

**OCR Level 3 Principal Learning in Engineering**

**UNIT F559**

Unit F559: Instrumentation and control engineering  
**Sample Paper**

Time: 2 hours

Candidates answer on the question paper.

Candidate Name

Centre Number

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Candidate Number

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**INSTRUCTIONS TO CANDIDATES**

- Write your name in the space above.
- Write your Centre number and candidate number in the boxes above.
- Answer **all** the questions in Section A and **four** question out of six in Section B
- Write your answers in blue or black ink, in the spaces on the question paper.
- Read each answer carefully and make sure you know what you have to do before starting your answer.

**INFORMATION FOR CANDIDATES**

- The number of marks is given in brackets [ ] at the end of each question or part question.
- The total number of marks for this paper is 60.

**ADVICE TO CANDIDATES**

- Read each question carefully and make sure you know what you have to do before starting your answer.

For Examiner's Use	
Section A	
Section B	
Total	

**Section A**

Answer **all** questions.

1. Explain what is meant by the term 'control'.

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[2]

2. Draw a block diagram of a system using the labels **input**, **output** and **control**.

[2]

3. Explain what is meant by the term 'open loop system'

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[2]

4. State which two of the following are input devices: heater, strain gauge, potentiometer, lamp

Input device 1.....

Input device 2.....

[2]

5. Complete the table by selecting **four** items from the list below :

mp3 player, electroplating plant, oil refinery, personal laptop computer, robotic arm, washing machine.

Chemical system	Electromechanical system
1	1.
2.	2.

[2]

6. In a domestic central heating system a programmer controls the time and a thermostat controls the temperature.

The system uses a logic controller to switch the boiler on and off.

The boiler will only come on if it is the right time and the temperature is set below a certain level.

Complete the table by writing in the word “on” or “off” in the third column to indicate the state of the boiler.

Thermostat control	Timer	Boiler
Off	Off	
Off	On	
On	Off	
On	On	

[1]

7. Name **two** types of display unit that can be used in a control system

Type 1 .....

Type 2 .....

[2]

8. Name the simulation software package you have used. Describe **one** benefit of how you would use the package to model and test control circuits.

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[5]

9. Give **two** benefits of using simulation software packages

Benefit 1 .....

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Benefit 2 .....

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[2]

[Section A Total 20]

**Section B**

Answer any **four** questions

10. (a) Explain, with the aid of a labelled diagram, what is meant by the terms:

(i) closed loop system

[3]

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(ii) negative feedback

[3]

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(b) Draw a labelled block diagram **and** a labelled circuit diagram showing how a light dependent resistor (LDR) can be used to control different levels of light.

[2]  
[2]

SAMPLE

[10]

11. (a) Explain what is meant by the term 'transducer' when used as a control unit.

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[2]

(b) A change in temperature of an engineering component can result in a number of other changes to that component. State **three** types of change that can occur.

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[3]

(c) Describe the principle of operation of a bimetallic strip thermometer. Use sketches where appropriate.

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[5]

[10]

12. (a) Explain what is meant by the term 'display unit'.

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[2]

(b) Draw fully labelled diagrams of the waveforms of an analogue signal and of a digital signal and give **one** benefit for each type of signal.

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[4]

(c) Describe a monitoring control signal within a washing machine.

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[4]

[10]



13. (a) Give **four** examples of level indicators that can be used in a domestic oil tank.

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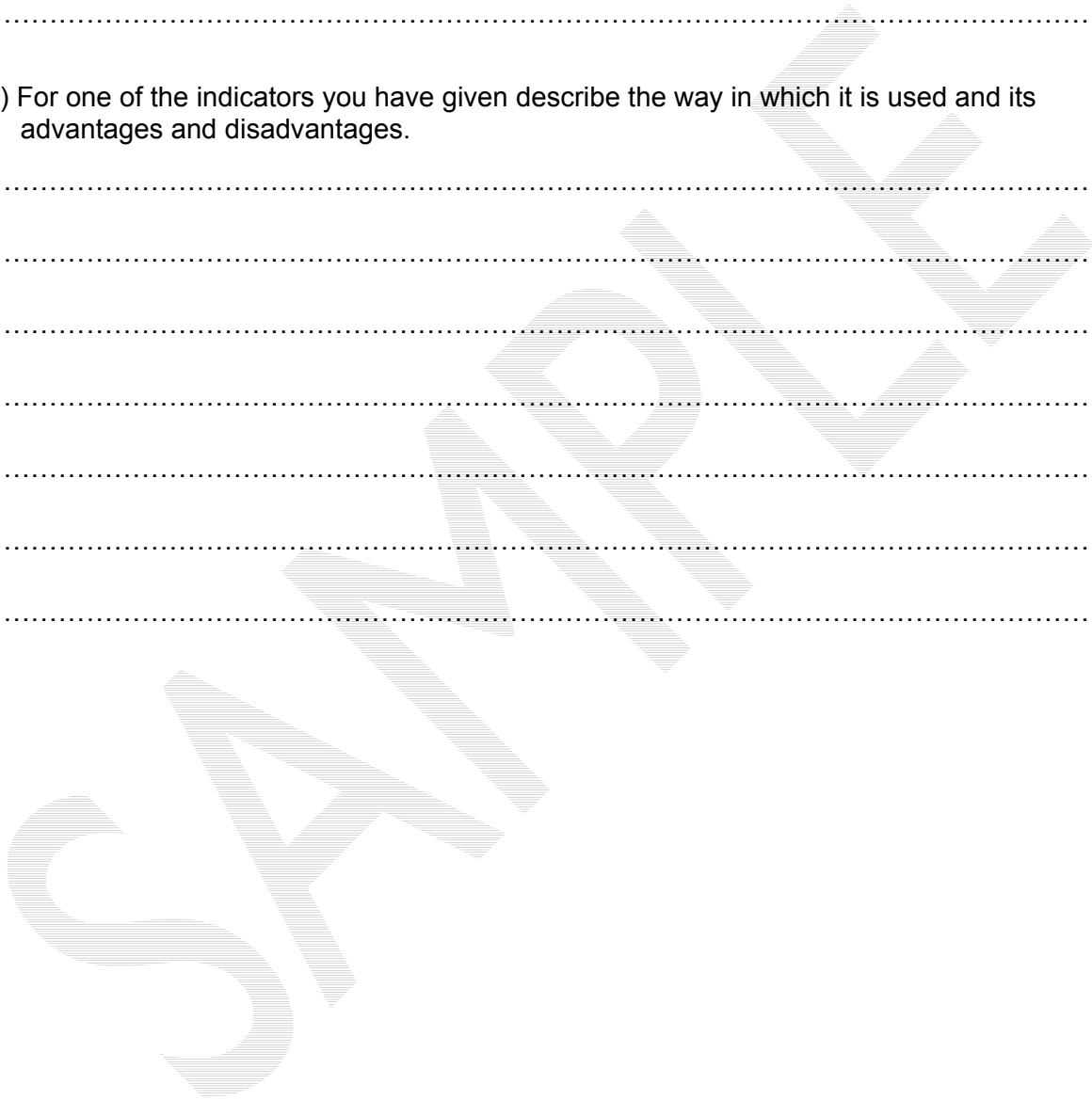
[4]

(b) For one of the indicators you have given describe the way in which it is used and its advantages and disadvantages.

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[6]

[10]



14. (a) Describe, with the aid of a labelled diagram, the principles of an R-2R ladder network digital-to-analogue (D to A) converter.

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[4]

(b) Explain the operating principles of a multiplexer.

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[3]

(c) Explain, with the aid of a labelled diagram, why it is sometimes necessary to use a multiplexer with a D to A converter.

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[3]

[10]

15. (a) An inverting operational amplifier has a gain of 10 and a feedback fraction of 0.08, which is used to apply negative feedback. Calculate the closed loop gain for the amplifier.

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[3]

(b) In a different operational amplifier with a constant input, the output falls from 50V to 25V when negative feedback is applied. Calculate the feedback fraction in this system.

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[4]

(c) For the amplifier in part (b) the amplifier gain falls to 35. Calculate the percentage change in gain:

(i) without negative feedback connected

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[1]

(ii) with negative feedback connected.

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[2]

[10]

SAMPLE

**[Section B Total 40]**

**[Paper Total 60]**

OCR Level 3 Principal Learning in Engineering **[F559]**

Unit F559: Instrumentation and control engineering

**Sample Mark Scheme**

The maximum mark for this paper is [60].

SAMPLE

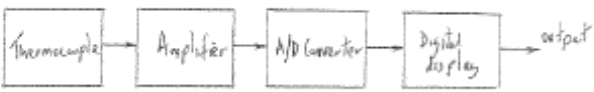
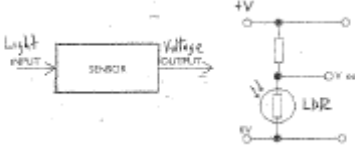
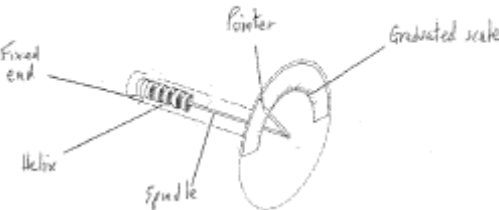
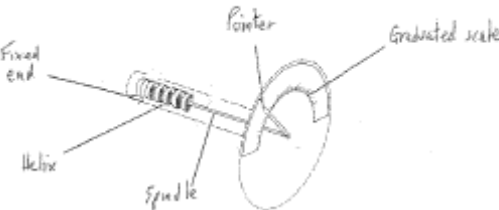
## Sample Mark Scheme

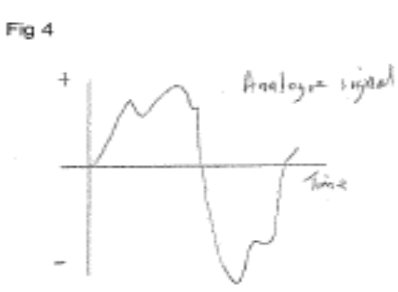
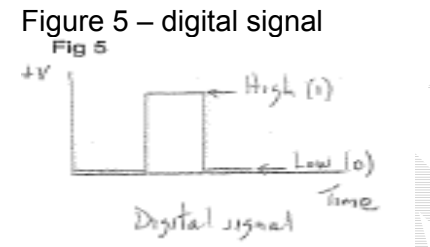
### Section A

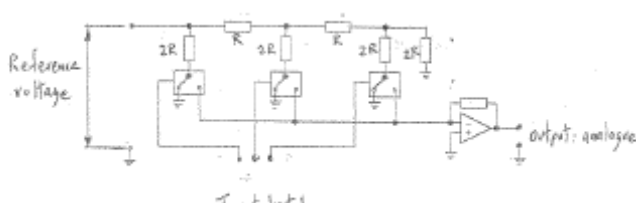
Question Number	Answer	Maximum Mark															
1	Control – part of a system that changes the input from one form into another so that there can be an output.	2															
2	Input → control → output →	2															
3	Open loop system – a system made up of a number of connecting blocks without any checks taking place i.e. without feedback.	2															
4	Input devices - strain gauge and potentiometer.	2															
5	<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="text-align: center;">Chemical system</th> <th style="text-align: center;">Electromechanical system</th> </tr> </thead> <tbody> <tr> <td style="text-align: center;">1 Oil refinery</td> <td style="text-align: center;">1. Washing machine</td> </tr> <tr> <td style="text-align: center;">2. Electroplating plant</td> <td style="text-align: center;">2. Robotic arm</td> </tr> </tbody> </table> <p>1 mark for two chemical systems and 1 mark for two electromechanical systems.</p>	Chemical system	Electromechanical system	1 Oil refinery	1. Washing machine	2. Electroplating plant	2. Robotic arm	2									
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1 Oil refinery	1. Washing machine																
2. Electroplating plant	2. Robotic arm																
6	<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="text-align: center;">Temperature</th> <th style="text-align: center;">Timer</th> <th style="text-align: center;">Boiler</th> </tr> </thead> <tbody> <tr> <td style="text-align: center;">Off</td> <td style="text-align: center;">Off</td> <td style="text-align: center;">Off</td> </tr> <tr> <td style="text-align: center;">Off</td> <td style="text-align: center;">On</td> <td style="text-align: center;">Off</td> </tr> <tr> <td style="text-align: center;">On</td> <td style="text-align: center;">Off</td> <td style="text-align: center;">Off</td> </tr> <tr> <td style="text-align: center;">On</td> <td style="text-align: center;">On</td> <td style="text-align: center;">On</td> </tr> </tbody> </table>	Temperature	Timer	Boiler	Off	Off	Off	Off	On	Off	On	Off	Off	On	On	On	1
Temperature	Timer	Boiler															
Off	Off	Off															
Off	On	Off															
On	Off	Off															
On	On	On															
7	Any two correct display units e.g. – voltmeter, ammeter, CRO, LED, etc.	2															
8	<p>Accept any known simulated computer software package and its description of how the package was used to model and test control circuits.</p> <p>Marks to be awarded according to the quality of response given.</p>	5															

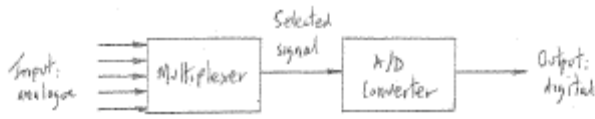
Question Number	Answer	Maximum Mark
9	<p>The benefits of using simulation software packages are:</p> <ul style="list-style-type: none"> <li>• no matter what the size of a system is e.g. power station, it can be produced as a software package</li> <li>• the provision of a safe environment with which learners can test hypotheses and study outcomes</li> <li>• allowing access to activities which would otherwise be difficult to experience</li> <li>• overcoming the need for multiple sets of specialised and expensive equipment</li> <li>• learners are allowed to concentrate on principles rather than techniques</li> <li>• with data logging equipment within the package readings can be taken <ul style="list-style-type: none"> <li>▪ with a high degree of accuracy,</li> <li>▪ over a long period of time or many readings in a short time</li> <li>▪ where there is a safety risk of extremes of heat or cold conditions</li> </ul> </li> <li>• learners can use the software out of class time for reinforcement, revision and self testing</li> <li>• it is eventually often less expensive and cumbersome than having to travel to observe a real system</li> </ul> <p style="text-align: right;">1 mark for a limited response and 2 marks for a full response.</p>	2
<b>Section A Total: 20 marks</b>		



Question Number	Answer	Maximum Mark
10	<p>(a) (i) closed loop system – carries out an action and has a means of checking to verify that the action has been carried ie feedback</p> <p>(a) (ii) negative feedback - when an output signal is fed back to the input and it opposes the input</p> <p>(b) Figure 1 - labelled block diagram</p>  <p>Figure 2 - labelled circuit diagram</p>  <p>(c) Figure 3 - bimetallic strip thermometer.</p>  <p>The thermometer has two different metal strips bonded together. Each strip has a different coefficient of expansion.</p> <p>The strip is wound in the form of a helix. Any change in temperature causes the length of each metal strip to change. The strip with the higher coefficient of expansion will be on the outside. This change in temperature will result in a rotation of the free end of the helix. This rotation moves a pointer on a scale thus recording temperature.</p>	<p>3</p> <p>3</p> <p>2</p> <p>2</p> <p>[10]</p>
11	<p>(a) transducer – a device that changes information from one form into another.</p> <p>(b) change in dimensions, change in electrical resistance, a thermoelectric change in the e.m.f. for two different materials joined together, change in the intensity and colour of the radiation emitted by the hot body.</p> <p>(c) Figure 3 - bimetallic strip thermometer.</p>  <p>The thermometer has two different metal strips bonded together. Each strip has a different coefficient of expansion.</p> <p>The strip is wound in the form of a helix. Any change in temperature causes the length of each metal strip to change. The strip with the higher coefficient of expansion will be on the outside. This change in temperature will result in a rotation of the free end of the helix. This rotation moves a pointer on a scale thus recording temperature.</p>	<p>2</p> <p>3</p> <p>2</p> <p>3</p> <p>[10]</p>

Question Number	Answer	Maximum Mark
12	<p>(a) display unit – a device that changes signals from one form into another which can be registered on a digital or analogue read-out.</p> <p>(b) Figure 4 – analogue signal</p> <p>Fig 4</p>  <p>Benefits – better for audio and radio signals and are amplifier type circuits</p> <p>Figure 5 – digital signal</p> <p>Fig 5</p>  <p>Benefits – better for two-state switching type circuits</p> <p>(c) Monitoring control systems in a washing machine</p> <ul style="list-style-type: none"> <li>• Door closed</li> <li>• Water level i.e. valves</li> <li>• Temperature of water</li> <li>• Drum rotation i.e. motor</li> <li>• Timing of cycles</li> <li>• Pump to empty water</li> <li>• Door open</li> </ul> <p>Award 1 mark for identifying a washing machine control system and up to a further 3 marks for the quality of description</p>	<p>2</p> <p>2</p> <p>2</p> <p>4</p> <p>[10]</p>

Question Number	Answer	Maximum Mark
13	<p>(a) Level indicators:</p> <ul style="list-style-type: none"> <li>• dip stick</li> <li>• glass gauge</li> <li>• float system</li> <li>• weight system</li> <li>• pressure measurement system</li> </ul> <p>Accept any other type of system that is correct</p> <p>(b) Description of one level indicator and its use  Advantages of chosen indicator  Disadvantages of chosen indicator</p> <p>For example:  Dip stick level indicator – the stick is inserted into the oil tank in a vertical manner. Time is allowed for the oil to adhere to the stick. It is carefully withdrawn from the tank, taking care not to disturb the oil on the stick. A reading is taken and the stick is wiped clean.  Advantages – less costly than other forms of indicator, easy to use and store.  Disadvantages – can give false readings if the indicator is not held vertically, not very accurate.</p>	<p>4</p> <p>2 2 2</p> <p>[10]</p>
14	<p>(a) Figure 6 -R-2R ladder network digital-to-analogue converter. The input to the digital to analogue converter is a binary word and the output is its equivalent analogue value. In this converter it uses only two values of resistor. The circuit uses an op amp as a summing amplifier with a feedback resistor. When an input is binary 1 it is connected to a fixed reference voltage and when it is a binary 0 it is connected to zero volts. The input voltages applied to the op amp by the three bit input via the resistors have one of two values, either zero volts or the reference voltage. Using the summing amplifier formula, the analogue output voltage is numerically calculated and displayed.</p> <div style="text-align: center;">  <p>Figure 6</p> </div> <p>(b) Multiplexer - A number of analogue signals go into the multiplexer which is basically a switching device. Each input is considered in turn and then sent to the analogue to digital converter</p> <p>(c) A multiplexer is needed because on many occasions there is a need for measurements to be sampled from more than one location or a set of different measurements to be taken. A number of analogue signals go into the multiplexer which is basically a switching device. Each input is considered in turn and then sent to the A/D converter.</p>	<p>4</p> <p>3</p>

Question Number	Answer	Maximum Mark
	<p>Figure 7-multiplexer with a digital to analogue converter.</p> <p>Figure 7</p> 	<p>3</p> <p>[10]</p>
<p>15</p>	<p>(a) Closed loop gain = <math>-A / (1 + A\beta)</math>  <math>= -10(1 + 0.08 \times 10)</math>  <math>= -10/1.8</math>  <math>= -5.556</math></p> <p>(b) Feedback fraction</p> $-25 = -50 / (1 + 50\beta)$ <p>so <math>(1 + 50\beta) = -50/-25</math>  <math>(1 + 50\beta) = 2</math>  <math>50\beta = 2 - 1</math>  <math>50\beta = 1</math>  <math>\beta = 1/50</math> or <math>0.02</math></p> <p>(c) (i) without negative feedback connected</p> <p>Fall in gain = <math>[(50 - 35)/50]100</math>  <math>= 30\%</math></p> <p>(ii) with negative feedback connected</p> <p>Gain = <math>35/(1 + 35 \times 0.02)</math>  <math>= 35/1.7</math>  <math>= 20.59</math></p> <p>Fall in gain = <math>[(25 - 20.59)/25]100</math>  <math>= 17.64\%</math></p>	<p>3</p> <p>4</p> <p>1</p> <p>1</p> <p>1</p> <p>[10]</p>
<p><b>Section B Total: 40 marks</b></p>		
<p><b>Paper Total marks [60]</b></p>		