

The Open University of Sri Lanka
Faculty of Engineering Technology
Department of Mechanical Engineering



Study Programme	: Bachelor of Science Honours in Engineering
Name of the Examination	: Final Examination
Course Code and Title	: DMX4410 Electrical and Pneumatic Machines
Academic Year	: 2024/2025
Date	: 23 rd February 2026
Time	: 09.30-12.30
Duration	: 3 hours

General Instructions

1. Read all instructions carefully before answering the questions.
2. This paper consists of five (5) questions on five (6) pages.
3. The answer for each question should commence from a new page.
4. This is a Closed Book Test (CBT).
5. Answers should be in clear handwriting and do not use a red pen.
6. Clearly state your assumptions, if any.
7. Answer to all questions.

Q1

- a) Briefly explain DC shunt motors and derive the voltage equation using a suitable electrical circuit diagram. [06]
- b) Explain the purpose of using H-bridge circuits for DC motor control. Draw a H-bridge circuit and explain how it provides bi-directional control. [06]
- c) A mobile robot uses a 12V DC supply and a H-Bridge motor driver to control one wheel motor. The motor parameters are:

Armature resistance R_a	=	0.8Ω
Back EMF constant K_e	=	0.06V/rad
Torque constant K_t	=	0.06Nm/A
Wheel radius	=	0.5m
Robot mass	=	8kg
Rolling resistance force	=	6N

- i) If the duty cycle (D) is 70%, Calculate the following: [03]
- Average armature voltage.
 - If motor speed is 100 rad/s, determine the motor current.
 - Calculate the developed motor torque.
- ii) Determine whether the robot can overcome the rolling resistance at 70% duty cycle, Justify your answer. [02]
- iii) Calculate the minimum duty cycle required for the robot to just start moving from rest. [03]

Use the following hint for calculations:

$$V_{avg} = D \times V_{Supply}, \quad E_b = K_e \omega, \quad V_{avg} = E_b + IR_a, \quad \tau = K_t I, \quad \tau = F \times r$$

Q2

- a) The machine having the magnetization curve shown in Figure Q2 is operating as a motor at a speed of 900 rpm with $I_A = 30\text{ A}$ and $I_F = 2.5\text{ A}$. The armature resistance is $0.3\ \Omega$ and the field resistance is $R_F = 50\ \Omega$. Find the following,
- i) Voltage V_F applied to the field circuit. [03]
- ii) Voltage V_T applied to the armature. [03]
- iii) Developed torque. [03]
- iv) Developed power. [03]

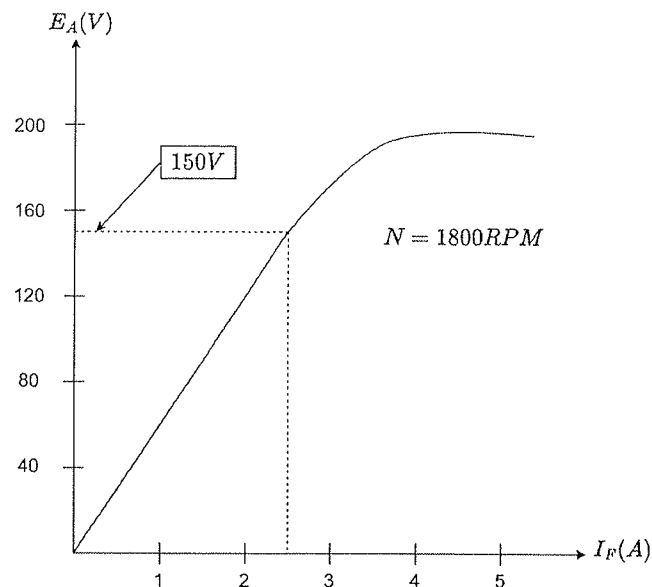


Figure Q02

- b) A 1ph transformer with a ratio of 440/110 V takes a no-load current of 5A at 0.2 power factor lagging. If the secondary supplies a current of 120 A at a p.f. of 0.8 lagging, estimate the current taken by the primary. [08]

Q3

- a) Compare the differences between lap windings and wave windings in generators. [02]
- b) Calculate the e.m.f. generated by a 6-pole DC Generator having 480 conductors and driven at a speed of 1200 RPM. The flux per pole is 0.012Wb.
- When the machine is lap wound [03]
 - When the machine is wave wound [03]
- c) A three-phase induction motor is supplied with power from a 60-Hz source. At full load the motor speed is 1728 rpm, and at no load, the speed is nearly 1800 rpm. At full-load conditions, determine the following:
- Number of poles and Slip. [01]
 - Frequency of the rotor voltages. [01]
 - Speed of the rotor field with respect to the rotor. [02]

- iv) Speed of the rotor field with respect to the stator. [02]
- v) Speed of the rotor field with respect to the stator field. [02]
- d) Single stack three phase variable reluctance stepper motor is illustrated in Figure Q3. Number of rotor teeth $n_r = 8$ and number of stator teeth $n_s = 12$.

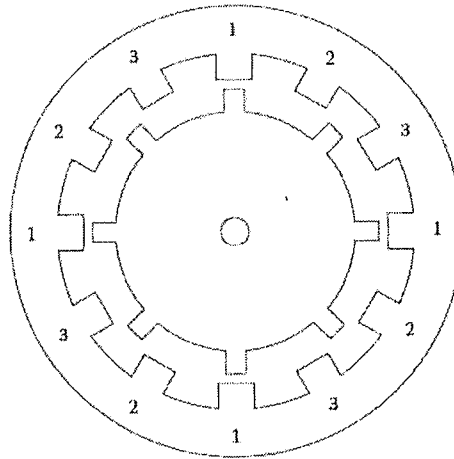


Figure Q3

If the switching sequence of the phase winding is 1-3-2-1 determines the direction of rotation and the step angle. [04]

Q4

- a) Briefly explain the following components of pneumatic system. [06]
- | | | |
|---------------|---------------|-----------------------|
| i) Compressor | ii) Reservoir | iii) Air service unit |
|---------------|---------------|-----------------------|
- b) Draw the standard symbol of following pneumatic components.
- | | |
|--|------|
| i) 3/2-way push button valve with spring return | [02] |
| ii) 2/2-way roller lever valve with spring return | [02] |
| iii) 4/2-way double solenoid electro-pneumatic valve | [02] |
- c) Figure Q4 shows a vice used in a drilling operation, where the workpiece must be securely clamped during machining. The vice is to be operated pneumatically by a double-acting

cylinder. To allow the operator sufficient time to position the workpiece, the vice should close slowly.

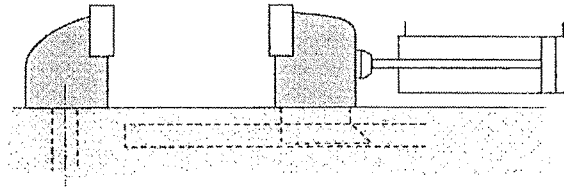


Figure Q4

Design a pneumatic system that will perform this task. (Draw pneumatic system using standard symbols and clearly label each component of the system). [08]

Q5

A pneumatically operated 3-axis pick-and-place robotic manipulator is shown in Figure Q5. The manipulator uses three double-acting cylinders to generate linear displacements along the d_1 , d_2 , and d_3 axes. The cylinders are designated as follows:

Cylinder A – horizontal motion (d_1)

Cylinder B – vertical motion (d_2)

Cylinder C – gripper actuation (d_3)

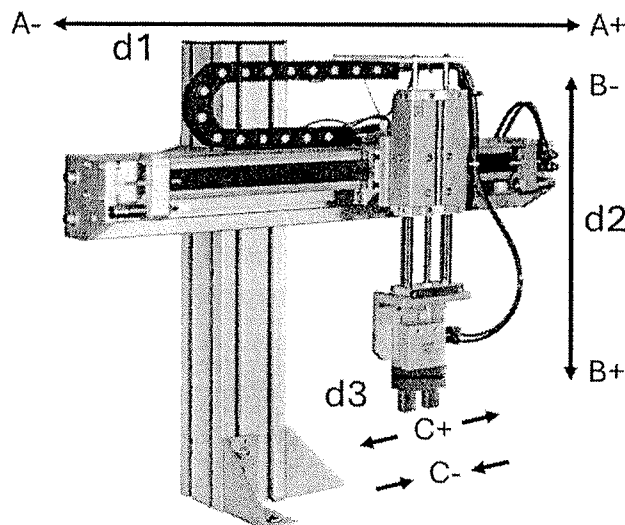


Figure Q05

- a) State the necessary assumptions and constraints required for developing the motion sequence of the manipulator. Then, write down the complete sequence of operations for a full pick-and-place cycle using $A+, A-, B+, B-, C+, C-$ notation. [06]
- b) list all required pneumatic or electro-pneumatic components needed to implement the manual control using the hand lever valves. [06]
- c) Draw a complete pneumatic or electro-pneumatic circuit diagram for **manual control** of the three cylinders, using standard ISO symbols and proper labeling of all components. [08]

END