KENT DENVER SCHOOL

ROBOTICS CLUB

TEAM MEMBERS

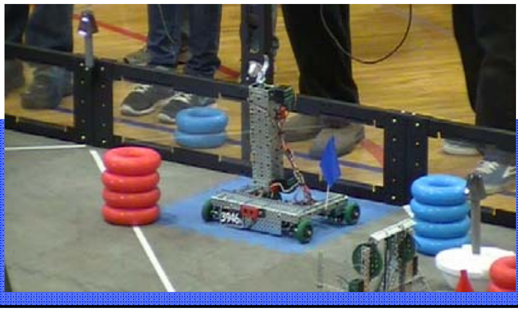
SUMMARY

- Team History
- Design Process
- Subsystems
  - Logic
  - Drivetrain
  - Object Manipulation
- Budget considerations
- Impact on the Community

VEX ROBOTICS COMPETITION

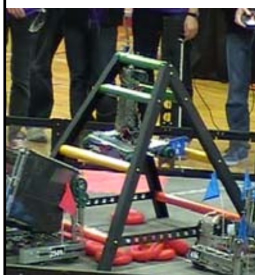
THE CLUB

- Goals
- Improve member's ability to use STEM
- Develop familiarity with the engineering process
- Use VRC to judge our progress, and give us direction through the year
- "Learn about science, technology, engineering, and mathematics through fun, innovative, and fulfilling team-oriented projects in robotics."



HISTORY: 2010-2011

- Started in 2010-2011 school year
- Competed in two tournament in 2010-2011
  - Berthoud
    - Placed last in qualification rounds
      - Inexperience/Structural Problems
    - Fine-tuned
      - Only low hang at the competition



2010 2011 2012

HISTORY: 2010-2011

- Elkhorn: 1 month later
  - Qualifications: Placed 16th out of 30 teams
  - Robot performed consistently well
    - High hang/autonomous score every round
    - Semifinalists
  - Judges impressed by knowledge of VEX parts

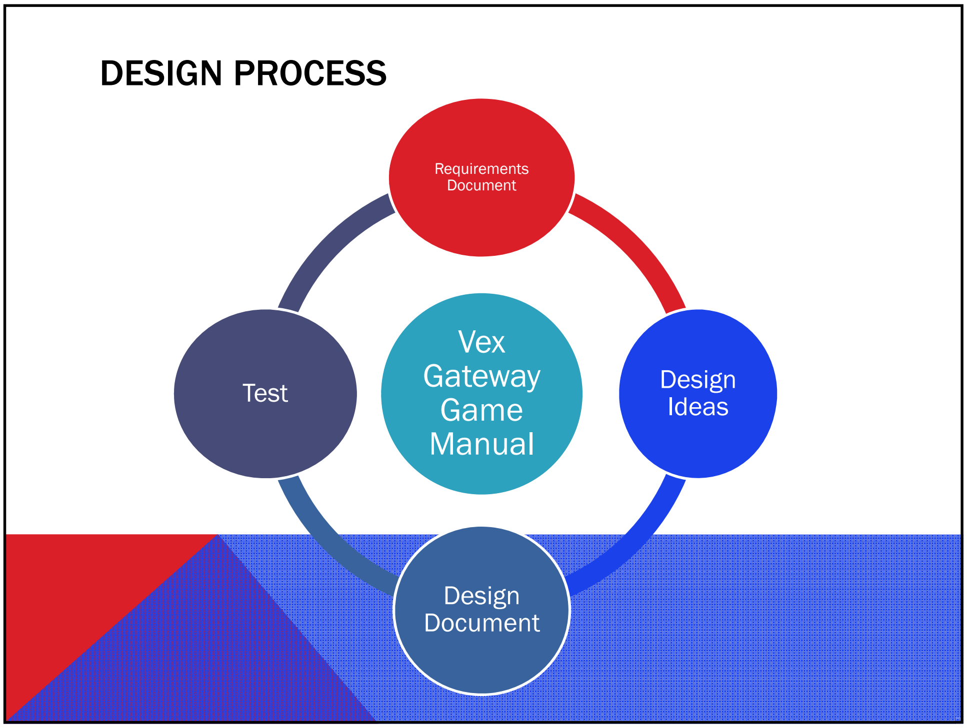
2010 2011 2012

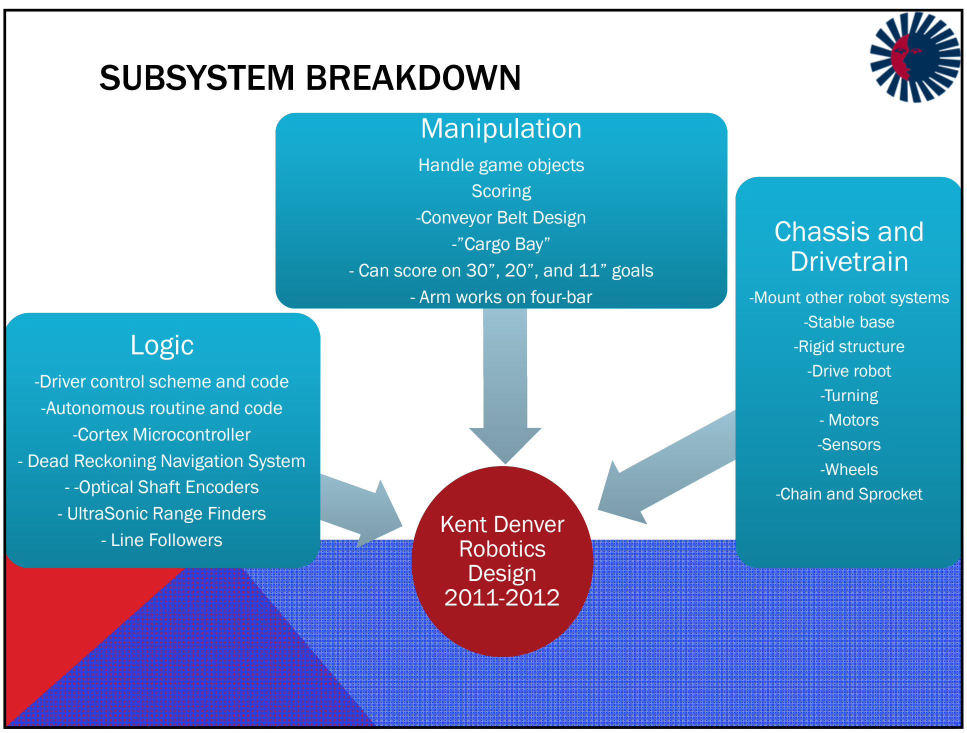
TEAM GOALS THIS YEAR

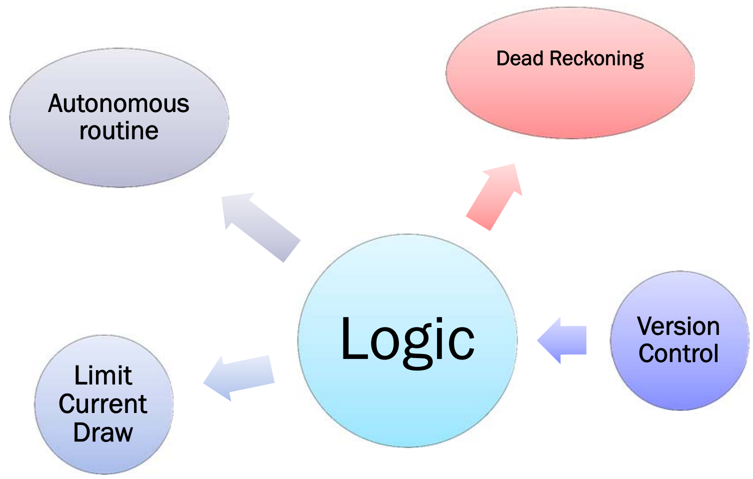
- Qualify for nationals ✓
- Qualify for worlds
- Be a picking team at a tournament ✓

ROBOT GOALS THIS YEAR

- Balance drivetrain between torque and speed
- Efficiently score objects
- Current-draw and battery consumption
- Programming and autonomous skills
- Turning on center/fixing center of gravity

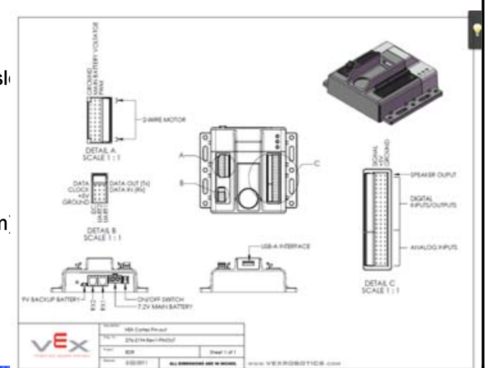

DESIGN PROCESS
Requirements Document
Design Ideas
Design Document
Test
Vex Gateway Game Manual


SUBSYSTEM BREAKDOWN
Manipulation
Handle game objects
Scoring
-Conveyor Belt Design
-"Cargo Bay"
- Can score on 30", 20", and 11" goals
- Arm works on four-bar
Chassis and Drivetrain
-Mount other robot systems
-Stable base
-Rigid structure
-Drive robot
-Turning
- Motors
-Sensors
-Wheels
-Chain and Sprocket
Logic
-Driver control scheme and code
-Autonomous routine and code
-Cortex Microcontroller
- Dead Reckoning Navigation System
- -Optical Shaft Encoders
- UltraSonic Range Finders
- Line Followers
Kent Denver Robotics Design 2011-2012



MANAGING CURRENT DRAW

- Thermal limiting in 393 motors
- Current limit for ports 1-5 and 6-10
- Code control
- not jumping from -127 to 127 (sl
- drivetrain <= |120|
- Driver control
- practice!
- Weight management (aluminum in arm)



CURRENT DRAW

V=IR P=IV

393 – 3.6 Amp +/- 20% stalling current

3-wire motors -1.8 Amp +/- 20% stalling current

7.2 volts +/- 20%

Power adaptor – one over current protection device

- 4 3-wire motors to lift arm

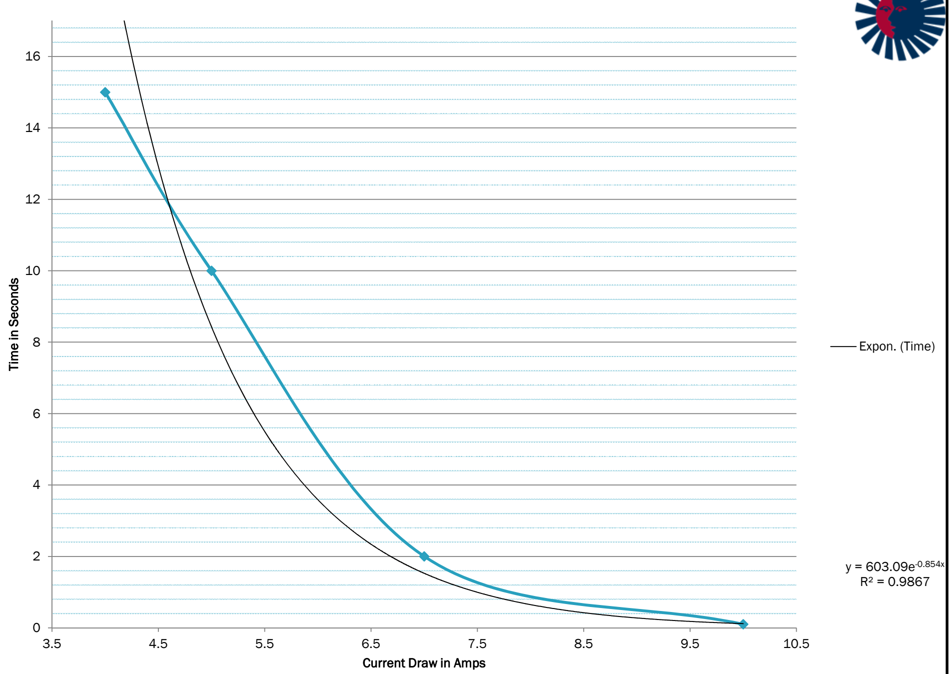
Ports 1-5 - one over current protection device

- One of each drive motor and a tank tread

Ports 6-10 - one over current protection device

- One of each drive motor and a tank tread

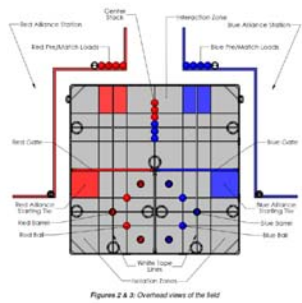
Maximum Current Draw Versus Time for the Vex Cortex



PROGRAMING SKILLS ROUTINE

1. Blue starting tiles w/ 2 preloads
2. Line follow to center 30” goal
3. Pick up game objects & score (4 objects)
4. Rotate 180, line follow back to starting tile
5. Match load 4 objects, reorient for line follow
6. Line follow to doubler barrel in blue isolation
7. Line follow to 30” goal in blue isolation
8. Pick up game objects in front of goal, score doubler & objects

…more if time permits



DEAD RECKONING (DR)

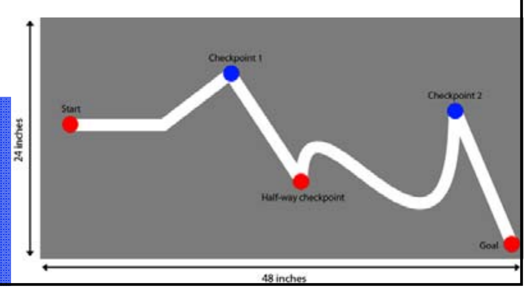
Wikipedia – (Dead reckoning) is the process of calculating one's current position by using a previously determined position, or fix, and advancing that position based upon known or estimated speeds over elapsed time, and course.

-Autonomous navigation based on robot’s location

- Accomplished using a variety of sensors

-Robot should be able to score by loading coordinates

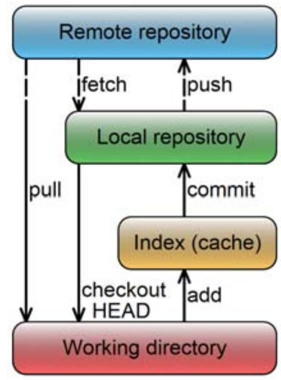
-Autonomous and driver control implementations



VERSION CONTROL

- Change management through Git
- Commonly used in professional software development
- Chosen for decentralized architecture
- Project history, code tracking

- Future plans….



Sensors
Ultrasonic Range Finders
Optical Shaft Encoders
Line Followers

Gearing
- Chain and Sprocket
-40:15 gear ratio
- 40:10 ratio

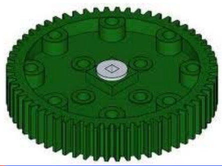
Drivetrain and Chassis

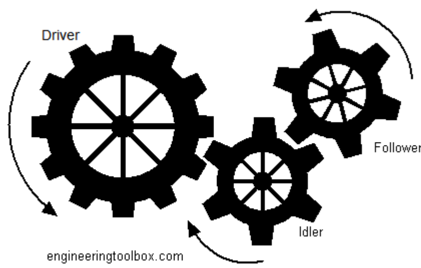
Wheels
- 4 4-inch Omni-wheels and 2 regular 4-inch wheels
- 6 wheel chassis

Motors
- 4 clutch-less 3-wire motors
- 6.5 inch-lbs of torque
-Free speed 100 rpm at 7.5 volts

"GEAR RATIO" - ANALYSIS

- On drive, wheels are geared 40:15 for speed with sprocket
- Shaft Encoders geared 15:10 for speed to the wheels
- Torque in from motors is 27 in-lbs. for each side, 54 in-lbs. overall
- Maximum velocity is 4.654 ft/sec with 4" diameter wheels





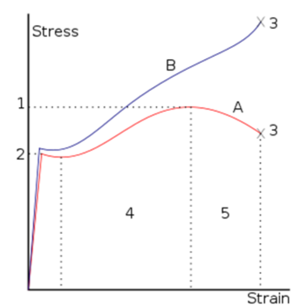
CHAIN DRIVE - ANALYSIS

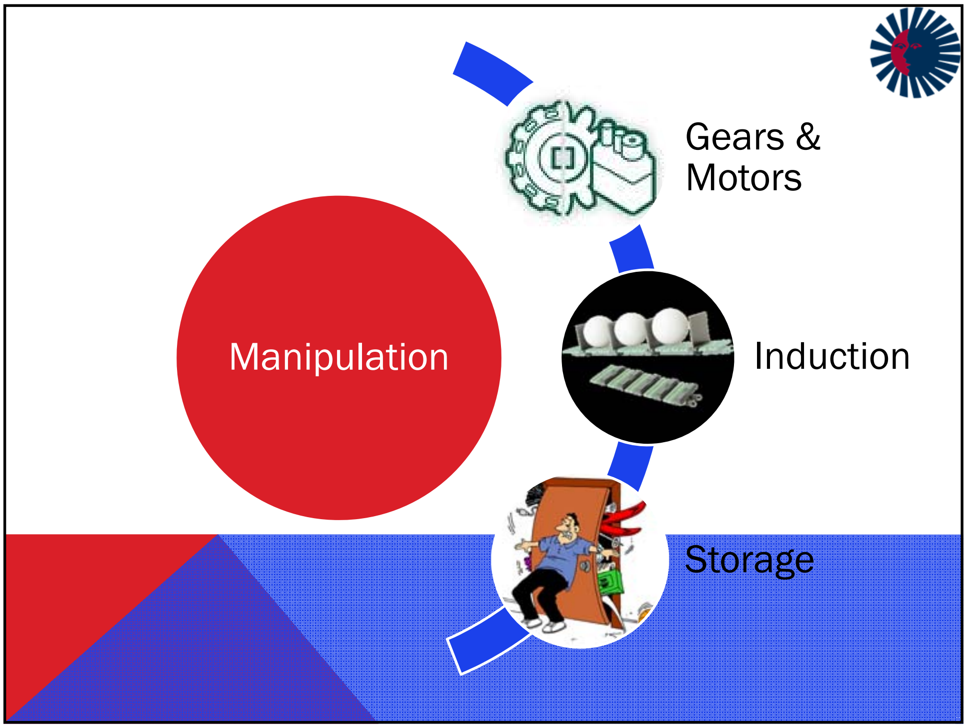
Each side drive through 2 coupled 393s (high strength gear to couple)

- Torque – 13.5 in-lb x 2 = 27 in-lbs
- Diameter of small sprocket = 1 inch, ½ inch radius
- Torque = Force x radius Force = Torque / radius
- Force = 27 in-lbs/0.5 in = 54 lbs

- Stress = Load / Cross sectional area
- Smallest area = 0.0248 in^2
- 54 lbs / 0.0248 in^2 = 2177.41 psi = 15,012.7135 KPa

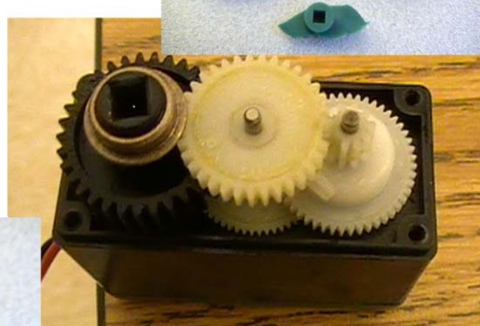
- Assume Delrin – Ultimate Strength of 23 MPa
- Safety factor – Strength/Stress = 1.5
- Matches Aerospace safety factor metrics



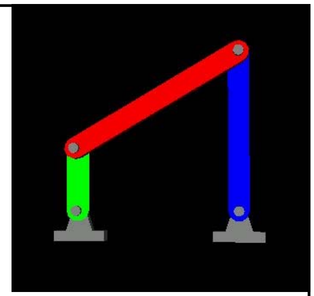


ANALYSIS-AGMA

Stress
- Gear stress/fracture
- AGMA Lewis equation
- Stress of 12.5 MPa
- Delrin Plastic maximum stress of 23 MPa
- (approximate safety factor of 2)



ANALYSIS-KINEMATICS



Four bar analysis

-Vector Loop analysis

Position in the x and y directions

$$(R_1 \cdot (\cos(\theta_1))) + (R_2 \cdot (\cos(\theta_2))) + (R_3 \cdot (\cos(\theta_3))) + (R_4 \cdot (\cos(\theta_4))) = -2.665 \cdot 10^{-15}$$

As an aproximation, we can consider this solution to be zero.

$$(R_1 \cdot (\sin(\theta_1))) + (R_2 \cdot (\sin(\theta_2))) + (R_3 \cdot (\sin(\theta_3))) + (R_4 \cdot (\sin(\theta_4))) = 4.441 \cdot 10^{-16}$$

As an aproximation, we can consider this solution to be zero.

$$((-(R_1 \cdot sin(\theta_1))) \cdot \theta_{1dot}) + ((-(R_2 \cdot sin(\theta_2))) \cdot \theta_{2dot}) + ((-(R_3 \cdot sin(\theta_3))) \cdot \theta_{3dot}) + ((-(R_4 \cdot sin(\theta_4))) \cdot \theta_{4dot})$$

$$((-(R_1 \cdot cos(\theta_1))) \cdot \theta_{1dot}) + ((-(R_2 \cdot cos(\theta_2))) \cdot \theta_{2dot}) + ((-(R_3 \cdot cos(\theta_3))) \cdot \theta_{3dot}) + ((-(R_4 \cdot cos(\theta_4))) \cdot \theta_{4dot})$$

$$(-R_1 \cdot sin\theta_1) \cdot \theta_{1dot2} - (R_1 \cdot cos\theta_1) \cdot \theta_{1dot}^2 - (R_2 \cdot sin\theta_2) \cdot \theta_{2dot2} - (R_2 \cdot cos\theta_2) \cdot \theta_{2dot}^2 - (R_3 \cdot sin\theta_3) \cdot \theta_{3dot2} - (R_3 \cdot cos\theta_3) \cdot \theta_{3dot}^2 - (R_4 \cdot sin\theta_4) \cdot \theta_{4dot2} - (R_4 \cdot cos\theta_4) \cdot \theta_4^2 = 0$$

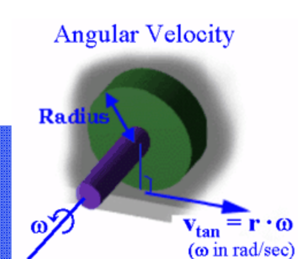
$$(R_1 \cdot cos\theta_1) \cdot \theta_{1dot2} - (R_1 \cdot sin\theta_1) \cdot \theta_{1dot}^2 + (R_2 \cdot cos\theta_2) \cdot \theta_{2dot2} - (R_2 \cdot sin\theta_2) \cdot \theta_{2dot}^2 + (R_3 \cdot cos\theta_3) \cdot \theta_{3dot2} - (R_3 \cdot sin\theta_3) \cdot \theta_{3dot}^2 + (R_4 \cdot cos\theta_4) \cdot \theta_{4dot2} - (R_4 \cdot sin\theta_4) \cdot \theta_4^2 = 0$$

KINEMATICS RESULTS

Opposite bar behaves exactly as driven

- Same angular velocity and angular acceleration
- Max angular velocity – 14.286 rpm
- Max angular acceleration – 0.349 rad/sec^2

$$\omega = \omega_0 + \alpha t$$



ANALYSIS-KINETICS (PENDING)

- Complete analysis by nationals
- Understand forces from 4 bar
- Eventually calculate stress, fatigue

$$\begin{bmatrix} 1 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ -R_{12y} & R_{12x} & -R_{32y} & R_{32x} & 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & -1 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & -1 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & R_{23y} & -R_{23x} & -R_{43y} & R_{43x} & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & -1 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & -1 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & R_{34y} & -R_{34x} & -R_{14y} & \square & 0 \end{bmatrix} := R$$

$$F := \begin{bmatrix} F_{12x} \\ F_{12y} \\ F_{32x} \\ F_{32y} \\ F_{43x} \\ F_{43y} \\ F_{14x} \\ F_{14y} \\ T_{12} \end{bmatrix} \qquad S := \begin{bmatrix} m_2 \cdot a_{g2x} \\ m_2 \cdot a_{g2y} \\ I_{G2} \cdot \alpha_2 \\ m_3 \cdot a_{g3x} - F_{px} \\ m_3 \cdot a_{g3y} - F_{py} \\ (I_{g3} \cdot \alpha 3) - ((R_{px} \cdot F_{py}) + (R_{py} \cdot F_{px})) \\ m_4 \cdot a_{g4x} \\ m_4 \cdot a_{g4y} \\ I_{g4} \cdot \alpha_4 - T_4 \end{bmatrix}$$

$$S := R \cdot F$$

INDUCTION SYSTEM

- Tested with a wide range of options
- Overnighted tank tread upgrade kit
- Powered by two 3-wire motors
- Can store up to 5 objects

BUDGET CONSIDERATIONS

Bill of Materials			
Item	Quantity	Unit Cost (USD)	Total Cost (USD)
Cortex	1	250	250
Power expander	1	50	50
393 motor	4	20	80
3 wire motor	6	20	120
Shaft encoder kit	1	20	20
Ultrasonic	3	30	90
Line Follow kit	2	40	80
Tank tread kit	1	30	30
Tank tread upgrade kit	1	25	25
Aluminum Structure kit	1	35	35
Booster Kit	1	40	40
High Strength Gear Kit	1	30	30
High Strength Chain and Sproket	1	40	40
Chain and Sproket Kit	1	30	30
Vexnet Joystick	1	150	150
Battery pack	2	30	60
RobotC	1	80	80
Programming kit	1	50	50
Game Object Kit	1	50	50
4" Omniwheels	2	25	50
4" wheels	1	20	20
Total			1380

COMMUNITY IMPACT

- 2nd year team, still growing
- Added a middle school student (hoping to add middle school team next year)
- Vex used for physics, AP physics, AP calculus, AP computer science, history (presentation), Advanced topics in computer science, lab science and technology
- "This I believe" essay (Shane)

SUMMARY

- -Team History
- - Design Process
- - Subsystems
  - -Logic
  - -Drivetrain
  - -Object Manipulation
- -Budget Considerations
- -Impact on the Community

QUESTIONS???

THANK YOU!