Homework 1, Automation Spring 2019
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Handed out 05.03.2019, due 12.03.2019 before class (8:15)

WOSSEN HAILEMARIAM

1 Help Charlie a.k.a. the automation puzzle

Use the sensor technologies explained in the class to improve the Feeding Machine from the movie excerpts shown in the class (source: https://www.youtube.com/watch?v=n_1apYo6-Ow). Propose sensors to add to the device in order for the augmented machine to satisfy the following specifications:

::::
1- Using which appears on a body in motion in a rotating reference frame, we can estimate the magnitude of rotation! We can adjust it so that the soup will rotate to a certain degree, while dispensing the soup.
….gyroscope or gravity sensor

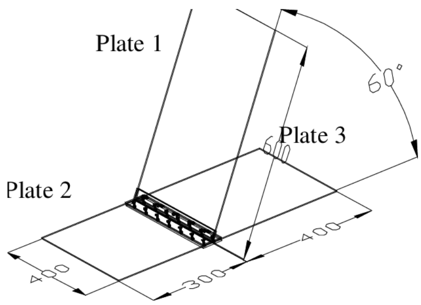
2- For this we can use an Ultrasonic Transducer, we can use the piezoelectric crystal technology to generate and receive the sound waves. We can also use Capacitive sensors.
Actually we can use any proximity sensor …. which are able to detect the presence of nearby objects without any physical contact. This way the soup will stop at a distance ‘dp’ from the person.

3- Again for this we can either use the Capacitor sensor or just piezoelectric sensors. This way when it is touched on the rim it will do the job properly.

4- We can use the accelerometer for this purpose. An **accelerometer** is an electromechanical device used to **measure** acceleration forces.
We can use this technology to check it does not accelerate to a certain degree. When it does … so that it will decrease the speed.

5- To sense the pressure we can simply use either the piezoelectric transducer of the capacitor sensor. However, to sense when certain point are touched and certain are not, the capacitor sensor maybe more preferable.
Then we can adjust it so that it will roll further to the right if the pressure on its left side is below threshold pl, and roll further to the left if the pressure on the right is below threshold pr

:::: Bonus,
1, It best to install at the bottom on the lever, preferably at the center. This way it will sense the rotation angle more precisely.

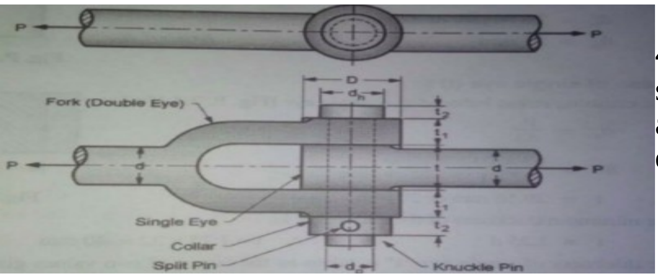


Also we have to consider the size of the sensor… does not matter if it is the gyroscope of the simply the gravity sensor. It is not necessary to install it on the plate, I think it much more efficient to install it on the lever some where.

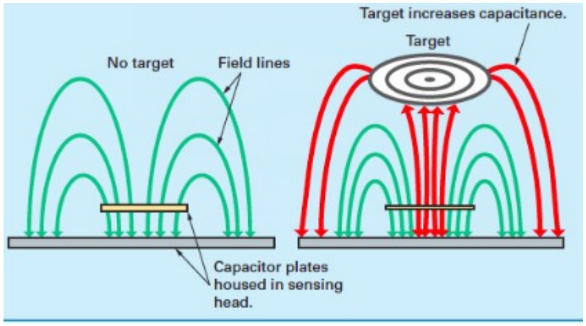
2- We can install the Ultrasonic Transducer, just at the rim of the lever. **NOT THE PLATE.** (Actually it does not make sense to install anything on the plate… what if we want to change the plate, it is simply not efficient to install any sensor on the plate.)

When it distance dp from the person it will stop.

3- Again, simply install the capacitive sensor on the rim of the plate/ lever.



4- The angle of the plate to horizontal plane maybe at $\cos^{-1} a$ [rad], should stop the tipping motor when the value reaches αp. And the acclerometer should just me installed at the tip of the hand that doesn’t rotate. Observing the rotation.



5- The capacitor sensor should be installed right underneath the face wiper. Certain distance under. When it is touched it will easily sense it.

2 Liquid level sensor

2.1 Measurement principle [5 Points]

Various liquids are pumped through and stored in a opaque plastic accumulator tank. It is tall, flat and of uniform thickness. The liquid level, which usually oscillates between level min. and level max. (see diagram) needs to be known at all times in order to avoid spills. Metal plates are installed on both sides of the tank in the arrangement shown. You can assume that each of the shown plates has identical properties such as thickness and material and is isolated from the rest. Lower and upper plates’ height is l1 and l2 respectively. Electric leads are connected to them according to the schema. The liquid is typically always present in the bottom part of the tank.

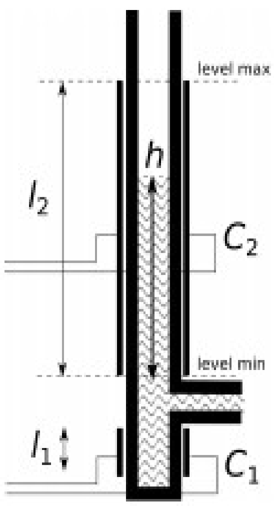


Figure 2: Level of liquid to be measured in a tall plastic accumulator tank.

::::

A Capacitive sensor can be use to sense the liquid level.

$C == h_w E_w + (h_l - h_w) E_a$

hl = the maximum height of the liquid

hw = height of the liquid

Ew = dielectric of the liquid

Ea = dielctric of air

From equation (1), the capacitance (C) value is affected by the value of , A , and l . Hence, equation (3) and (4), which shows the influence of the variables to sensor's capacitance value, can be derived from equation (1).

$$\ln C = \ln \varepsilon + \ln A - \ln l$$

$$\frac{\Delta C}{C} = \frac{\Delta \varepsilon}{\varepsilon} + \frac{\Delta A}{A} - \frac{\Delta l}{l}$$

$$S = \frac{\Delta C}{\Delta A} = \frac{1}{b}\frac{\Delta C}{\Delta x} = \frac{\varepsilon}{l}$$

2.2 Practical implementation

Let’s assume that you have a voltage source of 5V and a measurement device which can sense when the voltage is lower than 0.5V and higher than 4.5V. This device can trigger a timer which will measure the period P between “low” and “high” voltages. Take w as 1.5m, l2 1.0m and d =5cm. Assume that the liquid is water for this part of the exercise (look up the corresponding constant) and you can ignore the walls of the container. Using a method explained during the class, 1) explain in a couple of bullet points how to measure the level of water using timing P; 2) choose an approximation value of the resistance R to be able to measure cycles of 0.025s between low and high voltages at full water level. What will be the length of the cycle when the water level is below the measurement plates? (feel free to use numerical solution but do not forget to describe it!)

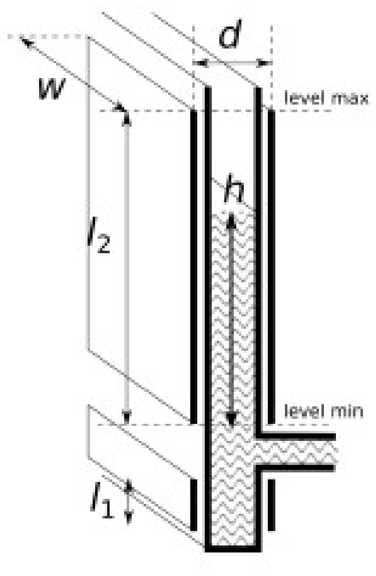


Figure 3: More information about the tank and the plates.

:::: As the question states the timing is triggered by the voltage change, and that how we can use timing to check the level of water. So, we just have to figure out how the water level affects the voltage, and we have discussed this very clearly in class that when there is more water/liquid between the plates… meaning less dielectric between the plate the voltage will decrease. When there is less water that is more dielectric between the plates, the voltage will of course increase. The length of the cycle when the water level is below the measurement plates if therefor very high.

3 The good, the bad and the ugly thermometer

Therm. 1 [°C]	Therm. 2 [°C]	Therm. 3 [°C]
19.926	20.904	19.800
19.562	20.542	20.400
19.692	20.499	19.500
20.061	21.087	20.100
19.436	21.092	19.500
19.700	20.782	19.500
20.613	21.053	19.500
19.933	21.142	19.800
20.630	20.856	20.100

……Which is the most accurate and the most precise of the three? Back your qualitative answer with the reference to the data. The third thermometer is likely suffering from a specific problem (hint: it's not bias!), can you guess which? What is the likely mechanism?

::::

The Accuracy is a measure of the degree of closeness of a measured or calculated value to its actual value.
We can simply compare their errors to know which one is the most accurate.

Error_Value = |Actual_Temperature – Measured_Temperature|
all in absolute value

: then we can add them up, and the one with the less SUMof-Error_Value is the most Accurate one.

Therm1 = |0.074| + |0.438| + |0.303| + |-0.062| + |0.564|
+ |0.300| + |-0.613| + |0.067| + |-0.630|

= 0.441

Thern2 = |-0.904| + |-0.562| + | -0.499| + |-1.087| + |-1.092|
+ |-0.782| + | -1.053| + |-1.142| + |-0.856|

= 7.997

Therm3 = |0.2| + |-0.4| + | 0.5| + |-0.1|+ | 0.5|+ | 0.5|
+ | 0.5|+ | 0.2|+ | -0.1|

= 1.8

: So clearly the **first thermometer** is the most accurate.

: To know which one is the most precise, we just have to take the average of each one of them. Then subtract each value from the average. Add them up, compare them with each other. The one with the lesser value. Or again with the lesser error value from the average is the most precise one.
…. in other word we must calculate the deviation of each thermometer.

Therm1 = 19.926 + 19.562 + 19.692 + 20.061 + 19.436 + 20.613 +19.933 + 20.630
…...
…… find the average first
…… we do the same for the other thermometers...(time consuming to type)

the subtract and compare….

at the end :the **second thermometer** is the most precise one….

: Regarding the third thermometer, it is suffering from **resolution** problem. All the last two digits do not show any number. So, some adjustment should be done with the calibration.

4 *Multiple choice*

Mark the following statements True (T) or False (F)

1- Piezoelectric crystals can produce high voltage without being subjected to oscillation.
:::: **FALSE**

2- Hysteresis can cause a sensor to output two different readings at different moments for the same measured input level.
::::**TRUE**

3- Coriolis acceleration arises from movement in inertial reference frames.
::::**TRUE**

4- Time of flight measurement principle can be used to estimate distance using light or sound waves.
::::**TRUE**

5- MEMS devices must involve semiconductor elements.
::::**FALSE**