An Introduction to Design and Physics in Robotics

FeMaidens Design

Fundamentals of Design

We must become one with our inner robot designers and for that we must always keep these core principles in mind!

We want to develop a robot that is:

1. Easily maneuverable or driven
2. Sturdy
3. Efficient in achieving points in a timely manner
4. Easily fixed and possesses an ergonomic space for electronics

As a design team we strive to ensure that the robot:

1. Will be effective and useful on the field in regards to strategy and goals
2. Will not malfunction or become disabled from severe blows

Calculations

Dimensional Consistency: When calculating, measuring, or Cadding ensure that you keep units consistent to prevent having to make conversions.

Certain Calculations should be done in specific units: Newton's law (f+ma), kinetic energy ($1/2mv^2$), momentum (mv), gravitational pull energy (mgh)

When measuring always make sure that you try to make the marker as precise as possible that means putting your line of sight right above the mark and keeping in mind how construction will either cut to the left or right side of it

When making dimensions it's always best to leave a little legroom for comfort which means that you shouldn't be cadding hole measurements that are rather large or rounding measurements down

~ Don't make holes too large! If they're too small construction can still fix it by enlarging them

~ Ex 2: When calculating gear ratios for motors and gearboxes always account for the motor taking up more electrical energy than expected and also calculate for a little extra torque as a safety in order to ensure that the robot functions in terms of extra power capabilities

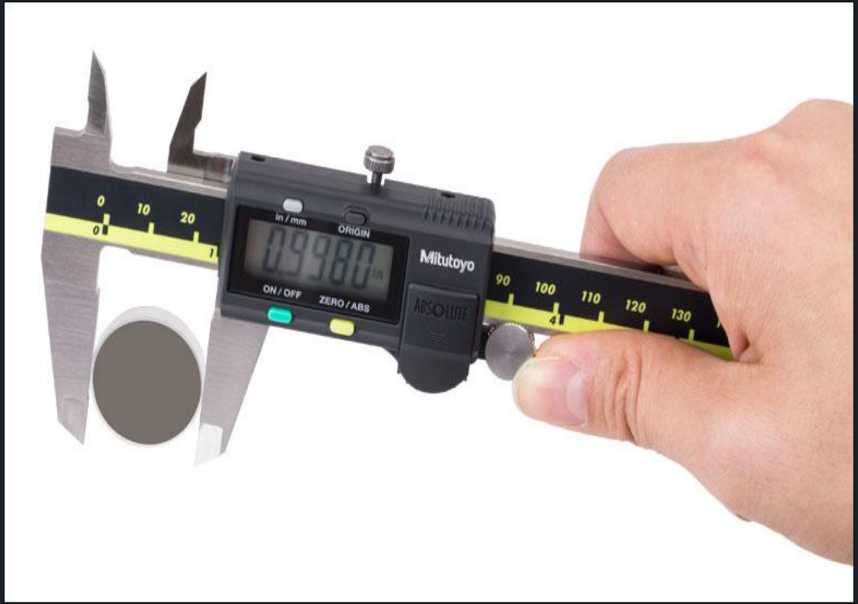
A designer’s best friend: the Digital Caliper

Precision is one of our best friends not just because it ensures that our robot comes together nicely, but also because when custom designing using the 3D printer we can easily find the measurements of parts that are otherwise unspecified elsewhere!

Additionally, the digital caliper comes in handy when you want to CAD small parts from the shop and incorporate them into the robot (for example, holes for bolts).

Keep in mind that we use inches to Cad

Keep in mind that the caliper makes finding the diameter of objects easier as well →



Forces

When designing always keep in mind that out in the game field the robot is prone to being jostled around, pushed from every direction, and on top of that extremely susceptible to having electronics and parts displaced, fall out, and/or stuck within the robot.

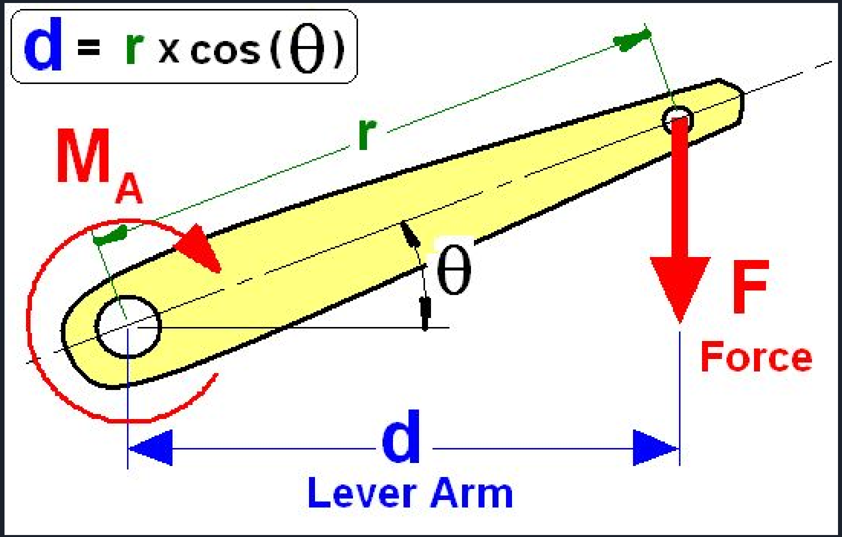
1. Forces that constantly interact with the robot:
   a. Gravity
   b. Direct hits and shoves
2. Variables to consider:
   a. A vector has both direction and magnitude

In order to counter forces we must always think of how to securely mount parts onto the robot and reinforce the robot (i.e. integrity, ensure that no pistons get bent out of shape, braces are incorporated where needed, etc.)

Moment of a Force

This is essentially the tendency of a force to make an object rotate.

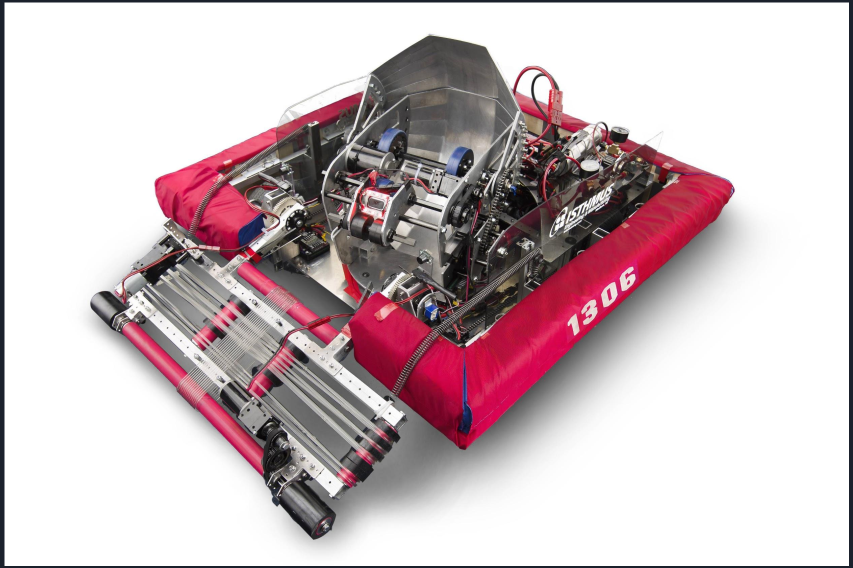
The magnitude depends on the force applied and the lever arm that separates the force from the point of rotation.



Elastic Potential Energy

When using polycord, belt, or spring it is essential to keep in mind that there is elastic potential energy stored within the object and that it will extend and compress in certain ways when stretched or bent.

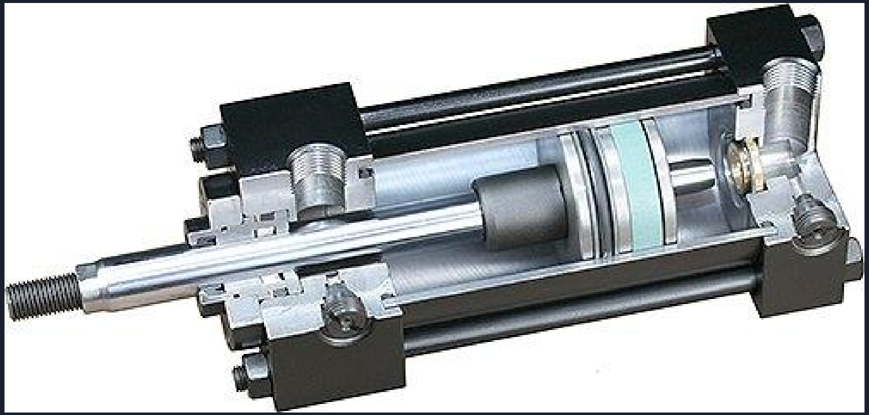
Which is why for calculating how long a cord or belt must be it helps to reduce the length by 10% in order to accommodate for elongation across the distance that it must stretch.



Work of a force W=(F)(△d)

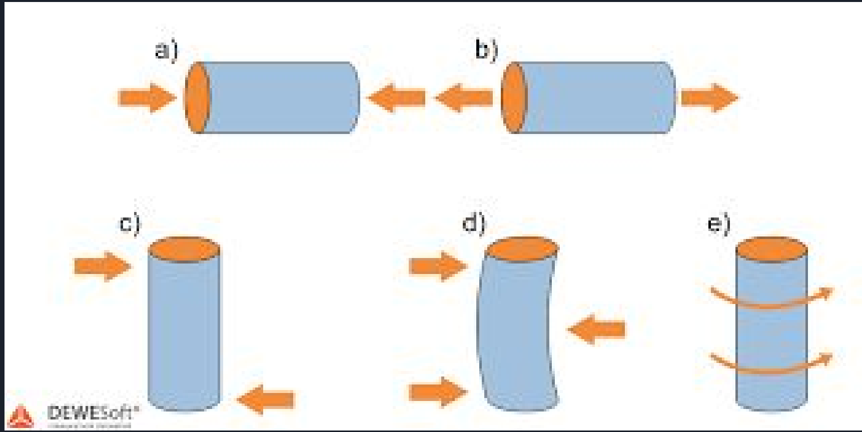
The force F is applied to the piston in order to compress the gas within the cylinder while the piston moves right (the work force is positive because the force acts in the same direction as the piston’s motion)

If the gas is already compressed to a high pressure and the piston moves left the force can be applied to resist expansion (so the work force is negative because it works against the piston).



Strain: Tension, Compression, Strain

a. Compression: the force is applied from the sides causing the rod to become thicker
b. Tension: the force is applied from the top/bottom causing the rod to elongate
c. Shear: forces act on opposite sides of the material and end up deforming the material into a parallelogram shape



Check this site to calculate strain, because if the force/stress is great enough the material can be plastically deformed

https://www.dewesoft.com/pro/course/strain-measurement-1

Rotational Work & Power

http://curriculum.vexrobotics.com/curriculum/lifting-mechanisms

The site above is a complete guide to rotating joints and the mathematics on degrees and work that may be helpful when designing a robot that can elevate objects.

Motors

http://motors.vex.com/introduction

This site should help us choose the right motors as well as find the official stats on the motor we decide to use for calculations involving systems like gearboxes

Gears: Teeth, Pitch, Gear Ratios

http://curriculum.vexrobotics.com/curriculum/mechanical-power-transmission

https://www.vexrobotics.com/vexiq/education/iq-curriculum/mechanisms/gear-ratio

The sites above are a complete guide into gears and motors…

1. Step by step instructions on how to calculate gear ratios *must sleuth out where Jason found the gear ratio site for Polysteamus*
2. How to choose the right gears based on the number of teeth and pitch
3. Basic fundamentals on how gearboxes work