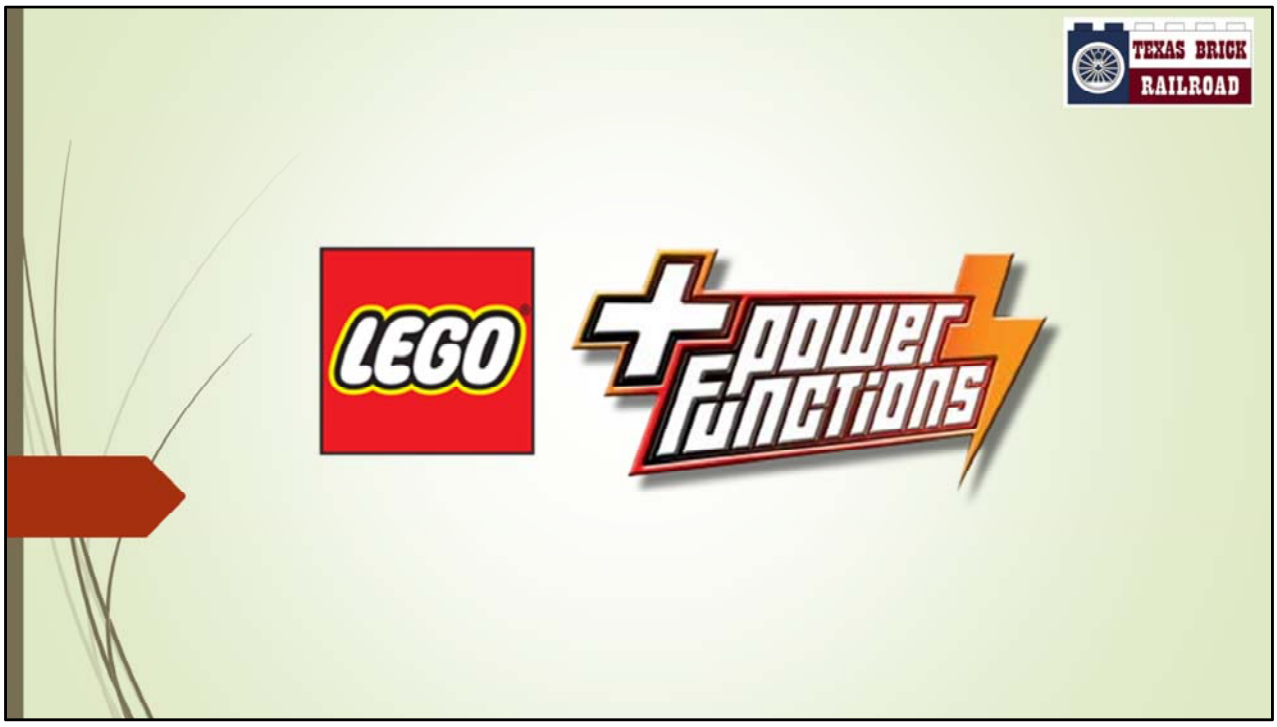

TEXAS BRICK
RAILROAD
LEGO
power Functions

Lego's Power Functions is a simple and fun way to control your Lego creations.

You have battery boxes to deliver the power, different types of motors and lights to make things move and light up with remote controls to real time control your creations.

There is even USB interfaces to control Power Functions from you computer and even connection to a computer.

Everything fits together in a system to let you build and control your own inventions.

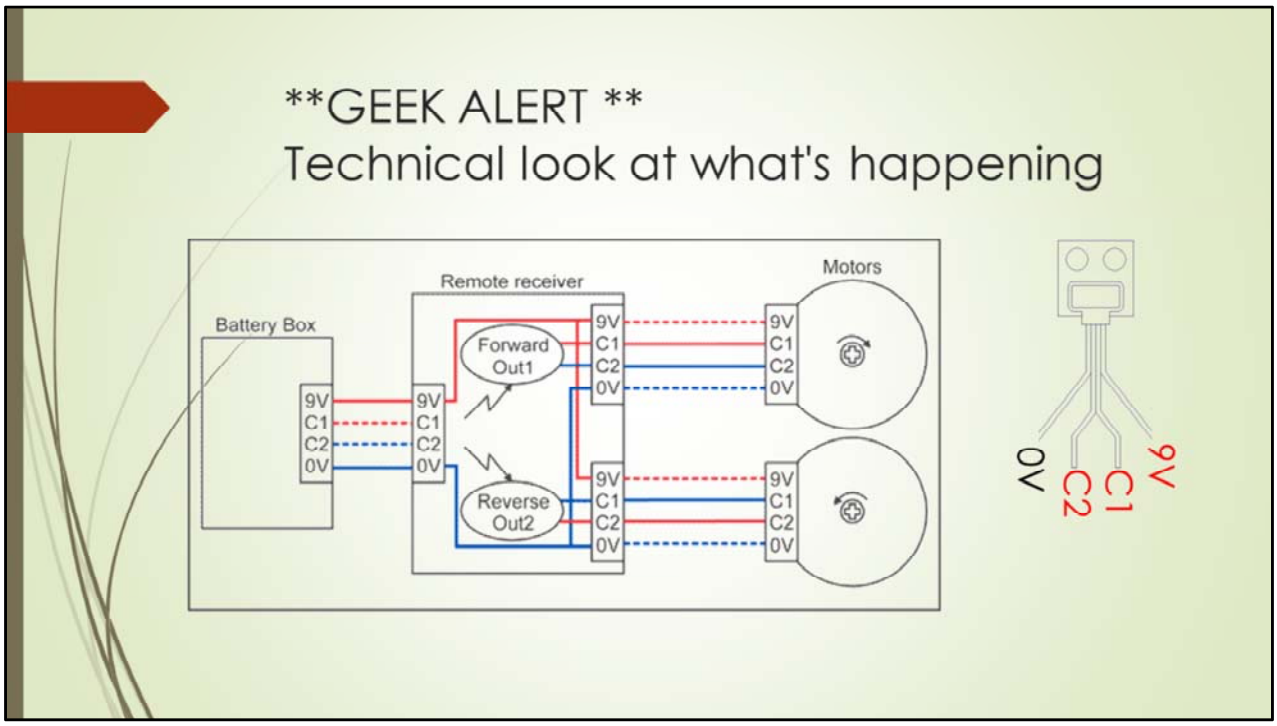
The Power Functions system has 4 wires instead of the 2 wires in the 9V System. This gives a range of new possibilities that were not available before.

2 cores for power like 9V

2 cores for control which opens the doors for

Remote control functions, sensors, and intelligent control that can now be used directly within the Power Functions system.

Power is distributed from one Battery Box to Power Functions elements that are chained together in whatever combination you like.



The backbone of PF is a 4-wire cable ended by a stackable connector. This connector is keyed so it is always plugged the right way.

Power lines carry supply voltage from the battery box to all devices that need it, such as the remote control receiver.

Control signals may be outputs (the remote receiver creates C1/C2 according to IR commands) or inputs (the motor takes power from C1/C2 and turns according to their state).

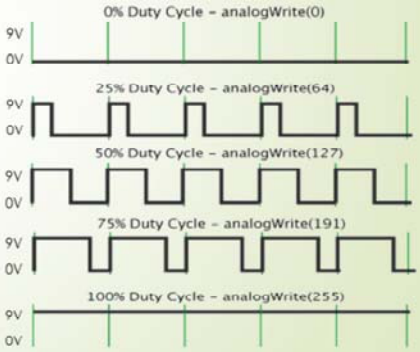
GEEK ALERT #2
Technical look at what's happening

9V

Variable Voltage

Power Functions

Pulse Width Modulation



To better understand Power Functions

Can be split up in to 4 categories

- Control
- Power
- Action
- Cables

Control devices allow a human or computer to interactively control the power functions allowing more creative use of motors and lights.

IR receiver can be set to use 4 different IR channels, and has 2 motor output channels

This means you can have 4 IR receivers next to each other, controlling 8 different motors or lights.

You set the IR channel using the A to D orange switch on the front.

The PF connector goes to a power source

2 versions, The IR Receiver V2 version has an improved motor driver giving you lower power loss and longer battery lifetime (currently the IR Receiver V2 is only available in the 4x4 Crawler).

IR standard remote has 2 control channels and can be set to 4 different IR channels

This means you can select to control one of 4 different IR receivers and control 2 motors on that channel

The remote is full on forward or reverse and springs back to center when not in use to the off position.

This is great for remotely controlled cars and vehicles

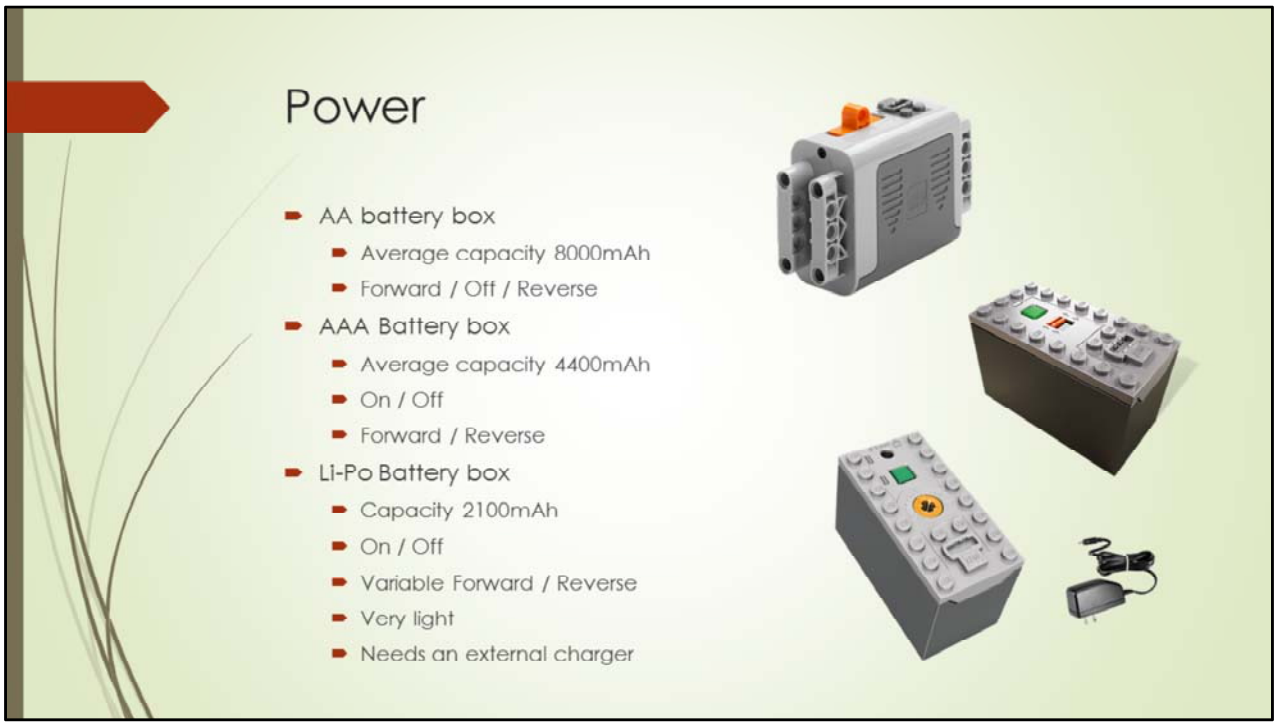
IR Variable remote has 2 control channels and can be set to 4 different IR channels

This again means you can select to control one of 4 different IR receivers and control 2 motors on that channel

The difference is that you turn the left wheel for channel A and the right wheel on channel b to get a variable motor speed or LED brightness

This is great for Trains as you can set the speed you want and leave it ion that speed.

The red buttons are the emergency stop buttons.



Power is supplied using battery boxes,

3 standard boxes exist, all have over load and short circuit protection.
AA battery box will use standard and rechargeable AA battery's. It has an average capacity of 8000mAh, depending on what batteries you put in. The orange sliding switch on the top is forward, off and reverse.

AAA battery box will use standard and rechargeable AAA battery's. It has an average capacity of 4000mAh, depending on what batteries you put in. The green button turns the box on and off, the orange switch selects forward or reverse.

Li-Po Battery box has a built in, non removable Lithium Polymer battery pack. This must be charged in place using the standard Lego charger. It is much lighter that the other two. Standard capacity is 2100mAh. The green button turns the box on and off, the orange internal dial will set a variable speed and direction. Note that this does require an external charger

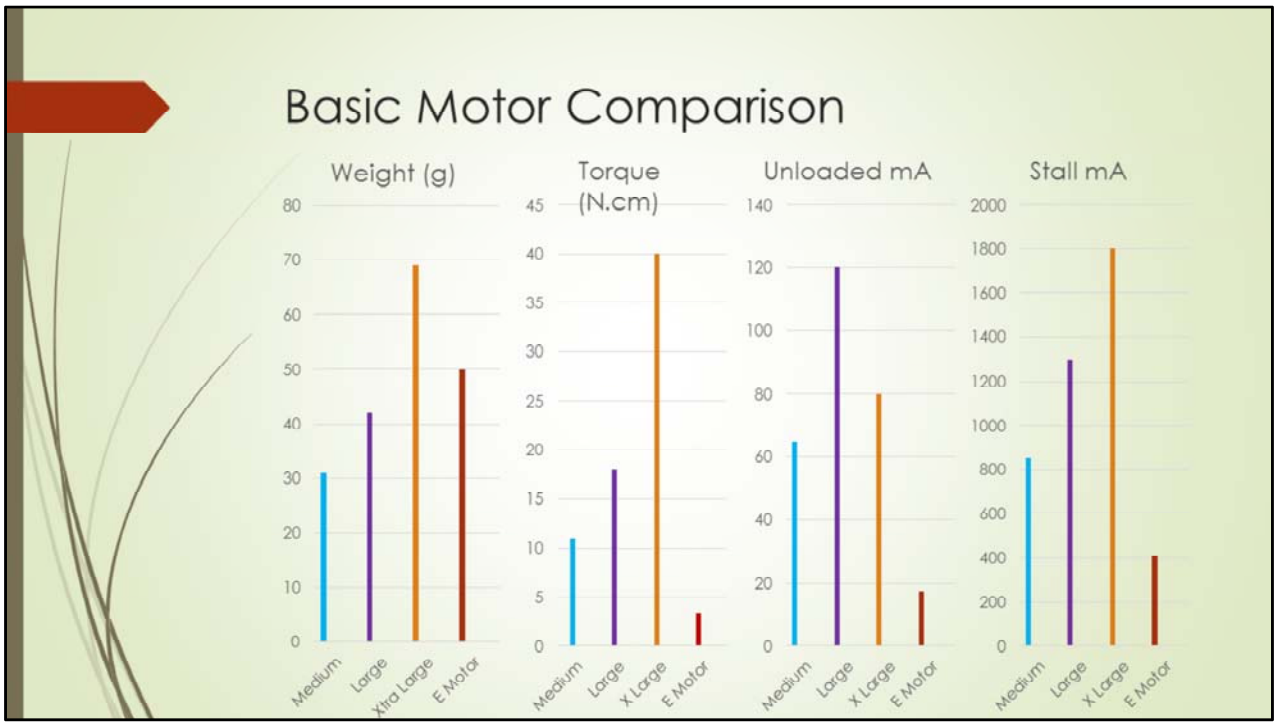
Action – Motors Basic

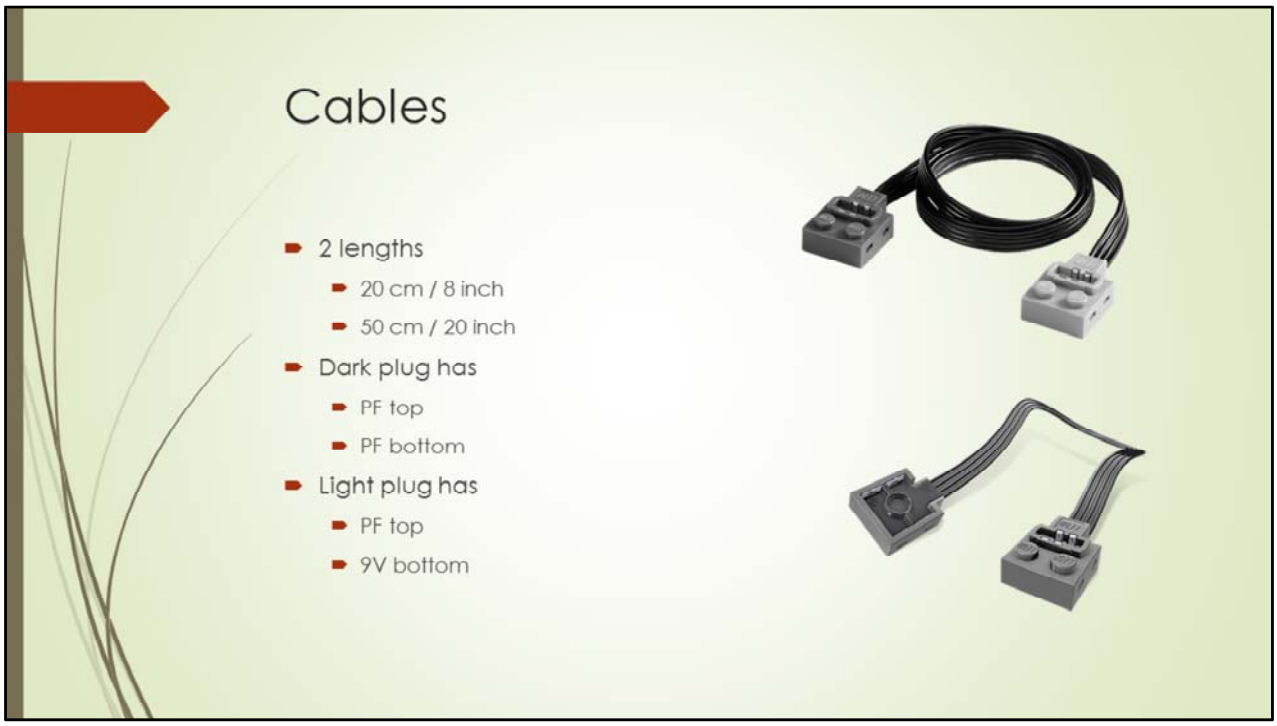
- Medium Motor
  - Studded & Studless mounting options
  - High speed, low power (Torque)
- Large Motor
  - Studless only mounting options
  - Med Speed, Med power
- Xtra Large Motor
  - Studless only mounting options
  - Low speed, High Power (Torque)

The servo motor is mainly used for steering applications, it will turn left and right, anti clockwise and clockwise depending on the amount of PWM signal it gets, the train controller will allow it to modulate to many positions, the basic lever controller will be full 90 to O and then -90 . It will return to center under powered centering (basically receiving no PWM the motor drives its self to position zero.)

The E motor is part of the Power function E series. We will cover this in a little more detail later but it is an 800 RPM 4.5N.cm motor at only 17.5mA unloaded and 410mA stalled.

Lastly is the Train Power function motor, perfect solution for trains, uses the standard bogie plate form factor that has been used in the past.


Basic Motor Comparison
Weight (g)
80
70
60
50
40
30
20
10
0
Medium
Large
Xtra Large
E Motor
Torque (N.cm)
45
40
35
30
25
20
15
10
5
0
Medium
Large
X Large
E Motor
Unloaded mA
140
120
100
80
60
40
20
0
Medium
Large
X Large
E Motor
Stall mA
2000
1800
1600
1400
1200
1000
800
600
400
200
0
Medium
Large
X Large
E Motor



2 lengths, 20 cm / 8 inch and 50 cm / 20 inch

On both cables is two types of connector, The Dark plug has PF top and PF bottom, the Light plug has PF top 9V bottom. This allows control of older 9V motors including train and technic motors.

Action - LED

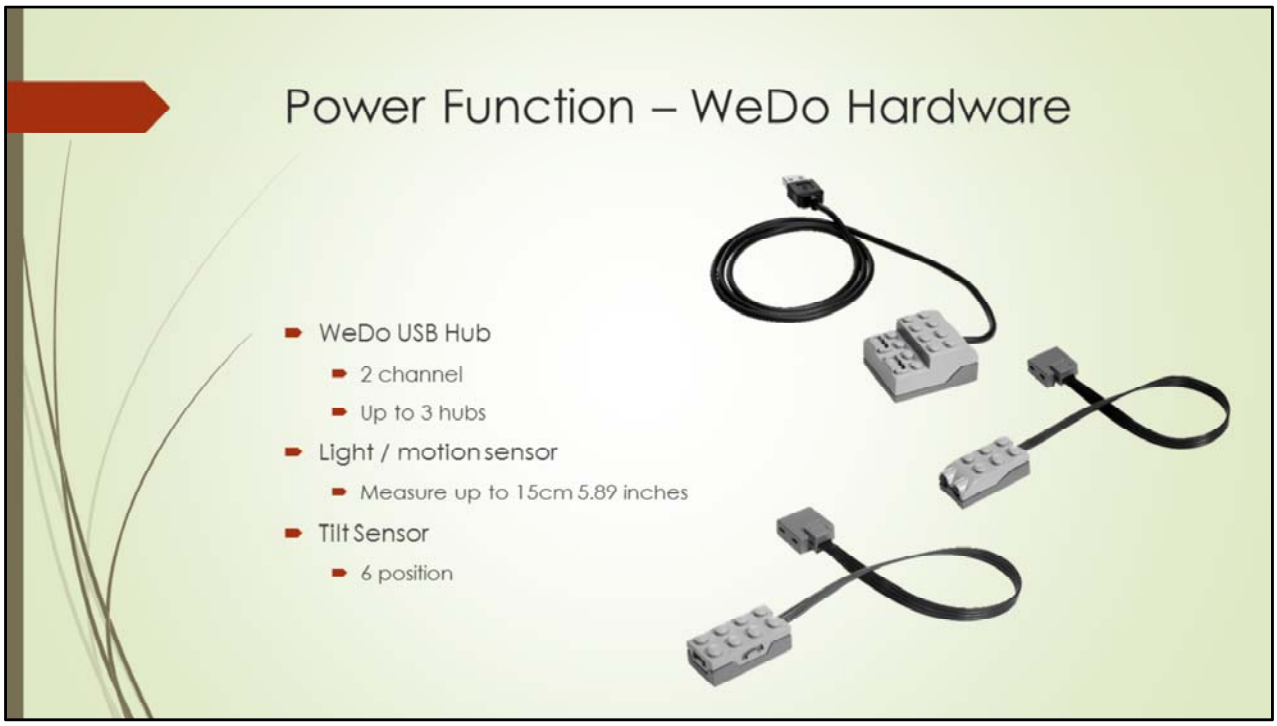
- 2 diodes
- Bright white
- Standard stud size, will fit in
  - Technic brick holes
  - Inside 1x1 round brick
- Can be dimmed using IR

The E-Motor is a 9V motor with an internal gearbox. Its 9.5:1 gearing ratio provides a maximum torque of 4.5 Ncm and approximately 800 rotations per minute without load. It also functions as a very efficient generator.

The Solar Panel provides sufficient power to operate the LEGO Energy Meter and motors. It delivers: 5V, 4mA in direct light from a 60W incandescent bulb positioned 25 cm from the solar panel (>2000 lux)

Displays input and output in volts, watts, amps, and energy storage level in joules.

This Ni-MH battery with connector is designed to be combined with the Energy Display. When combined, the two elements form the LEGO Energy Meter. Storage capacity: 150 mAh.

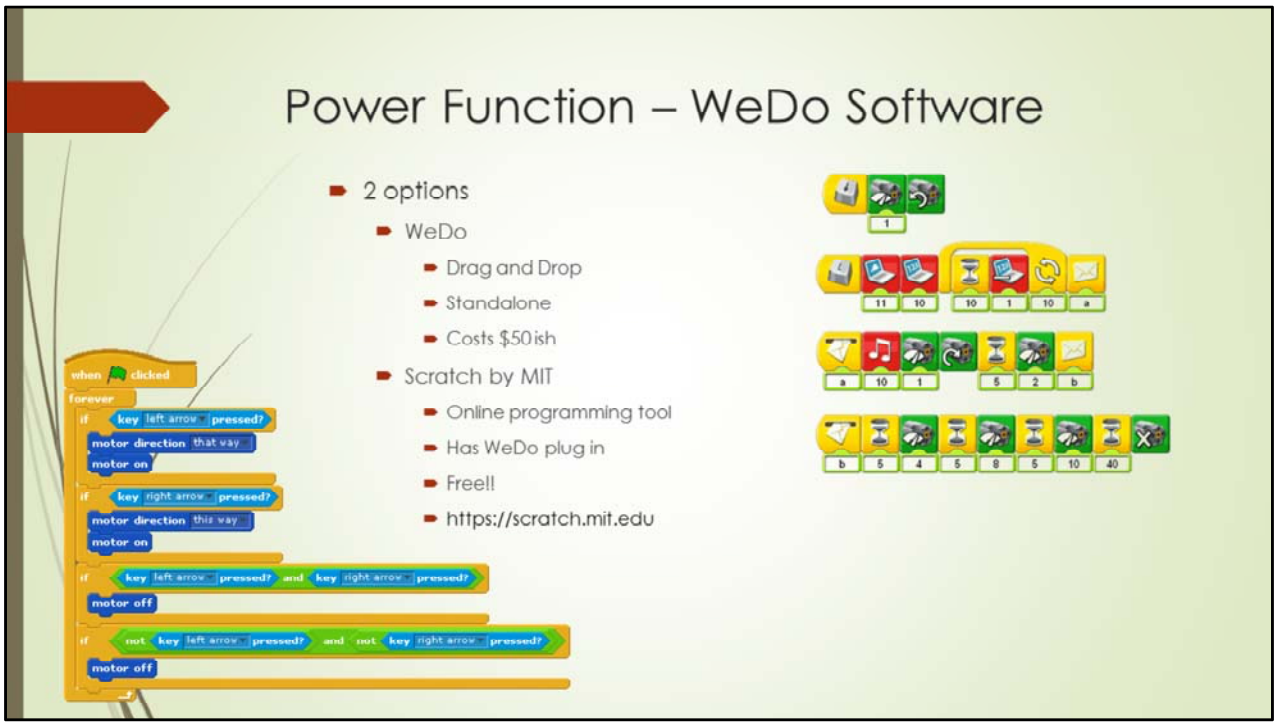


- WeDo USB Hub designed for the WeDo Construction Set controls PF sensors, PF motors and PF LEDs via the WeDo Software when connected to a computer's powered USB port.
- This two-port hub transmits power and data to and from the computer, and both ports are able to control motors and sensors. The LEGO USB Hub is automatically detected by the WeDo Software when connected to a computer. You can connect up to 3 WeDo USB hubs to the computer
- Great way to learn basic automation control or robotics

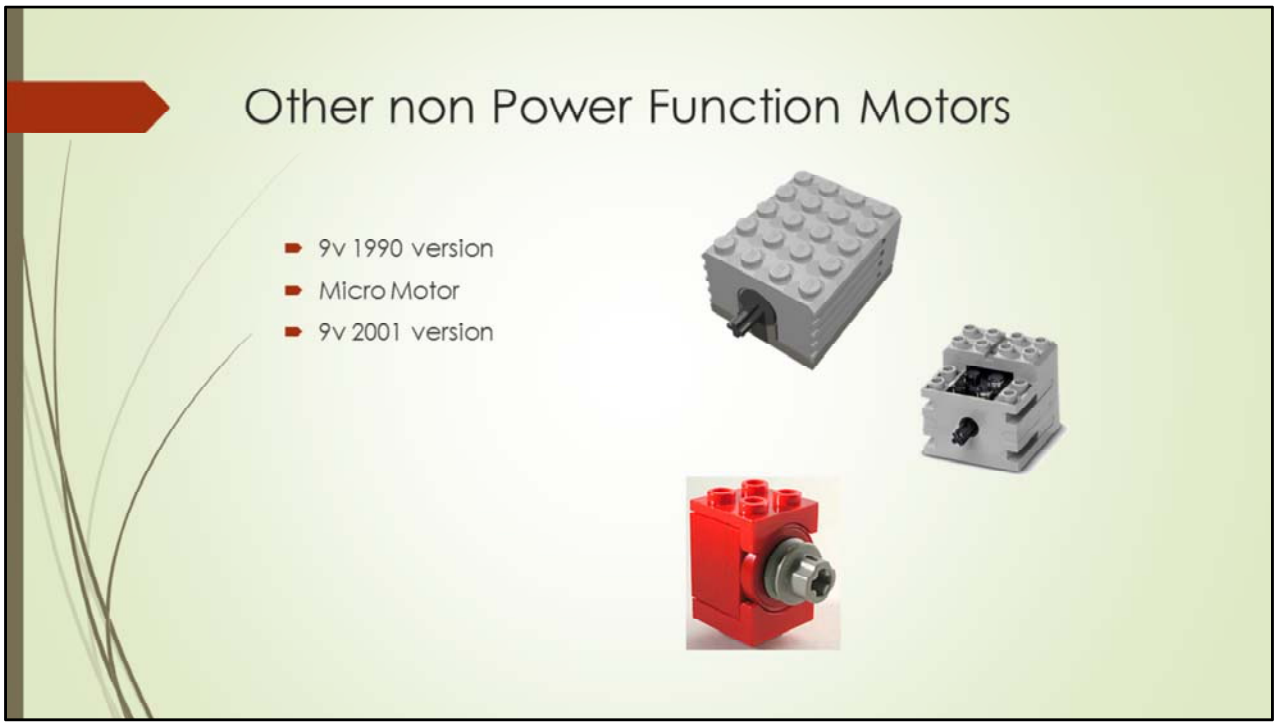
The limitations are that you need it connected to a laptop to run it, but coming soon is a Credit card sized micro computer called Raspberry Pi 2 which will have windows 10 embedded and a USB port.

The motion sensor designed for the WeDo Hub can detect objects within a range of 15 cm, depending on the design of the object, when attached to the LEGO USB Hub. The motion sensor is automatically detected by the WeDo Software

The tilt sensor designed for the WeDo Hub detects changes within six different positions: Tilt This Way, Tilt That Way, Tilt Up, Tilt Down, No Tilt and Any Tilt.



- WeDo
  - Easy-to-use software
  - The drag-and-drop software, powered by LabVIEW, is icon-based and provides an intuitive programming environment.
  - Standalone – install on your PC.
  - Costs $50
  - Features the digital Getting Started Guide with building tips and programming examples.
- Scratch
  - Online programming tool
  - Has WeDo plug in
  - Free!!
  - https://scratch.mit.edu/



1990 version high speed but no power, basically as there was no gearing inside, power is supplied underneath using a 9v wire or 9v plate

2001 version has gearing, is slower but much more powerful, power is supplied to the top

Micro motor, this is the smallest motor Lego ever made. Only 2x2 studs. Very rare. About $20 each on BL

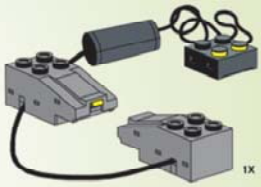
Other non Power Function train motors

- 9v train motor
- 9v RC train motor

Train Motor Comparison

Other non Power Function wires n such

- 9v Train power regulator
- 9v Train rail connector
- 9v wires
- 9v Electric Plates
- 9v battery boxes

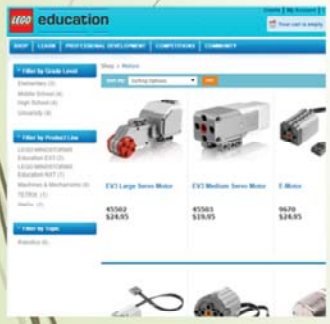


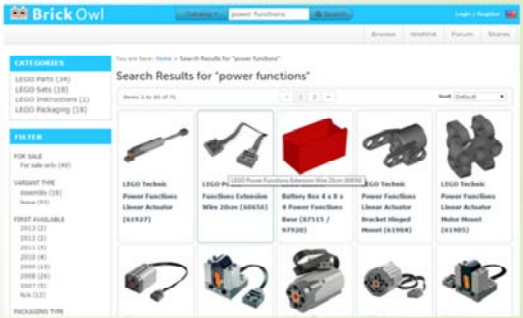
Other Factoids & nifty tricks

- Connect 2 motors to an output on the IR receiver (1.5A max continuous)
- Battery packs are only rated at 750mA
- Connect 1 XL PF motor with a crank to an LED
- Connect two PF motors together, one with a crank
- Connect 9v motor to PF or RC train motor (double up power)
- Connect PF LED to 9v motor
- Connect PF IR receiver to 9v track, PWM control

Where & how to buy

- www.shop.lego.com
- www.shop.education.lego.com
- www.bricklink.com
- www.brickowl.com






The End