1(a) The following assembly code in Fig. 1 is written for the Little Man Computer instruction set.

```
      INP
      STA  arg1
      INP
      STA  arg2
      LDA  arg1
loop  SUB  arg2
      BRP  loop
      ADD  arg2
      OUT
arg1  DAT
arg2  DAT
```

Fig.1

State the output when the inputs are 13 followed by 5.

---------- [1]

(b) In the line:

```
loop  SUB   arg2
```

(i) State what opcode SUB does.

---------- [1]

(ii) Name the register in which the result of this line is stored.

---------- [1]

(c)

(i) State what the program in Fig. 1 does.

---------- [1]

(ii) Using pseudocode write a program for a procedural language that takes in two inputs and gives the same output as the program in Fig. 1.

---------- [2]

2(a) The program, as shown in Fig.2 below, is written in assembly code using the Little Man Computer instruction set. It is *supposed* to take in two numbers and output the higher.

```
      INP
      STA   NUMA
      INP
      STA   NUMB
      SUB   NUMA
      BRP   NOTA
      LDA   NUMB
      BRA   QUIT
NOTA  LDA   NUMA
QUIT  OUT
      HLT

NUMA  DAT
NUMB  DAT
```

Fig.2

State what type of translator program would be needed to convert the code above into machine code.

---------- [1]

(b) Explain how you would correct the program so it outputs the higher of the two numbers entered.

[2]

(c) The program does not work correctly. Describe what the program actually does, using the numbers 4 and 9 being entered as an example.

[2]

(d) Programs can also be written in high level languages. In pseudocode write a procedural program that takes in two numbers and outputs the higher of them.

[4]

(e) A processor executes this program following the Fetch-Decode-Execute cycle. To do this it needs to make use of registers.

One of the registers used is the Program Counter (PC). Ordinarily it would be incremented by one each cycle.

(i) Identify an instruction in the Little Man Computer program shown in Fig.2 that would cause the PC to change in a different way.

---

[1]

(ii) State which register the contents of the PC would be copied to in order for the processor to access the next instruction.

---

[1]

3(a) The following is a program written using the Little Man Computer instruction set.

```
start  LDA   one
       OUT
       LDA   zero
       OUT
       LDA   count
       SUB   one
       STA   count
       BRP   start
       HLT
one    DAT   1
zero   DAT   0
count  DAT   3
```

Describe the difference between the STA and LDA instructions.

---

[2]

(b) Identify the type of memory addressing the program uses.

---

[1]

(c) State the output this program generates.

---

[3]

(d) Describe **one** issue the line `BRP start` may cause for a CPU using pipelining.

---

[2]

(e) Explain the buses and registers used when the line `SUB one` is executed.

---

[5]

(f) Explain, giving an example, how pipelining in a CPU could speed up the execution of this program.

---[3]

END OF QUESTION PAPER