Princeton University
COS 217: Introduction to Programming Systems
A Subset of SPARC Assembly Language for the Assembler Assignment

Abbreviations Used in Instruction Formats	
rs1	Source register 1.
rs2	Source register 2.
rd	Destination register.
constX	Constant that fits into X bits, expressed in decimal.
labelX	Label that the assembler (and linker) evaluates to a constX instruction displacement.

Abbreviations Used in Instruction Descriptions	
r[X]	The contents of register X. The instruction descriptions view r as an array of ints.
mem[X]	The contents of memory at location X. The instruction descriptions view mem as an array of chars.
constX	Constant that fits into X bits.
Z	Zero condition code. The instruction descriptions view Z as an int whose value is either 0 (FALSE) or 1 (TRUE).
N	Negative condition code. The instruction descriptions view N as an int whose value is either 0 (FALSE) or 1 (TRUE).
V	oVerflow condition code. The instruction descriptions view V as an int whose value is either 0 (FALSE) or 1 (TRUE).
C	Carry condition code. The instruction descriptions view C as an int whose value is either 0 (FALSE) or 1 (TRUE).

Load and Store Mnemonics (Format 3)	
	Load unsigned byte
ldub [rs1],rd	r[rd] = (unsigned int)mem[r[rs1]];
ldub [rs1+rs2],rd	r[rd] = (unsigned int)mem[r[rs1] + r[rs2]];
ldub [rs1+const13],rd	r[rd] = (unsigned int)mem[r[rs1] + const13];
ldub [rs1-const13],rd	r[rd] = (unsigned int)mem[r[rs1] - const13];
ldub [const13+rs1],rd	r[rd] = (unsigned int)mem[r[rs1] + const13];
ldub [const13],rd	r[rd] = (unsigned int)mem[const13];
	Load signed byte
ldsb [rs1],rd	r[rd] = (int)mem[r[rs1]];
ldsb [rs1+rs2],rd	r[rd] = (int)mem[r[rs1] + r[rs2]];
ldsb [rs1+const13],rd	r[rd] = (int)mem[r[rs1] + const13];
ldsb [rs1-const13],rd	r[rd] = (int)mem[r[rs1] - const13];
ldsb [const13+rs1],rd	r[rd] = (int)mem[r[rs1] + const13];
ldsb [const13],rd	r[rd] = (int)mem[const13];
	Load unsigned halfword
lduh [rs1],rd	r[rd] = *(unsigned short*)(mem + r[rs1]);
lduh [rs1+rs2],rd	r[rd] = *(unsigned short*)(mem + r[rs1] + r[rs2]);
lduh [rs1+const13],rd	r[rd] = *(unsigned short*)(mem + r[rs1] + const13);
lduh [rs1-const13],rd	r[rd] = *(unsigned short*)(mem + r[rs1] - const13);
lduh [const13+rs1],rd	r[rd] = *(unsigned short*)(mem + r[rs1] + const13);
lduh [const13],rd	r[rd] = *(unsigned short*)(mem + const13);
	Load signed halfword
ldsh [rs1],rd	r[rd] = *(short*)(mem + r[rs1]);
ldsh [rs1+rs2],rd	r[rd] = *(short*)(mem + r[rs1] + r[rs2]);
ldsh [rs1+const13],rd	r[rd] = *(short*)(mem + r[rs1] + const13);
ldsh [rs1-const13],rd	r[rd] = *(short*)(mem + r[rs1] - const13);
ldsh [const13+rs1],rd	r[rd] = *(short*)(mem + r[rs1] + const13);
ldsh [const13],rd	r[rd] = *(short*)(mem + const13);

	Load word
ld [rs1],rd	r[rd] = *(int*)(mem + r[rs1]);
ld [rs1+rs2],rd	r[rd] = *(int*)(mem + r[rs1 + r[rs2]]);
ld [rs1+const13],rd	r[rd] = *(int*)(mem + r[rs1] + const13);
ld [rs1-const13],rd	r[rd] = *(int*)(mem + r[rs1] - const13);
ld [const13+rs1],rd	r[rd] = *(int*)(mem + r[rs1] + const13);
ld [const13],rd	r[rd] = *(int*)(mem + const13);
	Store byte
stb rd,[rs1]	mem[r[rs1]] = r[rd];
stb rd,[rs1+rs2]	mem[r[rs1] + r[rs2]] = r[rd];
stb rd,[rs1+const13]	mem[r[rs1] + const13] = r[rd];
stb rd,[rs1-const13]	mem[r[rs1] - const13] = r[rd];
stb rd,[const13+rs1]	mem[r[rs1] + const13] = r[rd];
stb rd,[const13]	mem[const13] = r[rd];
	Store halfword
sth rd,[rs1]	*(short*)(mem + r[rs1]) = r[rd];
sth rd,[rs1+rs2]	*(short*)(mem + r[rs1] + r[rs2]) = r[rd];
sth rd,[rs1+const13]	*(short*)(mem + r[rs1] + const13) = r[rd];
sth rd,[rs1-const13]	*(short*)(mem + r[rs1] - const13) = r[rd];
sth rd,[const13+rs1]	*(short*)(mem + r[rs1] + const13) = r[rd];
sth rd,[const13]	*(short*)(mem + const13) = r[rd];
	Store word
st rd,[rs1]	*(int*)(mem + r[rs1]) = r[rd];
st rd,[rs1+rs2]	*(int*)(mem + r[rs1] + r[rs2]) = r[rd];
st rd,[rs1+const13]	*(int*)(mem + r[rs1] + const13) = r[rd];
st rd,[rs1-const13]	*(int*)(mem + r[rs1] - const13) = r[rd];
st rd,[const13+rs1]	*(int*)(mem + r[rs1] + const13) = r[rd];
st rd,[const13]	*(int*)(mem + const13) = r[rd];

Shift Mnemonics (Format 3)

	Shift left logical
sll rs1,rs2,rd	r[rd] = r[rs1] << r[rs2];
sll rs1,const13,rd	r[rd] = r[rs1] << const13;
	Shift right logical
srl rs1,rs2,rd	r[rd] = (unsigned int)r[rs1] >> r[rs2];
srl rs1,const13,rd	r[rd] = (unsigned int)r[rs1] >> const13;
	Shift right arithmetic
sra rs1,rs2,rd	r[rd] = r[rs1] >> r[rs2];
sra rs1,const13,rd	r[rd] = r[rs1] >> const13;

Arithmetic Mnemonics (Format 3)

	Add
add rs1,rs2,rd	r[rd] = r[rs1] + r[rs2];
add rs1,const13,rd	r[rd] = r[rs1] + const13;
	Add, and set condition codes
addcc rs1,rs2,rd	r[rd] = r[rs1] + r[rs2]; N = r[rd]<0; Z = r[rd]==0; V = (r[rs1]<0 & r[rs2]<0 & r[rd]>0) | (r[rs1]>0 & r[rs2]>0 & r[rd]<0); C = (r[rs1]<0 & r[rs2]<0) | (r[rd]>0 & (r[rs1]<0 | r[rs2]<0));
addcc rs1,const13,rd	r[rd] = r[rs1] + const13; N = r[rd]<0; Z = r[rd]==0; V = (r[rs1]<0 & const13<0 & r[rd]>0) | (r[rs1]>0 & const13>0 & r[rd]<0); C = (r[rs1]<0 & const13<0) | (r[rd]>0 & (r[rs1]<0 | const13<0));
	Subtract
sub rs1,rs2,rd	r[rd] = r[rs1] - r[rs2];
sub rs1,const13,rd	r[rd] = r[rs1] - const13;
	Subtract, and set condition codes
subcc rs1,rs2,rd	r[rd] = r[rs1] - r[rs2]; N = r[rd]<0; Z = r[rd]==0; V = (r[rs1]<0 & r[rs2]>0 & r[rd]>0) | (r[rs1]>0 & r[rs2]<0 & r[rd]<0); C = (r[rs1]>0 & r[rs2]<0) | (r[rd]<0 & (r[rs1]>0 | r[rs2]<0));
subcc rs,const13,rd	r[rd] = r[rs1] - const13; N = r[rd]<0; Z = r[rd]==0; V = (r[rs1]<0 & const13>0 & r[rd]>0) | (r[rs1]>0 & const13<0 & r[rd]<0); C = (r[rs1]>0 & const13<0) | (r[rd]<0 & (r[rs1]>0 | const13<0));

	Negate
neg rs2,rd	Synthetic instruction for: sub %g0, rs2, rd
neg rd	Synthetic instruction for: sub %g0, rd, rd
	Increment
inc rd	Synthetic instruction for: add rd, 1, rd
inc const13,rd	Synthetic instruction for: add rd, const13, rd
	Decrement
dec rd	Synthetic instruction for: sub rd, 1, rd
dec const13,rd	Synthetic instruction for: sub rd, const13, rd
	Compare
cmp rs,rs2	Synthetic instruction for: subcc rs, rs2, %g0
cmp rs,const13	Synthetic instruction for: subcc rs, const13, %g0

Logical Mnemonics (Format 3)

	And
and rs1,rs2,rd	r[rd] = r[rs1] & r[rs2]
and rs1,const13,rd	r[rd] = r[rs1] & const13
	And, and set condition codes
andcc rs1,rs2,rd	r[rd] = r[rs1] & r[rs2]; N = r[rd]<0; Z = r[rd]==0; V=0; C=0;
andcc rs1,const13,rd	r[rd] = r[rs1] & const13; N = r[rd]<0; Z = r[rd]==0; V=0; C=0;
	Or
or rs1,rs2,rd	r[rd] = r[rs1] | r[rs2]
or rs1,const13,rd	r[rd] = r[rs1] | const13
	Or, and set condition codes
orcc rs1,rs2,rd	r[rd] = r[rs1] | r[rs2]; N = r[rd]<0; Z = r[rd]==0; V=0; C=0;
orcc rs1,const13,rd	r[rd] = r[rs1] | const13; N = r[rd]<0; Z = r[rd]==0; V=0; C=0;
	Exclusive or
xor rs1,rs2,rd	r[rd] = r[rs1] ^ r[rs2];
xor rs1,const13,rd	r[rd] = r[rs1] ^ const13;
	Exclusive or, and set condition codes
xorcc rs1,rs2,rd	r[rd] = r[rs1] ^ r[rs2]; N = r[rd]<0; Z = r[rd]==0; V=0; C=0;
xorcc rs1,const13,rd	r[rd] = r[rs1] ^ const13; N = r[rd]<0; Z = r[rd]==0; V=0; C=0;
	Exclusive nor
xnor rs1,rs2,rd	r[rd] = ~(r[rs1] ^ r[rs2]);
xnor rs1,const13,rd	r[rd] = ~(r[rs1] ^ const13);
	Exclusive nor, and set condition codes
xnorcc rs1,rs2,rd	r[rd] = ~(r[rs1] ^ r[rs2]); N = r[rd]<0; Z = r[rd]==0; V=0; C=0;
xnorcc rs1,const13,rd	r[rd] = ~(r[rs1] ^ const13); N = r[rd]<0; Z = r[rd]==0; V=0; C=0;
	Clear
clr rd	Synthetic instruction for: or %g0, %g0, rd
	Move
mov rs2,rd	Synthetic instruction for: or %g0, rs2, rd
mov const13,rd	Synthetic instruction for: or %g0, const13, rd
	Not
not rs1,rd	Synthetic instruction for: xnor rs1, %g0, rd
not rd	Synthetic instruction for: xnor rd, %g0, rd

Integer Branch Mnemonics (Format 2)

Unconditional branching:	
	Branch to label always

ba{,a} label22	pc = npc;
	npc = const22 << 2;
	if (a == 1) { pc = npc; npc += 4; }

Signed number branching:	
	Branch if equal

be{,a} label22	pc = npc;
	if (Z) npc = const22 << 2;
	else if (a == 0) npc += 4;
	else { pc += 4; npc += 8; }

	Branch if not equal

bne{,a} label22	pc = npc;
	if (! Z) npc = const22 << 2;
	else if (a == 0) npc += 4;
	else { pc += 4; npc += 8; }

	Branch if less than

bl{,a} label22	pc = npc;
	if (N ^ V) npc = const22 << 2;
	else if (a == 0) npc += 4;
	else { pc += 4; npc += 8; }

ble{,a} label22	**Branch if less than or equal to**
	pc = npc;
	if (Z | (N ^ V)) npc = const22 << 2;
	else if (a == 0) npc += 4;
	else { pc += 4; npc += 8; }

bge{,a} label22	**Branch if greater than or equal to**
	pc = npc;
	if (!(N ^ V)) npc = const22 << 2;
	else if (a == 0) npc += 4;
	else { pc += 4; npc += 8; }

bg{,a} label22	**Branch if greater than**
	pc = npc;
	if (!(Z | (N ^ V))) npc = const22 << 2;
	else if (a == 0) npc += 4;
	else { pc += 4; npc += 8; }

Unsigned number branching:	
blu{,a} label22	**Branch if less than (unsigned)** Synonym for: bcs{,a} label22

bleu{,a} label22	**Branch if less than or equal to (unsigned)**
	pc = npc;
	if (C | Z) npc = const22 << 2;
	else if (a == 0) npc += 4;
	else { pc += 4; npc += 8; }

bgeu{,a} label22	**Branch if greater than or equal to (unsigned)** Synonym for: bcc{,a} label22

bgu{,a} label22	**Branch if greater than (unsigned)**
	pc = npc;
	if (!(C | Z)) npc = const22 << 2;
	else if (a == 0) npc += 4;
	else { pc += 4; npc += 8; }

Control Mnemonics (Format 3)

jmpl rs1,rd
jmpl rs1+rs2,rd
jmpl rs1+const13,rd
jmpl rs1-const13,rd
jmpl const13+rs1,rd
jmpl const13,rd
	Jump and link
	r[rd] = pc; pc = npc; npc = r[rs1];
	r[rd] = pc; pc = npc; npc = r[rs1] + r[rs2];
	r[rd] = pc; pc = npc; npc = r[rs1] + const13;
	r[rd] = pc; pc = npc; npc = r[rs1] - const13;
	r[rd] = pc; pc = npc; npc = r[rs1] + const13;
	r[rd] = pc; pc = npc; npc = const13;

call rs1	**Call indirect** Synthetic instruction for: jmpl rs1, %o7
ret	**Return from subroutine** Synthetic instruction for: jmpl %i7 + 8, %g0
retl	**Return from leaf subroutine** Synthetic instruction for: jmpl %o7 + 8, %g0

save rs1,rs2,rd
 	
save rs1,const13,rd
	Save register window and add
	temp = r[rs1] + r[rs2];
	save the register window
	r[rd] = temp;
	temp = r[rs1] + const13;
	(save the register window)
	r[rd] = temp;

restore rs1,rs2,rd
 	
restore rs1,const13,rd
	Restore register window and add
	temp = r[rs1] + r[rs2];
	(restore the register window)
	r[rd] = temp;
	temp = r[rs1] + r[rs2];
	(restore the register window)
	r[rd] = temp;

restore	**Restore register window and add** Synthetic instruction for: restore %g0, %g0, %g0

Control Mnemonics (Format 2)

nop	**No operation**
sethi const22,rd	**Set high-order bits** r[rd] = const22 << 10;
set label30,rd	**Set** Synthetic instruction for: sethi %hi(label30), rd or rd, %lo(label30), rd

Control Mnemonics (Format 1)	
call label30	**Call** r[o7] = pc; pc = npc; npc = pc + const30

Assembler Directives	
label:	Record the fact that label marks the current location within the current section
.section ".sectionname"	Make the sectionname section the current section, where sectionname is either data, bss, or text
.skip n	Skip n bytes of memory in the current section
.align n	Increase the current section's location counter so it is evenly divisible by n
.byte bytevalue1, bytevalue2, ...	Allocate memory containing bytevalue1, bytevalue2, ... in the current section
.half halfvalue1, halfvalue2, ...	Allocate memory containing halfvalue1, halfvalue2, ... in the current section
.word wordvalue1, wordvalue2, ...	Allocate memory containing wordvalue1, wordvalue2, ... in the current section
.ascii "string1", "string2", ...	Allocate memory containing the characters from string1, string2, ... in the current section
.asciz "string1", "string2", ...	Allocate memory containing string1, string2, ..., where each string is NULL terminated, in the current section
.global label1, label2, ...	Mark label1, label2, ... so they are available to the linker