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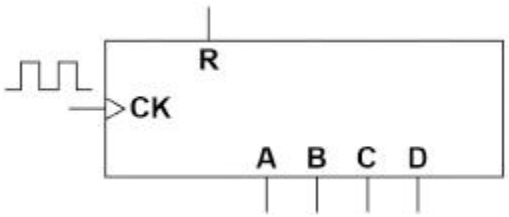
Exam Preparation and Free Resources

Q1.

Figure 1 shows the input and output pins for a 4-bit binary counter. The output pin for the least significant bit is **A**.

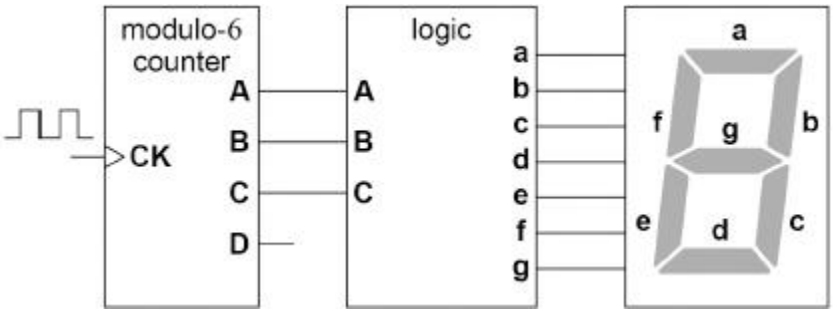


(a) Complete **Figure 1** by adding a single logic gate to the binary counter so that the circuit functions as a modulo-6 counter.

(2)

Figure 2 shows three outputs of the modulo-6 counter connected to a logic sub-system that controls a 7-segment display.
The decimal point on the display is not shown.
The whole system shown in **Figure 2** is to be used as an electronic dice.

Figure 2



Segments in the 7-segment display are turned on or off by the logic sub-system to display the decimal numbers 1 to 6 in sequence.
A segment in the display turns on when the logic output with the same letter as the segment is at logic 1.

The table below shows how the values of **CBA** control the logic level applied to each of the segments **a** to **g** during the counting cycle.

Logic inputs	Logic outputs

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C	B	A	a	b	c	d	e	f	g
0	0	0	0	1	1	0	0	0	0
0	0	1	1	1	0	1	1	0	1
0	1	0	1	1	1	1	0	0	1
0	1	1	0	1	1	0	0	1	1
1	0	0	1	0	1	1	0	1	1
1	0	1	1	0	1	1	1	1	1

(b) One of the logic outputs **a** to **g** is controlled by a single NOT gate. This gate uses one of the inputs **A**, **B** or **C**.

State the input that is used and the segment that this NOT gate controls.

input = _____

segment = _____

(1)

(c) **X** represents one of the logic outputs. The Boolean expression for this output is:

$$\mathbf{X} = (\mathbf{A} \cdot \mathbf{B}) + \mathbf{C}$$

State which of the logic outputs **a** to **g** is being controlled by this function.

logic output = _____

(1)

(d) **Y** represents another of the logic outputs. The Boolean expression for this output is:

$$Y = \left(\overline{A} \cdot \overline{B}\right) + \left(\overline{\overline{B} \cdot \overline{C}}\right)$$

Complete **Figure 3** to show the combination of logic gates needed to represent the expression. You should only use logic gates that represent the individual functions shown in the expression.

Figure 3

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A ○

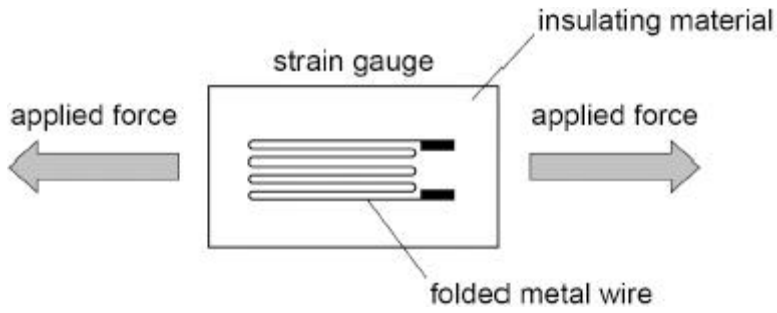
B ○ ○ Y

(3)
(Total 7 marks)

Q2.

Figure 1 shows a strain gauge that consists of a folded metal wire glued to a piece of insulating material.

Figure 1



The resistance of the metal wire:

- increases when the gauge is stretched by forces applied as shown
- changes when there is a change in temperature.

(a) **Figure 2** shows a circuit that contains two identical strain gauges **A** and **B**.
The resistance of each strain gauge is 120.00 Ω when the strain is zero.

R_1 is a 560 Ω fixed resistor.
R_2 is a 100 Ω variable resistor.
R_3 is a 510 Ω fixed resistor.

Assume that the voltmeter is ideal.

Figure 2

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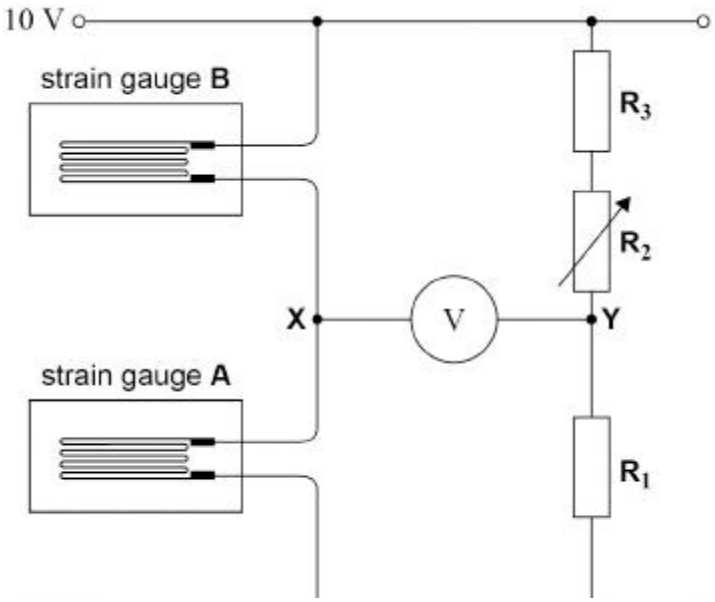

The circuit is used to measure changes in strain in a metal beam.
A is glued firmly to the metal beam.
B is placed on the beam near **A** but is not glued to the beam.

Initially, with the gauges under zero strain, $\mathbf{R_2}$ is adjusted to produce 0 V on the voltmeter.
When the beam bends, **A** stretches and **B** remains unstretched.
The resistance of **A** increases to 120.06 Ω.

Calculate, in mV, the new reading on the voltmeter.

reading on the voltmeter = _____ mV

(3)

(b) Explain the advantage of using strain gauge **B** rather than a 120.00 Ω resistor in the circuit.

_____

_____

_____

_____

_____

_____

(2)

(c) The voltages at **X** and **Y** in **Figure 2** are now used as inputs to an operational amplifier.
The operational amplifier is configured as a difference amplifier with a gain of +5

Complete **Figure 3** to show the difference amplifier circuit.
Any resistors used must be labelled with their values. These values must be in the range 10

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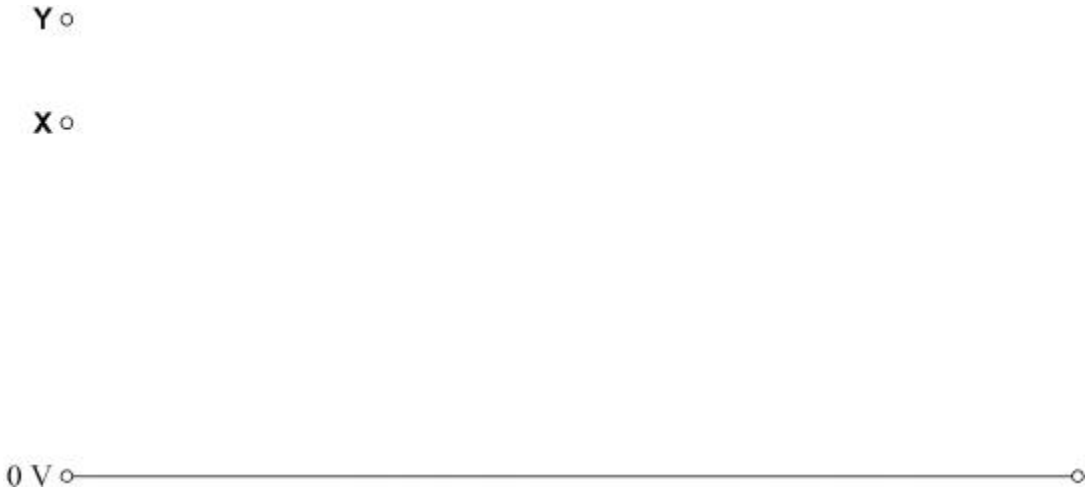
kΩ–10 MΩ.
Do not show the supply rails.

Figure 3

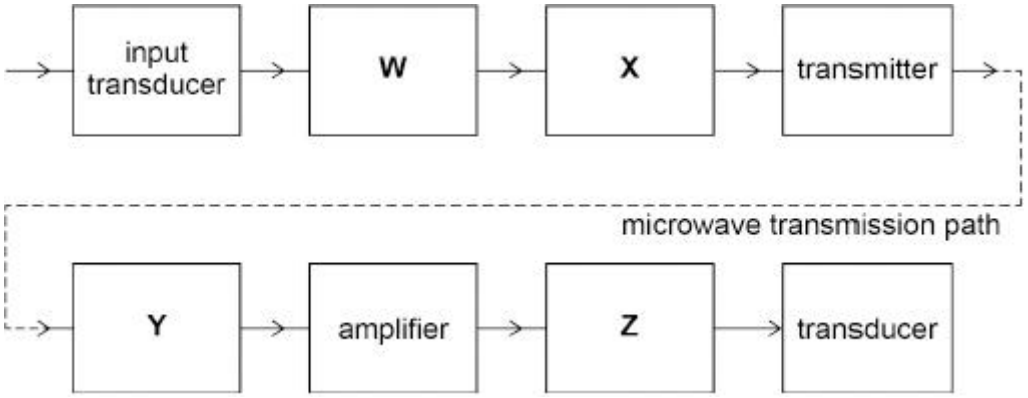


(3)

(Total 8 marks)

Q3.

(a) The figure below shows a block diagram for part of a communication system that transmits control information from Earth to a satellite.



Which row gives the functions of the boxes **W**, **X**, **Y** and **Z** in the figure above?

Tick ✓ **one** box.

W	X	Y	Z	
amplifier	modulator	demodulator	receiver	☐
modulator	amplifier	receiver	demodulator	☐
demodulator	amplifier	modulator	receiver	☐
amplifier	demodulator	receiver	modulator	☐

(1)

(b) Syncom 3 was the first geostationary communication satellite.

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The satellite was used to broadcast television signals of the 1964 Olympic Games from Tokyo in Japan to Los Angeles in the USA.

State what is required so that de-sensing does not occur in a radio receiver such as that on Syncom 3.

_____

_____

_____

(1)

Commentators in Los Angeles interviewed athletes in Tokyo using Syncom 3.

The commentators found that there was a significant time delay between the end of each question and the arrival of its reply.

This time delay was made up of:

- the total time that the signals spent travelling
- the total processing time.

(c) The distance of the geostationary satellite from both Tokyo and Los Angeles was 40 000 km.

The time delay was 900 ms.

Calculate, in ms, the total processing time.

total processing time = _____ ms

(2)

(d) The television signals received in the USA were relayed to the UK using a satellite in low Earth orbit.
The availability of live coverage was different for viewers in the USA and viewers in the UK.

Explain why.

_____

_____

_____

_____

_____

_____

(2)

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(e) For the 2020 Olympics, digital TV signals between Tokyo and Los Angeles used a fibre-optic cable. The cable lies on the seabed.

Explain why a fibre-optic cable rather than a satellite link is now preferred for intercontinental communication.

_____

_____

_____

_____

(2)

(Total 8 marks)

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