Test 3, 2022 **Sample Correct Student Answers**

Note: This question is similar to question 2 on Problem Set 3, and Example 4.11.

10 **1.** For the mechanical system shown in the figure below:

a) Properly label the displacements, springs, dampers and mass. None of the springs or dampers are the same.

b) State your assumptions about the displacements and velocities.

c) Draw the <u>three</u> free-body diagrams that are necessary for analysing this system. The forces shown on these diagrams must be consistent with your assumptions from part (b).

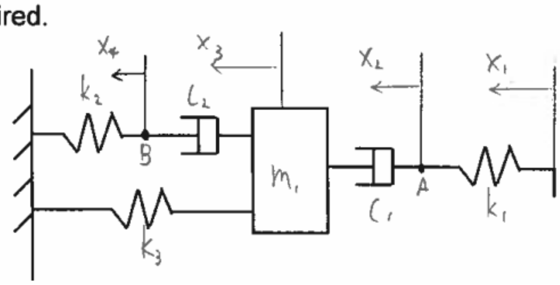
d) <u>For each of your free-body-diagrams</u>, derive the corresponding dynamic equation. The use of Laplace transforms is not required.

b) Assume $x_1 > x_2$ Assume $x_3 > x_4$

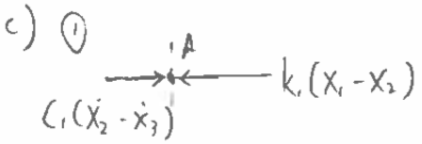
Assume $\dot{x}_1 > \dot{x}_2$ Assume $\dot{x}_3 > \dot{x}_4$

Assume $x_2 > x_3$

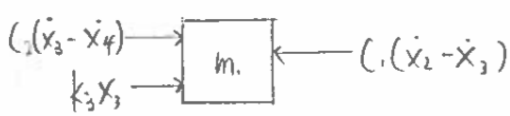
Assume $\dot{x}_2 > \dot{x}_3$



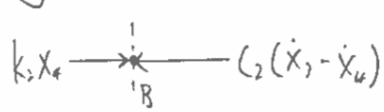
c) ①



②



③



d) ① $\Sigma F = m\ddot{x}_2$

$0 = k_1(x_1 - x_2) - c_1(\dot{x}_2 - \dot{x}_3)$

② $\Sigma F = m_1\ddot{x}_3$

$m_1\ddot{x}_3 = c_1(\dot{x}_2 - \dot{x}_3) - c_2(\dot{x}_3 - \dot{x}_4) - k_3x_3$

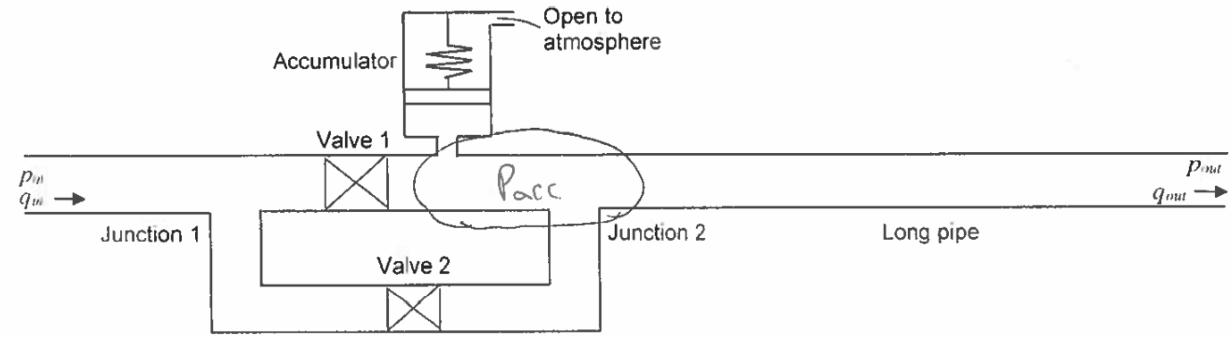
③ $\Sigma F = m\ddot{x}_4$

$0 = c_2(\dot{x}_3 - \dot{x}_4) - k_2x_4$

Note: This question is similar to question 1 on Problem Set 3.

10 **2.** The circuit diagram for a hydraulic system is given below. <u>It consists of two junctions, two valves, one accumulator, and one long pipe.</u> <u>The valves are different sizes</u>. <u>The pressures p_{in} and p_{out} are larger than atmospheric pressure.</u>

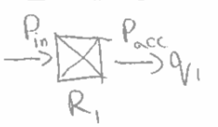
Draw a separate, properly labelled, small diagram for each hydraulic element. Write the dynamic equation for each element next to each drawing. Do not use redundant variables. For example, if A=B then write the equation in terms of A instead of creating another variable. The use of Laplace transforms is not required.



Junction 1

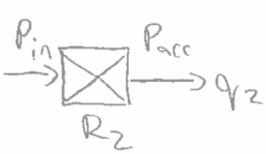
$$q_{in} = q_1 + q_2$$

Valve 1



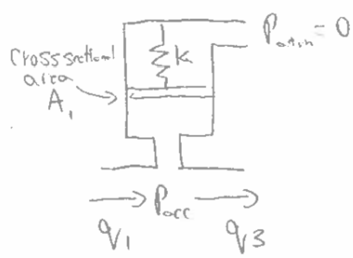
$$P_{in} - P_{acc} = R_1 q_1$$

Valve 2



$$P_{in} - P_{acc} = R_2 q_2$$

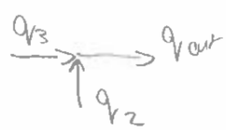
Accumulator



$$q_1 - q_3 = C\,\frac{d(P_{acc} - P_{atm})}{dt}$$

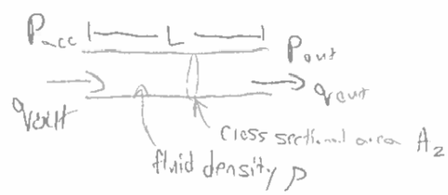
$$q_1 - q_3 = \frac{A_1^2}{k}\dot{P}_{acc}$$

Junction 2



$$q_{out} = q_3 + q_2$$

Long pipe



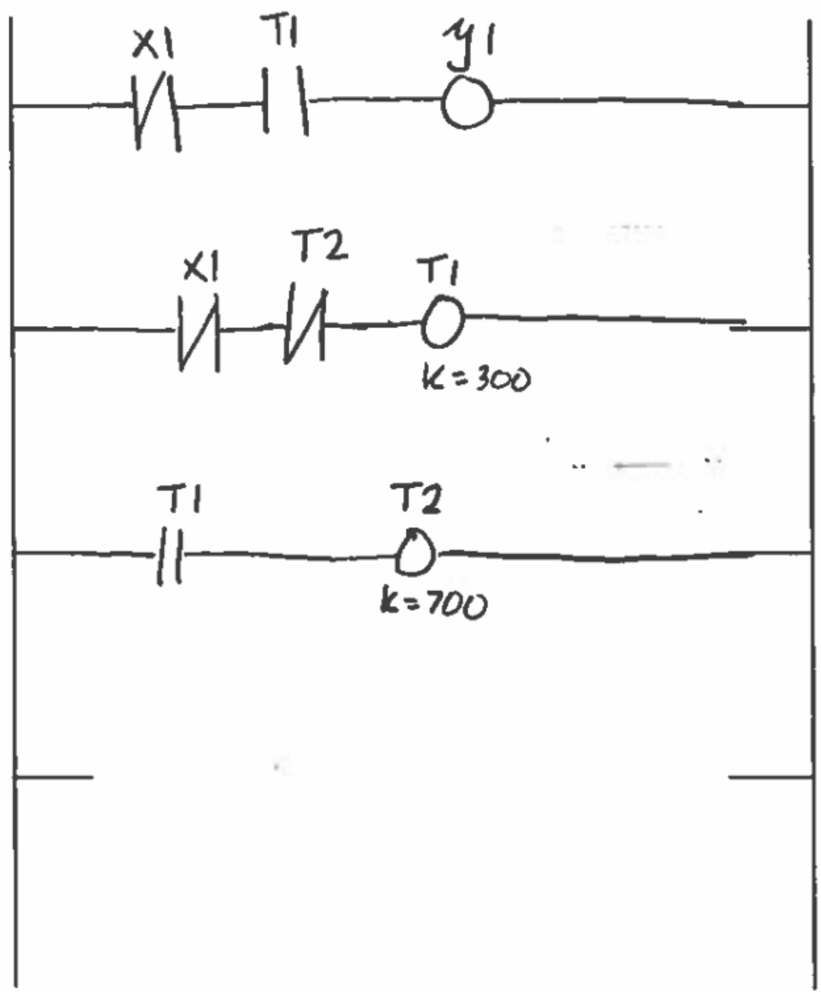
$$P_{acc} - P_{out} = I_1\frac{dq_{out}}{dt}$$

$$P_{acc} - P_{out} = \frac{L\rho}{A_2}\dot{q}_{out}$$

Note: This question is very similar to Problem Set 4, question 6.

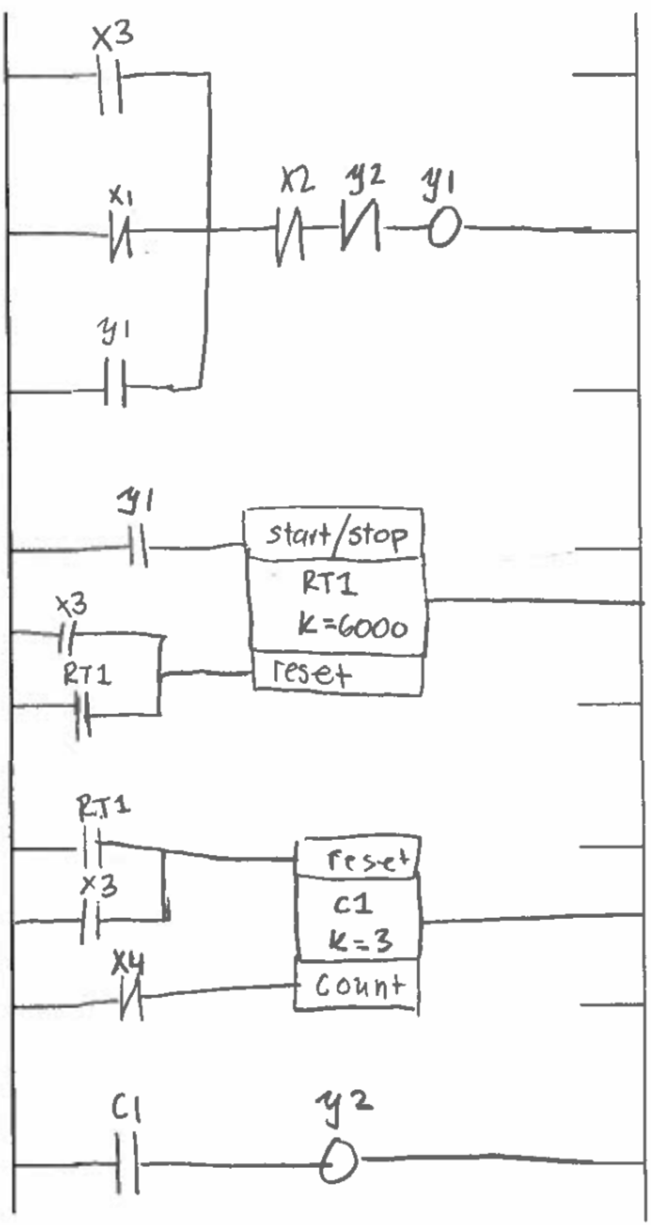
5 **3.** Whenever a proximity sensor's output is off, a motor should be turned off for 3 s, then on for 7 s, then off for 3 s, and so on. The motor should be turned off whenever the sensor's output is on. **The timer resolution is 0.01 seconds. Write the required ladder logic program in the space provided below. Use the signal definitions listed in the table below.** <u>Use only the instructions taught in this course in your answer. Do not use any Markers, RT or UDC instructions.</u>

Signal	Description
X1	Proximity sensor
Y1	Motor
T1	Timer for OFF period
T2	Timer for ON period



Note: This question is very similar to Problem Set 4, question 8.

15 **4.** The motor of a conveyor carrying parts should be started by pressing a normally closed switch and stopped by pressing a normally off open switch. The motor should remain on after the start button is no longer being pressed. The motor should be turned off (or not turn on initially) whenever the stop button is pressed. When a part is defective a vision system sends an OFF signal to the PLC, otherwise it sends an ON signal. When more than 2 defective parts occur over a 100 minute period of motor operation, the motor should be stopped, and a warning light turned ON to signal the operator. The timing of motor operation should <u>not</u> be affected if the motor is stopped by the user pressing the stop switch and started later using the start switch. The system should be reset, warning light turned off, and the conveyor restarted when a normally off open "Restart" switch is pressed. All switches are momentary pushbutton switches. **Using the signals defined in the table below, and the instructions taught in this course, write the required ladder logic program in the space provided below. <u>The timer resolution is 1 second.</u>**



Signal	Description
X1	<u>Normally ON closed</u> start switch
X2	<u>Normally OFF open</u> stop switch
X3	<u>Normally OFF open</u> restart switch
X4	Signal from vision system
C1	Counter
RT1	Timer
Y1	Motor
Y2	Warning light