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APRIL EXAMINATION

NATIONAL CERTIFICATE

INSTRUMENT TRADE THEORY N3

(11040463)

5 April 2016 (X-Paper)
09:00–12:00

Calculators may be used

This question paper consists of 7 pages and 1 formula sheet.
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. Write neatly and legibly.
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 (1.1–1.5) in the ANSWER BOOK.

1.1 Butterfly valves are generally favoured because …
   A  they are low in cost and light in weight.
   B  they have very good shut-off capabilities.
   C  they have reduced bore and full bore.
   D  the flow is controlled by raising or lowering the valving element.

1.2 A wire strain gauge is made by which component?
   A  Inductor
   B  Capacitor
   C  Resistor
   D  Diode

1.3 An instrumentation system consists mainly of three sections which are used together for measuring and controlling.
Which ONE below is not part of the sections?
   A  Input
   B  Controlling
   C  Process
   D  Output

1.4 Which ONE of the following is not a disadvantage of a pneumatic system?
   A  Large time lag
   B  Pressure drop
   C  Leakages
   D  None of the above-mentioned

1.5 Detecting element is …
   A  a primary device in direct contact with the process.
   B  an element that receives a signal from the detecting element.
   C  an element which provides a control signal for transmission to the correcting element.
   D  part of the correcting unit which adjusts the correcting element in response from the controller output signal.
1.6 Pressure that is less than the atmospheric pressure
   A  Vacuum.
   B  Gauge pressure
   C  Absolute pressure
   D  None of the above.

1.7 Capacitive transducer cannot be used to measure:
   A  Light intensity
   B  Pressure
   C  Level
   D  All of the above

1.8 What is the degree of boiling water in Fahrenheit ?
   A  212
   B  100
   C  373
   D  460

1.9 Which factor does not influence capacitance in capacitive transducers
   A  The area of the plates
   B  The distance between the plates
   C  Linear output
   D  The insulating material between the plates

1.10 Area of application for strain gauges are:
   A  Torque
   B  Force
   C  All of the above
   D  None of the above
QUESTION 2

Choose an item from COLUMN B that matches a description in COLUMN A. Write only the letter (A–G) next to the question number (2.1–2.5) in the ANSWER BOOK.

<table>
<thead>
<tr>
<th>COLUMN A</th>
<th>COLUMN B</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1 A device with a moveable feature that opens and closes a passageway in order to allow, prevent or control the flow of fluids</td>
<td>A strain gauge</td>
</tr>
<tr>
<td>2.2 With this type the wire is not cemented but rather wound around the structure</td>
<td>B precaution when using resistance thermometer</td>
</tr>
<tr>
<td>2.3 A device that measures a potential difference which is unknown by comparing it with a known potential difference</td>
<td>C precaution when using pyrometers</td>
</tr>
<tr>
<td>2.4 Compensation for long-term drift</td>
<td>D potentiometer</td>
</tr>
<tr>
<td>2.5 The device embedded inside electric irons and street lights that triggers them to switch on and off</td>
<td>E non-bonded strain gauges</td>
</tr>
<tr>
<td>2.6 A very interesting principle of the piezoelectric effect</td>
<td>F bonded strain gauges</td>
</tr>
<tr>
<td>2.7 Instruments used to measure inductance</td>
<td>G valves</td>
</tr>
<tr>
<td>2.8 Transducers that work on a physical condition causing the resistance of the device to change</td>
<td>H Detecting element</td>
</tr>
<tr>
<td>2.9 Device that is in direct contact with the process-thermocouple</td>
<td>I LVDT</td>
</tr>
<tr>
<td>2.10 The pyrometer is so designed that the necessity of focusing the instrument with an eyepiece is eliminated</td>
<td>J Wedge type</td>
</tr>
<tr>
<td></td>
<td>K Resistance</td>
</tr>
<tr>
<td></td>
<td>L Crystal</td>
</tr>
<tr>
<td></td>
<td>M Rare Earth</td>
</tr>
<tr>
<td></td>
<td>N Mirror type</td>
</tr>
</tbody>
</table>

(10 x 1) [10]

TOTAL SECTION A: 20
SECTION B

QUESTION 3

3.1

![FIGURE 1]

3.1.1 What is the function of the instrument represented by the picture above? (1)

3.1.2 The instrument above (FIGURE 1) has load cells inside. Explain how a load cell works. (3)

3.1.3 What is calibration? (3)

3.1.4 How would you calibrate the instrument above (FIGURE 1)? (2)

3.2 A load cell makes use of a copper-nickel alloy strain gauge which has a nominal resistance of 120 Ω and a gauge factor of 2. The load cell is then subjected to a mass which results in a compression of stress of 27 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 120 GPa. (8)

3.3 State THREE advantages of a bonded strain gauge. (3)

[20]
QUESTION 4

4.1 Thermistors have a negative temperature coefficient; this means that with an increase in temperature the thermistor's resistance decreases and vice versa.

4.1.1 Give TWO applications of thermistors (2)

4.1.2 Explain how thermistors are constructed. (5)

4.1.3 State THREE disadvantages of thermistors. (3)

4.2 Optical pyrometers are nothing more than a photometer using monochromatic light which compares the intensity of radiation from a standard source with the intensity of radiation emitted by the body whose temperature is to be measured.

Make a neat, labelled sketch illustrating a disappearing filament, optical pyrometer (7)

4.3 State Stefan Boltzmann's law. (3) [20]

QUESTION 5

5.1 Pneumatic telemetering, also known as transmission telemetering uses a flapper and nozzle to vary pressure and is used in the absence of electrical supply.

5.1.1 Draw a neat, labelled sketch of a flapper-and-nozzle system that is used to vary the pressure of the output signal which is proportional to the measured variable. (2 x 5)

5.1.2 Explain how the system in QUESTION 5.1.1 works. (10)

5.2 Draw a non-bleed type relay valve and explain its working principle. (2 x 5) [20]
**QUESTION 6**

6.1 A valve positioner is a device installed between the controller and the valve actuator.

6.1.1 Draw a labelled sketch for a motion-balanced type valve positioner. (7)

6.1.2 Give FIVE factors to consider when choosing a valve. (5)

6.1.3 State THREE reasons for using valve positioners. (3)

6.2

**FIGURE 2**

6.2.1 Considering that there are THREE main control processes in use, what does the system in the above sketch represent? (2)

6.2.2 Give the definition for the system above. (3)

[20]

**TOTAL SECTION B:** 80

**GRAND TOTAL:** 100
INSTRUMENT TRADE THEORY N3

FORMULA SHEET

\[ P_G = P_{abs} - Pa \]

\[ P_1 - P_2 = h \Delta g \]

\[ P_1 - P_2 = d \rho g \left( \frac{A_1}{A_2} + 1 \right) \quad OR \quad P_1 - P_2 = d \rho g \left( \frac{A_2}{A_1} + 1 \right) \]

\[ p = \frac{Mg}{A} \]

\[ \frac{Q_1}{Q_2} = \frac{k}{k} \sqrt[1]{h_1} \]

\[ D.C. = \left( \frac{\rho_2}{\rho_2 - \rho_1} \right) \times W.C. \]

\[ W.C. = \left( \frac{\rho_2}{\rho_2 - \rho_1} \right) \times D.C. \]

\[ H = \frac{\Delta P}{\rho g} \]

\[ H = h \left( \frac{\rho_2}{\rho_1} - \frac{1}{2} \right) \]

\[ H = \frac{\rho_2}{\rho_1} h - \frac{h}{2} - H = \left( \frac{P_2}{P_1} - \frac{1}{2} \right) h - H_1 \]

\[ t^\circ C = \frac{9}{5} t + 32^\circ F \]

\[ t^\circ C = (t + 273.15) \text{ kelvin} \]

\[ t^\circ F = \frac{5}{9} (t - 32) \text{ } ^\circ C \]

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MARKING GUIDELINE

NATIONAL CERTIFICATE
APRIL EXAMINATION
INSTRUMENT TRADE THEORY N3

5 APRIL 2016

This marking guideline consists of 6 pages.

✓ = 1 Mark

✓ = \frac{1}{2} Mark
SECTION A

QUESTION 1

1.1 A
1.2 C
1.3 B
1.4 D
1.5 A
1.6 A
1.7 A
1.8 A
1.9 C
1.10 C

(10 x 1) [10]

QUESTION 2

2.1 G
2.2 E
2.3 D
2.4 B
2.5 A
2.6 L
2.7 I
2.8 K
2.9 H
2.10 N

(10 x 1) [10]

TOTAL SECTION A: 20

SECTION B

QUESTION 3

3.1 3.1.1 To measure weight/mass. ✓ (1)

3.1.2 Load cell is a special type of a spring ✓ that works on a principle of deforming in proportion to the weight placed on the load-receiving end ✓ and the weight of the object placed would be given digitally on the screen. ✓ (3)

3.1.3 Calibration is the set of operations that establish ✓ under specified conditions, the relationship between the values of quantities indicated by a measuring instrument ✓ and the corresponding values realised by reference standard ✓ (3)

3.1.4 The scale can be calibrated by weighing the known weight on a scale ✓ and noting discrepancies (if any) on the display ✓ (2)
3.2 **GIVEN**

\[ R = 120 \, \Omega \]
\[ K = 2 \]
\[ \text{STRESS } (\sigma) = 27 \, \text{MPa} \]
\[ \Delta R = ? \]
\[ E = 120 \, \text{GPa} \]

\[
E = \frac{\sigma}{\varepsilon} \]

\[ \therefore \varepsilon = \frac{\sigma}{E} \]

\[ \varepsilon = \frac{27 \times 10^6}{120 \times 10^9} \]

\[ \varepsilon = 2.25 \times 10^{-4} \]

\[ \Delta R = K \times \varepsilon \times R \]

\[ \Delta R = 0.054 \, \Omega \]  

(4)

(8)

3.3
- They have a slightly higher gauge factor. ✓
- They can easily be made waterproof. ✓
- They follow the contour of the surface onto which they are bonded more accurately. ✓
- Hysteresis and creep effect is smaller.
- Special patterns are easily produced.
- Special forms of the element can be easily manufactured as required.
- Because of high contact area, foil gauges dissipate heat easily.

(Any 3 x 1)  

[20]

**QUESTION 4**

4.1 4.1.1
- Can be used to measure temperature (alarm). ✓
- Can be used as a current suppressor (current limiter). ✓ (2 x 1)  

4.1.2
- They are made from metal oxides. ✓
- The oxides used are that of cobalt, copper, iron, tin and zinc. ✓
- The oxides in powder form are pressed into a shape and then heated forming a ceramic body. ✓
- Two terminals are also added before the heating process. ✓
- There are a few shapes such as beads, rods, disc and washers.✓  

(5 x 1)  

4.1.3
- They are not all manufactured exactly the same. ✓
- Interchangeability can be a problem. ✓
- Non-linear temperature vs resistance curve. ✓  

(3 x 1)  

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Please turn over
4.2

If two bodies of different temperatures are placed opposite each other, there is a transfer of heat energy from the hot body to the colder body and the amount of radiated energy per time unit is roughly proportional to the fourth power of the absolute temperature difference between the two bodies. This fourth power ratio is known as Stefan Boltzmann's law.

4.3

QUESTION 5

5.1

5.1.1

When the flapper is completely away from the nozzle we have a high flow-out of the nozzle creating a low pressure at the output receiver. When the flapper seals the nozzle the output pressure builds up to supply pressure which is then a small flow from the nozzle and a high pressure to the output receiver. The reason for the restriction is that when the flapper is away from the nozzle there is a large pressure drop. If the flapper is nearest to the nozzle then there is a small pressure drop across the restrictor.
5.2

No air bleeds out if the nozzle back-pressure is lower than the diaphragm forces. With only the supply pressure on the relay no air will bleed to atmosphere. The input pressure area is bigger than the feedback area. When the back pressure increases the supply port will be opened and therefore cause the output pressure to increase. Air will now bleed to the atmosphere.

QUESTION 6

6.1

6.1.1

- Valve size
- Type of plug
- Valve characteristics
- Type of connection to process lines
- Type of material and physical strength of valve

(5 x 1)

(5)
6.1.3  
- To move the actuator stem in accordance with the value of the input signal ✓
- To increase the accuracy and speed ✓
- To overcome friction ✓ 

6.2  
6.2.1  Closed-loop control ✓ / Feedback system ✓

6.2.2  A closed-loop system is a system which has feedback from the measuring element back to the correcting element ✓. The measured variable is compared to the set-point of the controller ✓, and the difference between these two signals is sent to the correcting element ✓. 

[20]

TOTAL SECTION B: 80
GRAND TOTAL: 100
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