higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE (VOCATIONAL)

INSTRUMENTATION TECHNOLOGY
NQF LEVEL 2

(6060452)

15 November 2024 (Y-paper)
13:00–16:00

Non-programmable calculators may be used.

This question paper consists of 11 pages.

221Q1N2415

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DEPARTMENT OF HIGHER EDUCATION AND TRAINING
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE (VOCATIONAL)
INSTRUMENTATION TECHNOLOGY
NQF LEVEL 2
TIME: 3 HOURS
MARKS: 150

INSTRUCTIONS AND INFORMATION

1. Answer all the questions.
2. Read all the questions carefully.
3. Number the answers according to the numbering system used in this question paper.
4. Start each section on a new page.
5. Use only a black or blue pen.
6. Write neatly and legibly.

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SECTION A

QUESTION 1

Various options are given as possible answers to the following questions. Choose the answer and write only the letter (A–D) next to the question number (1.1–1.10) in the ANSWER BOOK.

1.1 A … is primarily an ON/OFF valve.

A plug valve
B ball valve
C globe valve
D rotary shaft valve

1.2 A measure of the change in instrument output that occurs when the quantity being measured changes by a given amount.

A Range
B Sensitivity
C Responsiveness
D Repeatability

1.3 The piping or tubing used in a process plant to connect transmitters to the process.

A Sensor
B Recorder
C Impulse lines
D Cables

1.4 The minimum and maximum values of a quantity that the instrument is designed to measure.

A Error
B Range
C Threshold
D Hysteresis

1.5 A(n) … compares the input signal from the controller to the actual valve position and applies a pneumatic output to the actuator to ensure that the valve moves to the proper position.

A actuator
B positioner
C controller
D control valve

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1.6 One of the conditions that must be met for the formula E = Blv to successfully infer volumetric flow rate is … .

A the pipe must be completely filled with liquid
B the flow tube must be properly grounded
C the flow must be laminar
D the liquid must be a reasonably good conductor of electricity

1.7 The term used to specify the probability of finding that particular material in the hazardous area.

A Class
B Group
C Division
D Zone

1.8 … are completely passive sensing elements, requiring the application of an externally-sourced electric current in order to function as temperature sensors.

A Thermocouples
B Thermopiles
C Pyrometers
D RTDs

1.9 It is designed to prevent a hazardous event by taking a process to a tolerable risk level.

A Safety instrumented system
B Safety integrity levels
C Safety instrumented function
D Measurement instrumentation and control

1.10 The closeness of agreement among a number of consecutive measurements of the output for the same input under identical operating conditions.

A Precision
B Sensitivity
C Accuracy
D Range ability

(10 × 1) **[10]**

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QUESTION 2

Indicate whether the following statements are TRUE or FALSE by writing only 'True' or 'False' next to the question number (2.1–2.5) in the ANSWER BOOK.

2.1 In a two-wire RTD circuit, wire resistance adds to the sensing element's resistance to create a larger total circuit resistance which will be interpreted by the ohmmeter as a falsely high temperature reading.

2.2 Thermocouples are formed when two similar metals are joined together to form a junction.

2.3 The actuator's position if there is no external force applied is known as free position.

2.4 Fail safe closed means that an input signal must be present in order for the safety device to stay open.

2.5 Safety integrity levels are used to monitor the condition of values and parameters of a plant within the operational limits.

(5 × 1) **[5]**

QUESTION 3

Choose a term from COLUMN B that matches a description in COLUMN A. Write only the letter (A–P) next to the question number (3.1–3.10) in the ANSWER BOOK.

COLUMN A		COLUMN B	
3.1	Locations in which flammable gases or vapours may or may not be in sufficient quantities to produce explosive or ignitable mixtures	A	controller
3.2	An actuator that pushes down on the valve stem with increasing pressure	B	thermocouples
3.3	An actuator that pulls up on the valve stem with increasing pressure	C	temperature
3.4	A device that provides the power and motion to manipulate the moving parts of a valve (L)	D	float and counterweight flow meter
3.5	The degree or intensity of heat measured on a definite scale	E	class III
3.6	Devices made of pure metal wire which always increase in resistance with increasing temperature	F	laminar flow
3.7	A flowmeter which uses a solid object called a float as a flow indicator, suspended in the midst of a tapered tube	G	class II
3.8	They provide an electrical output proportional to the difference in temperature between two different points	H	direct-acting actuator
3.9	A flow stream that exhibits no turbulence, with each fluid molecule traveling in its own path, with limited mixing and collisions with adjacent molecules.	I	Bernoulli's equation
3.10	Conservation of energy at different points in a fluid stream is neatly expressed as a constant sum of elevation, pressure, and velocity heads	J	reverse-acting actuator
		K	rotameter
		L	actuator
		M	turbulent flow
		N	cavitation
		O	flashing
		P	resistance thermometer

(10 × 1) **[10]**

TOTAL SECTION A: 25

SECTION B

QUESTION 4: PROCESS CONTROL PRINCIPLES

All measuring instruments used to measure different process variables consists of three parts.

4.1 Name THREE parts that a measuring instrument consists of. (3)

4.2 Explain the function of each part of a measuring instrument. (4)

4.3 Name the FOUR most common process variables that instruments are used to measure. (4)

[11]

QUESTION 5: CONTROL VALVES

5.1 Control valves for liquid service may be subject to phenomena known as *flashing* and *cavitation*. Explain these TWO phenomenon. (6)

5.2 Control valves regulate the flow of materials and energy into and out of a process. Study the diagram in FIGURE 1 below and answer the questions that follow.

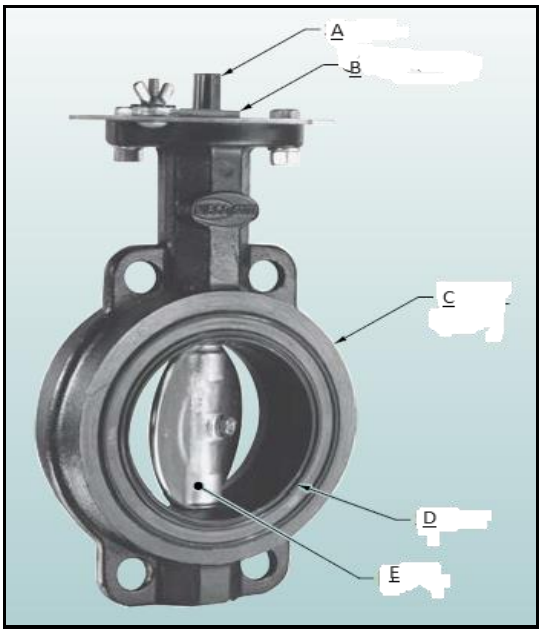


FIGURE 1

5.2.1 What type of a control valve is shown in FIGURE 1? (2)

5.2.2 Name the parts labelled A, B, C, D and E. (5)

5.2.3 What type of a flow characteristic does this control valve have? (2)

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5.3 Explain the term *limit switch* as applicable to valve control. (5)

5.4 Explain the following terms as used for diaphragm and spring actuators:

5.4.1 Direct acting actuator (2)

5.4.2 Reverse acting actuator (2)

5.4.3 What other term is used to mean direct acting? (1)

5.4.4 What other term is used to mean reverse acting? (1)

[26]

QUESTION 6: PRESSURE MEASUREMENT

6.1 Define the following terms used to quantify pressure:

6.1.1 Absolute pressure

6.1.2 Gauge pressure

6.1.3 Differential pressure

(3 × 2) (6)

6.2 Study the diagram in FIGURE 2 below and provide labels for the components marked A, B, C, D, E and F by writing only the answer next to the letter in the ANSWER BOOK. (6)

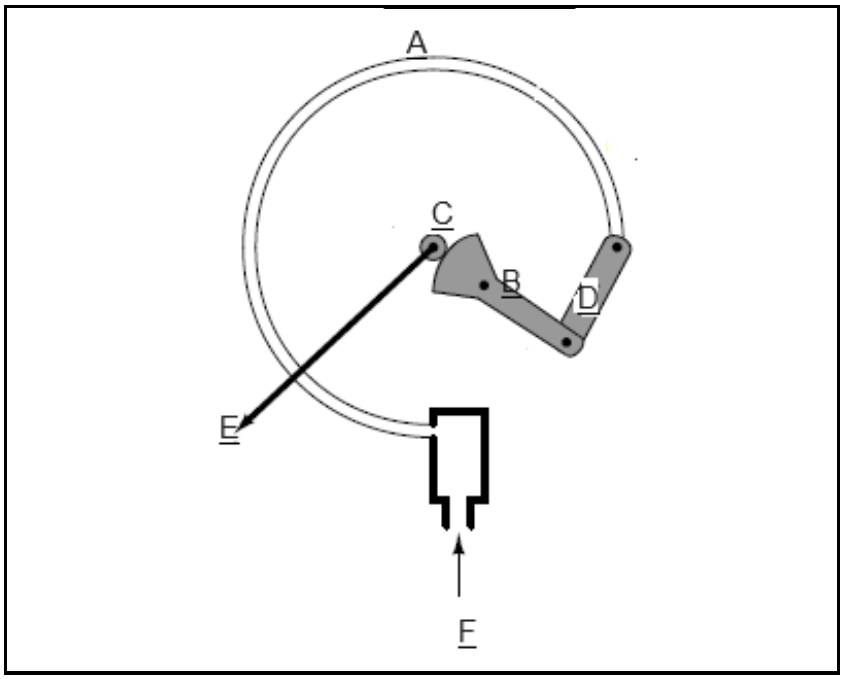


FIGURE 2

6.3 Explain the working principle of the C-type Bourdon tube pressure gauge. (8)

6.4 Manometers are passive instruments that give a visual indication of pressure values. Various types of manometers exist.

Study the diagram in FIGURE 3 below and answer the questions that follow:

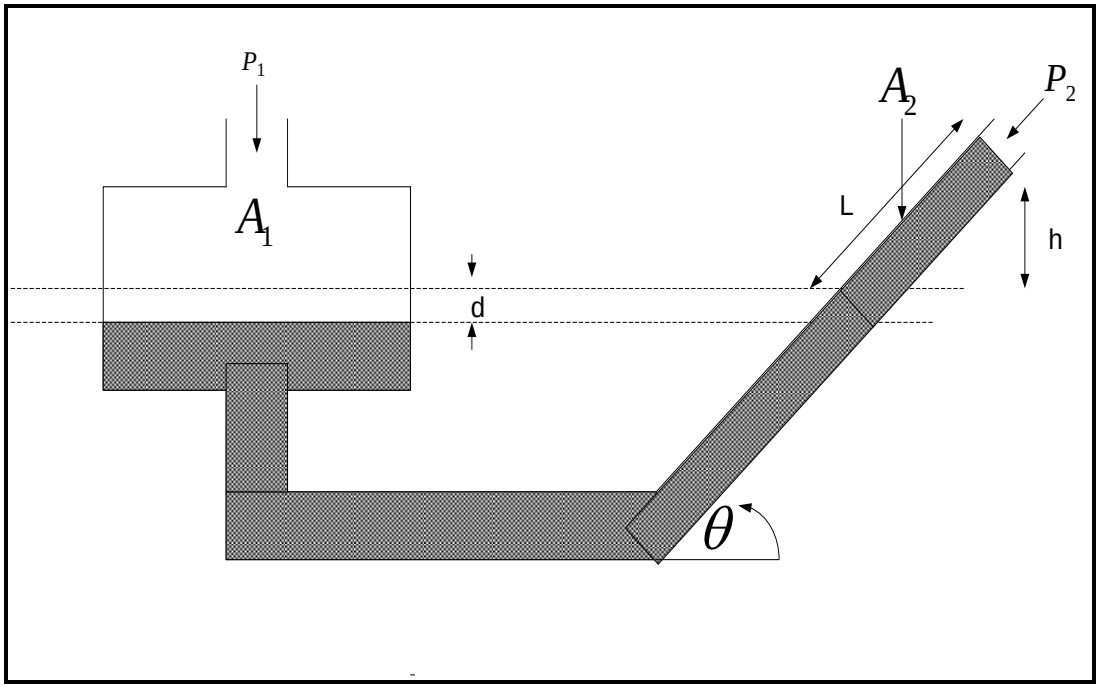


FIGURE 3

6.4.1 What type of a manometer is shown in FIGURE 3? (2)

6.4.2 Using the symbols shown in the diagram, the following pressure equation can be derived:

$$\Delta P = \rho g L \left[\sin\theta + \frac{A_2}{A_1}\right]$$

Calculate the applied differential pressure if the following are known:

- Angle of tube with the horizontal = 40º
- Area of cistern = 0,03 m²
- Area of tube = 0,00002 m²
- Scale reading = 20 cm
- Density = 13 600 kg/m^3
- g = gravitational acceleration = 10 m/s^2 (4)

6.4.3 Name FOUR other types of manometers. (4)

[30]

QUESTION 7 : TEMPERATURE MEASUREMENT

7.1 Thermocouples are completely active sensing elements generating their own electric potential in order to measure temperature. The operation of a thermocouple is influenced by the room temperature at the reference junction.

7.1.1 Name TWO junctions found in a thermocouple. (2)

7.1.2 Multiple techniques exist to deal with the influence of the reference junction's temperature. One technique is to physically fix the temperature of that junction at some constant value so it is always stable. This can be accomplished by immersing the reference junction in a bath of ice and water, the ice/water mixture ensuring a stable temperature by means of water's latent heat of fusion.

Make a neat, labelled sketch showing this technique. (6)

7.1.3 Fixing the reference junction at the temperature of freezing water is impractical for any real thermocouple application outside of a laboratory.

Explain a practical method used to compensate for reference junction voltages. (2)

7.2 Resistance thermometers are based on the principle that the resistance of a metal increases with temperature. The relationship between resistance and temperature may then be expressed as $R_t = R_o (1 + \alpha o t)$. A platinum resistance thermometer measure 100 Ω at 0 °C and 139,1 Ω at 100 °C.

Calculate:

7.2.1 The temperature coefficient for platinum

7.2.2 The resistance of the thermometer at 50 °C

7.2.3 The temperature when the resistance is 110 Ω

(3 × 3) (9)

7.3 Convert 86 °F into degrees Celsius, Rankine and Kelvin. (6)
[25]

QUESTION 8: FLOW MEASUREMENT

8.1 Differentiate between *volumetric flow* and *mass flow*. (2)

8.2 Turbine meters are best suited to measuring clean and low viscosity liquids, thus turbine flow meters are almost always suitable for water flow measurement.

8.2.1 Make a neat, labelled sketch of a turbine flow meter. (6)

8.2.2 Explain the principle of operation of a turbine flow meter. (4)

8.2.3 What is the formula for turbine meter flow rate calculations? All the symbols used must be defined. (4)

8.3 Study the following positive displacement meter in FIGURE 4 below and answer the questions that follow.

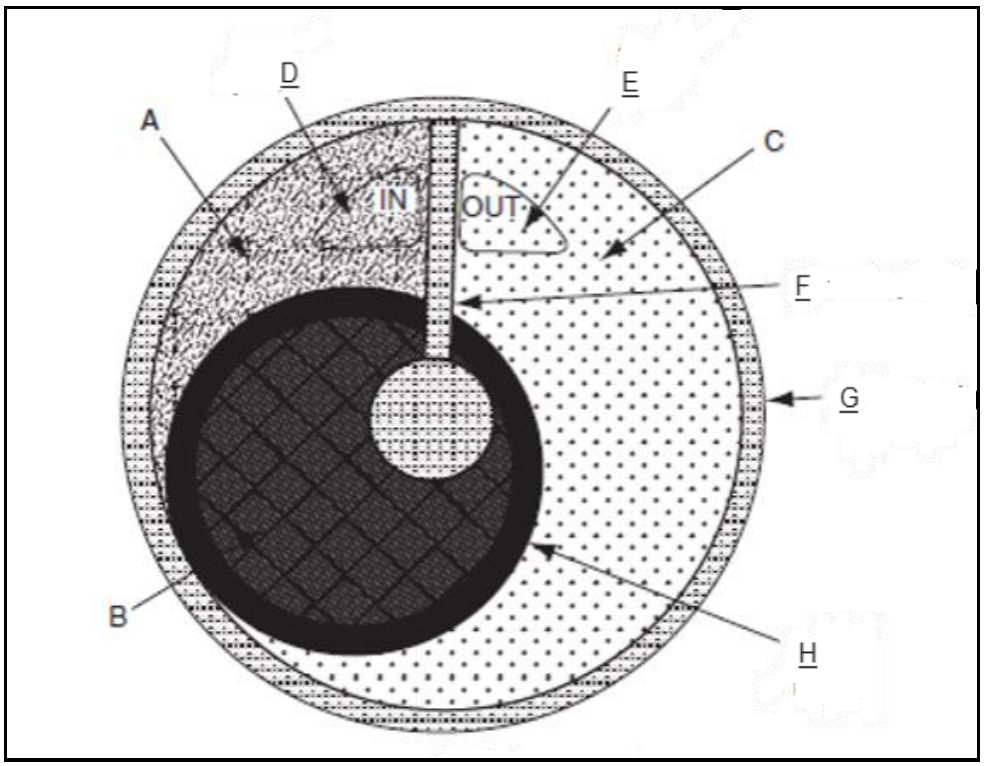


FIGURE 4

8.3.1 Name the flow meter shown in FIGURE 4. (1)

8.3.2 Provide labels for the components marked D, E, F, G, and H. (5)

8.3.3 Explain the working principle of the meter in QUESTION 8.3.1 with reference to volume A, volume B and volume C. (10)
[33]

TOTAL SECTION B: 125
GRAND TOTAL: 150

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