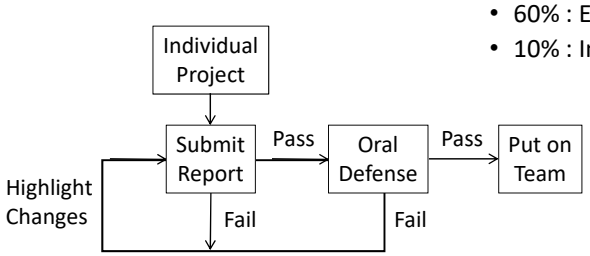
ELEC 391 - 2021

- Mini-Project
  - ~ 4 weeks (no due date)
  - 30% of Course Grade
    - Pass=**30** / Fail=**0**
- Project
  - May request team-mates
    - Assigned end of each week
  - Remaining Time (~ 8 weeks)
  - 70% of Course Grade
    - 60% : Engineering Reports
    - 10% : Integration Video



ELEC 391 - 2021

- Mini-Project
  - Individual
  - Active Pendulum
- Project
  - 3 Student Teams
  - 3 ½ DOF Quality Control Robot
    - SCARA + Wrist + Gripper
    - Grab cylindrical object
    - Drop into waste bin
- Design & Simulation Software
  - Electronics
    - MultiSim
    - UltiBoard
  - Mechanics
    - Solidworks
    - SimulationX
  - Control
    - Matlab
    - Simulink
    - Arduino IDE

Mini-Project
- 30% of Total Grade

Report
- PPT Slide Deck
  - Notes Page Format
- Evidence of all REQ met

Oral Defence
- 2 minute demo
- 3 minute Q&A

- Prove its your work
- Software loaded & ready

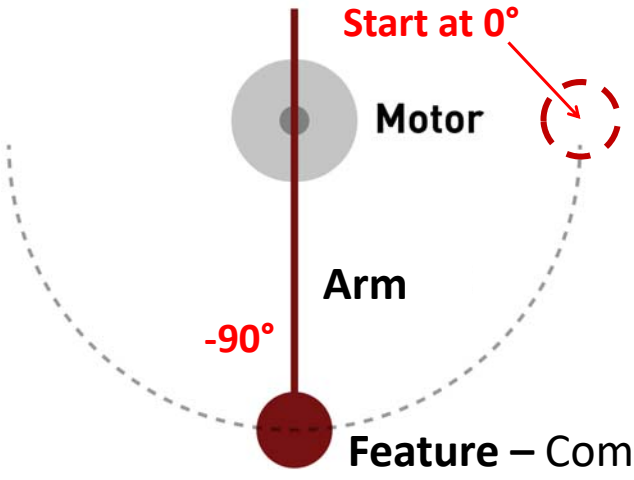
Project
- 70% of Total Grade

Reports – 60%
- All design work & results
- 3 Separate Reports
  - Electrical
  - Mechanical
  - Robotics & Control

System Integration Video – 10%

Progress Meetings – 0%
- Feedback Only
- Ahead / On-Time / Late

Mini-Project – Active Pendulum



Feature – Company Logo

Mini-Project – Components

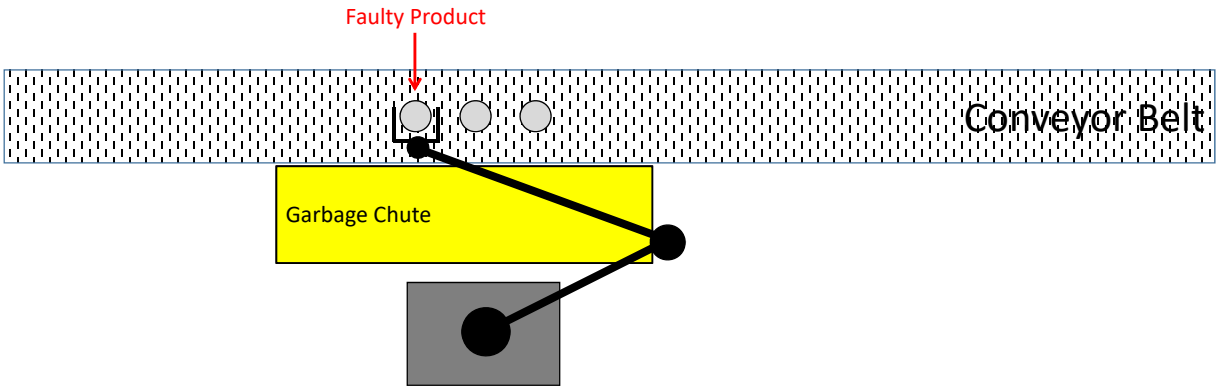
1. Model motor
   - Look up PN using **maxmot*** tool
   - Specs in **Maxon catalog***
   - Develop **Simulink model***
2. Arduino IDE
   - Write simple P-Controller in C
   - Compute **ISR Frequency***
3. MultiSim
   - **Amplifier CCT***
     - Use motor R (Ω) for load
     - Develop Matlab model
     - Show I/P Current < Arduino Spec @ nom V
   - Layout PCB in Ultiboard
     - Components
     - Terminal block connectors
4. SolidWorks
   - Arm + Logo
   - Steel
   - Approx same length & diameter as motor
5. Simulink
   - P-Control + Driver + Motor + Pendulum
     - 50% Ku (from root-locus)
6. Simulation-X
   - Motor + Primitive-Based Pendulum
   - Motor + STL-Based Pendulum
   - Horizontal - No Gravity
7. Co-Simulation
   - Simulink & SX
   - Optional
     - Tune for improved response
     - Add gravity

* See reference on Canvas or Project page of website

Mini-Project – Deliverables

1. Motor data sheet & PN
2. Micro-Controller
   a) C-code for controller routine
   b) Execution time
   c) Control frequency calculation
3. Driver
   a) Multisim circuit drawing
   b) Multisim step response (V & I)
   c) Matlab model & step response
   d) Ultiboard PCB layout
4. Pendulum
   a) SolidWorks model
   b) Centre of mass & stress analysis
   c) Assembly with motor & fasteners
      - Exploded view
5. Simulink System
   a) P + Driver + Motor + Pendulum
      - Step response
   b) P + Driver + Motor (Elec Only)
      - Use for Co-Simulation
6. Co-Simulation System
   a) Simulation-X Primitive Pendulum
      - Step Response
   b) STL Pendulum
      - Step Response

Project – Virtual Quality Control Robot



RCGs

Requirements

- Virtual Quality Control Robot
- 3 ½ DOF
  - SCARA Robot with Wrist
  - Gripper
- 3 marshmallows on stopped conveyor
  - Cylindrical (3cm Diam x 3cm Tall)
  - Negligible mass & stiffness
- 0 → 3 products discarded
  - Grab / Move 10cm / Drop
- 0% Overshoot before gripping
  - Must not tip or push
- Custom Driver Circuit

Constraints

- Maxon or Faulhaber
  - Motor
  - Gearhead
  - Encoder
- Motors operate at or below nominal voltage / current
- Arduino Leonardo
  - One only
- McMaster Carr
  - Components
- Dual 2-Amp Power Supply

RCGs

Goals

- Minimum processing time
- Minimum cost
- Minimum footprint
  - Electronics
- Minimum working volume
  - Robot
- Minimum power requirements

Free Parameters

- Spacing between products
- Size of garbage chute
- Location of robot arm base
- Nothing above conveyor to interfere
- Damage to faulty product ok

Electrical – 20%

- Choose OTS Parts
  - Maxon or Faulhaber Catalogue
  - Any M-C DC Motor
  - Planetary Gearhead (optional)
  - Optical Encoders
- Design Driver CCTs
- Simulate
- Develop Linear Models
- Layout PCB
  - All drivers integrated on 1 board.
  - Connectors
  - Mounting HW
- Export CAD Model
- Design housing

Mechanics – 20%

- Design Parts & Assemblies
  - Gripper & Arms & Joints
  - Minimize Inertia
  - Satisfy Stress Constraint
  - McMaster Carr components
- Develop SX Model
  - Replace simple SW parts to optimize simulation time
- Identify Forces / Torques
- For each joint
  - Develop linear approx.
  - Reasonable operating point

Control – 20%

- Develop Control System
  - Import Linear Models
  - Optimize PID or Lead/Lag Controller
- Implement controller
  - All 4 joints
  - User-Defined Matlab Function
    - No PID or Transfer Function Block
  - Derivative Filter
    - Encoder Resolution
    - ISR Clock-Rate (estimated)
  - Port to C
    - Compute ISR time (Arduino IDE tool)
    - Adjust filter pole
- Interface with SX
  - Co-Simulation TCP / IP
  - Re-Tune Controller
- Robotics
  - Direct Kinematics
  - Inverse Kinematics
  - Path Planning

System Performance & Features – 10%

- Control System
  - Exotic Tuning Algorithm
  - Performance Evaluation
- Electronics
  - PCB footprint (size)
  - Details
    - Bypass capacitors
    - Fuses
    - Labels
- Mechanics
  - Custom mechanism (parallel?)
  - Gripper design
  - Stress / Inertia optimization
- System
  - Performance measurements
  - Cost estimate

Project – Report Deliverables

1. Actuator Specs
   a) Motor / gear / sensor data-sheets
2. Mechanical
   a) Custom parts designs
   b) Stress analysis
   c) OTS components & modifications
   d) SX model
3. Electronics
   a) Multisim circuit drawing
   b) Multisim step response
   c) Linear Matlab model
   d) Matlab step response
   e) PCB layout
4. Robotics & Control
   a) PID Controller (Matlab Function)
   b) PID Controller (C Code)
   c) Tuning Strategy (each joint)
   d) Robot Kinematics
   e) Path Plan
5. Results / Evaluation
   - Verify ALL **Requirements** met
   - Verify ALL **Constraints** met
   - Identify **Goals** and identify which are met

   a) Cost
   b) Controller (Joint & Task-Space) Performance
      - Rise Time
      - Settle Time
      - Overshoot

   c) Cycle Time
      - Discard 1-3 objects

Project – Video Deliverables

1. YouTube link

2. System Demo
   a) < 1 minute
   b) Satisfied RCGs
   c) Unsatisfied RCGs

3. Feature Demo
   a) Remaining time (~4 min)
   b) Debugging tools
   c) Complex/Clever designs
   d) Additional simulations
   e) etc.