ELG4157 Design Project Proposal

**Proposed Title of the Project:**

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**Mechanical Engineering Team:**

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| **Name** | **Email** |
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**ELG Student if Applicable:**

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|  | **Email** |
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**TA Supervisor:**

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| **Name** | **Email** |
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Engineering design is the application of math, science and engineering principles to the creation and development of systems components and processes.

**Project Details and Brief Design**

**Problem Statement**

Clearly and concisely identify the problem.

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**Design Statement**

The design statement is challenging; it is about taking action to address the need and to solve the problem. It must specify the degree to which you will carry out the solution. The design statement may also contain an underlying theme or very important constraint.

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**Constraints**

These are guidelines that must be followed. Examples include time, budget, aesthetics, codes, safety, and physical attributes.

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**Generated Concept**

Brainstorming and preliminary sketches

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**Deliverables by End of March, 2016:**

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| --- | --- |
| **Item** | **YES or NO** |
| Poster |  |
| Simulation Work |  |
| Specifications |  |
| Sizing of Components |  |
| Skills of Arduino |  |

**Deliverables by End of November, 2016:**

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| **Item** | **YES or NO** |
| Prototype |  |
| Report |  |
| Demonstration of Prototype |  |
| Video |  |

**Required Facilities**

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**Knowledge Areas and Simulation Tools Needed for Project**

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**Estimated Budget**

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| **Item** | **Cost** |
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**Green Engineering Theme**

Identify the green and sustainability theme followed in the proposal**.**

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**ELG Assignment**

**The Pant**

Identify the main plant of the project, for example an embedded DC servo motor used for an arm of a robot manipulator. Write its specifications:

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| General |  |
| Input Voltage |  |
| Output Torque |  |
| Angular Velocity |  |
| Output Power |  |
| Torque Linearity |  |
| Input Current |  |
| Built in Gear Ratio |  |

**Power Supply**

The power supply to be used is a voltage source for which the output voltage is controlled by the input voltage. Write its specifications:

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| Input Voltage |  |
| Maximum Current |  |
| Voltage Gain |  |
| Input Impedance |  |
| Settling Time |  |

The mechanical specifications are known only in terms of the time constant associated with each arm. A particular arm of interest may be quoted as 2 seconds.

**System Description**

Write the basic differential equation that describes the dynamics of the arm or similar component as a second order differential equation.

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If the arm is vertically placed instead of horizontally, the arm will be affected by the gravitational field. In this case, the system’s equation needs to be modified by taking an additional torque into account.

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**Transfer Function**

From the above differential equation, derive the transfer function in terms of mechanical time constant. Assume that the torque is a linear function of the input voltage. The transfer function should be written in terms of rotational angle *θ* and angular velocity *ω*.

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**Parameters**

From the given specifications and Using the final value theorem of the Laplace transform, we now determine two important parameters, the gain *K* and time constant *T*.

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**Open Loop Control**

The arm of the robot manipulator may do angular positioning without negative feedback. By simply applying a fixed voltage for a certain time period, the arm rotates and settles on the desired position. Determine how long a voltage of 24V has to be applied to change the arm position by 90o or 1/4 of a revolution.

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**Feedback Control**

Similar task as considered in open-loop control may be achieved by feedback control that provides negative feedback. The open-loop control cannot correct the set position of 90o in the event that the angle is subject to disturbance. However, the feedback has ability to detect the error caused by the disturbance and correct the error. This feature is achieved at the expense of response time as well as higher power requirements. Investigate how the performance of the system is altered by the closed loop configuration with a negative feedback loop.

A position sensor to detect the angular position of the robot arm is needed. The simplest position detector is a potentiometer. ±12V may be supplied between the two end terminals and measure the voltage of the brush relative to the ground. Since one revolution gives a voltage change of 24 volts, the sensor gain is 24 volts per revolution. Write the transfer function and draw the block diagram of the feedback system. Two potentiometers, one to set a reference angle and the other to measure the output angular position are needed.

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Simplify the block diagram into a unity feedback system

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**Robust System**

Design a controller that provides the system with overshoot of 10% and settling time of 1 second.

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**Implementation**

Implement the controller and pre-filter.

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**Digital Control System**

Design a digital phase lead compensator with *τ* = 0.01 seconds. *Gc*(*s*) should account for negative phase contribution of the zero-order hold and that of the transportation lag. The performance specifications are: phase margin *φm* of at least 55o, settling time of 1 s, and sampling rate of 0.01 s.

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