KON301E SYSTEM MODELING & SIMULATION

HW1

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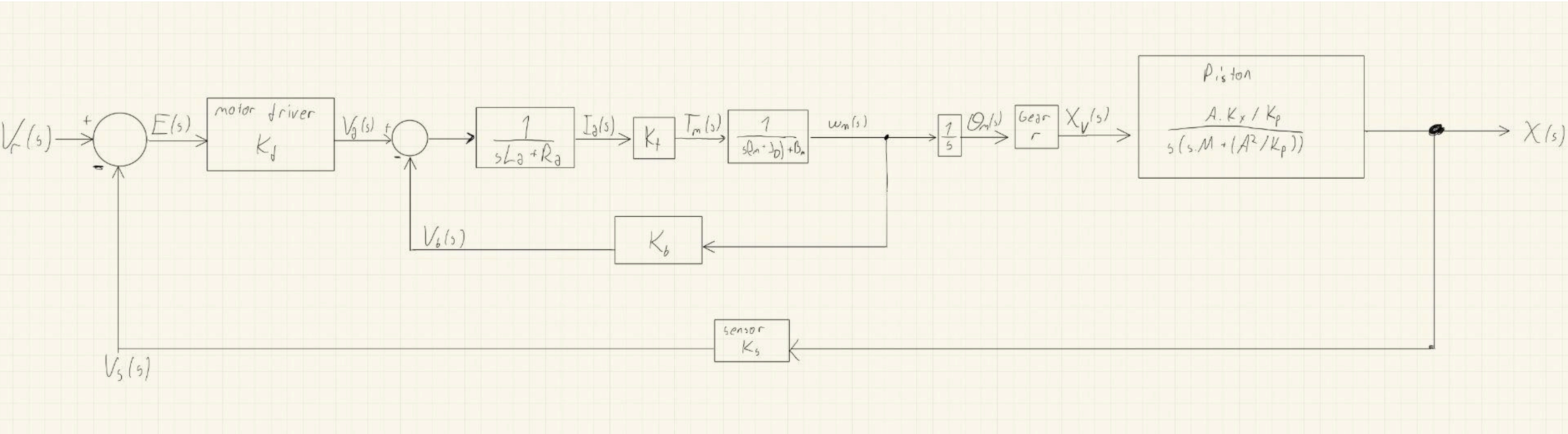
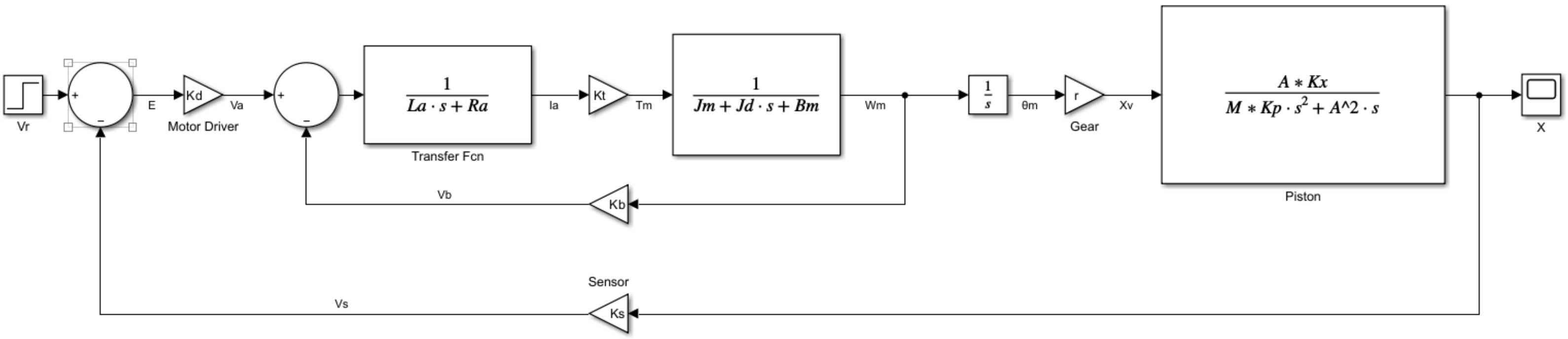
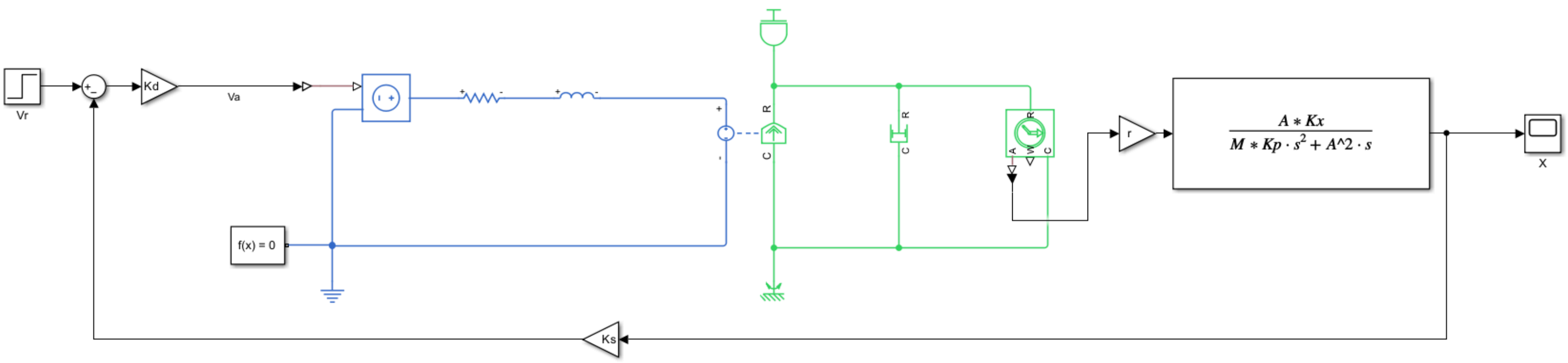
a) Draw a block diagram of the system.



b) Implement the system model in MATLAB Simulink based on the diagram from (a).



c) Develop an equivalent model in MATLAB Simscape.



d) Choose appropriate numerical values for the system parameters and simulate the system:
i. In Simulink,
ii. In Simscape, and
iii. Compare the simulation results from Simulink and Simscape.

In this study, the **PT00500 model 500 ml PET bottle** manufactured by Erbaşlar was selected as the reference product. This bottle represents a commonly used standard packaging solution in the market, making it a suitable sample for the scope of this study.

Detailed technical specifications, dimensional data, and logistical information of the bottle are provided in Appendix A in tabular form. Only the key properties relevant to the study are included in the main text to ensure clarity and readability.

Reference Product:

- **Brand:** Erbaşlar
- **Model:** PT00500
- **Capacity:** 500 ml PET bottle
- **Product Link:** https://www.erbaslar.com.tr/urun/pt00500-500-ml-pet-sise

- **Height:** 205 mm
- **Diameter:** 65 mm
- **Cap Diameter:** 28 mm
- **Weight:** 18.5 g

As a result of the conducted research, it has been determined that the volume of crushed plastic bottles is reduced by approximately **70–80%**. Considering these ratios for the PT00500 model bottle, the remaining internal volume after crushing is estimated to be in the range of **100–150 ml**.

Based on this remaining volume, the physical dimensions of the crushed bottle were evaluated, and the post-crushing bottle length was found to be approximately **30–45 mm**. For consistency in calculations throughout the study, the crushed bottle length was assumed to be **35 mm**.

The difference between the original bottle height of **205 mm** and the assumed crushed length corresponds to **170 mm (17 cm)**. Taking into account system tolerances and safe operating conditions, an additional **3 cm safety margin** was included in the design.

Accordingly, the maximum displacement value was determined as:

x_{max} **= 20 cm**

In order to determine the force required for the crushing process, experimental data obtained from a **visual-audio source** related to the subject were used as a reference. According to the experiment presented in the referenced video, the maximum force required to crush a plastic bottle was observed to be **292.2 N [1]**.

To ensure system reliability and operational safety, a pneumatic piston capable of generating a force significantly higher than this reference value was selected. Accordingly, the **Festo DSBC-32-200-PPVN3** pneumatic cylinder was chosen.

The selected cylinder has a **diameter of 32 mm** and is capable of generating a maximum force of approximately **483 N** at an operating pressure of **6 bar**. This force exceeds the required maximum value and provides an adequate safety margin for stable and efficient system operation.

As a result, it was concluded that the selected pneumatic cylinder meets the application requirements and is suitable for use in the designed system.

In order to ensure compatibility with the selected pneumatic cylinder, an appropriate control valve was chosen. Accordingly, the **Festo MPYE-5-1/8-LF-010-B** proportional valve was selected. The valve selection was based on its ability to meet the flow rate requirements of the cylinder and to provide stable system operation.

An examination of the valve specifications shows that the **nominal flow rate is 350 L/min**. In the system design, the maximum valve spool displacement was assumed

as $X_{v\ max}$ **= 0.005 m**. $r = 0.0016\, m$

Using these values, the flow–position gain of the valve was calculated as follows:

$$K_x = \frac{Q_{max}}{X_{v\ max}}$$

After converting the maximum flow rate to SI units, the valve gain was determined as:

$$K_x = 1.17\, m^2/s$$

This calculated value was taken as a reference parameter for system modeling and control analysis.

In the system design, a **Maxon RE 25 – 20 W (Part No: 118752)** DC motor was used as the drive unit. The technical specifications provided in the manufacturer's datasheet were adopted as **model parameters** for the mathematical modeling and simulation studies of the system.

Parameters such as nominal power, torque, speed, resistance, and electromechanical constants were directly obtained from the manufacturer's documentation and incorporated into the model. This approach ensures a realistic representation of the system behavior and consistency in the calculations.

The main parameters and their corresponding values used in the modeling, design, and analysis stages of this study are summarized below. These parameters were defined based on the technical specifications of the selected mechanical and pneumatic components, as well as data obtained from experimental and literature-based references.

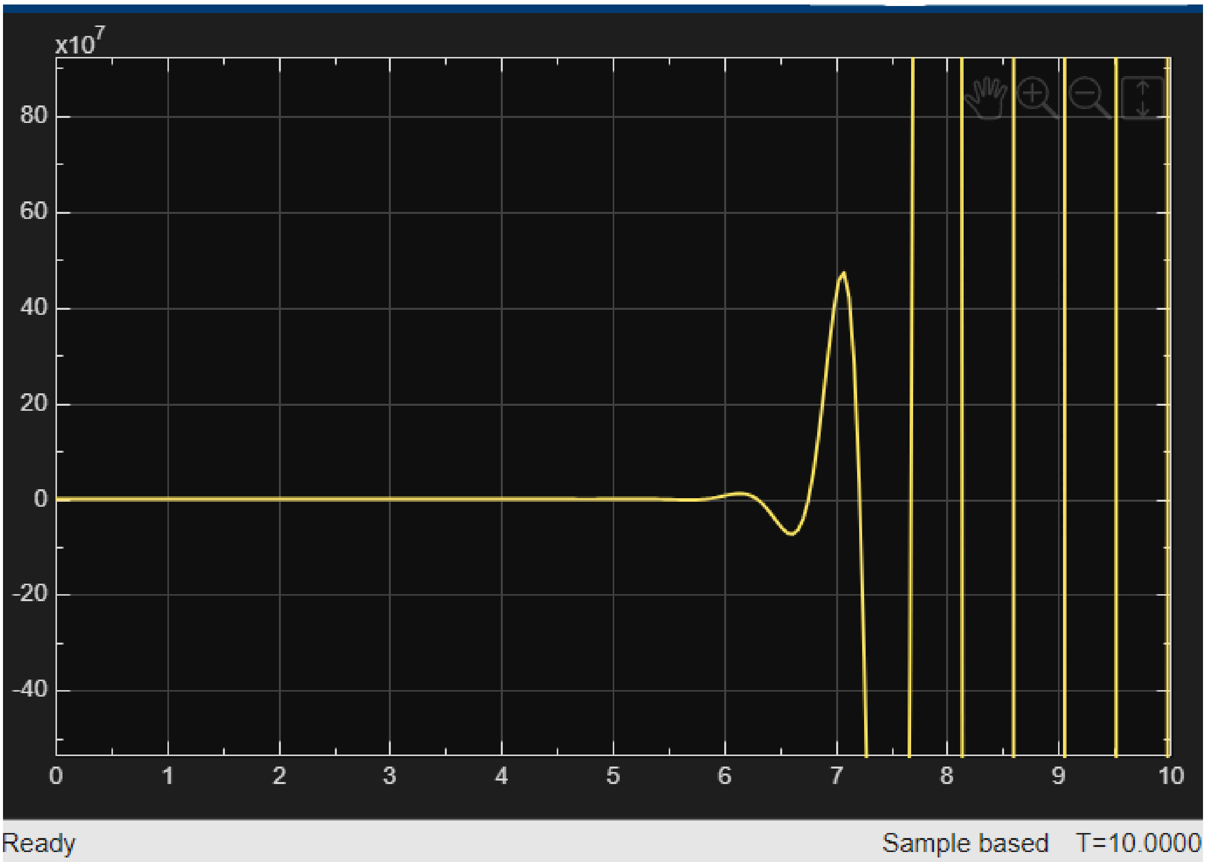
$R_a = 2.32\,\Omega$	$K_s = 50$
$L_a = 0.238e-3\,H$	$r = 0.0016\,m$
$K_b = 0.0234\,V/(rad/s)$	$J_D = 1e-7\,kg.m^2$
$J_m = 10.8e-7\,kg.m^2$	$A = 8e-4\,m^2$
$B_m = 1e-6\,kg.m^2/s$	$M = 15\,kg$
$K_t = 0.0234\,Nm/A$	$K_x = 1.17\,m^2/s$
$K_d = 2.4$	$K_p = 1e-6$

The outputs obtained from the modeling and simulation studies conducted using the defined system parameters were analyzed. However, **the desired performance and expected results could not be achieved** with the selected parameter set.

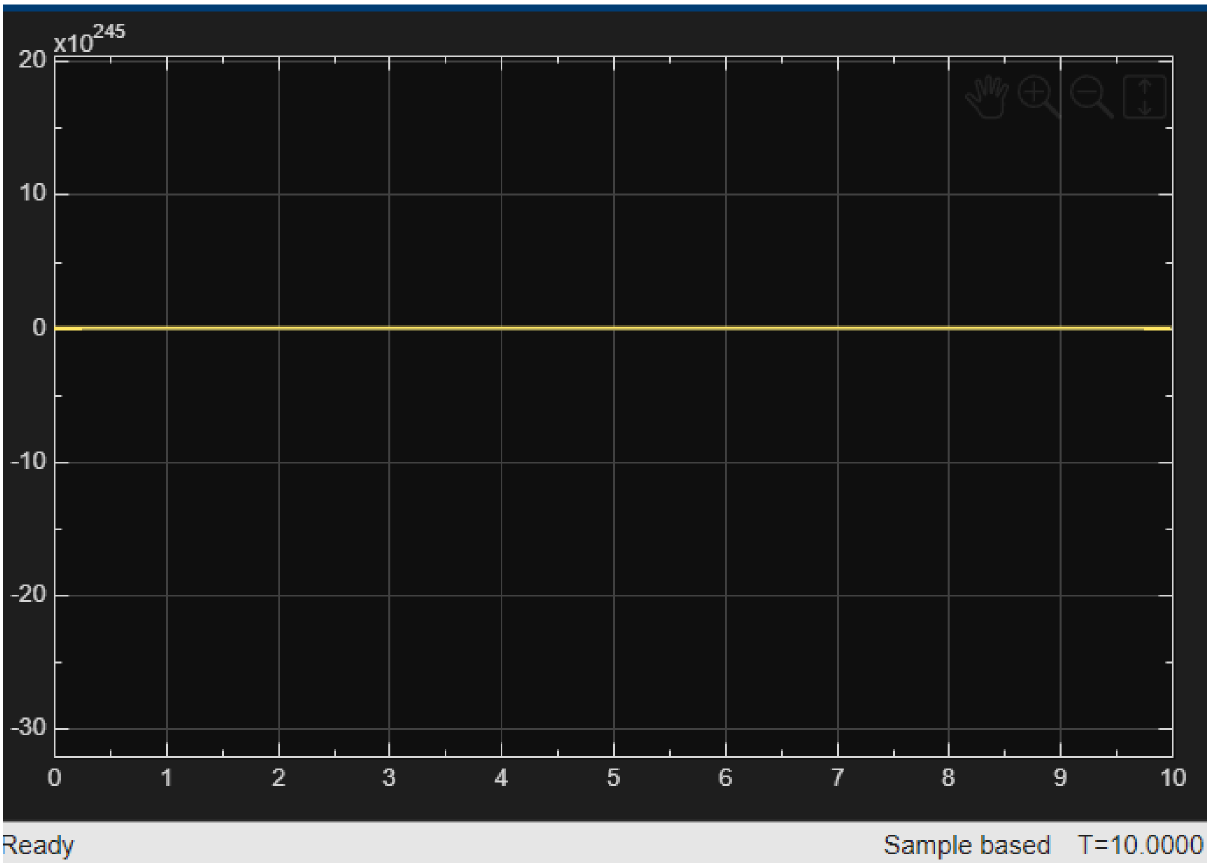
The simulation results indicate that the system does not exhibit the expected dynamic response and produces outputs that do not fully meet the design objectives. This outcome may be attributed to factors such as modeling assumptions, the use of idealized parameter values, and the insufficient consideration of nonlinear system behaviors.

Within this context, **two different simulation outputs** are presented below to illustrate the system behavior under the current parameter configuration.

Simulink output



Simscape output



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