Experimental Setup with LabView Virtual Instrument

While working at Seattle’s Synapse Product Development, I was asked to create an experimental apparatus to test the 0-100 psig pressure characteristics of a client’s high-volume consumer product. After researching and purchasing an appropriate electronic pressure regulator, I designed a LabView virtual instrument (VI) with which I could precisely control the regulator for both one-time and cyclical pressurizations. The VI also communicated with a pressure/flow meter so that the state of the experimental system could be observed in its entirety on one screen. The virtual instrument was employed successfully for several different experiments and thousands of trials.

**Top Left** — Screenshot of the virtual instrument’s “dashboard.”  **Top Right** — The Kelly Pneumatics low-flow pressure regulator was installed into the apparatus with the help of ¼” NPT fittings.  **Bottom Left** — The Alicat pressure and flow meter confirmed the pressure in the tested product and registered any gas leakage through its seals.  **Bottom Right** — A section of the VI’s block diagram, showing the graphical programming language with which LabView VIs are coded.
I engineered this brake pedal assembly for use on the 2012 University of Washington Formula Motorsports race car. After interviewing the team’s drivers and brake engineer for their preferences, I wrote a multi-hundred line-long MATLAB script to analyze resultant force vectors and to optimize the pedal’s geometry. Using ANSYS Workbench, I developed and built two iterations of a safe and lightweight design that could withstand 450lb of force with a minimum factor of safety of 2.0. The race-ready second iteration was constructed using water jet-cut 6061-T6 aluminum and machined brass and 7050-T4571 aluminum. With military-grade fasteners, it weighs just 1.13lb.

Top Left — Two views of the 3D SolidWorks pedal model. The left view includes the hydraulic master cylinders that actuate the brake rotors when the pedal is depressed. Top Right — An ANSYS Workbench model of the strain induced during one of the three separate worst-case loading scenarios. Bottom Left — The final version of the brake pedal (left) was built upon the successes and failures of its first iteration (right). Bottom Right — Brass bushings were press fit to the bracket and pedal after each was cut on a three-axis CNC mill with Siemens NX.
This lightweight, easy-to-manufacture foot contact surface was cut with a water jet from 6061-T6 aluminum. Bent gussets add strength.

I-beam-like design allows the pedal to be both strong and low-mass. The thin member opposes hydraulic master cylinder forces in tension.

The pedal was designed around the master cylinder bracket and assembly. Multiple hole locations enable the bracket position to be adjusted for ideal driver-over-master cylinder mechanical advantage.

Weight reduction slots stop briefly to allow pedal surface gussets to meet a flat surface.

The multi-slot hinge and internal bushings eliminate lateral slop when depressing the pedal.

The lowered step forward of the hinge stops the pedal from rotating too far and shearing off the master cylinders’ hydraulic fittings.

The “heel well” has two functions. First, it captures the driver’s heel, keeping his or her foot in place during high-G maneuvers. Second, it advantageously redistributes internal stresses to the bracket’s rear chassis connection bolt.

Like the brake pedal surface, the kill switch bracket is water jet-cut. Simple bent gussets strengthen the kill switch bracket and prevent it from rotating with respect to its attachment bolt.

Brass spacers keep the master cylinders rotating in-plane, while the support arms prevent nearby wiring from interfering with rotation.
Formula SAE
Throttle Pedal

This throttle pedal assembly was engineered for use on the 2012 University of Washington Formula Motorsports race car. For safety, the pedal connects to the engine throttle via two (rather than one) bicycle shifter cables. With military-grade fasteners, it weighs less than a pound.

Top Left — Two views of the 3D SolidWorks throttle pedal model. Top Right — UW Formula Motorsports racer competing at FSAE German, where it finished 14th overall. Bottom Left — The brake pedal and throttle pedal in situ. The brown pole in the middle of the photo is the steering column. Bottom Right — An ANSYS Workbench analysis of the worst case stress scenario for the first iteration of the 4130 steel throttle bracket.
Formula SAE
Throttle Pedal

Design Intent

1. This lightweight, easy-to-manufacture foot contact surface was cut with a water jet from 6061-T6 aluminum. Bent gussets add strength and help retain the driver’s foot during high-G maneuvers.

2. Weight-saving grooves stop briefly for the surface attachment screws to mount and to allow a surface to for the stop screw to contact.

3. Holes on the pedal—along with cable tensioners—allow the team to position the throttle cables for just the right amount of pedal travel.

4. The easily adjusted and locked stop screw prevents the pedal from over-rotating.

5. This V-shaped bent steel bracket keeps the cable ferrules and cables pointing precisely at the cable connection points on the pedal.

6. The aluminum heel cup keeps the driver’s foot locked in place, and along with an unseen tension spring helps the driver return the pedal to the “throttle closed” position.

7. Lightweight chassis bracket comprises two pieces of 4043 steel that are welded together.

8. Nylon bumpers stop the pedal from over-rotating past the throttle-closed position, without damaging the chassis bracket.
Fishing Vessel Evacuation Device

Our team's senior capstone project sponsor asked us to investigate if life rafts used by the fishing industry could be improved. After extensive interviews with rescue swimmers, fishing captains, survival trainers, and others, we found that what was actually needed is a device to prevent evacuees from being swept away by wind, waves, and currents as they swim from distressed vessels to their life rafts. As the team manager, I led our team through the quarter-long design process. After my “claw” design won an internal design competition, I machined a proof-of-concept device that we tested in a diving pool.

How it works: Before entering the water, evacuees insert the painter line (a rope connecting the distressed vessel to the life raft) into the claw device. During the jump, evacuees use one hand to secure the seat between their legs. A webbed safety lanyard connects the claw to the seat and limits deceleration shock. Upon surfacing, the evacuee discards the seat and uses the claw to traverse the painter line to the life raft.

Top Left — A 3D SolidWorks model of the “claw” concept. Top Right, Bottom Left — The proof-of-concept device used dynamic climbing line to connect a plywood disc seat to the claw. A commercially available cam cleat controlled the painter line. Bottom Right — A team member traverses the painter line during pool testing.
Fishing Vessel Evacuation Device

Design Intent

1. Once in the water, evacuees can use this handle to slide the device along the painter line. By doing so, evacuees can traverse the painter line more easily toward the life raft.

2. The cam cleats allow for passage along the painter line in only one direction—toward the life raft. The cleats lock up when the device attempts to move back toward the vessel, but do so without harming the painter line.

3. Elastic cords keep the lynchpin retracted in position. The corrosive marine environment makes elastic preferable to steel springs.

4. The aluminum lynchpin extends well beyond the cleat box so that evacuees in gloved immersion suits may easily grasp it. At the same time, the lynchpin penetrates only slightly past the painter line slot to cut down on the amount of lynchpin travel needed to open the slot.

5. The lynchpin opens perpendicularly to the direction of travel so that forces exerted by the painter line do not unpin it. The prongs are set low to the fore and aft of the cleat to keep the painter line moving in the plane of the cleat and to prevent an untaught painter line from bowing above the cleat.

6. This hole serves as a mounting point for the webbed safety lanyard that connects the claw to the seat.

7. Lightweight, high-strength plastic keeps the device buoyant. High-contrast orange color allows for quick detection in dark sea water.
Balsa Car Chassis

What a fun project! Could a team of engineering design students create a balsa car chassis that would protect an imaginary family from a crushing force? Most teams strove to build the strongest frame possible. Our team took a different approach: barely fulfilling the requirements through a series of clever cheats. Our quarter-pound chassis withstood 285 lbs. of force, saving our make-believe occupants and producing a class-leading 995:1 strength-to-weight ratio. Visit www.samgoldberg.com to watch a video of the frame being crushed... And yes, I know it looks nothing like a car.

Top Left — Our three-sled-blade design was meant to use as little balsa as possible. We hung the cube-like passenger cabin so as to prevent it from ever seeing crushing forces. Top Right — The agony and the ecstasy of watching success in action. Bottom Left — No matter what level of force transmitted through the sled blades, none reaches the passenger cabin. Bottom Right — The short post extending from the top of the passenger cabin and the toothpick windshield and hood beams fulfill dimensional requirements without providing any structural support.
Lying awake one night, I committed myself to designing a collapsible solar hot dog cooker. In the morning I started with some sketches. Later on I wrote a 350-line JavaScript program that spat out dimensions, angles, and solar power concentration for different geometric configurations. I gleaned insights from paper-and-tape prototypes, made lots of changes, and then ordered 22 reflectors to be laser-cut. I delighted in the work, neglecting food and sleep for hours at a time. Shortly after completing the project I enrolled in mechanical engineering courses.

Top Left — “Flower petals” of mirror-finish stainless steel reflect the sun’s rays onto a central axis. By watching the shadow produced by a short post, the cook can keep the device pointed directly at the sun. Top Right — As Seattle television viewers found out, one can make a hot dog glow white with sunlight without heating up the surrounding area. Bottom Left — Being interviewed about my invention by a television weatherman at precisely the hottest moment in recorded Seattle history. Bottom Right — A stream of bursting juices signals a well-done dog.
The process of developing interactive exhibits is similar to that of designing mechanical devices. Each begins with a client’s wild idea. Research and conversation distill a focus and a strategy. Concepts are turned into models, and prototypes are tested so that developers can work through technical and resetting issues. Finally, a device emerges that is built durable enough to withstand anything a seven-year-old might contemplate doing to it.
Wondermine’s Ken Burns and I conceived The Wellbody Academy to be an entirely new breed of exhibition. Much more than a tired ol’ demonstration of physiology, the exhibition immerses visitors in a mythical school where they can explore how their lifestyles affect their wellbeing. In addition to leading a team that developed over 30 interactive devices, I wrote every word in the fundraising book that helped raise $7 million for construction. The 6,000 sq. ft. exhibition opened in late 2012.

Top Left — The Sneeze Wall’s spray of fine mist convinces visitors to sneeze into their sleeves. Top Center — Conceptual drawing of Professor Wellbody and his academy. Top Right — With a Little Help from My Friends reveals how teamwork can reinforce wellness goals. Middle Left — Conceptual drawing of the exhibition’s physical activities. Middle Center — The Sleepability System Maximizer clues visitors in to some of the most common obstacles to a good night’s sleep. Middle Right — This fast food drive-thru window allows for role play about choosing better food options. Bottom Left — In the Cafedium, visitors can analyze a conveyor belt of different foods and build a day’s worth of healthful meals. Bottom Center — The Sleep Machine explains hour-by-hour what happens inside a sleeping body. Bottom Right — Gross! This interactive device projects an open wound onto a visitor’s forearm to simulate the area affected by poor periodontal health.
Lucy’s Legacy

In 2008, Seattle’s Pacific Science Center tasked me with augmenting a traveling exhibition featuring “Lucy”—the world-famous early hominid skeleton. A team of talented exhibit prototype artists and I created dozens of interactive devices, embedded artifact displays, and information panels for the show. I personally researched and wrote a roughly 3000 sq. ft. footprint of content about the discovery and scientific analysis of Lucy’s fossilized skeleton.

Top Left — Strata Twister simulates the tectonic forces that resulted in the exposure of hominid fossils in Ethiopia. Top Right — Brain Drains lets museum patrons compare the cranial capacities of humans, chimpanzees, and Lucy’s species by seeing how much liquid drains from two-liter soda bottles into model skulls. Bottom Left — Pattern Recognition challenges museum patrons to find hominid fossils hidden in plain sight within its faux Ethiopian landscape. Bottom Right — Hip Comparison explains what can be learned by looking closely at the different pelvic bones of chimpanzees, Lucy’s species, and humans.
Pacific Science Center partnered with MESA to produce this popular bilingual exhibition meant for Washington’s farming communities. Its 15 interactive devices help agriculture workers talk to their children about the everyday science and engineering involved in their work. I researched, developed, and wrote copy for each of the devices and helped ensure that each could collapse into a box or suitcase for easy storage. Two copies of the exhibition travel on vans to fairs, festivals, and schools throughout the state.

**Top Left** — Kids love using Pump It Up’s hand-cranked wind turbine to deliver well water to livestock. **Top Right** — Splice of Life shows how viticulturists graft grapevines onto stumps of different grape species. **Bottom Left** — Pick up this ‘manure clump’ to see which parasites are infecting your horse. **Bottom Right** — Some of Harvesting Science’s 15 interactive devices.
Washington State Science at Work

The sequel to Harvesting Science, this Spanish-English bilingual exhibition highlights some of Washington’s most important STEM fields, including aerospace, seismology, fisheries science, and hydroelectricity. I researched and helped to develop the concepts and prototypes that were later turned into the collapsible interactive devices and posters that make up this traveling show.

Top Left — Test your salmon identification skills with Which Fish. Top Right — Washington is known for its many bridges. Try your hand at piecing together two different types: a cable bridge (above) and a truss bridge (below). Bottom Left — Balancing Act teaches why wings are placed where they are on Washington’s biggest exports—airplanes. Bottom Right — Can you design an earthquake-safe building? Engineer a structure and try shaking it to the ground with Shake, Rattle & Roll.