RoboJackets

FIRST - IGVC - BATTLEBOTS - ROBOCUP

2009 TE Sessions Supported by

Caterpillar

National Instruments

The Arthur M. Blank Family Foundation

Rockwell Automation

The George W. Woodruff School of Mechanical Engineering

Georgia Tech College of Computing

Mechanical Power Transmission

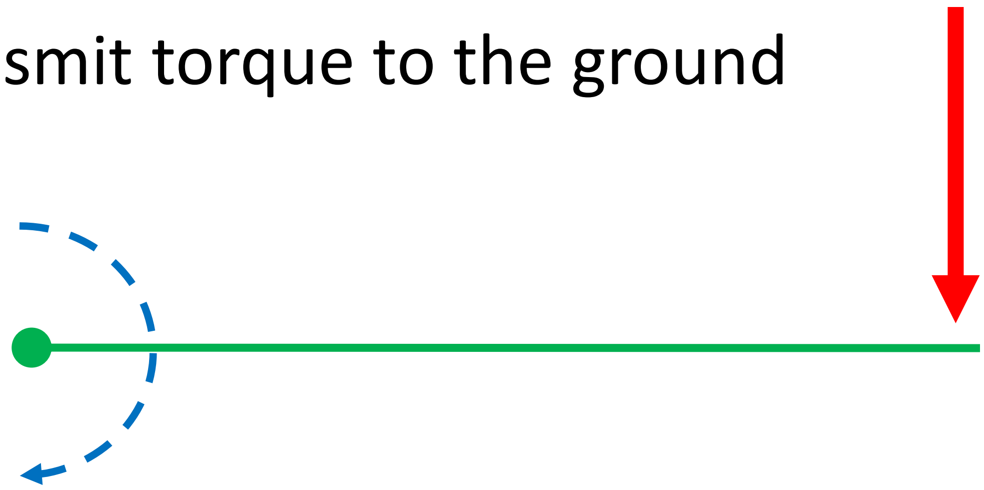
September 29, 2008

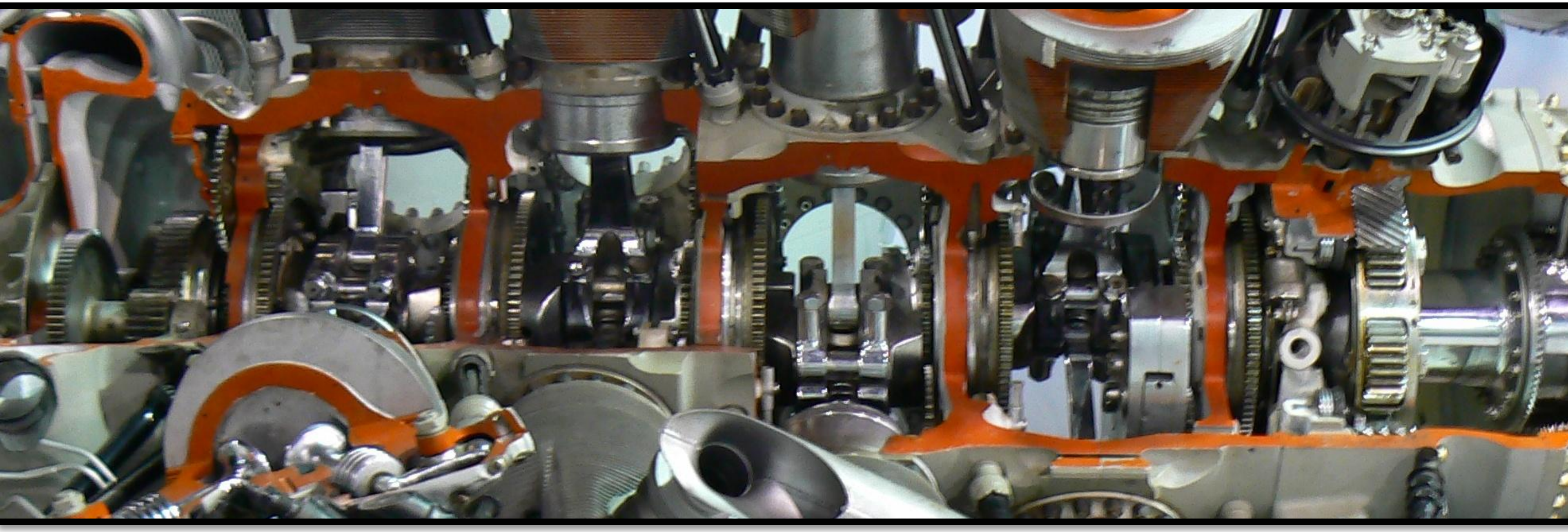
TE Schedule

Basic		Advanced / Special
– Teacher Orientation Meeting	09/08	
– Intro to Robotics and LabVIEW	09/15	– Autonomy & Navigation
– 2009 FLOOD	09/22	
– Mech Power Transmission	09/29	– Control Theory
– Fluid Power & Automation	10/06	– Computer Vision
– Manipulation	10/13	– Autodesk Inventor
– Drive Types	10/27	– Eagle CAD
– Auto Control: Sensors	10/30	– Soldering
– Auto Control: LabVIEW Flow	11/03	– CompactRIO
– Competition Techniques	11/10	– Compact RIO II

Rotation

- Key to most machines and a moving robot
- Torque = Force acting at a distance
  - Motors transmit torque to gears
  - Gears transmit torque to wheels
  - Wheels transmit torque to the ground



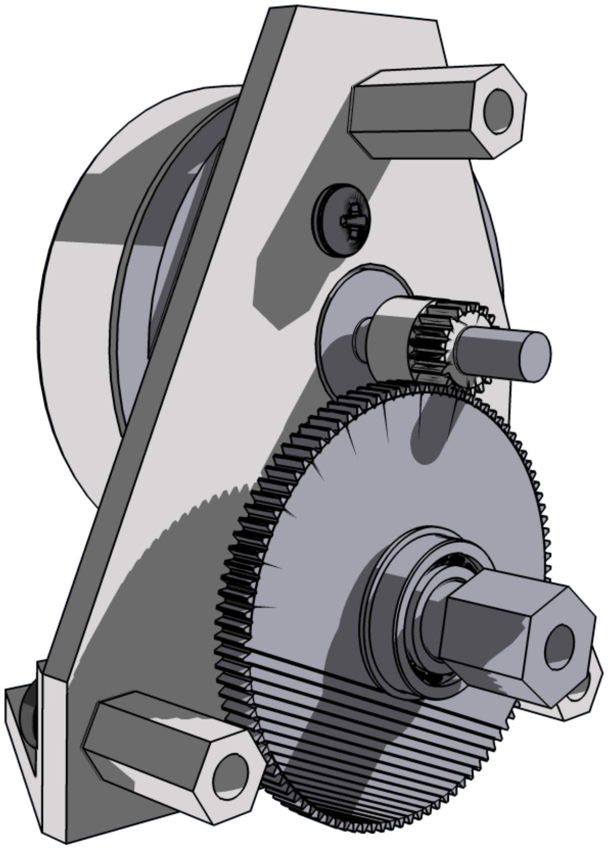


*Pratt & Whitney R-4360

MECHANISMS

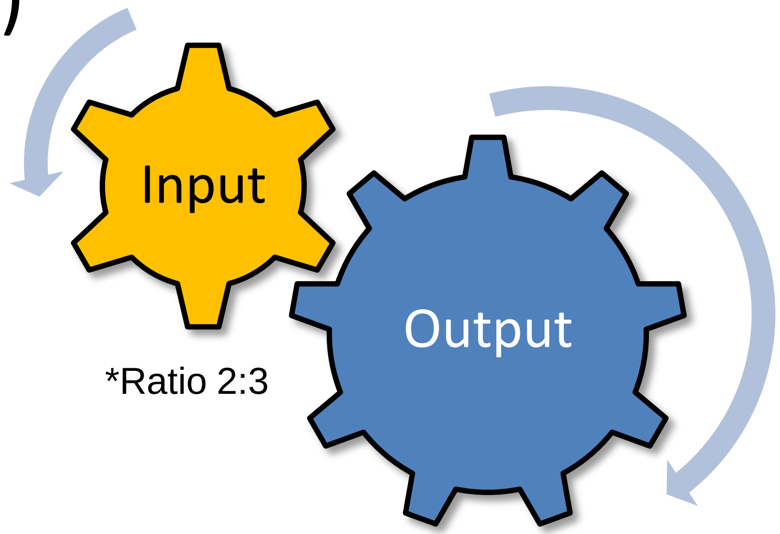
Gears

- Types
  - *Spur*, Helical, Bevel, Internal
- How they work
  - Teeth
  - Pitch Diameter
    - Center line of meshing
  - Diametrial Pitch
    - Must have same size teeth



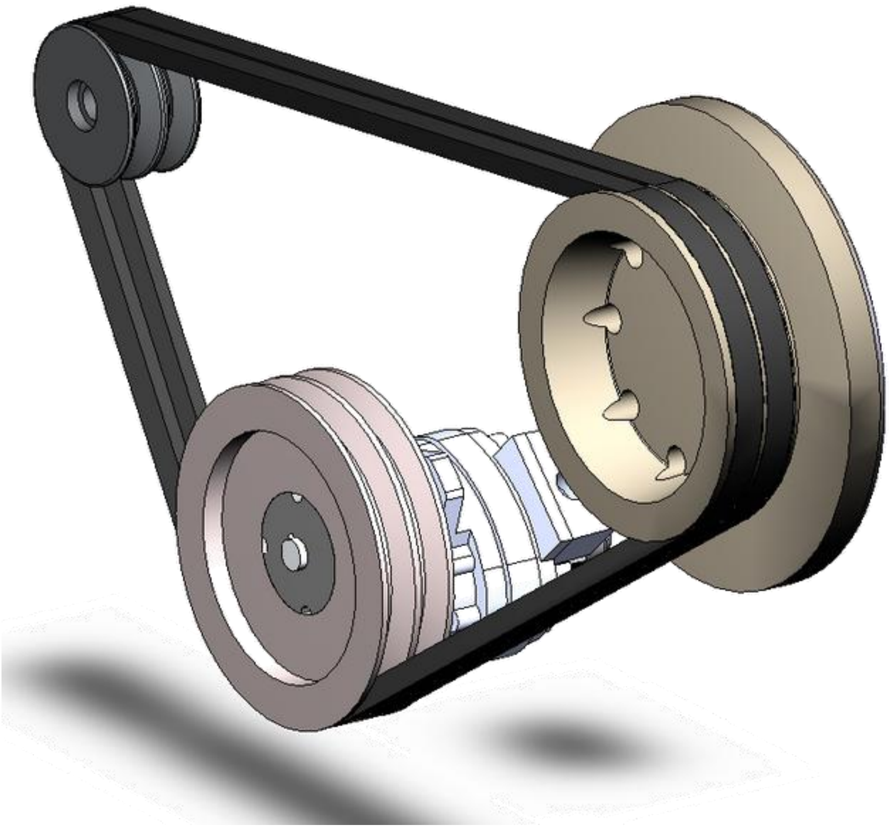
Gear Ratio

- Teeth to Teeth (Dia to Dia)
- Big Input : Small Output
  - Speed Faster
  - Torque Less
- Small Input : Big Output
  - Speed Slower
  - Torque More
- Same In and out
  - Direction Changes



Belts & Pulleys

- Types
  - V-Belts
  - Timing Belts
- How they work
  - V-Shaped Groove
  - Notches
  - Pitch diameter
    - (outside pulley)



Chains & Sprockets

- How they work
  - Links
  - Master Link
    - Connects ends / links (Full and half)
  - Chain Numbering
    - 35 Larger stronger, but less efficient
    - 25 Smaller, lighter, weaker, but more efficient.
  - Pitch diameter (chain centerline)
- Tools
  - Chain break (& chain puller)

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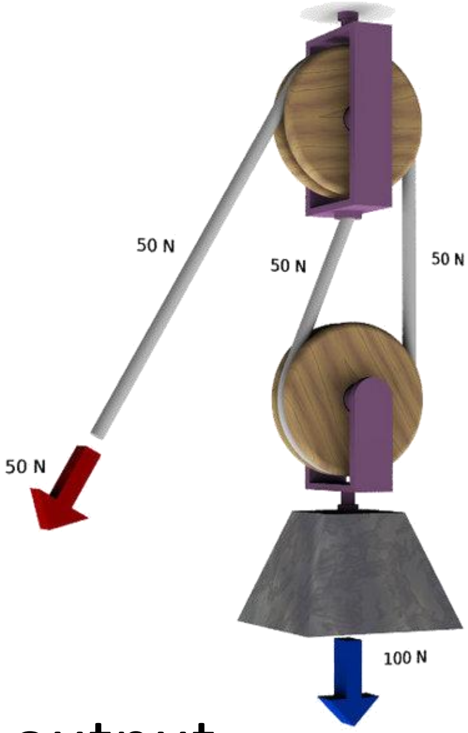
Cable & Pulleys

- Note
  - Increase force
  - A potentially easy way to gain mechanical advantage
- Other
  - Need constant tension
  - Location – Motor can be far from output
  - Travel distance increase



DESIGN CONSIDERATIONS

Gears

- Good
  - Easy to design with (no tensioning)
- Bad
  - Weight – You will be removing mass
  - Backlash
- Other
  - Location – Motor is close to output

Chains & Belts

- Good
  - Weight – Much less than gears
- Bad
  - Less efficient transfer compared to gears
- Other
  - Location - Motor can be far from output
  - Tensioning
    - Loose - could skip
    - Tight – Drains battery, moves slow, loads motors
  - Need to wrap around pulley / sprocket

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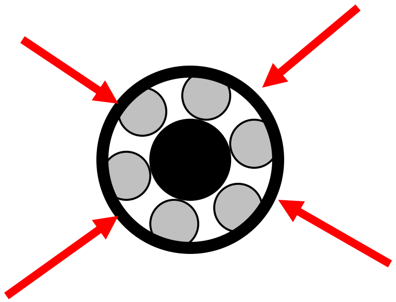
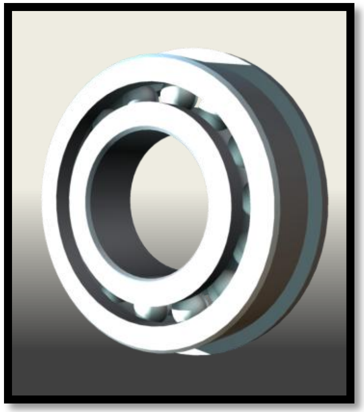
OTHER EQUIPMENT

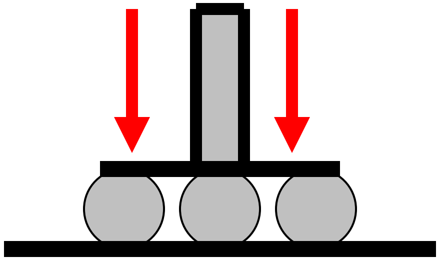
Radial Bearings





- Handle radial loads
- Why?
  - Bearings reduce drag and handle forces
  - Without bearings, the shaft would heat up so much that it would swell and seize in its housing

Thrust Bearings



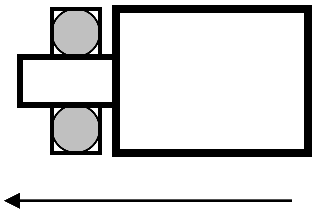
- Thrust bearings handle loads in the axial direction
- Why?
  - Support a rotating robot arm assembly

Bushings

- What's the difference?
  - Act like bearings
  - No moving parts
  - Low speed apps
  - Less $$$$
  - For FIRST typically
    - Plastic
    - Brass
  - Below 1000 rpm

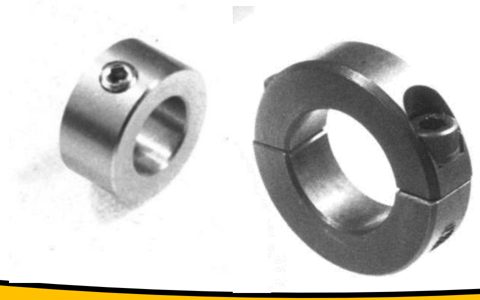
Shaft Restraints

- **Why?**
  - Shafts can still move axially within bearings
- **Types**
  - Shoulders – Prevent motion in one direction



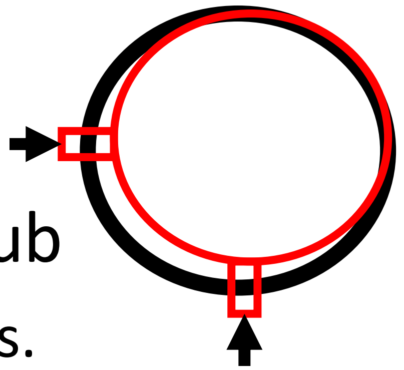
  - Snap Rings & E-Clips – Fit in grooves to stop motion

  - Shaft Collars – Grip shaft by friction / set screws

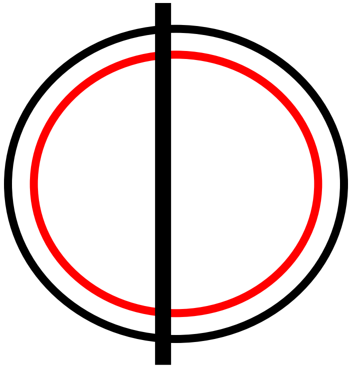


Shaft Restraints

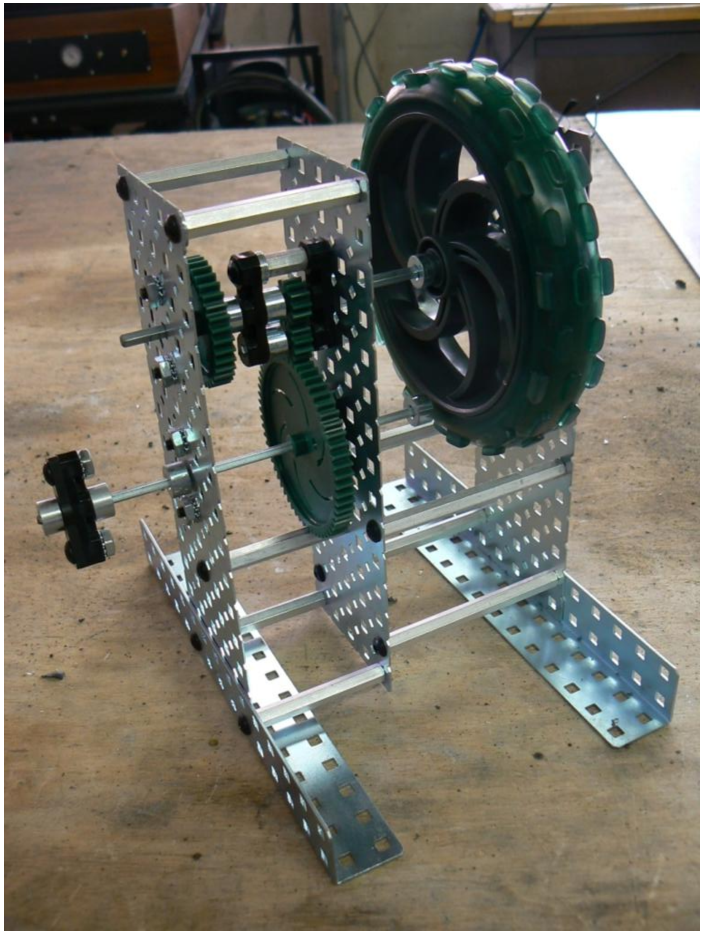
- **Types**
  - Set Screws – seize the shaft onto a hub
    - A shaft needs flats at set screw locations.
    - Even though off-centered, the set screws work



  - Pinning – simple but can shear



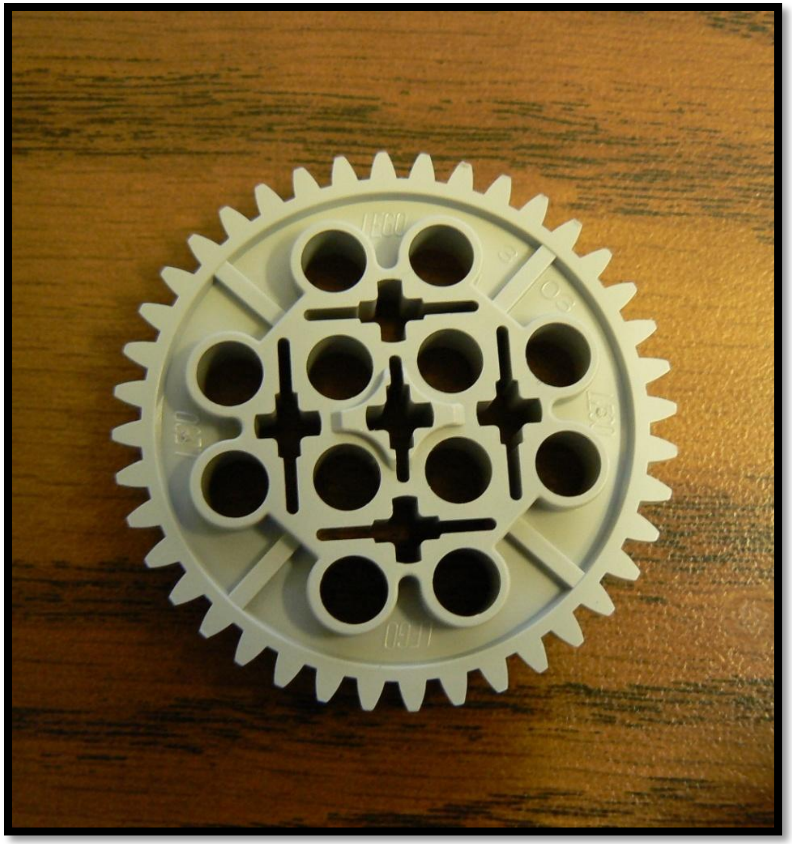
ACTIVITIES



Gears Demo

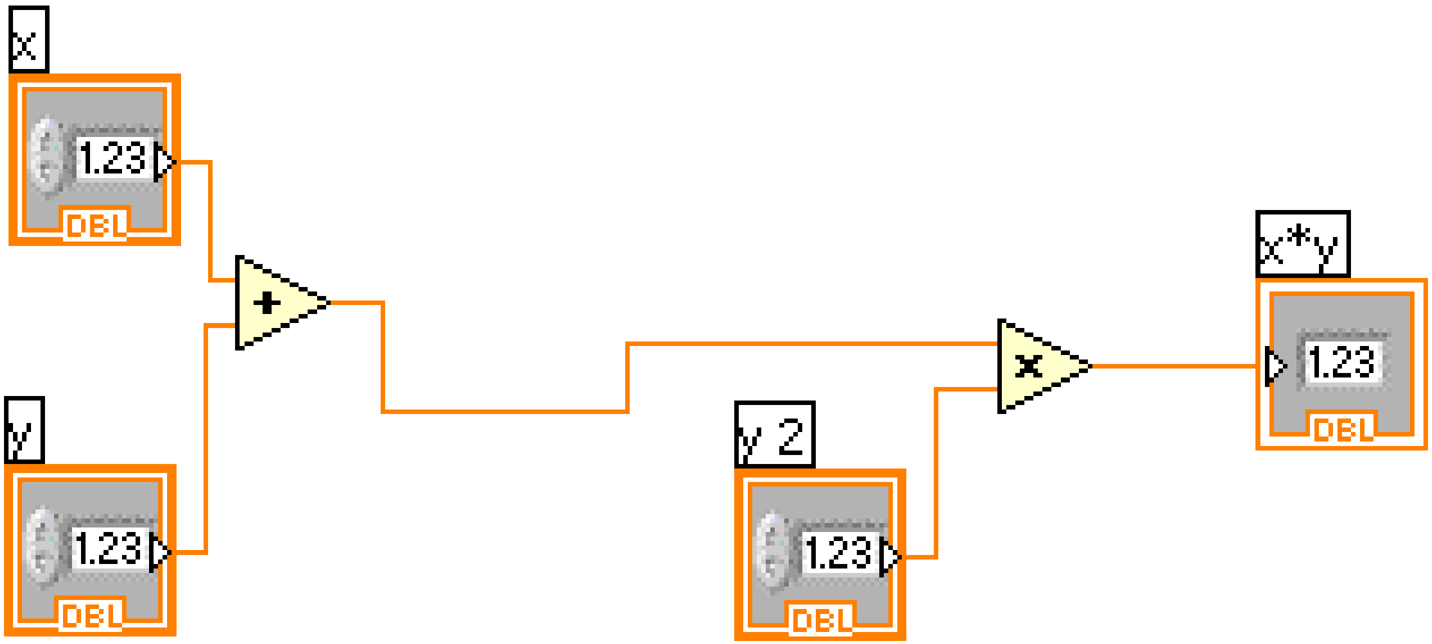
Activity – Spur Gearbox

- Build One Lego Gear Box
  - 5 : 1
  - 1 : 5
  - 5 : 3
  - 1:15
- Build a Tetrix Gear Box of your choosing
- 30 minutes time limit



LABVIEW BASICS

Data Flow

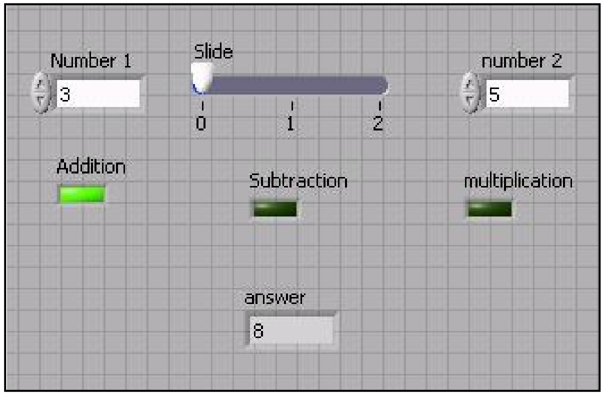


- Graphical programming language
- *Data Flow* language

LabVIEW Virtual Instruments

Front Panel

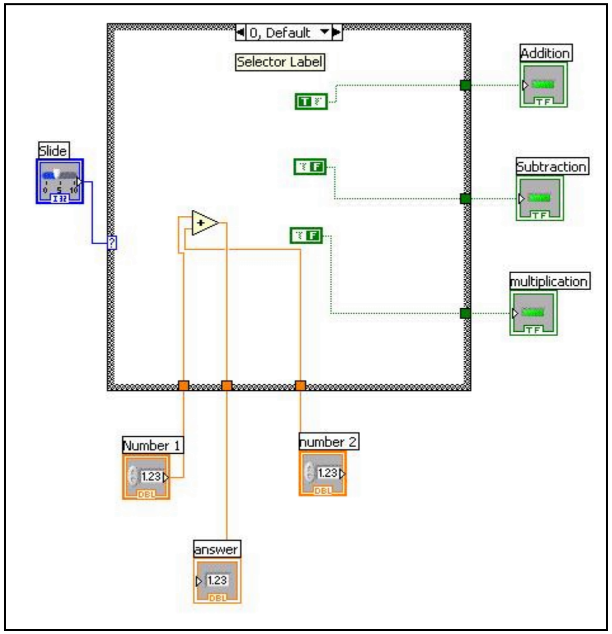
- User Interface
  - Controls = Inputs
  - Indicators = Outputs



Called
"VI"

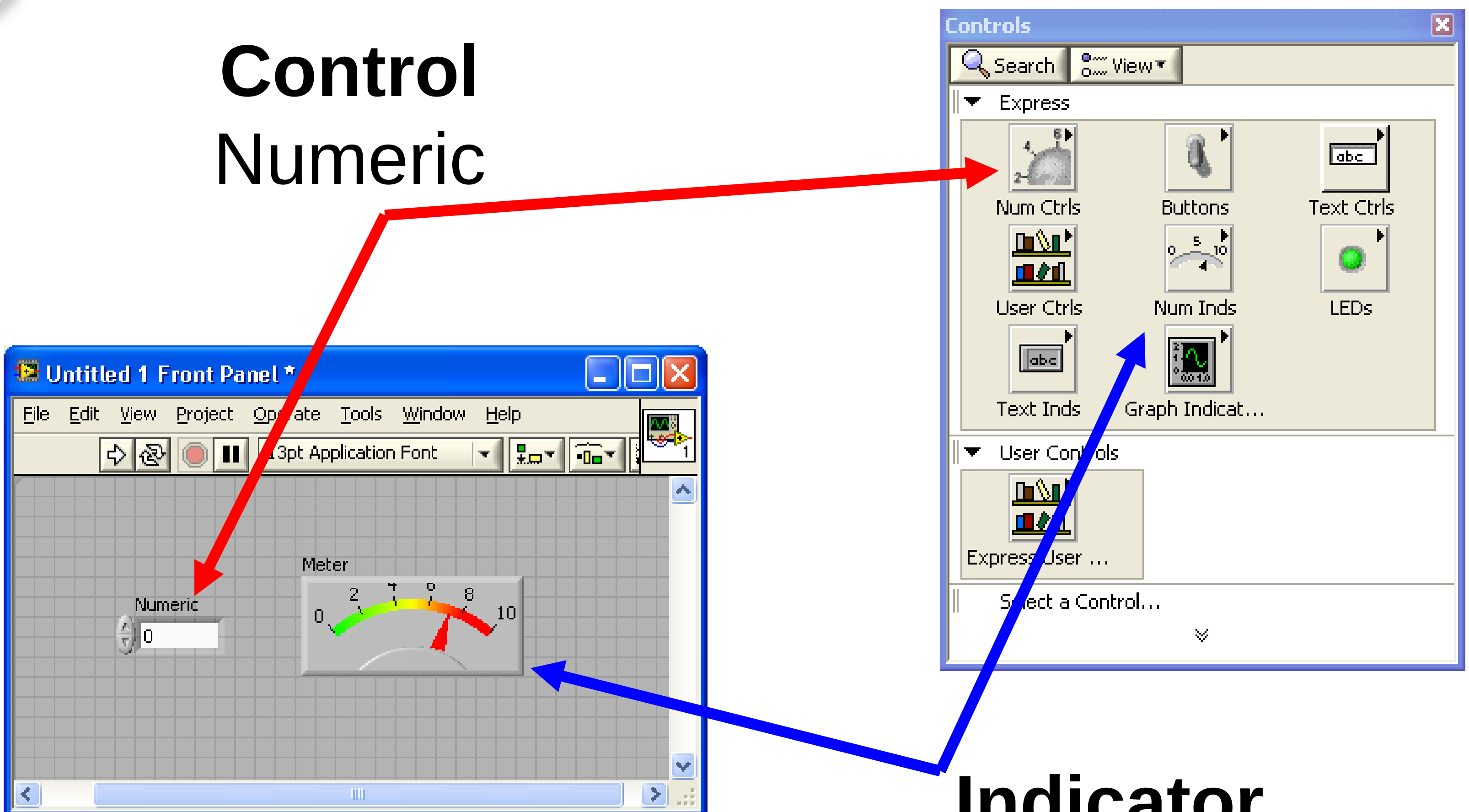
Block Diagram

- Data travels on wires from controls through functions to indicators
- Blocks execute by dataflow



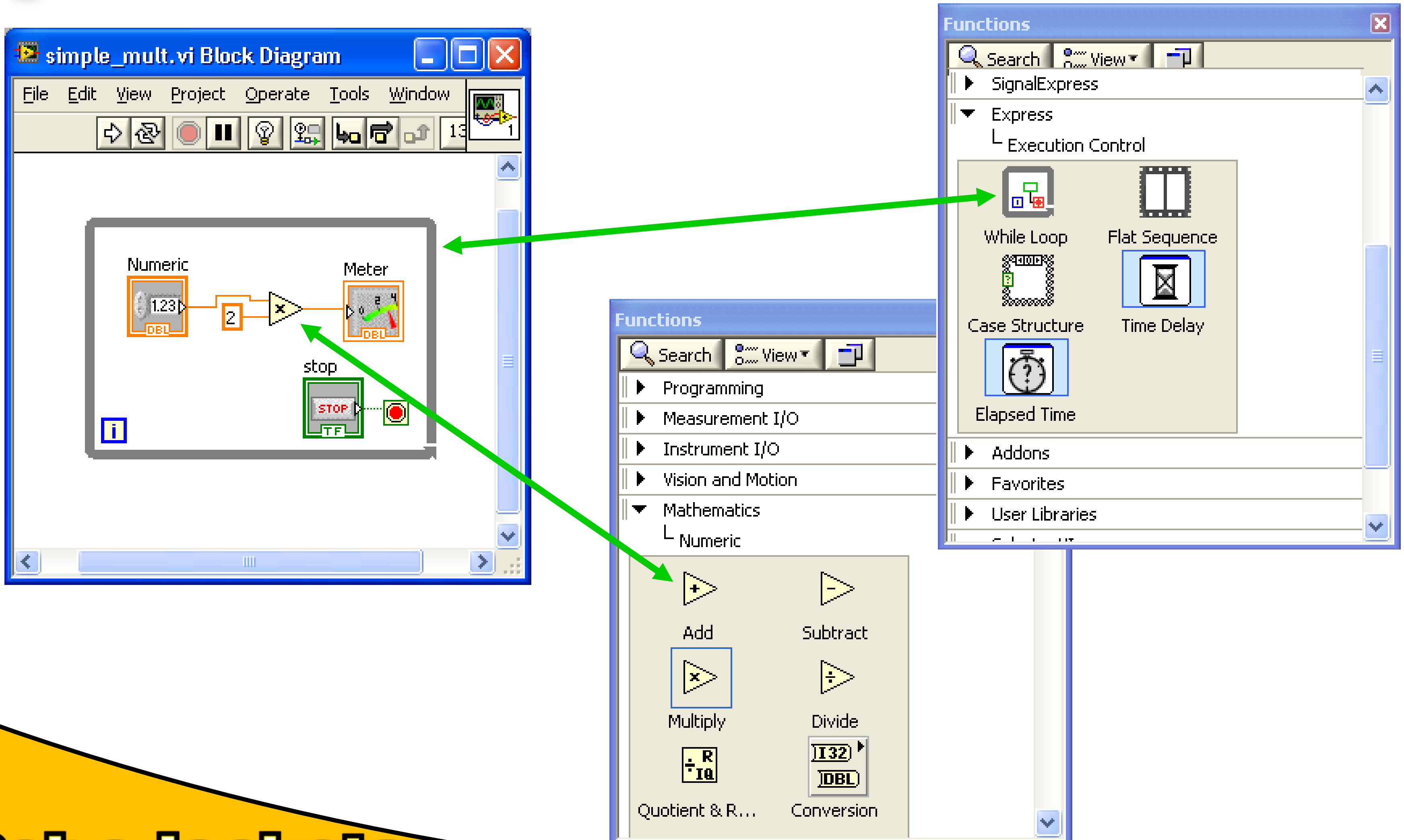
Controls Palette

Control
Numeric



Indicator
Meter

Functions and Structures Palette



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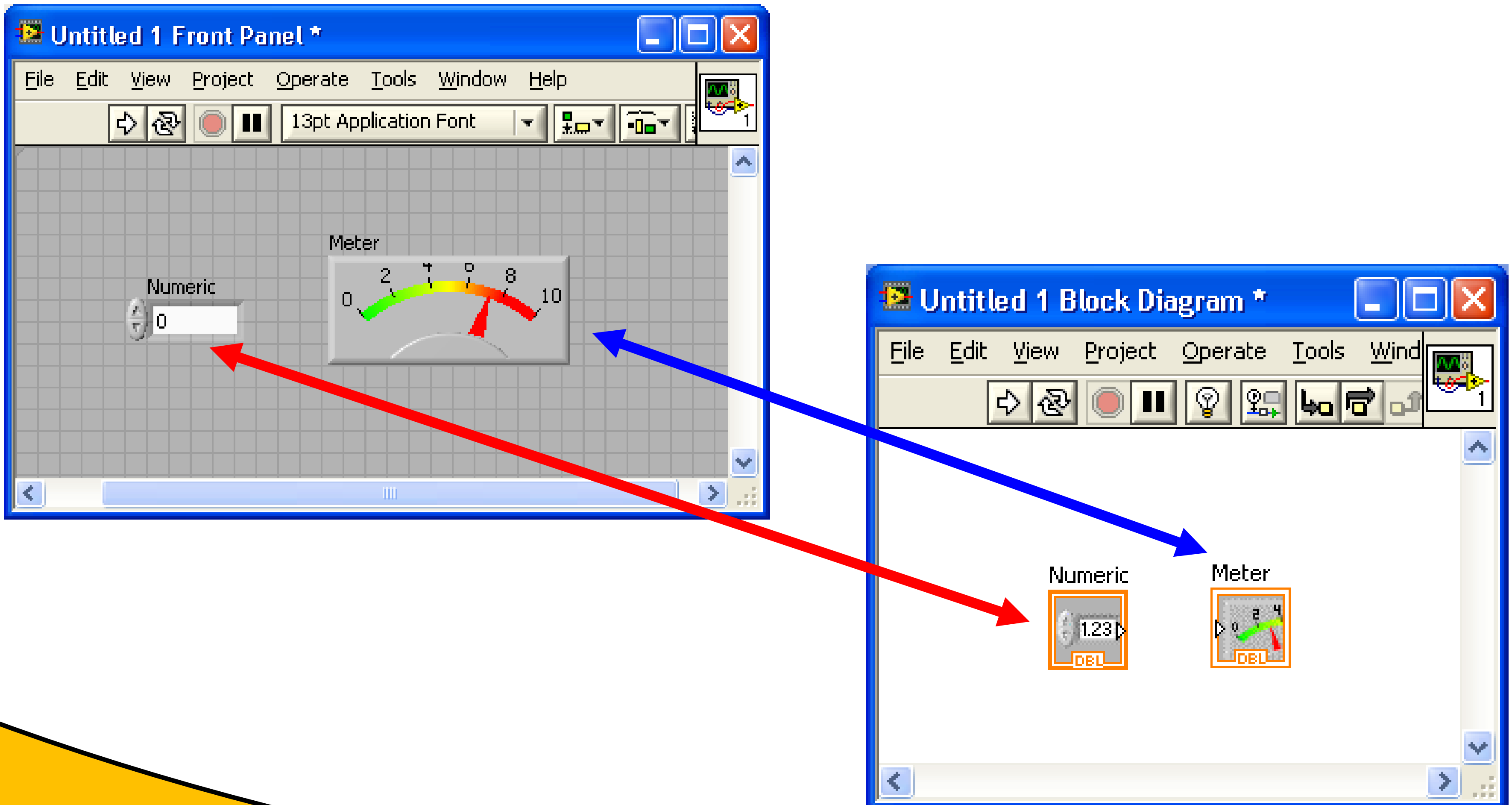
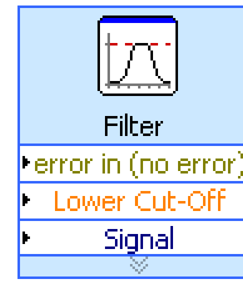
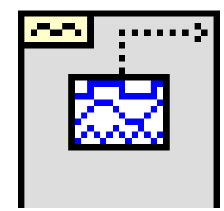
Front Panel Block Diagram Mapping

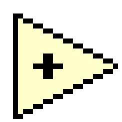


Types of Functions

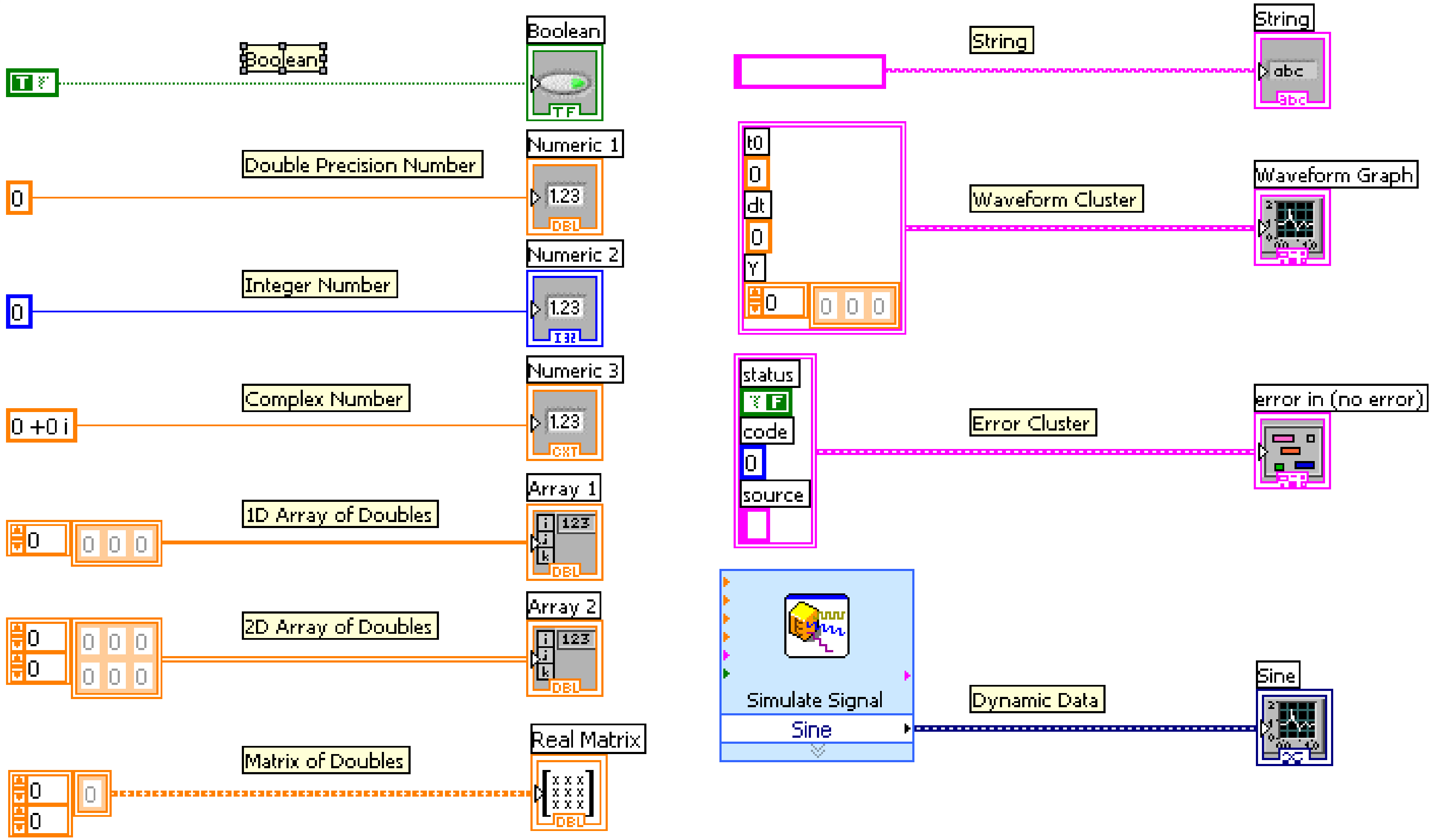
- **Express VIs:** Interactive Vis with configurable dialog page (blue)
- **Standard VIs:** Modularized VIs customized by wiring
- **Functions:** fundemental elements of LabVIEW (yellow)





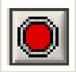


Variables

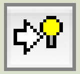
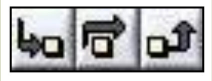


Boolean
Boolean
Double Precision Number
Numeric 1
Integer Number
Numeric 2
Complex Number
Numeric 3
0 +0 i
1D Array of Doubles
Array 1
2D Array of Doubles
Array 2
Matrix of Doubles
Real Matrix
String
String
Waveform Cluster
Waveform Graph
t0
dt
Y
status
code
source
Error Cluster
error in (no error)
Simulate Signal
Sine
Dynamic Data
Sine

Status Toolbar

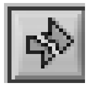
	**Run Button**
	**Deploy (Download) Button**
	**Abort Execution**

Additional Buttons on the Diagram Toolbar

	**Run With Debug Button**
	**Step Function Buttons**

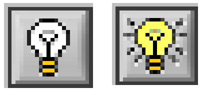
It’s Broken :(

- **Finding Errors**



Click on broken **Run** button.
Window showing Error appears.

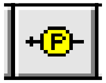
- **Execution Highlighting**



Click on **Execution Highlighting**; data flow is animated using bubbles. Values are displayed on wires.

- **Probes**

Right click on a wire to display a probe which shows data as it flows through the wire segment.



You can also select the probe tool from the Tools palate and click on a wire.

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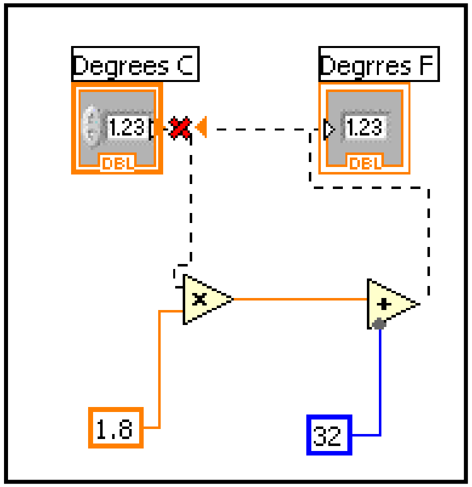
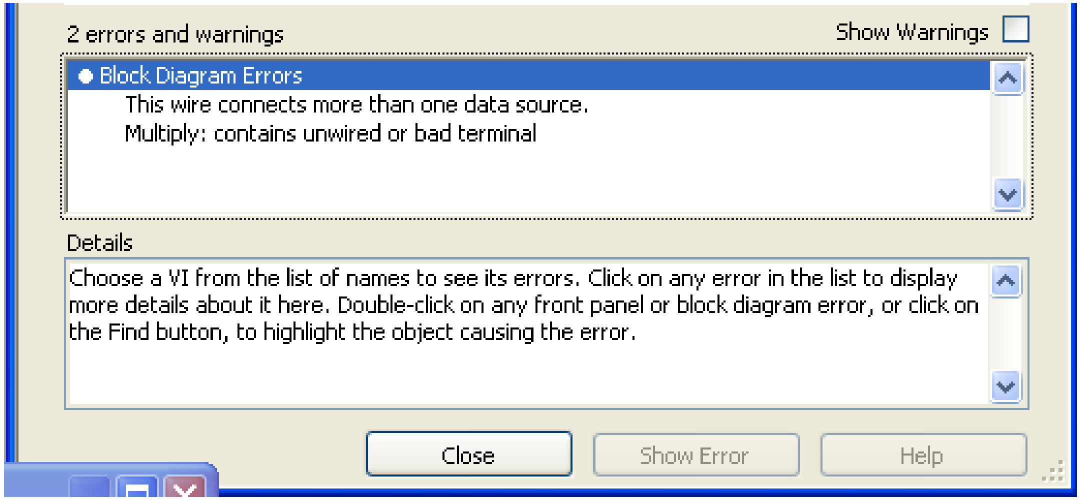
Broken Example :(





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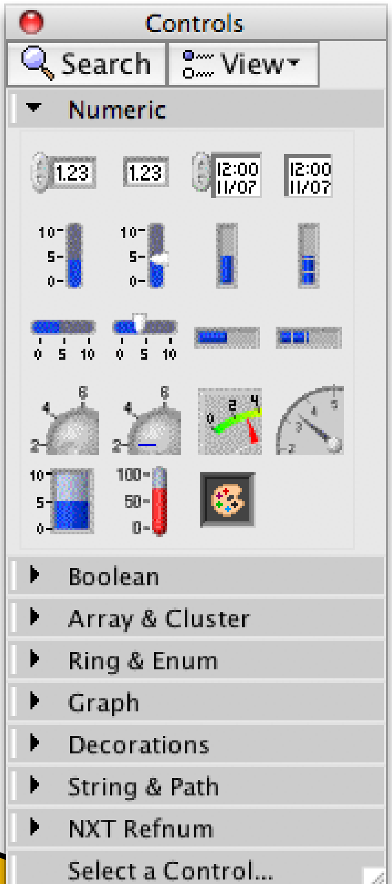
Protips

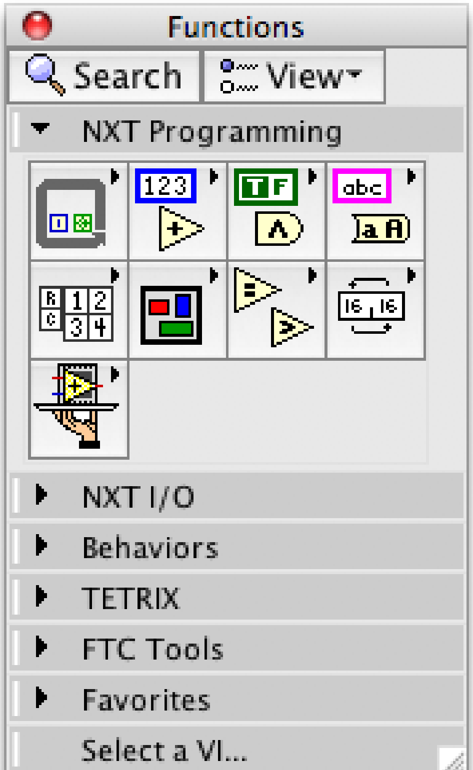
- <Ctrl+H> – Context Help
- <Ctrl+E> – Toggle Between Front Panel and Block Diagram
- <Ctrl+Z> – Undo
- **<Ctrl+B> – Remove Broken Wires from Block Diagram**

NXT Toolkit



Only blocks in the NXT Toolkit can be used with the NXT

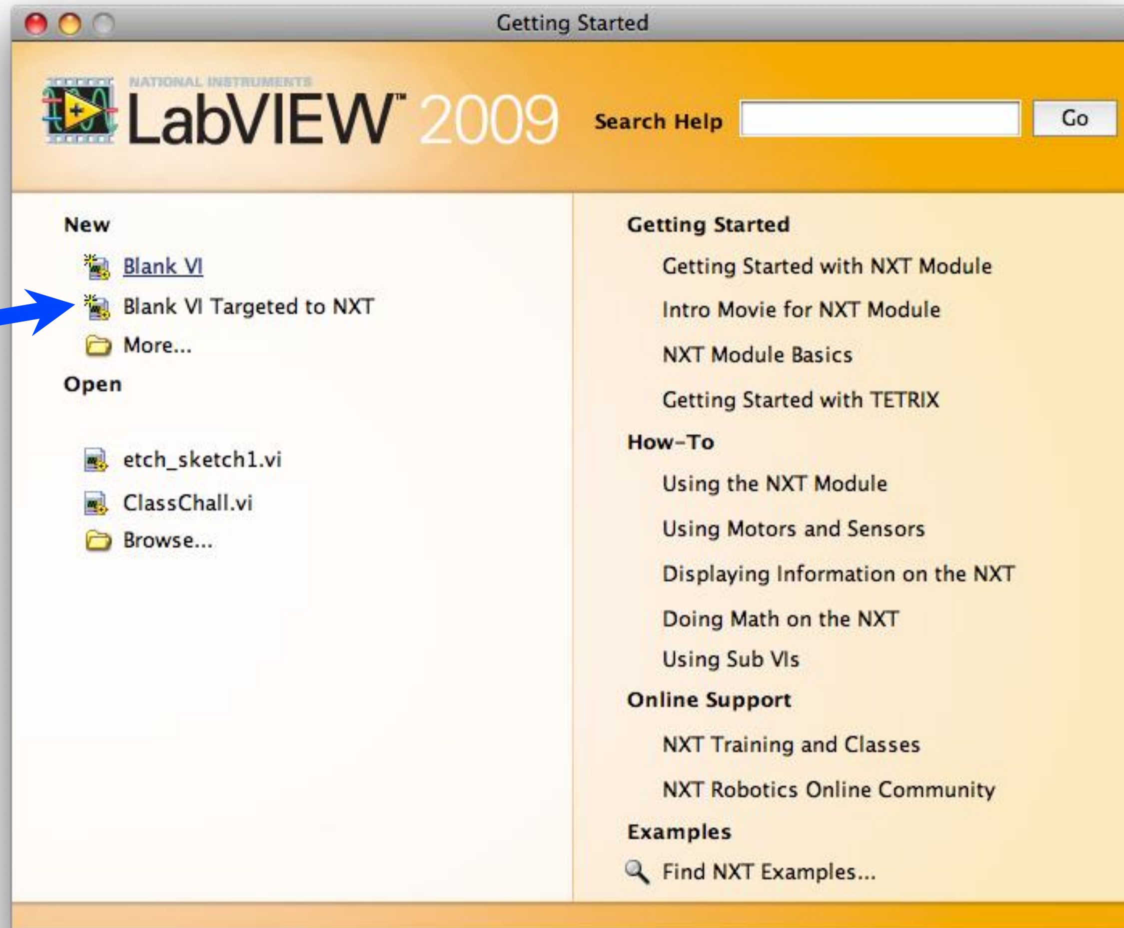
Math, motor control, flow control (while loops etc), sensors, readouts…



INTRODUCTION TO LABVIEW

NXT Toolkit Activity

Make a new **VI** Targeted to **NXT**



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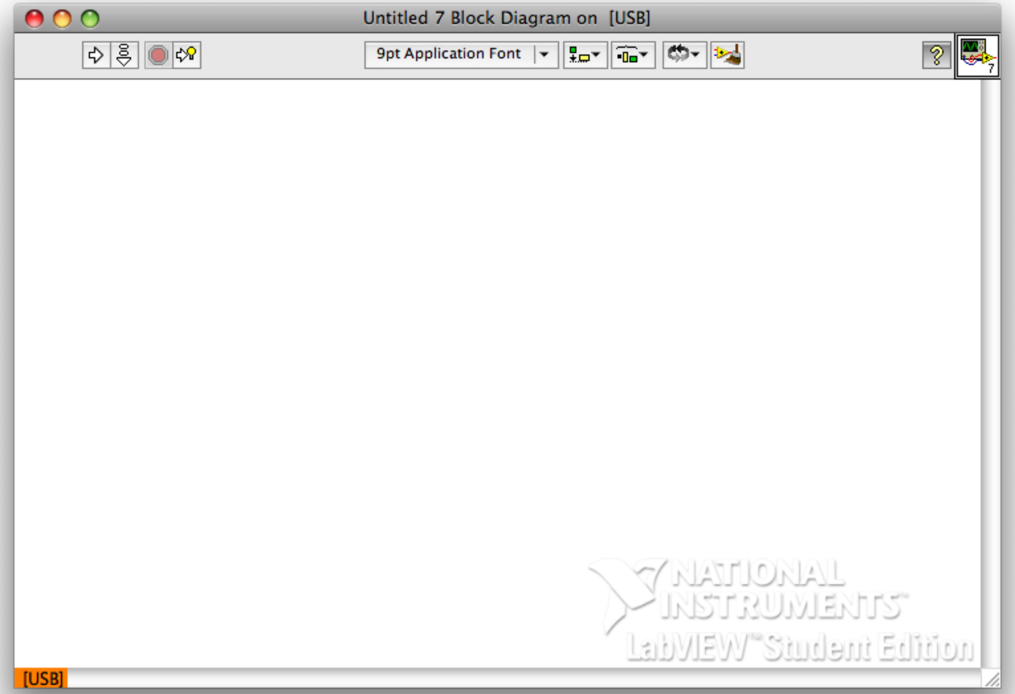
NXT Toolkit Activity

Bring up the **Block Diagram**

– Control-E

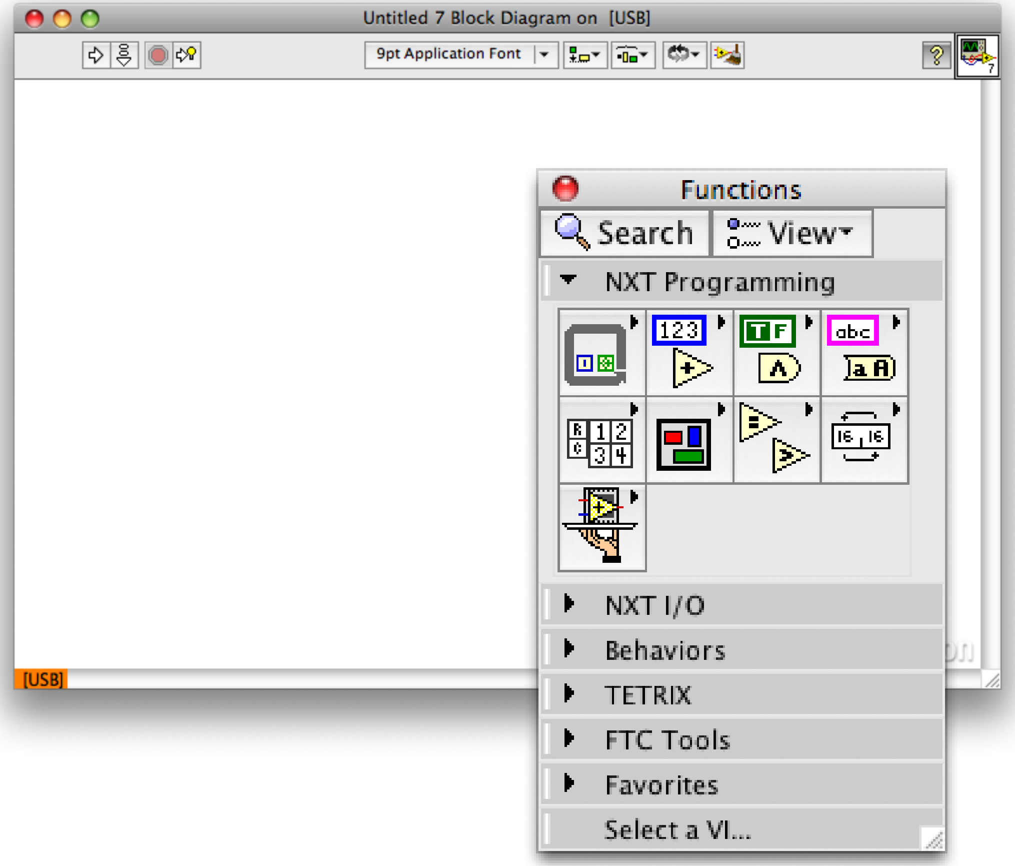
– Window >> Show Block Diagram



NXT Toolkit Activity

Bring up the **Functions Palette**

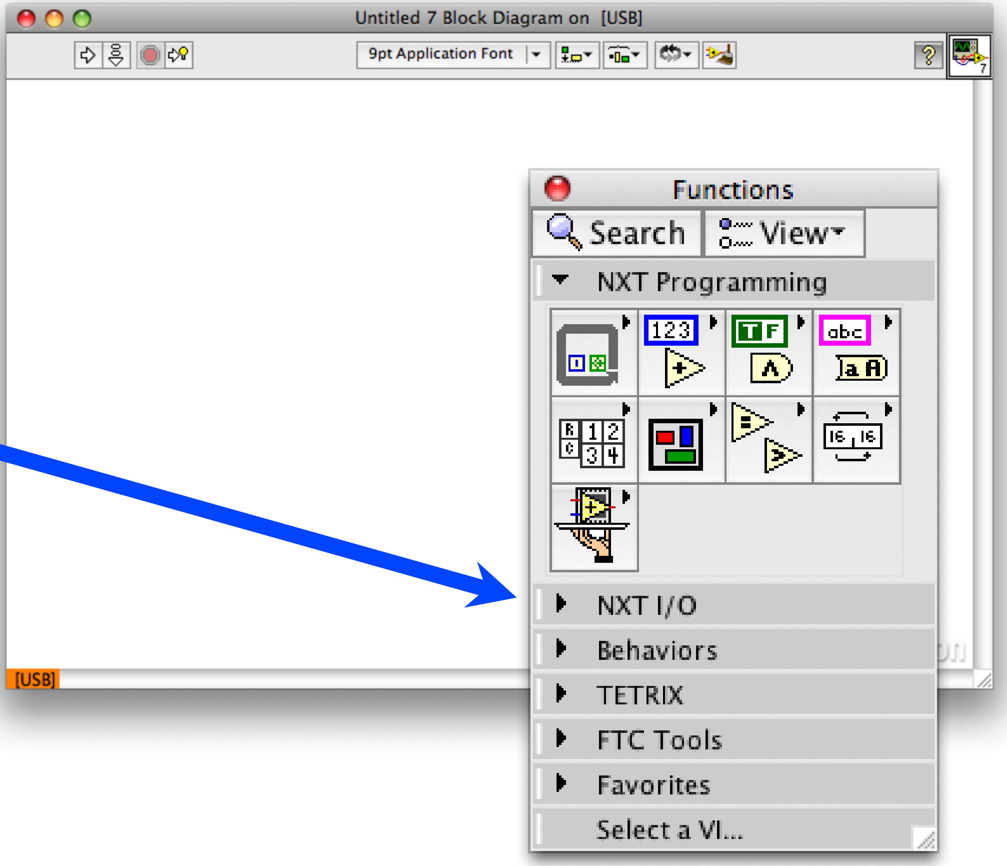
- Left Click
- View >> Functions Palette



NXT Toolkit Activity

Select the **NXT I/O Menu**

– Click NXT I/O



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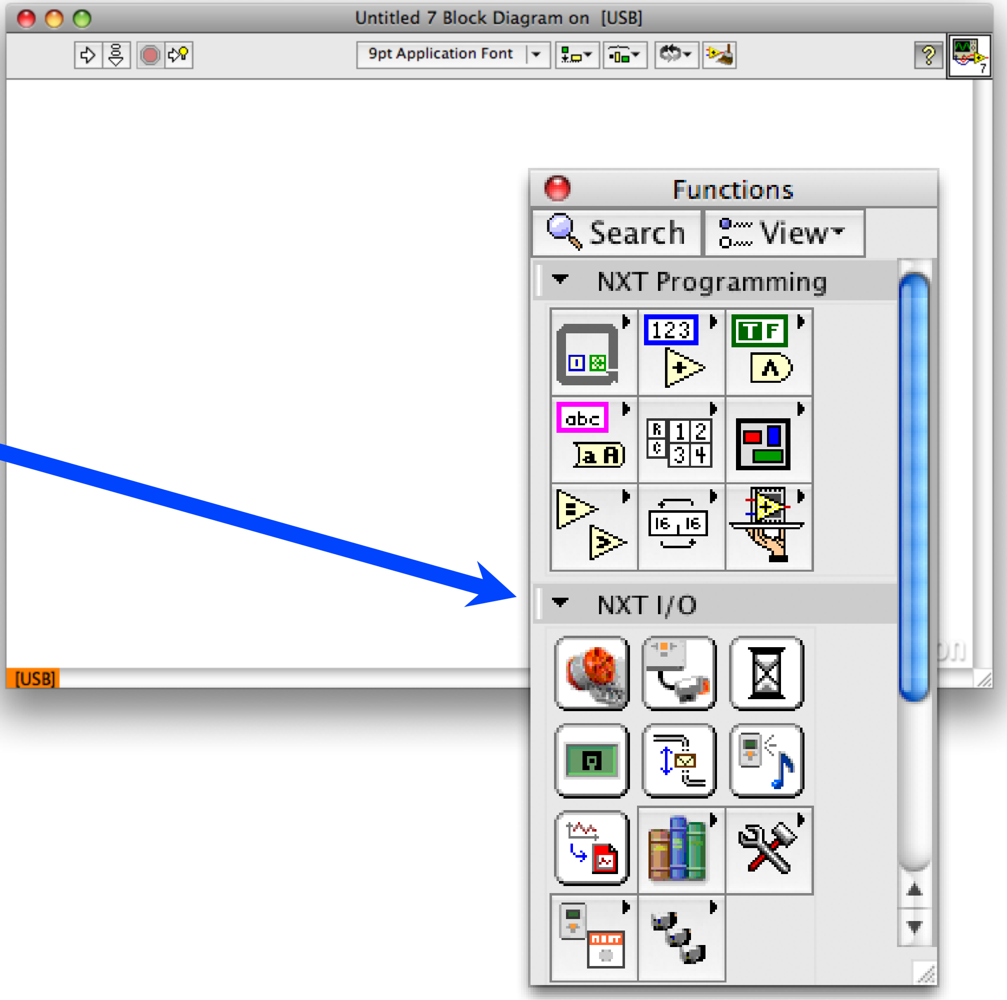
NXT Toolkit Activity

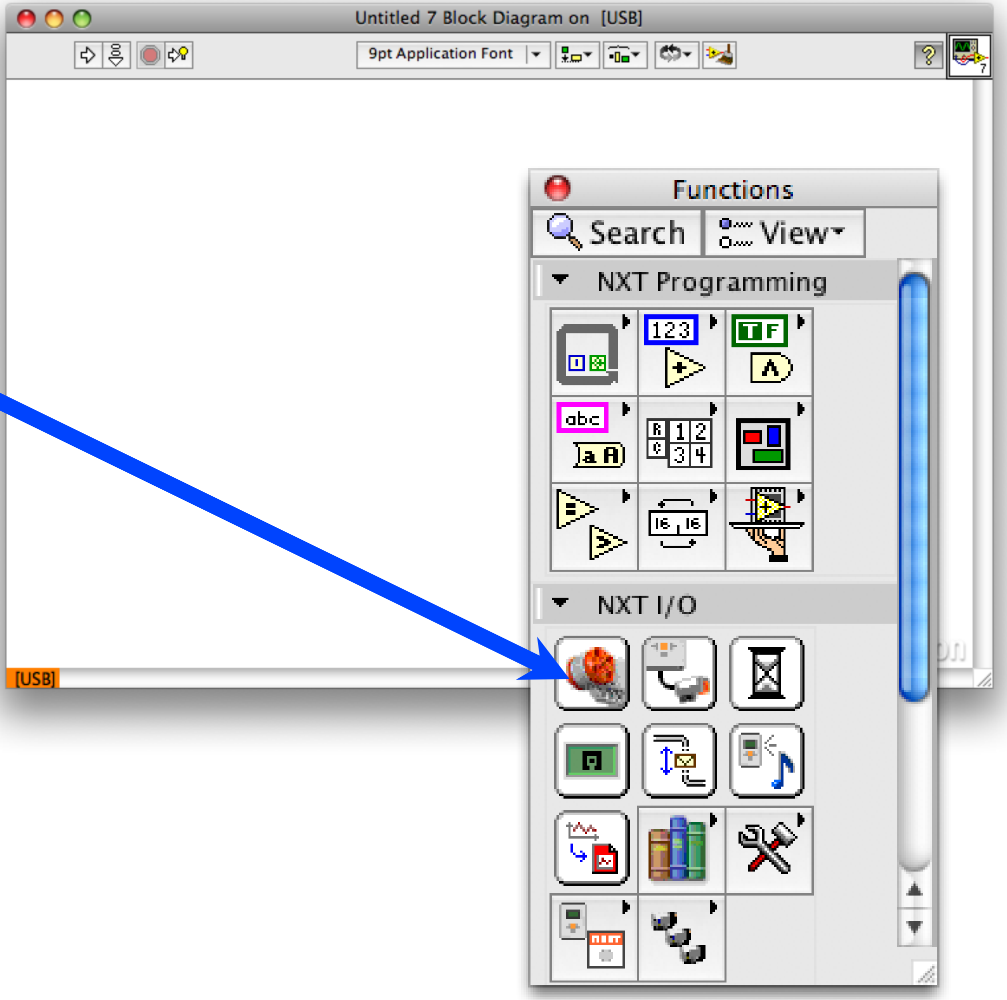
Select the
NXT I/O Menu

– Click NXT I/O



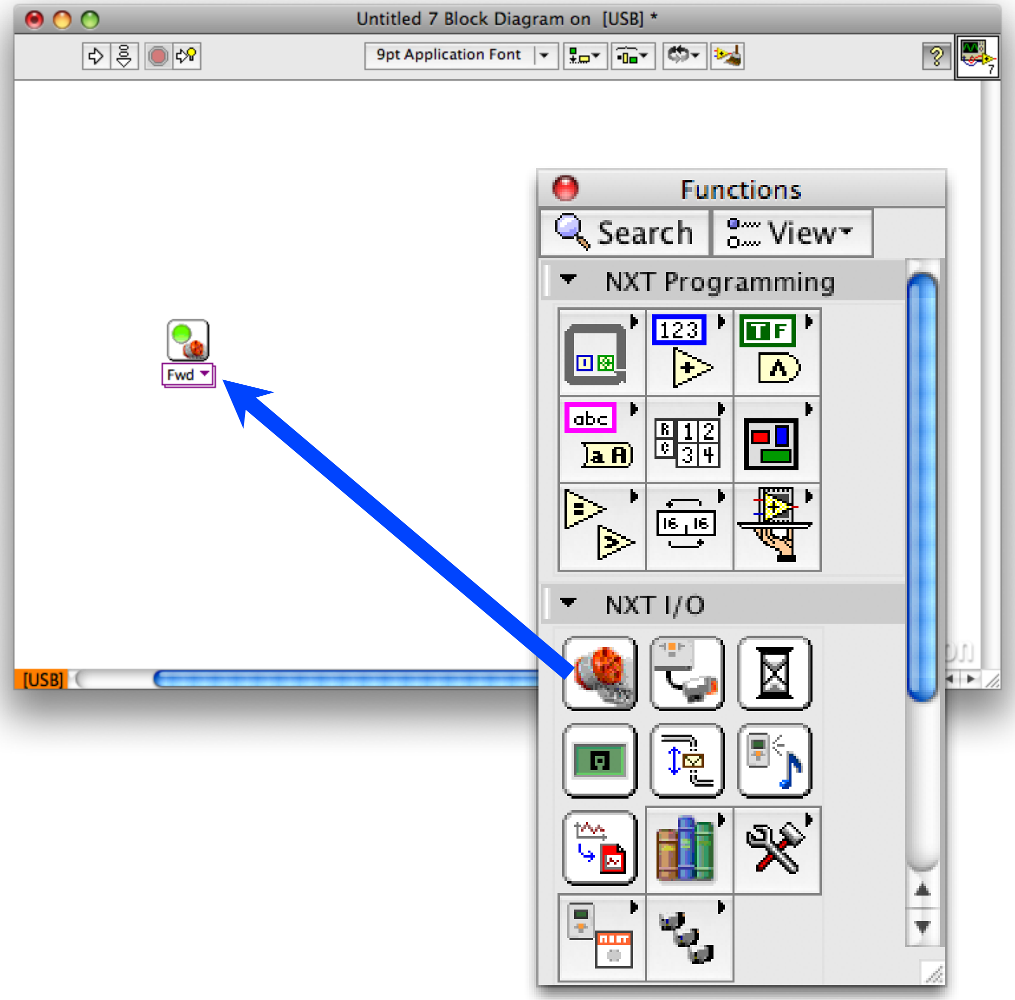
NXT Toolkit Activity

Drag a **Motor** into the VI



NXT Toolkit Activity

Drag a **Motor** into the VI



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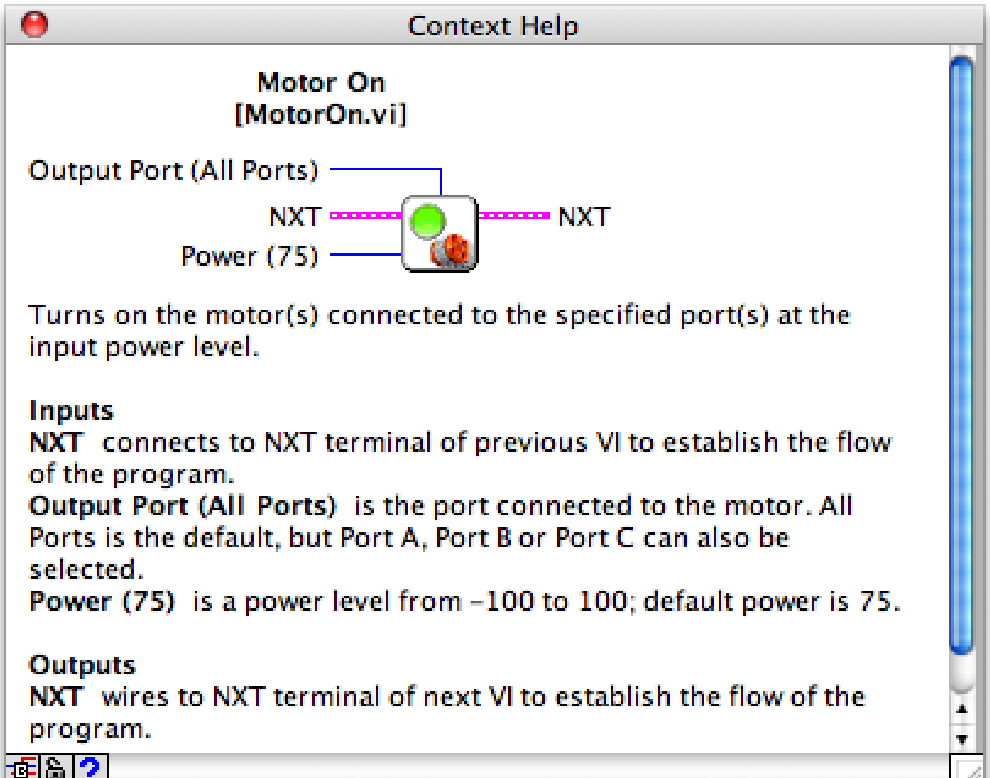
NXT Toolkit Activity

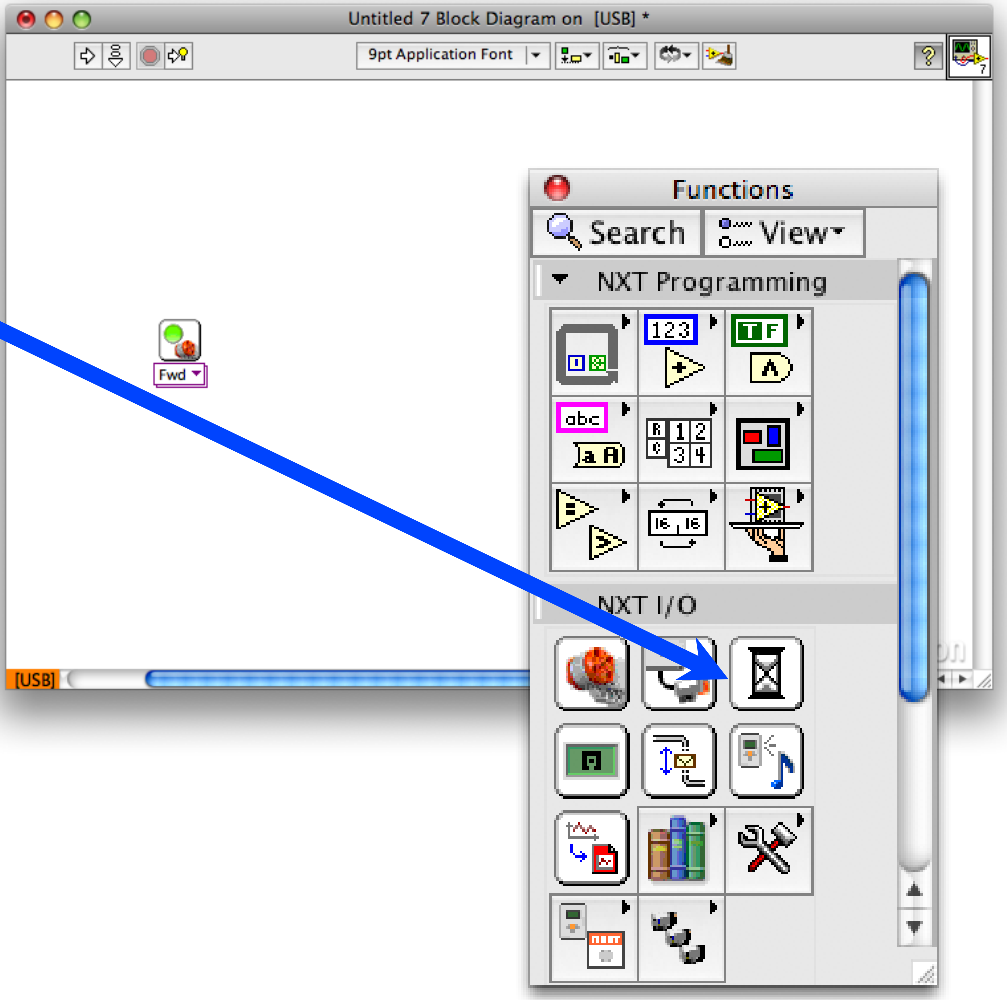


Context Help shows us how to connect to the motor VI

- CNTRL-H
- Help >> Context Help

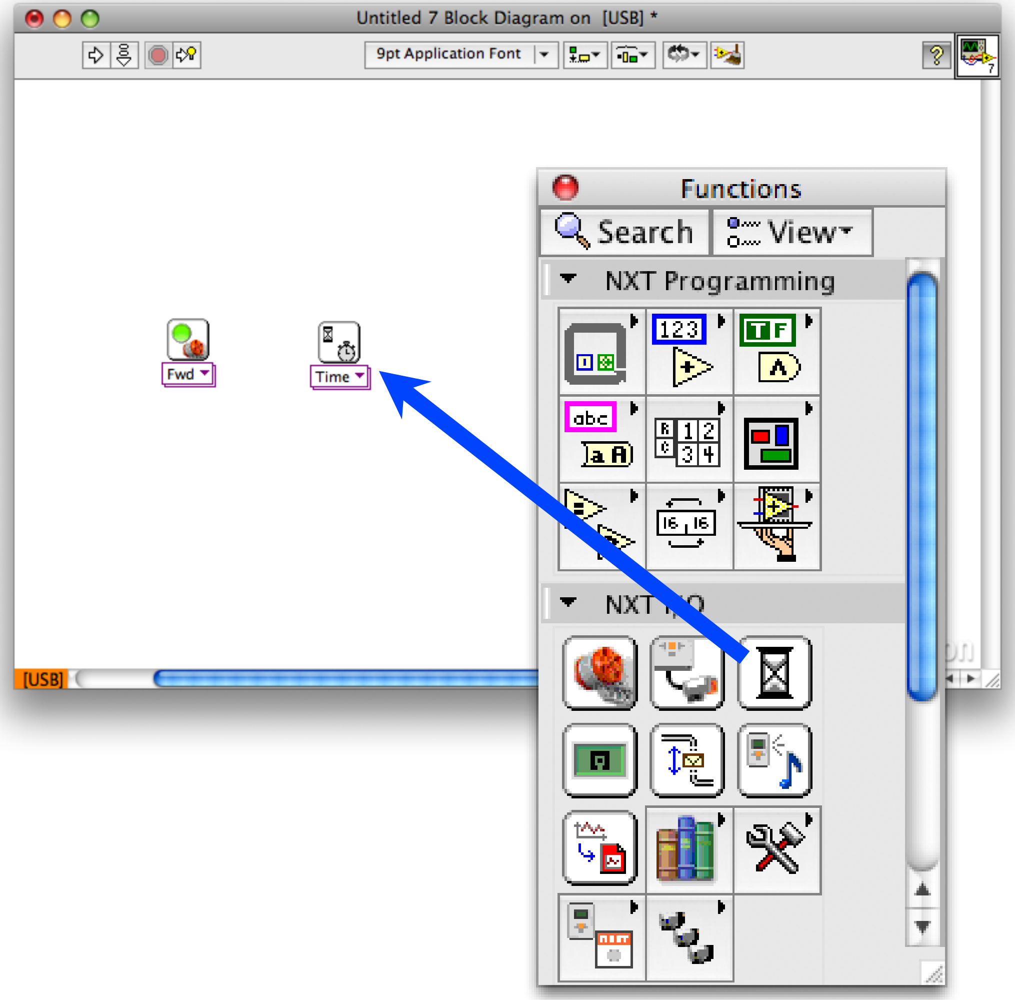
NXT Toolkit Activity

Drag a **Timer** into the VI



NXT Toolkit Activity

Drag a **Timer** into the VI



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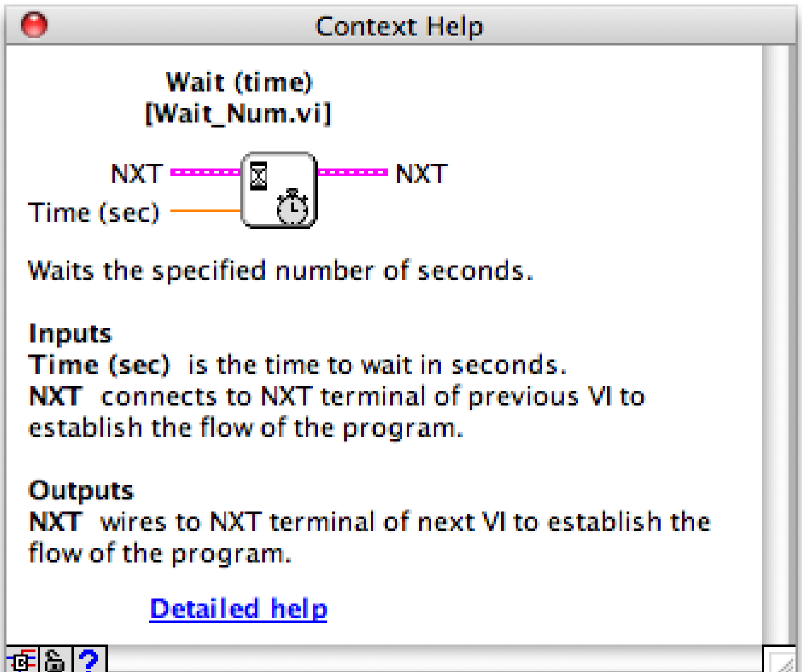
NXT Toolkit Activity

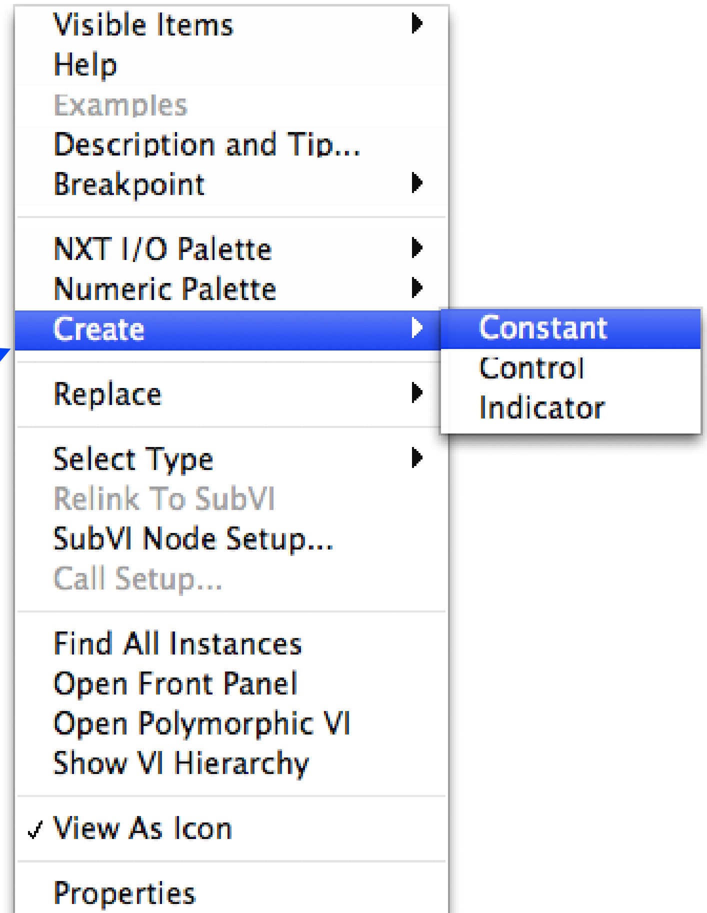


Examine the **Context Help** to **Specify the time**

NXT Toolkit Activity

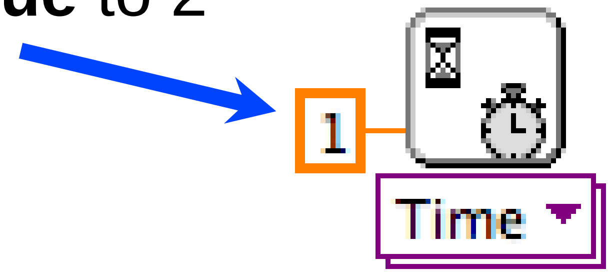
Right Click on the **Time** input

Select **Create >> Constant**



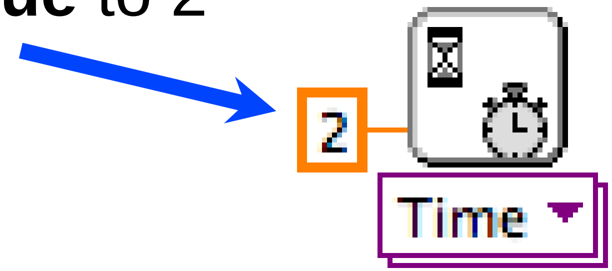
NXT Toolkit Activity

Change **value** to 2



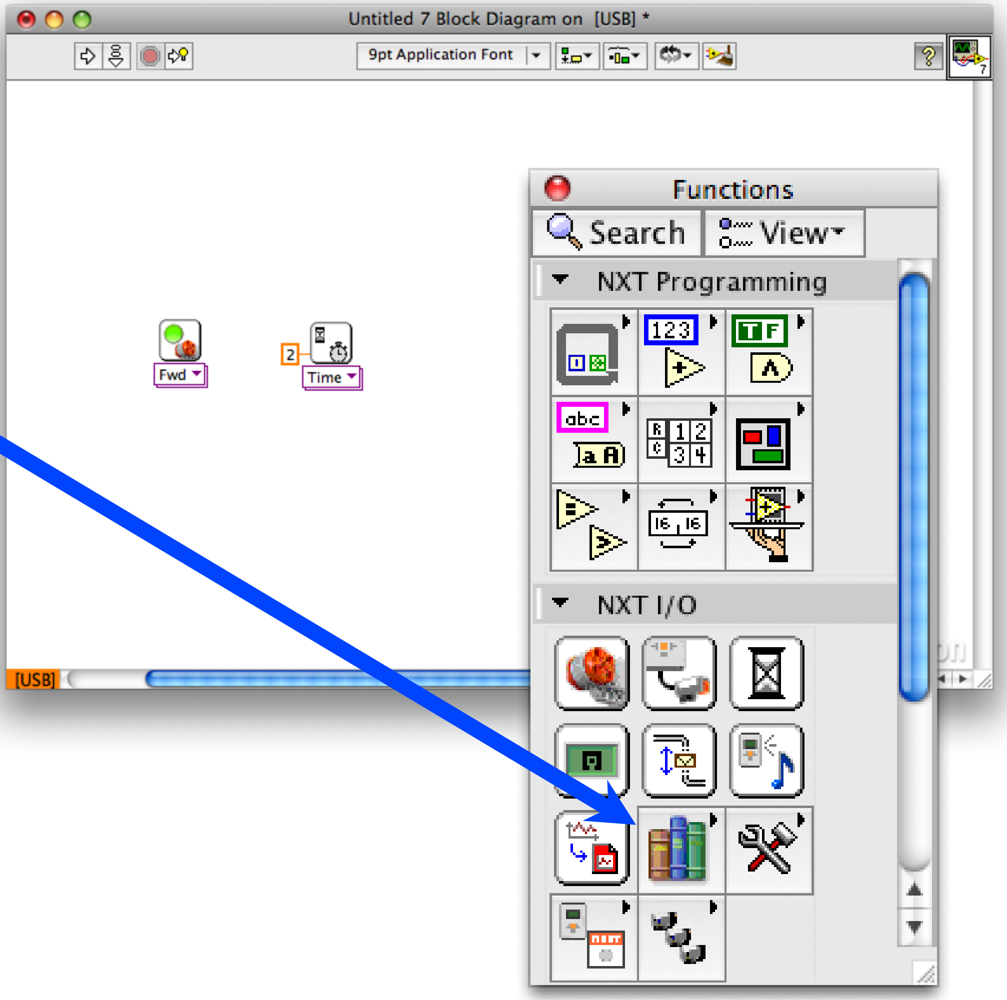
NXT Toolkit Activity

Change **value** to 2



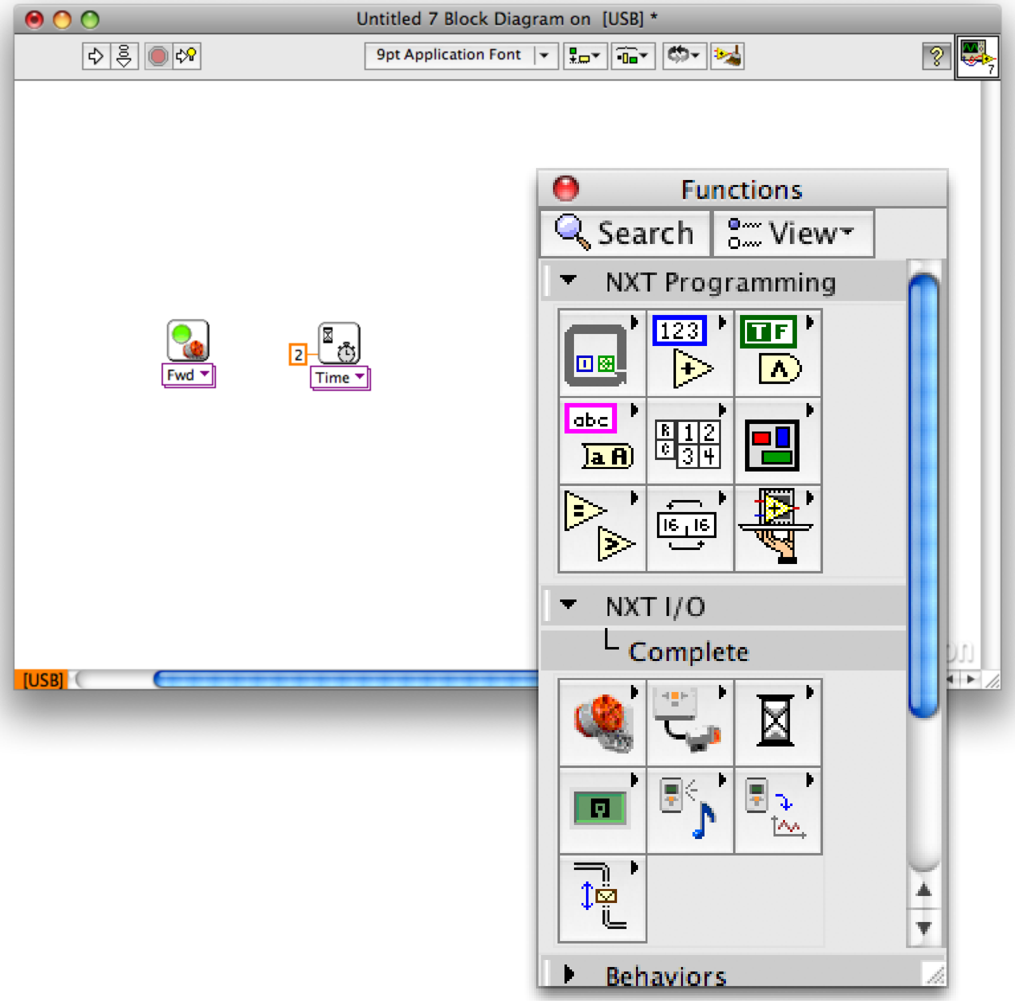
NXT Toolkit Activity

Click **Complete**



NXT Toolkit Activity

Click **Complete**



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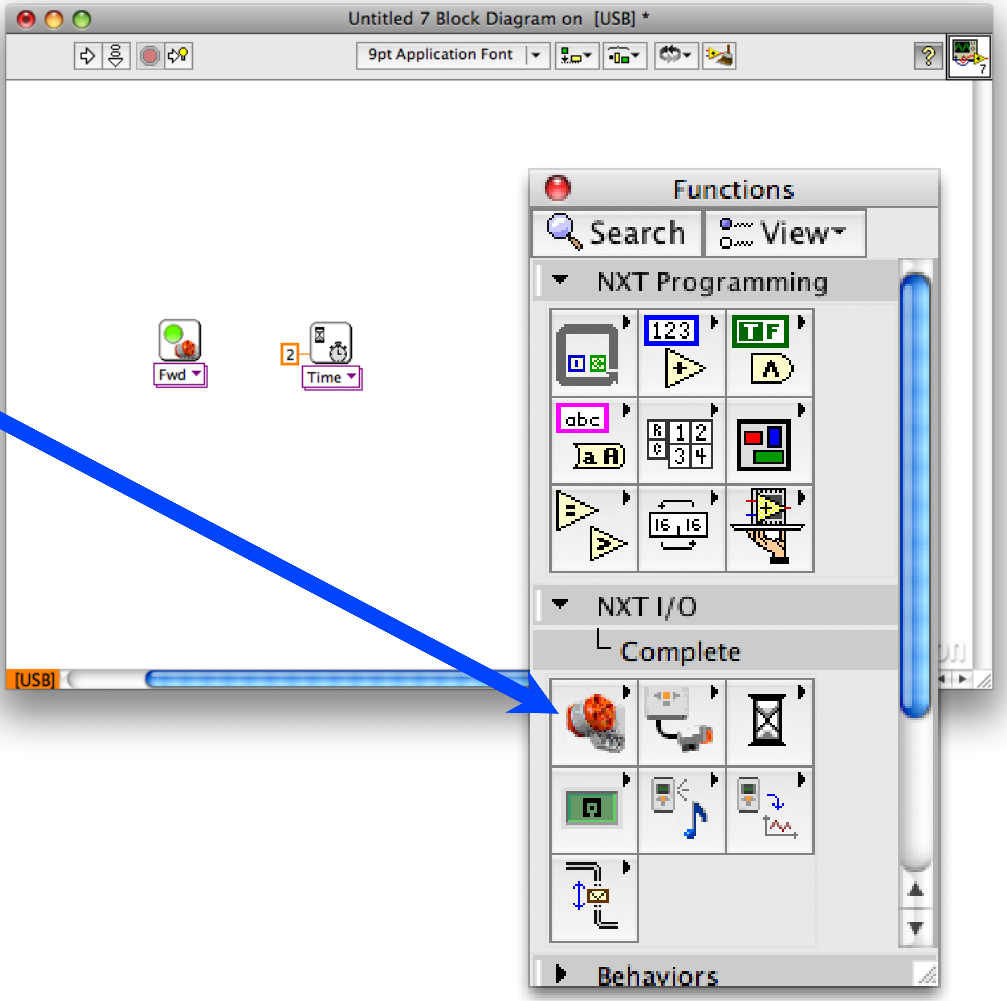
NXT Toolkit Activity

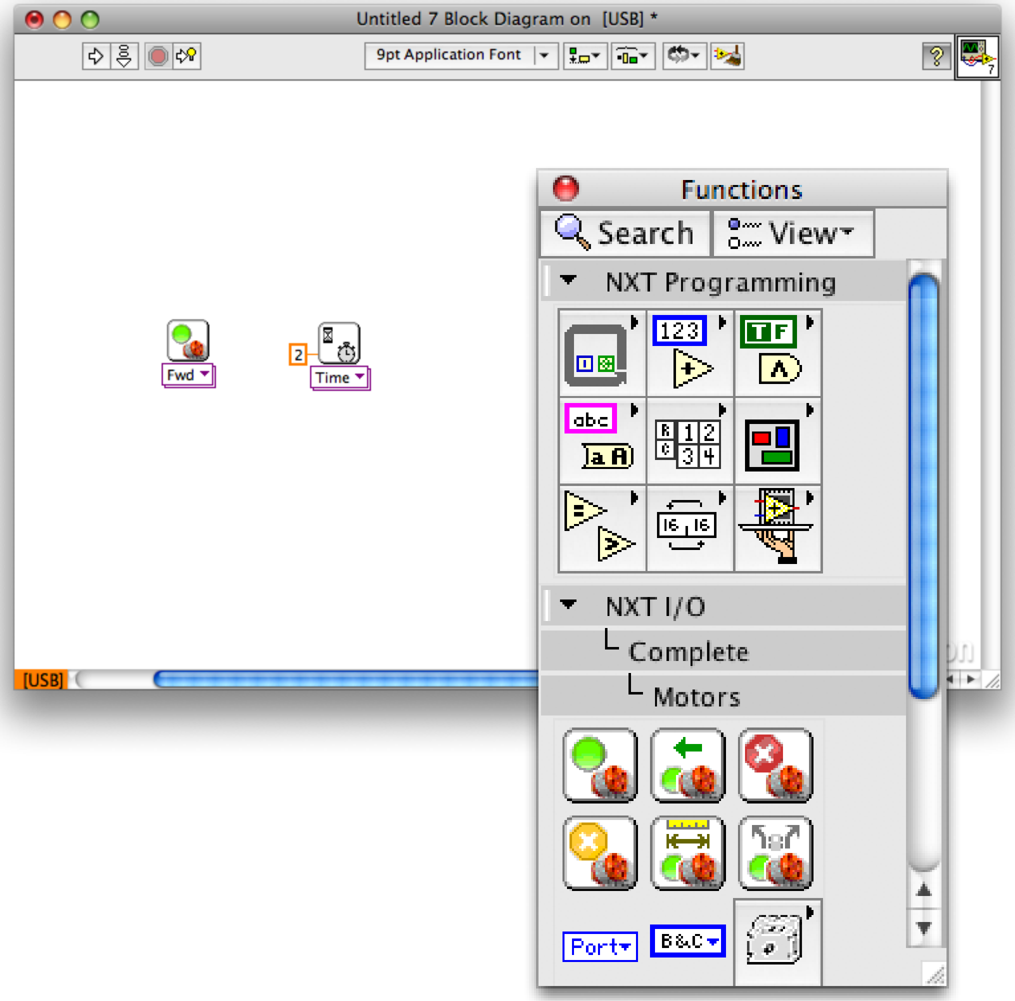
Click **Motors**



RoboJackets

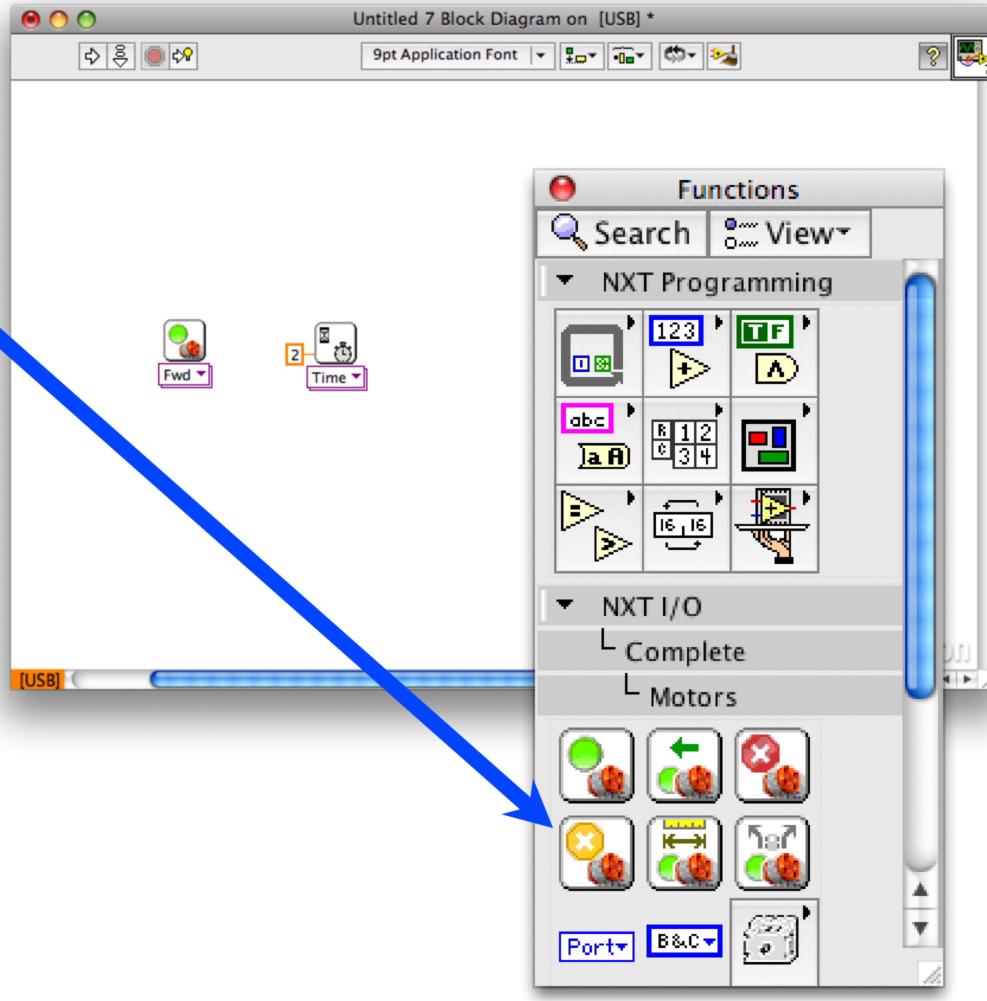
NXT Toolkit Activity

Click **Motors**



NXT Toolkit Activity

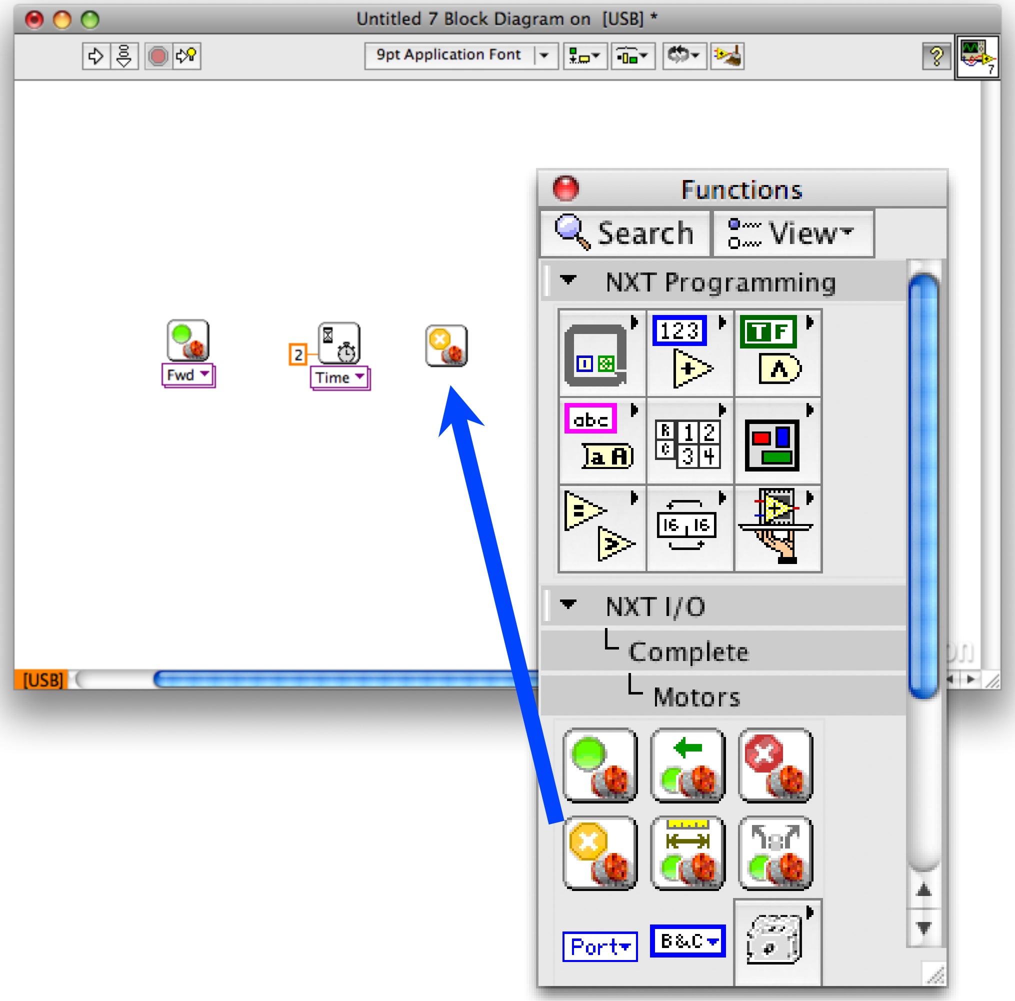
Drag **Motor Coast** onto the block diagram



RoboJackets

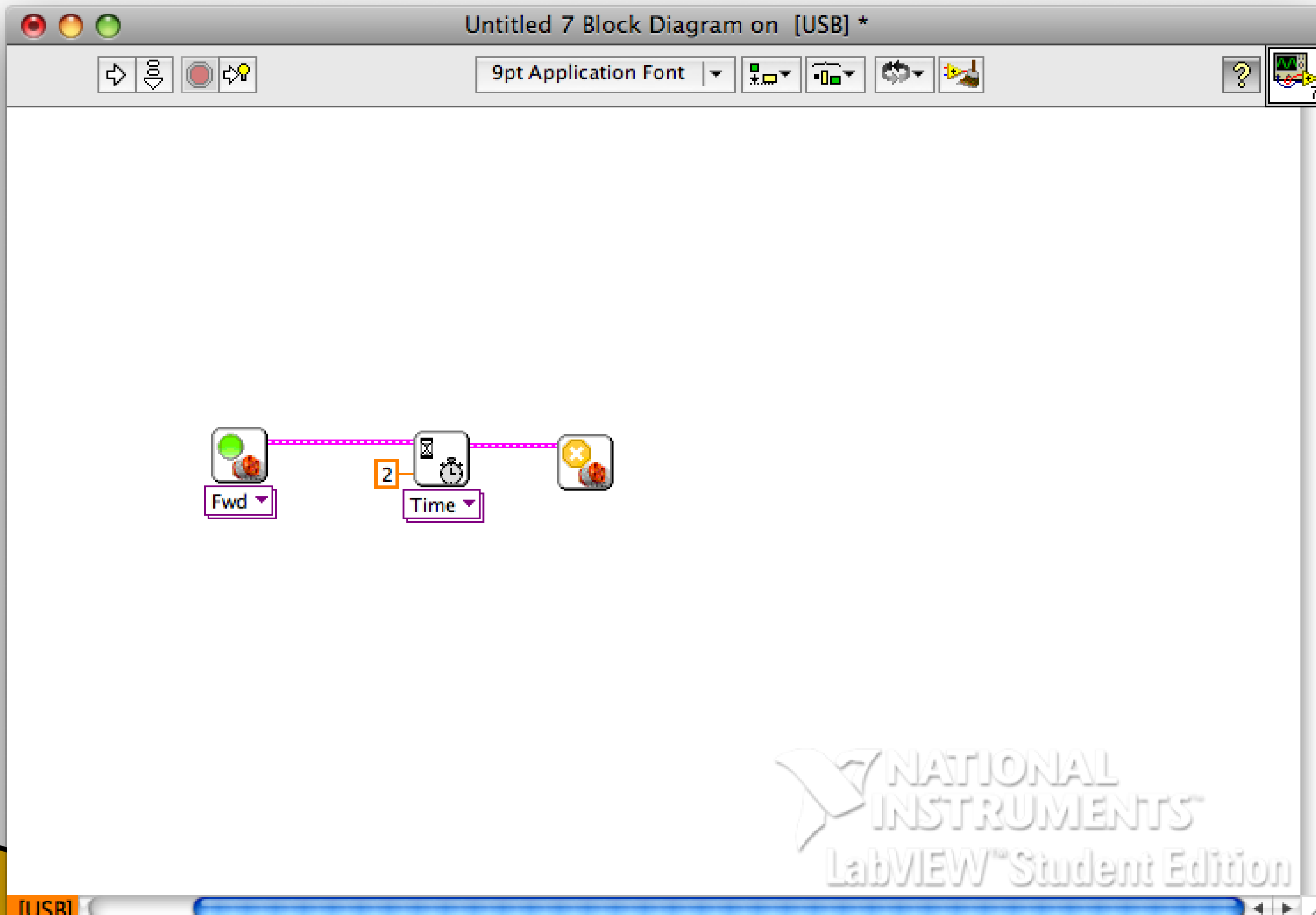
NXT Toolkit Activity

Drag **Motor Coast** onto the block diagram



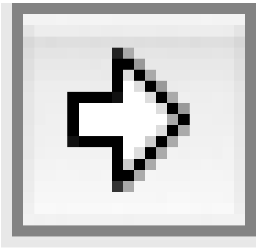
NXT Toolkit Activity

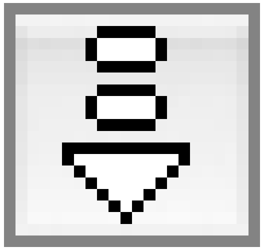
Wire the blocks together



NXT Toolkit Activity

- Connect the **NXT**
- Run the VI by pressing the **Run** button
- Load the VI onto the NXT with the **Deploy** button





Further Resources

- Wikipedia's Page on Gears
  - http://en.wikipedia.org/wiki/Gears
- WM Berg's pdf on gears, bearing, etc
  - http://wmberg.smartcats.com/pdf/techsessionpdf.pdf
- TIMKEN's presentation on bearings
  - http://www.timken.com/AntiFriction/player.html