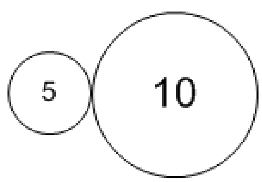
**Lab #1 – Antikythera Mechanism**

**Introduction**:

The Antikythera Mechanism is an Ancient Greek mechanical calculator that used gear-wheels to keep track of astronomical cycles and eclipses. When a date was entered via a crank, the mechanism could calculate the position of the sun, moon, and various planets, and also make predictions regarding upcoming solar and lunar eclipses.

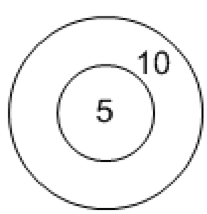
This lab focuses on the concept of a gear ratio, which is the relationship between the number of teeth on two gears that are meshed. We can also imagine rubber wheels that do not have teeth, but rather are connected by friction. In that case, the relevant ratio is the relationship between the radii of the two gears. Both representations -- with and without teeth -- are equivalent because the number of teeth that fit on a wheel is proportional to its circumference, and thus to its radius as well. The bigger the wheel, the more teeth it fits.

In the diagram below, the smaller wheel to the left has a radius of 5, and the larger wheel to the right has a radius of 10.




If the two wheels are connected, either by interlocking teeth or friction, the rotation of one will cause the other to rotate as well. If the smaller wheel rotates once to the right, the larger wheel will make one-half of a rotation to the *left*. This movement can be predicted by the radius ratio of 5/10, or 1/2.

In the next diagram, the two wheels are coaxial, meaning they share an axis of rotation.



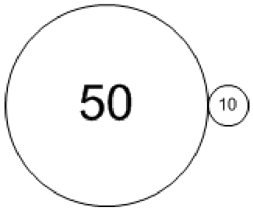

There are two possibilities:

1. If either one rotates, the other will rotate at the same speed, in the same direction.
2. The two wheels will rotate independently of one another.

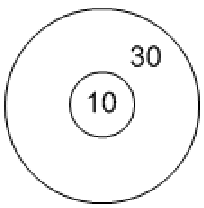
For the purposes of this lab, assume the first possibility, unless stated otherwise.

In this lab, circles are labeled with their radii. Express your answers as ratios. A rotation in the same direction as the first wheel has positive sign; a rotation in the opposite direction has negative sign.

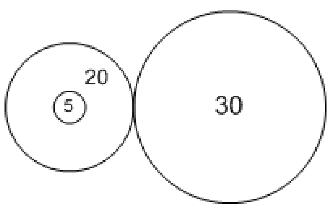
1. There are two adjacent wheels in the diagram below. Suppose the wheel on the left, with a radius of 50, rotates once clockwise. How will the wheel on the right move?



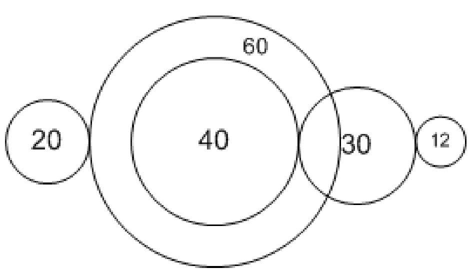

2. The two wheels below are coaxial and rotate together. Suppose the bottom wheel rotates once counterclockwise. How will the top wheel move?



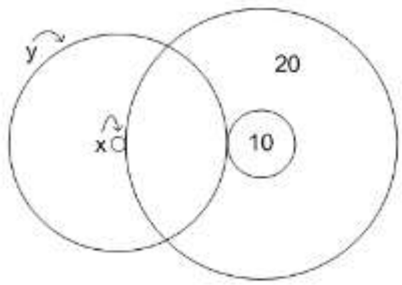

3. The two wheels on the left are coaxial. If the top wheel rotates twice clockwise, how will the right wheel move?




4. The wheel on the left rotates three times counterclockwise. How will the wheel on the far right move?



5. The diagram below represents the gears of a clock. The 10 wheel represents the minute hand, and rotates once per minute. The 20 wheel represents the hour hand, and rotates once per hour. As a result, the 10 and 20 wheels must be able to rotate independently. The x and y wheels, however, rotate together. In order for the 10 and 20 wheels to rotate in the right ratio, what must the values of x and y be?




6. There are different ways of expressing the lunar month:

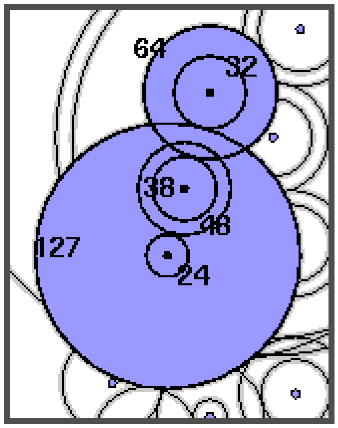
   Sidereal month: 27.3216 days
   The period of the Moon's orbit as defined with respect to the celestial sphere; amount of time it takes the Moon to return to a given position among the stars. The sidereal month is the moon's true orbital period around the earth.

   Synodic month: 29.5305 days
   The average period of the Moon's revolution with respect to the sun; the time between two of the same phases of the moon, because the Moon's phase depends on the position of the Moon with respect to the Sun as seen from the Earth.

   a. Why is the synodic month longer than the sidereal month?

   b. In a period of 19 solar years, we have 254 sidereal months and 235 synodic months. Based on this information, what is the ratio of the speed of the moon’s orbit to the speed of the sun’s orbit?

7. The diagram below is of the Antikythera's sun-moon mechanism.



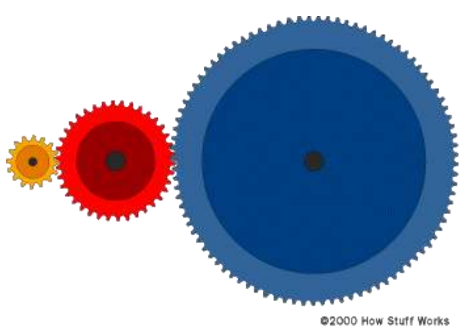

a. The top 64 and 32 wheels are coaxial and spin independently, but the 38/48 pair and the 127/24 pair spin together. If the 64 wheel rotates once counterclockwise, how will the 32 wheel move?

b. Based on your answer to question 7, what might this ratio represent?

c. Based on your answer to part c, what does one rotation of the 64 wheel represent? One rotation of the 32 wheel?

8. Challenge Problem

Say you want a gear ratio of 6:1. One way to create that ratio is with the following three-gear train:




In this train, the red (middle) gear has 3 times the diameter of the yellow (small) gear, and the blue (large) gear has 2 times the diameter of the red gear (giving a 6:1 ratio).

However, what if you want the axis of the output gear to be the same as that of the input gear? Design a gear system with such a design. Hint: consider having gear teeth on the inside of a wheel.