PRINCE OF SONGKLA UNIVERSITY
FACULTY OF ENGINEERING

Final Examination: Semester I — Academic year: 2009
Date: October 3, 2009 — Time: 13.30-16.30
Subject: 230 – 425 Process Dynamics and Control — Room: หัวหุ่นยนต์

ทุจริตในการสอบ โทษขั้นต่ำ คือ ปรับตกในรายวิชาที่ทุจริต และพักการเรียน 1 ภาคการศึกษา

- **Only hand written note on a sheet of A4, calculator and a dictionary are allowed.**
- There are 9 pages of the exam.
- Write your name or your code on each page.
- If need to write the answers on the back of each page, please identify the problem number.

Problem Number	Score	
1	25	
2	25	
3	30	
4	15	
5	30	
6	40	
7	15	
Total	180	
Bonus	2	

Dr. Kulchanat Prasertsit

1 (25 points) From the class room report, answer the following questions:

1.1 (2 points) Show how pH sensor works?

1.2 (2 points) Show 5 types of load cell:

1.3 (3 points) Show example of 2 types of flow sensor.

1.4 (6 points) Show advantage and disadvantage of 3 moisture sensor

Moisture sensor	advantage	disadvantage
Capacitive		
Resistive		
Thermal conductivity		

1.5 (1.5 points) What is the meaning of "psid"?

1.6 (1.5 points) What is the property for material used as diaphragm in pressure sensor?

1.7 (2 points) Concentration detector works by using…

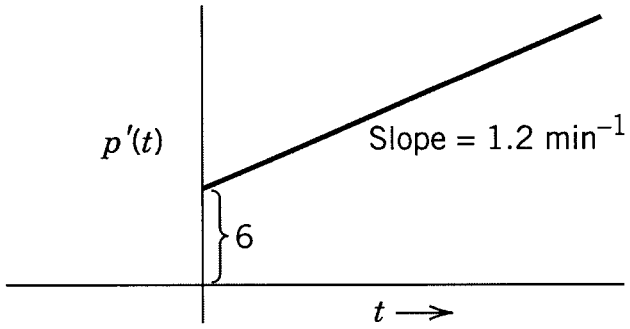
1.8 (3points) Show type of temperature sensors almost used in industries and their examples

Type	**example**

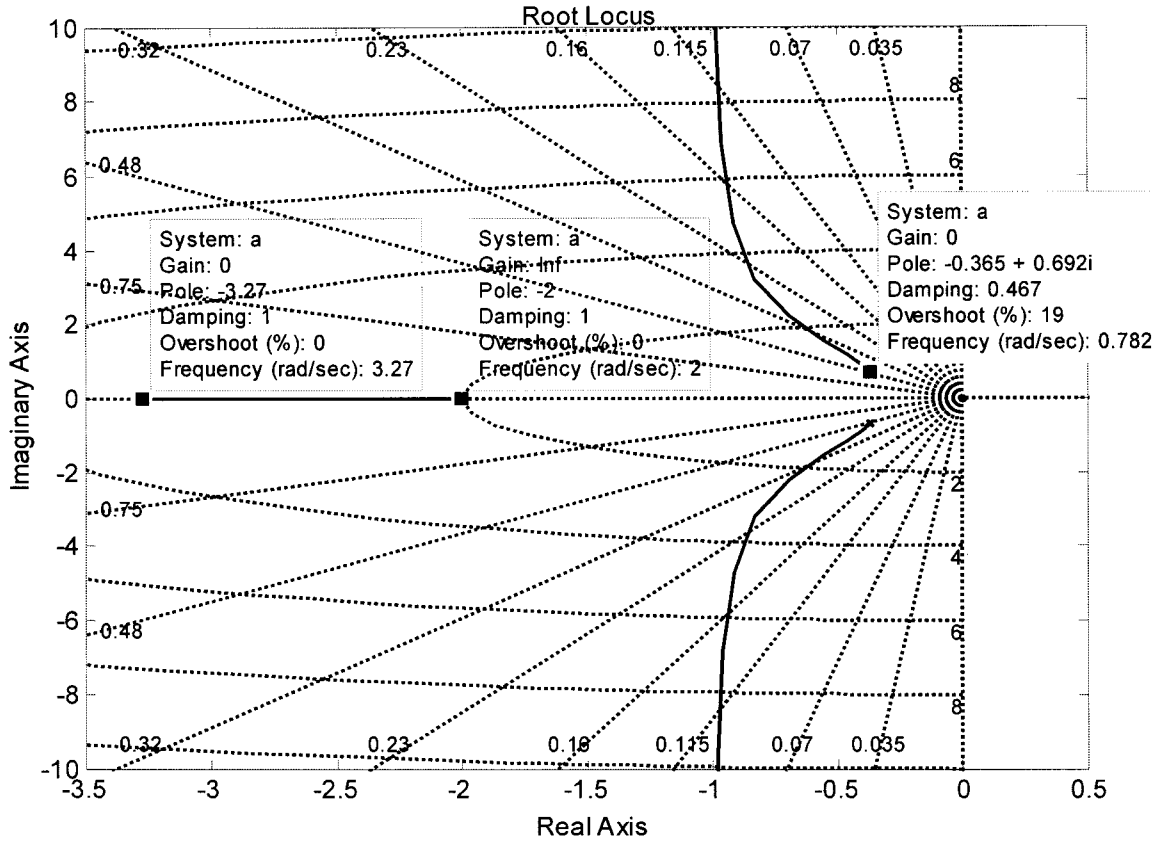
1.9 (2 points) What is the difference between point and continuous level sensors?

1.10 (2 points) Explain concept of composition analyzer.

2 (25 points) If the input Y_M to a PI controller changes stepwise ($y'(t) = 2$) and the controller output $p'(t)$ changes initially as in figure below, determine the value of the controller gain and integral time constant.



3 (30 points) From Root Locus plot below, answer the following question :



3.1 What range of gain that makes process stable?

3.2 What are the positions of zero and pole of the process?

3.3 Find out the system order.

3.4 Show the transfer function of this process.

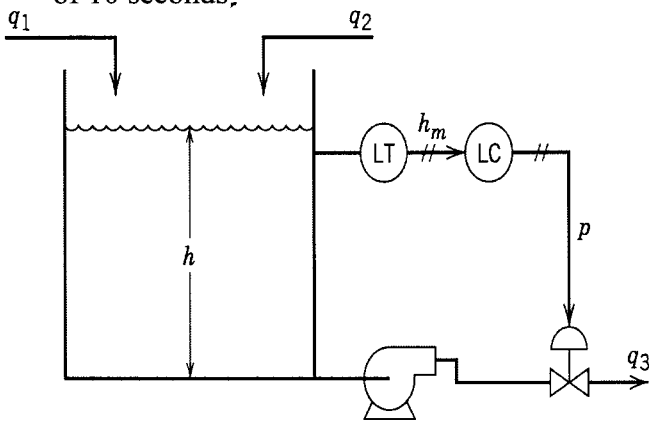
3.5 Mark on the figure for the gain that makes process has damping factor of 0.25 and calculate its % overshoot.

4 (15 points) A heat transfer process has the following transfer function between a temperature T and an inlet flowrate Q:

$$\frac{T'(s)}{Q'(s)} = \frac{3(1-s)}{s(2s+1)}$$

where the time constant has unit of **minute**. If the flowrate varies sinusoidally with amplitude of 2 L/min and a period of 0.5 min, what is the amplitude of the temperature signal after the transients have died out?

5 (30 points) For the liquid level control system (PI controller) in figure below, determine each transfer functions and the value of Kc and τ_I which make closed-loop system stable. The level transmitter has negligible dynamics, while the control valve has a time constant of 10 seconds.



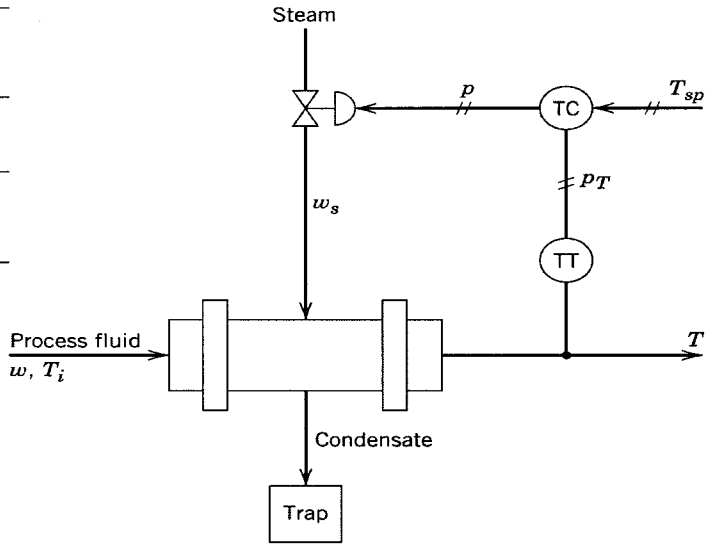
Given data

Gp =-1/(AS)
A= 22.4 gal,
$\bar{q}_3 = 10 gal/\min$
Kv = -1.3 gal/min/mA
Km=-4mA/ft

6 (40 points) The dynamic behavior of heat exchanger and other symbols shown in figure below can be described by the following transfer function (H.S. Wilson and L. M. Ziss, *ISA J.*, 9, 59 (1962)):

Process	$\frac{T'}{W's} = \frac{2^{o}F/lb \cdot \min}{(0.432s+1)(0.017s+1)}$
Control valve	$\frac{X'}{P'c} = \frac{0.047in/psi}{0.083s+1}$, $\frac{W's}{X'} = 112\frac{lb}{\min \cdot in}$
Temp. sensor	$\frac{P'_T}{T'} = \frac{0.12psi/^{o}F}{0.024s+1}$

The valve life x is measure in inches.



If PI controller (which Kc = 5.84 and τ_I = 0.288 min) is used in this process, calculate the corresponding gain and phase margins.

7 (15 points) Describe how each control loop works.

7.1 Cascade control

7.2 Ratio control

7.3 Auctioneering control

Bonus (2 points) Write 2 names of 2009 best alumni from chemical engineering department. (write in Thai)