CS/ECE 354
MIDTERM EXAMINATION #2
November 1, 1990
Open Book

Write your name and the last four digits of your student ID on each page. Each of the questions or incomplete statements below is followed by five suggested answers or completions. Select the **single best** answer and circle the corresponding letter (A-E). This test has 21 multiple-choice questions. Each question counts equally, though some questions are harder than others. You may show your work and your reasoning on the test itself. If you think a question is ambiguous, explain way, but understand that the intent is that there be only a single correct answer.

Scoring: There is a penalty for guessing. Correct answers add four points to your score. Incorrect answers subtract one point from your score. Thus you should guess if you can eliminate at least one incorrect answer.

1. Which of the following is the ASCII code for ’2’:

(A) `0x02` (B) `0x13` (C) `0x20` ***(D)*** `0x32` (E) `0x40`

2. Which of the following statement(s) is/are true about arrays?

(A) Arrays are stored in memory as a contiguous block to make access easier.
(B) They can be accessed by pointers.
(C) Two-dimensional arrays can be stored in column or row major order.
(D) All of the above.
(E) None of the above.

3. How many bytes of memory would be required to store a two-dimensional array of 4-byte words, if one index goes from 0 to 10 and the other goes from 10 to 20?

(A) 100 (B) 121 (C) 200 (D) 400 ***(E)*** 484

4. If the string, `"This is the test string!"`, is packed into 32-bit words and zero terminated, how many words would be needed?

(A) 6 ***(B)*** 7 (C) 24 (D) 25 (E) 400

5. Given the following information, which statement is true about virtual origins? `B` is base address of array `A`. N_r is the number of elements in a row. N_c is the number of elements in a column. L_x is the smallest defined value for `x`. L_y is the smallest defined value for `y`. The address of `A[x,y]` is $B + (x - L_x) N_r + (y - L_y)$.

(A) Virtual origin is at `M[0]`.
(B) Virtual origin is at address $B - L_y - (L_x * N_r)$.
(C) Virtual origin is at address $B + (x - L_x) N_r + (y - L_y)$.
(D) Virtual origin is at $A[L_x, L_y]$.
(E) Virtual origin is always the same regardless of whether elements are stored in row-major or column-major order.

6. Consider the following fragment of assembly program written for the MIPS microprocessor:

```
target:  lw     $9, 0($8)     # load array element a[i]
         add    $9, $9, $11   # add scalar: a[i] := a[i] + s
         sw     $9, 0($8)     # store back array element
         addi   $8, $8, -4    # i := i-1
         bgtz   $8, target    # go to target if i > 0
```

The branch instruction in the MIPS R2000 is composed of a 6 bit opcode field, a 5 bit register specifier, 5 zeros and a 16 bit offset field. The offset field is a 2's complement number computed as follows:

<offset> := <address of the branch instruction> **-** <address of the target>

addresses here being word addresses. The value of offset for the `bgtz` instruction in the previous fragment of code is

(A) `0x0004.` (B) `0x8004.` ***(C)*** `0xFFFB.` ***(D)*** `0xFFFC.` (E) `0xFFFD.`

7. The look-ahead problem occurs in the assembly process because a symbol is referenced before it is defined. The problem can best be resolved by

(A) assembling the program in reverse order.

(B) making multiple passes over the source code to resolve symbol references.

(C) defining symbol values when first encountered.

(D) requiring that all labels be defined before they are referenced.

(E) allowing only backward jumps in a program.

8. Consider the following code declarations for the MIPS R2000 using `asm` and `sim`:

```
        .data
ptr:    .word str
str:    .space 0x10
```

Which of the following instruction(s) puts the first word of str into register 8?

(A) `add $8, $0, ptr`

(B) `add $8, $0, str`

(C) `lw $8, ptr`

(D) `lw $8, str`

(E) `lw $8, ptr`
`add $8, 0($8), $0`

9. Assume that when Gust's Simple machine is turned on all memory locations are initialized with their own address (i.e. address 0 contains 0, address 1 contains 1, etc...).

Consider the following array declaration:

```
a : array [0..9][0..9] of integer;
```

Suppose further that this array is stored in row major order at base address 48. Which value is contained in a[5,7]? All numbers are base 10.

(A) 57 (B) 100 ***(C)*** 105 (D) 116 (E) 123

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10. Which of the following statement(s) is/are generally true about scanning arrays using loops and pointers?

I. The pointer is incremented during each iteration.

II. The pointer is used to determine when to exit the loop.

III. The base address is computed during each iteration.

(A) I only. ***(B)*** I and II only. (C) I and III only. (D) II and III only. (E) I, II, and III.

11. The following fragment of code is supposed to access element `a[i,j]`, where `0≤i,j≤9`, `i` and `j` being stored respectively in locations `I` and `J` prior to execution of the code fragment. The array is stored in column-major order.

Line Number	**Code**		
1		`...`	
2	`RS`	`DATA`	`0xa`
3	`BA`	`DATA`	`48`
4	`W`	`BSS`	`1`
5		`...`	
6		`LOAD`	`J`
7		`MUL`	`RS`
8		`ADD`	`I`
9		`ADD`	`BA`
10		`STORE`	`W`
11		`LOAD`	`@W`
12		`...`	

What needs to be changed such that the previous fragment of code correctly loads the element `a[i,j]` into the accumulator?

(A) Change line 2 to:

```
2   RS   DATA   0x9
```

(B) Change line 6 and 8 to:

```
6      LOAD   I
8      ADD    J
```

(C) Both of the above changes.

(D) No change.

(E) None of the above.

12. Which of the following statements about procedures is/are true?

I. Procedures usually reduce the size of a program because code need not be duplicated.

II. Procedures make a program execute fewer instructions because the program size is smaller.

III. Procedures allow a program to be divided into modules, with each module performing specific functions.

(A) I only (B) II only (C) I and II only. ***(D)*** I and III only. (E) I, II, and III.

13. Consider the "IICSA" representation of characters. IICSA is just like ASCII except that the ordering of the bits is reversed (*i.e.* in ASCII the character 'K' would be represented as 1001011, so in IICSA a 'K' would be represented as 1101001). Which of the following statements is true?

(A) In IICSA, the representation for 'T' can be found by adding one to the representation of 'S.'

(B) In IICSA, the representation for 'T' can be found by subtracting one from the representation of 'S.'

(C) IICSA can represent '%' two different ways.

(D) In IICSA, the representation of a digit can be found by adding the value of the digit to the representation of zero.

(E) Some characters have the same representation in both ASCII and IICSA.

14. Which of the following statements is true about the MIPS machine?

I. Using only the `J` instruction multiple times it is possible to jump from anywhere to anywhere else in the 4 gigabytes of memory.

II. Using only the `BEQ` instruction multiple times it is possible to jump from anywhere to anywhere else in the 4 gigabytes of memory.

III. The 2 least significant bits of the PC are cleared to zero for a `J` instruction, so the address is aligned to a word boundary. To jump to a byte address we can use the `JR` instruction with the 2 least significant bits indicating which of the four bytes we want to access.

(A) I only. ***(B)*** II only. (C) III only. (D) I and II only. (E) I, II, and III.

15. Consider the following two instructions for the MIPS R2000:

```
i.   beq   $0, $0, target
ii.  j     target
```

Which of the following statements about the two instructions is true?

(A) They always have exactly the same effect.

(B) Instruction (*ii*) is more powerful because it can accomplish everything (*i*) can, and more.

(C) Instruction (*i*) is more powerful because it can accomplish everything (*ii*) can, and more.

(D) Instruction (*i*) is more powerful because it can branch to negative addresses.

(E) Both instructions are capable of accomplishing something the other cannot do.

16. Consider the following two instructions for the MIPS R2000:

```
i.   beq    $9, $9, target
ii.  bgez   $0, target
```

Which of the following statements about the two instructions is true?

(A) They always have exactly the same effect.

(B) Instruction (*ii*) is more powerful because it can accomplish everything (i) can, and more.

(C) Instruction (i) is more powerful because it can accomplish everything (*ii*) can, and more.

(D) Instruction (i) is more powerful because it can branch to negative addresses.

(E) Both instructions are capable of accomplishing something the other cannot do.

17. Consider an array defined as `A[0..7][0..15]`. When we reference array element `A[i,j]`, we wish to check that this is a valid access to an array element. Consider the following tests for validity of the array reference.

I. The address of `A[i,j]` is an address within the range of memory allocated for the array A.

II. `i≤7` and `j≤15`.

III. `0≤i` and `0≤j`.

Which of the following combinations of the above tests *minimally* guarantees that the array access is valid?

(A) I only. (B) II only. (C) III only. ***(D)*** II and III only. (E) I, II, and III.

The following information applies to questions 18 and 19. This code segment, written for the MIPS R2000, reads in two characters and prints their "sum":

```
         .data
ten:     .word    10
eleven:  .word    11
         .text
start:   lw       $4, eleven($0)   # Prepare to Read
         syscall                   # Read character into $2
         add      $8, $0, $2       # Save character read in $8
         syscall                   # Read character into $2
         add      $5, $8, $2       # Put sum into $5
         lw       $4, ten($0)      # Prepare to Write
         syscall                   # Print character
         ...
```

18. What character is sent to the terminal when the characters '2' and '3' are typed in?

(A) The digit '5'.

(B) The lowercase letter 'e'.

(C) The lowercase letter 'q'.

(D) The non-printing character *enq* (0x05).

(E) The non-printing (control) character ∧E.

19. What character is printed when the characters '9' and '8' are typed in?

(A) The digit '8'.

(B) The lowercase letter 'q'.

(C) The non-printing character *dc1* (0x11).

(D) The non-printing character *etb* (0x17).

(E) The lowercase letter 'w'.

20. Just as with integers, ASCII strings can be compared for “less than,” “equal to,” or “greater than.” Which of the following strings is the *smallest*?

(A) `"abc"` (B) `"ABC"` ***(C)*** `"ABAD"` (D) `"aaaa"` (E) `"XYZ"`

21. Given the data declarations,

```
             .data
ten:         .word   10
eleven:      .word   11
space:       .word   0x20
```

which of the given MIPS instructions implement the following Pascal code?

```
char c;

read(c);
while (c <> ' ') do
begin
     write(c);
     read(c);
end
```

(This question not graded).

(A)
```
           lw        $8, space
loop:      lw        $4, eleven
           syscall
           sub       $2, $2, $8
           beq       $2, $0, out
           add       $5, $2, $0
           lw        $4, ten
           syscall
           j loop
out:
```

(B)
```
loop:      lw        $4, eleven
           syscall
           beq       $2, 0x20, out
           add       $5, $2, $0
           lw        $4, ten
           syscall
           j loop
```

(C)
```
           lw        $8, space
loop:      lw        $4, ten
           syscall
           beq       $2, $8, out
           add       $5, $2, $0
           lw        $4, eleven
           syscall
           j         loop
out:
```

(D)
```
           lw        $8, space
loop:      lw        $4, eleven
           syscall
           beq       $5, $8, out
           add       $5, $2, $0
           lw        $4, ten
           syscall
           j         loop
out:
```

(E)
```
           lw        $8, space
loop:      lw        $4, eleven
           syscall
           sub       $2, $2, $8
           beq       $2, $0, out
           add       $5, $2, $8
           lw        $4, ten
           syscall
           j         loop
out:
```