# CSE495A

Sunday, February 11, 2024 10:37 AM

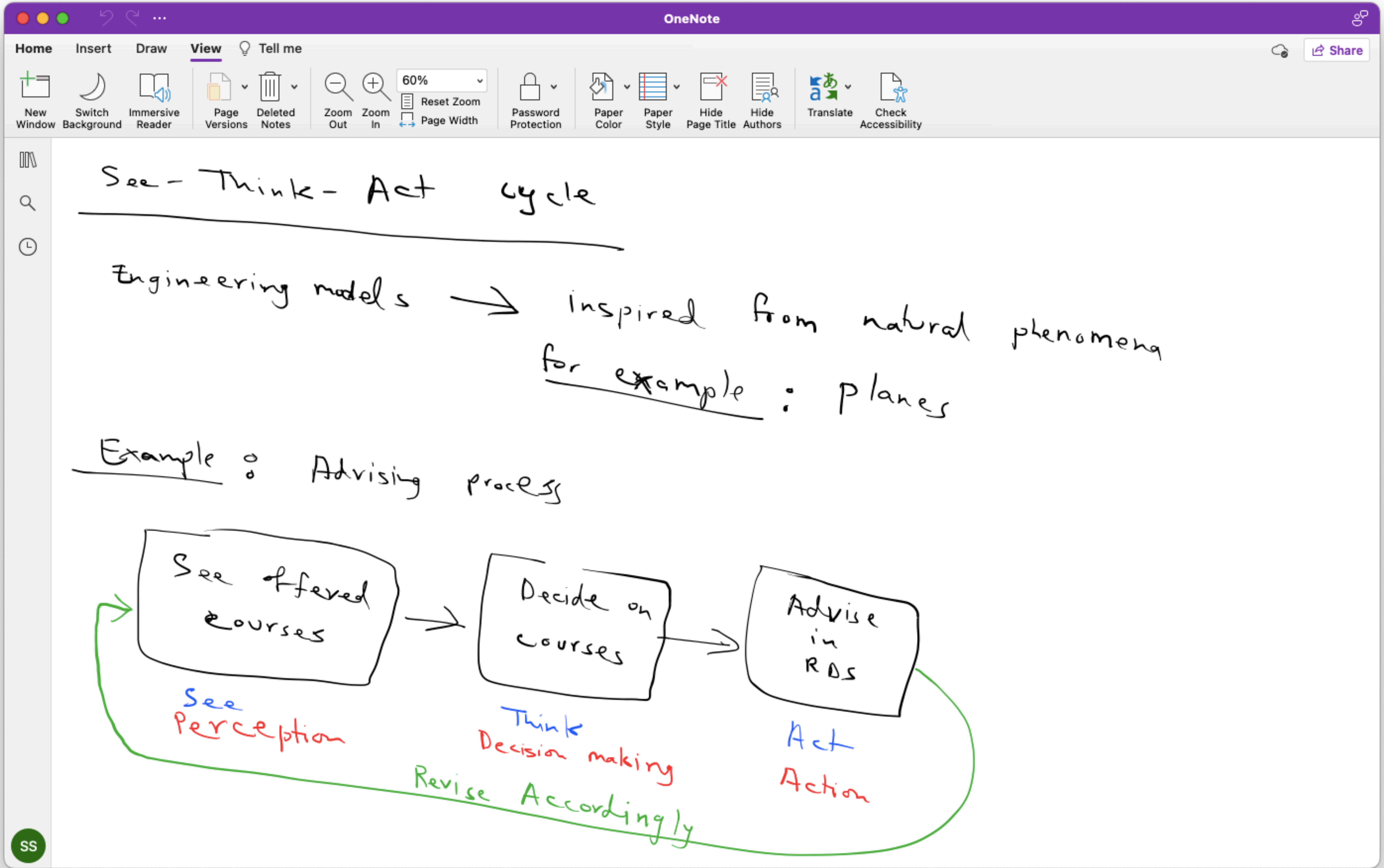
## Introduction to Robotics

**Prerequisite:** Linear Algebra, Differential equations,
Probability (less important this specific class),
Programming (CSE 115 minimum)

CSE 225
CSE 373 (if you focus on that part of robotics)

Computer vision → Linear Algebra
Eigenvalues, SVD

Research paper
or
Project (for example: simulation)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See - Think - Act cycle
Engineering models → inspired from natural phenomena
for example : planes
Example : Advising process
See offered courses
Decide on courses
Advise in RDS
See
Perception
Think
Decision making
Act
Action
Revise Accordingly

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# Stages of analysis & design

stage ① Develop mathematical model for the robot.

i.e.: differential equations (this Newton's laws)

Apply Newton's laws to obtain DE.

Stage ② Simulate the mathematical model to find the correct algorithms to solve your mission/problem.

Example: python, gazebo, pybullet, matlab etc.

Stage ③ Implement in physical robot

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## Robot dynamical models (differential equations, equations of motion)

General equation $\boxed{\dot{x} = f(x(t), u(t))}$ ← differential equation

↑ from applying Newton's law

$t$ : time

$x(t)$ : state vector

$u(t)$ : control vector

$\dot{x} = \frac{dx}{dt}$

$\ddot{x} = \frac{d^2x}{dt^2}$

Example : $x = \begin{bmatrix} - \\ - \\ - \end{bmatrix}_{3\times1}$ $u = \begin{bmatrix} - \\ - \end{bmatrix}_{2\times1}$

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$u(t)$ : control vector

$\ddot{x} = \dfrac{d^2x}{dt^2}$

from applying Newton's law

Example :

$x = \begin{bmatrix} - \\ - \\ - \end{bmatrix}_{3\times 1}$

$u = \begin{bmatrix} - \\ - \end{bmatrix}_{2\times 1}$

$$x(t) \longrightarrow \boxed{\dot{x} = f(x,u)} \longrightarrow u(t)$$

input from sensor

Decision making

output to actuators

SS

## Unicycle model

$$\begin{bmatrix} \dot{x} \\ \dot{y} \\ \dot{\theta} \end{bmatrix} = \begin{bmatrix} \cos\theta & 0 \\ \sin\theta & 0 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} v \\ \omega \end{bmatrix}$$

$$\dot{x} = f(x, u)$$

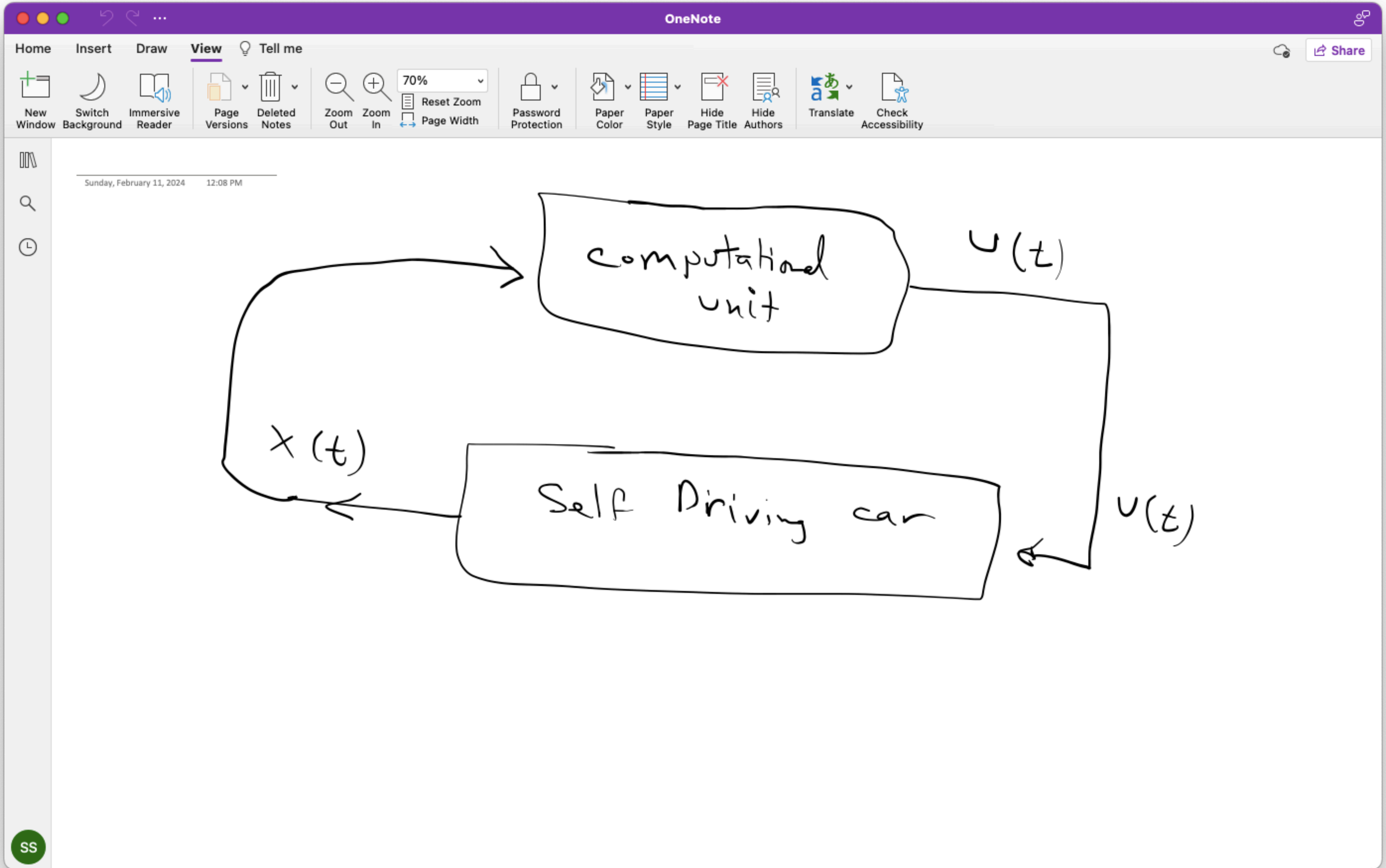
$$x = \begin{bmatrix} x \\ y \\ \theta \end{bmatrix} \qquad u = \begin{bmatrix} v \\ \omega \end{bmatrix}$$

$(x, y) \rightarrow$ position

$\theta \rightarrow$ angle with x-axis

$v \rightarrow$ translational velocity

$\omega \rightarrow$ rotational velocity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