The University of Alabama in Huntsville Electrical and Computer Engineering Department CPE 221 01 Test 1 February 22, 2018

This test is closed book, closed notes. You may not use a calculator. You should have the 6 page ARM Instruction Reference. You must show your work to receive full credit.

- (1 point) ______ are used to hold data when faster access than main memory is needed.
- 3. (1 point) ______ instructions can alter the normal flow of control from executing the next instruction in sequence.
- 4. (1 point) In RTL, the symbol _____ is used to indicate a data transfer.
- 5. (1 point) ______ is an example of an addressing mode found in processors.
- 6. (10 points) Represent 528 and -719 as signed (2s complement) 16-bit numbers

- 7. (10 points) If $r1 = 0 \times 0000$ OFFF and r2 = 7, what is the value of r0 after each of the following instructions has been executed (assume that each instruction uses the same data)?
 - (a) ADD r0, r1, r1, LSL #2_111
 - (b) ADD r0, r1, r1, ROR #21
 (c) ADD r0, r1, r1, LSR r2

- 8. (10 points) For each of the following operations on 6 bit signed numbers, calculate the values of the C, Z, V, and N flags
 - (a) 101011 + 001101 (b) 111111 + 001001

9. (15 points) Assume that r2 contains the initial value 0xFF001000 and that r0 contains 0xFFFF 8700. Explain the effect of each of the following instructions, and give the value in r2 after each instruction executes. Use register transfer notation.

(a) LDR r1, [r2] (b) STR r1, [r2, #2_110101] (c) STR r1, [r2, #0x2C]! (d) STR r1, [r2], #16 (e) STR r1, [r2, r0, ASR #7] 10. (25 points) Consider the following ARM program. Trace the values of the registers shown as they change during program execution. Also, trace the writes to memory by the STR instructions. There may be unused columns or rows in the tables. If you need to add columns or rows, you may do so. DCD 1 reserves one word of storage and sets it equal to 1. SPACE 3 reserves 3 bytes of memory but does not give those bytes a value.

	AREA ENTRY	COUNT_ONES_BIT0_MASK, CODE, READONLY						
	LDR	r1, num						
	LDR	r3, mask						
	SUB	r2, r2, r2						
	SUB	r5, r5, r5						
	MOVS	rl, rl						
	BEQ	store						
next	ANDS	r4, r1, r3						
	ADD	r5, r5, #1						
	BEQ	shift						
	ADD	r2, r2, #1						
shift	MOVS	r1, r1, LSR #1						
	BNE	next						
store	STR	r2, count						
	STR	r5, bits						
done	В	done						
count	SPACE	4						
bits	SPACE	4						
num	DCD	2341						
mask	DCD	1						
	END							

r0									
r1									
r2									
r3									
r4									
r5									
r6									

Results of the STR instruction.

Memory	Contents					
Address						

11. (25 points) Complete the ARM assembly language program below so that it implements the following C++ statements.

```
int neg = 0;
int pos = 0;
int size = 10;
int nums[10] = {5, 3, -1, 2, 4, 37, -100, 13, -5, 0};
for (i = 0; i < size; i++)
  if (nums[i] < 0)
     neg++;
  else
     pos++;
           PROB_11, CODE, READONLY
      AREA
      ENTRY
nums DCD 5, 3, -1, 2, 4, 37, -100, 13, -5, 0
     SPACE 4
neg
pos
    SPACE 4
i
    DCD 0
size DCD 10
```