

Today's Outline

1. Attendance
2. Syllabus
3. Weekly Schedule
4. Lecture
5. Lab Group Formation

Course Objective I

MEM 351
Dynamic Systems Lab

Course Objective II



Fuzzy Control

How Do We Achieve This?

System Modeling (Simulation)

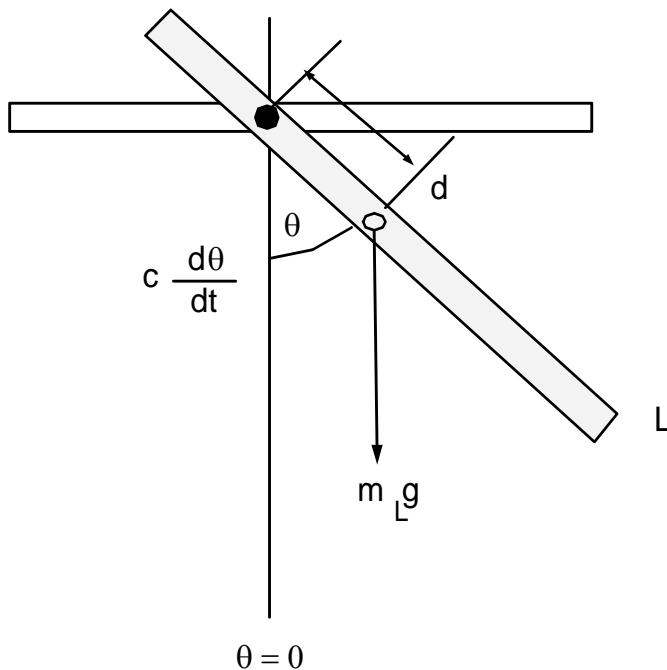
- Dynamic equations of motion
- System Identification
- Control theory background (review?)
 - Transfer functions, poles & zeros, state space
- Result is a model of system
 - Test different input responses, controllers, disturbance reactions, etc.

Implementation

- Software (i.e. LabVIEW)
- Sensors (i.e. optical encoders)

System Modeling

Dynamic Equations of Motion



$$\ddot{\theta} + \frac{c}{J} \dot{\theta} + \frac{m_L g d}{J} \theta = 0 \quad (1)$$

Linearized 2nd order differential equation assumes **small angles**

L	Bar length [m]
d	Pivot to CG distance [m]
m_L	Mass of pendulum [kg]
J	Moment of Inertia [$kg \cdot m^2$]
C	Viscous damping coefficient [$\frac{Nms}{rad}$]

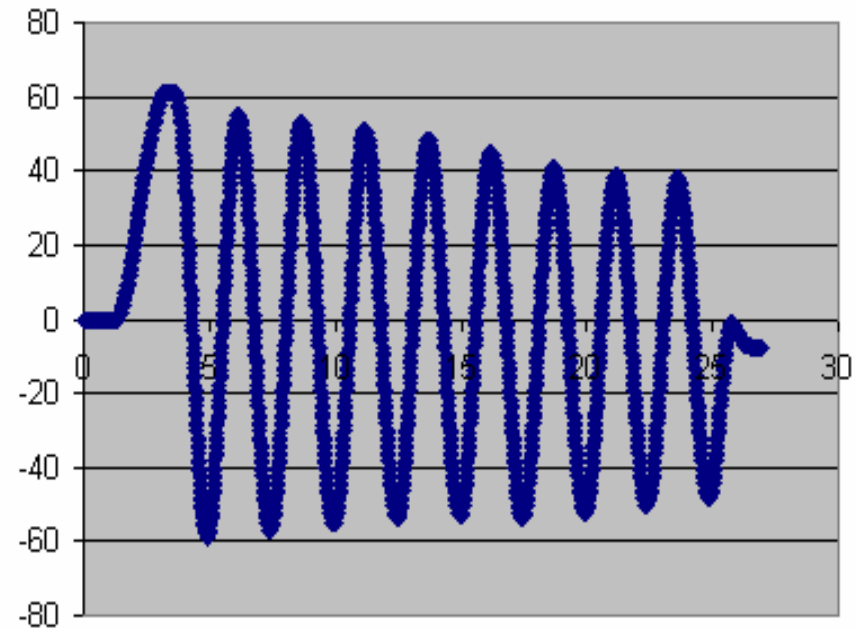
System Modeling

System Identification

- Used to identify system parameters such as damping ratio (ζ), natural frequency (ω_n), and damping coefficient (c).

The Damped Compound
Pendulum

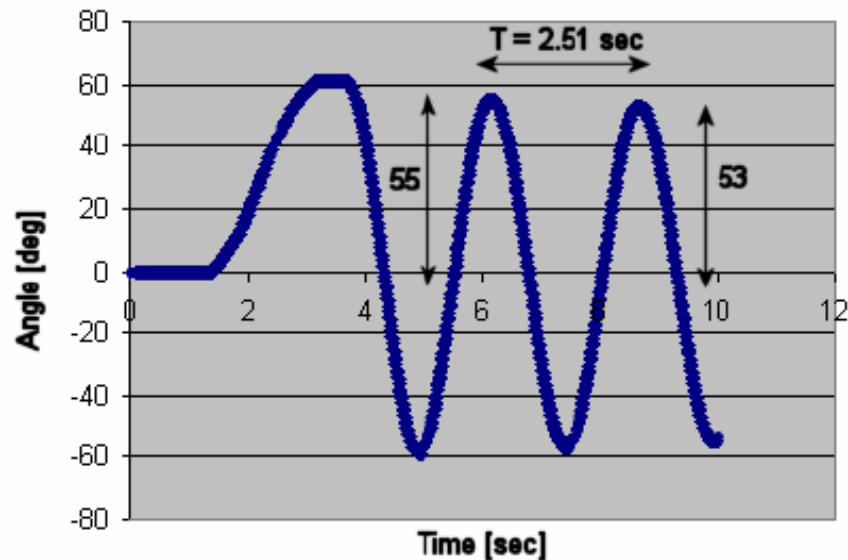
A Second Order System



System Modeling

System Identification

- Used to identify system parameters such as damping ratio (ζ), natural frequency (ω_n), and damping coefficient (c).



$$\ddot{\theta} + 2\zeta\omega_n\dot{\theta} + \omega_n^2\theta = 0 \quad (2)$$

$$\ln \frac{a}{b} = \frac{\zeta 2\pi}{\sqrt{1-\zeta^2}} = \frac{1}{N} \ln \frac{X_1}{X_{N+1}} \quad (3A)$$

$$\frac{2\pi}{T} = \omega_n \sqrt{1-\zeta^2} \quad (3B)$$

System Modeling

System Identification

- Match coefficients of equations (1) and (2)

$$\ddot{\theta} + \frac{c}{J} \dot{\theta} + \frac{m_L g d}{J} \theta = 0$$

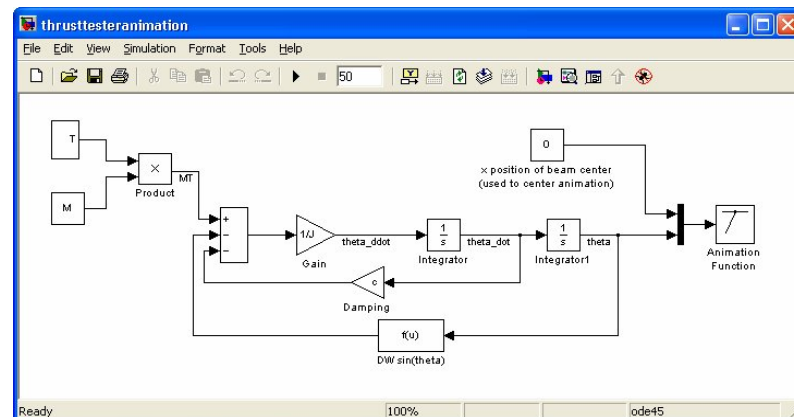
$$\ddot{\theta} + 2\zeta\omega_n \dot{\theta} + \omega_n^2 \theta = 0$$

- Yields

$$\omega_n = \sqrt{\frac{m_L g d}{J}} \quad (4A)$$

$$c = 2\zeta\omega_n J \quad (4B)$$

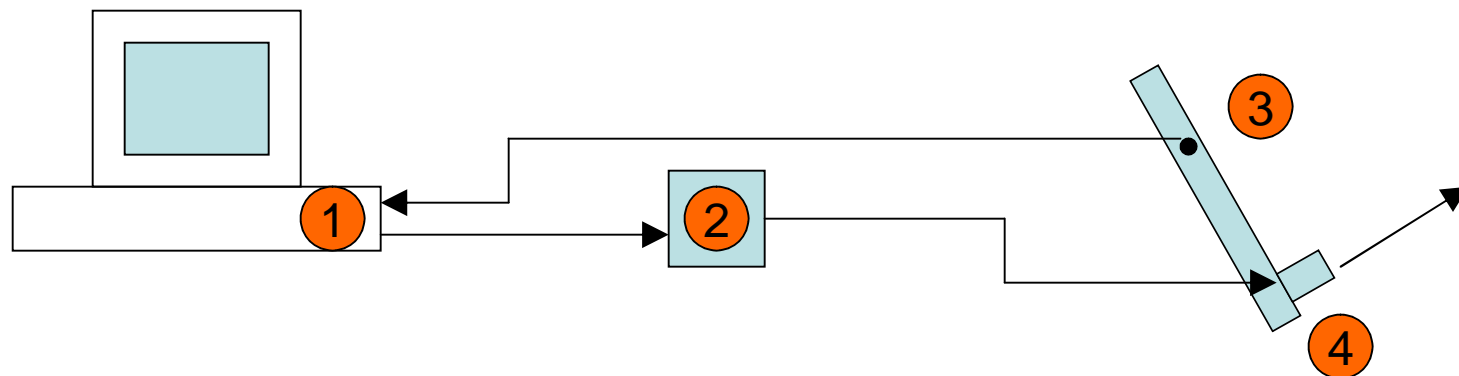
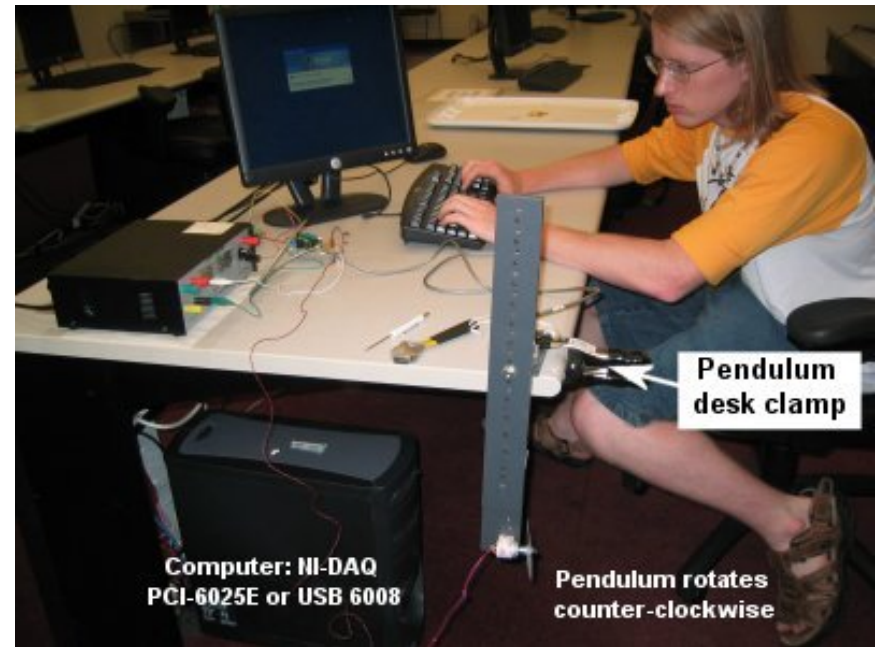
- Now we can model our system!



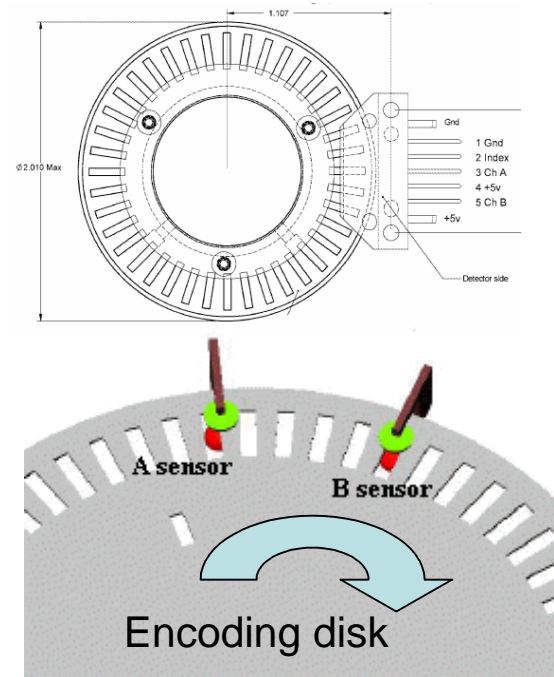
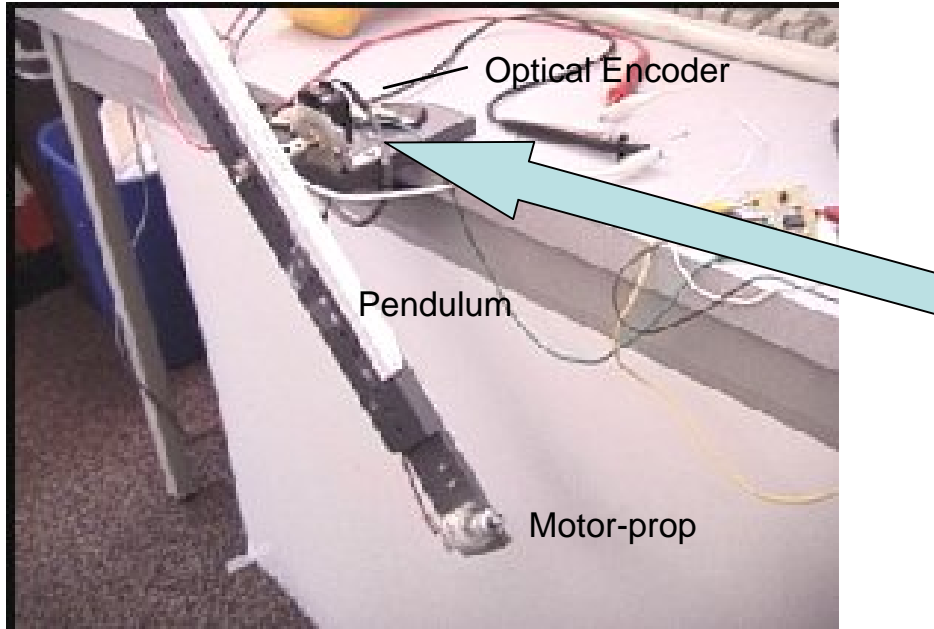
Hardware Implementation

System

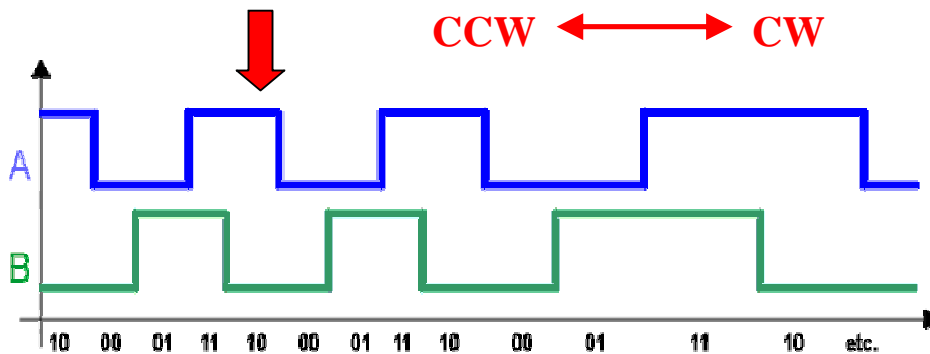
1. PC & NI-DAQ Board
2. Motor Amp
3. Optical Encoder
4. Motorized Propeller



Optical Encoder



Incremental optical encoders generate two data signals that are electrically 90° out of phase with each other. The term *quadrature* refers to this 90° phase relationship.



CCW A-B		CW A-B	
From	To	From	To
1-0	1-1	1-0	0-0
0-0	1-0	0-0	0-1
0-1	0-0	0-1	1-1
1-1	0-1	1-1	0-0

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6. Initial Survey