Eastern
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University

Name: ______________________ **Std.No:** ____________

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CMSE423 Embedded System Design (HE)
Midterm Exam. Fall-XXXX-XX (XX-XX-XXXX)

Assoc. Prof. Dr. Mehmet Bodur,

Total three pages (including the cover page), 10 question, 90 minutes. Please attempt all questions.

- Student who ATTEMPT TO CHEATİNG will GET ZERO for the exam, and may be directed to disciplinary investigation for further punishment. Sharing pen, pencil, eraser, and sharpeners is considered as attempt to cheating.

- Remove all notes, books and unnecessary objects from your desk. Keep only THİS BOOKLET, PEN-PENCİL-ERASES AND YOUR ID CARD on your desk.

- Having any kind of electronic calculators, computers, phones and gadgets such as earphones, intelligent watches etc. at any easy accessable place is strictly not allowed. You are allowed to keep electronics gadgets in your bags after turning their power off. Do not keep electronic watches on your wrist, desk, or in your pocket.

- Talking, making any kind of noise, asking questions are not allowed. Do not talk, and do not create any sound once the exam is started.

Evaluates the following course learning outcomes:

Q1-Q2-Q3-Q9 5-**Know common cyber modelling tools and methods**, and apply **FSM** techniques on HES (1)
Q4-Q7 1-Perform **kinematic and dynamics modelling, and analysis** of simple physical systems (1).
Q5 2-Know **typical structure of a HES**, and use simple digital i/o ports in C (1).
Q6 4-Know typical **control, and monitoring approaches** for High End Embedded Systems (HES) (1).
Q8-Q10 3-Know **analogue, digital and hybrid approaches, and use a typical AD converter** of a HES (1).

Q1. List two computing tools commonly used for modeling continuous systems which we used in this lecture:

1. ....4p
2. ....4p

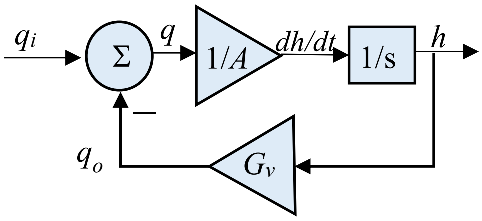
Q2. Which kind of equations can describe the output of a continuous system mathematically?

....4p

Q3. What is the name of the diagram that describes the change of outputs of a continuous system in time graphically?

....4p

Q4. The following system describes the height of water h in a water tank with crosssectional area A that leaks by valve-V q_o liters per hour (lt/h). The tank is filled by an inflow q_i.



i- Write the equation that describes the relation between the rate of water height (dh/dt) and the net inflow q into the tank.

....4p

ii- Write the equation that describes the leak q_o.

....4p

iii- Write the equation that describes the water height h for the water inflow q_i in terms of area A, and leak coefficient G_v.

....4p

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vi- Find the time constant of the water height in terms of A and G_v.

....4p

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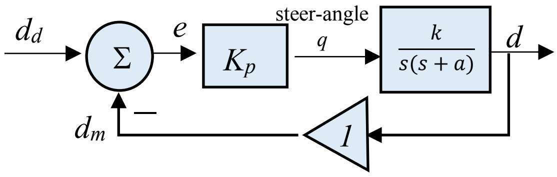
Q5. List three common parts of a Cyber Physical system which is built using a High-End Embedded System and contains multiple processing units.

....4p

....4p

....4p

Q6. The lateral position (y-position) of a vehicle is controlled by measuring the distance of vehicle to the side line of the road, and calculating the direction to turn the steer from the error between the desired side line distance d_d (= 1m) and measured side-line distance d_m.



i- While using P control with gain K_p=10, measured distance d_m is 1.2m, and desired distance is 1m.
What is the value of error e in units of meter?

....4p

ii- The steering system is a second order system with a pure integration. As a result, the proportional control law does give a stable control action. What kind of control do you propose to get a stable lateral position control for this system?

....4p

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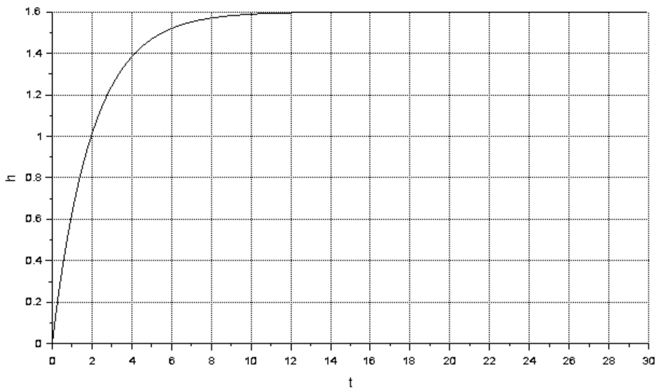
Q7. The tank in Q4 is tested to get the steady state gain and time constant of the leaking tank. Engineer starts from empty tank, and sets the inflow to q_i=2.2 lt/h. He gets the following chart after 20 hours of test.



i- Find the steady state value for q_i=2.2 lt/h.

....4p

ii- At steady state dh/dt=0, thus q_o shall be equal to q_i. Using this property find the leak coefficient G_v.

....4p

iii- Using the "63%" method find the time constant.

....4p

....

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Q8- A cat-door has an electronic lock mechanism that analyze the sound of the house-cat and distinguish it from street-cats by analyzing the [1kHz, 8kHz] frequency range of her sound when the cat is at the front of the door.
The special cover design of the microphone limits audio frequencies above 12 kHz. This mic converts 0-2 Pa pressure range to 0-0.2V output range.

i- What shall be the minimum ADC sampling frequency of mic output for lossless processing of the sound.

....4p

ii- Does the ADC need an anti-aliasing filter? What shall be the bandwidth of the filter?

....4p

....

iii- The precision of the mic is 0.4 mV. Find the dynamic range of the mic.

....4p

iv- What shall be the mic-amplifier gain to utilize the full range of a 0-5V ADC input?

....4p

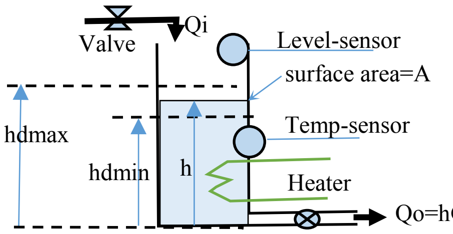
iv- Among {8-bit, 9-bit, 10-bit, 11-bit, 12-bit} conversion options of the ADC, which option is just sufficient to use the full precision of the mic?

....4p

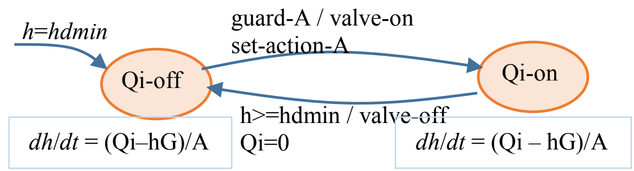
Q9- An LED is required to display the value of `D` ∈ {1,2,3}. Draw a single mode FSM diagram of an extended state machine that:

4p i- runs time-triggered at every 0.1 sec. period.
4p ii- always increments an extended st. counter `C`.
4p iii- sets `C=1` if `C` exceeds `6` (for cyclic counting)
4p iv- outputs `Lon` if `(2*D>C) and ((C mod 2)==1)`,
4p v- outputs `Loff` if `(C mod 2) == 0`.

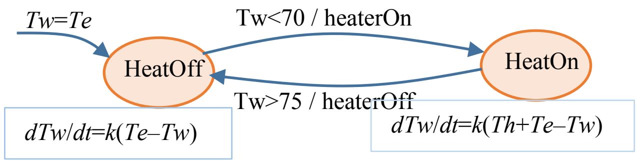
Q10. The model of the simultaneous temperature and level control of a water tank is shown by two concurrent hybrid FSMs.



The level controller actuates the valve to fill in the tank when level drops under hdmin until it exceeds hdmax. Valve lets Q_i lt/min water to fill the tank, while water leaks out by Qo=h G lt/min. Water height changes by dh/dt= Q/A, where Q=Qi-Qo is the net inflow to the tank and A is the water surface area.



The temperature control turns on a heater that can heat up the tank *Th* Celsius more. While heater is off, water temperature *Tw* cools down at a rate $dTw/dt=k(Te-Tw)$, and when heater is on it is heated up at a rate $dTw/dt=k(Th+Te-Tw)$.



According to the FSM diagrams

i- how much water shall be in the tank at the starting time of FSM?

....4p

ii- What shall be guard-A for the described operation of the water level control?

....4p

iii- What shall be set-action-A of the water level control?

....4p

iv- For a safe operation, the heater shall be off while the water level is below hdmin. The guard of HeatOff to HeatOn transition shall be modified to improve the safety accordingly. Write the modified guard down:

....4p