Directions: Work only on this sheet (on both sides, if needed); do not turn in any supplementary sheets of paper. There is actually plenty of room for your answers, as long as you organize yourself BEFORE starting writing. In order to get full credit, SHOW YOUR WORK.

1. This problem is about the read() system call.

   (a) (10) During execution of read() the CPU is in _________ mode. It got into this mode because the function is called via the _________ instruction instead of by the _________ instruction.

   (b) (10) The OS will need to check which system call has been made, i.e. check whether it was a call to write(), a call to read(), a call to open(), etc. Give a single instruction from the Intel CMP family which checks whether the call was to read().

2. Consider the following Java code and its compiled JVM machine language:

   public class First8 {
      public static void main(String[] CLArgs) {
         int X[];
         X = new int[3];
         X[0] = 4; X[1] = 8; X[2] = 1;
         System.out.println(First(X,8));
      }
      public static int First(int A[], int K) {
         int I;
         for (I = 0; ; I++)
            if (A[I] == K) break; // name this line L
         return I;
      }
   }

   Method void main(java.lang.String[])  
   0 iconst_3  
   1 newarray int  
   3 astore_1  
   ...
   17 getstatic #2 <Field java.io.PrintStream out>  
   20 _________  
   21 bipush _________  
   23 invokestatic #3 <Method int First(int[], int)>  
   26 invokevirtual #4 <Method void println(int)>  
   29 return  
   Method int First(int[], int)  
   0 iconst_0  
   1 istore_2  
   2 goto 5  
   5 aload_0  
   6 iload_2  
   7 iaload  
   8 iload_1  
   9 if_icmpne 15  
   12 goto 21  
   15 iinc 2 1  
   18 goto 5  
   21 _________  
   22 ireturn  

   (a) (20) The compiled code for the source line named L (see comment in source code) is in offsets ______ through ______ of First().
(b) (15) Give the machine code for the instructions in offsets 8-9 of First(). Your answer must consist of four bytes of hex.

(c) (20) Fill in the blanks in offsets 20 and 21 of main() and in offset 21 of First().

3. (25) The following MIPS code, which could be part of an OS, changes an entry in the page table to indicate that the given page is not resident in memory. The labels pgtbl and pgnum are in the .data segment; pgtbl is the beginning of the page table, and pgnum contains the number of the page to be recorded as nonresident. Assume the page table structure on p.16 of our PLN unit on OS. Fill in the blanks (MIPS pseudoinstructions are allowed).

\[
\begin{align*}
\text{lw } & \$8, \underline{\text{pgnum}} \\
\text{sll } & \$9, \$8, \underline{\text{2}} \\
\text{lw } & \$10, \underline{\text{pgtbl}}(\$9) \\
\text{and } & \$11, \$10, \underline{0x \text{fff}} \\
\text{sw } & \$11, \underline{\text{pgtbl}}(\$9)
\end{align*}
\]

Solutions:

1. Kernel; \text{int; call}

2. Since \text{read()} is system call number 3, we should use

\text{cmpl } \$3, \%eax

3.a 5-12; note that offset 12 implements the \text{break}

3.b The opcode is 0x1b for \text{iload\textunderscore 1}. For \text{if\textunderscore cmpne} the opcode is 0xa0 and there is a 2-byte operand for the distance to the jump target, in this case 15-9 = 6. So, the two instructions have machine code 0x1ba00006.

3.c In offsets 20 and 21 of \text{main()}, we need to pass the two arguments for the call to \text{First()}. The first argument, \(X\), is an array name, thus an address, so we need an instruction from the \text{aload} family, in this case \text{aload\textunderscore 1} since \(X\) is in slot 1. The second argument is 8, which we push in offset 21. If offset 21 of \text{First()}, we need to push the return value, for use by the \text{ireturn} in offset 22. Since the return value is \(I\), in offset 2, we need \text{iload\textunderscore 2}.

4.

\[
\begin{align*}
\text{lw } & \$8, \underline{\text{pgnum}} \quad \# \text{index into the table} \\
\text{sll } & \$9, \$8, \underline{\text{2}} \quad \# \text{multiply by 4, since each entry is 4 bytes} \\
\text{lw } & \$10, \underline{\text{pgtbl}}(\$9) \quad \# \text{get the page table entry} \\
\text{and } & \$11, \$10, \underline{0xff} \quad \# \text{change the residence bit to 0} \\
\text{sw } & \$11, \underline{\text{pgtbl}}(\$9) \quad \# \text{store new entry}
\end{align*}
\]