

Q1. Which of the following statements below is correct.

A subroutine is:

- (a) A program that links software routines into one executable program.
- (b) A program that allows you to enter the source program as a file on disc.
- (c) A program module that performs a well defined function.
- (d) A program that translates from assembly-level source to machine code.

Q2. Describe the operation of the following code snippet, and state what its function is.

```
NUMBER    equ    h' 20'
DATUML    equ    h' 30'
DATUMH    equ    h' 31'
STATUS    equ    3
C          equ    0

; -----

        clr    DATUMH
        movf   NUMBER,w
        addwf  NUMBER,w
        movwf  DATUML
        btfsc  STATUS,C
            incf DATUMH,f
NEXT     -----
```

Q3. Compare and contrast the operation of both the von Neumann and Harvard computer structures using diagrams to illustrate your answer. What are the main advantages and disadvantages of each architecture?

Q4. (a) Write a PIC MCU assembly-level program to check that the byte content of File h'30' (to be named **NUMBER1**) and the byte content of File h'31' (to be called **NUMBER2**) are the same, and if they are, the contents of File h'40' (to be named **EQUAL**) are to be made h'FF' otherwise the contents of File h'40' are to be h'00'.

(b) Without writing code, how could you extend your approach to (a) to determine if **NUMBER2** is higher than or lower than **NUMBER1**?

After the subtraction **NUMBER1 - NUMBER2**, check for a Borrow using the **C** flag (which acts as an inverted Borrow)

- IF **C == 0** (Borrow) THEN **NUMBER1 > NUMBER2**
- IF **C == 1** (No Borrow) THEN **NUMBER1 <= NUMBER2**

The **Z** flag gives the equality test so can be used with **C==1** to give **NUMBER1 < NUMBER2** (to eliminate the = case)

Q5. (a) Briefly detail the advantages and disadvantages of a modular approach to writing software, using the concept of the subroutine to illustrate your answer.

(b) Write a PIC MCU subroutine in assembly language to give a fixed delay of 200 μ s. You may assume that a 4 MHz oscillator is being used. For full marks you must show your timing calculations.

(c) How might you alter your code if the crystal were replaced by a 1 MHz crystal?

Q6. A student project involves the detection and display of wind direction; namely north, east, south or west. It is suggested that a disc, having black and white markings as shown in Fig. Q.C3, be connected to a weather vane and that two reflected opto-switches, A and B, detect the position the disc is turned to. Each sensor outputs a logic 1 when light is reflected and logic 0 otherwise. Four LEDs are to be used to indicate the wind direction.

- a. List the four patterns for the various directions and draw a flow chart showing a process of systematically testing the two signals A and B, with one of four outcomes being indicated for the various possibilities.
- b. Show how the two opto-switches and four LEDs could be interfaced to a PIC16F84 MCU.
- c. Write a program to:
 - I. Set up the port(s) as appropriate to (b) above.
 - II. Implement your four tests to light the appropriate LED for each pattern.