

Advanced Mechatronics System Design – MANU 2451

Final Exam (Semester 1, Year 2019)

Question 1 (3 Marks)

- a. Apart from “Input Signal Interfacing” and “Output Signal Interfacing”, what are the other 3 main components within a “Mechatronics” device? (1.5 Marks)
- b. Assume you have a drone, which you have to control via remote control in order for it to fly to its destination. Would you consider it a “Mechatronics” device?
 - If yes, justify your answer.
 - If no, explain what modifications you need to make to the drone, so that it becomes a truly “Mechatronics” system. (1.5 Marks)

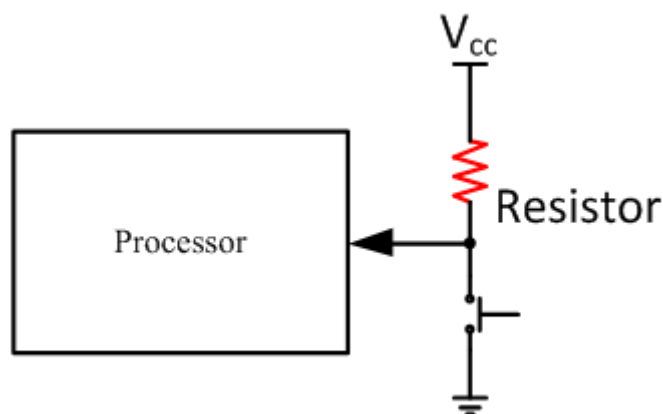
Question 2 (4 Marks)

- a. The input port of your data acquisition device has a range of 0V to 8V. What is the resolution (in volt) of the device, if the resolution (in bits) is 4 bits? Show your work out, not just the final answer. (1 Mark)
- b. Sketch a circuit which can help to remove high-frequency measurement noise from low-frequency signal. Label the parts clearly. (1 Mark)
- c. The highest frequency component of a signal is 10 Hz. What maximum sampling time should your data acquisition device have, in order to correctly capture the signal frequency? Show your work out, not just the final answer. (1 Mark)
- d. What is the name of the theorem which guides you to the answer in part c? (0.5 Mark)
- e. If, in addition to frequency, you also wish to capture the actual shape of the signal, what sampling time should your data acquisition device have? (0.5 Mark)

Question 3 (4 Marks)

- Give an example of a gripper which uses the “surface gripping” method. (0.5 Mark)
- What does a flat-faced finger gripper rely on to hold the object? (0.5 Mark)
- A driving spur gear and a driven spur gear have the same module, and radii of 10cm and 50cm respectively. If the driving gear is attached to a motor with a torque of 1Nm, how much load can the driven gear carry? Show your work out, not just the final answer. (1 Mark)
- Sketch a set of helical gears. (1 Mark)
- What is the advantage of helical gears, compared to spur gears? (0.5 Mark)
- What is the advantage of worm gears, compared to spur gears? (0.5 Mark)

Question 4 (2 Marks)

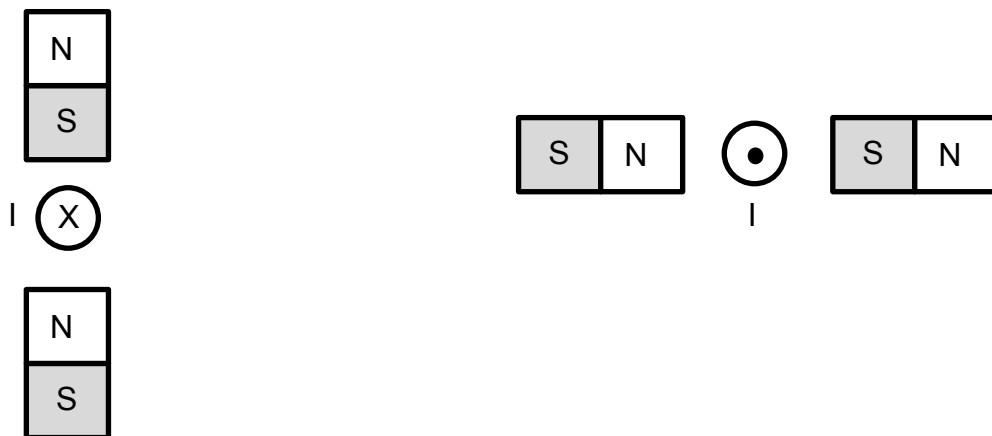


- In the figure above, what is the name of the resistor? (0.5 Mark)
- If $V_{cc} = 5V$, how much voltage would the processor measure if the push button is pressed / closed? (0.5 Mark)
- Explain why there is a need to have the resistor as shown in the circuit above. (0.5 Mark)
- Give an example of how you could use the push button as a sensor for a mobile robot. You may also draw a sketch if that helps with your explanation. (0.5 Mark)

Question 5 (2 Marks)

- Using one single strain gauge would lead to low sensitivity when measuring the strain of a bending beam. Explain how the sensitivity can be doubled. You may also use some sketches to help with your explanation. (1 Mark)
- Temperature can affect the resistance of the strain gauge, and thus might lead to wrong results. Explain how the effect of temperature can be compensated. You may also use some sketches to help with your explanation. (1 Mark)

Question 6 (5 Marks)

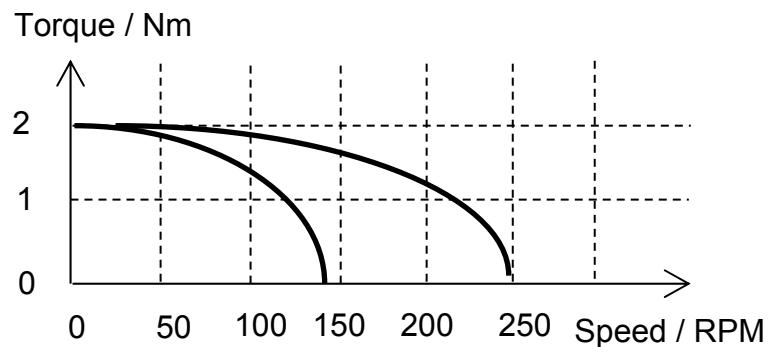


When current “I” moves through a piece of wire, which sits within a magnetic field, a force will be created.

- For the left image, in which direction would the force point to? (Upwards, downwards, to the left, to the right) (0.5 Marks)
- For the right image, in which direction would the force point to? (Upwards, downwards, to the left, to the right) (0.5 Marks)
- A permanent magnet DC motor has a stall torque of 1Nm, and a no-load-speed of 200 RPM. What is the maximum attainable speed, when the motor is carrying a load of 0.25Nm? Explain how you get this answer, by using equations or graphs. (2 Marks).
- If the motor draws a current of 1A at 0.25Nm, how much is the stall current? Explain your answer, by using equations or graphs. (2 Marks)

Question 7 (4 Marks)

- Explain the working principle of a permanent magnet stepper motor, in a 1-phase full-step drive. You may also use some sketches to help with your explanation. (2 Marks).
- The torque-speed curves of a permanent magnet stepper motor are as follows:



If the load is 1Nm, what is the maximum speed which the motor can reach from rest instantly? (0.5 Mark)

- What should be done if you want the stepper motor to reach 200 RPM? (1 Mark)
- How much is the holding torque of the stepper motor? (0.5 Mark)

Question 8 (4 Marks)

- Give two reasons why feedforward control would fail. (1 Mark)
- Sketch a block diagram of a feedback control loop. Label the blocks clearly. (1 Mark)
- What is the purpose of an integrator control? And why would the integrator control achieve that purpose? (1.5 Mark)
- What is the purpose of a derivative control? (0.5 Mark)

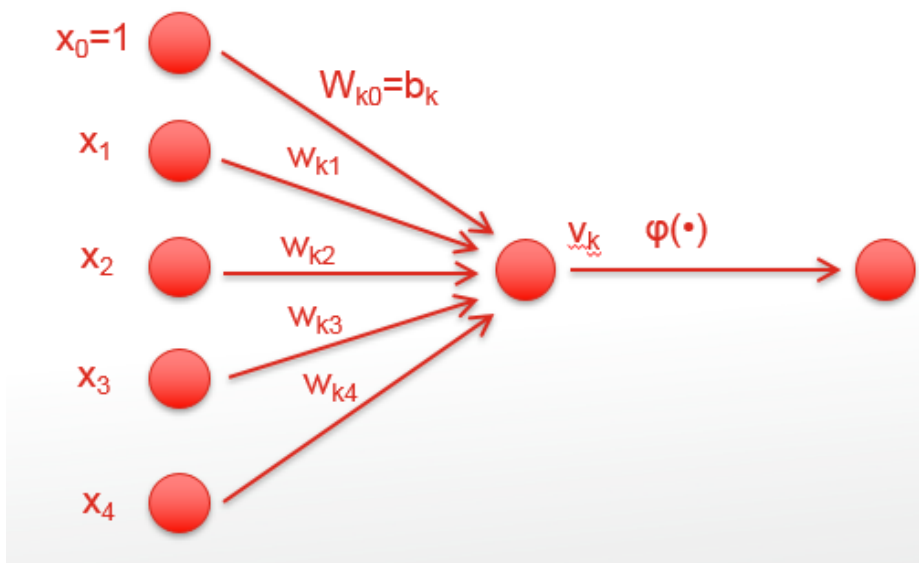
Question 9 (4 Marks)

- a. Draw a circuit which would allow you to change the direction of DC motor programmatically, without physically changing the wire connections. (1 Mark)
- b. What is the name of the circuit you drew in part a? (1 Mark)
- c. If you only have digital outputs on your embedded system (e.g. myRIO), you can only provide 0V or 5V to run your DC motor. This will either make the motor stop or run at full speed. Explain how you can achieve a varying speed on your motor, using only the digital output. You may use sketches to explain how the method works. (2 Marks)

Question 10 (4 Marks)

- a. A single piezo-actuator element only has a very small stroke. Explain how you can achieve a larger stroke using piezo-actuators. You may draw a sketch to help your explanation. (1 Mark)
- b. Sketch and explain how you can make a 2 degrees-of-freedom positioning stage using piezo-actuators. (1 Mark)
- c. Most piezo-actuators suffer from structural resonances. If you wish to resolve this issue using control method, what do you need to add into your control loop? Give the name of this control element, and also provide a block diagram of the feedback loop. (2 Marks)

Question 11 (4 Marks)



- The model of a neuron is shown in the figure above. If $x_1 = 1$, $x_2 = 2$, $x_3 = 3$ and $x_4 = 4$; $W_{k0} = 5$, $W_{k1} = 2$; $W_{k2} = 0$; $W_{k3} = -2$ and $W_{k4} = -4$, what would be the value for v_k ? Show your work out, not just the final answer. (1 Marks)
- If the activation function, ϕ , is a hard limiter, what would be the output of this neuron? (1 Mark)
- What is the purpose of using a neuron with a hard limiter activation function? (1 Mark)
- What is the name of the technique which is used to train a multi-layer perceptron? (1 Mark)