WORKFORCE DEVELOPMENT AUTHORITY
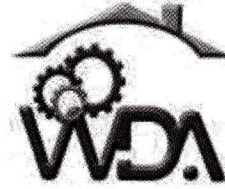
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ADVANCED LEVEL NATIONAL EXAMINATIONS, 2015, TECHNICAL AND PROFESSIONAL TRADES

EXAM TITLE: Automation

OPTION: Electricity (ELC)

DURATION: 3hours

INSTRUCTIONS:

The paper is composed of **three (3) Sections**:

Section **I**: Fourteen **(14)** questions, all **Compulsory**.   **55marks**

Section **II**: Five (5) questions, **Choose Three (3) only.**   **30marks**

Section **III**: Three (3) questions, **Choose only One (1).**   **15marks**

Every candidate is requested to strictly obey the above instructions. Punishment measures will be applied to anyone who ignores these instructions.
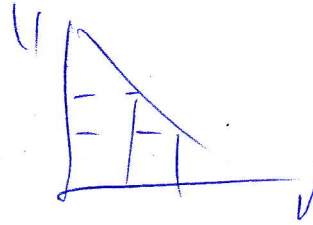
The use of geometric material and scientific calculator is accepted

Section I. Fourteen (14) Compulsory questions.   55marks

01. What do you mean by:
   a. Hydraulic system?
   b. Sequence valve?
   c. Pneumatics?   **6marks**

02. State the Boyle's law.   **3marks**

03. An air compressor takes in air at 105 Pa and 27ºC volume of 1.5 m³/kg and compress it to 4.5 x 105 Pa. Find the work done, heat transfer and change in internal energy if the composition is isothermal.   **5marks**

04. A cylinder is supplied with 100 bar pressure; its effective piston area is equal to 700 mm². Find the maximum force which can be attained.   **3marks**

05. What is direction control valve? Give its sketch (figure).   **4marks**

06. How does a limit switch differ from a push button switch?   **2marks**

07. Find the maximum stroke of a cylinder with rod of 16mm diameter as shown in the figure below: **4marks**
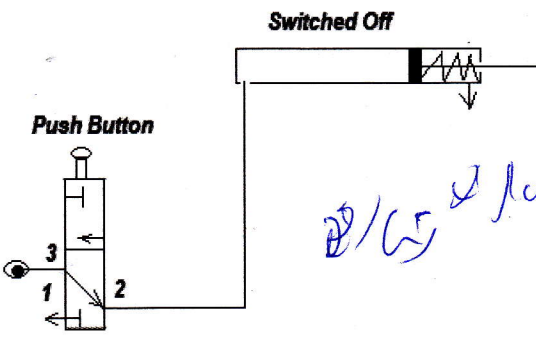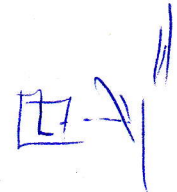

08. From the following sketch of switched off 2/3 control valve, design 2/3 control valve in work state.   **3marks**
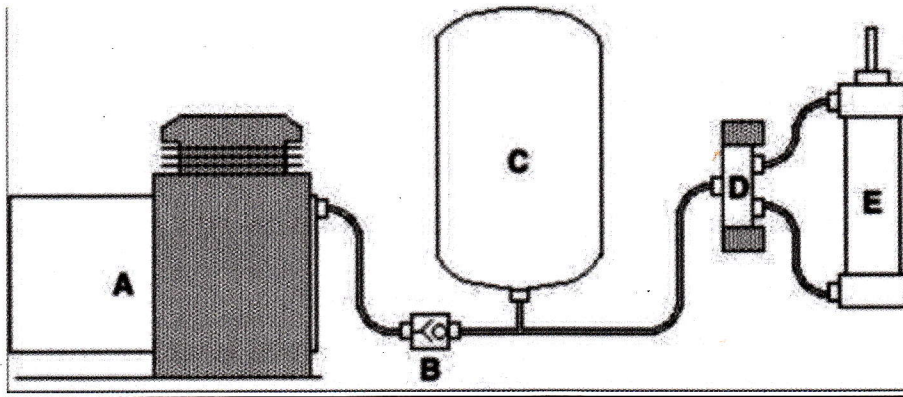

09. What is the main difference between a open loop and closed loop system.   **10marks**

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10. Name the components of the following Compressed Air Pneumatic System as represented by the letters bellow: **5marks**

11. What are the conditions for two cylinders to be synchronized? **3marks**

12. What are the factors to be considered while designing a hydraulic circuit? *— efficiency, Justify, operates* **3marks**

13. A hydraulic cylinder is used to move a work piece in a manufacturing operation through a distance of 250 mm in 15 s. If a force of 50 KN is required to move the work piece, what is the required working pressure and hydraulic liquid flow rate if a cylinder with a piston diameter of 150 mm is available. **5marks**

14. a) What are the basic elements of PLC? *Control, Copy* **3marks**

   b) What is the difference between PLC and computer? **2marks**

Section II. Answer any three (3) questions of your choice *(6)*

   (Do not choose more than three questions). **30marks**

Control

15. a) What are the tasks of a hydraulic reservoir?

   b) Indicate the different sections of a hydraulic system. **10marks**

16. Classify the different hydraulic pumps according to the displacement principle. **10marks**

Turbulent

17. An annulus section is formed by placing a stainless steel pipe with an outer diameter of 200mm inside a stainless steel pipe with an inner diameter of 500mm. The annulus section is 10m long and carries water flow rate of 1000 liters/s. *(m³/s)*

- Relative roughness = 0.00018
- The friction factor = 0.0150.
- Viscosity of the liquid = 1004.10^{-9} m²/s.

Determine the nature of the flow and the frictional head loss in meters.

$$\left(\frac{L}{D}\right)\frac{V^2}{2g}\right) \quad 0.316$$

10marks

18. Draw a circuit diagram of a feed drive using proportional valves. In this circuit we found:

- An electric motor to drive a hydraulic pump which has a fixed displacement and one direction
- A reservoir
- A normal pressure relief valve
- Two pressure gauges: one on pressure line; the other, after the flow control valve and on the port of the DAC (line entering in the large chamber)
- A proportional pressure relief valve
- A proportional directional control valve 4/3 middle center opened
- An adjustable flow control valve to control the flow on the full side of the piston (two ways)

The proportional control valve is actuated by means of an electrical control signal. The control signal influences the flow rate and flow direction. The rate of movement of the drive can be infinitely adjusted by means of changing the flow rate. A second control signal acts on the proportional pressure relief valve. The pressure can be continually adjusted by means of this control signal. **10marks**

19. a) Give at least 5 types of sensors (switches) that are commonly used in electropneumatic and electrohydraulic systems.

b) Draw and name the components of absorption dryer.   **10marks**

Section III. Answer any one (1) question of your choice

(Do not choose more than <u>one question</u>).   **15marks**

20. The initial values for the volume and pressure of a certain amount of nitrogen gas are $V_1 = 0.06$ m³ and $p_1 = 10^5$ N/m², respectively. First, the gas undergoes an isochoric process (process 1-2), which triples the pressure; then it is followed by an isobaric process (process 2-3), which reduces the volume by a factor of three; finally, the volume of the gas is tripled by an isothermal process (process 3-4).

a) Give the initial and final temperatures T_1 and T_4 of the gas if the temperature after the first process is $T_2 = 1083^0$ K

b) Find the volume V_4 and pressure p_4 at the final state of the gas

c) How is heat gained by the gas during the first process and how much is heat given away by the gas during the second process? The amount of heat required to raise the temperature of 1 mole of nitrogen by 1^0K while the gas pressure is kept constant is $c_p = 29.12/$ (mol^{0}K).

d) Find the charge in internal energy of nitrogen gas by the end of the final process compared to the initial value.

     15marks

21. a) A pump has a displacement volume of 200 cm³. It delivers 0.003m³/s at 1000rpm and 80 bar. If the prime mover input torque is 350 Nm,

     i.   What is the overall efficiency of the pump?

     ii.   What is the theoretical torque required to operate the pump?

b) The pump is driven by an electric motor having an overall efficiency of 85%. The hydraulic system operates 10 hours per day for 250 days per year. The cost of electricity is Rwf 150 per kWh. Determine:

     i.   The yearly cost of electricity to operate the hydraulic system

     ii.   The amount of yearly cost of electricity that is due to inefficiency of electric motor and the pump.

                                                       15marks

22. a) What is the troubleshooting of a pneumatic service unit?

b) Find the flow rate that an axial piston pump delivers at 1000 rpm. The pump has nine 15-mm diameter pistons arranged on a 125 mm diameter piston circle. The offset angle is set at 10° and the volumetric efficiency is 94%.   **15marks**