Gears Learning Activity 1

In this first learning activity, students are expected to understand the following definition and basic ideas with regard to gears.

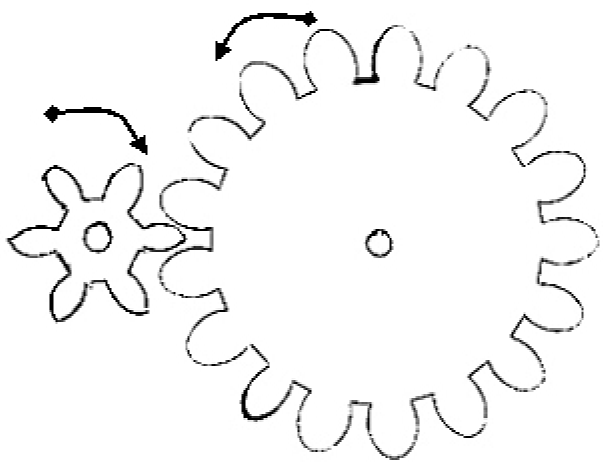
DEFINITION **A gear is a toothed wheel attached to a rotating shaft. Most often, a gear is attached to another gear, and a system of gears can serve a variety of functions---for instance:**

(1) In a bicycle, a chain connects large gears to a set of smaller gears in order to change the back wheel's speed of rotation.

(2) Gears are used in an automobile's differential to transmit motion at 90^{o} from the driveshaft to the wheels' axle.

(3) Gears are often connected to small motors so that a quick-turning small gear can transfer its energy to a larger gear, which has more turning force.

THE BASIC IDEAS

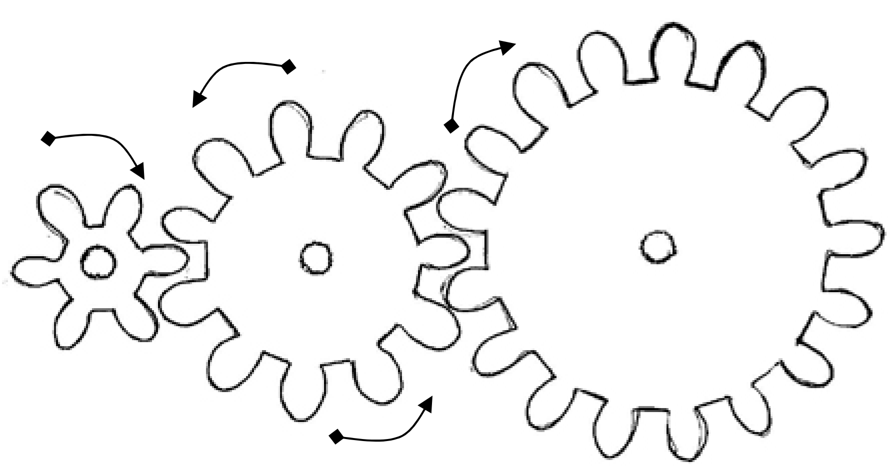


a. Gears and Direction of Motion

If the smaller gear is turned clockwise, the motion of the larger gear will be counterclockwise.

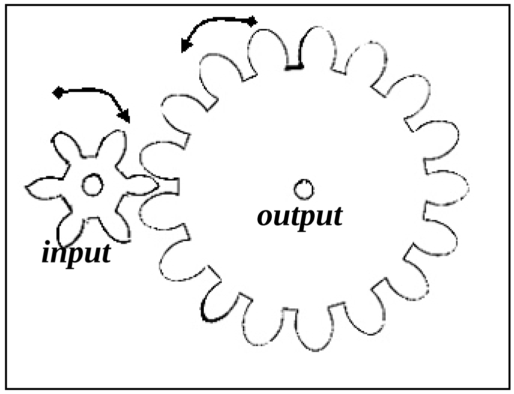
- Whenever we attach an *even* number of circular gears in sequence, the first and last gear will always turn in *opposite* directions.

-If an *odd* number of gears are attached in sequence, then the first and last gear will turn in the *same* direction.



Gears Learning Activity 1

b. Gear Ratios

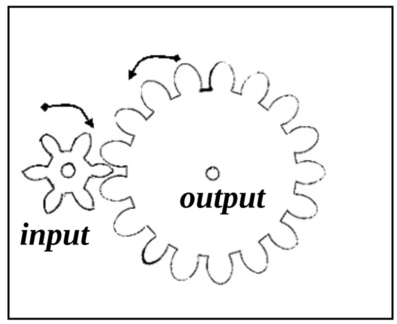


A gear or speed ratio simply translates into how many turns will be produced in the output gear for every full turn of the input gear. In principle it is the ratio of the circumference[C]or diameter[d]) of the input wheel to that of the output wheel; but what makes it simple is that the gear's circumference is proportional to its number of teeth[n].

Gear or velocity ratio = $\frac{C_{input}}{C_{output}} = \frac{d_{input}}{d_{output}} = \frac{n_{input}}{n_{output}}$

So in the above diagram, if the power is applied to the small wheel, the gear ratio will be 6 to 17 or 6/17. Since the fraction is less than 1 it implies that there will be a loss in velocity. If we apply the turning force to the larger gear, the ratio will be the reciprocal: 17/6, and the output gear will experience a gain in velocity.

c. Gears, Energy and Torque



Since the energy is almost completely transferred from the small to the larger gear, if there is a loss of speed, the larger gear ends up with more turning force or torque, which has practical advantages. In a VCR for example small gear attached to the small motor is easily and quickly turned, but the large gear's extra torque will be able to turn the heavy VHS tape.

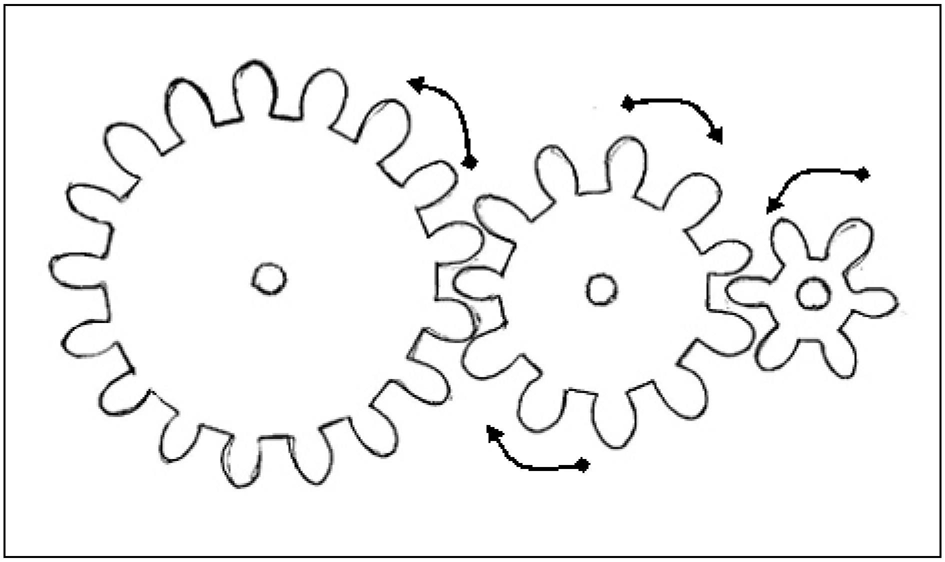
Conversely, a large gear ratio is favorable when we want turning power to be converted into a greater speed as occurs in a bicycle or car transmission gears.

A ratio can be used to show the gain in torque: it is known as mechanical advantage, and it is the reciprocal of the velocity ratio.

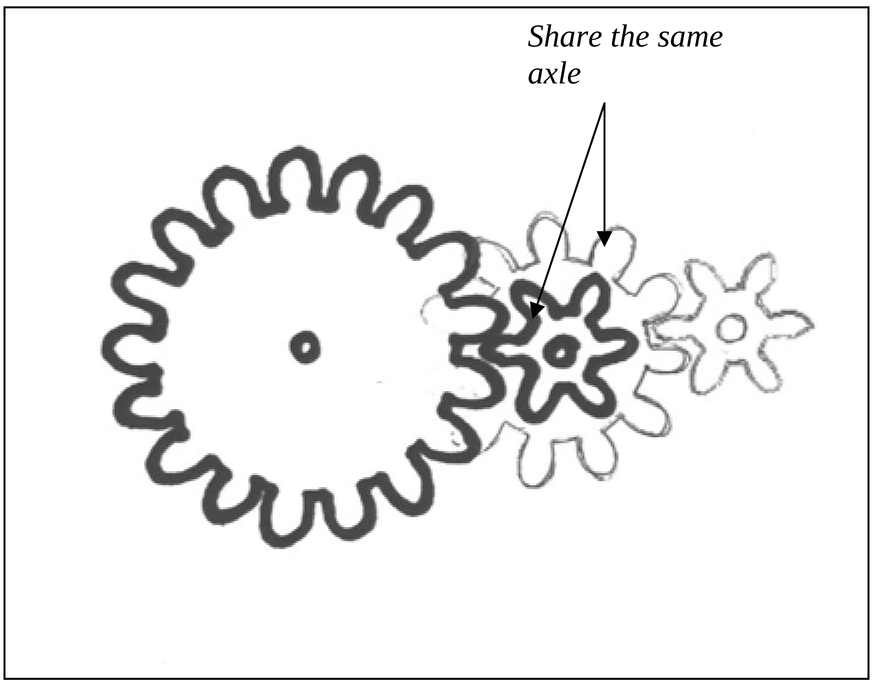
Mechanical advantage = $\frac{C_{output}}{C_{input}} = \frac{d_{output}}{d_{input}} = \frac{n_{output}}{n_{input}}$. If we apply a force to the smaller gear, the larger one gains turning force at the expense of its slower speed. Recall that the velocity ratio was 6/17, but since the output dimension is in the numerator, the mechanical advantage becomes 17/6.

Gears Learning Activity 1

d. <u>Gear Boxes</u>



In the above, although we restore the counter clockwise motion of the large small gear, introducing the middle gear does not change the overall gear ratio. Specifically if we hooked up the large gear to the small gear, the ratio would have been 17/6. The gear ratio between the large and the medium and is 17/11. Between the medium and small it is 11/6. Overall then the ratio remains (17/11)(11/6) = 17/6.



Can we create a system of gears where we can create a larger ratio?

By letting the small gear share the same axle as the medium gear, we now have *two pairs* **of gears working together in what is called a gear box. Since the middle gear is no longer caught in the middle, the overall ratio becomes (17/6)(11/6) = 187/36 = 5.19. So instead of turning almost 3 times faster (17/6), when we had the large-medium-small sequence) the gear box causes the last small wheel to turn more than 5 times faster than the larger wheel.**