PROGRAM 1:

To practice writing and using subroutines, write a subroutine that calculates the expression: \( Z = (a0 \times x0) - (a1 \times x1) \).

The values of the four variables \( a0, a1, x0, x1 \) are to be passed to the subroutine in registers. The address of variable \( Z \) is to be passed to the subroutine in a register.

The “main” program is to call the subroutine two times, once for each of the following sets of data. You may not use “immediate” data – all values are to be read from memory and results are to be stored in memory. The data formats are to be as follows.

\( x0 \) and \( x1 \) are to be 32-bit integers.
\( a0, a1, \) and \( z \) are to be stored using Q24.8 format, i.e. 24 integer bits and 8 fraction bits, stored in a 32-bit word as follows: \( n_{23}n_{22}n_{21}... n_{1}n_{0} . n_{-1}n_{-2} ... n_{-7}n_{-8} \)

Qn.m format is described on the ARM web page: http://infocenter.arm.com/help/index.jsp?topic=/com.arm.doc.dui0066d/CHDFAAEI.html

For the first call: \( x0=200, x1=100, a0=5.25, a1=6.75 \).
Store the answer at variable \( z1 \).

For the second call: \( x0=300, x1=200, a0=3.5, a1=4.125 \).
Store the answer at variable \( z2 \).

Define all ten variables in a DATA section, and use a debug initialization file to set the eight “arguments” to the test values indicated above.

You may test this with the simulator, but the version to be submitted must be executed in RAM on the Discovery board. Submit a printout of your source program, and a screen image of the Debug window, with the results either highlighted (circled) in a Memory window or displayed in a Watch window.

(Program 2 on next page.)
PROGRAM 2:

Given below is a C program that includes several function calls.

a. Write the equivalent routines in ARM assembly language and test the program in the Keil debugger. Submit two screen captures of the debug window, showing the final result returned for each of the two functions called by the main program. The main program and the three “functions” should be implemented as separate routines/subroutines as defined below (i.e. do not “merge” them to optimize the program.)

b. Create a new project and then enter and compile the C program, as given, and compare the “listing file” to your hand-written assembly language program. Alternatively, you may view the disassembled code in the debugger window to see the C and equivalent assembly language instructions. Turn off any optimizations that would normally be performed by the C compiler.

This program can be done in the simulator or on the Discovery board.

```c
int k;  //global variable

int f1(int x1, int x2) {  
    return x1 + x2;
}

int f2(int x1) {  
    return x1 + 1;
}

void f3(int r) {  
    int j;
    for (j = 0; j < 2; j++)  
        k = k + f1(r + j, 5);
}

void main () {  
    int a;
    k = 0;
    f3(3);
    a = f2(2);
}```