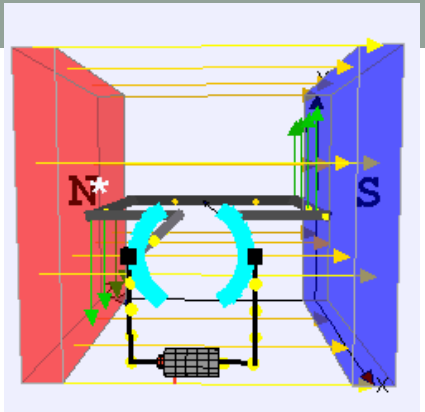
CISC 1003 - EXPLORING ROBOTICS

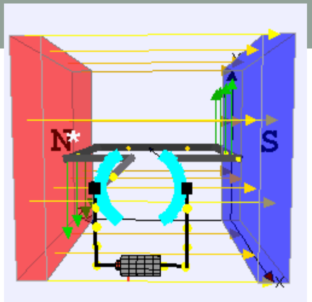
GEARS

Motors



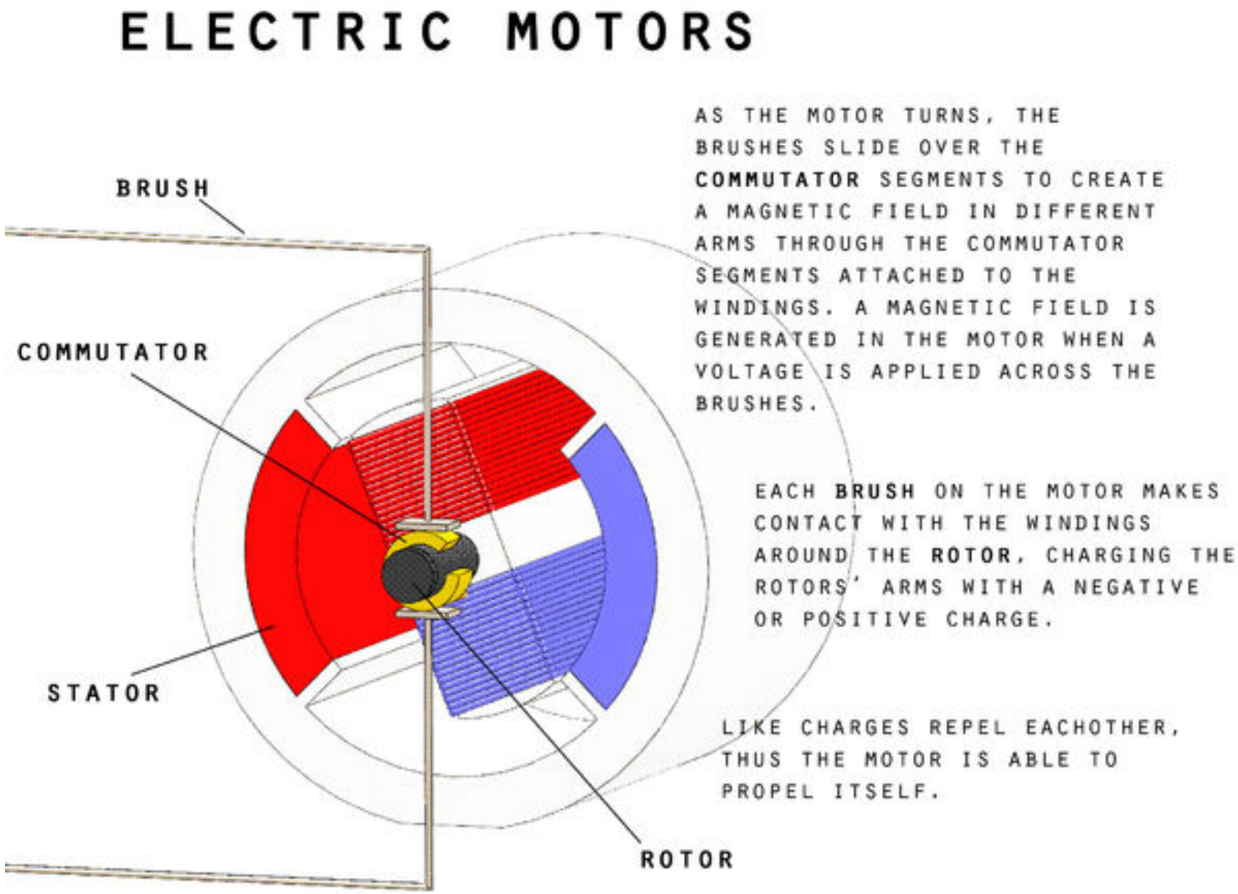
- Compared with all other types of actuators, ***direct current (DC) motors*** are simple, inexpensive, easy to use, and easy to find.
- Motors have a copper wire wound in a way that creates magnetic fields
  - These “push" the rotor inside of the motor around in a circle.

Motors



- To make a motor run, you need to provide it with electrical power in the right voltage range.
  - Low voltage, slower movement.
  - Higher voltage, faster movement
    - but more wear on the motor and can burn out if run fast for too long.
    - Like a lightbulb on a battery. More voltage means a brighter light.

Motors



http://makezilla.com/2016/01/21/how-to-motors/

Gears

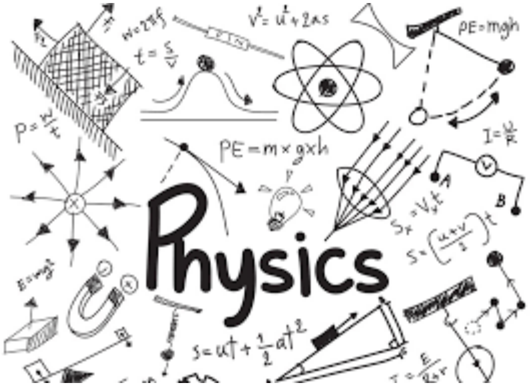
- Gears are wheels with teeth. Gears mesh together and make things turn.
- Gears are used to transfer motion or power from one moving part to another.

Gearing of motors

- Combining different ***gears*** is used to change the speed and ***torque*** (turning force) of motors.

http://www.jsumo.com/steel-gear-bundle-08-module-6421-reduction

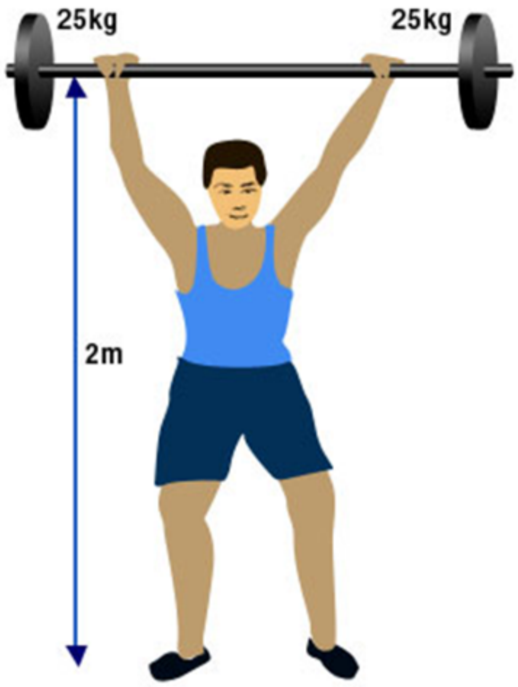
SOME PHYSICS



http://theconversation.com/physics-is-taught-badly-because-teachers-struggle-with-basic-concepts-86083

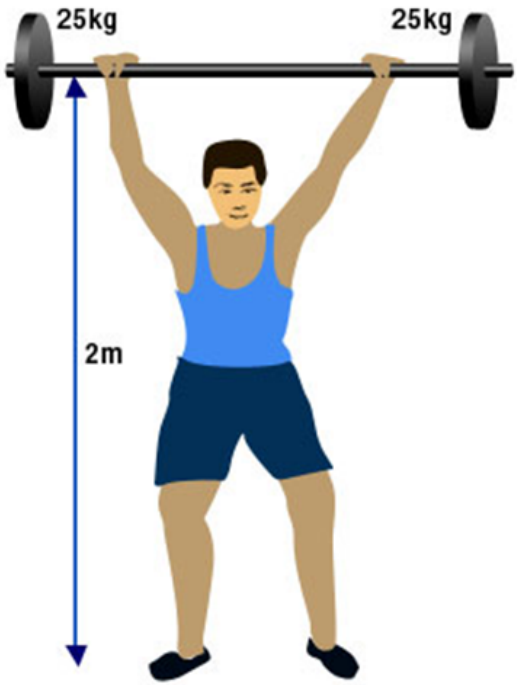
Work, Force and Distance

- Energy is the ability to do work
- Measured in Joules
- Work: The action of a *force* to cause *displacement* of an object
  - Work(J) = Force (N) x distance (m)
    - 1 joule = 1 Newton * 1 meter



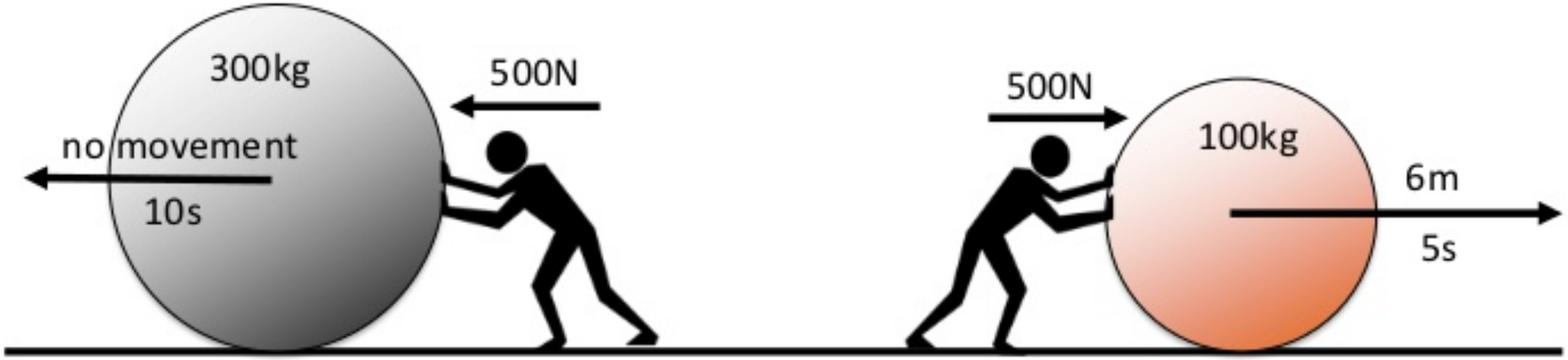
Work, Force and Distance

- Here, in this figure, we can say that, the work done upon the weight against gravity is
- (Mass × acceleration due to gravity) × Displacement
- = (25 x 2 × 9.8) × 2 = 980 J



Work, Force and Distance

- Who has done the most work?
  - Work = Force x Distance



http://www.clker.com/clipart-man-push.html

Work, Force and Distance

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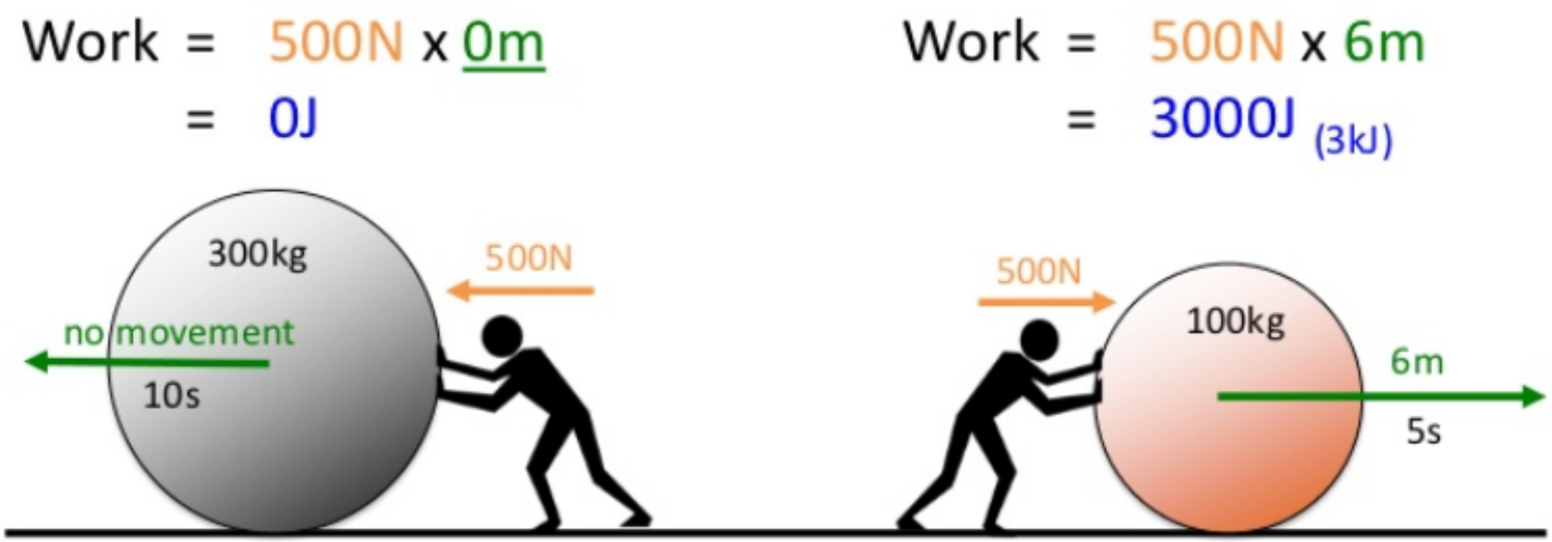


https://www.slideshare.net/gurustip/energy-work-power-10148820

Torque

- Torque is a measure of the force that can cause an object to rotate about an axis.
- TORQUE measures ROTATIONAL FORCE
- $TORQUE\ = FORCE\ x\ DISTANCE$
  $= \ FORCE\ x\ Radius$
  - RADIUS of the rotational circumference.

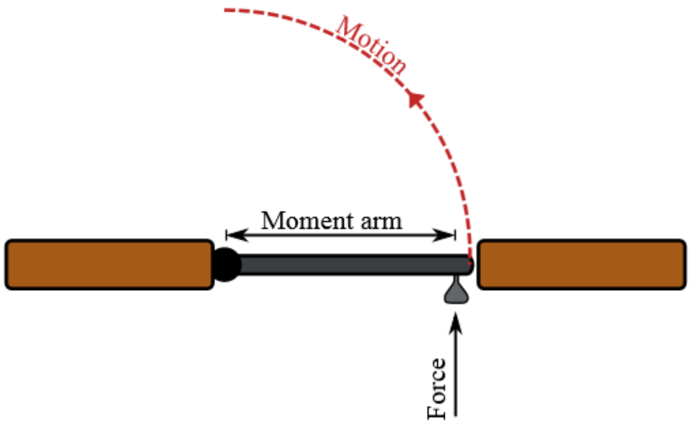
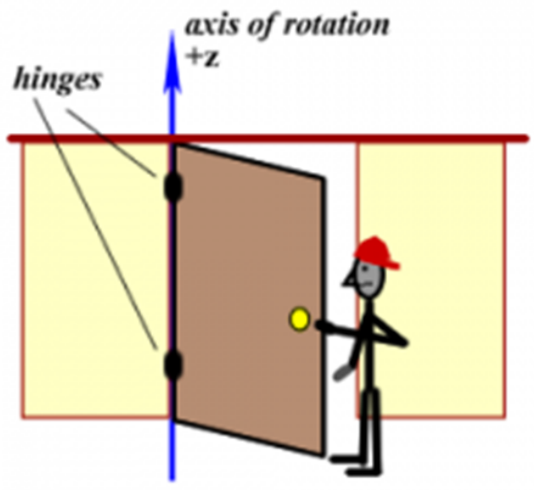


Figure 1: Opening a door with maximum torque.

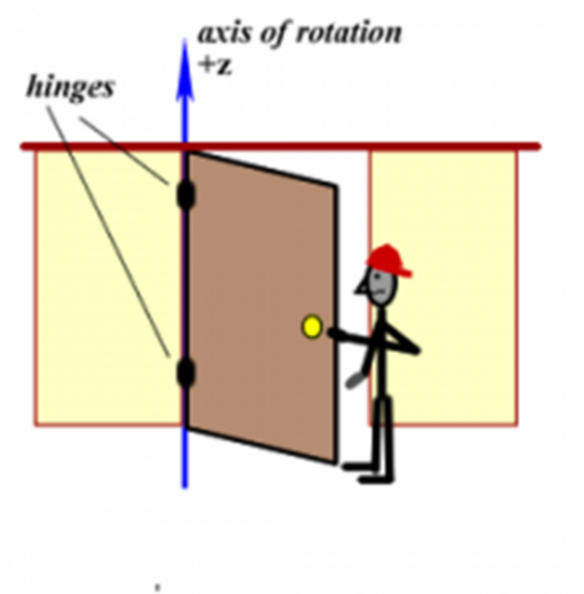
Torque

- Example: opening a door:
  - Torque is the angular force that the person exerts



Torque

- What if your door knob was closer to the hinge?
  - But you used the same force to open it?
    - It would be much harder to open
      - Torque is smaller
    - $TORQUE\ = FORCE\ x\ DISTANCE = \ FORCE\ x\ Radius$
      -



Gearing of motors

- Combining different *gears* is used to change the speed and torque (turning force) of motors.
- Work, as defined in physics, is the product of force and distance.
  - Work = force × distance
  - Distance moved in the direction of the force
- Gears rotate around their axis in a certain velocity
  - Rotational Velocity is specified in Rotations Per Minute.

Gearing of Motors

- ***Torque*** provided by motor is typically constant
- For a wheel on the ground, ***torque*** needed to turn wheel equals to overcome friction
  - $Torque = F_f * Radius$
- For a larger wheel, smaller rotational force will be provided by same engine
  - Harder to turn larger wheels
    - Think of a truck vs. car, who has the bigger engine?

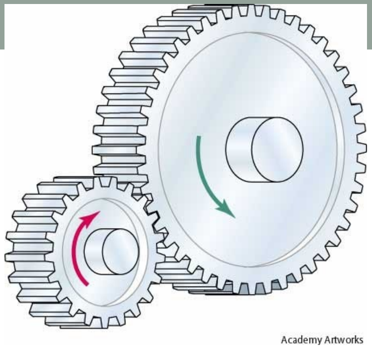
Gears

- Both the input gear (driven gear) and the output gear each have a set number of teeth
- The ratio between these two gears can be used to find the torque and speed of the output gear
  - if the input torque/speed to the driven gear is known.

Gears

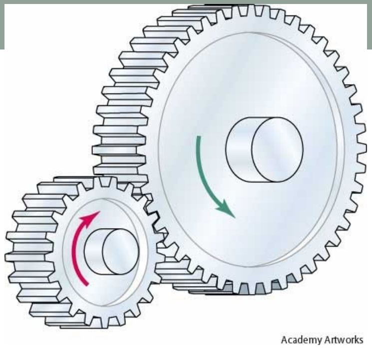
- **Output Speed** = (*Input gear* / *Output gear*) * *Input Speed*
- **Output Torque** = (*Output gear* / *Input gear*) * *Input Torque*

Gears - example



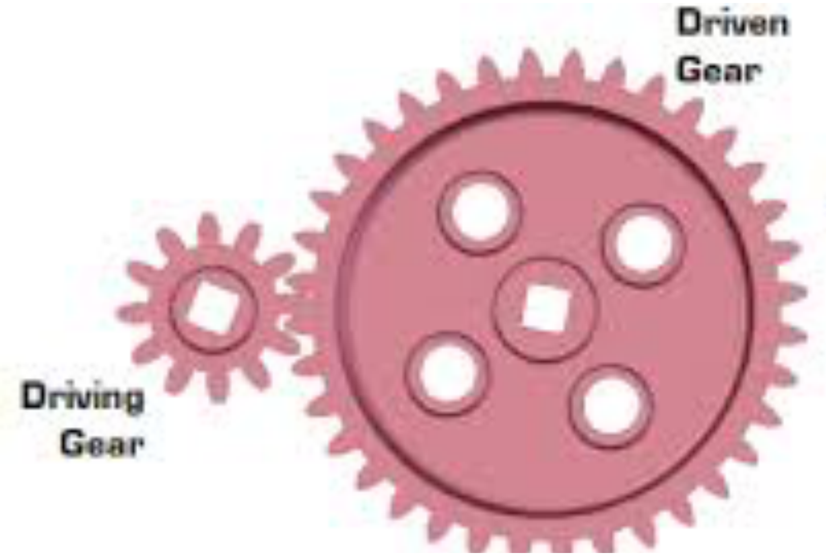
- A motor is attached to a 10 tooth spur gear
  - Gear spins at 100 rpm (rotations per minute)
  - Gear has a torque of 1 joule
- 20 tooth gear attached to the 10 tooth gear
- What are the output speed and torque?

Gears - example



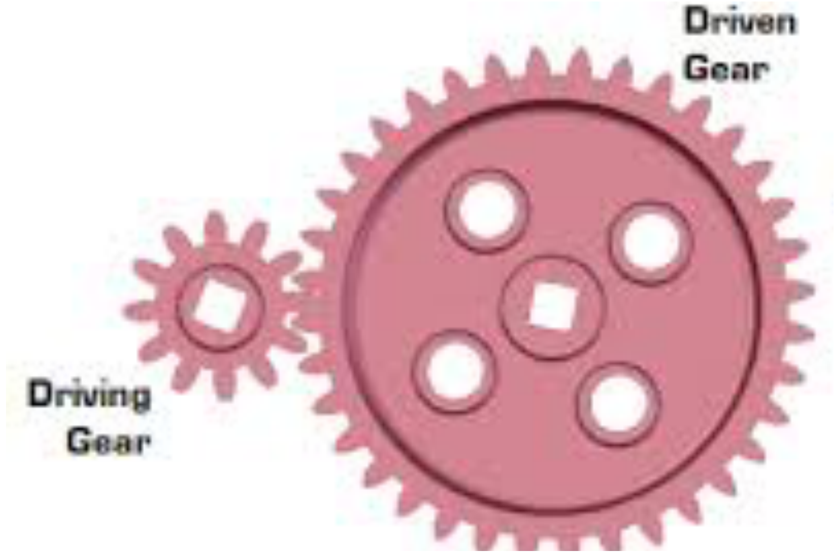
- A motor is attached to a 10 tooth spur gear
  - Gear spins at 100 rpm (rotations per minute)
  - Gear has a torque of 1 joule
- 20 tooth gear attached to the 10 tooth gear
- What are the output speed and torque?
  - Output speed = (10 /20) * 100 = 50 rpm
  - Output torque = (20 / 10) * 1 = 2 joules

Combining Gears



Combining Gears

- What happens to the speed?
- What happens to the torque?



Combining Gears

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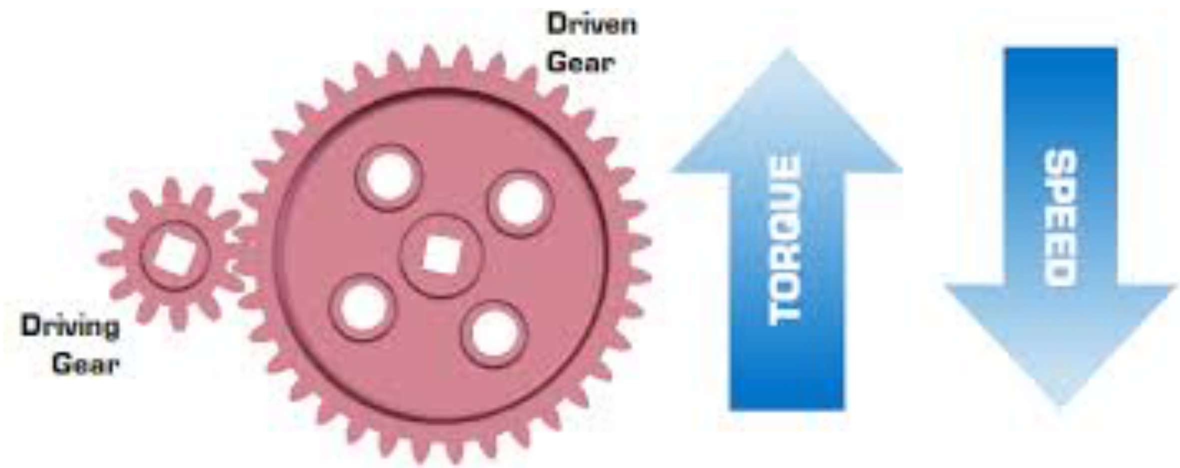
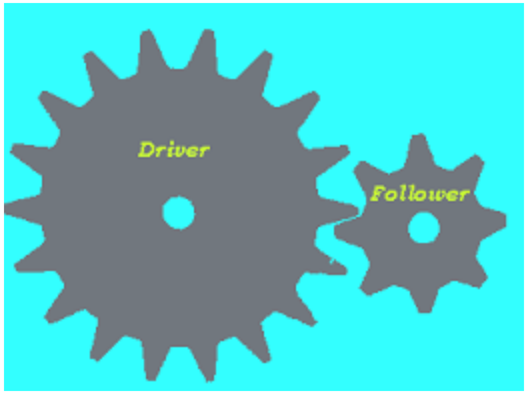
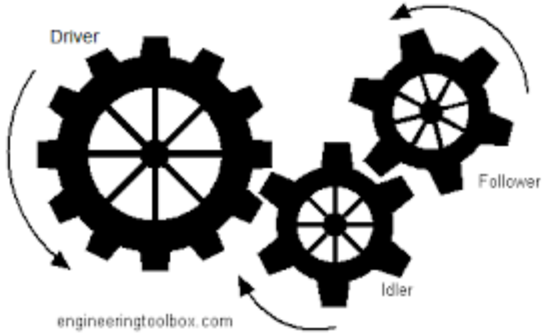


http://klinikrobot.com/product/gear-sets/plastic-gear-fs5-0508-000-gear-14-32t.html

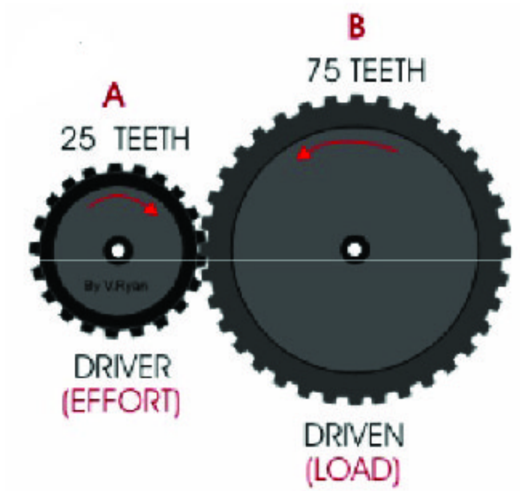
Gear System



- Compound Gears

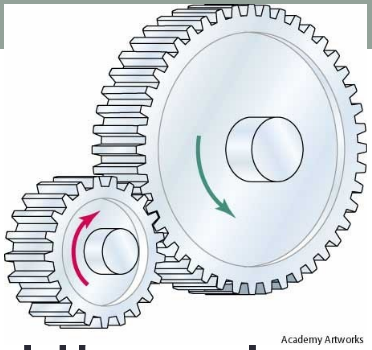


Gear Ratio



$$\frac{\text{Driven}}{\text{Driving}} = \frac{75}{25} = \frac{3}{1} \longrightarrow 3:1$$

Gears – The Purpose

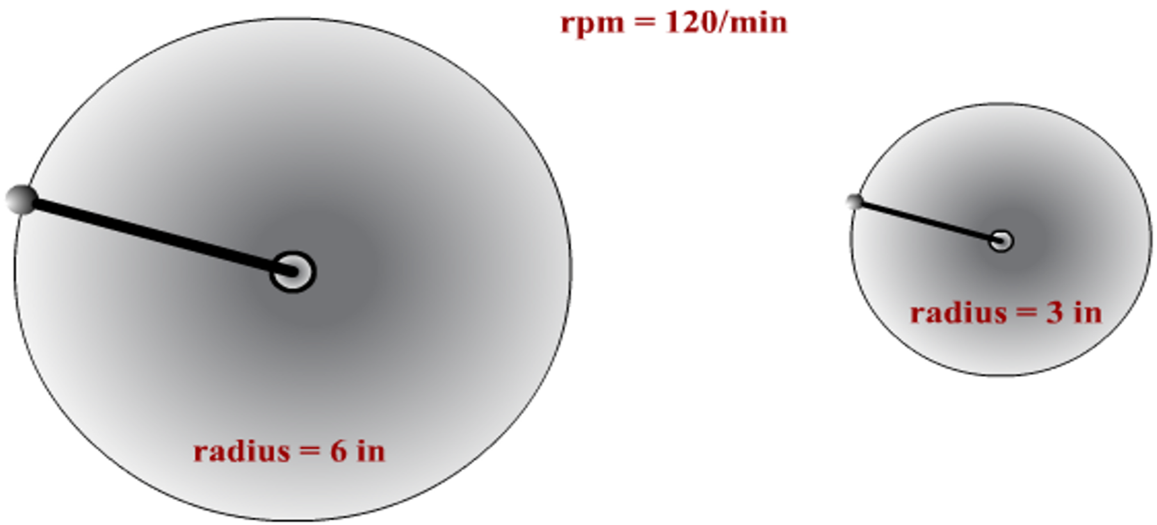


Gears are generally used for one of four different reasons:

- To reverse the direction of rotation
- To increase or decrease the speed of rotation
- To move rotational motion to a different axis
- To keep the rotation of two axis synchronized

Rotational and Linear Velocity

- Both wheels touch the ground and rotate at 120rpm
- Which wheel will travel further?
  - Larger wheel will travel further!
    - Can we calculate its linear velocity?



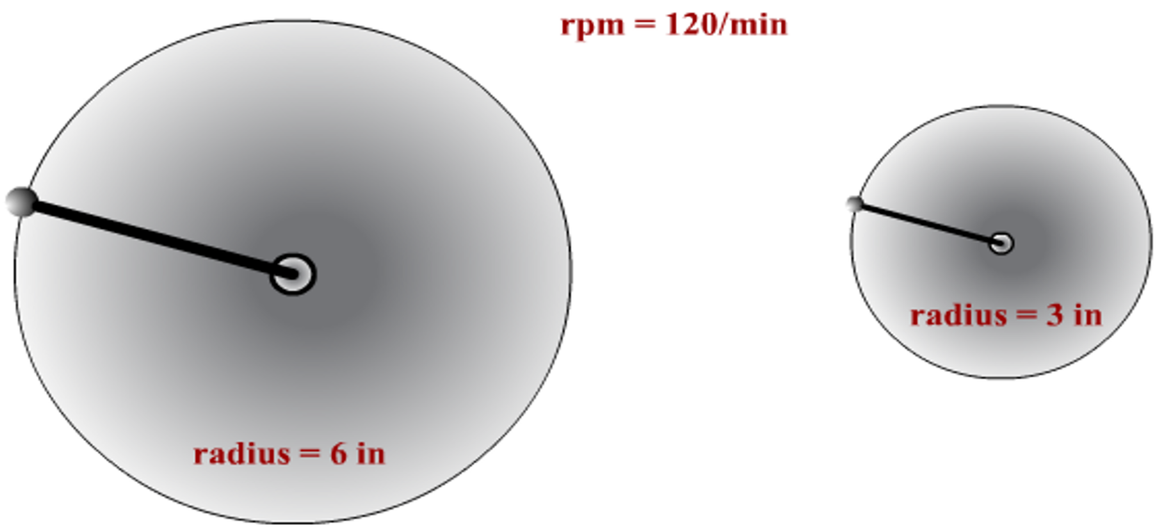
Rotational and Linear Velocity

- Rotational Velocity (RV) to Linear Velocity (LV) conversion:
  - Find the Circumference (C) of the circles: $C \quad = 2 \times \pi \times r$ inches (where r is the radius)
    - Where $r \ = \ radius$
  - $Linear\ Velocity \ = \ C\ x\ Rotational\ Velocity$

http://domarcompanies.com/velocity-business-systems/

RV to LV conversion:

- Find the Circumference (C) of the circles:
  - $C \quad = 2 \times \pi \times r$ inches (where r is the radius)
- Larger circle: $C_1 = 2 \times \pi \times 6 = 37.70\ inches$
- Smaller circle: $C_2 = 2 \times \pi \times 3 = 18.85\ inches$



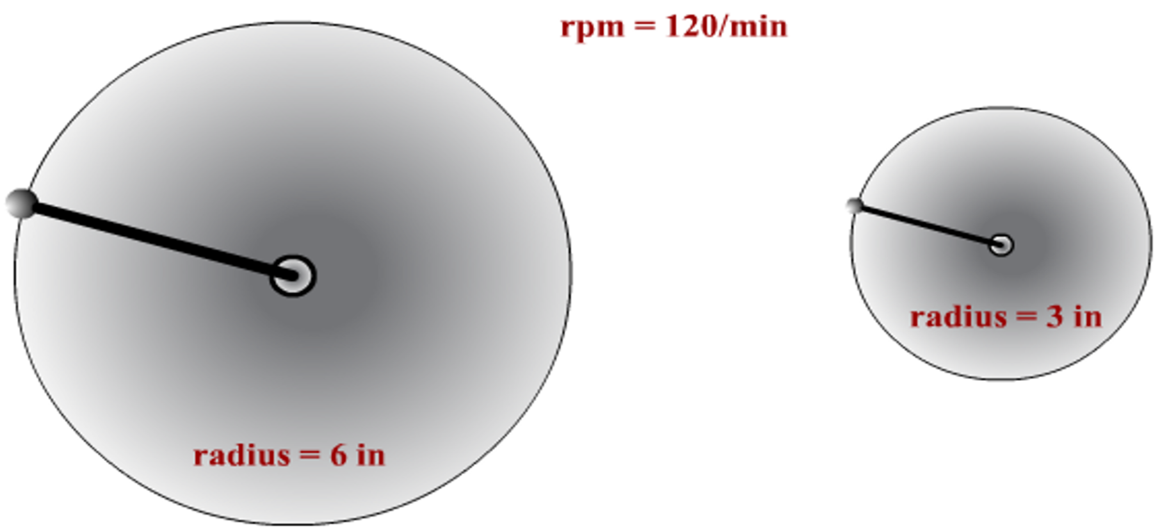
http://domarcompanies.com/velocity-business-systems/

RV to LV conversion:

- $Linear\ Velocity\ =\ C\ x\ Rotational\ Velocity$ (120 rpm speed of both circles)
  Larger wheel:
  - $V_l = 37.70\ * 120 = 4524\ inches/min$
- Smaller wheel:
  - $V_2 = 18.85\ * 120 = 2262\ inches/min$

Rotational and Linear Velocity

- Note:
  - Rotational Velocity is specified in Rotations Per Minute.
  - Linear Velocity is usually specified in Feet Per Minute



Lab time!

- Let's work with our robots!