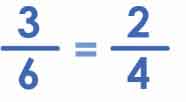
**►**

**Choice #1:**  
Convert ratios into **decimal**s by dividing   
the **numerator** by the **denominator**.

**□**

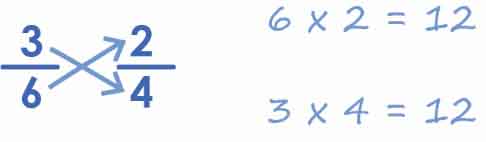


****



**Choice #2:**  
Determine a **cross product** by multiplying   
the **numerator** of one fraction by the **denominator** of another fraction.

**□**



**Proportion**

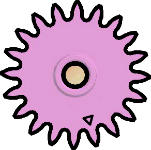
**5**



Spin the gear combinations to determine their ratio. Write it as a **fraction**.   
 *The input’s revolutions are the* ***numerator****, while the output’s the* ***denominator****.*



|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Gears I** | **# of Teeth** | **Rotation Direction** | **# of**  **Revolutions** | **Revolutions’**  **Ratio** | **Reduced Ratio** | **Fraction** |
| **A Input** | 20 | **CW** | 6 |  |  |  |
| **B Output** | 10 |  |  |

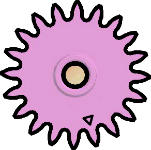
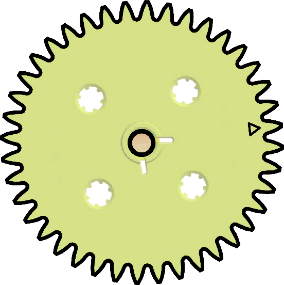


**A**

**B**

**Use for   
Proportion**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Gears II** | **# of Teeth** | **Rotation Direction** | **# of**  **Revolutions** | **Revolutions’**  **Ratio** | **Reduced Ratio** | **Fraction** |
| **C Input** | 40 | **CW** | 6 |  |  |  |
| **D Output** | 20 |  |  |



**C**

**D**

**Gears I Fraction**



**=**

**Gears II Fraction**



Were the ratios of meshed   
gears I & II equal **proportions**?   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**►**



Balance the **proportions** below by converting to decimals   
 or multiplying the cross products.

3

6

43

**=**

86

2

50

**=**

32

40

**=**

5





**Gear Trains** can be   
as small as two gears,   
or many more in big, industrial machines.



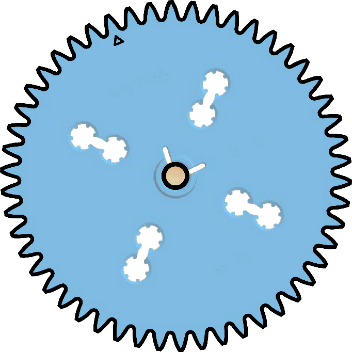
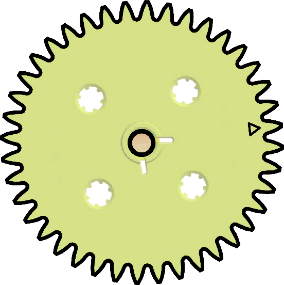
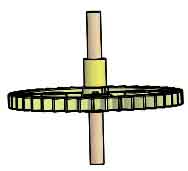
Meshing multiple gears together creates a **gear train**, transmitting **force** (power) to do one of three things:   
  
 **►** **Change Speed   
 ► Change Force (Power)   
 ► Change Direction**

**Compound** gear trains are attached   
gears that rotate around the same **center**.

**6**



Create a **compound gear** by stacking a 10-Tooth on a 50-Tooth Gear and  
 meshing the 10-Tooth with a 40-Tooth gear that has **slide stop** on its dowel.



**Be careful:**Make sure there   
is no space between the stacked gears.

**?**





**►**

Which **direction** did the 10-Tooth gear on the **compound gear** rotate?

Clockwise Counter Clockwise

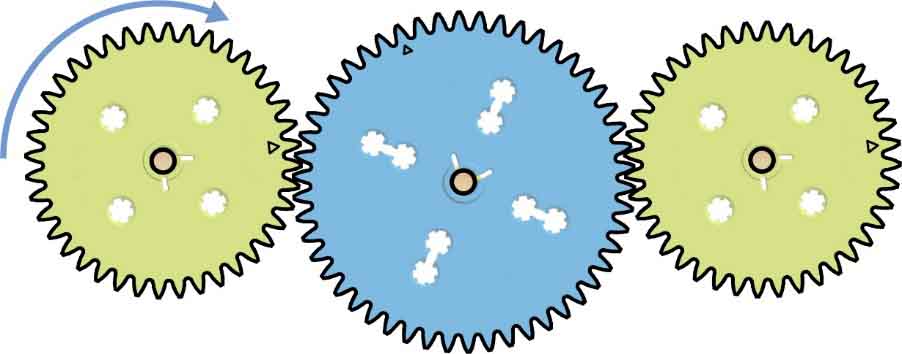
**►**



Mesh two 40-Tooth gears on either side of a 50-Tooth gear on the base plate.  
 Spin **Gear A** clockwise one full **revolution**. Draw an around **Gear B**   
 and **Gear C** to show their directions of **rotation**.



|  |  |  |  |
| --- | --- | --- | --- |
| **Gear** | **# of Teeth** | **Rotation Direction** | **# of**  **Revolutions** |
| **A Input** | 40 | **CW** | 1 |
| **B Output** | 50 |  |  |
| **C Output** | 40 |  |  |



**A**

**C**

**B**

**►**

The revolutions’ ratio for **Gear A** and **Gear B** ? \_\_\_\_\_\_\_\_ **:** \_\_\_\_\_\_\_\_

**►**

Multiply the two ratios together.  
 ( \_\_\_\_\_ : \_\_\_\_\_ ) x ( \_\_\_\_\_ : \_\_\_\_\_ )  
 = **\_\_\_\_\_** : **\_\_\_\_\_** (**reduce** if you can).



A gear inserted *between* two or more gears   
 is known as the **idler-wheel**. It works to keep the direction of rotation of the input and output gears the same, without affecting **gear ratio**.

The revolutions’ ratio for **Gear B** and **Gear C** ? \_\_\_\_\_\_\_\_ **:** \_\_\_\_\_\_\_\_

**►**

**►**

Which gear in the gear train above acts as the   
idler-wheel? Why? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**7**

**8**

**8**

**9**