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SET A

UNIVERSITI KUALA LUMPUR
Malaysia France Institute

FINAL EXAMINATION

SEPTEMBER 2013 SESSION

SUBJECT CODE	:	**FAB 30503**
SUBJECT TITLE	:	**MECHATRONICS SYSTEM DESIGN**
LEVEL	:	**BACHELOR**
TIME / DURATION	:	**(3 HOURS)**
DATE	:	

INSTRUCTIONS TO CANDIDATES

1. **Please read the instructions given in the question paper CAREFULLY.**
2. **This question paper is printed on both sides of the paper.**
3. **Please write your answers on the answer booklet provided.**
4. **Answer should be written in blue or black ink except for sketching, graphic and illustration.**
5. **This question paper consists of TWO (2) sections. Section A and B. Answer ALL questions in Section A. For Section B, answer THREE (3) questions only.**
6. **Answer all questions in English.**

THERE ARE 8 PAGES OF QUESTIONS, EXCLUDING THIS PAGE.

SECTION A (Total: 40 marks)

INSTRUCTION: Answer ALL questions.
Please use the answer booklet provided.

Question 1

(a) i. Explain the different between open-loop and closed-loop control system

(2 marks)

ii. Describe **three (3)** types of controller that are normally used in control system

(3 marks)

iii. The mechatronic design process consists of three phases. List all **three (3)** phases.

(3 marks)

iv. Briefly describe the meaning of modeling and simulation.

(2 marks)

(b) A simple physical system with a few sensors and actuators need to be integrating with a computer system. Draw and label a block diagram of complete mechatronics system with the essential elements of mechatronics.

(5 marks)

(c) Power systems are designed to transmit large quantity of electrical energy. List two types of power systems devices.

(2 marks)

(d) Explain the discrete control system and give an example.

(3 marks)

Question 2

(a) Describe product development and give **two (2)** examples of product.

(4 marks)

(b) The product live cost and profit cycle can be divided into two phases; premarket phase and market phase. Draw the curve of product live cost and profit cycle and explain each of phases in terms of profit and loss.

(5 marks)

(c) Illustrate with a block diagram a traditional design process in mechatronics design approach.

(3 marks)

(d) Explain the differences between concept generation and concept selection in conceptual design.

(4 marks)

(e) **Figure 1** shows the power-assisted device that Company A plan to introduce in the fourth quarter of year 2010. The mission statement of the product planning is shown in **Figure 2.** Produce **four (4)** steps of product planning activities from planning to production ramp-up.

(4 marks)

Figure 1: Power-assisted device

Product Description
- A hand-held, power-assisted device for installing threaded fasteners

Key Business Goals
- Product introduced in 4th Q of 2010
- 50% gross margin
- 10% share of cordless screwdriver market by 2015

Primary Market
- Do-it-yourself consumer

Secondary Markets
- Casual consumer
- Light-duty professional

Assumptions
- Hand-held
- Power assisted
- Nickel-metal-hydride rechargeable battery technology

Stakeholders
- User
- Retailer
- Sales force
- Service center
- Production
- Legal department

Figure 2: Mission statement

SECTION B (Total: 60 marks)

INSTRUCTION: Answer only THREE (3) questions.
Please use the answer booklet provided.

Question 3

(a) A PCB drilling machine can move 1000 mm along the x-axis and 500 mm along the y- axis. The machine drilling head is driven by a combination of lead screws and electric motors. Each axis has an absolute encoder which permits a placement accuracy of 0.01mm.

i. Calculate the minimum number of code bits required to achieve the designed placement accuracy on the x-axis.

(5 marks)

ii. Describe the difference between incremental and absolute encoders using the above mechatronics application as a practical example.

(4 marks)

(b) Refer to **Figure 3,** describe the working operation of inductive proximity sensor.

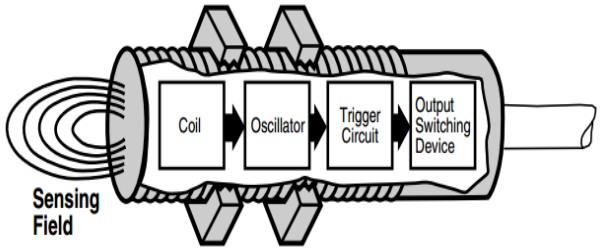

Figure 3: Inductive proximity sensor

(c) A thermocouple giving an output of 0.5mV/°C. find the word length required when its passes through ADC if temperature from 0°C to 200°C are to be measured with the resolution of 0.5°C.

(6 marks)

(d) Inverting operational amplifier which has a resistance of 1 MΩ in the inverting input line and feedback the résistance of 20 MΩ. Calculate the voltage gain of the circuit.

(2 marks)

(e) Consider the situation where the microprocessor gives and output of an 8 bit word. This is fed through and 8 bit digital to analog converter to a control valve. The control valve required 6 V to be fully open. If the fully open state is indicated by 1111 1111, calculate the output of the valve for a change of 1 bit.

(3 marks)

Question 4

Figure 4 shown a schematics diagram of PIC 16F877A wiring diagram. This is a simple application on how to start a basic PIC programming.

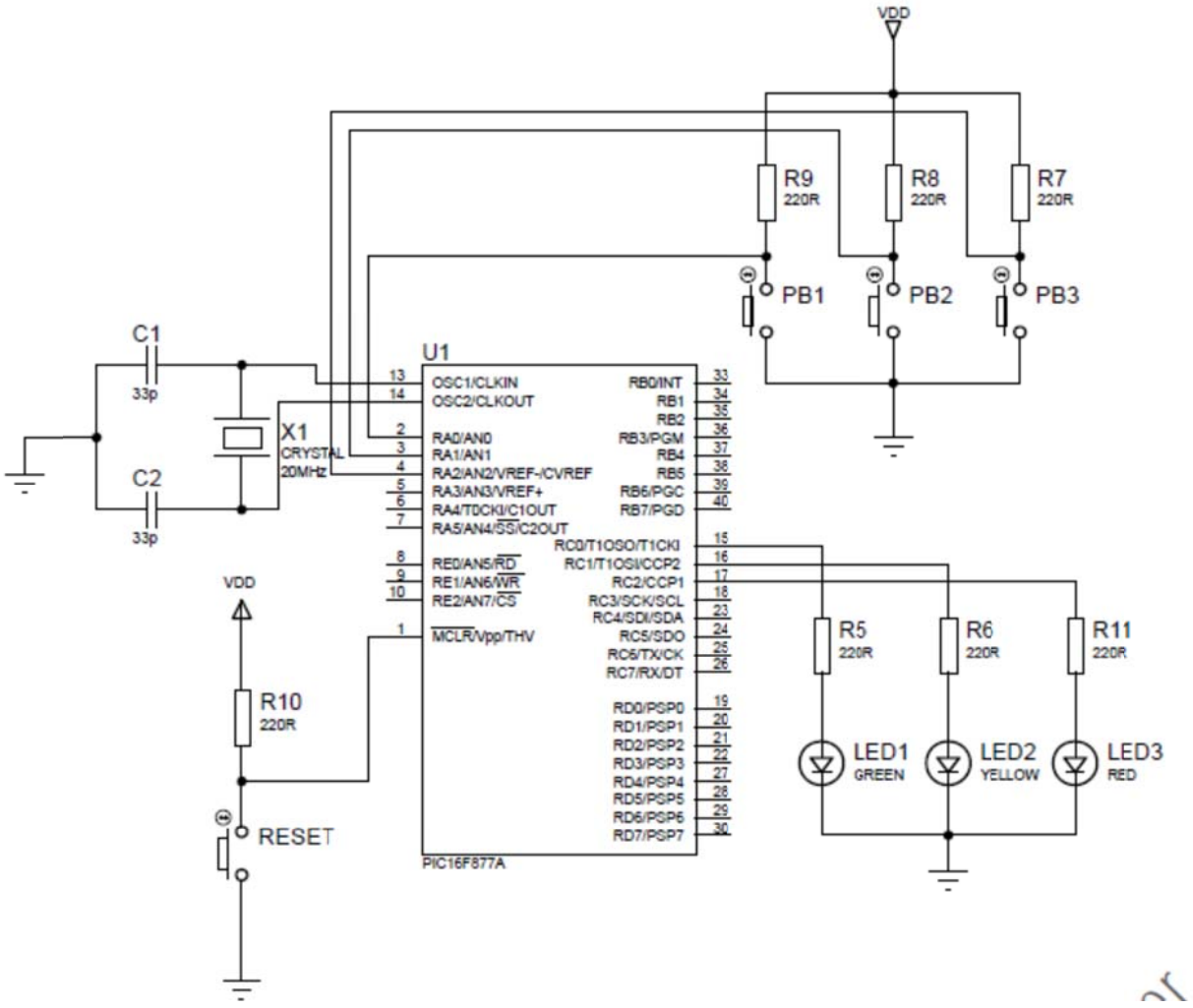

Figure 4: Schematic of PIC16F877A

(a) Determine the inputs and outputs of the PIC. (2 marks)

(b) Describe the functionality of the component label X1, CRYSTAL, 20MHz. (2 marks)

(c) Create a program of pin configuration for push buttons (PB) and LEDs at PORT A and PORT C. (4 marks)

(d) Based on **Figure 5** and **Figure 6** create a main program of LED blinking pattern 1 and pattern 2. Pattern 1 will be blinked if PB1 is pressed and pattern 2 will be blinked if PB2 is pressed. Call function delay_ms(100) for delay. The header file should be as follows:

```
#define PB1 RA0
#define PB2 RA1
#define PB3 RA2
```

(10 marks)

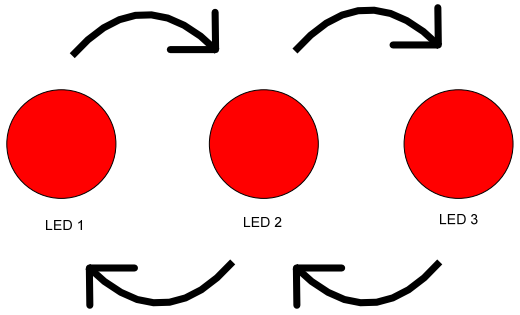

Figure 5: Pattern 1

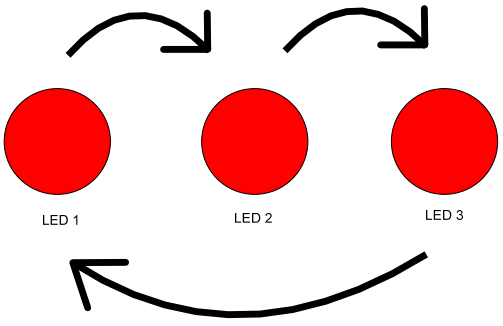

Figure 6: Pattern 2

(f) A microcontroller PIC 16F877A have a few 8-bit bidirectional port. Explain the meaning of 'TRISA = 0x07' in term of input and output bits, if this statement stated in the programming step.

(2 marks)

Question 5

(a) Consider three meshed gear wheels A, B and C in **Figure 7.** If there are 40 teeth on wheel A, 80 teeth on wheel B and 120 teeth on wheel C, find the overall gear ratio of the angular velocities at the input and output shafts.

(6 marks)

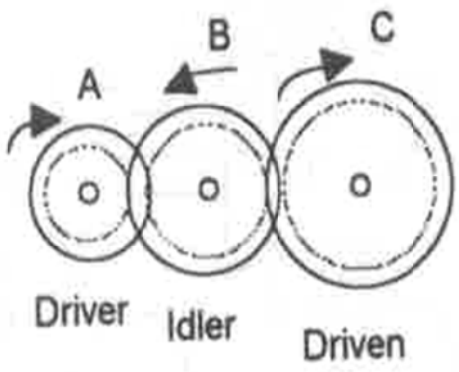

Figure 7: Three meshed gear wheels

(b) Draw the graph Displacement against Rotation for this CAM if the follower is a point as in **Figure 8**.

(6 marks)

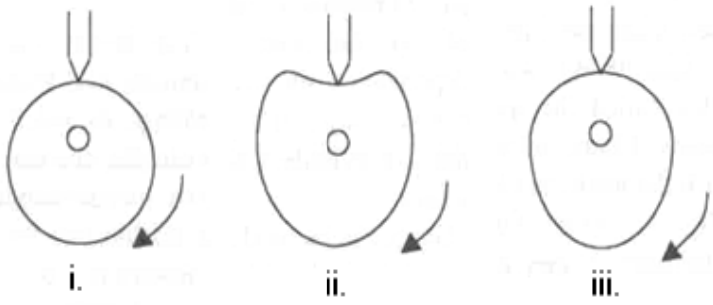

Figure 8: CAMs

(c) Refer to **Table 1**, find the valve size that is required to control the flow of water when the maximum flow required is 0.012m^3/s and the permissible pressure drop across the valve at this flow rate is 300 kPa. Density of water is about 1000 kg/m³.

(4 marks)

Table 1: Flow coefficient and flow control valves.

Flow coefficients	Valve size (mm)							
	480	640	800	960	1260	1600	1920	2560
C_V	8	14	22	30	50	75	110	200
$A_V \times 10^{-5}$	19	33	52	71	119	178	261	474

(d) Draw a pneumatic circuit for extend and retract cylinder by using 3/2 way valve.

(4 marks)

Question 6

(a) List 2 key steps of modeling methodology.

(2 marks)

(b) Initially, there is no current flow in the circuit and the switch is in open position. At time *t*=0, the switch is places in closed position and voltage *e* is applied. Current starts to build up in the circuit and starts charging the capacitor. The voltage in the circuit at time t is given by:

resistor voltage + inductor voltage + capacitor voltage = applied voltage

Determine the transfer function for voltage *V*(s) and applied input $E(s)$ for the following circuit:

(8 marks)

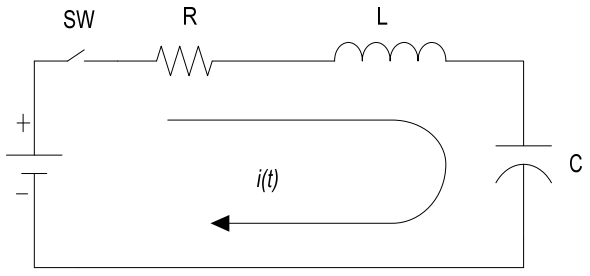

Figure 9: RLC Circuit

(c) **Figure 10** shows the two (2) tanks connected in series that fluid level in downstream tank does not affect the fluid-level dynamics of the upstream tanks**.**

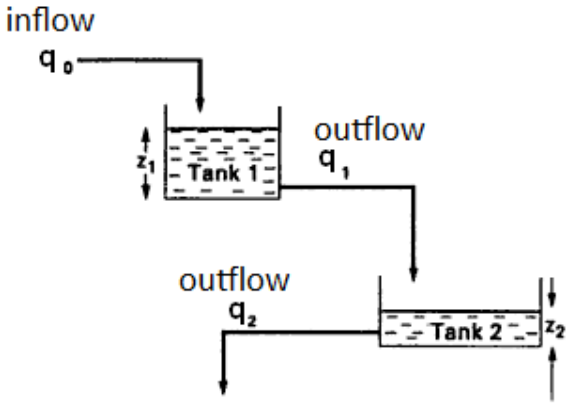

Figure 8: Noninteracting tanks

Variables used:

z_1 = fluid level in the upstream tank (1)
z_2 = fluid level in the upstream tank (2)
q_0 = fluid flow rate into tank 1
q_1 = fluid flow rate out of tank 1 and into tank 2
q_2 = fluid flow rate out of tank 2
R_1 = resistance of the tank 1 outlet
R_2 = resistance of the tank 2 outlet

I. Find the transfer function; $\frac{Z_1(s)}{Q_0(s)}$ of tank 1.

(5 marks)

II. Find the transfer function; $\frac{Z_2(s)}{Q_1(s)}$ of tank 2.

(5 marks)

END OF QUESTION