WALKER TEAM

LINKAGE VEHICLE

THE WALKER



TEAM MEMBERS

Eric Schlange - Frame and Drive Design Seth Bohlken - Leg Design Landon Stephens - Arm Design Gage Fox - Arm Design Avery Coronado - Claw Design Thomas Prater - Electrical Programming

OBJECTIVE

• Create a walking linkage vehicle

• Build mechanical arm to grab objects

Successfully walk and move objects

OVERALL SPECIFICATIONS

Requirement	Nominal	Tolerance
Overall Weight	50 lb	max
Overall Size	2'W x 3'L x 2'H	max
Max Added Weight	15 lb	min

OVERALL DIMENSIONS





FRAME OF VEHICLE

- Made primarily out of Delrin
- Provides mounting locations for motors and other controls
- Location for arm to be mounted



SIDE PLATE ANALYSIS



TOP PLATE ANALYSIS





POWER TRANSMISSION TO THE LEGS



WALKING MECHANISM

Requirement	Nominal	Tolerance
Step Up	7 in	min
Max Incline	30 deg	min
Turn	360 deg	min
Multi-Terrain	Present	N/A
Walk Speed	3 mph	min

 $\frac{45 \text{ rot}}{\min} * \frac{2 \text{ ft}}{5280 \text{ ft}} * \frac{60 \text{ min}}{\ln} = 1.02 \text{ mph}$



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WALK TEST 1







WALK TEST 2





Driver Torque



LEG TORQUE

Motor Specifications:

- 12 V
- Rated Torque: 6 Nm = 53 in*lb
- Stall Torque: 29 Nm = 256 in*lb
- Low RPM: 50 rpm max
- Weight: 3.3 lb



https://www.ebay.com/itm/DC-12V-Electri-Right-Angle-Reversible-Gear-Motor-45Rpm-45W-High-Torque-176Lbs-/172470709765?hash=item28280e2e05:g:bfUAAOSwo4pYa1V-





FULL LENGTH PINS







TENSIONER 1,2,3

- Two connected to the same rotational axis fight against each other
- The single rod allows spool mounts to rotate



FINAL TENSIONER







ONBOARD MECHANICAL ARM



ARM REACH

Requirement	Nominal	Tolerance
Max Radial Reach	24 in	min
Max Vertical Reach	36 in	min
Max Arm Pivot	90 degrees	min



MOTOR CLAMP





MOTOR MOUNT





MECHANICAL ARM





REMOVABLE ARM





TURNTABLE BEARING

- Allows arm to rotate about the body
- Powered by Vex servo motor
- Total: \$34.98
- Material: Acetal Copolymer
- Yield Strength: 9,800 psi





TURNTABLE BEARING ANALYSIS







CENTER OF MASS - TIPPING









END EFFECTOR

Requirement	Nominal	Tolerance
Max Object Weight	1 lb	Min
Max Object Width	4 in	Min
Anti-Crush Grabbing	Present	N/A









END EFFECTOR MOTOR

• 17.35 in*lb Servo Motor

• Size: 1.6"x1.6"x.8"

• Amazon: \$18



https://www.amazon.com/LewanSoul-LD-20MG-Standard-Digital-Aluminium/dp/B073F92G2S

LINEAR ACTUATOR



https://www.servocity.com/100-mm-stroke-17-lb-thrustlight-duty-linear-servo • Provides leveling motion for end effector

• DC 6V

• \$69.99

POWER SOURCE

Requirement	Nominal	Tolerance
Battery Powered	Present	N/A
Battery Time	15 min	min

Battery Specifications: 13 V 9 Ah 4.25"L x 2.25"W x 3.75"H 1.9 lbs



https://shop.antigravitybatteries.com/products/starter-batteries/small-case/ag-801.

CONTROLS

Requirement	Nominal	Tolerance
Remote Distance	100 ft	min
Camera	Present	N/A
Camera Distance	100 ft	min

RC Remote Specifications:

10 Channels 2.4 GHz



https://www.amazon.com/Flysky-Upgrade-Transmitter-Receiver-Crazepony/dp/B01NABG5TY/ref=sr_1_2?ie=UTF8&qid=1508 871195&sr=8-2&keywords=8+channel+rc+controller

PROCESSOR

- Arduino Mega 2560
- Capable of analog & digital input
- Capable of digital and PWM output
- Can source 3.3v or 5v power



https://www.arduino.cc/en/Main/arduinoBoardMega2560/



PROGRAMMING THE DRIVING MOTORS

- Receiver sends voltage to Arduino based on the left joystick's position
- Arduino compares these two values to each other and default to decide between forwards, backwards, rotational, or no motion.





CONSTRUCTION SCHEDULE



BUDGET

Spending to Date: \$1,242.87 Income to Date: \$1,100.00 Grant - \$500.00 Pitt Power Page - \$600.00 Out of Pocket Expenses: Hardware Receiver Wire Wood

Category	Amount
Motors	220.95
Electronics	219.87
Main Assembly: Frame, Legs, Arm, Claw, Hardware	677.71
Accessories	78.16
Shipping	46.18
Total	1242.87





Requirement	Nominal	Tolerance	Rationale	Weight	Testing	Description
Overall						
Overall Weight	50 lb	max	So that one person can lift somewhat easily, as compared to the average 50lb bag, UPS is 70 lb limit (http://www.snagajob.com/ups-employmen t/)	10	Weigh entire assembly on a scale	Walker and arm
Overall Size	2'W x 3'L x 2'H	max	Can fit in the back seat of the average car - measured Jeep Patriot SUV (48"L x 28"W) and Mazda 6 Sedan (56"L x 36"W)	10	Measured in its most retracted state, with arm	Retracted: the arm is folded in and the legs are not stepping out
Max Added Weight	15 lb	min	30% of overall weight	5	Will walk with added weight on top, without arm	Walking on a flat, smooth surface
Legs						
Walking Ability	Present	N/A	So it does not have to roll like most vehicles	10	Will walk by a linkage mechanism	Multiple legs
Max Incline	30 degrees	min	Equivalent to NASA Rover requirement	10	Will climb a wooden incline surface	When carrying an object within specification
Turn	360 degrees	min	So that it can walk in any direction from one point	10	Will make a complete 360 degree turn	Will turn similar to "zero turn"
Step Up	7 in	min	Measured curb height north side of College of Technology (curb height varies)	7	Will walk onto a 7" wooden platform or a curb on the course	When carrying an object within specification
Top Walk Speed	3 mph	min	Average human walk speed (http://www.usroads.com/journals/p/rej/971 0/re971001.htm)	5	Walking next to it on course and testing it on treadmill	When unloaded
Multi-Terrain	Present	N/A	So that it does not have to stay on one surface	5	Will walk across tile, asphalt, grass, and obstacles that are within the above parameters	

Arm						
Grabbing Arm	Present	N/A	So this vehicle can also pick up an object and move it, not just walk	8	Will pick up an object and carry it while walking	
Removable Arm	Present	N/A	For easy storage and maintenance	10	Will remove and reattach arm	Can be removed in less than 3 minutes
Max Horizontal Reach	24 in	min	Will reach past the legs	7	Will pick up an object from that distance or further	Radius from arm attachment
Max Vertical Reach	36 in	min	1 ft above height	7	Will pick up an object from that height or higher	Measured from ground
Arm Pivot	90 degrees	min	So that wires will not get damaged	5	Will rotate to pick up an object off-centered from robot	
Object Weight	1 lb	min	Weighs more than a 12 oz soda can	5	Arm will lift object and move it	
Object Width	4 in	min	Slightly larger than the average 12 oz soda can	7	Will grab objects within specified range to be picked up	Center of mass within 3" of the grabber in the y- axis
Anti-Crush Grabbing	Present	N/A	So it won't crush the object being grabbed	3	Will pick up a soda can and not crush it	

Control						
Battery Powered	Present	N/A	So it does not have to be limited by a tethered connection	10	Will walk untethered using portable batteries as power source	
Battery Time	15 min	min	A 56V battery runs on an electric mower for 30-45 min, so a 24V battery would be around 12-19 min (http://www.toptenreviews.com/home/outdoor/best-electric-lawn-mowers/) RC airplanes last around 25 min with low torque, high rpm. Ours is high torque low rpm (https://www.rcgroups.com/forums/showthread.php?1154008-how-long- should-a-battery-last-per-flight)	5	Will walk the unloaded robot for that amount of time on a single charge	Will have at least one extra charged battery
Remote Controlled	Present	N/A	So it is not tethered and operator does not have to walk with it	10	Will be wirelessly controlled by a remote	
Remote Distance	100 ft	min	To stay within camera range	5	Will control robot from that distance	Without any signal obstructions between the controller and robot
Camera	Present	N/A	So it can be controlled when you can't physically see it	3	Will view through camera and control robot out of sight	
Camera Distance	100 ft	min	Within the same wi-fi and bluetooth signal of the camera, not of a modem	2	Will use camera from that distance	Without any signal obstructions between the camera and robot
Accessories						
Obstacle Course	Present	N/A	A course to demonstrate the abilities	10	Will run the course	Incline, step up, 360 degree turn, arm picking up object and transporting it
Stand	Present	N/A	So walking can be displayed without operator following it	10	Will put on the stand and display walking	
Operating Instructions	Present	N/A	Instructions so that others can operate robot	10	Will have instructions available	

Walker Budget								
Part	Quantity	Ur	nit Price	То	tal Price	Supplier		
Flysky FS-i6X 2.4GHx 10 Channel Radio	1	\$	59.60	\$	59.60	Amazon		
oul LD-27MG Full Metal Gear Standard Digital Servo with 20kg High	1	\$	17.99	\$	17.99	Amazon		
Arduino	1	\$	14.99	\$	14.99	Amazon		
Test Course building supplies	1	\$	78.16	\$	78.16	Local Lumber Yard		
Retaining Clips (per 100)	2	\$	16.16	\$	32.32	Fastenal		
Radial Ball Bearing .5" ID .1.125" OD 60355K601	8	\$	6.82	\$	54.56	McMaster Carr		
91259A172_ALLOY STEEL SHOULDER SCREW	4	\$	2.44	\$	9.76	McMaster Carr		
91259A533_ALLOY STEEL SHOULDER SCREW	4	\$	1.08	\$	4.32	McMaster Carr		
M4 X 0.7 91294A190 Fastener 100pk	1	\$	4.82	\$	4.82	McMaster Carr		
.25 Dowel Pin 97395A475 10pk	2	\$	10.21	\$	20.42	McMaster Carr		
M6 X 1mm 91263A839 Fastener 20mm 50pk	1	\$	6.67	\$	6.67	McMaster Carr		
M6 X 1mm 91263A469 Fastener 70mm 10pk	1	\$	5.20	\$	5.20	McMaster Carr		
Radial Ball Bearing .375" ID .875" OD	2	\$	1.83	\$	3.66	ebay		
Di 3/8" 0.031 Nylon Washers (Pack of 5)	10	\$	0.65	\$	6.50	Fastenal		
.5" Diameter Steel Rod 3ft	1	\$	8.79	\$	8.79	Rice Precision Manufaturing		
.375 Diameter Steel Rod 6ft	1	\$	8.70	\$	8.70	Rice Precision Manufaturing		
3/8" Wide XL Synchronous Drive Gearbelt 14"	4	\$	5.81	\$	23.24	ebay		
Gearbelt XL pulley 14	4	\$	12.30	\$	49.20	ebay		
Gearbelt XL pulley 32	4	\$	23.84	\$	95.36	ebay		
Linear Actuator for End Effector	1	\$	69.99	\$	69.99	servocity		
TS-30GZ6287L-LS 12V 50 RPM DC Gear Motor	2	\$	58.99	\$	117.98	ebay		
28"x28"x3/8" Aluminum 6061-T6	1	\$	81.00	\$	81.00	Rice Precision Manufaturing		
1"x1"x3' Aluminum Tubing 6061-T6	1	\$	8.26	\$	8.26	Rice Precision Manufaturing		
2"x1"x12" Aluminum Bar 6061-T6	1	\$	13.21	\$	13.21	Rice Precision Manufaturing		

Delrin Sheet 0.250" X 2' X 4'	1	\$ 90.00	\$ 90.00	eplastics.com
Delrin Sheet 0.375" X 2' X 4'	1	\$ 90.00	\$ 90.00	eplastics.com
Claw Gears	2	\$ 3.36	\$ 6.72	servocity.com
Claw Pinion	1	\$ 15.00	\$ 15.00	servocity.com
Turntable Bearing	1	\$ 20.00	\$ 20.00	vexrobotics.com
Metal 12 Tooth Turntable Pinion	1	\$ 20.00	\$ 20.00	vexrobotics.com
Turntable Motor	1	\$ 14.99	\$ 14.99	vexrobotics.com
Breadboard	1	\$ 4.50	\$ 4.50	<u>Digikey</u>
10kOhm Potentiometer	4	\$ 0.60	\$ 2.40	Digikey
Breadboarding Wire Bundle	1	\$ 4.95	\$ 4.95	Digikey
500 Ohm Resistor	10	\$ 0.49	\$ 4.90	Digikey
Red LEDs	10	\$ 0.43	\$ 4.26	Digikey
Force Sensor	1	\$ 7.84	\$ 7.84	Digikey
10k Ohm Resistor	1	\$ 0.10	\$ 0.10	Digikey
Box of Paper Clips	1	\$ 0.67	\$ 0.67	Walmart
Motor Driver	2	\$ 21.59	\$ 43.18	RobotShop
Serial Camera	1	\$ 45.00	\$ 45.00	RobotShop
Bluetooth Adapter	1	\$ 10.00	\$ 10.00	RobotShop
F/F or F/M DuPont-style Jumper Cables	1	\$ 7.49	\$ 7.49	Amazon
Voltage Regulator (Six Pack)	1	\$ 9.99	\$ 9.99	Amazon
Shipping Expenses	1	\$ 46.18	\$ 46.18	Total Shipping
Total	-	-	\$ 1,242.87	-

CONSTRUCTION SCHEDULE

Task N; e	Duratior	Start	Finish	er 2017 January 2018 Febr	uary 2018 March 2018
· · · · · · · · · · · · · · · · · · ·		▼ T		7 10 13 16 19 22 25 28 31 3 6 9 12 15 18 21 24 27 30 2	2 5 8 11 14 17 20 23 26 1 4 7 10 13 16 19
4 Frame & Leg	36 days	Mon 12/4/1	7 Mon 1/22/1		
Order Material	3 days	Mon 12/4/17	7 Fri 12/8/17 !	l	
Water Jet	1 day	Mon 12/11/2	1 Mon 12/11/	🔍 🔍	
Ream Holes	1 day	Tue 12/12/1	7 Tue 12/12/1		
Create Pins for legs	1 day	Mon 12/11/2	1 Mon 12/11/	i i i i i i i i i i i i i i i i i i i	
Check Location of	1 day	Mon 1/22/18	8 Mon 1/22/1		
reamed holes on					
frame base and top					
Arm Construction	15 days	Mon 1/22/1	8 Fri 2/9/18 5:		
Order Material	1 day	Mon 1/22/18	8 Mon 1/22/1	n de la companya de l	
Cut Tubular Members	3 days	Tue 1/23/18	Thu 1/25/18		
Motor Clamps	2 days	Tue 1/23/18	Wed 1/24/1		
Assembly	10 days	Mon 1/29/18	8 Fri 2/9/18 5:		
Claw Construction	2 days	Fri 2/2/18 8:	(Mon 2/5/18	Г	
Order Material	1 day	Fri 2/2/18 8:	(Fri 2/2/18 5:		
Water Jet	1 day	Mon 2/5/18	Mon 2/5/18		
Programming	15 days	Wed 1/31/1	8 Tue 2/20/18		
Order Electronic	1 day	Wed 1/31/18	8 Wed 1/31/1	🕂 🖬 🛛	
Components					
Write Program to	10 days	Wed 1/31/18	8 Tue 2/13/18		
communicate with					
Debug	6 days	Tue 2/13/18	Tue 2/20/18		
Testing	15 days	Tue 2/20/18	Mon 3/12/1		
Accessories	10 days	Tue 2/20/18	Mon 3/5/18		
Obstacle Course	5 days	Tue 2/20/18	Mon 2/26/1		
Display Stand	5 days	Tue 2/20/18	Mon 2/26/1		
Manual	6 days	Mon 2/26/18	8 Mon 3/5/18		
Complete Project	0 days	Fri 3/16/18 8	8 Fri 3/16/18		♦ 3/16
4					



X100.SLDASM			Optio	ns
Override Mass Propertie	·s] [Recalculate]	
Include hidden bodies/co	mponents			
Create Center of Mass feat	ture			
Show weld bead mass				
 Report coordinate values rela	tive to: de	fault		•
Mass properties of X100 Configuration: Default Coordinate system: defa	ult			Â
Mass = 43.99 pounds				
Volume = 485.01 cubic inche	s			
Surface area = 3695.76 squar	e inches			
Center of mass: (inches) X = 9.15 Y = 4.11 Z = -9.18				
Principal axes of inertia and p	orincipal mor	ents of inertia:	(pounds * squ	
Taken at the center of mass.	Dr - 2056 1			H
$I_X = (1.00, 0.08, 0.06)$ Iy = (1.00, 0.08, 0.06)	Py = 3220.1	3		
Iz = (-0.09, 0.95, 0.30)	Pz = 3792.3	1		
Moments of inertia: (pounds	* square incl	hes)	oordinate syste	
Lxx = 3223.57	Lxy = 61.50	in the output	Lxz = -21.96	
Lyx = 61.50 Lzx = -21.96	Lyy = 3630. Lzy = -496.	62 34	Lyz = -496.84 Lzz = 2214.39	
Moments of inertia: (pounds	* square inc	hes)		
Ixx = 7673.18	Ixy = 1714.0	01	Ixz = -3717.58	
lyx = 1714.01	Iyy = 11021	.92	lyz = -2154.97	
Izx = -3717.58	Izy = -2154	.97	Izz = 6638.94	
One or more components ha	ve overridder	mass propertie	s:	Ŧ
4 In Linear Actuator Assen				

