Fill in these boxes and read what is printed below.

Full name of centre

Town

Forename(s)

Surname

Date of birth

Day Month Year

Scottish candidate number

Number of seat

1 Answer all the questions.

2 Read every question carefully before you answer.

3 Write your answers in the spaces provided.

4 Do not write in the margins.

5 Do not sketch in ink.

6 All dimensions are given in millimetres.

7 Show all working and units where appropriate.

8 Reference should be made to the Standard Grade and Intermediate 2 Data Booklet (2008 edition) which is provided.

9 Before leaving the examination room you must give this book to the Invigilator. If you do not, you may lose all the marks for this paper.
1. A mobile pitch-side camera system is used during a rugby match.

(a) Describe, with reference to the control diagram, the operation of the system.

The camera system makes use of closed loop control.

(b) Explain the difference between open loop and closed loop systems.
An action film sequence uses a number of special effects operated by a microcontroller.

The program makes use of a **sub-procedure** “Action”, shown on the flowchart below.
2. (continued)

Input and output connections to the microcontroller are shown in the table below.

<table>
<thead>
<tr>
<th>Input Connection</th>
<th>Pin</th>
<th>Output Connection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smoke effect</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Blast effect</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Sensor</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

Complete the PBASIC program for sub-procedure “Action”, with reference to the flowchart, Data Booklet, and the input/output connections.

Init: let dirs = %11000000  
      symbol counter = b0

Action:
3. A digital electronic system is used to control part of an electronic toy as shown in the truth table below.

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>Z</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
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<td>1</td>
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</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

(a) Complete, with reference to the truth table, a Boolean expression for Z in terms of A, B and C.

\[ Z = \ \text{________________________} \]

(b) Complete a logic diagram for the following Boolean expression.

\[ Z = (A \cdot C) + B \]

A \hspace{1cm} B \hspace{1cm} C \hspace{1cm} Z
3. (continued)

(c) State, with reference to the Data Booklet, the **full name** of the following two ICs (Integrated Circuits) required to form part of the circuit.

IC Number 7408

Full Name ____________________________________________

IC Number 7404

Full Name ____________________________________________

(d) State **two** characteristics of a 7400 series IC (Integrated Circuit).

1. ____________________________________________________________  
2. ____________________________________________________________

[Turn over

[4040/31/01]  
Page seven
4. A prototype for a burglar alarm system is required.

A buzzer will sound if master switch C is on and either pressure switch A or B is also pressed.

(a) Complete the circuit below using three SPST switches and a buzzer.

```
  C
 /     \
A     B
 /     \
  6V
```
4. (continued)

The circuit is adapted so that an LED switches on when the system is active.

(b) Draw the symbol for an LED.

c) Describe how an LED should be protected when wired in a circuit.

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________
5. A Scottish island community is looking to become self-sufficient in energy production.

(a) Describe an advantage that tidal power has over wind power.

(b) Describe how a wind turbine typically produces electricity.

(c) Describe two disadvantages of using finite energy sources.
5. (continued)

Holiday cottages on the island are installed with solar thermal panels to heat the cold water.

It was found that 100 kg of water at 10 °C entered the solar panels and absorbed 7 MJ of heat energy.

(d) (i) Calculate, with reference to the Data Booklet, the final temperature of the water.

(ii) Calculate the efficiency of the solar panels if the sun provided 11 MJ of heat energy.
6. Microcontrollers are increasingly used in electronic control systems.

(a) Explain why microcontrollers are often used instead of hard-wired electronic circuits.


(b) Complete the table below to match the microcontroller sub-system to its function.

<table>
<thead>
<tr>
<th>Sub-system</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clock</td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>Links the microcontroller to the outside world</em></td>
</tr>
<tr>
<td>EEPROM</td>
<td></td>
</tr>
<tr>
<td>ALU</td>
<td></td>
</tr>
</tbody>
</table>
6. (continued)

(c) State the full name of EEPROM.

(d) Explain why sub-procedures are commonly used in a control program.

Microcontrollers use binary numbers in their calculations and operations.

(e) (i) Convert the following decimal value number to an **8-bit** binary number.

\[ 56 = \% \quad \text{____________________} \]

(ii) Convert the following binary number to decimal.

\[ \%11001101 = \quad \text{____________________} \]

(f) State the name of a method of controlling the speed of a motor using a microcontroller.

[Turn over
7. A solar-powered water-pumping system is being tested for use in developing countries.

The system consists of two separate mechanisms.

(a) State the name of the following mechanisms.

Mechanism A: ________________________________

Mechanism B: ________________________________

(b) Describe the change in motion produced by mechanism B.

__________________________________________________________________________
7. (continued)

(c) Calculate the output speed of mechanism A.

Mechanism A is decided to be too bulky and is replaced by the following mechanism.

(d) State the name of this mechanism.

(e) Describe how friction could be reduced in a mechanical system.

(f) State the names of two mechanisms that will convert rotational motion into linear motion.

1

2
8. A model dragon is used as part of a stage production.

The dragon’s mouth is operated by pressing Valve A, or by pressing Valve A and B together.

(a) Describe, using appropriate terminology, how the pneumatic circuit operates.

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________
8. (continued)

(b) State the **full name** of the following components.

Valve (C) .................................................................

Device (E) .................................................................

It was decided to control the dragon’s mouth with an electronic control system.

(c) (i) State the name of the actuator that is used for electronic control of a pneumatic valve.

........................................................................................................

(ii) Draw the symbol for this actuator.

Air pressure is supplied to the double-acting cylinder at 0.2 N/mm².

![Diagram of a double-acting cylinder with labels Diameter 30 mm and Diameter 10 mm.]

(d) Calculate the **instroking** force produced by the cylinder.
9. A game show contestant must perform a task without covering a light sensor. If it is covered then an alarm sounds. The circuit is shown below.

During testing the light level is varied.

(b) (i) Determine, with reference to the Data Booklet, the resistance of the LDR at 20 Lux.

(ii) Calculate the base current ($I_B$) when $V_{out}$ is 3.2 V and $R_b$ is 1.5 kΩ.
9. (continued)

(c) Explain the function of the following components that are often used in this type of circuit.

(i) Relay

(ii) Base Resistor (Rb)

(iii) Diode

(d) Describe an advantage of testing an electronic circuit using computer simulation.

[Turn over
During the design of a new lightweight family car the forces acting on it are analysed.

The forces are shown on the diagram above.

(a) State the name of this type of diagram.

(b) Calculate the reaction force at R₂.
   (Take moments about R₁).

[END OF QUESTION PAPER]
ACKNOWLEDGEMENTS

Question 10—Image of Citroën car. Permission is being sought from Citroën UK.