

# THE UNIVERSITY OF AUCKLAND

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SECOND SEMESTER, 2010  
Campus: City

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## COMPUTER SCIENCE

### Computer Systems 1

(Time Allowed: TWO HOURS)

Note:

- The use of calculators is NOT permitted.
- Compare the exam version number on the Teleform sheet supplied with the version number above. If they do not match, ask the exam supervisor for a new sheet.
- Enter your name and student ID on the Teleform sheet. Your name should be entered left aligned. If your name is longer than the number of boxes provided, truncate it.
- Answer ALL **Multiple-choice** questions on the Teleform answer sheet provided.
- Use a dark pencil to mark your answers in the multiple choice answer boxes on the Teleform sheet. Check that the question number on the sheet corresponds to the question number in this question/answer book. If you spoil your sheet, ask the supervisor for a replacement.
- This examination counts 60% towards your final grade, and is marked out of 120.
- An appendix is included on the last page. You may detach this appendix.

CONTINUED

Read the following description before answering the following THREE questions.

A 32-bit IEEE-754 floating point number consists of 1 sign bit, 8 exponent bits and 23 mantissa/significand bits.

Given the following real number:

$$1.11101101 * 2^{-5}$$

#### Question 1

[3 marks] Which of the following represents the 8-bit EXPONENT field of the above number?

- (a) 10000100
- (b) 10000101
- (c) 01111011
- (d) 01111010

#### Question 2

[3 marks] Which of the following represents the 23-bit MANTISSA of the above number?

- (a) 1111 0110 1000 0000 0000 000
- (b) 000 0000 0000 0000 1110 1101
- (c) 1110 1101 0000 0000 0000 000
- (d) 000 0000 0000 0001 1110 1101

#### Question 3

[3 marks] Which of the following represents the IEEE standard floating point representation of the above number in Hexadecimal?

- (a) 0x3AB60000
- (b) 0x7AF68000
- (c) 0xED7A0000
- (d) 0x3D768000

#### Question 4

[2 marks] Which of the following represents the normalized scientific notation of the following binary number?

$$0.000101 * 2^6$$

- (a)  $1.010 * 2^6$
- (b)  $1.010 * 2^4$
- (c)  $10.10 * 2^5$
- (d)  $1.010 * 2^2$

CONTINUED

**Question 5**

[3 marks] Consider the following real numbers:

$$A = 0.13 \cdot 10^2,$$

$$B = 0.42 \cdot 10^2$$

Evaluate  $A \cdot B$ .

- (a) 5.46
- (b)  $5.46 \cdot 10^2$
- (c)  $546 \cdot 10^{-1}$
- (d) 5460

**Question 6**

[3 marks] Given that +1.28125 is represented (in hexadecimal) as 3FA40000, give the binary digits (in hexadecimal) of the same representations of +1.78125?

- (a) 40240000
- (b) 3FE40000
- (c) 3FB80000
- (d) 3FF40000

**Question 7**

[3 marks] Given that +3.45 is represented (in hexadecimal) as 405CCCCD, give the binary digits (in hexadecimal) of the same representations of +13.8.

- (a) 425CCCCD
- (b) 408CCCCD
- (c) 415CCCCD
- (d) 403CCCCD

**Question 8**

[3 marks] Two values  $A = 0xA3$  and  $B = 0x02$  are representations of 8-bit, 2's complement integers. Evaluate  $A \gg B$ .

- (a) 0x28
- (b) 0xE8
- (c) 0x8C
- (d) 0xA3

**Question 9**

[3 marks] Two values  $A = 10101000$  and  $B = 10000011$  are representations of 8-bit, 2's complement integers.

Evaluate  $A - B$

- (a) 00100100
- (b) 10100101
- (c) 00100101
- (d) 00101011

CONTINUED

**Question 10**

[2 marks] Using 2's complement representation, what is the decimal value of the following binary number?

**11000101**

- (a) -58
- (b) 197
- (c) -69
- (d) -59

Read the truth table below before answering the following question:

input			output
A	B	C	D
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	1
1	1	1	1

**Question 11**

[3 marks] Which one of the following logic expressions represents the logic function specified in the truth table above?

- (a)  $D = A \cdot \bar{B} \cdot \bar{C} + \bar{A} \cdot B \cdot \bar{C} + \bar{A} \cdot \bar{B} \cdot C + \bar{A} \cdot B \cdot C$
- (b)  $D = \bar{A} \cdot B \cdot C + \bar{A} \cdot \bar{B} \cdot C + A \cdot B \cdot \bar{C} + A \cdot B \cdot C$
- (c)  $D = (A + \bar{B} + \bar{C}) \cdot (\bar{A} + B + \bar{C}) \cdot (\bar{A} + \bar{B} + C) \cdot (\bar{A} + \bar{B} + \bar{C})$
- (d)  $D = \bar{A} \cdot \bar{B} \cdot \bar{C} + B \cdot C + A + A \cdot B \cdot C$
- (e)  $D = \bar{A} + \bar{B} + \bar{C}$

**Question 12**

[2 marks] Which one of the following statements is correct?

- (a) An R-S latch has three input lines, i.e. one data line D, and, two control lines R and S.
- (b) An R-S latch can store two bits of information.
- (c) When R and S are both set to 1, the state of the R-S latch does not change.
- (d) When R and S are both set to 0, the R-S latch holds its current value.
- (e) For an R-S latch, R and S must not be given the same value.

CONTINUED

**Question 13**

[2 marks] Which one of the following statements is correct?

- (a) A multiplexer has the property that exactly one of its outputs is 1 and all the rest are 0s.
- (b) A decoder selects one of its inputs and connects it to the output.
- (c) A sequential logic circuit can be used to store information.
- (d) The output of a combinational logic circuit depends on the current and past inputs to the circuit.
- (e) The output of a sequential logic circuit only depends on the current inputs to the circuit.

**Question 14**

[3 marks] Assume that an LC-3 machine instruction “0001010011100101” is stored at address x3000, label X corresponds to memory address x30E5, and, label Y corresponds to memory address x30E6. Which one of the following assembly language instructions corresponds to the machine instruction?

- (a) ADD R2, R3, R5
- (b) ST R2, Y
- (c) BRnp Y
- (d) ADD R2, R3, #5
- (e) BRz X

**Question 15**

[3 marks] Assume that an LC-3 machine instruction “0000100000000100” is stored at address x4010, label X corresponds to memory address x4015, label Y corresponds to memory address x4016, and, label Z corresponds to memory address x4014. Which one of the following assembly language instructions corresponds to the machine instruction?

- (a) BRzp Z
- (b) BRn X
- (c) LD R0, Z
- (d) BRzp Y
- (e) BRn Z

**Question 16**

[3 marks] Assume that an LC-3 assembly language instruction “NOT R3, R4” is stored at address x4500, and, label X corresponds to memory address x4503. Which one of the following machine instructions corresponds to the LC-3 assembly language instruction?

- (a) 1001011100000011
- (b) 1001011100111111
- (c) 1001011100000010
- (d) 1001100011000011
- (e) 1001100011111111

CONTINUED

Read the program below before answering the following SIX questions.

```

.ORIG x3600
S   LD   R0, A
    LDI  R2, B
    LEA  R3, C
    LDR  R4, R3, 2
    HALT
A   .FILL 6
B   .FILL x3605
C   .FILL 7
    .FILL 8
    .FILL 9
    .FILL 10
    .END

```

**Question 17**

[2 marks] What is the address of label S?

- (a) x3000
- (b) x3601
- (c) x3600
- (d) x0000
- (e) x3605

**Question 18**

[2 marks] What is the address of label A?

- (a) x3605
- (b) x3606
- (c) x3005
- (d) x3607
- (e) x4006

**Question 19**

[2 marks] What is the value stored in register 0 after instruction “LD R0, A” is executed?

- (a) 0
- (b) x3605
- (c) 7
- (d) xF025
- (e) 6

CONTINUED

**Question 20**

[2 marks] What is the value stored in register 2 after instruction “LDI R2, B” is executed?

- (a) 7
- (b) 6
- (c) x3605
- (d) 8
- (e) 0

**Question 21**

[2 marks] What is the value stored in register 3 after instruction “LEA R3, C” is executed?

- (a) x3608
- (b) 6
- (c) x3606
- (d) 7
- (e) x3607

**Question 22**

[2 marks] What is the value stored in register 4 after instruction “LDR R4, R3, 2” is executed?

- (a) 8
- (b) x360A
- (c) 10
- (d) 9
- (e) x3609

Read the following description before answering the following TWO questions.

A fragment of an assembly language program is shown below. The memory location with label A is at address x3700.

```
A .BLKW 5
B .STRINGZ "abcd"
C .FILL 5
```

**Question 23**

[2 marks] What is the address of the memory location with label B?

- (a) x3701
- (b) 5
- (c) x3706
- (d) x3705
- (e) 6

CONTINUED

**Question 24**

[2 marks] What is the address of the memory location with label c?

- (a) x3705
- (b) x370A
- (c) x3702
- (d) x3709
- (e) x370B

**Question 25**

[2 marks] Assume that an LC-3 assembly language instruction “JSR x” is stored at address x4010, and, the memory location with label x is at address x4020. Which one of the following statements is correct?

- (a) After the execution of instruction “JSR x”, the value stored in the program counter is x4021.
- (b) After the execution of instruction “JSR x”, the value stored in register 7 is x4011.
- (c) After the execution of instruction “JSR x”, the value stored in the program counter is x4011.
- (d) After the execution of instruction “JSR x”, the value stored in register 7 is x4010.
- (e) After the execution of instruction “JSR x”, the value stored in register 7 is x4021.

**Question 26**

[2 marks] Which one of the following statements is correct?

- (a) The values in the condition code registers of LC-3 are set as a result of executing an instruction that writes a value to one of the general purpose registers.
- (b) The condition code registers of LC-3 are set by the instructions that store values in the memory.
- (c) The values in the condition code registers of LC-3 are set as a result of executing branch instructions.
- (d) The condition code registers of LC-3 are set by the control instructions.
- (e) The values in the condition code registers of LC-3 are not affected by the execution of the operate instructions.

CONTINUED

**Question 27**

[2 marks] Which one of the following statements is correct?

- (a) LC-3's ST instruction allows the program to store a value at any location in the memory.
- (b) LC-3's BR instruction always changes the execution sequence of the instructions in a program.
- (c) LC-3's JSR instruction allows the program to call a subroutine stored at any location in the memory.
- (d) LC-3's JMP instruction allows the program to branch to execute an instruction stored at any location in the memory.
- (e) LC-3's LD instruction can access any location in the memory.

Consider the following short C++ program.

```
#include <iostream>
int
main()
{
    std::cout << "hello world\n";
    return 1;
}
```

**Question 28**

[2 marks] Which of the following statements is FALSE with respect to the above program?

- (a) std is the namespace containing all the C++ standard library entities
- (b) The include file iostream contains definitions of the types and constants of the C++ input output library
- (c) The program will compile correctly, and upon execution will output "hello world".
- (d) The program returns a fail status to the invoking environment
- (e) cout is the standard output stream

**Question 29**

[2 marks] What does the Unix command 'strip' do?

- (a) It removes the continuation bit of every single uintvar in the given file
- (b) It removes the magic number from a given file (either binary or text)
- (c) It collapses multiple white-spaces to a single white-space in a given text file
- (d) It removes the symbol table of a given executable file
- (e) It strips the extraneous characters at the end of a given binary file

CONTINUED

Consider the following short C++ program.

```
#include <iostream>

int
main()
{
    const int MAX = 4;
    const int MID = 2;
    int a[MAX];
    int i = MID;
    for ( int k = 0; k < MAX; ++k ) a[k] = 0;

    i[a] = MAX;

    std::cout << i << " ";
    for ( int k = 0; k < MAX; ++k ) std::cout << a[k] << " ";
    std::cout << i[a] << " ";
    std::cout << "\n";

    return 1;
}
```

**Question 30**

[2 marks] Which of the following statements is true with respect to the above program?

- (a) The output of the program is "2 0 0 0 0 4"
- (b) The output of the program is "2 0 0 0 0 2"
- (c) The program will not compile
- (d) The output of the program is "2 0 0 4 0 4"
- (e) The output of the program is "4 0 0 0 0 4"

**Question 31**

[2 marks] Consider a byte address 0xCAFE on 16-bit machine. What is the corresponding word address?

- (a) 0xCAFA
- (b) 0xCAFD
- (c) 0xCAFB
- (d) 0xCAFC
- (e) 0xCAFE

**Question 32**

[2 marks] Consider a byte address 0xCAFE on a 32-bit machine. What is the corresponding word address?

- (a) 0xCAFA
- (b) 0xCAFC
- (c) 0xCAFE
- (d) 0xCAFB
- (e) 0xCAFD

CONTINUED

Consider the following C++ code fragment.

```
float v = 2;
int* i = (int*)&v;
std::cout << std::hex << *i << "\n";
```

**Question 33**

[2 marks] What is the likely value printed out when this fragment is executed? Assume that the size of both int and float are 4 bytes each.

- (a) 40000000
- (b) 2
- (c) 40800000
- (d) 41800000
- (e) 41000000

**Question 34**

[2 marks] Which of the following statements is true?

- (a) Java has a keyword 'class' to declare classes, but C++ does not have the keyword to declare classes.
- (b) The Java Virtual Machine uses registers for communication between methods
- (c) A Java class file and a C++ object file can be linked together easily to form a single executable.
- (d) The Java Virtual Machine is an application that runs on a real machine
- (e) Both Java and C++ are compiled down to a assembly and on to object code that will execute on the real CPU.

**Question 35**

[2 marks] What is the magic number of a Java class file?

- (a) The string "Java"
- (b) 0xCAFEBADE
- (c) The string "JCLASS"
- (d) The string "JDK"
- (e) 0xA0B1C2D3

**Question 36**

[2 marks] Which of the following is necessary to consider when supporting function calls?

- (a) How to return to the callee function
- (b) How to pass parameters to the callee function
- (c) How to pass the stack pointer and frame pointer to the caller function
- (d) Where the code for the callee function is located on the stack
- (e) Where the code for the caller function is located on the frame

CONTINUED

**Question 37**

[2 marks] Which of the following is true of function calls?

- (a) Some of the function parameters can be passed through the keyboard
- (b) The maximum number of parameters passed to a function is limited by the number of registers in the CPU
- (c) On a register-based machine, a stack is used to support function calls
- (d) A function cannot call itself
- (e) Function parameters can be Unicode, if there is a suitable way of entering Unicode text

**Question 38**

[2 marks] When a system call is executed a sequence of actions take place

- I. The current PC and the state (registers & stack) are saved
- II. The current stack pointer becomes the new PC
- III. The system function is completed
- IV. The saved PC and state are restored
- V. Register \$v0 contains the return value from the system function

Which one of the above actions is incorrect?

- (a) II
- (b) V
- (c) I
- (d) III
- (e) IV

**Question 39**

[2 marks] An in-disk memory layout of an executable file has two items: code and static data. What other items are present in an in-memory layout of an executable file loaded by the OS for execution?

- (a) dynamic data, dynamic code, and frame buffers
- (b) dynamic data only
- (c) dynamic data and stack
- (d) usually dynamic data only, but can sometime contain dynamic code as well.
- (e) dynamic data and dynamic code

**Question 40**

[2 marks] What is the uintvar representation of 0x25A?

- (a) 0x84 0x5A
- (b) 0x84 0x0A
- (c) 0x82 0x0A
- (d) 0x80 0x0A
- (e) 0x82 0x5A

CONTINUED

**Question 41**

[2 marks] What is the hexadecimal value represented by the uintvar 0x95 0x3C?

- (a) 0xDAC
- (b) 0xADC
- (c) 0xBDC
- (d) 0xABC
- (e) 0xBAC

**Question 42**

[2 marks] What is temporal locality when applied to a cache?

- (a) The observation that if a cache is localized to a disk in addition to the memory, the CPU is likely to benefit from a better hit rate
- (b) The observation that if a memory location is accessed, its nearby locations are likely to be accessed
- (c) The observation that if a memory location is accessed once, it is likely to be accessed again soon
- (d) A temporary inability of the cache to localize contents for the CPU
- (e) The observation that if a cache is localized to a memory, the CPU is likely to benefit from a better hit rate

Consider a direct-mapped cache of size 4. Each slot in the cache can have just one item (i.e. the line size is 1 item). The cache is empty to start with.

Work out if the following sequence of accesses to the given addresses are hits or misses. Each access is numbered for your convenience.

Sequence Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Address	1	2	3	4	5	1	2	3	4	5	2	3	4	5	6	2	3	4	5	6

**Question 43**

[2 marks] Accesses 3, 4, and 5 are respectively

- (a) Miss, Hit, Miss
- (b) Hit, Hit, Hit
- (c) Miss, Miss, Miss
- (d) Miss, Hit, Hit
- (e) Miss, Miss, Hit

CONTINUED

**Question 44**

[2 marks] Accesses 6, 7, and 8 are respectively

- (a) Hit, Hit, Hit
- (b) Miss, Hit, Miss
- (c) Miss, Miss, Miss
- (d) Miss, Miss, Hit
- (e) Miss, Hit, Hit

**Question 45**

[2 marks] Accesses 9, 10, and 11 are

- (a) Miss, Miss, Hit
- (b) Hit, Hit, Hit
- (c) Miss, Hit, Miss
- (d) Miss, Miss, Miss
- (e) Hit, Miss, Hit

**Question 46**

[2 marks] Accesses 12, 13, and 14 are

- (a) Miss, Miss, Miss
- (b) Hit, Hit, Hit
- (c) Hit, Hit, Miss
- (d) Hit, Miss, Hit
- (e) Miss, Hit, Hit

**Question 47**

[2 marks] Access 15, 16, and 17 are

- (a) Hit, Hit, Hit
- (b) Miss, Miss, Hit
- (c) Miss, Miss, Miss
- (d) Hit, Miss, Hit
- (e) Hit, Hit, Miss

**Question 48**

[2 marks] Access 18, 19, and 20 are

- (a) Hit, Miss, Miss
- (b) Miss, Miss, Miss
- (c) Miss, Miss, Hit
- (d) Hit, Hit, Hit
- (e) Hit, Hit, Miss

CONTINUED

Consider a fully-associative cache of size 4. Each slot in the cache can have just one item (i.e. the line size is 1 item). The cache is empty to start with.

The cache uses an LRU replacement policy: every slot has a counter; every time a slot is accessed, a global counter is incremented and the value stored in the slot counter; the slot with the lowest counter value is chosen for replacement.

Work out if the following sequence of accesses to the given addresses are hits or misses. Each access is numbered for your convenience.

Sequence Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Address	2	3	3	5	8	5	0	8	2	3	5	8	0	3	5	8	0	2	3	5

**Question 49**

[2 marks] Accesses 3, 4, and 5 are respectively

- (a) Hit, Hit, Hit
- (b) Miss, Miss, Hit
- (c) Miss, Hit, Hit
- (d) Miss, Miss, Miss
- (e) Hit, Miss, Miss

**Question 50**

[2 marks] Accesses 6, 7, and 8 are respectively

- (a) Miss, Hit, Hit
- (b) Miss, Miss, Miss
- (c) Hit, Hit, Hit
- (d) Hit, Miss, Miss
- (e) Hit, Miss, Hit

**Question 51**

[2 marks] Accesses 9, 10, and 11 are

- (a) Miss, Miss, Miss
- (b) Miss, Hit, Hit
- (c) Hit, Hit, Hit
- (d) Miss, Hit, Miss
- (e) Miss, Miss, Hit

CONTINUED

**Question 52**

[2 marks] Accesses 12, 13, and 14 are

- (a) Hit, Hit, Hit
- (b) Hit, Miss, Hit
- (c) Miss, Miss, Miss
- (d) Hit, Hit, Miss
- (e) Miss, Hit, Hit

**Question 53**

[2 marks] Access 15, 16, and 17 are

- (a) Miss, Miss, Hit
- (b) Hit, Miss, Miss
- (c) Hit, Hit, Hit
- (d) Hit, Hit, Miss
- (e) Miss, Miss, Miss

**Question 54**

[2 marks] Access 18, 19, and 20 are

- (a) Hit, Hit, Miss
- (b) Miss, Miss, Miss
- (c) Hit, Miss, Hit
- (d) Hit, Hit, Hit
- (e) Miss, Miss, Hit

CONTINUED



APPENDIX

Base Conversion Table and Powers of two

Decimal	Hexadecimal	Binary	2 <sup>n</sup> Hex	2 <sup>n</sup> Decimal
0	0	0000	1	1
1	1	0001	2	2
2	2	0010	4	4
3	3	0011	8	8
4	4	0100	10	16
5	5	0101	20	32
6	6	0110	40	64
7	7	0111	80	128
8	8	1000	100	256
9	9	1001	200	512
10	A	1010	400	1024
11	B	1011	800	2048
12	C	1100	1000	4096
13	D	1101	2000	8192
14	E	1110	4000	16384
15	F	1111	8000	32768

Table E.2 The Standard ASCII Table

ASCII			ASCII			ASCII			ASCII		
Character	Dec	Hex	Character	Dec	Hex	Character	Dec	Hex	Character	Dec	Hex
nul	0	00	@P	32	20	@	64	40	`	96	60
soh	1	01	!	33	21	A	65	41	a	97	61
stx	2	02	"	34	22	B	66	42	b	98	62
etx	3	03	#	35	23	C	67	43	c	99	63
eot	4	04	\$	36	24	D	68	44	d	100	64
enq	5	05	%	37	25	E	69	45	e	101	65
ack	6	06	&	38	26	F	70	46	f	102	66
bel	7	07	'	39	27	G	71	47	g	103	67
bs	8	08	(	40	28	H	72	48	h	104	68
ht	9	09	)	41	29	I	73	49	i	105	69
lf	10	0A	*	42	2A	J	74	4A	j	106	6A
vt	11	0B	+	43	2B	K	75	4B	k	107	6B
ff	12	0C	,	44	2C	L	76	4C	l	108	6C
cr	13	0D	-	45	2D	M	77	4D	m	109	6D
so	14	0E	.	46	2E	N	78	4E	n	110	6E
si	15	0F	/	47	2F	O	79	4F	o	111	6F
dle	16	10	0	48	30	P	80	50	p	112	70
dc1	17	11	1	49	31	Q	81	51	q	113	71
dc2	18	12	2	50	32	R	82	52	r	114	72
dc3	19	13	3	51	33	S	83	53	s	115	73
dc4	20	14	4	52	34	T	84	54	t	116	74
nak	21	15	5	53	35	U	85	55	u	117	75
syn	22	16	6	54	36	V	86	56	v	118	76
etb	23	17	7	55	37	W	87	57	w	119	77
can	24	18	8	56	38	X	88	58	x	120	78
em	25	19	9	57	39	Y	89	59	y	121	79
sub	26	1A	:	58	3A	Z	90	5A	z	122	7A
esc	27	1B	;	59	3B	[	91	5B	{	123	7B
fs	28	1C	<	60	3C	\	92	5C		124	7C
gs	29	1D	=	61	3D	]	93	5D	}	125	7D
rs	30	1E	>	62	3E	^	94	5E	~	126	7E
us	31	1F	?	63	3F	_	95	5F	del	127	7F

CONTINUED

A.3 The Instruction Set

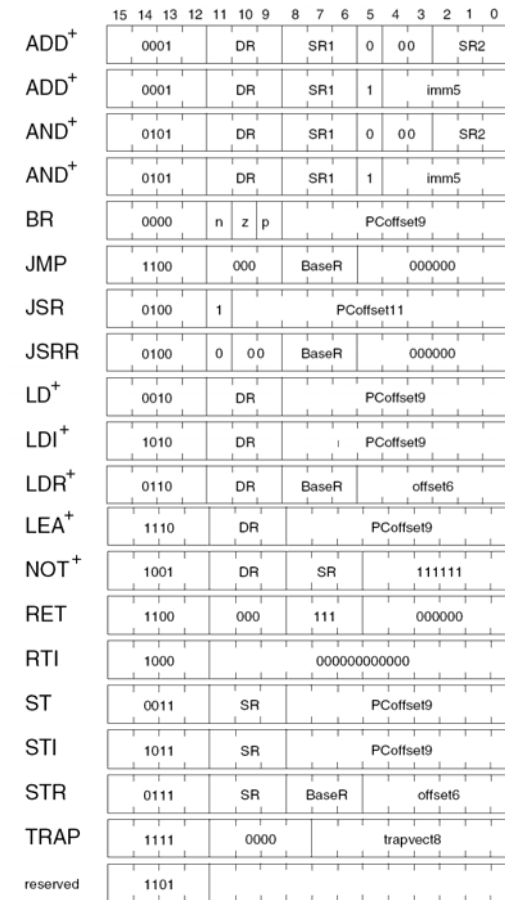


Figure A.2 Format of the entire LC-3 instruction set. Note: + indicates instructions that modify condition codes

Source: Data Abstraction and Problem Solving with Java, Frank M Carrano & Janet J Pritchard