ME 370 - Creepy Coffin - Team 12

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Section AB3, Friday 11:10 am - 12:20 pm
TA: Christopher L Johnson
Professor van der Zande
Due Date: May 3, 2018

Summary

The Creepy Coffin is a walking mechanism meant to bring enjoyment to all, but is especially designed for older kids. Kids are able to turn on the mechanism and watch a spider walk on any surface with a coffin attached to its back. The coffin opens and closes and a man can be seen floating in the coffin up and down. The movement of the walker is so lifelike that it would work great to scare other kids. The Creepy Coffin can be used as a Halloween decoration that moves, or just as a common toy that children can watch and try to understand how the mechanics work. With its clear sides, it is easy to see inside of the mechanism so kids can see all of the gears and cranks that are turning on the inside.

Figure 1: Creepy coffin traverses grass

CAD

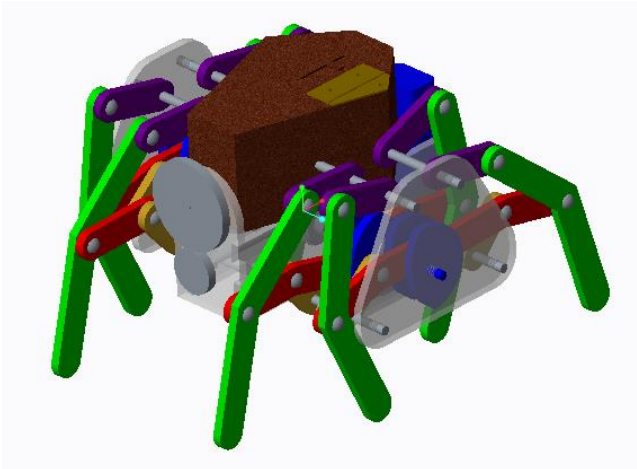

Figure 2: CAD from the design review

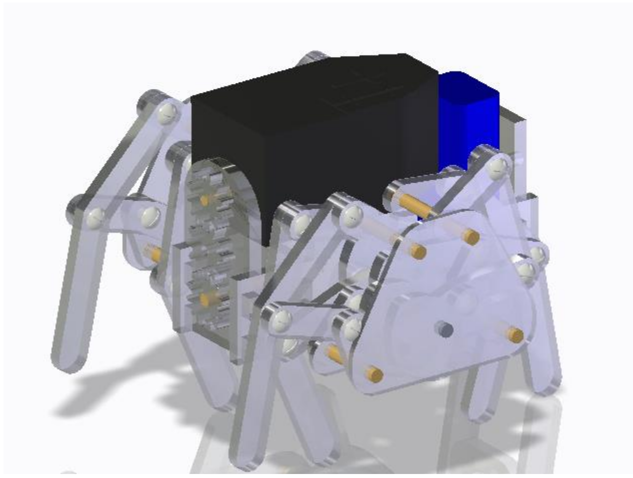

Figure 3: Final CAD Assembly

Discussion

The creepy coffin is driven by one motor; that motor actuates three separate movements: the walking, performed by 4 pairs of legs with a Klann linkage design (emulating a spider), the opening and closing of the coffin door, performed by a simple three-bar linkage, and the elevating of the platform within the coffin, performed by a cam-follower mechanism. The motor was connected to a large gear, which connected to a crankshaft that allowed adjacent legs to remain 180 degrees out of phase to allow for less tipping during walking. The motion of the automaton was connected to the motion of the walker through a gear train as well as bevel gears. Bevel gears driven by the motor transferred the rotation perpendicular to the motor axis. Then a gear train at the back of the coffin translated the rotation to a crankshaft inside the coffin. That crankshaft drove a linkage that opened the coffin door and it contained two cams that lifted the platform within the coffin.

Other than mechanical functions, our CAD design contained many structural components that allowed the walker to operate. First of all, a rectangular frame was designed to hold the coffin in place as well as provide a housing for the motor, battery, and switch. A small hole was even cut at the front of the frame for the switch to protrude through and sit at an easily accessible location. Another structural component of the CAD is the trapezoidal frame pieces on the outside edges of the walker. Those pieces, along with nylon spacers, kept the legs in one plane and prevent twisting of the legs, and subsequently, additional torques.

Reflection

Our designed compared well to the average of all of the groups robots, however we were not able to complete the course in time. Our robot went about 2/3s of the way to the finish line and seemed like it would be able to finish in time, however the motor wire snagged in our front leg, and the added tension caused our D-shafts in our crank to come loose. This problem could have been avoided by using more ties to keep the wire from moving around, however this was the first time this problem came about, and so were were unable to make the necessary precautions to prevent this from happening. Another problem was that our robot tended to turn to the left rather than walk completely straight. This could be attributed to a non-level surface as well as a non-even torque distribution between the legs. Other than that, our robot performed well and handled our biggest worry, the gap between the concrete and the grass, extremely well. This was an issue for us in early testing because our robot was noticeably front heavy, and having it switch between walking on grass

Budget

Part Name	Description	Quantity	Source	Unit Cost	Shipping Cost	Total Cost
Kit (Included)						
Motor	DC motor	1	Kit	$0.00	$0	$0.00
Battery		1				
Wires		1				
Switch		1				
Gear	red, plastic; unused in walker	1				
Walker						
Acrylic Sheet 1	12"X24"X1/4"	1	Innovation	$20.00	$0	$20.00
Acrylic Sheet 2	12"X24"X1/8"	1	Innovation	$20.00	$0	$20.00
Leg Linkages*	1/4" Acrylic	32	Innovation	$0.00	$0	$0.00
Frames**	1/8" Acrylic	4	Innovation	$0.00	$0	$0.00
Cranks*	1/4" Acrylic	7	Innovation	$0.00	$0	$0.00
Gear Train*	1/4" Acrylic	2	Innovation	$0.00	$0	$0.00
Pins	1/4" bolts	24	Innovation	$0.00	$0	$0.00
Leg Shafts	1/4" wood dowel	4	Innovation	$0.50	$0	$2.00
Crank Shaft	1/4" steel dowel	1	Innovation	$15.00	$0	$15.00
Spacers	1/4" nylon (package of 20)	1	McMaster-Carr	$10.71	$0	$10.71
Set Screws	1/16"	16	Innovation	$0.00	$0	$0.00
Washers	1/4" ID	10	Innovation	$1.00	$0	$10.00
Automaton						
Coffin Exterior	ABS	100	Ford Lab	$0.03	$0	$3.00
Coffin Door	ABS	20	Ford Lab	$0.03	$0	$0.60
Coffin Platform	ABS	20	Ford Lab	$0.03	$0	$0.60
Coffin Linkages**	1/8" Acrylic	3	Innovation	$0.00	$0	$0.00
Bevel Gears	Nylon	2	McMaster-Carr	$5.40	$0	$10.80
Cams*	1/4" Acrylic	2	Innovation	$0.00	$0	$0.00
Shaft	1/4" wood dowel	1	Innovation	$0.50	$0	$0.50
Figurine	Batman LEGO figurine	1	Owned	$0.00	$0	$0.00
Gears*	1/4" Acrylic	3	Innovation	$0.00	$0	$0.00
Hinge	Black tape	1	Owned	$0.00	$0	$0.00
Frame*	1/4" Acrylic	4	Innovation	$0.00	$0	$0.00
Ziptie	Fastens battery	1	Owned	$0.00	$0	$0.00
Paint/accessories	Eyes, fangs, paint	1	Craft Store	$6.47	$0	$6.47
*this material was used with the acrylic sheet in line 6 **this material was used with the acrylic sheet in line 7					**Total Cost**	$99.68

Figure 4: Final Bill of Materials

PVA/DFA Analysis

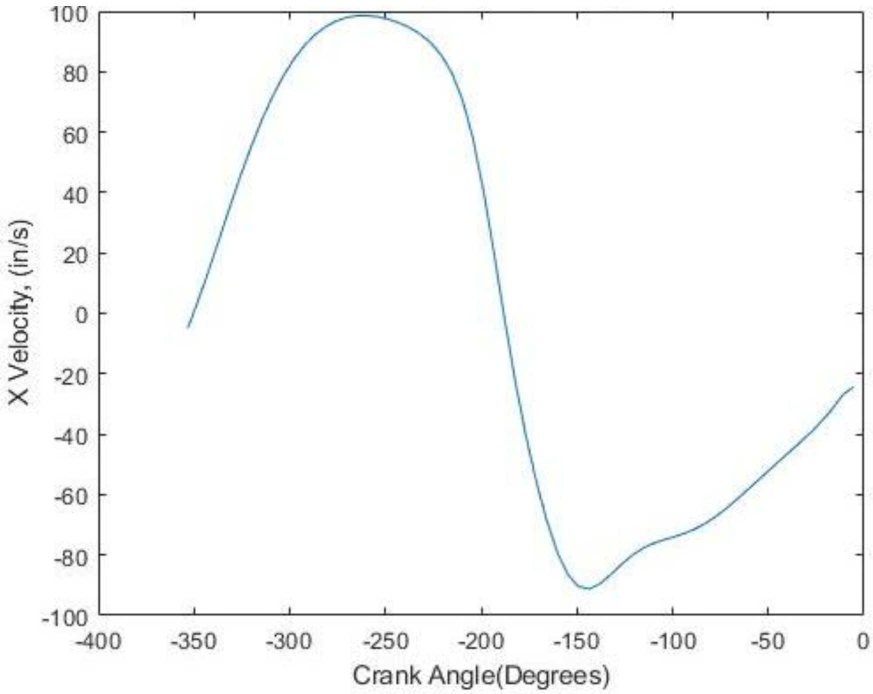

Figure 5: X Velocity vs. Crank Angle Analysis

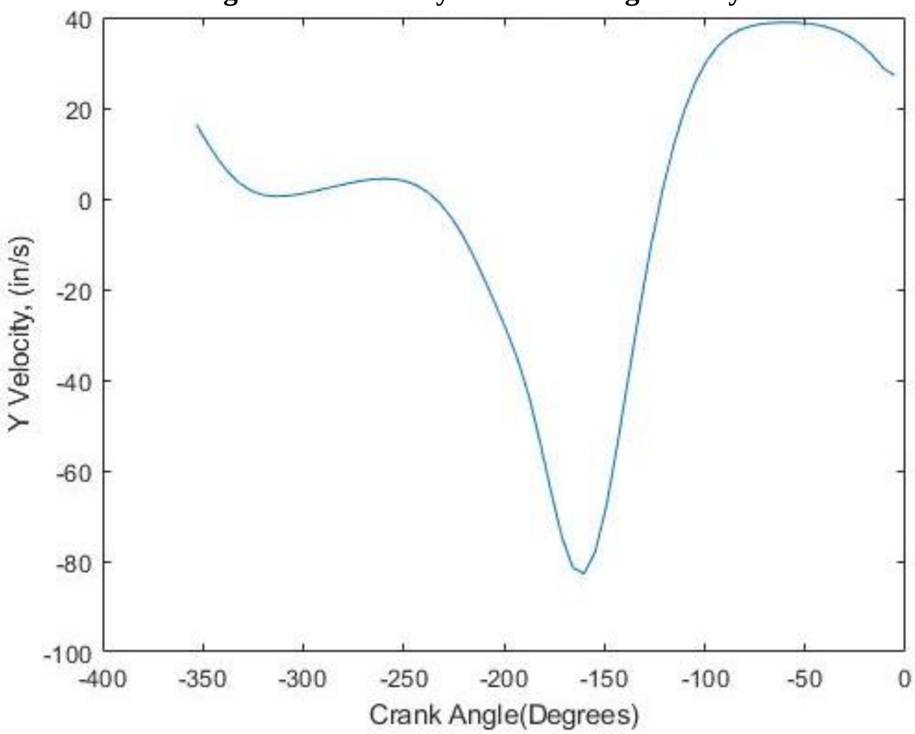

Figure 6: Y Velocity vs. Crank Angle Analysis

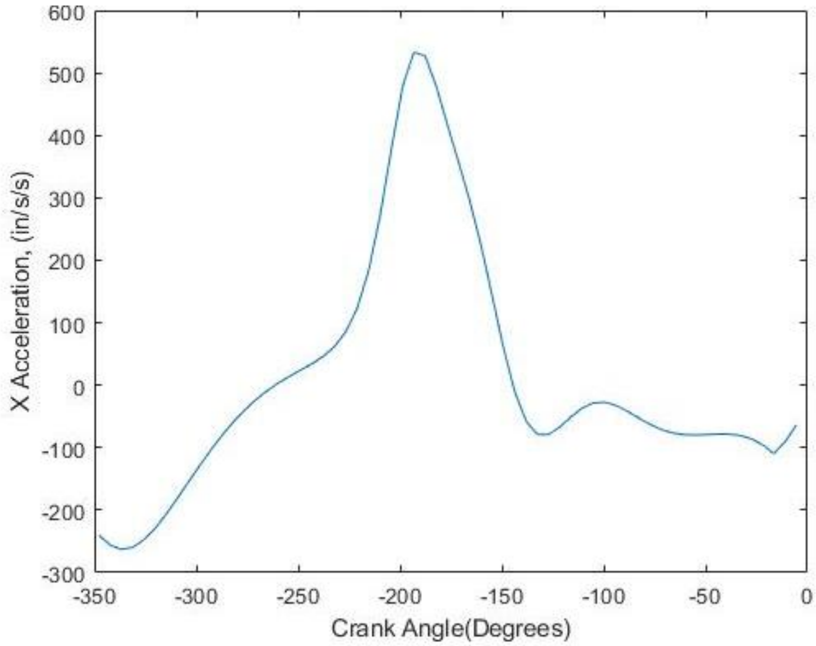

Figure 7: X Acceleration vs. Crank Angle Analysis

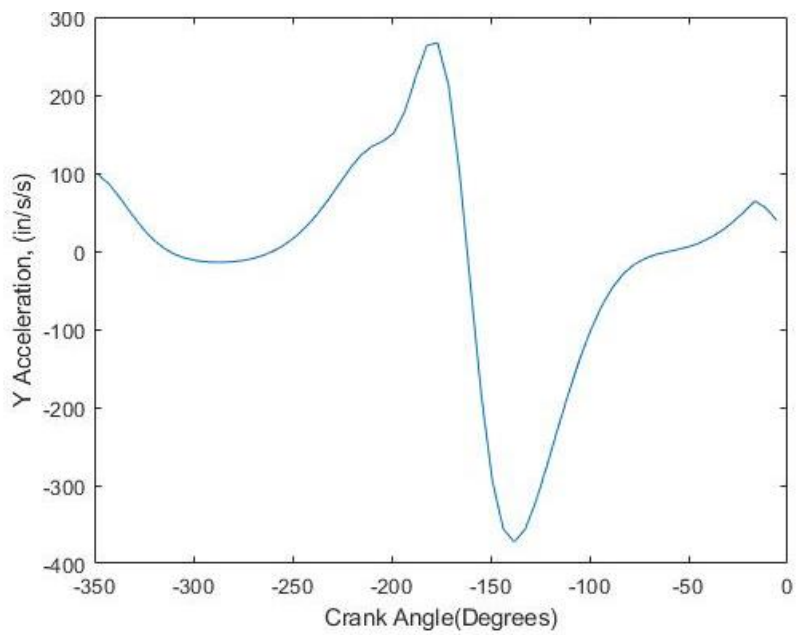

Figure 8: Y Acceleration vs. Crank Angle Analysis

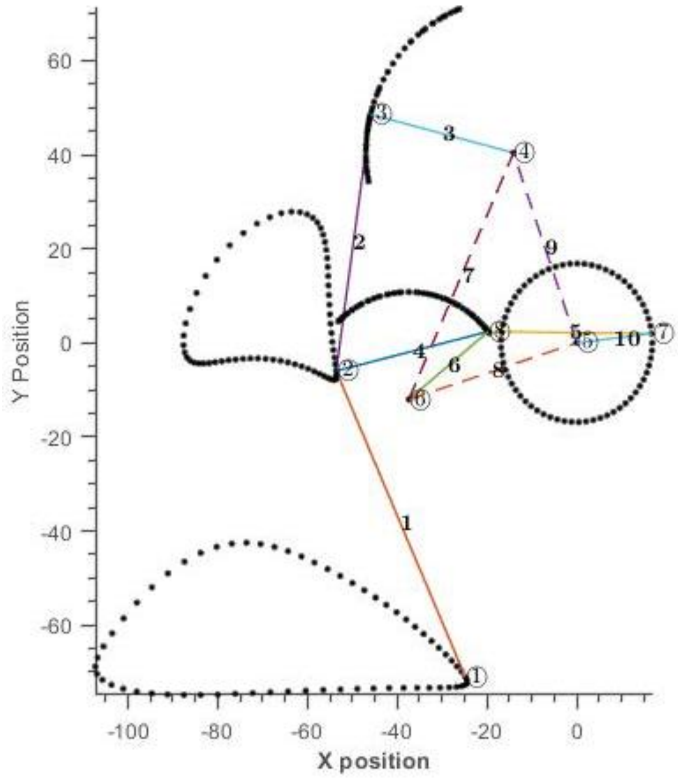

Figure 9: Linkage Motion

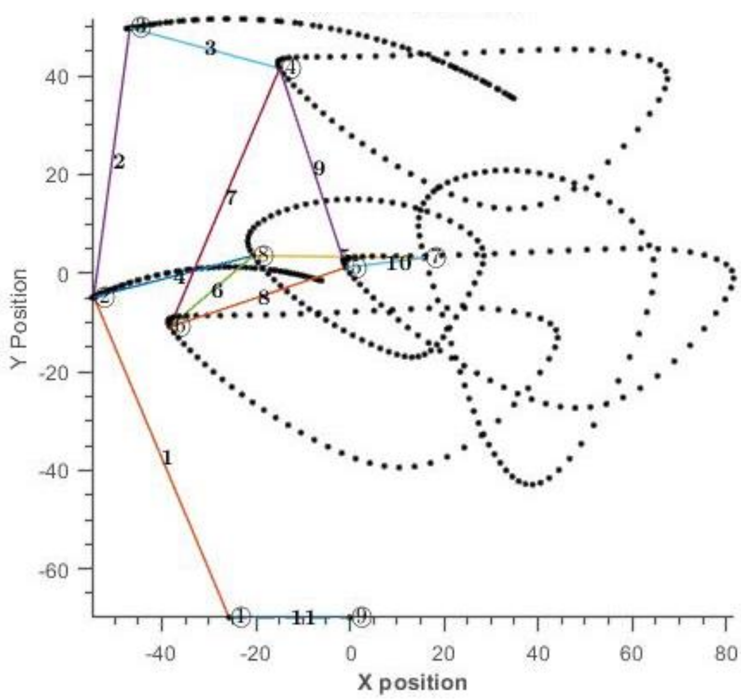

Figure 10: Linkage Motion of the Fixed Foot System

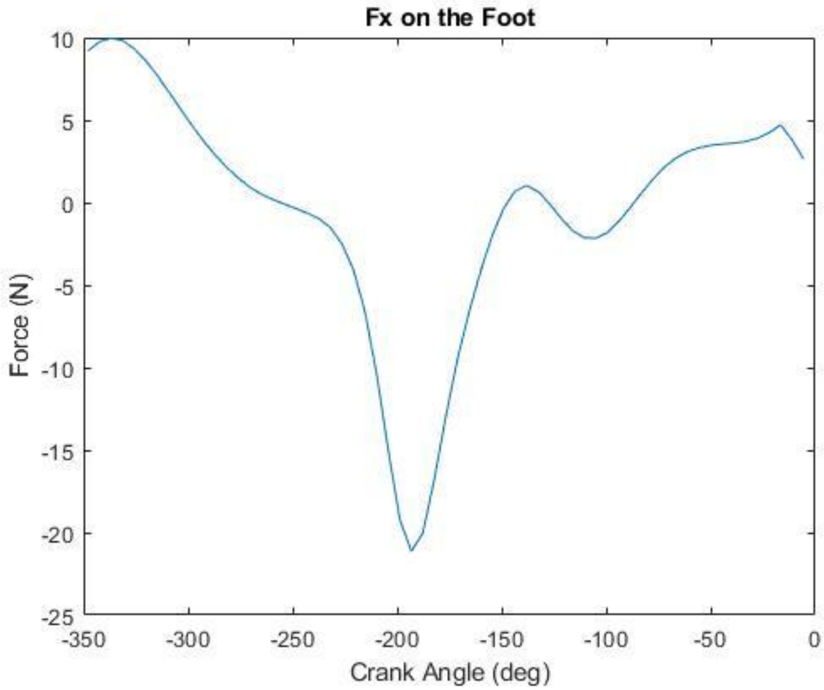

Figure 11: Forces in X Direction on Foot Analysis

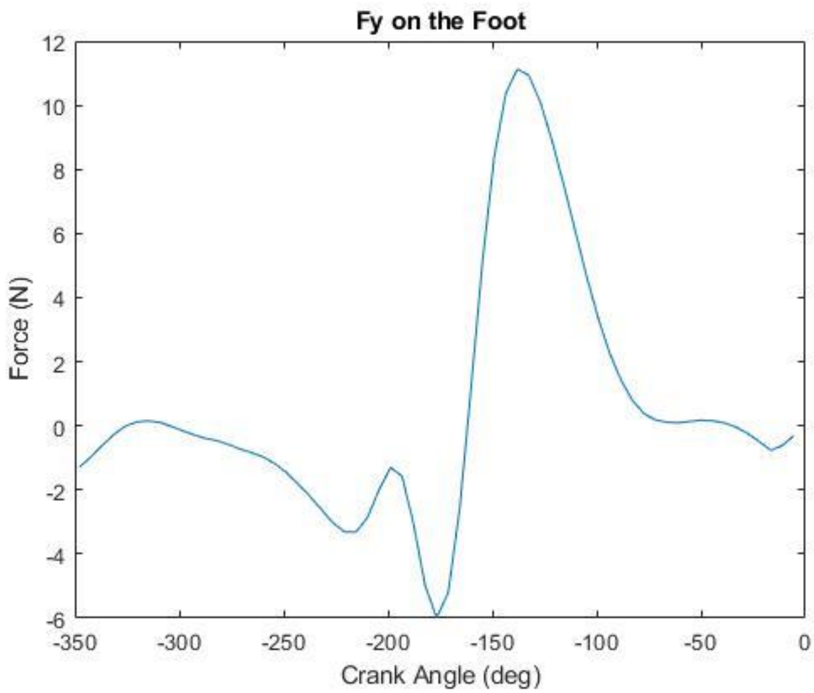

Figure 12. Forces in Y Direction on Foot Analysis

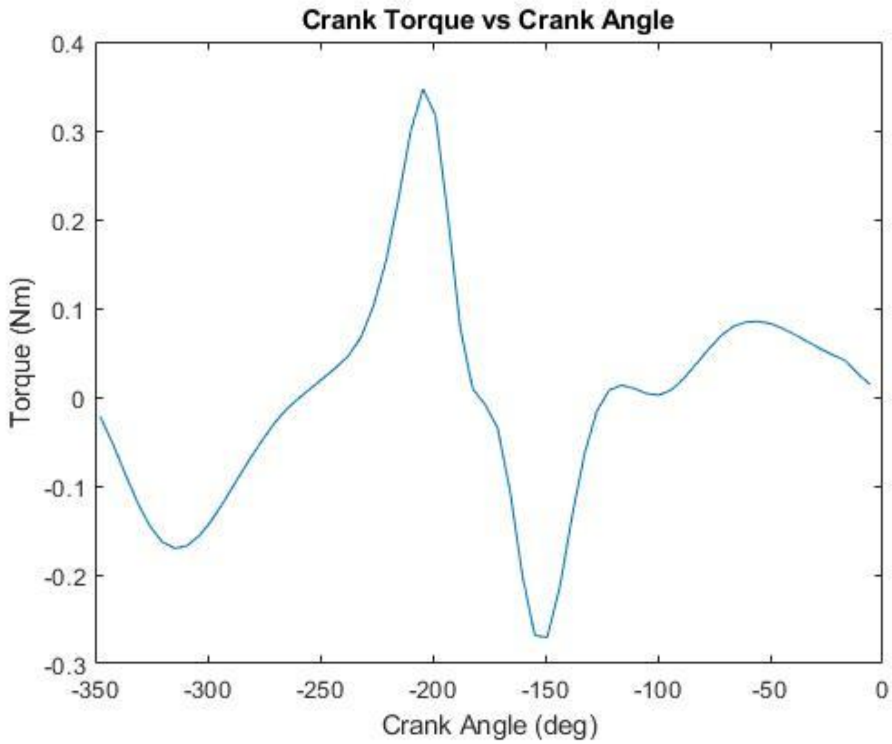

Figure 12: Crank Torque vs. Crank Angle Analysis

PVA/DFA Discussion

Using the velocity estimate from the Design Review, the DFA was re-run with the adjusted angular velocity of the crank and the PVA with a different grounded link. The above PVA analysis diagram initially demonstrates the motion of our Klann linkage mechanism showing the effective stride of the leg to be long with enough Y displacement to traverse uneven ground and obstacles. The second of the two PVA analyses was taken with respect to the point of contact the leg makes with the ground. By taking the PVA analysis of the leg with respect to this point as the ground allows for a more accurate DFA analysis highlighting the X and Y forces of the ground reaction forces acting on the leg. This not only allows for a more accurate demonstration of the effects of the weight of the mechanism on the legs individually, but also on the motion of the walker itself while walking. Specifically, we added the weight of the mechanism as a constant weight to one of the original ground links that represent our walker's body to show this. The addition of this weight is considering that the walking mechanism is in its worst case scenario of all of the walker's weight on one leg. Diving into our PVA analysis we can see that with our design that the walker itself has a greater fluctuation in the Y direction displacement meaning that with each stride the walker will have a tendency to raise and lower. This is expected and therefore by having eight legs, this motion should be reduced. Taking this into consideration when analyzing the ground reaction forces, we see that in the Y direction there is a small dip followed by a steep spike in the plot accounting for the foot striking the ground. This steep spike shows a slightly greater force acting on the leg than the effective weight of the walker which is normal since during the "heel strike" stage of the gait there should be recorded a 5-7% increase in ground reaction force compared walker weight due to the effects of the joint movement with the impulse between the foot and ground. This is a rule of thumb through biomechanics of gait cycle analysis. Additionally, analysis of the crank torque and angle show a correlation between the foot strike of the walker and the spike-dip of the crank torque. The torque dips after the foot strikes the ground which quantitatively verifies our analysis of the leg's ground reaction force analysis.