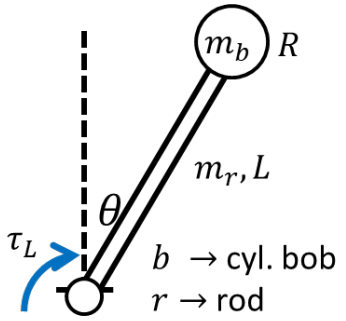
DEPARTMENT OF MECHANICAL ENGINEERING
AUBURN UNIVERSITY

MECH 5970/6970 INTERMEDIATE SPECIAL TOPICS IN MECHANICAL ENGINEERING:
APPLIED MECHATRONICS

Project 2: Analog Control

The performance requirements are $\zeta = 0.707$ and $t_{2\%} = 0.5\ sec$.



The pendulum has the following properties:

- $L_{rod} = 101.6\ mm$
- $m_{rod} = 18.14\ g$
- $m_{bob}(cylindrical, axis\ of\ symmetry\ rod\ axis) = 32\ g$
- $r_{bob} = 6.35\ mm\ (0.25\ in)\ (note\ radius\ is \perp\ to\ rod)$
- $Servoamp\ gain = 0.3 \frac{Amp}{Volt}\ \left(\frac{current\ output}{command\ voltage\ input}\right)$.

Submission Instructions: Project 2 will be submitted in four parts:

1. Circuit for position and velocity due 2/18 9:00 AM
    - The first document you will upload will be the circuit design for position and velocity sensing (eagle/orcad or other clean printout) and supporting calculations. Submissions will be reviewed and feedback provided. Submit a single PDF document that includes:
        - Team member names
        - Circuit schematic(s)
        - Supporting calculations, easy to read, with annotations to describe methods
2. Full state feedback circuit (current input model): due 2/25 9:00 AM
    - Full-state feedback gain calculations (mathematical gains and electronic gains) with updated circuit design including control gain stages, and summation to the amplifier. Submit a printout of your updated circuit design (completed with your software of choice) and supporting calculations. Circuits and calculations will be reviewed, and feedback provided. Submit a single PDF document that includes:
        - Team member names
        - Circuit schematic(s)
        - Supporting calculations, easy to read, with annotations to describe methods
3. Demonstration of Control by 3/2 9:00 AM
4. Final Submission due 3/4 by 9:00 AM: Submit a SINGLE pdf document that includes:
    - Team member names
    - Final schematic(s) with *designed* and *actual* component values
    - Supporting calculations, easy to read, with annotations to describe methods
    - Photo(s) [max 3] of analog control circuit and connections to the pendulum, sufficient that I can grade you on circuit layout/neatness
    - Evidence of the following:
        - +/- 10 V signal for +/- 10 degrees of pendulum motion (and adjustable offset)
        - +/- 10 V signal for reasonable range of pendulum velocities (supporting calcs should provide this range)
        - Control signal on an oscilloscope/DAQ
        - Video (make sure you have an active hyperlink to YouTube video), plots, screenshots and other evidence to support successful control of inverted

pendulum. You might also want to adjust k_θ and k_ω gains to show different performance of the closed loop controller. Remember that you only need to show response for a SMALL displacement of the pendulum from vertical!

References: datasheets are uploaded to the canvas page for relevant subsystems/components.

- Op-Amp: LF412 (LF412CN/NOPB-ND)
- Voltage Regulator: LM336 (LM336Z-5.0/NOPB-ND)
- Maxon RE-30 (P/N 310007)
- Midori CP-45 (10 KΩ) Potentiometer
- AMC B12A6 Linear Current Amplifier
- DAQ Options include Oscilloscope and NI Labview based Virtual DAQ

Testing Dates: Testing will occur during class periods/office hours. Priority will be given to those with conflicts during office hours.

- Position/Velocity Circuit will be tested on Friday, 2/25 during class.
- Analog Control will be tested on Monday, 2/28 and Wednesday, 3/2 during class.
- If you require another time slot, email me.

Grading Rubric:

Criteria	Points
Supporting Calculations	10 pts
Circuit design/layout organization and layout/labels	7 pts
Position signal demonstration to specifications	10 pts
Velocity signal demonstration to specification	10 pts
Control signal on scope (the one that goes to the amplifier)	3 pts
Control of pendulum to spec, and calculations to support demo	10 pts