Coláiste na Tríonóide, Baile Átha Cliath
Trinity College Dublin
Ollscoil Átha Cliath | The University of Dublin

Faculty of Engineering, Mathematics and Science

School of Computer Science & Statistics

Integrated Engineering **Semester 2 2024**
Year 3 Annual Examinations

Microprocessor Systems 1

??, ??????th ?????? 2024 **Unknown Hall** **??:?? – ??:??**

Prof. John Waldron

Instructions to Candidates:

Attempt as many questions as you can in the time available. Enter your answers on the CSU33D01 Optical Mark Recognition Answer Sheet provided. Fill in the circle corresponding to your answer for each question ●, preferably using a black pen. Do not write anything else anywhere on sheet. Do not make holes in the sheet or fold it. Place it inside the front cover of your answer book. If you make a mistake the Invigilator can provide you with a spare sheet. All code is GNU ARM Assembly for a Gumstix Connex (PXA255) board. You may not start this examination until you are instructed to do so by the Invigilator. Exam Paper is not to be removed from venue.

Instructions for Invigilators:

Non-programmable calculators are permitted for this examination. To be accompanied by a CSU33D01 Optical Mark Recognition Answer Sheet.

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Question 1
The Gumstix Connex PXA255 machine code immediate value occupies

(A) 12 bits (B) 4 bits (C) 5 bits (D) OTHER (E) 16 bits

A correct answer is worth 4 marks, an incorrect answer loses 1.00 marks.

Question 2
The Gumstix Connex PXA255 non volative byte storage space is

(A) 32K (B) OTHER (C) 16MB (D) 64MB (E) 64K

A correct answer is worth 4 marks, an incorrect answer loses 1.00 marks.

Question 3
The Gumstix Connex PXA255 machine code data processing opcode field occupies

(A) 12 bits (B) OTHER (C) 5 bits (D) 4 bits (E) 16 bits

A correct answer is worth 4 marks, an incorrect answer loses 1.00 marks.

Question 4
The Gumstix Connex PXA255 Architecture is

(A) ARMv4T (B) OTHER (C) ARMv8-A (D) ARMv6 (E) ARMv5TE

A correct answer is worth 4 marks, an incorrect answer loses 1.00 marks.

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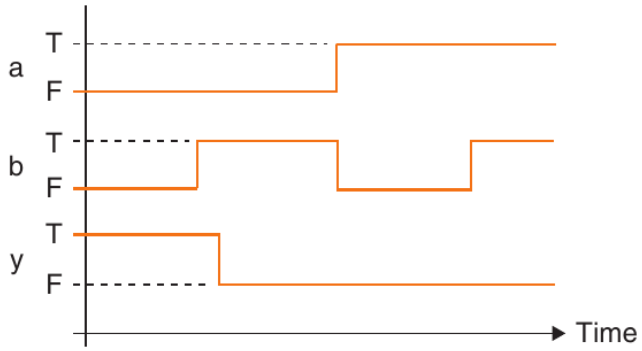
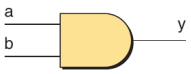
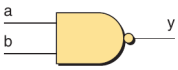
Question 5

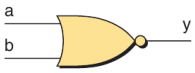
Which logic gate symbol corresponds to the diagram?

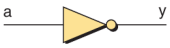


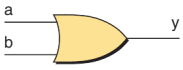
(A) 

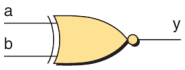
(B)

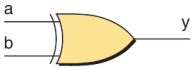
(C) 

(D) 

(E) 

(F) 

(G) 

(H) 

(I) OTHER

A correct answer is worth 3 marks, an incorrect answer loses 0.38 marks.

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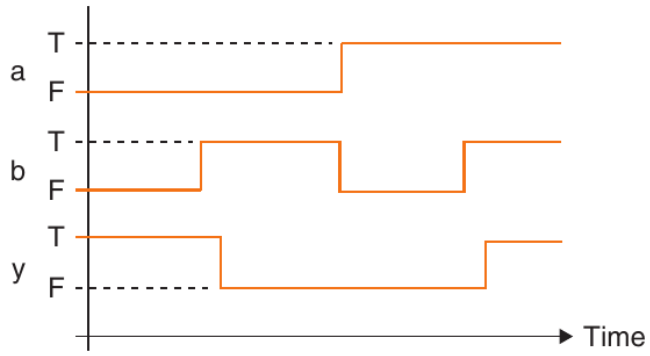
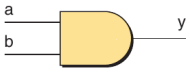
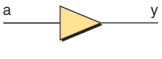
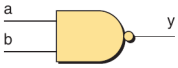
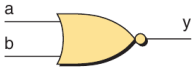
Question 6
Which logic gate symbol corresponds to the diagram?

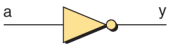


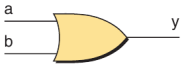
(A) 

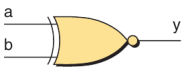
(B) 

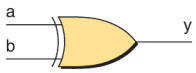
(C) 

(D) 

(E) 

(F) 

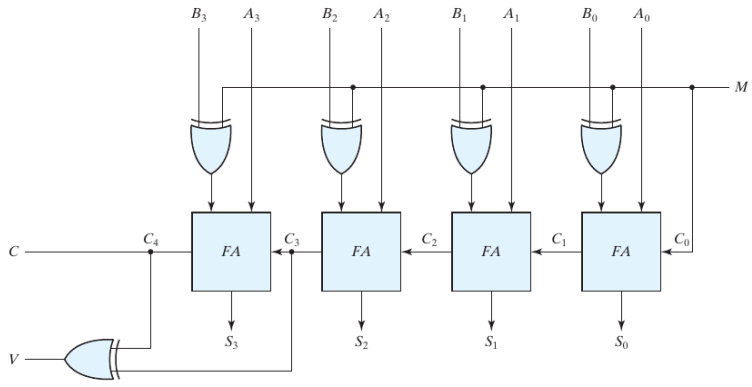
(G) 

(H) 

(I) OTHER

A correct answer is worth 3 marks, an incorrect answer loses 0.38 marks.

Question 7
// For the Adder Subtractor Circuit below and the inputs
// M = 0 A = 0101 and B = 1000
// Enter the outputs S0 S1 S2 S3 and the flags N Z C V



A fully correct answer is worth 14 marks, an incorrect answer is worth 0 marks.

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Question 8
@ After execution of the following instructions
@ what value will be in register r3?

```
00 1F00A0E3         MOV   r0, #0x1F
04 1010A0E3         MOV   r1, #0x10
08 003041E0         SUB   r3, r1, r0
```

(A) 0x00000001 (B) 0x00000004 (C) 0x3736CE3E
(D) 0x38C13316 (E) 0xFFFFFFF1 (F) OTHER
A correct answer is worth 3 marks, an incorrect answer loses 0.60 marks.

Question 9
@ After execution of the following instructions
@ what value will be in the condition code flags?

```
00 2000A0E3         MOV   r0, #0x20
04 2010A0E3         MOV   r1, #0x20
08 002051E0         SUBS  r2, r1, r0
```

(A) 0x6 (B) 0xA (C) 0x0
(D) 0xB (E) 0x1 (F) OTHER
A correct answer is worth 3 marks, an incorrect answer loses 0.60 marks.

Question 10
@ After execution of the following instructions
@ what value will be in register r2?

```
00 0C00A0E3         MOV   r0, #0xC
04 0710A0E3         MOV   r1, #0x7
08 910002E0         MUL   r2, r1, r0
```

(A) 0x00000078 (B) 0x00000054 (C) 0x00000010
(D) 0x00000015 (E) 0x0000004C (F) OTHER
A correct answer is worth 3 marks, an incorrect answer loses 0.60 marks.

Question 11
@ After execution of the following instructions
@ what value will be in the condition code flags?

```
00 0201A0E3         MOV   r0, #0x80000000
04 0211A0E3         MOV   r1, #0x80000000
08 002051E0         SUBS  r2, r1, r0
```

(A) 0x3 (B) 0x5 (C) 0x9
(D) 0x8 (E) 0x6 (F) OTHER
A correct answer is worth 3 marks, an incorrect answer loses 0.60 marks.

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```
Question 12
@ After execution of the following instructions
@ what value will be in register r1?

00 20009FE5         LDR    r0, =str
04 0010A0E3         MOV    r1, #0
08 0120D0E4 loop:   LDRB   r2, [r0], #1
0c 011081E2         ADD    r1, r1, #1
10 000052E3         CMP    r2, #0
14 FBFFFF1A         BNE    loop
18 011041E2         SUB    r1, r1, #1
            Data Segment
20 6461654A str:    .asciz "daeJ8aa"
   38616100

(A) 0x0000000A (B) 0x00000007 (C) 0x0000000B
(D) 0x00000023 (E) 0x00000003 (F) OTHER
A correct answer is worth 5 marks, an incorrect
answer loses 1.00 marks.

Question 13
@ After execution of the following instructions
@ what value will be in register r0?

00 0100A0E3         MOV     r0, #1
04 0410A0E3         MOV     r1, #0x4
08 0420A0E3         MOV     r2, #0x4
0c 0220B0E1         MOVS    r2, r2
           while:
10 0200000A         BEQ     end
14 910000E0         MUL     r0, r1, r0
18 012052E2         SUBS    r2, r2, #1
1c FBFFFFEA         B       while
           end:

(A) 0x00000100 (B) 0x000000F6 (C) 0x0000008E
(D) 0x00000001 (E) 0x00005B00 (F) OTHER
A correct answer is worth 5 marks, an incorrect
answer loses 1.00 marks.
```

```
Question 14
@ After execution of the following instructions
@ what value will be in register r3?

00 0030A0E3         MOV    r3, #0
04 2C109FE5         LDR    r1, =test
08 0020D1E5         LDRB   r2, [r1]
0c 021081E2         ADD    r1, r1, #2
10 023083E0         ADD    r3,r2
14 0020D1E5         LDRB   r2, [r1]
18 031081E2         ADD    r1, r1, #3
1c 023083E0         ADD    r3,r2
20 0020D1E5         LDRB   r2, [r1]
24 023083E0         ADD    r3,r2
            Data Segment
2c 415A6E74 test:  .asciz "AZntOka9Sk"
   4F6B6139
   536B00

(A) 0x00011598 (B) 0x00000001 (C) 0x0000011A
(D) 0x0000CBCA (E) 0x00012DD4 (F) OTHER
A correct answer is worth 5 marks, an incorrect
answer loses 1.00 marks.

Question 15
@ After execution of the following instructions
@ what value will be in register r1?

00 2C009FE5         LDR    r0, =test
04 0010A0E3         MOV    r1, #0
08 0020D0E5 loop:   LDRB   r2, [r0]
0c 5A0052E3         CMP    r2, #'Z'
10 0000003A         BLO    skip
14 011081E2         ADD    r1, r1, #1
18 010080E2 skip:   ADD    r0, #1
1c 000052E3         CMP    r2, #0
20 F8FFFF1A         BNE    loop
            Data Segment
28 485A694E test:   .asciz "HZiNBkcr"
   426B6372
   00

(A) 0x00000008 (B) 0x00000009 (C) 0x0000000A
(D) 0x00000005 (E) 0x00000002 (F) OTHER
A correct answer is worth 5 marks, an incorrect
answer loses 1.00 marks.
```


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Question 16
@ After execution of the following instructions
@ what value will be in register r0?

```
00 0000A0E3         MOV     r0, #0
04 38109FE5         LDR     r1, =nums
08 0020A0E3         MOV     r2, #0
0c 023191E7 do1:    LDR     r3, [r1, r2, LSL #2]
10 030080E0         ADD     r0, r0, r3
14 012082E2         ADD     r2, #1
18 080052E3         CMP     r2, #8
1c FAFFFF3A         BCC     do1
            Data Segment
24 0F000000 nums:   .4byte  0xF, 0x9, 0x9, 0xE
   09000000
   09000000
   0E000000
34 0A000000         .4byte  0xA, 0x1, 0x1, 0x3
   01000000
   01000000
   03000000
```

(A) 0x00000024 (B) 0x0000003E (C) 0x00000016
(D) 0x00000075 (E) 0x00000AE6 (F) OTHER
A correct answer is worth 8 marks, an incorrect answer loses 1.60 marks.

Question 17
@ After execution of the following instructions
@ what value will be in register r0?

```
00 38C09FE5         LDR   r12, =0xA1000400
04 2000A0E3         LDR   r0, =0x20
08 04C04CE2         SUB   r12, r12, #4
0c 00008CE5         STR   r0, [r12]
10 B200A0E3         LDR   r0, =0xB2
14 04C04CE2         SUB   r12, r12, #4
18 00008CE5         STR   r0, [r12]
1c 0200A0E3         LDR   r0, =0x2
20 04C04CE2         SUB   r12, r12, #4
24 00008CE5         STR   r0, [r12]
28 00009CE5         LDR   r0, [r12]
2c 04C08CE2         ADD   r12, r12, #4
30 00009CE5         LDR   r0, [r12]
34 04C08CE2         ADD   r12, r12, #4
38 B80040E2         SUB   r0, #0xB8
```

(A) 0xFFFFFFFA (B) 0x3AC7348D (C) 0x037F08D2
(D) 0x00000001 (E) 0x4CF5836F (F) OTHER
A correct answer is worth 8 marks, an incorrect answer loses 1.60 marks.

Question 18
@ After execution of the following instructions
@ what value will be in register r1?

```
00 34009FE5         LDR   r0, =nums
04 0010A0E3         MOV   r1, #0
08 0220D0E4         LDRB  r2, [r0], #2
0c 021081E0         ADD   r1, r2
10 0220D0E4         LDRB  r2, [r0], #2
14 021081E0         ADD   r1, r2
18 0220D0E5         LDRB  r2, [r0, #2]
1c 021081E0         ADD   r1, r2
20 012070E5         LDRB  r2, [r0, #-1]!
24 021081E0         ADD   r1, r2
28 022070E5         LDRB  r2, [r0, #-2]!
2c 021081E0         ADD   r1, r2
            Data Segment
34 08060D08 nums:   .byte 0x8, 0x6, 0xD, 0x8
38 0C01070B         .byte 0xC, 0x1, 0x7, 0xB
```

(A) 0x0000063C (B) 0x00000594 (C) 0x00000054
(D) 0x0000002A (E) 0x00000001 (F) OTHER
A correct answer is worth 8 marks, an incorrect answer loses 1.60 marks.

Question 19
@ After execution of the following instructions
@ what value will be in register r5?

```
00 3CD09FE5         LDR   sp, =0xA1000400
04 0700A0E3         LDR   r0, =0x7
08 3A10A0E3         LDR   r1, =0x3A
0c 04002DE5         STR   r0, [sp, #-4]!
10 04102DE5         STR   r1, [sp, #-4]!
14 010000EB         BL    vp
18 08D08DE2         ADD   sp, #8
1c FEFFFFEA stop:   B     stop
20 00502DE9 vp:     STMFD  sp!, {r12,lr}
24 08C08DE2         add    r12, sp, #8
28 1F002DE9         STMFD  sp!,{r0-r4}
2c 04309CE5         LDR    r3, [r12, #4]
30 00109CE5         LDR    r1, [r12, #0]
34 030081E0         ADD    r0, r1, r3
38 035041E0         SUB    r5, r1, r3
3c 1F00BDE8         LDMFD  sp!, {r0-r4}
40 0090BDE8         LDMFD  sp!, {r12,pc}
```

(A) 0x00000693 (B) 0x00000033 (C) 0x00000001
(D) 0x00000060 (E) 0x0000002B (F) OTHER
A correct answer is worth 8 marks, an incorrect answer loses 1.60 marks.

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Condition Code Flags

ASCII Table

	0	1	2	3	4	5	6	7
0	NUL	DLE	SPACE	0	@	P	`	p
1	SOH	DC1	!	1	A	Q	a	q
2	STX	DC2	"	2	B	R	b	r
3	ETX	DC3	#	3	C	S	c	s
4	EOT	DC4	$	4	D	T	d	t
5	ENQ	NAK	%	5	E	U	e	u
6	ACK	SYN	&	6	F	V	f	v
7	BEL	ETB	'	7	G	W	g	w
8	BS	CAN	(	8	H	X	h	x
9	HT	EM	)	9	I	Y	i	y
A	LF	SUB	*	:	J	Z	j	z
B	VT	ESC	+	;	K	[	k	{
C	FF	FS	,	<	L	\	l	|
D	CR	GS	-	=	M	]	m	}
E	SO	RS	.	>	N	^	n	~
F	SI	US	/	?	O	_	o	DEL

Conditional Branch Instructions

Branch Instruction	Condition Code Flag Evaluation	Description
B (or BAL)	don't care	unconditional (branch always)
BEQ	Z	equal
BNE	$\bar{Z}$	not equal
BCS / BHS	C	unsigned ≥
BCC / BLO	$\bar{C}$	unsigned <
BMI	N	negative
BPL	$\bar{N}$	positive or zero
BVS	V	overflow
BVC	$\bar{V}$	no overflow
BHI	$C\bar{Z}$	unsigned >
BLS	$\bar{C} + Z$	unsigned ≤
BGE	$NV + \bar{N}\bar{V}$	signed ≥
BLT	$N\bar{V} + \bar{N}V$	signed <
BGT	$\bar{Z}(NV + \bar{N}\bar{V})$	signed >
BLE	$Z + N\bar{V} + \bar{N}V$	signed ≤

Summary of LDR/STR Addressing Modes

Addressing mode	Syntax	W, B	H, SH, SB	Operation
Immediate Offset	`[<Rn>, #+/-<offset>]`	✓	✓	`address ← Rn +/- offset`
Register Offset	`[<Rn>, +/-<Rm>]`	✓	✓	`address ← Rn +/- Rm`
Scaled Register Offset	`[<Rn, +/-<Rm>, <shift> #<count>]`	✓		`address ← Rn +/- (Rm <shift> <count>)`
Immediate Pre-Indexed	`[<Rn>, #+/-<offset>]!`	✓	✓	`Rn ← Rn +/- offset` `address ← Rn`
Register Pre-Indexed	`[<Rn>, +/-<Rm>]!`	✓	✓	`Rn ← Rn +/- Rm` `address ← Rn`
Scaled Register Pre-Indexed	`[<Rn, +/-<Rm>, <shift> #<count>]!`	✓		`Rn ← Rn +/- (Rm <shift> <count>)` `address ← Rn`
Immediate Post-Indexed	`[<Rn>], #+/-<offset>`	✓	✓	`address ← Rn` `Rn ← Rn +/- offset`
Register Post-Indexed	`[<Rn>], +/-<Rm>`	✓	✓	`address ← Rn` `Rn ← Rn +/- Rm`
Scaled Register Post-Indexed	`[<Rn], +/-<Rm>, <shift> #<count>`	✓		`address ← Rn` `Rn ← Rn +/- (Rm <shift> <count>)`

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