higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE

INDUSTRIAL INSTRUMENTS N4

(8080194)

7 December 2023 (X-paper)
09:00–12:00

Drawing instruments and nonprogrammable calculators may be used.

This question paper consists of 6 pages and 1 formula sheet.

301Q1G2307

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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. For the value of π, use 3,14.
6. Use only a blue or black pen.
7. Write neatly and legibly.

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QUESTION 1: PRESSURE MEASUREMENT

1.1 Define:

1.1.1 Density

1.1.2 Manometer

(2 × 2) (4)

1.2 1.2.1 Which instrument would one use to calibrate a C-type Bourdon tube pressure measuring device? (2)

1.2.2 Name THREE types of materials that are used in manufacturing Bourdon tubes. (2)

1.2.3 Indicate THREE calibration faults in Bourdon tube devices. (3)

1.3 Discuss Boyle's law as it applies to the McLeod vacuum gauge. (2)

1.4 A strain gauge has a nominal resistance of 270 Ω and a gauge factor of 2. It is firmly attached to a beam that is subjected to a stress of 18 MPa. The modulus of elasticity is 82 GPa.

Calculate the change in resistance of the gauge. (6)

1.5 The material used as a conductor in strain gauges must meet certain requirements.

Name these FIVE requirements. (5)

[25]

QUESTION 2: LEVEL MEASUREMENT

2.1 A U-tube manometer is used to measure the height of water in an open tank. The manometer is filled with mercury and its zero is on the same level as the tank's zero level.

Calculate the height of water in the tank if the height between the manometer liquid levels is 0,5 m. (5)

2.2 Make a neat, labelled sketch of a buoyancy-type level gauge using a torque tube transmission. (5)

[10]

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QUESTION 3: FLOW MEASUREMENT

3.1 Explain why eccentric orifice plates are suitable for fluids carrying solids in suspension. (2)

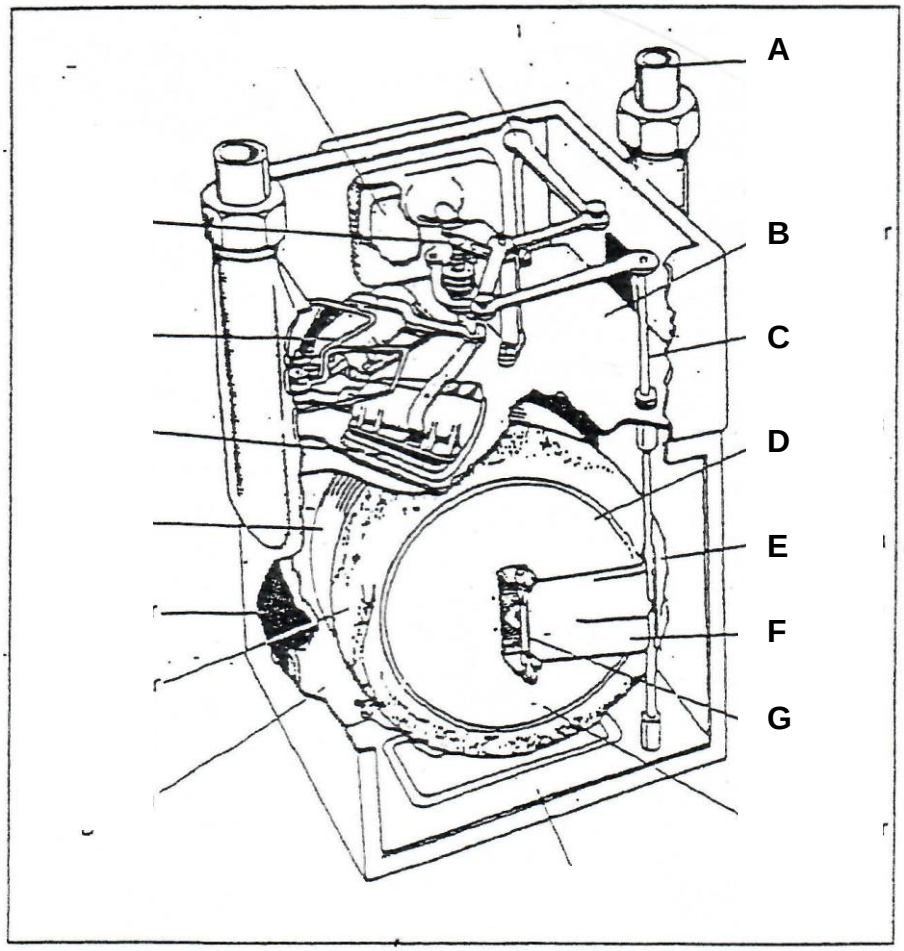
3.2 Name FOUR advantages of Pitot tubes. (4)

3.3 Explain what is meant with the term D and D/2 taps with reference to the tapping points when an orifice plate is installed. (2)

3.4 Explain the operation of a nutating-*disc* flow meter. (5)

3.5 Study the bellows-type dry gas meter in the FIGURE below.

Identify the working parts of this instrument labelled by the letters (A–G). In your ANSWER BOOK, write A, B, C, etc in separate lines underneath each other. Next to each letter, write the name of the particular part. (7)



[20]

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QUESTION 4: TEMPERATURE AND TELEMETERING

4.1 Name FOUR non-electrical thermometer measuring principles. (4)

4.2 Name FOUR liquids that are suitable to be used in a vapour pressure thermometer. (4)

4.3 Name ONE disadvantage of nickel used in a nickel resistance thermometer. (1)

4.4 Explain the Peltier effect with regard to thermocouple circuits. (3)

4.5 Complete the following table regarding the most common types of thermocouples. Write the letters (A−F) underneath each other in the ANSWER BOOK and then write the correct answer next to each letter.

ANSI Type/Thermocouple type	Positive Element	Negative Element
E	Originally Chromel	Constantan
(A)	(B)	Constantan
K	(C)	(D)
(E)	Copper	(F)

(6)

4.6 In your own words, explain the laws of addition pertaining to thermo-electric EMFs. (3)

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

Draw a Wheatstone bridge circuit diagram using the three-lead method of compensating. (3)

4.8 What are *optical* pyrometers useful for? (1)

[25]

QUESTION 5: AUTOMATIC CONTROL

5.1 Sketch the valve characteristic curves for % flow against % valve opening of the following valve types:

- Quick-opening valve
- Equal-percentage valve
- Linear valve

(3)

5.2 Make a neat, labelled sketch of a basic electronic proportional controller. (2 + 6) (8)

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5.3 What is meant by the term *load change*? (2)

5.4 Make a neat, labelled sketch of a *pneumatic motion balance-type valve positioner*. (5 + 2) (7)

[20]

TOTAL: 100

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(8080194)

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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