



higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE INDUSTRIAL INSTRUMENTS N4

(8080194)

**17 April 2020 (X-paper)
09:00–12:00**

This question paper consists of 8 pages and 1 formula sheet.

297Q1A2017

DEPARTMENT OF HIGHER EDUCATION AND TRAINING
REPUBLIC OF SOUTH AFRICA
NATIONAL CERTIFICATE
INDUSTRIAL INSTRUMENTS N4
TIME: 3 HOURS
MARKS: 100

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. 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 ... is defined as the opposition to the generation of magnetic fields.

- A Inductance
- B Piezo-electric effect
- C Reluctance
- D Dielectric



1.2 Mathematical expression or formula for stress:

- A $E\varepsilon = \sigma$
- B $\varepsilon L = \Delta L$
- C $K = (\Delta R/R)/(\Delta L/L)$
- D $F = ma$

1.3 Device measuring temperature of a hot object by means of intensity of radiant energy exiting a phototube:

- A Thermistor
- B Potentiometer
- C Pyrometer
- D Resistance thermometer



1.4 Bernoulli primary flow element measuring average velocity of a stream:

- A Pitot tube
- B Flow nozzle
- C Annubar
- D Orifice plate

1.5 ONE of the following can be used to compensate for ambient temperature changes:

- A Vapour pressure expansion thermometer
- B Bimetallic expansion thermometer
- C Liquid expansion thermometer
- D Gas expansion thermometer

1.6 ... is used to eliminate offset in process control.

- A Proportional action
- B Derivative action
- C Integral action
- D Feedback control action



- 1.7 Control process requiring direct human intervention:
- A Open-loop control
 - B Closed-loop control
 - C Cascade control
 - D Fuzzy control 
- 1.8 Relay valve increasing output when nozzle back-pressure decreases:
- A Direct-acting continuous bleed relay valve
 - B Reverse-acting continuous bleed relay valve
 - C Nonbleed relay valve
 - D Butterfly valve
- 1.9 Stators of a magstrip system consist of an internally slotted laminated iron ring with three sets of windings arranged in slots at angles of ... to one another.
- A 30°
 - B 60°
 -  C 120°
 - D 180°
- 1.10 Associated with calibration faults in Bourdon tube devices:
- A Hysteresis error
 - B Capillary error
 - C Parallax error
 - D Systematic error

(10 × 1) [10]

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.

- 2.1 400 °F is equivalent to 204 °C.
- 2.2 A capacitive level sensor measures the level in a tank where the liquid serves as dielectric.
- 2.3 In an ultrasonic level sensor, the time travelled by the transmitted pulse back to the receiver is an indication of the level in a tank.
- 2.4 The relationship between the pipe diameter and the diameter of a hole in the orifice plate cannot influence the calibration of this gauge. 
- 2.5 Derivative action time is defined as the time it takes for a proportional action to repeat a derivative action.

(5 × 1) [5]

QUESTION 3

Choose a term from COLUMN B that matches a description in COLUMN A. Write only the letter (A–I) next to the question number (3.1–3.5) in the ANSWER BOOK.

COLUMN A		COLUMN B	
3.1	Algebraic difference between the highest and the lowest calibration point of an instrument	A	fundamental interval
		B	orifice plate
3.2	Ability of some crystals to generate an emf proportional to the pressure variation	C	integral action time
		D	derivative action
3.3	Resistance difference of a thermometer between 100 °C and 0 °C	E	resistance thermometer
3.4	It consists of a disc with a hole placed in a pipe between two flanges	F	drift
		G	span
3.5	Time taken for the integral action to repeat the proportional action if the measured variable has a constant deviation	H	open channel
		I	piezo-electric effect

(5 × 1)

[5]**TOTAL SECTION A:****[20]**

SECTION B

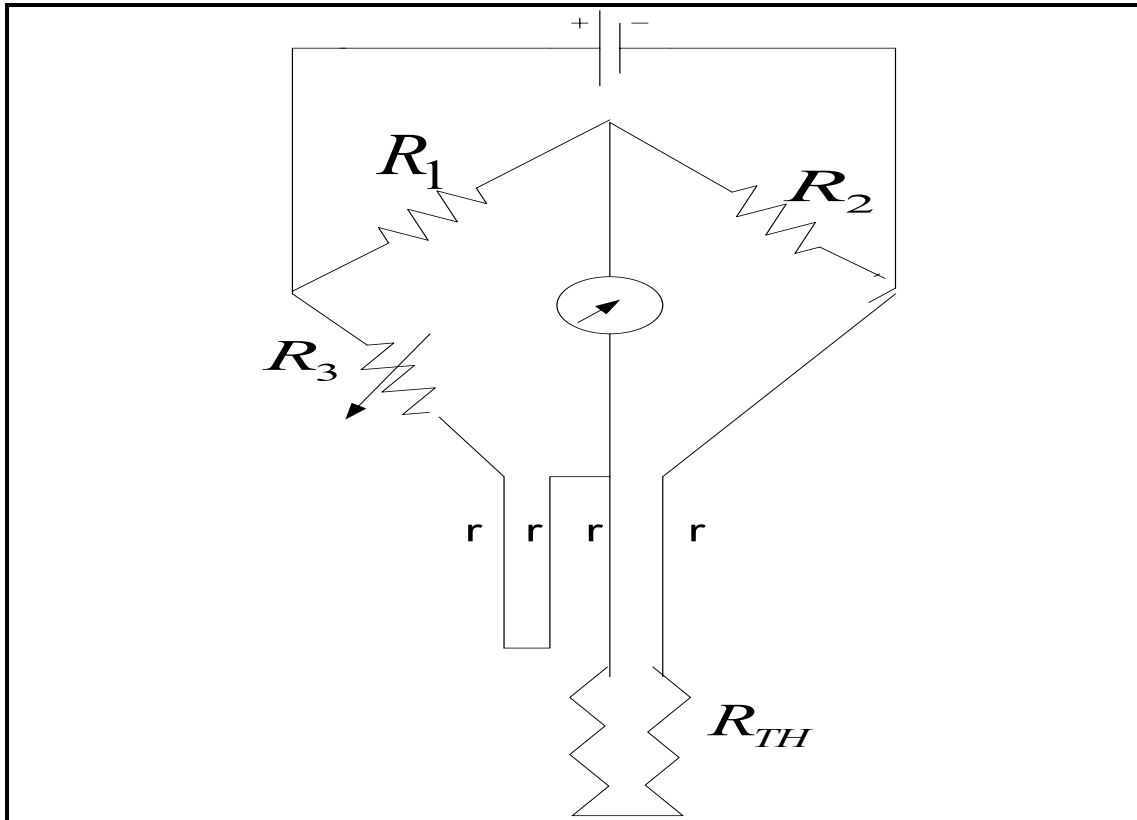
QUESTION 4: ELECTRICAL AND NONELECTRICAL PRESSURE MEASUREMENT

- 4.1 Calculate the applied differential pressure of an inclined manometer using mercury as a sealing liquid if the following information is known:
- Angle of tube with horizontal = 45°
 - Area of cistern = $0,039 \text{ m}^2$
 - Area of tube = $0,00009 \text{ m}^2$
 - Scale reading = 15 cm
- (5)
- 4.2 Calculate the resistance of a conductor with a length of 50 m, a diameter of 1 mm and a specific resistance of $8 \times 10^{-5} \Omega/\text{m}$. (4)
- 4.3 Explain the relationship between *inductance* and *reluctance*. (1)
- 4.4 Transducers are used to change mechanical signals to electrical signals.
- 4.4.1 Make a neat, labelled sketch of a piezo-electric pressure transducer. (5)
- 4.4.2 Explain how this transducer converts a mechanical signal to an electrical signal. (2)
- 4.4.3 Name THREE disadvantages of this type of a transducer. (3)
- [20]**

QUESTION 5: NONELECTRICAL AND ELECTRICAL TEMPERATURE MEASUREMENT

- 5.1 An analogue millivolt meter consisting of a moving coil meter can be used to monitor the output of a thermocouple.
- 5.1.1 Make a neat, labelled sketch of a moving coil meter. (5)
- 5.1.2 Explain the operating principle of the moving coil meter in QUESTION 5.1.1. (4)
- 5.2 What combination of metals is generally used in the construction of a bimetal thermometer? (2)

5.3 Study the circuit diagram and answer the questions.



CIRCUIT DIAGRAM

- 5.3.1 Name the circuit diagram. (1)
- 5.3.2 Calculate the output of the resistance thermometer R_{TH} at a temperature of $100\text{ }^{\circ}\text{C}$ if its resistance is $10\text{ }\Omega$ at $0\text{ }^{\circ}\text{C}$. The thermometer wire has a positive temperature coefficient of $0,004\text{ }\Omega/\Omega\text{ }^{\circ}\text{C}$. (3)
- 5.3.3 State the conditions which must be met for the circuit so that it will compensate at any change of ambient temperature. (4)
- 5.3.4 Determine the value of R_3 if the circuit compensates at any change of ambient temperature. (1)

[20]

QUESTION 6: AUTOMATIC CONTROL AND TELEMETERING

- 6.1 Draw simple electronic circuit diagrams showing each of the actions below in an operational amplifier. Clearly indicate the output for each of the control actions if a step input is used.
- 6.1.1 Integral control action (4)
- 6.1.2 Derivative control action (4)
- 6.2 Sketch the characteristic curves (% flow against valve opening) of a butterfly valve.  (2)
- 6.3 Make a labelled sketch of a resonant impedance bridge telemetering system. (7)
- 6.4 State the functions of the feedback element of a pneumatic telemetering system. (3)
- [20]**

QUESTION 7: LEVEL AND FLOW MEASUREMENT

- 7.1 The pressure difference across the narrowing in a pipe is 50 mm water at a flow rate of 80 m³/h.
- What will the flow rate be at a pressure difference of 100 mm water?  (3)
- 7.2 Explain the operating principle of a Pitot tube with the aid of a simple sketch. (11)
- 7.3 Make a neat, labelled sketch of a bellows-type level-measuring device consisting of a transmitter bellows in the tank and a receiver bellows at the pressure gauge. (6)
- [20]**

TOTAL SECTION B: 80
GRAND TOTAL: 100

INDUSTRIAL INSTRUMENTS N4

FORMULA SHEET

$$(1) \quad \Delta P = \rho g h$$

$$(2) \quad \Delta P = \rho g h \left[\frac{A_2}{A_1} + 1 \right]$$

$$(3) \quad \Delta P = \rho g L \left[\sin \theta + \frac{A_2}{A_1} \right]$$

$$(4) \quad P_1 - P_2 = \frac{r_2 M g \sin \theta}{A r_1}$$

$$(5) \quad P_1 - P_2 = \frac{M g r \sin \theta}{A L}$$

$$(6) \quad F = m a$$

$$(7) \quad P = \frac{F}{A}$$

$$(8) \quad A = \frac{\pi d^2}{4}$$

$$(9) \quad R = \frac{\rho L}{A}$$

$$(9) \quad ^\circ\text{F} = \frac{9}{5} ^\circ\text{C} + 32$$

$$(10) \quad R_T = R_0(1 + \alpha T)$$

$$(11) \quad R_T = R_0(1 + \alpha T + \beta T^2)$$

$$(12) \quad Q = k \sqrt{h}$$

$$(13) \quad H_L = \left[\frac{\rho_m}{\rho_L} \right] \times h - \frac{h}{2}$$

$$(14) \quad H_L = \left[\frac{\rho_m}{\rho_L} \right] \times h - H_1 - \frac{h}{2}$$