

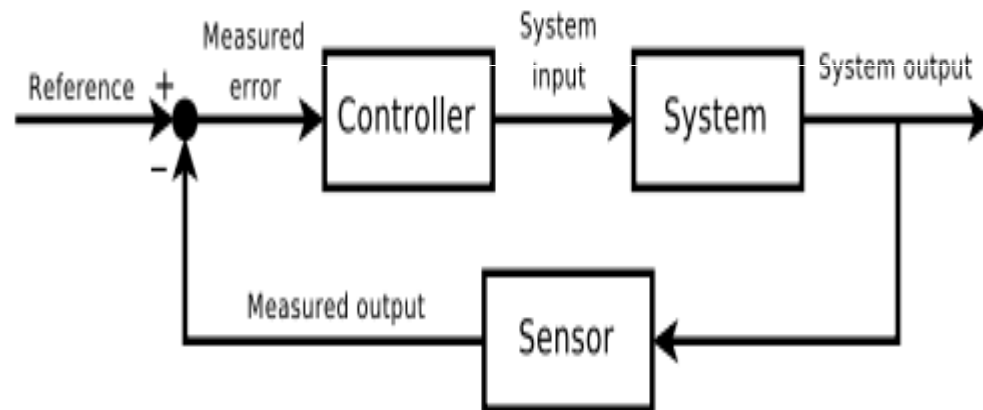
ECGR4161/5196 – Lecture 3 – June 2, 2011

YouTube Videos:

- Biologically inspired foot (and robot) designs
http://www.youtube.com/watch?v=AscqI_RoeBU
- Madeline - turtle
http://www.youtube.com/watch?v=l3llcUklC_s
<http://www.youtube.com/watch?v=gcc6UTIEDlw>

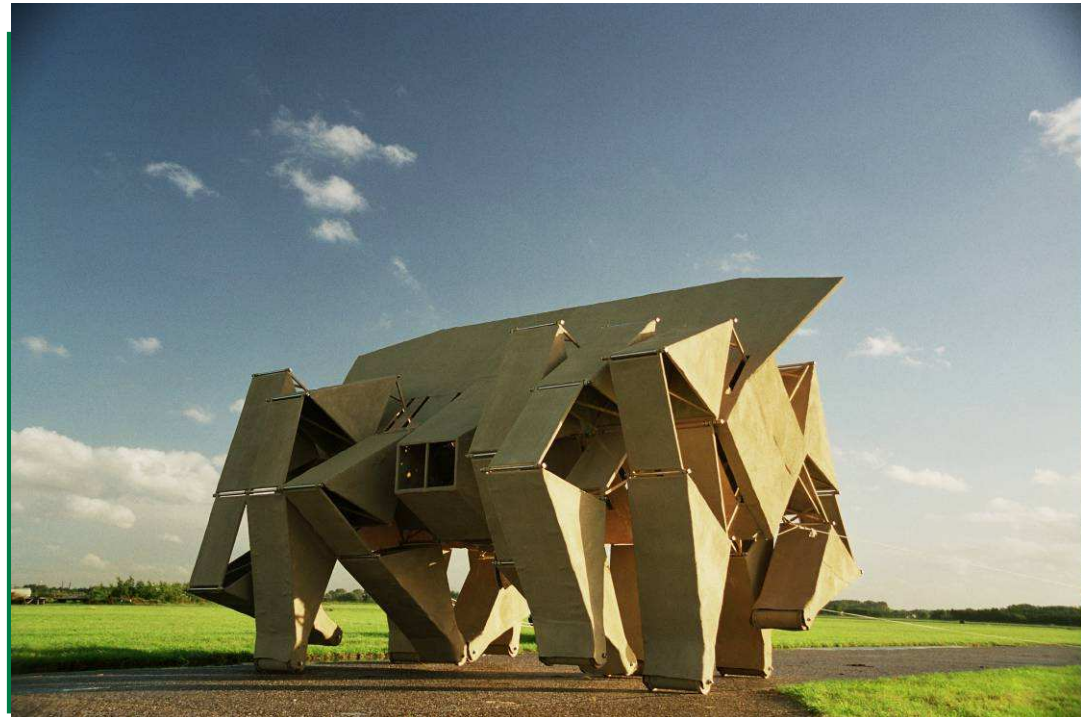
Servomotor – Actuator

- control theory
- negative feedback – error signal between desired and actual
- controller, plant, feedback, and actuation



Actuators - Legs

- The purpose of a 'Leg' actuator is to take simple linear or rotational movements and convert them to complex ambulatory movements
- A discussion of 'Legs' lends itself to the greater topic of Kinematics, the mechanical side of robotics – which is principally the design of linkages
- A well thought out kinematic design can simplify a robotic task greatly. Similarly, a poorly thought out design may be a disaster



A four-bar single-DOF crank-rocker leg we designed for my Mechanical Undergrad

[Wind powered Walker \(21 sec\)](#)



Linear Actuator (the screw type)

Travelling-Nut Linear Actuator:

Utilizes a motor's rotational movement to turn a screw that has been, in most cases, fixed in place or attached to the motor, gearing, or bearings. A Nut is placed on the screw and is therefore moved linearly on the axis of the screw. A load or structure may be placed on the Nut to move it in a linear fashion with respect to the motor/screw housing. In some cases the nut is turned by a motor and the screw can be extended or retracted linearly, similar to the most recent robot video of the tree climber.

Example: http://www.firgelliauto.com/product_info.php?cPath=94&products_id=162

A few applications:

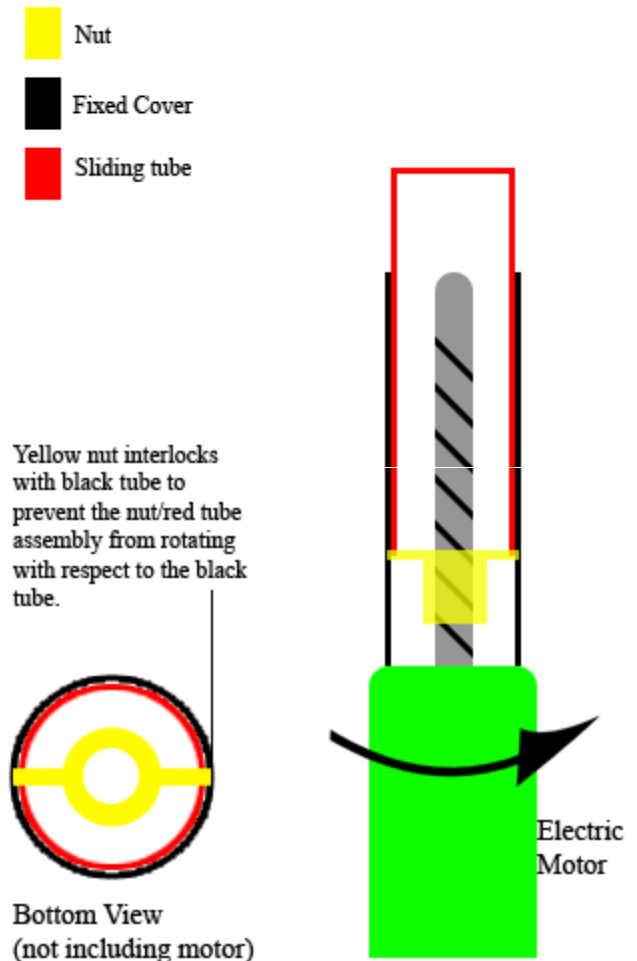
CD/DVD/BR Players, CNC Mills, Laser Cutters, 2-D/3-D printers/cutters, valve opening and closing, etc.

Reference:

Slater, N., Mechanisms and Mechanical Devices Source book, 4th Edition (2007), 25, McGraw-Hill

Linear Actuator, Wikipedia

http://en.wikipedia.org/wiki/Linear_actuator



accredited to Bcraig15 Wiki user (public domain)
http://en.wikipedia.org/wiki/File:Linear_actuator_basic.gif

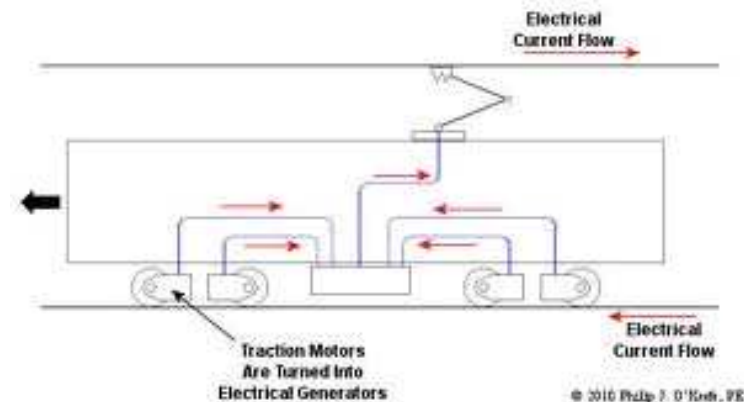
Traction Motors

- Rotational torque à Linear motion
- Used in electrically powered rail vehicles and ERVs
- SIEMENS EV TRACTION MOTOR MODEL 1PV5133:
 - 215 - 380 Volt,
 - 282 Amp RMS (400 peak)
 - 67 Kw peak (30 Kw continuous)
 - 42 Horse Power
 - 3500 - 9700 RPM
 - 6 pole, 3 Phase AC Induction
 - Liquid cooled



By Samer Hawayek

<http://www.commoditiesrecoverycorp.com/electricmotors.htm>



Maglev Actuators

Definition:

Magnetic levitation is the phenomenon in which two magnetic objects are repelled from each other in the vertical direction [1].

Principle:

Two materials with opposite magnetic polarities are used to maintain the object in the levitation state.

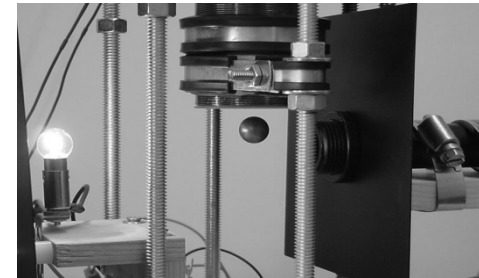


Figure 1: Stable Levitation of Steel Ball [2]

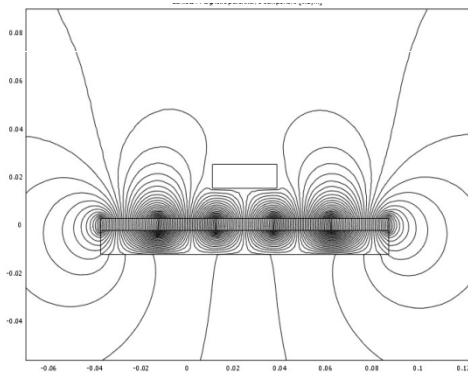


Figure 2: Contour: Magnetic Potential, z-Component [3]

Examples:

- Electromagnetic Levitation System

(<http://www.youtube.com/watch?v=7o4TdX3o098>)

- 10kW Magnetically Levitated Vertical Axis Wind Turbine VAWT

(<http://www.youtube.com/watch?v=j2yopwSBXn0&NR=1&feature=fvwp>)

Sources:

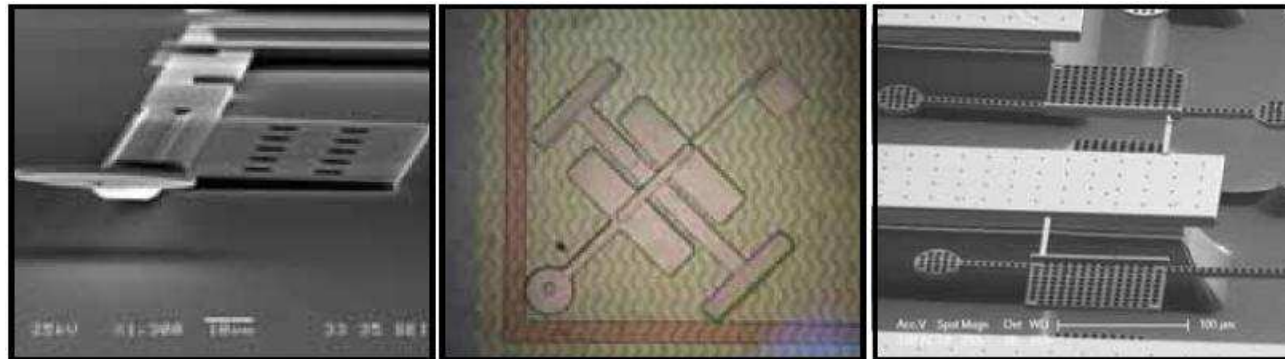
[1] Magnetic Levitation <<http://science.jrank.org/pages/4073/Magnetic-Levitation.html>>

[2] Paschall II, S. "Design, Fabrication, and Control of a Single Actuator Test Bed" <<http://www1.mengr.tamu.edu/wjkim/pdf/Abstracts/Paschall02syn.pdf>>

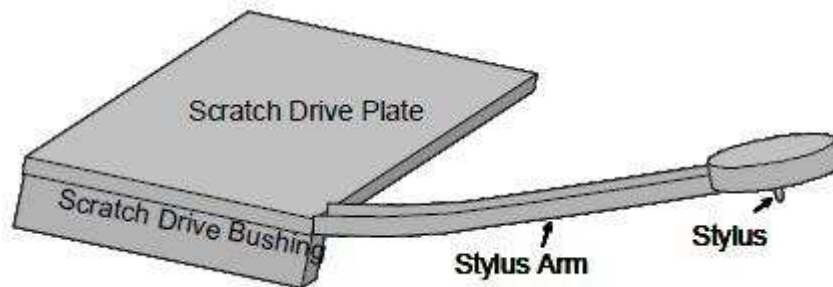
[3] Spal, P. "Overview of Magnetic Levitation Principles and Their Application in Maglev Trains" <http://www.digitaledition.org/adveng/AE0201/AE0201_019-028.pdf>

MEMS and Electrostatic Actuation

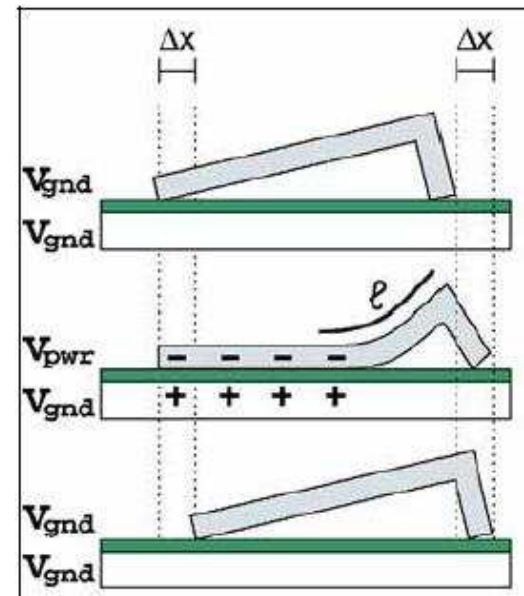
- MEMS – **M**icro **E**lectro **M**echanical **S**ystem



- Electrostatic Actuation = Scratch-Drive Actuation



- Snap-down Voltages



ROTORK Compact Pneumatic Actuator (CP)

Pneumatics is a branch of technology, which deals with the study and application of use of pressurized gas to effect mechanical motion

- Nitrogen
- Air Compressors
- 80 -100 psi
- Oxygen
- Air Brakes
- Carbon Dioxide
- Robot Wars – Weaponry
- Air Engines

ROTORK Compact Pneumatic Actuator (CP)

- **Operating Pressure:** 12 bar (174 psi)
- **Torque Output:** 4,500 Nm (39,828 lbf-in)
- **Operating Temp:** -60 to 160 deg C
- **Cylinder Diameter:** 100 cm

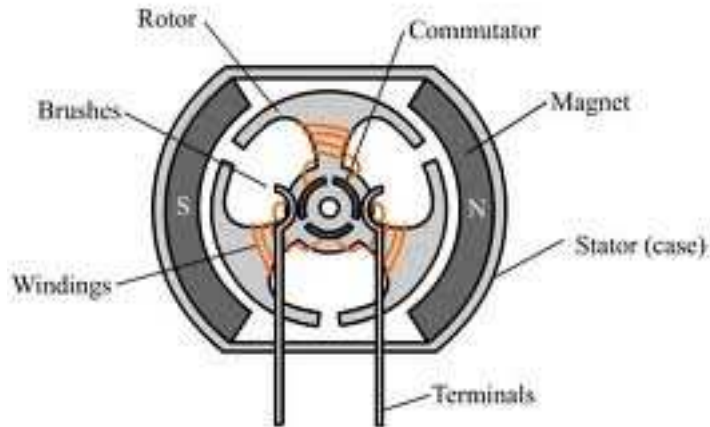


$$\pi r^2 (\text{Air Pressure}) = \text{Total Force Output}$$

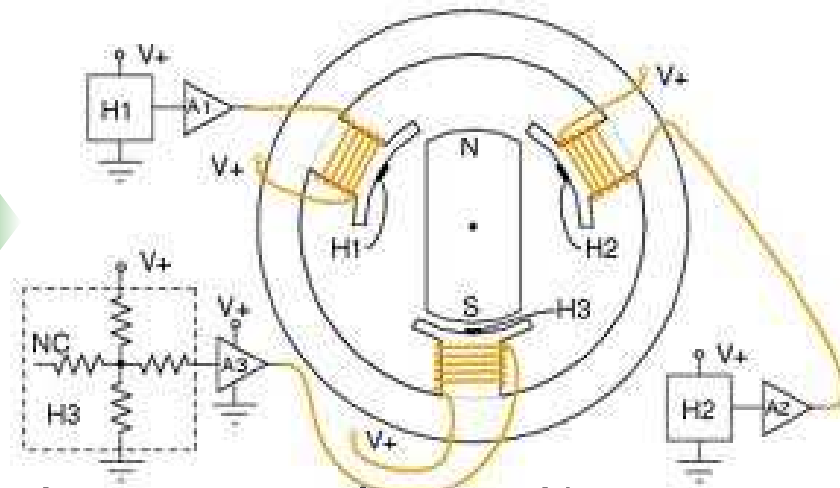
$$\pi (19.685 \text{ in})^2 (174 \text{ psi}) = 211,714 \text{ lbf}$$

DC Brushless Motors

Typical Brushed Motor in Cross-section[2]



Typical Brushless Motor in Cross-section[1]



Brushless DC motors can take in rectangular and/or trapezoidal wave forms[1]

Cut down on arcing, higher torque

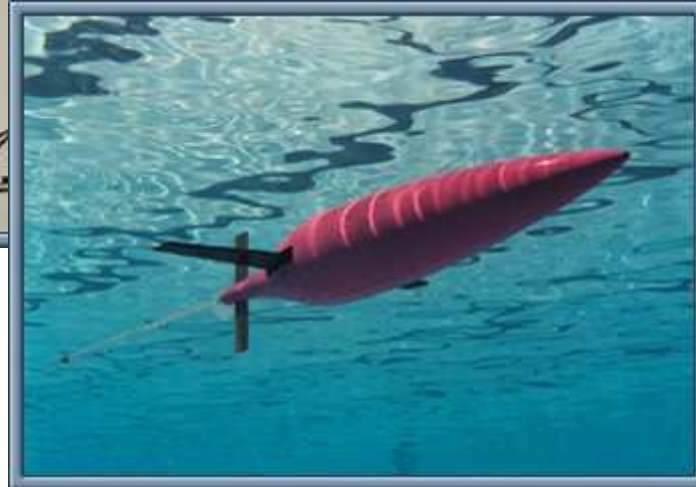
Two poles are always north ([Example](#))

Needs an electronic speed controller(ESC) to generate the driving signal

1). "Brushless DC Motor : AC MOTORS." *All About Circuits : Free Electric Circuits Textbooks*. Web. 01 June 2011. <http://www.allaboutcircuits.com/vol_2/chpt_13/6.html>.

2). "Motor Brush Replacment – A Step by Step How To « Experimental Electric Vehicles." *Experimental Electric Vehicles*. Web. 01 June 2011. <<http://experimentalev.wordpress.com/2011/03/22/motor-brush-replacment-how-to/>>.

Autonomous Underwater Vehicle



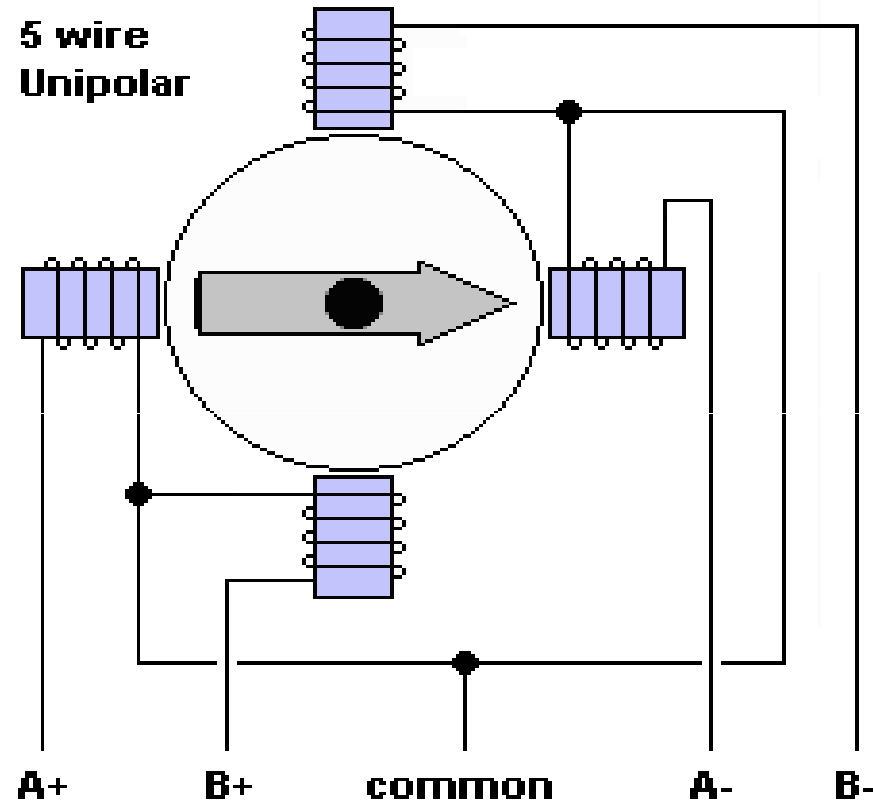
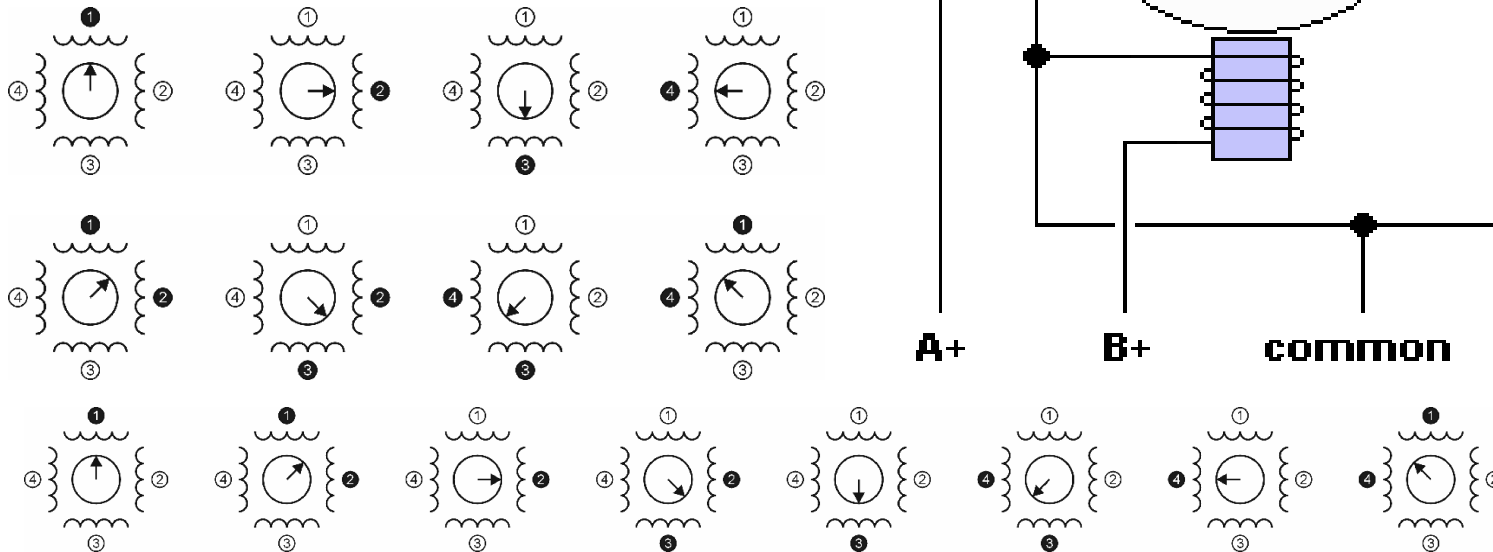
1. <http://www.youtube.com/watch?v=faEqAb6MEZw>
2. <http://www.apl.washington.edu/projects/seaglider/summary.html>
Papers published in the IEEE Journal of Oceanic Engineering
3. <http://www.princeton.edu/~naomi/publications/2001/LeoGraJOE01.pdf>
4. [http://www.apl.washington.edu/downloads/eriksen et al 2001.pdf](http://www.apl.washington.edu/downloads/eriksen%20et%20al%202001.pdf)
5. [http://www.irobot.com/gi/more information/gulf oil spill response/](http://www.irobot.com/gi/more%20information/gulf%20oil%20spill%20response/)



Nirmal Boriwala – Parallax unipolar Stepper Motor #27964

Rotation angle proportional input pulse.
Rotation speed proportional to pulse frequency.
High accuracy, non cumulative error.
Open loop control, less costly.

12 VDC, 4 Phase, 7.5' step, unipolar.
Robotics, Motion Control and Industrial equipment.



Piston-Type Hydraulic Actuator

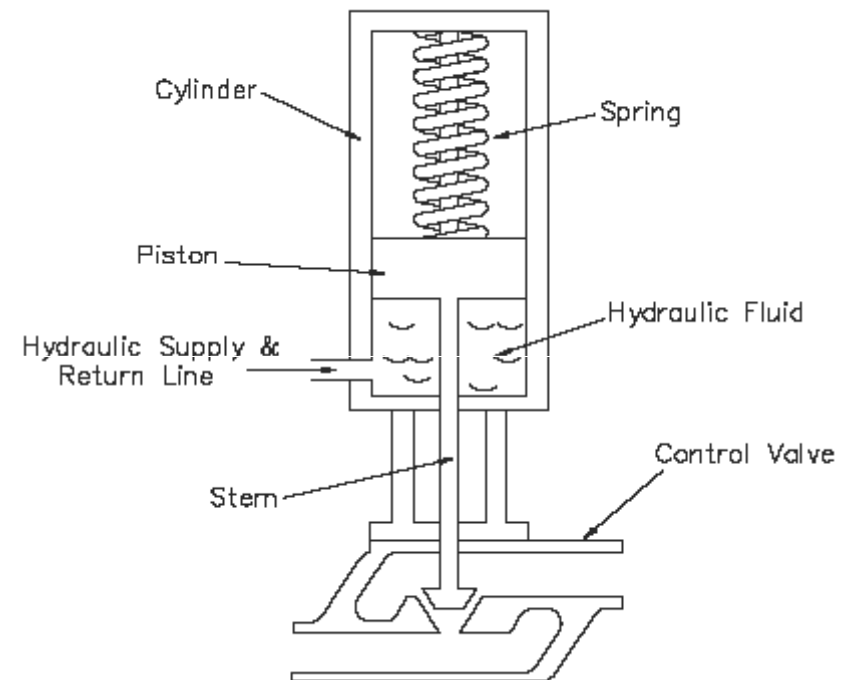
Consists of a cylinder, piston, spring, hydraulic supply & return line, and stem

Piston slides vertically inside the cylinder separating it into two chambers (upper contains spring and lower contains hydraulic fluid)

Hydraulic supply can flow in and out of the chamber forcing the piston to move up and down

Without fluid pressure – spring is uncompressed and valve is closed

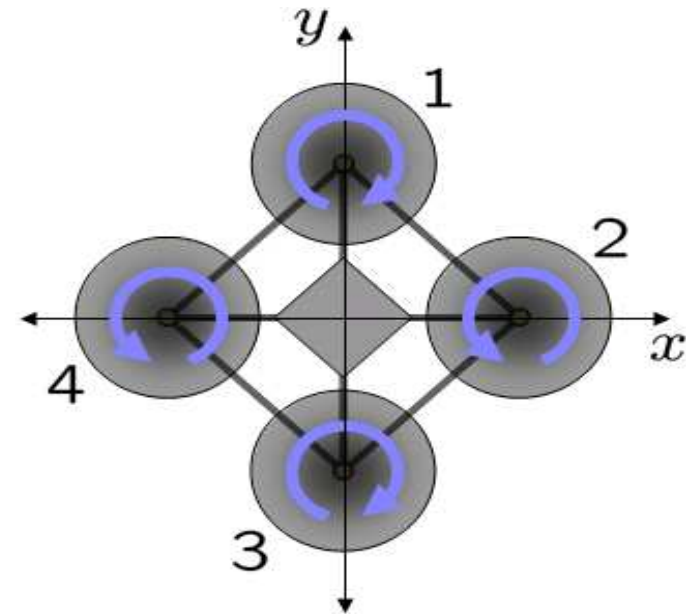
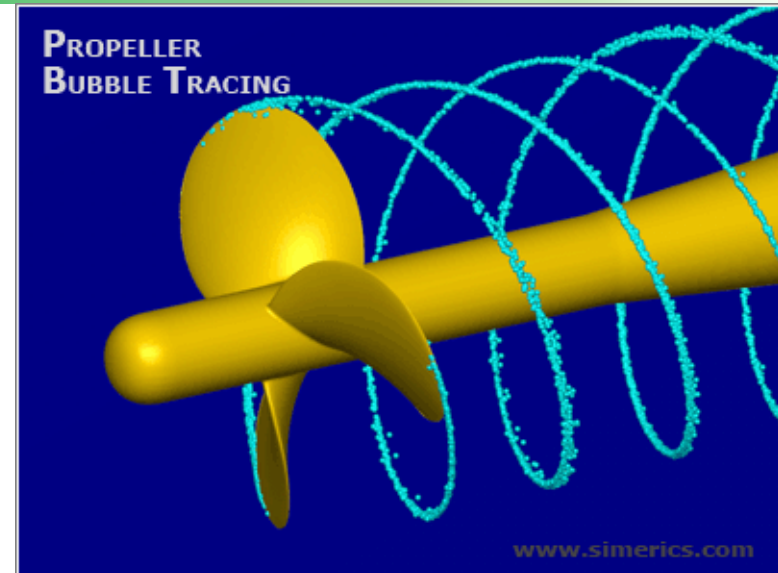
With fluid pressure – spring begins to compress, piston moves upward, and valve begins to open



Jeffrey Skelnik – ECGR 5196 Actuator Presentation
http://www.engineersedge.com/hydraulic/hydraulic_actuator_2.htm

Propellers

- Mounted to motors and acts like a screw that PULLS
- Torque is dependent on:
 - Propeller “pitch”
 - Size (dependent on max RPM)
 - RPMs



[1] <http://www.explainthatstuff.com/how-propellers-work.html>

[2] http://www.thaitechnics.com/propeller/prop_intro.html

[3] http://www.simerics.com/gallery_propeller.html