higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

T810**(E)**(J26)T

NATIONAL CERTIFICATE

INDUSTRIAL INSTRUMENTS N4

(8080194)

13 August 2019 (X-Paper)
09:00–12:00

Calculators and drawing instruments may be used.

This question paper consists of 5 pages and 1 formula sheet.

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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. Take gravitational acceleration as 10 m/s^2.
5. Write neatly and legibly.

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QUESTION 1: PRESSURE

1.1 An inclined-tube manometer uses mercury as a sealing liquid.

Calculate the applied differential pressure by using the following information:

- Angle of tube with the horizontal = 45°
- Area of cistern = 0,04 m^2
- Area of tube = 0,00009 m^2
- Scale reading = 15 cm (4)

1.2 Make a simple, neat, labelled sketch of a C-type Bourdon-tube pressure gauge showing ALL operating parts. (4)

1.3 Make a neat, labelled sketch of a stacked capsule-type diaphragm element which could be used to determine differential pressure. (4)

1.4 A load cell uses a strain gauge with a nominal resistance of 1 000 Ω and a gauge factor (GF) of 2. The load cell is then subjected to a mass which results in a compressive stress of 120 MPa.

Calculate the change in resistance of the strain gauge if the module of elasticity of the load-cell beam (to which the strain gauge is attached) is 200 GPa. (4)

1.5 Make a neat, fully labelled diagrammatic sketch of a Pirani vacuum meter. (4)

1.6 Explain the *piezoelectric effect* as applicable to piezoelectric pressure transducers. (1)

1.7 Make a neat, labelled sketch of a diaphragm-type variable-capacitance pressure transducer. (4)

[25]

QUESTION 2: LEVEL

2.1 A single-standpipe gas-purge system is used to measure the level of water in an open tank. The back pressure of the gas-purge pressure gauge is 115 kPa when air is purged through the water.

Calculate the level in the tank if the open end of the tube is 6 cm above the bottom of the tank. (4)

2.2 Draw a diagram of a sight glass which is used to measure the level of liquid in a boiler. Show the necessary taps and explain what it is used for. (4)

2.3 Explain the operation of a single-standpipe gas-purge system which is used to measure the height of the level in an open tank. (2)

[10]

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QUESTION 3: FLOW

3.1 Show, by means of diagrams, the difference between each of the following primary flow devices:

3.1.1 Dall tube

3.1.2 Venturi tube

(2 × 4) (8)

3.2 Make a neat, fully labelled sketch of a shaped-chamber flowmeter. (4)

3.3 Draw a neat graphical representation illustrating the difference between the scaling of a rotameter and an orifice plate. (2)

3.4 Briefly explain the principle of displacement-type flowmeters. (2)

3.5 Calculate the different readings for dry and wet calibrations of a mercury-filled manometer if the pressure difference is 10 kPa under dry conditions. The measuring liquid is water. (4)

[20]

QUESTION 4: TEMPERATURE AND TELEMETERING

4.1 State FOUR nonelectrical thermometer measuring principles. (4)

4.2 The resistance of a platinum resistance thermometer is 25 Ω at 0 °C.

Calculate the resistance at 500 °C if the temperature coefficients of resistance of platinum are $\alpha = 3{,}9 \times 10^{-3}\ \Omega/\Omega/°C$ and $\beta = -5{,}78 \times 10^{-7}\ \Omega/\Omega/°C$. (4)

4.3 A Wheatstone bridge can be used to measure the output of a resistance thermometer.

4.3.1 Draw a Wheatstone bridge circuit diagram by using the four-wire method of compensating. (4)

4.3.2 Determine the imbalance voltage of a Wheatstone bridge if the following are given:

- $R_1 = R_2 = R_3 = 120\ \Omega$
- R_{TH} (resistance-thermometer output) = 200 Ω
- Supply voltage = 12 V

Ignore ALL lead resistance. (4)

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4.4 Optical pyrometers are very useful for checking and calibrating total-radiation pyrometers.

4.4.1 Give ONE example of a total-radiation pyrometer. (1)

4.4.2 Make a neat cross-sectional sketch of a disappearing-filament optical pyrometer. (4)

4.5 Draw a neat, labelled block diagram of a frequency-telemetering system. Clearly indicate the changeover steps. (4)
[25]

QUESTION 5: CONTROL

5.1 Define each of the following:

5.1.1 Proportional action control

5.1.2 Integral action control

(2 × 2) (4)

5.2 Sketch and explain the operation of a basic proportional electronic controller which uses an operational amplifier. (10)

5.3 Draw single-line diagrams to illustrate the mechanical construction of each of the following valves:

5.3.1 Two-way valve, double-seated

5.3.2 Three-way valve with mixing services

(2 × 3) (6)
[20]

TOTAL: 100

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FORMULA SHEET

$$^{\circ}C = \frac{5}{9}(^{\circ}F - 32)$$

$$^{\circ}F = \left(^{\circ}C \times \frac{9}{5}\right) + 32$$

$$K = 273{,}15 + {}^{\circ}C$$

$$W = \sigma T^4$$

$$W = \in \sigma T^4$$

$$W = \in \sigma\,(T_b^4 - T_a^4)$$

$$R_t = R_o\,(1 + \alpha t)$$

$$R_t = R_o\,(1 + \alpha t + \beta t^2)$$

$$I_s = \frac{1}{S} = \frac{V}{R} \rightarrow S = \frac{R}{V}$$

$$R_{sc} = \frac{V_{sc}}{I_s}$$

$$R_{cj} = R_o + \Delta R$$

$$R_z = \frac{V_{\min}}{I_s} + R_{cj}$$

$$R_s = \frac{R_{sw} \times R_t}{R_{sw} - R_t} \rightarrow R_t = \frac{V_{\max} - V_{\min}}{I_s}$$

$$R_u = \frac{V_{sc} - V_{\max}}{I_s}$$

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