



Dave Wilson

Director of Academic Programs
National Instruments

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Steps in the Technology Design Process

Dave Wilson
Director of Academic, Training and Certification Programs
National Instruments Corporation

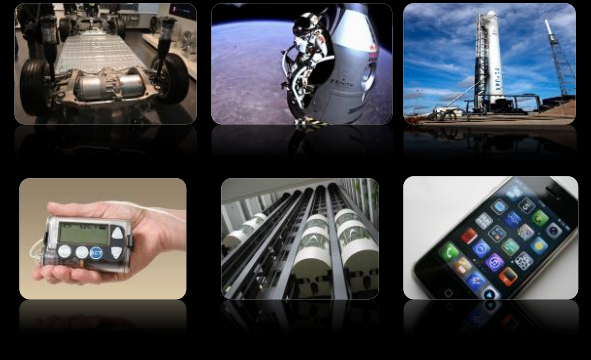
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Engineering Grand Challenges

 Advance health informatics	 Engineer the tools of scientific discovery	 Reverse-engineer the brain	 Provide energy from fusion
 Engineer better medicines	 Provide access to clean water	 Enhance virtual reality	 Restore and improve urban infrastructure
 Develop carbon sequestration methods	 Advance personalized learning	 Make solar energy economical	 Prevent nuclear terror
 Secure cyberspace	 Manage the nitrogen cycle		

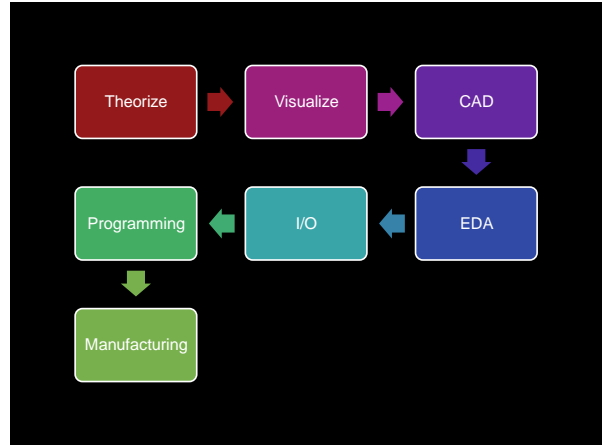
Systems are Everywhere



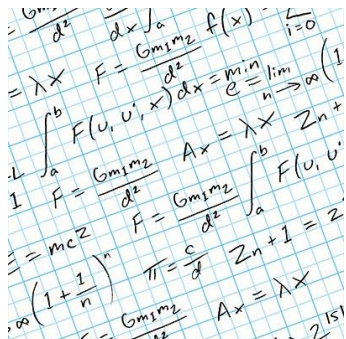
“The ensemble is the function...”



Dr. Alberto Sangiovani Vincentelli
University of California at Berkeley



Learn the Theory



Theory is Important

P Wave $v_p = \sqrt{M/\rho}$ $P = I^2 R = \frac{V^2}{R}$,
Power Output

S Wave $\beta^2 = \frac{\mu}{\rho}$ $\frac{V_s}{V_p} = \frac{N_s}{N_p}$
Transformer

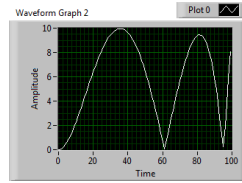
$$C(s) = (K_P + K_I \frac{1}{s} + K_D s)$$

PID

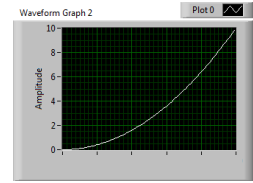
Using PID...



Math... the shape maker

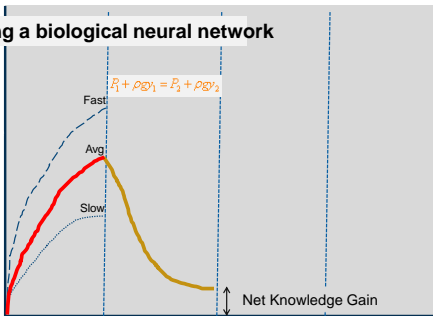


$$Y = \text{abs}(G \cdot (A \cdot x^4 + B \cdot x^3 - C \cdot x^2))$$

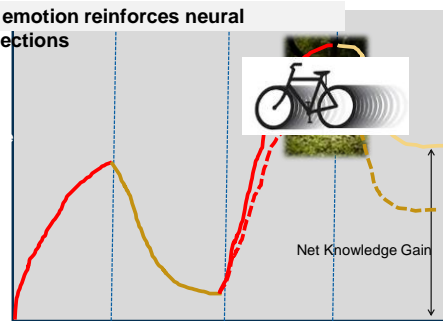


$$Y = X^2$$

Training a biological neural network

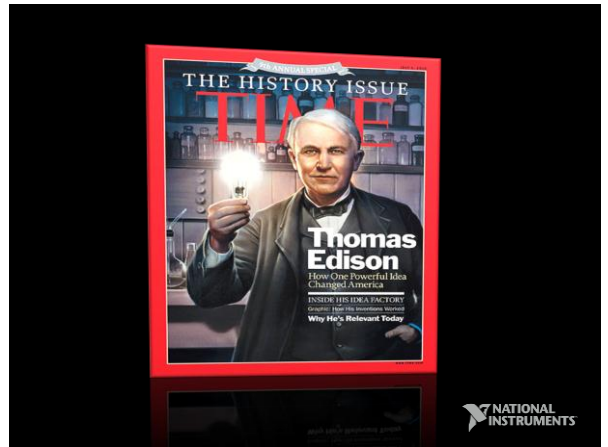
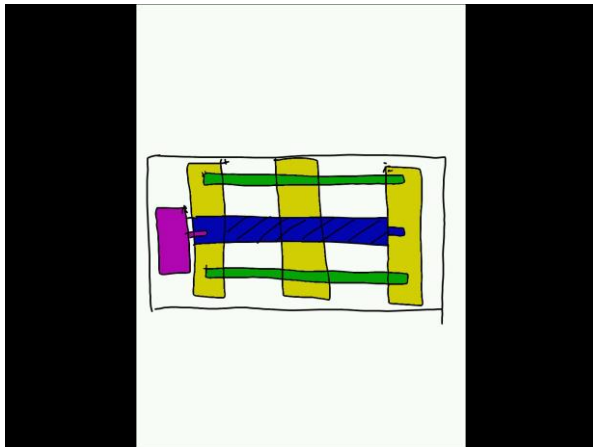
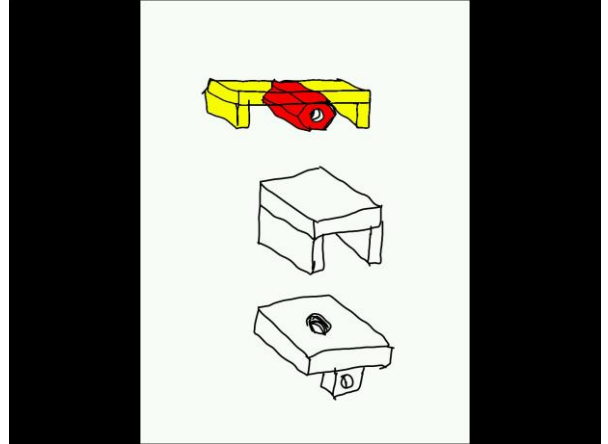


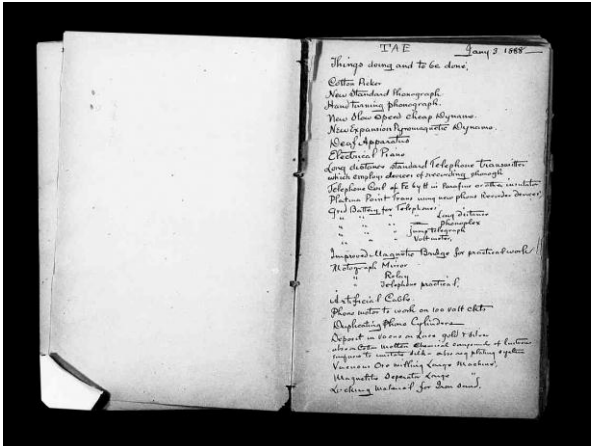
High emotion reinforces neural connections



Visualize the Theory

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Controls, Mechatronics, and Robotics
Do Engineering: On One Platform from Concept to Proof

ni.com/academic/controls **Meghan Kerry**
 Product Marketing Manager

Mechanical Prototyping

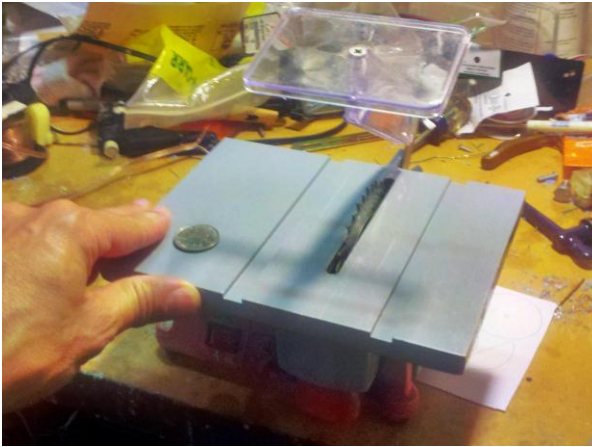
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The screenshot shows the Harbor Freight Tools website homepage. At the top, there's a navigation bar with links for CONTACT US, \$6.99 FLAT-RATE SHIPPING | GET COUPONS NOW, LOG IN / REGISTER, MY WISHLIST, and MY CART. Below this is the Harbor Freight Tools logo and a search bar. A prominent banner advertises a "SAVE up to 80%" promotion, with "MOST ORDERS SHIP IN 24 HOURS!" and "FedEx SHIPPING AS LOW AS \$6.99". The main content area is divided into several promotional tiles:

- DRIVE CLICK STOP TORQUE WRENCH:** \$9.99 with coupon (regular price \$34.99). Item # 230 / # 2696 / # 897.
- ELECTRIC CHAIN SAW SHARPENER:** \$29.99 with coupon (regular price \$45.99). Item # 69271.
- 13 DRAWER GLOSS RED INDUSTRIAL QUALITY ROLLER CABINET:** \$369.99 with coupon (regular price \$599.99). Item # 62754.
- 6.5 HP HORIZONTAL SHAFT GAS ENGINE (212 CC):** \$99.99 with coupon (regular price \$179.99). Item # 68120.
- 3 PIECE DECORATIVE SOLAR LIGHT SET:** \$11.99 with coupon (regular price \$20.99). Item # 95258.
- 7.3 AMP 3-IN-1 1" SDS ROTARY HAMMER:** \$69.99 with coupon (regular price \$159.99). Item # 61276.

Navigation categories include POWER TOOLS, AIR TOOLS, HAND TOOLS, AUTOMOTIVE & MOTORCYCLE, ENGINES & GENERATORS, GARAGE & SHOP, HOUSEHOLD, LAWN & GARDEN, and MATERIAL HANDLING.





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287 Products

About Performance Plastics

Optically Clear and Colored Cast Acrylic

- Optically Clear, unless noted
- Temperature Range: Sheets and Cubes, -20° to 170° F; Anti-Fog Sheets, Rods, and Tubes, 0° to 150° F; Rectangular Bars and Circles, 170° F; Ion and not noted
- Solforming Temperature: 190° to 230° F, unless noted
- Tensile Strength: Good
- Impact Strength: Fair
- Good electrical insulator, unless noted
- Use indoors and outdoors
- Matches with carbide tooling
- Hardness: Rockwell M90-M103

Others include optical clarity than molded and extruded acrylic.

Rectangular Bars—Smooth Finish

- Not rated as an electrical insulator

Width and length tolerances are ±1/16".

Thick.	Thick. Tolerance	Each	0" Wide	1" x 1/2" Wide	2" Wide	2 1/2"
1/4"	-0.011" -0.011"	1227711	53.52	1227712	54.40	1227713
1/2"	-0.011" -0.009"	1227721	5.48	1227722	7.50	1227723
3/4"	-0.009" -0.008"	1227731	7.72	1227732	10.76	1227733
1"	-0.002" -0.008"	1227741	8.80	1227742	14.60	1227743

Sheets—Smooth Finish

When heated, sheets will uniformly shrink 1.5-2% in width and 1-2% in length. Width and length tolerances:

Thick.	Thick. Tolerance	Each	24" x 24"	36" x 24"	48" x 24"
0.002"	-0.015" -0.015"	8560K171	\$4.85	0.002"	-0.015" -0.015"
0.003"	-0.014" -0.020"	8560K181	4.80	0.003"	-0.014" -0.020"
0.004"	-0.015" -0.020"	8560K191	4.80	0.004"	-0.015" -0.020"
0.005"	-0.014" -0.020"	8560K201	7.04	0.005"	-0.015" -0.020"
0.006"	-0.015" -0.020"	8560K211	9.27	0.006"	-0.015" -0.020"



Replicate

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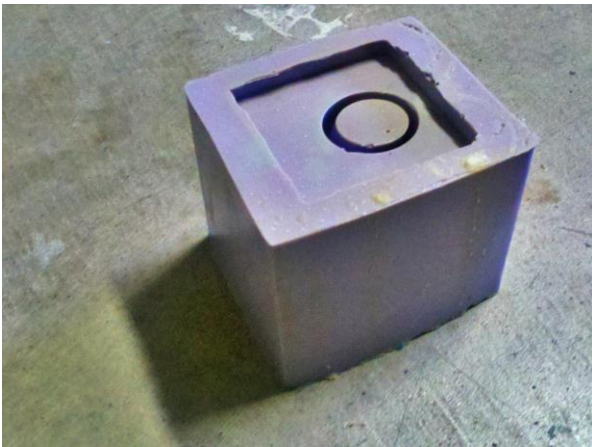
Epoxy Page
Silicone Mold Making
Casting Resin
Epoxy Adhesives
Bar Top Epoxy
Expanding Foam
Concrete Mold Making
Latex Mold Rubber
Dry Rot Repair Epoxy
Pebble Flaving Epoxy
Encapsulating Resins
"Holdmaking 101"
Product Videos
Free Cured Samples

Seven of Aeromarine Products' most popular mold making supplies are shown on this page:

- **Most popular silicone, AM 128**
- **Easiest to use silicone, AM 125**
- **Transparent silicone, AM 121**
- **Reusable silicone, AM 128**
- **High-heat, highest temperature silicone, AM 150**
- **Fast silicone rubber, AM 128**
- **Mold releases for silicone**
- **Draft Scale**

Click this link for our "Mother Mold," (a rigid plastic shell to support thin-walled molds).

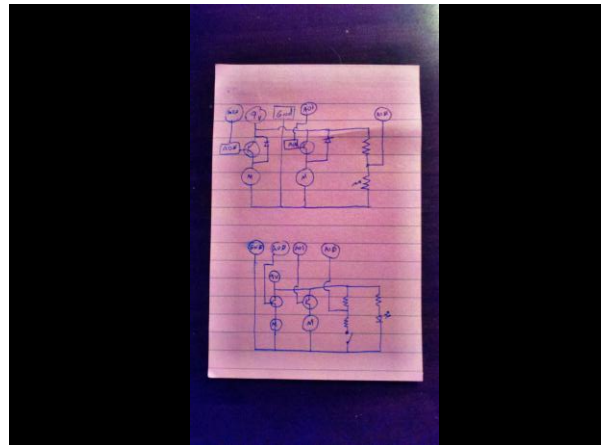
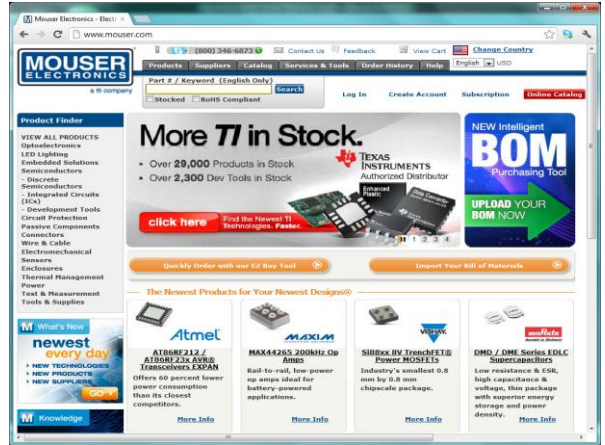
Description	Image	Price
AM 128 Flexible Silicone Rubber, 1/2 gallon kit - 4.4 lbs. \$40		AM 128 Flexible Silicone Rubber, 1/2 gallon kit - 4.4 lbs. \$40
AM 128 Silicone Rubber RTV- Our most popular mold making		AM 128 Silicone Rubber RTV- Our most popular mold making

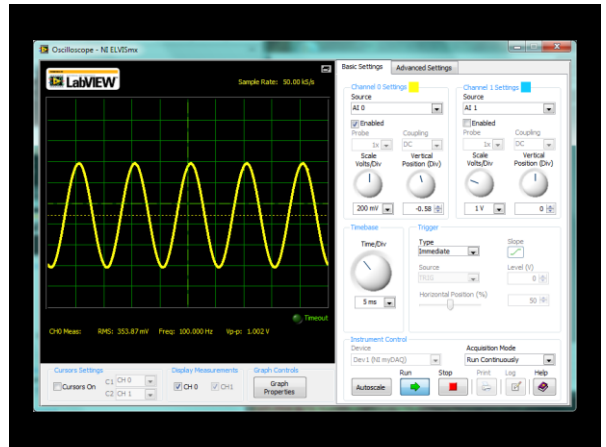
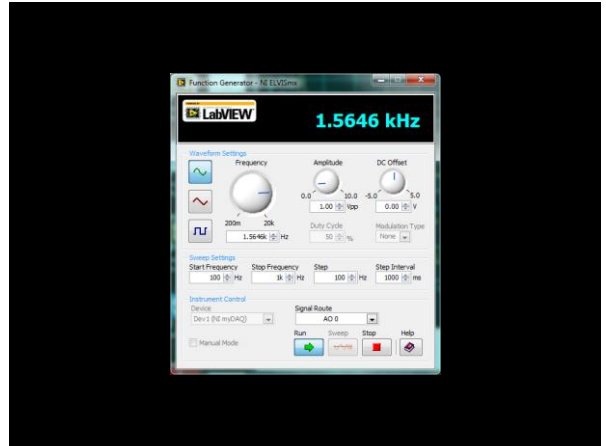
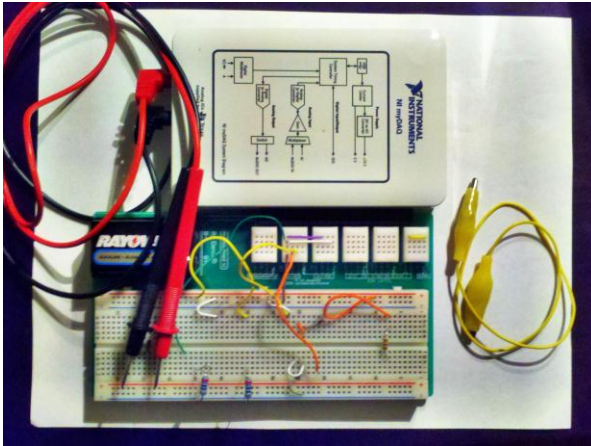


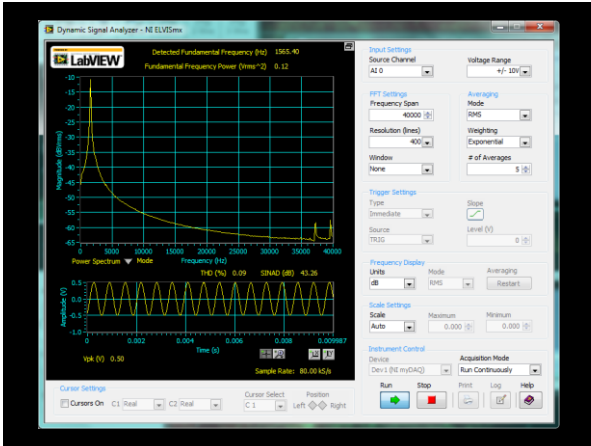


Electronic Prototyping

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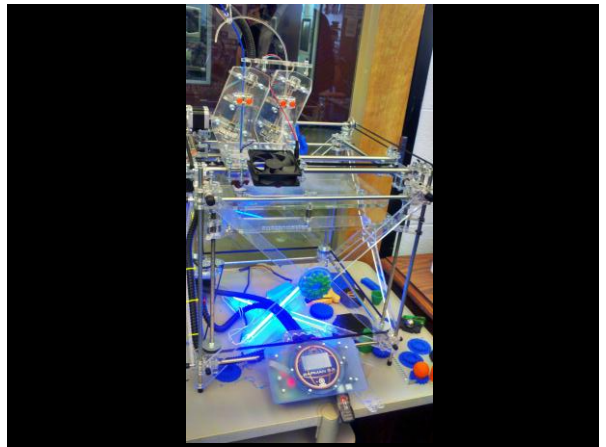


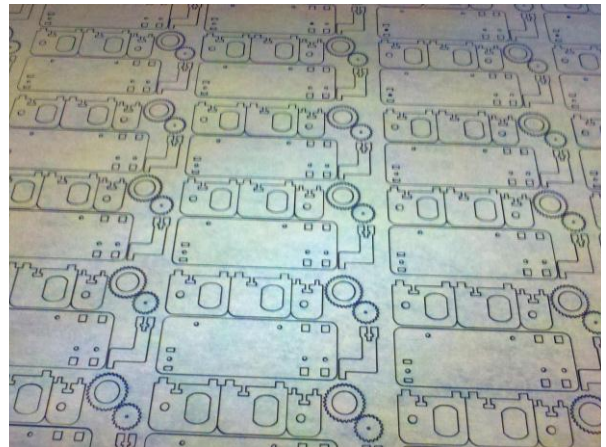
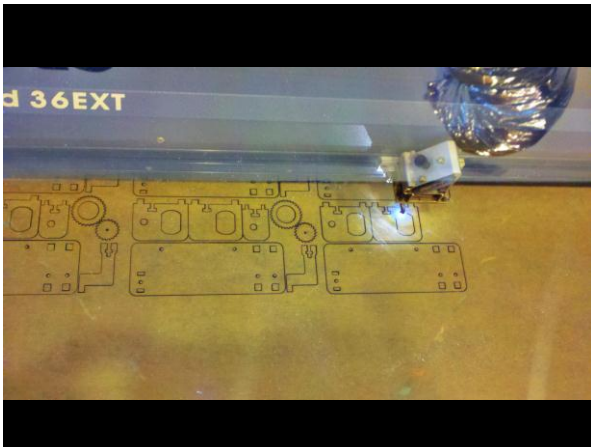
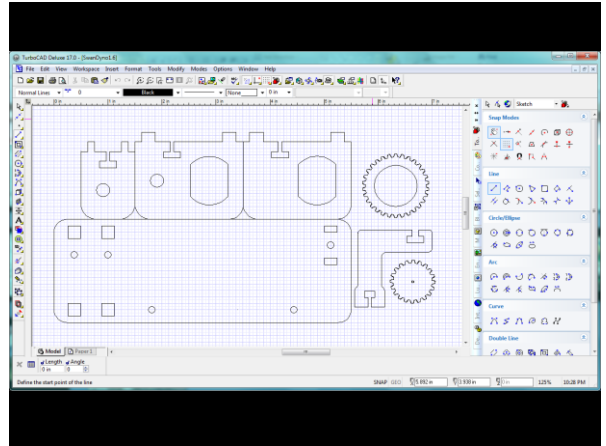
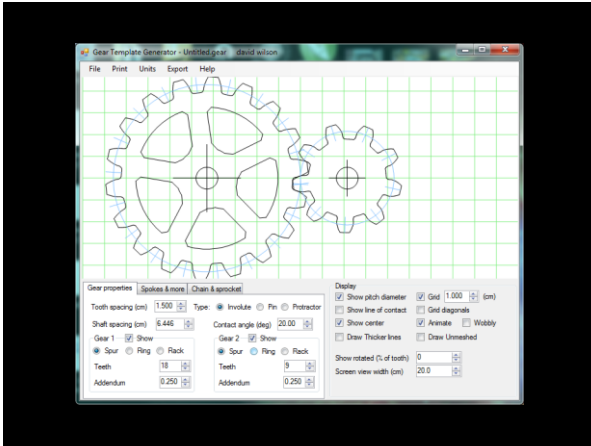


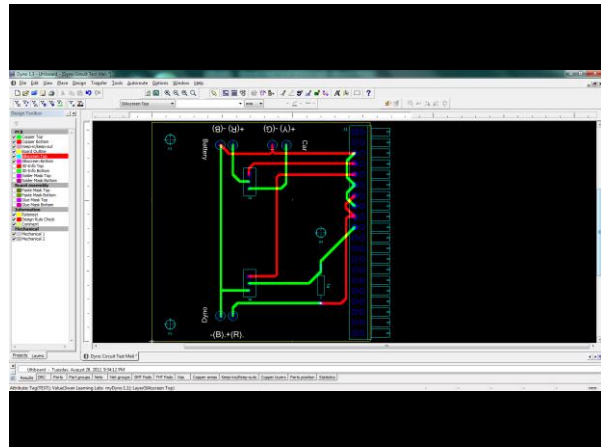
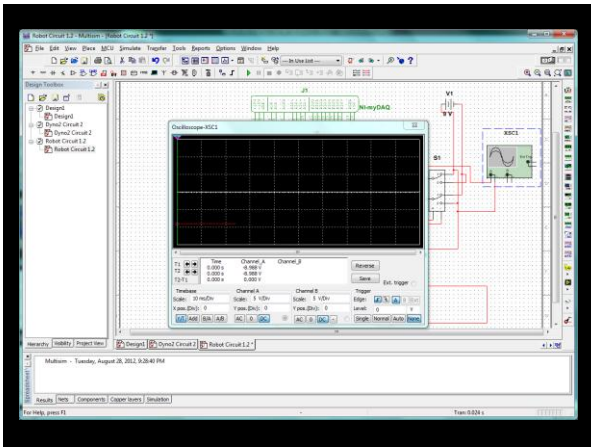
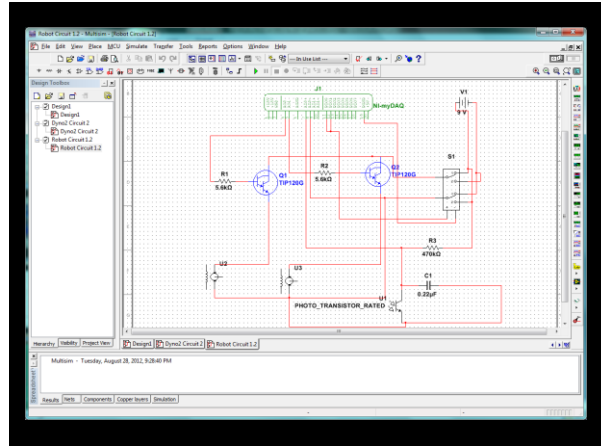
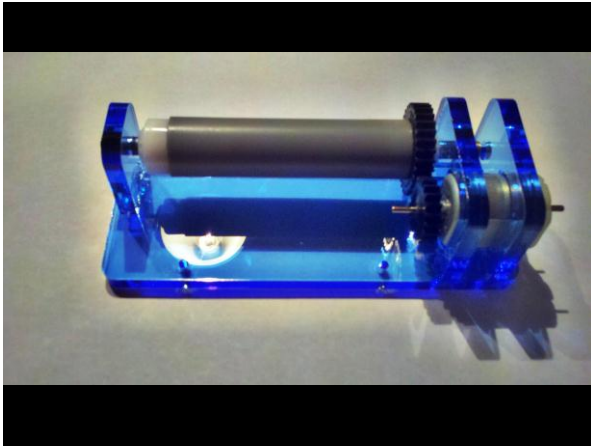


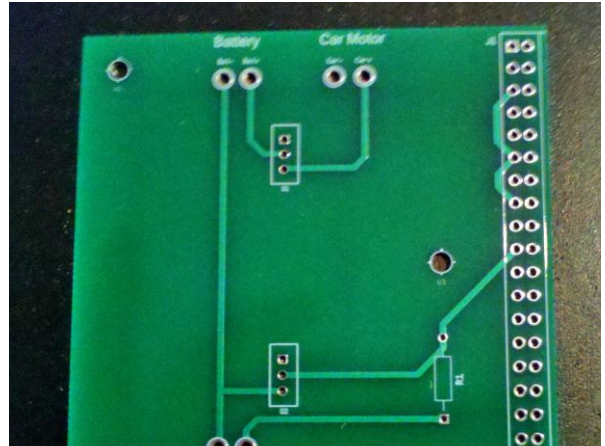
Production

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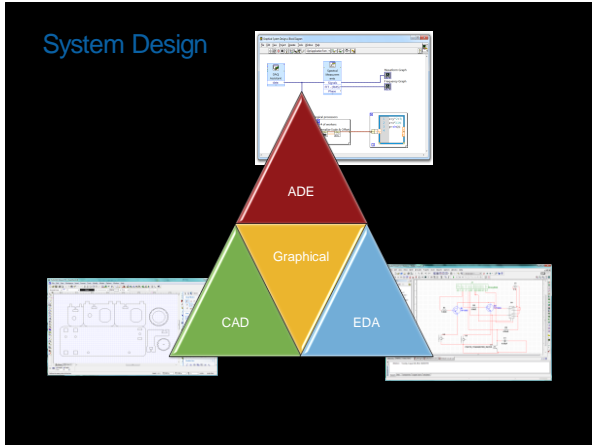




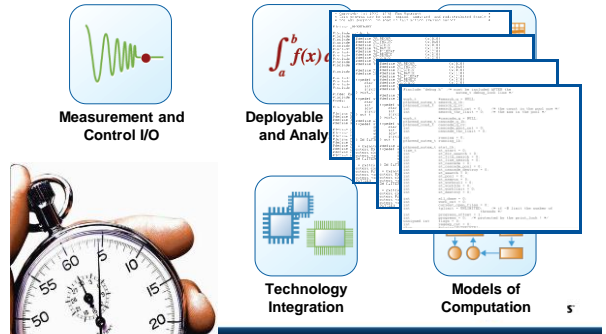




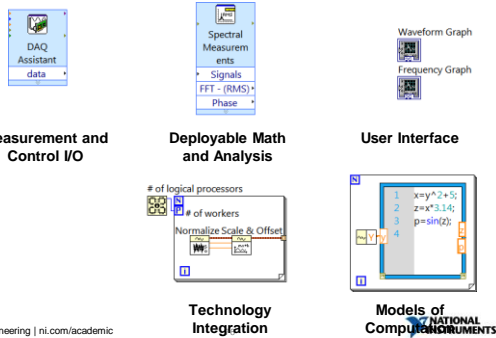
Programming



Elements of Engineering Systems

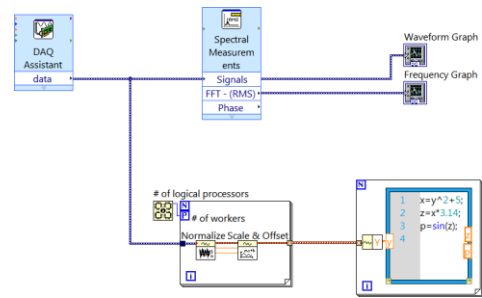


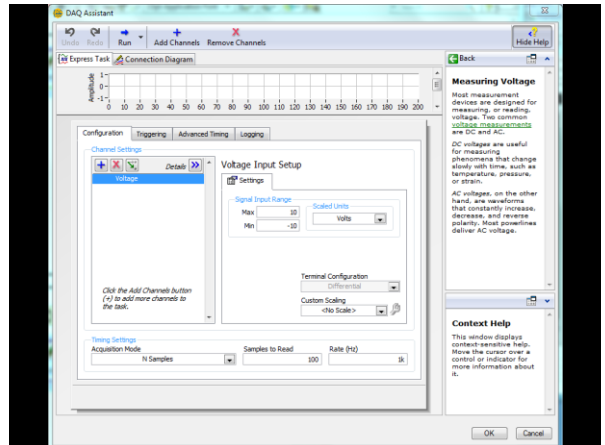
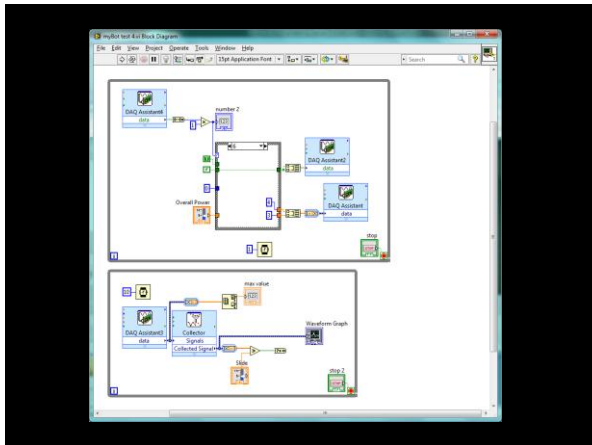
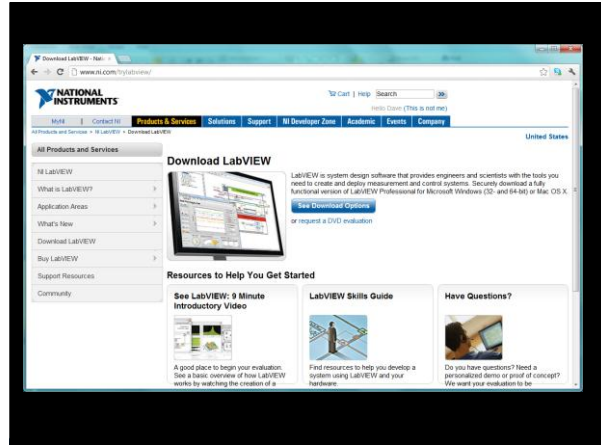
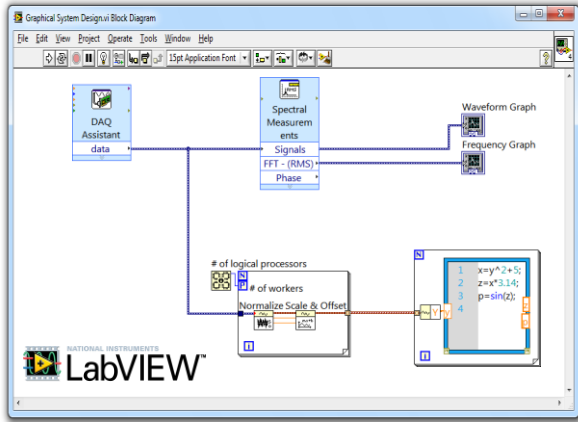
Compatible Elements



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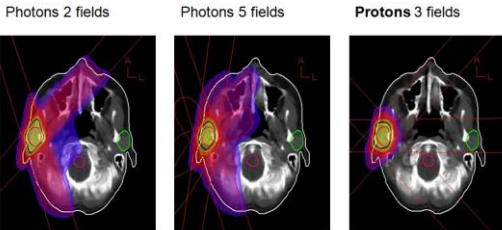
Easily Combined





CERN: MedAustron

Example: glandula parotid cancer

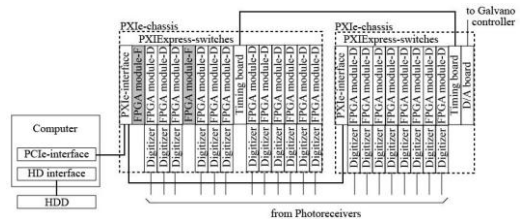
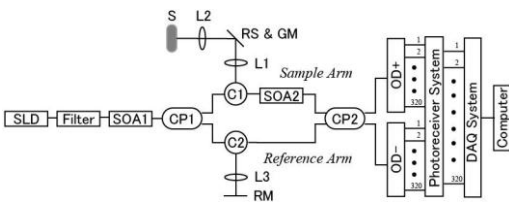


Courtesy: University clinic for radiotherapy and radio-biology, AKH Vienna, Austria

Application Notes

- Particle accelerator used for cancer therapy without damaging healthy tissue
- Wide energy range from 60 MeV to 800 MeV per nucleon with selectable beam energy in steps of 0.1 MeV
- 300,000 settings for the beam based on particle type, ion source, beam line, energy level, beam dimension, and spill length
- Concurrent beam control and reconfiguration in less than 250 msec
- Reconfigure the software on the FPGA for the next cycle while current beam is generated
- Distributed control system synchronously generates magnetic fields for 300 magnets by generating waveforms for power converters in real time at 2 kHz
- Power converter synchronization at the microsecond level to generate/control the beam
- Power converters distributed over 800 m2 in access controlled area
- 500 beam cycles with different beam energies for a single medical irradiation session of about 2 minutes duration
- More than 20,000 shared variables for control, configuration, and monitoring
- Solution completed in time because the researchers did not need to learn VHDL

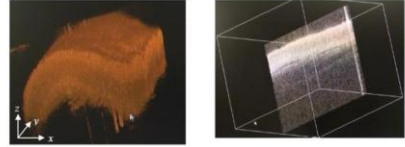
Optical Coherence Tomography





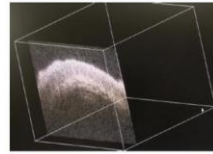
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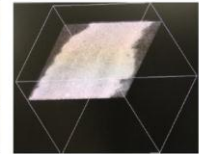


(a)

(b)



(c)



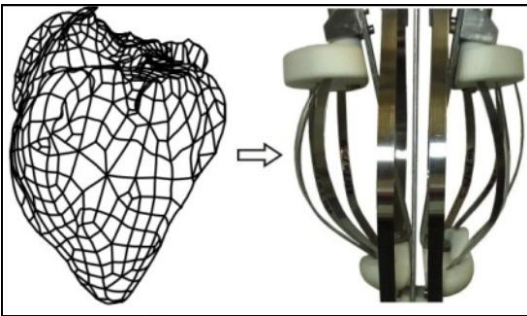
(d)

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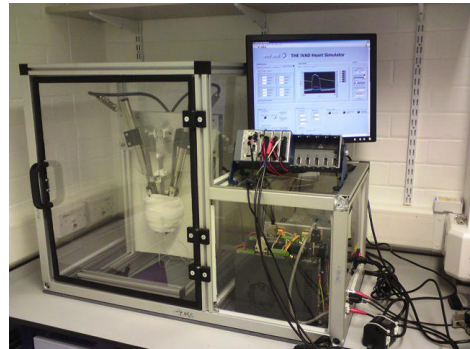


Heart Assist



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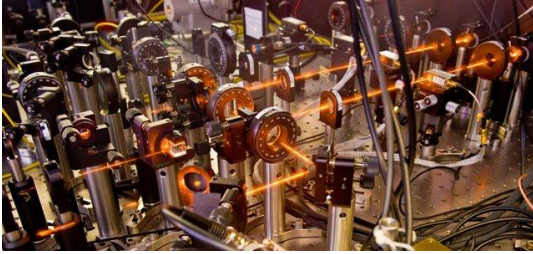


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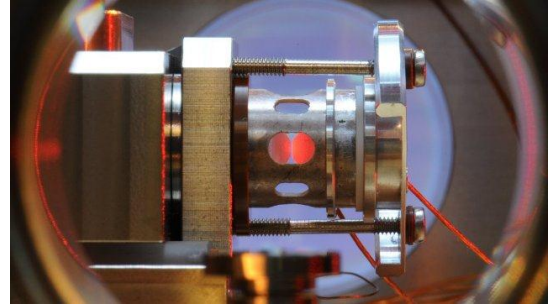


Freezing an Atom



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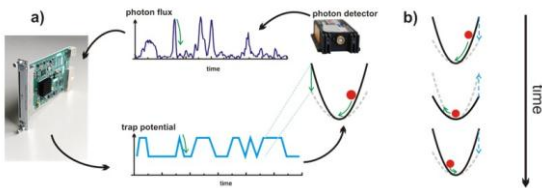


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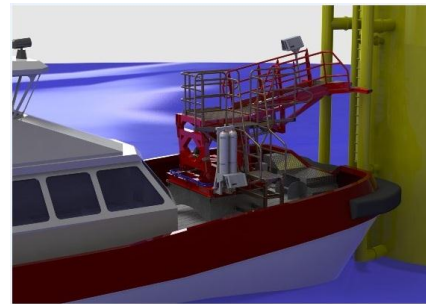


Wave Motion Cancellation



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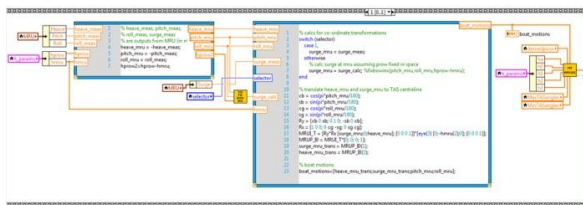
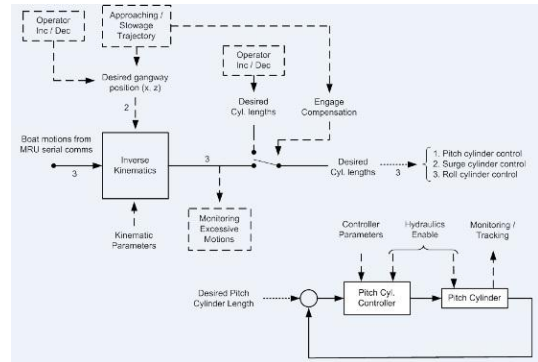
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Mechatronics and Robotics Today



UC Boulder
Autonomous Underwater Vehicle



Virginia Tech
Rotary Inverted
Pendulum



Virginia Tech
Adult sized humanoid robot



Case Western
Autonomous lawn
mower



MIT
Surface
inspecting
pendulum robot



UC San Diego
Multi-modal treaded rover



UC Berkeley
Canfield Joint

Title	Controlling a Hydraulic Motion Compensated Gateway to Access Offshore Wind Turbines
Author	Andrew Clark - Industrial Systems & Control LTD, UK
Challenge	Creating a system to safely transfer personnel & equipment to offshore wind turbines in rolling seas & bad weather
Solution	Using LabVIEW & cRIO to develop a movable gateway with an algorithm using boat motions to provide required hydraulic cylinder lengths to maintain position
	wind turbines located further offshore, sea conditions become adverse
	transferring personnel to sea based wind turbines for maintenance
	movable gateway mounted on hydraulically actuated base on boat front
	up & down pitch cylinder, forward & back surge cylinder, port/starboard roll cylinder
	compensate for boat motions in roll, pitch, heave
	used LVRT, FMGA & MathScript RT modules
	did dynamic simulations to test control strat & hydraulic specs to meet perf targets
	use emulator to test algorithm functionality
	switched to real system to evaluate control loop performance for different loads, size, speed of motions, orientations
	AD & control algorithm on cRIO
	Motion Reference Unit measures vessel motion, translates positions & angles via serial link to MPX
	use mathscript nodes in LV for complex algorithms
	inverse kinematics transforms motion plan into joint actuator trajectories
	hydraulic cylinder lengths & maintain gateway 0.1m from target
	real-time adaptive control with four forward & backward compensation
	minimal length error for simulation & real testing showed simulation was reasonable rep of final system
	development, implementation & factory testing took a little more than a year
	sea trials confirm that range of motion compensation meets expectations from final factory testing

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2



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