



**UNIVERSITI KUALA LUMPUR**  
**Malaysia France Institute**

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**FINAL EXAMINATION**  
**JANUARY 2010 SESSION**

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<b>SUBJECT CODE</b>	<b>:</b>	<b>FAB 30903</b>
<b>SUBJECT TITLE</b>	<b>:</b>	<b>MECHATRONICS DESIGN PROJECT</b>
<b>LEVEL</b>	<b>:</b>	<b>BACHELOR</b>
<b>TIME / DURATION</b>	<b>:</b>	<b>9.00am – 12.00pm</b> <b>( 3 HOURS )</b>
<b>DATE</b>	<b>:</b>	<b>03 MAY 2010</b>

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**INSTRUCTIONS TO CANDIDATES**

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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.
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**THERE ARE 9 PAGES OF QUESTIONS, EXCLUDING THIS PAGE.**

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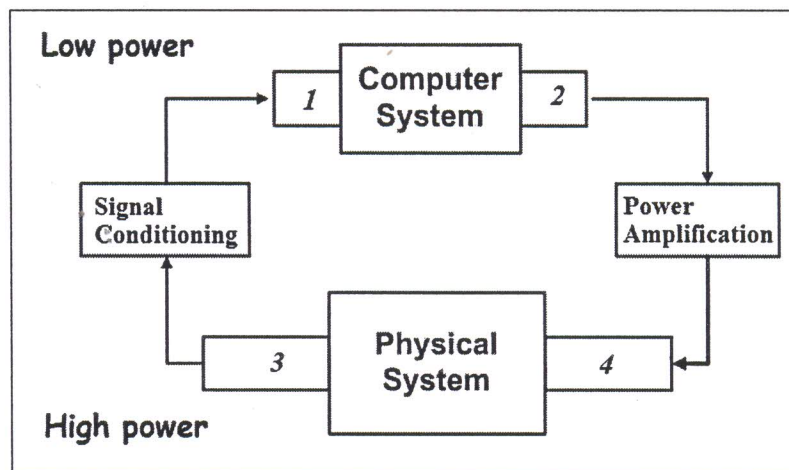
**SECTION A (Total: 40 marks)****INSTRUCTION: Answer ALL questions.****Please use the answer booklet provided.****Question 1**

a)

- i. Describe the four (4) key elements of mechatronics. (4 marks)
- ii. Explain the difference between continuous and discrete control system. (2 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) Refer to **Figure 1**,

- i. Name elements 1, 2, 3 and 4. (2 marks)
- ii. Explain the function of all elements in **Figure 1**. (7 marks)

**Figure 1: Block diagram of a mechatronic system**

## Question 2

a)

- i. Referring to **Figure 2**, explain the relationship between product development time and product development cost.

(2 marks)

- ii. Describe the curve of product live cost and profit cycle as shown in **Figure 3**.

(4 marks)

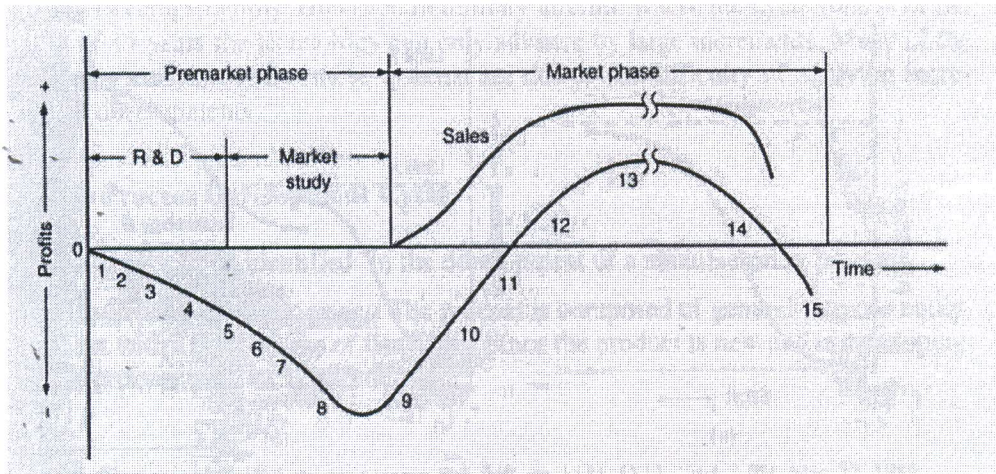
- iii. Briefly describe the difference between traditional design approach and mechatronic design approach. Give an example for each approach.

(4 marks)

	Stanley Tools Jobmaster Screwdriver	Rollerblade Bravoblade In-Line Skates	Hewlett-Packard DeskJet 500 Printer	Chrysler Concorde Automobile	Boeing 777 Airplane
Annual- production volume	100,000 units/year	100,000 units/year	1.5 million units/year	250,000 units/year	50 units/year
Sales lifetime	40 years	3 years	3 years	6 years	30 years
Sales price	\$3	\$200	\$365	\$19,000	\$130 million
Number of unique parts (part numbers)	3 parts	35 parts	200 parts	10,000 parts	130,000 parts
Development time	1 year	2 years	1.5 years	3.5 years	4.5 years
Internal development team (peak size)	3 people	5 people	100 people	850 people	6,800 people
External development team (peak size)	3 people	10 people	100 people	1400 people	10,000 people
Development cost	\$150,000	\$750,000	\$50 million	\$1 billion	\$3 billion
Production investment	\$150,000	\$1 million	\$25 million	\$600 million	\$3 billion

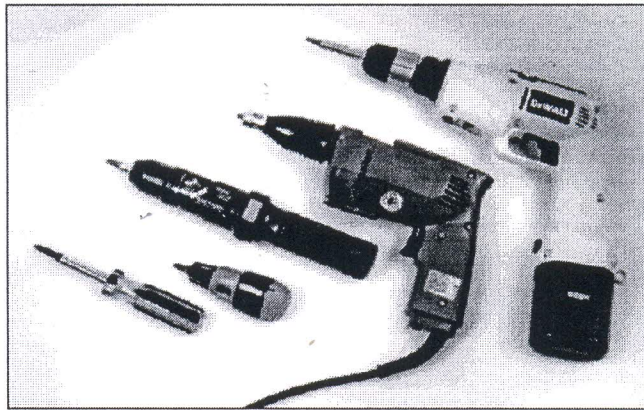
Figure 2: Product development cost and time





**Figure 3: Product live cost and profit cycle**

- b) **Figure 4(a)** 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 4(b)**.
- i. List five (5) steps of product planning activities to produce the mission statement  
(5 marks)
  - ii. Describe the meaning of stakeholders  
(2 marks)



**Figure 4(a): Power-assisted device**

<b>Product Description</b>
•A hand-held, power-assisted device for installing threaded fasteners
<b>Key Business Goals</b>
•Product introduced in 4th Q of 2010
•50% gross margin
•10% share of cordless screwdriver market by 2015
<b>Primary Market</b>
•Do-it-yourself consumer
<b>Secondary Markets</b>
•Casual consumer
•Light-duty professional
<b>Assumptions</b>
•Hand-held
•Power assisted
•Nickel-metal-hydride rechargeable battery technology
<b>Stakeholders</b>
•User
•Retailer
•Sales force
•Service center
•Production
•Legal department

**Figure 4(b): Mission statement**

- c) Product design can be classified into industrial design and engineering design. What are the meaning of industrial design and engineering design.

(3 marks)

**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 0.1mm.
- Calculate the minimum number of code bits required to achieve the designed placement accuracy on the x-axis.  
(5 marks)
  - Describe the difference between relative and absolute encoders using the above mechatronics application as a practical example.  
(4 marks)
- b) An inkjet printer uses a stepper motor to drive the print head mechanism along the carriage
- Briefly describe the operation of one type of stepper motor.  
(2 marks)
  - State why a system using a stepper motor is consider as using open loop control.  
(2 marks)
- c)
- Sketch and label the basic block diagram of a closed loop control system.  
(3 marks)
  - State how a closed loop control system generally differs from an open loop control system in terms of complexity.  
(2 marks)
  - State the main advantages of introducing Integral and Derivative control actions into Proportional control system  
(2 marks)



## Question 4

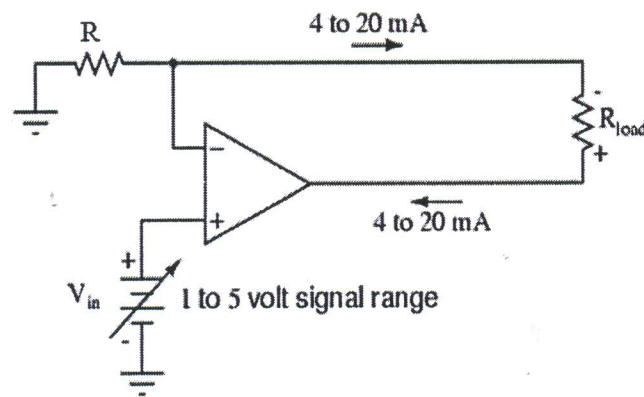


Figure 5: voltage to current converter

- a) Refer to **Figure 5**, the operational amplifier is used to convert voltage to current.
- Given the current output range is 4mA to 20mA. Determine the value of resistor R. (2 marks)
  - Determine the current output range if the value of resistor R is 100Ω. (2 marks)

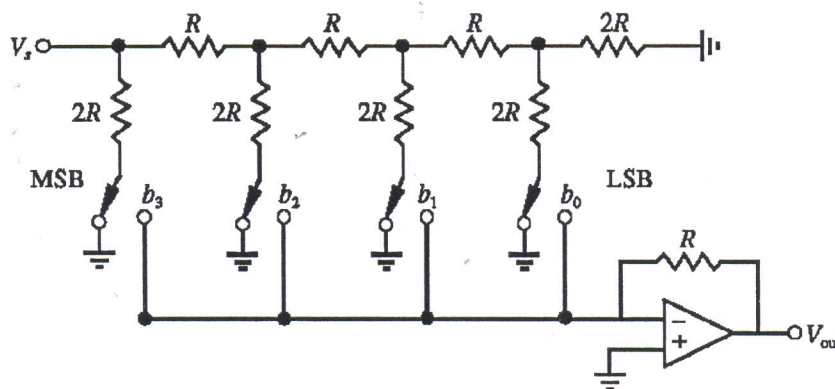


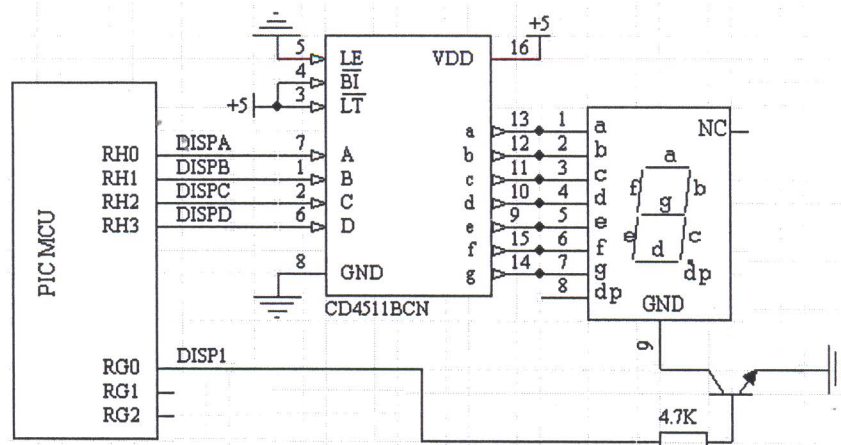
Figure 6: R-2R digital to analog converter

- b) Refer to **Figure 6**, a R-2R DAC ladder of resistors has its output fed through an inverting operational amplifier with a feedback resistance of 2R. If the reference voltage,  $V_s$  is 5V, determine the resolution of the converter. (5 marks)

- c) Consider a tachometer with a gain of  $2V/1000\text{rpm}$ . It is interfaced to a data acquisition system through an analog-to-digital converter (ADC) which has 12-bit resolution and  $\pm 10V$  input range. The sensor specifications state that the ripple voltage due to commutators on the tachometer is 0.25% of the maximum voltage output.
- Determine the maximum speed that the sensor and data acquisition system can measure.  
(4 marks)
  - Find the maximum errors due to the ripple voltage and due to ADC resolution  
(5 marks)
  - If the ADC was 8 bit, which error source is more significant between ripple and ADC resolution.  
(2 marks)

### Question 5

- Write a mathematic operation on how to display number "2010" on four digit 7-segment display. Use your own variables to represent each of 7-segment display.  
(6 marks)
- Figure 7** shows an interfacing circuit of a 7-segment display with decoder. Draw a truth table for the input signal (A-D) and the output signals (a-g) of a 7-segment decoder (CD4511BCN) to display number 0 to 9.  
(10 marks)

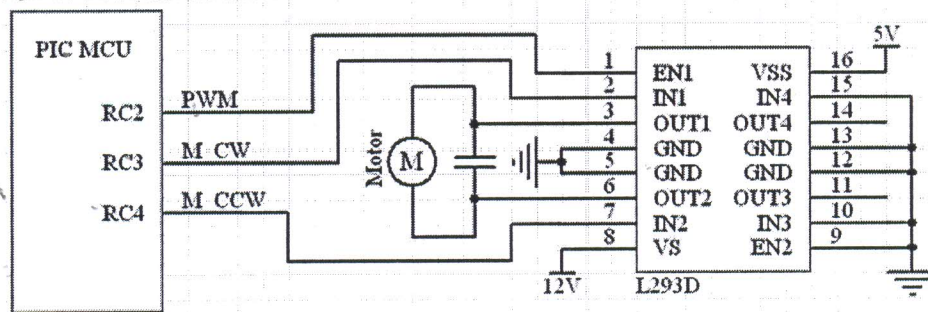


**Figure 7:** 7-segment display circuit



- c) **Figure 8** shows a schematic diagram of control a DC brush motor. Describe the operation of Pulse Width Modulation (PWM) used to control the motor's speed.

(4 marks)



**Figure 8:** DC brush motor schematic diagram

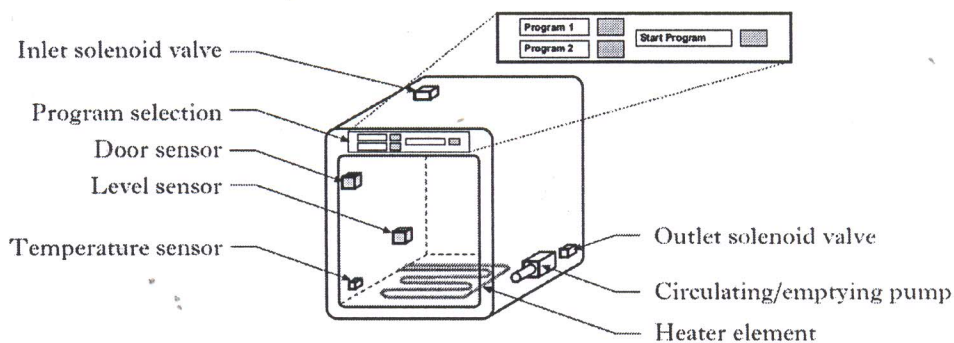
### Question 6

A manufacturer of a parts washer for industrial application has decided to change from a mechanical controller to a microcontroller based system.

The washer in **Figure 9** has two programs:

Program 1 – Rinse only cycle

Program 2 – Rinse, wash and dry cycle



**Figure 9:** Washer machine schematic diagram

The system operates at two temperatures – inlet water temperature and hot (90°C). A door sensor enables the microcontroller to stop the cycle if the door is opened. If the door is then closed, the cycle continues from where it left off.

The system includes – an inlet solenoid valve (cold water only), a circulating / emptying pump, a heater element, an outlet solenoid valve, a level sensor, a temperature sensor, a door sensor, program selection switches and a start program switch.

The inlet solenoid valve controls the water supply whilst the outlet solenoid valve controls the circulation and emptying of the system. The water can only circulate while the outlet solenoid valve is closed or can only empty while the outlet solenoid valve is open.

Program 1 consists of a rinse only cycle. Assume the system is loaded with parts which require rinsing the inlet solenoid valve is closed, the outlet solenoid valve is open and the door is shut. The system operates as follows:

- The system is filled with water to the required level;
  - Then rising / circulation takes places for 5 minutes;
  - After rising / circulation is complete, the circulating / emptying pump continues for a further 2 minutes to drain the system;
  - The inlet and outlet solenoid valves are operated at the correct times in the cycle.
- a) Give two (2) benefits of changing the system from a mechanical controller to a microcontroller based system. (2 marks)
- b) For the microcontroller based system, list the input signals and output signals (6 marks)
- c) Sketch a detailed flowchart for Program 1 (the rinse only cycle). Your flowchart should clearly show the conditions and decisions required for the correct sequence of events to take place. (6 marks)
- d) Suggest a suitable sensor for measuring the level of the water in the system and describe the principle of operation of your chosen sensor. (4 marks)
- e) List two safety issues that should be considered in the design of this system. (2 marks)

**END OF QUESTION**