Questions in this assignment are about VAX, an ISA that was mentioned in class but for which no details were given. Use the VAX-11 Architecture Reference Manual (Cover, 1982; text, 1980), which is linked to the course references page, as a reference for this assignment. (The VAX MACRO and Instruction Set Reference Manual can be used as a secondary reference; you may also use any other resources that you can find.) Chapter and section numbers in this assignment refer to the VAX-11 manual, not to the VAX MACRO manual.

Problem 1: Compare the design goals for VAX as described in Section 1.1 to the design goals for SPARC as described in the SPARC Architecture Manual V8 Section 1.1 (also linked to the course references page).

(*a*) List the design goals for each architecture that are considered defining elements of the respective ISA family (CISC and RISC). Explain whether the design goals in VAX and SPARC are mutually exclusive (meaning you can't easily do both).

(*b*) List a feature or design goal for each ISA that is unrelated to the features of the respective ISA family. Briefly explain why it is unrelated.

Problem 2:   Answer the following questions about VAX and RISC instruction formats.

(*a*) MIPS has three instruction formats for the integer instructions, SPARC has from three to five (depending on how you count). The VAX ISA seems to have a simpler format, according to Section 2.6 (it takes just half a page to describe). Even if the VAX format is conceptually simpler (and many would dispute that), why is it more complex in a way that is important to implementers. *Hint: This is an easy question.*

(*b*) In class each operand of a typical CISC instruction had a *type* and *info* field to describe its addressing mode. What are the corresponding VAX field names?

(*c*) Some RISC instructions have something like a type field, though not capable of specifying the wide range of operand types as the VAX type fields (see the previous problem). Find two examples of MIPS instructions that have an equivalent of a type field. Identify the field and explain what operand types it specifies. *Hint: Consider instructions that deal with floating-point numbers.*

(*d*) Both MIPS and SPARC have an opcode field that appears in every instruction format and some kind of an opcode extension field that appears in some of the formats. Name the opcode extension fields in MIPS and SPARC. What is the closest equivalent to an opcode extension field in VAX?

Problem 3:   Find the VAX addressing modes requested in the problems below. The term *addressing mode* can refer to registers, immediates, as well as memory addresses.

(*a*) Find the VAX addressing modes corresponding to the addressing mode used by the indicated operands in each instruction below.

   Name the mode, and show how the operand would be encoded in the instruction (there is no need to show the entire instruction).

```
 addi r1, r2, 3      # Both source operands.

 lw r1, 0(r2)        # Source operand. Note that the displacement is zero.

 lw r3, 4(r4)        # Source operand
```

```
ld [l1+l2], l3      # SPARC insn, source operand
```

(*b*) Find the VAX addressing mode that can be used in place of the three instructions below. Name the mode, and show how it is encoded.

```
sll r1, r2, 2
add r3, r1, r4
lw r5, 0(r3)
```