Directions:

a. DO NOT OPEN YOUR EXAM BOOKLET UNTIL YOU HAVE BEEN TOLD TO BEGIN.

b. This exam booklet contains 30 questions, each of which will be weighted equally. The exam is worth 180 points (18% of your course grade).

c. You may use one 8.5" x 11" note sheet during the examination. No other reference materials or electronic devices (such as calculators) may be used during the examination.

d. You may not ask questions once the examination has begun.

If there is a structural problem with your exam booklet, such as a missing page or poorly printed page, please bring your exam booklet to the proctor.

If you believe that a question is ambiguous or contains a typographic error, write your interpretation of the question on the same page as the question, then put a note on the cover sheet of your exam booklet.

e. You should choose the single best alternative for each question, even if you believe that a question is ambiguous or contains a typographic error. If a question has more than one correct answer, full credit will be awarded for any correct answer.

f. Please fill in the requested information at the top of this exam booklet.

g. Use a #2 pencil to encode any information on your OMR form (bubble sheet).

h. Please encode the following on the OMR form:

   -- Last name and first initial
   -- MSU PID
   -- Exam form (2 X)

i. Only answers recorded on your OMR form will be counted for credit. Completely erase any responses on the OMR form that you wish to delete.

j. You must turn in this exam booklet and the OMR form when you have completed the exam. When leaving, please be courteous to those still taking the exam.
01. Figure 1 gives the format of ARM data processing instructions. What ARM assembly language instruction is equivalent to the machine language instruction shown below in binary?

```
1 1 1 0 0 0 1 1 0 1 0 1 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0
```

A) `cmp r4, r5`
B) `cmp r4, #5`
C) `adcs r0, r4, r5`
D) `adc r0, r4, #5`
E) None of the above.

02. Figure 1 gives the format of ARM data processing instructions. What ARM assembly language instruction is equivalent to the machine language instruction shown below in binary?

```
1 1 1 0 0 0 0 1 0 1 1 1 0 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1
```

A) `adc r6, r9, #5`
B) `adc r6, r9, r5`
C) `subs r9, r6, #5`
D) `subs r9, r6, r5`
E) None of the above.

03. Figure 1 gives the format of ARM data processing instructions. What ARM machine language instruction (in hexadecimal) is equivalent to the assembly language instruction shown below?

```
rsc r5, r2, #9
```

A) `e0f25009`
B) `e2f25009`
C) `e0e25009`
D) `e2e25009`
E) None of the above.

04. Figure 1 gives the format of ARM data processing instructions. What ARM machine language instruction (in hexadecimal) is equivalent to the assembly language instruction shown below?

```
movs r3, r10
```

A) `e1a3000a`
B) `e3a3000a`
C) `e1b3000a`
D) `e3b3000a`
E) None of the above.
05. Consider the ARM assembly language statements in Figure 2. Which of the following correctly lists the contents of the indicated register after the statement labeled "Line 1" is executed?

A) r0: 51000145 (base 16)
B) r0: 9b000139 (base 16)
C) r0: 61000145 (base 16)
D) r0: 9b0000d9 (base 16)
E) None of the above.

06. Consider the ARM assembly language statements in Figure 2. Which of the following correctly lists the contents of the integer condition code bits after the statement labeled "Line 1" is executed?

A) NZCV: 0010 (base 2)
B) NZCV: 1010 (base 2)
C) NZCV: 0011 (base 2)
D) NZCV: 1001 (base 2)
E) None of the above.

07. Consider the ARM assembly language statements in Figure 2. Which of the following correctly lists the contents of the indicated register after the statement labeled "Line 2" is executed?

A) r1: f300005d (base 16)
B) r1: 13000063 (base 16)
C) r1: f4ffff5d (base 16)
D) r1: 0cffffa3 (base 16)
E) None of the above.

08. Consider the ARM assembly language statements in Figure 2. Which of the following correctly lists the contents of the indicated register after the statement labeled "Line 3" is executed?

A) r2: c70000f1 (base 16)
B) r2: c7000145 (base 16)
C) r2: c7000011 (base 16)
D) r2: c6ffffff1 (base 16)
E) None of the above.
09. Consider the ARM assembly language statements in Figure 3. Which of the following correctly lists the contents of the indicated register after the statement labeled "Line 1" is executed?

A) r0: 130000a5 (base 16)
B) r0: 03000081 (base 16)
C) r0: c400001a (base 16)
D) r0: d70000bf (base 16)
E) None of the above.

10. Consider the ARM assembly language statements in Figure 3. Which of the following correctly lists the contents of the indicated register after the statement labeled "Line 2" is executed?

A) r1: 130000a5 (base 16)
B) r1: 03000081 (base 16)
C) r1: c400001a (base 16)
D) r1: d70000bf (base 16)
E) None of the above.

11. Consider the ARM assembly language statements in Figure 3. Which of the following correctly lists the contents of the indicated register after the statement labeled "Line 3" is executed?

A) r2: 0000009b (base 16)
B) r2: c7000000 (base 16)
C) r2: 00000000 (base 16)
D) r2: c7000000 (base 16)
E) None of the above.

12. Consider the ARM assembly language statements in Figure 3. Which of the following correctly lists the contents of the indicated registers after the statement labeled "Line 4" is executed?

A) r3: 0009b000 (base 16) r4: 0000c700 (base 16)
B) r3: 0009b0ff (base 16) r4: 0000c700 (base 16)
C) r3: 0009b000 (base 16) r4: ffffc700 (base 16)
D) r3: 0009b0ff (base 16) r4: ffffc700 (base 16)
E) None of the above.
13. Assume that the integer condition code bits contain 1001 (base 2). Which of the following ARM assembly language instructions would cause control to branch to the symbolic address "target":

A) bne target  
B) bmi target  
C) bvs target  
D) All of the above.  
E) None of the above.

14. Consider the C language statements in Figure 4. Assume the task is to be implemented in ARM assembly language instead of C. An outline of the required assembly language statements is given below:

```c
int A, B;
if (20 <= A && A <= 30)
{
    B = A;
}
```

Which of the following statement sequences is a valid replacement for the comment "*** Line 1 *** to complete the required statements?"

A) cmp r1, #20  
bge endif  
cmp r1, #30  
ble endif  
stra, [r2]  

B) cmp r1, #20  
blt endif  
cmp r1, #30  
bgt endif  
stra, [r2]  

C) cmp r1, #20  
ble endif  
cmp r1, #30  
bge endif  
stra, [r2]  

D) cmp r1, #20  
bgt endif  
cmp r1, #30  
blt endif  
stra, [r2]  

E) None of the above.
15. Consider the C language statements in Figure 5. Assume the task is to be implemented in ARM assembly language instead of C. An outline of the required assembly language statements is given below:

```assembly
ldr   r0, =A
ldr   r1, [r0]
ldr   r2, =B
ldr   r3, [r2]

loop:
   @ *** Line 1 ***

endloop:
```

Which of the following statement sequences is a valid replacement for the comment "*** Line 1 ***" to complete the required statements?

A)  ```assembly
    add   r1, r1, #1
    str   r1, [r0]
    cmp   r1, r3
    bgt   loop
```

B)  ```assembly
    add   r1, r1, #1
    str   r1, [r0]
    cmp   r1, r3
    ble   loop
```

C)  ```assembly
    cmp   r1, r3
    bgt   endloop
    add   r1, r1, #1
    str   r1, [r0]
    b     loop
```

D)  ```assembly
    cmp   r1, r3
    ble   endloop
    add   r1, r1, #1
    str   r1, [r0]
    b     loop
```

E)  None of the above.

16. Which of the following statements about ARM assembly language syntax is correct?

A)  Register sp is another name for register r12.
B)  Register lr is another name for register r13.
C)  Register pc is another name for register r14.
D)  All of the above.
E)  None of the above.
int A, B;
void test( int*, int, int );

int main()
{
    test( &A, 25, 4*B );
}

17. Consider the C language statements in Figure 6. Assuming that function
"main" is to be implemented in ARM assembly language instead of C, which of the
following statements about the register contents is true?

A) Registers r0 through r3 might be different after calling function "test".
B) Registers r4 through r7 might be different after calling function "test".
C) Registers r8 through r11 might be different after calling function "test".
D) All of the above.
E) None of the above.

18. Consider the C language statements in Figure 6. Assuming that function
"main" is to be implemented in ARM assembly language instead of C, which of the
following statement sequences could be used to place the first argument in the
correct location before calling function "test"?

A) ldr   r0, =A
B) ldr   r0, =A
   ldr   r0, [r0]
C) mov   r0, &A
D) mov   r0, &A
   ldr   r0, [r0]
E) None of the above.

19. Consider the C language statements in Figure 6. Assuming that function
"main" is to be implemented in ARM assembly language instead of C, which of the
following statement sequences could be used to place the third argument in the
correct location before calling function "test"?

A) ldr   r2, =B
   lsl   r2, r2, #2
B) mov   r2, &B
   lsl   r2, r2, #2
C) ldr   r2, =B
   ldr   r2, [r2]
   lsl   r2, r2, #2
D) mov   r2, &B
   ldr   r2, [r2]
   lsl   r2, r2, #2
E) None of the above.
20. Consider the ARM assembly language statements in Figure 7. Which of the following correctly lists the contents of the indicated registers after the statement labeled "Line 1" is executed?

A) r4: 00000077 (base 16) r5: ffffffff99 (base 16)
B) r4: 00000077 (base 16) r5: 00000099 (base 16)
C) r4: 00000066 (base 16) r5: ffffffff88 (base 16)
D) r4: 00000066 (base 16) r5: 00000088 (base 16)
E) None of the above.

21. Consider the ARM assembly language statements in Figure 7. Which of the following correctly lists the contents of the indicated registers after the statement labeled "Line 2" is executed?

A) r6: ffffddcc (base 16) r7: 0000ffee (base 16)
B) r6: 0000ddcc (base 16) r7: ffffffee (base 16)
C) r6: ffffffffbb (base 16) r7: ffffeedd (base 16)
D) r6: 0000ccbb (base 16) r7: 0000eedd (base 16)
E) None of the above.

22. Consider the ARM assembly language statements in Figure 7. Which of the following correctly lists the contents of the indicated registers after the statement labeled "Line 3" is executed?

A) r8: 44556677 (base 16) r9: 8899aabb (base 16)
B) r8: 8899aabb (base 16) r9: 44556677 (base 16)
C) r8: 77655544 (base 16) r9: bbba9988 (base 16)
D) r8: bbba9988 (base 16) r9: 77655544 (base 16)
E) None of the above.

23. Consider the ARM assembly language statements in Figure 7. Which of the following statements would cause a run-time error if it was executed after the statement labeled "Line 3"?

A) ldr r10, [r0, #8]
B) ldr r10, [r0, #4]
C) ldr r10, [r0, #2]
D) All of the above.
E) None of the above.
24. Consider the ARM assembly language statements in Figure 8. After the
statement labeled "Line 1" is executed, which of the following lists the
contents of the 8 bytes of memory starting at address 00026030 (hexadecimal)?

A) 00026030: 88 99 78 56 cc dd ee ff
B) 00026030: 88 99 34 12 cc dd ee ff
C) 00026030: 78 56 aa bb cc dd ee ff
D) 00026030: 34 12 aa bb cc dd ee ff
E) None of the above.

25. Consider the ARM assembly language statements in Figure 8. After the
statement labeled "Line 2" is executed, which of the following lists the
contents of the 8 bytes of memory starting at address 00026038 (hexadecimal)?

A) 00026038: 78 11 22 33 44 55 66 77
B) 00026038: 12 11 22 33 44 55 66 77
C) 00026038: 00 78 22 33 44 55 66 77
D) 00026038: 00 12 22 33 44 55 66 77
E) None of the above.

26. Consider the ARM assembly language instructions shown below:

```
.data
.balign 2
vector:
    .short 10, 20, 30
    .short 40, 50
    .balign 4          @ *** Line 1 ***
```

How many bytes of padding will be generated by the instruction labeled
"*** Line 1 ***"?

A) 3
B) 2
C) 1
D) 0
E) None of the above.
struct Player
{
    short int Number;
    int Points;
    char Name[35];
};

int exam( struct Player List[], int I )
{
    return List[I].Points;
}

27. Consider the C language statements in Figure 9. Function "exam" is to be implemented in ARM assembly language instead of C. A stub for function "exam" is given below:

    .global exam
    .text
    .balign 4
exam:
    push {lr}
    @ *** Line 1 ***
    pop {lr}
    bx lr

Which of the following statement sequences is a valid replacement for the comment "*** Line 1 *** in function "exam"?

A)  mov r3, #44
    mul r3, r1, r3
    add r2, r0, r3
    ldr r0, [r2, #4]

B)  mov r3, #43
    mul r3, r1, r3
    add r2, r0, r3
    ldr r0, [r2, #4]

C)  mov r3, #42
    mul r3, r1, r3
    add r2, r0, r3
    ldr r0, [r2, #2]

D)  mov r3, #41
    mul r3, r1, r3
    add r2, r0, r3
    ldr r0, [r2, #2]

E)  None of the above.
28. Consider the C language statements in Figure 10. Function "update" is to be implemented in ARM assembly language instead of C. A stub for function "update" is given below:

```
.global update
.text
.balign 4
update:
    push {lr}
    @ *** Line 1 ***
    pop {lr}
    bx lr
```

Which of the following statement sequences is a valid replacement for the comment "*** Line 1 *** in function "update"?"

A)  ldr r2, [r0]
    ldr r3, [r2, #64]
    add r3, r3, r1
    str r3, [r2, #64]

B)  ldr r2, [r0]
    ldr r3, [r2, #60]
    add r3, r3, r1
    str r3, [r2, #60]

C)  ldr r3, [r0, #64]
    add r3, r3, r1
    str r3, [r0, #64]

D)  ldr r3, [r0, #60]
    add r3, r3, r1
    str r3, [r0, #60]

E)  None of the above.
29. Consider the C and ARM assembly language statements in Figure 11. Assume the program displays "Result: 17" on the screen when it is translated and executed. Which of the following statement sequences is a valid replacement for the comment "*** Line 1 *** in function "test"?"

A) mov r0, r1
B) ldr r0, [r1]
C) ldr r0, [r1]
   ldr r0, [r0]
D) ldr r0, [sp, #4]
E) None of the above.

30. Consider the C and ARM assembly language statements in Figure 11. Assume the program displays "Result: 41" on the screen when it is translated and executed. Which of the following statement sequences is a valid replacement for the comment "*** Line 1 *** in function "test"?"

A) mov r0, r4
B) ldr r0, [r4]
C) ldr r0, [r4]
   ldr r0, [r0]
D) ldr r0, [sp, #4]
E) None of the above.