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

Study Programme	: Bachelor of Technology Honours in Engineering
Name of the Examination	: Final Examination
Course Code and Title	: **DMX4410 Electrical and Pneumatic Machines**
Academic Year	: 2019/20
Date	: 16th October 2020
Time	: 0930hr – 1230hr
Duration	: **3 hours**

General Instructions

1. Read all instructions carefully before answering the questions.
2. This question paper consists of **Eight (8)** questions in **Six (6)** pages.
3. Answer any **Five (5)** questions only. All questions carry equal marks.
4. Answer for each question should commence from a new page.
5. This is a Closed Book Test (CBT).
6. Answers should be in clear hand writing.
7. Do not use Red color pen.

Question 01

a) List down three advantages of a DC shunt motor.

[3 Marks]

b) A 440-V, shunt motor has armature resistance of 0.8 Ω and field resistance of 200 Ω. Determine the back emf when giving an output of 7.46 kW at 85 percent efficiency.

[5 Marks]

c) A 220 V shunt motor has armature and field resistance of 0.2 Ω and 220 Ω respectively. The motor is driving a constant load torque and running at 1000 rpm drawing 10 A current from the supply. Calculate the new speed and armature current if an external armature resistance of value 5 Ω is inserted in the armature circuit. Neglect armature reaction and saturation.

[12 Marks]

Question 02

a) State three differences between Step-up transformer and Step-down transformer.

[3 Marks]

b) List down five characteristics of an Ideal transformer.

[3 Marks]

c) An ideal transformer is rated at 2400/120-V, 9.6kVA and has 50 turns on the secondary side. Calculate:

i. Turns ratio.

[1 Mark]

ii. The number of turns on the secondary side.

[1 Mark]

iii. The current ratings for the primary and secondary windings.

[1 Mark]

d) A 50-kVA, 4600/230-V, 50-Hz, single-phase, step-down transformer is designed so that at the condition of full load and unity power factor, the core loss equal the copper losses. The copper losses are equally divided between the two windings. At full load the efficiency is 96.5%.

Calculate;

i. The core loss.

[3 Marks]

ii. The total copper losses.

[2 Marks]

iii. The rated current of the primary winding and secondary windings. (Neglect the losses and assume that the input and the output are the same).

[2 Marks]

iv. The effective resistance of the primary and the secondary windings.

[4 Marks]

Question 03

a) List the types of Synchronous Machines.

[2 Marks]

b) Draw the round rotor synchronous generator equivalent circuit and clearly indicate the parameters.

[3 Marks]

c) A 3-phase synchronous generator produces an open-circuit line voltage of 6928 V when the do exciting current is 50 A. The AC terminals are then short-circuited, and the three-line currents are found to be 800 A.

i. Calculate the synchronous reactance per phase.

[2 Marks]

ii. Calculate the terminal voltage if three 12 Ω resistors are connected in wye across the terminals.

[4 Marks]

d) A 3-phase, star-connected alternator is rated at 1600 kVA, 13500 V. The armature effective resistance and synchronous reactance are 1.5 Ω and 30 Ω respectively per phase. Calculate the percentage regulation for a load of 1280 kW at power factors of,

i. 0.8 leading.

[3 Marks]

ii. Unity leading.

[3 Marks]

iii. 0.8 lagging.

[3 Marks]

Question 04

a) State the two basic essential parts of an electrical generator.

[2 Marks]

b) Briefly describe what is a prime mover for an electrical generator and give some examples for prime movers.

[3 Marks]

c) A series motor has an armature resistance of 0.2Ω and a series field resistance of 0.3Ω. It is connected to a 240 V supply and at a particular load runs at 1440 rpm when drawing 15 A from the supply.

i. Determine the back e.m.f at this load.

[3 Marks]

ii. Calculate the speed of motor when the load is changed such that the current is increased to 30A. (Assume that this case a **doubling of flux**).

[5 Marks]

d) On full-load a 300V series motor takes 90A and runs at 900 r.p.m the armature resistance is 0.1Ω and the series winding resistance is 50mΩ. Determine the speed when developing full load torque but with a 0.2 Ω diverter in parallel with the field winding. (assume that the flux is proportional to the field current).

[7 Marks]

Question 05

a) List the disadvantages of AC generator.

[3 Marks]

b) State the three main types of stepper motors.

[3 Marks]

c) An AC generator is connected across the terminals of a 2.69μF capacitor. If the capacitive reactance is 400Ω, what is the frequency of the AC generator?

[3 Marks]

d) A stepper motor has 51 rotor poles and 45 stator poles. The winding inductance and resistance are 2mH and 15Ω respectively. The rated current is 0.3 A.

i. What is the step size, in degrees?

[3 Marks]

ii. If the motor is stepping at 6000 Hz, what is the synchronous speed in rpm?

[3 Marks]

iii. To achieve rated pull-out torque requires a stepping period of 5-time constants. What is the synchronous speed of the motor at rated torque, in rpm?

[5 Marks]

Question 06

a) Sketch and label a schematic layout of components of a pneumatic system.

[5 Marks]

b) Describe the advantages and disadvantages of Pneumatics.

[3 Marks]

c) In an oil refinery plant, a double acting cylinder is used to open and close a pipeline's gate (shutter) in a chemical process industry as shown in Figure 01. When a push button is pressed, the cylinder extends fully with slow movement and keeps the valve closed. Then it retracts to open and stays in the retracted position for a period of 15 seconds, before extending again. Draw the pneumatic circuit for the given application with parts name and port numbers and also write the working of the application circuit.

[12 Marks]

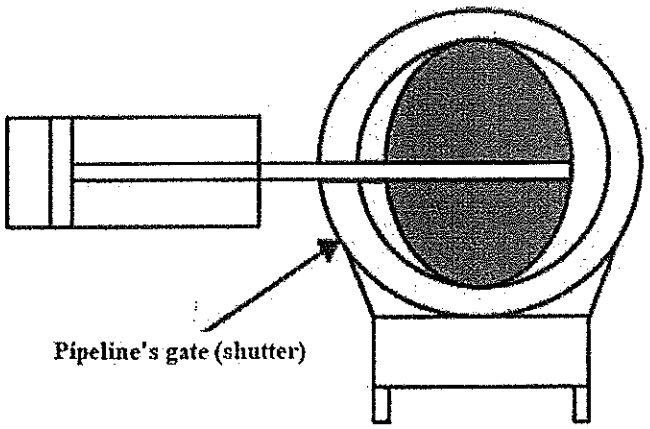

Figure 01

Question 07

a) Draw the symbols of the 3/2-way Single solenoid valve (spring return) and the 5/2-way double solenoid valve.

[4 Marks]

b) At a transfer station, boxes are transferred from one conveyor to another as shown in Figure 02. When a pushbutton PB1 (NO without latch) is pressed, the transfer station is shifted to Conveyor 1 and is to remain in this position until a second pushbutton PB2 (NO without latch) is pressed. Then the station is retracted to Conveyer 2. Two limit switches RS1 (NO) and RS2 (NO) mounted on the cylinder body provide confirmations of extended and retracted positions, respectively. The double acting cylinder is controlled by a 5/2 double solenoid valve. Design an electro-pneumatic system for this task, assuming that the control panel is remotely located.

[16 Marks]

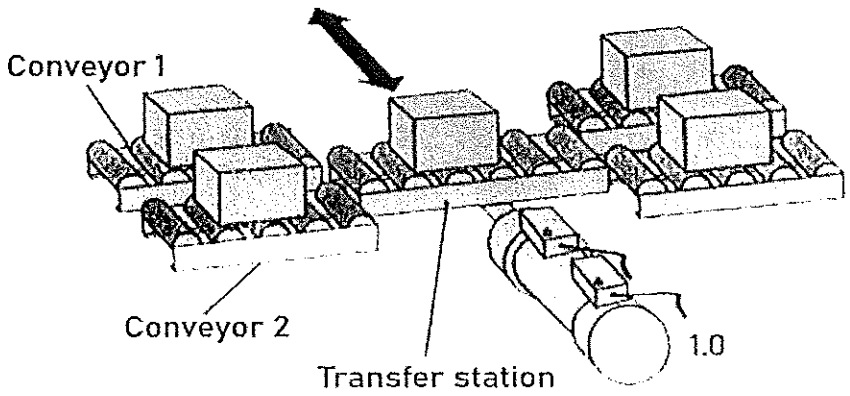

Figure 02

Question 08

a) List down three practical automation applications in which a linear actuator is used.
[4 Marks]

b) If the cylinder of a pneumatic actuator has an internal diameter of 51mm and operates at a pressure of 2070kPa gage, calculate the force on the ends of the cylinder.
[4 Marks]

c) A pneumatic displacement gage is designed according to the arrangement in Figure 03. An air supply pressure of 137895 Pa is available, and displacements are to be measured over a range of 1.27×10^{-3} m. The orifice diameter is 6.35×10^{-4} m. Calculate the maximum displacement which maximum displacement which may be measured in the linear range of operation and the outlet tube diameter d_2.
[Ambient Pressure (P_a) = 101325 Pa, Density of Air (ρ) = 2.62 kg/m^2]
[12 Marks]

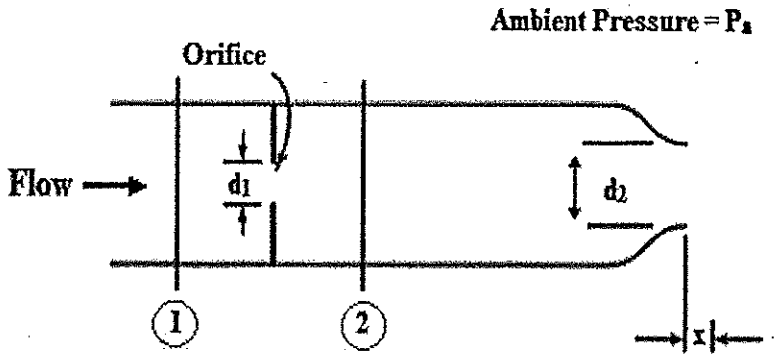

Figure 03

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