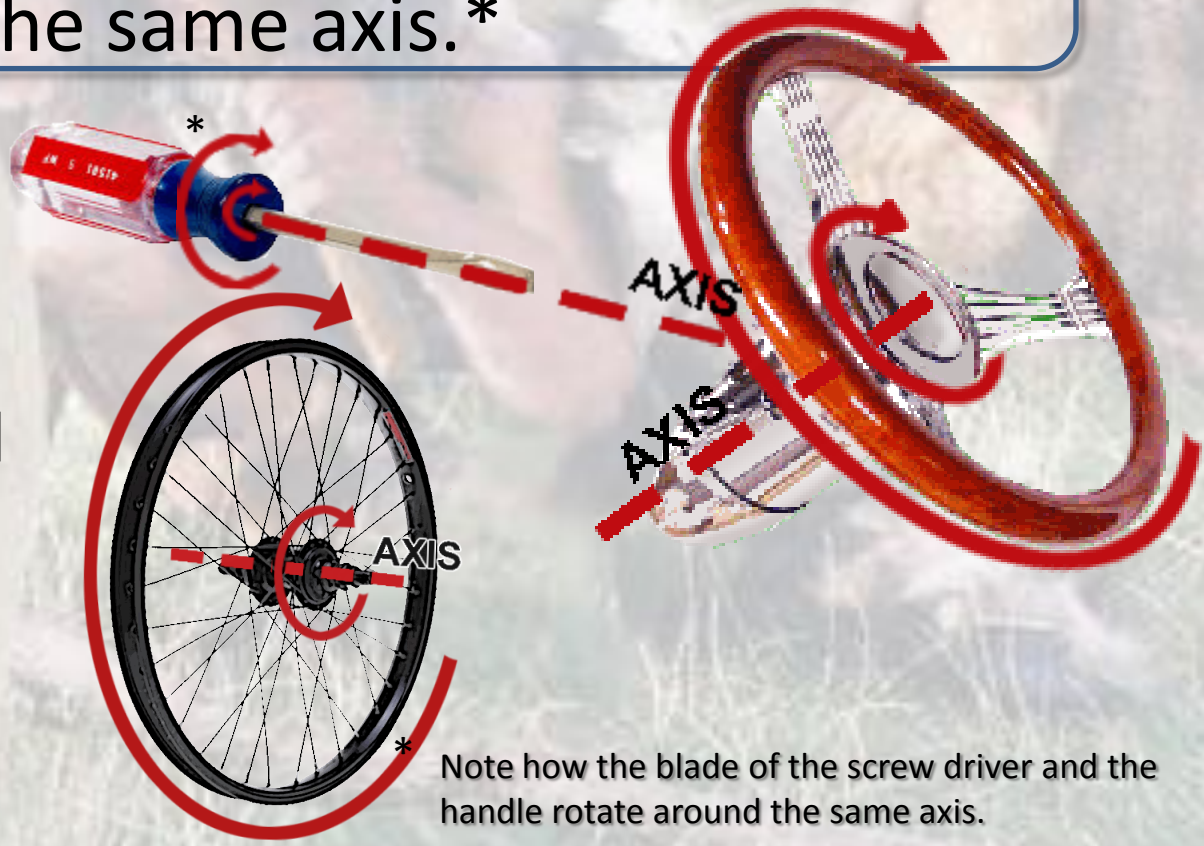
DEFINITION

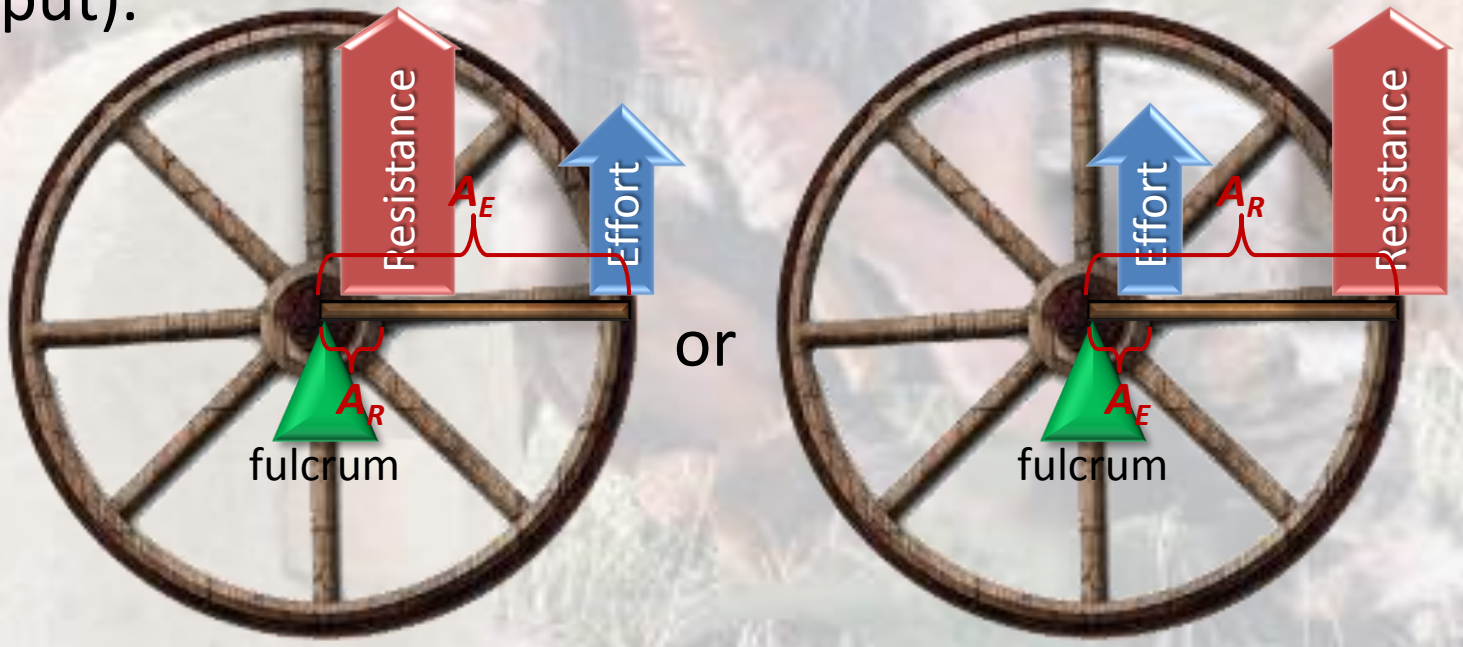
- A wheel and axle consists of two objects of different size attached in such a way that they rotate around the same axis.*
- Examples
  - Screw driver
  - Steering wheel
  - Bicycle wheel



Note how the blade of the screw driver and the handle rotate around the same axis.

The Wheel & Axle vs. the Lever

- A wheel and axle functions similarly to a 2nd or 3rd class lever depending on whether the wheel turns the axle (wheel = input), or the axle turns the wheel (axle = input).

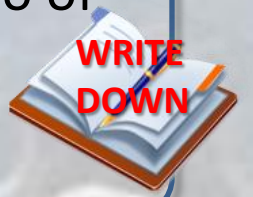


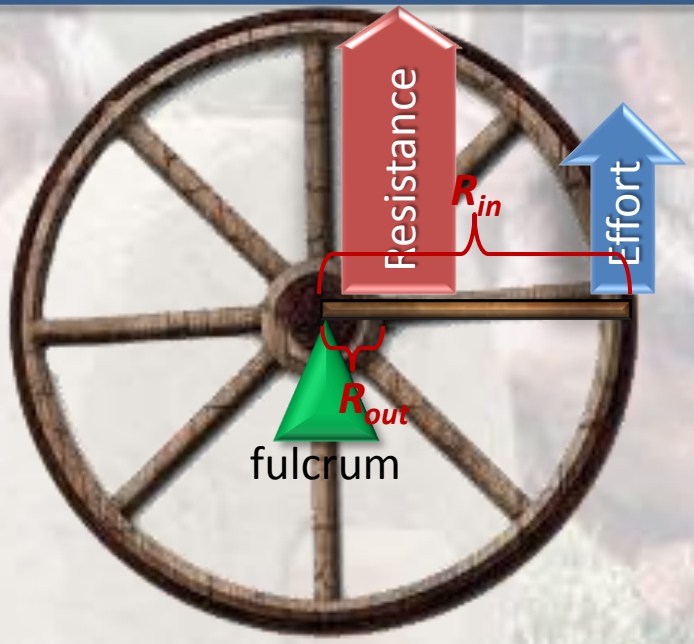
- The input radius is like the effort arm, while the output radius is like the resistance arm.

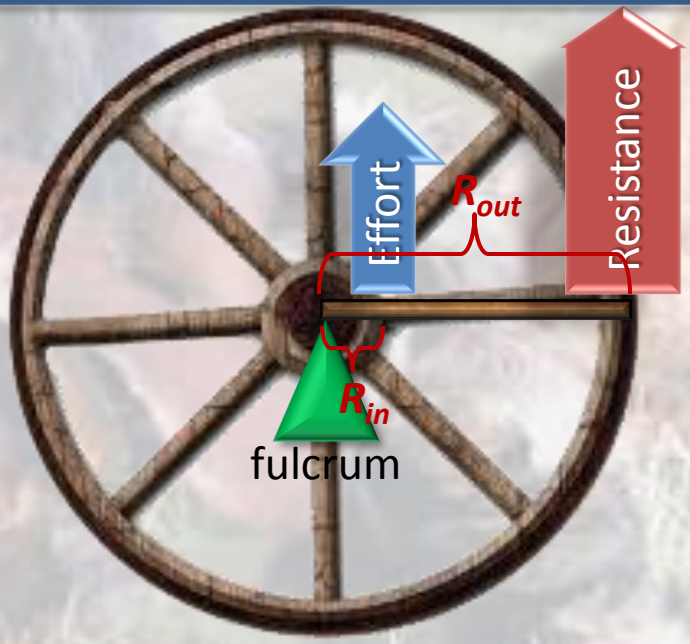
MECHANICAL ADVANTAGE

- The ideal mechanical advantage of a wheel and axle is the ratio of the input radius to the out put radius.

$$IMA = \frac{\text{input radius}}{\text{output radius}}; \quad IMA = \frac{R_{in}}{R_{out}}$$



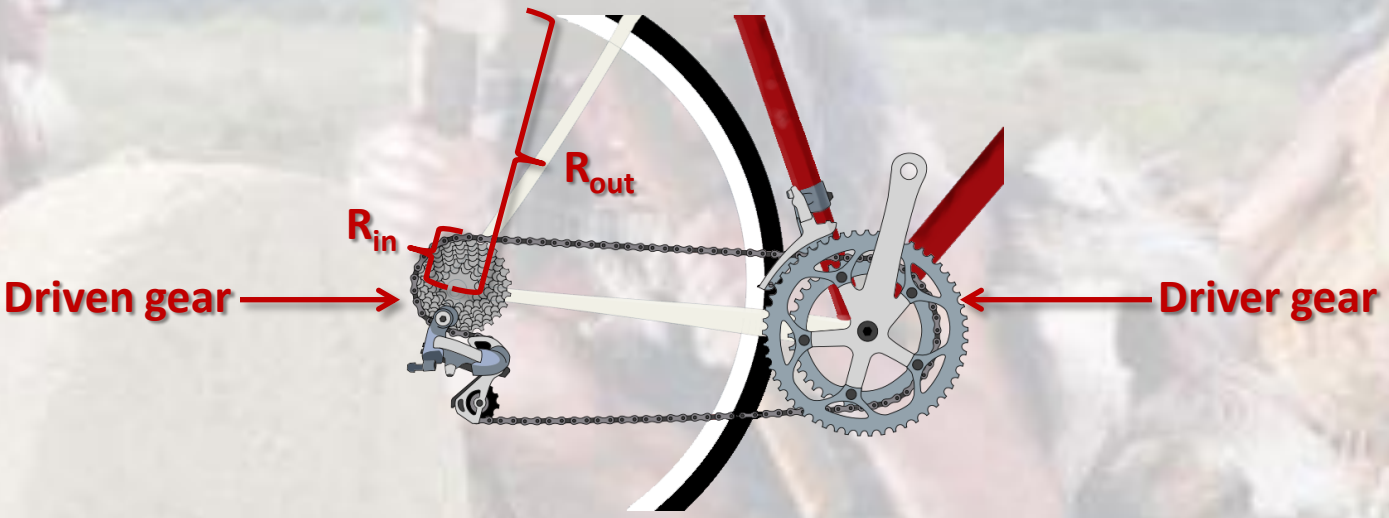




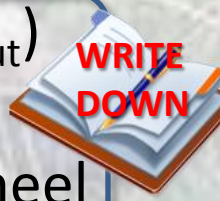
- When the wheel is used for input the mechanical advantage is greater than 1.
- When the axle is used for input, the mechanical advantage is less than 1

Uh, MA < 1 . . . Why Bother?

- Do people use bicycles because riding is easy, or because riding is fast?

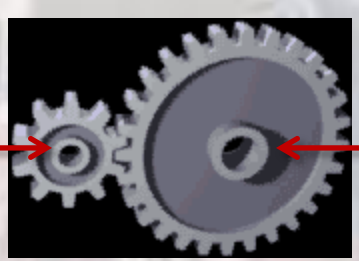


- In the diagram above, the pedal turns a gear with a smaller radius than the wheel it turns.
  - A bicycle gear is smaller than the wheel it turns ($R_{in} < R_{out}$)
  - $IMA = \frac{R_{in}}{R_{out}}$, so the IMA < 1
  - When the wheel and gear each go around once, the wheel has gone a greater distance, so it is faster.

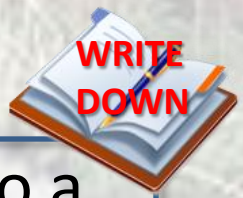


CHANGING GEARS

- Gears have teeth that mesh.



- The smaller the driven gear is, the lower its mechanical advantage is.
  - The smaller driven gear makes more rotations for each rotation of the driver gear.
  - This means it turns faster.



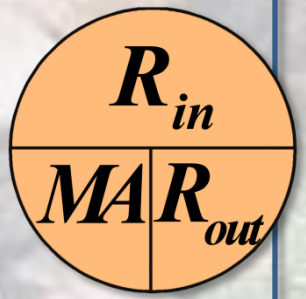
- Changing to a higher gear, which means changing to a smaller driven gear, reduces the power, but enables the vehicle to move faster at a lower engine or pedaling speed.

SAMPLE PROBLEM

A screw is rusted in place. A force of 50 N must be applied to a screw driver with a handle having a radius of 1 cm. The blade has a radius of 0.25 cm. How much force was needed to turn the screw?

- **Step 1**: Determine the mechanical advantage.

$$IMA = \frac{R_{in}}{R_{out}} = \frac{1\ cm}{0.25\ cm} = 4$$



- **Step 2**: Determine the output force.

$$F_{out} = F_{in} \times MA = 50\ N \times 4 = 200\ N$$