7.3 Control and timing. Processor communication. Device communication. Data buffering. Error detection.

7.5 With **memory-mapped I/O**, there is a single address space for memory locations and I/O devices. The processor treats the status and data registers of I/O modules as memory locations and uses the same machine instructions to access both memory and I/O devices. With **isolated I/O**, a command specifies whether the address refers to a memory location or an I/O device. The full range of addresses may be available for both.

Problems

7.1 In the first addressing mode, $2^8 = 256$ ports can be addressed. Typically, this would allow 128 devices to be addressed. However, an opcode specifies either an input or output operation, so it is possible to reuse the addresses, so that there are 256 input port addresses and 256 output port addresses. In the second addressing mode, $2^{16} = 64K$ port addresses are possible.

7.2 In direct addressing mode, an instruction can address up to $2^{16} = 64K$ ports. In indirect addressing mode, the port address resides in a 16-bit registers, so again, the instruction can address up to $2^{16} = 64K$ ports.

7.3 64 kB

7.6 **a.** The printing rate is slowed to 5 cps.
b. The situation must be treated differently with input devices such as the keyboard. It is necessary to scan the buffer at a rate of at least once per 60 ms. Otherwise, there is the risk of overwriting characters in the buffer.

7.9 **a.** The processor scans the keyboard 10 times per second. In 8 hours, the number of times the keyboard is scanned is $10 \times 60 \times 60 \times 8 = 288{,}000$.
b. Only 60 visits would be required. The reduction is $1 - (60/288000) = 0.999$, or 99.9%

7.11 **a.** The device generates 8000 interrupts per second or a rate of one every 125 μs. If each interrupt consumes 100 μs, then the fraction of processor time consumed is $100/125 = 0.8$
b. In this case, the time interval between interrupts is $16 \times 125 = 2000$ μs. Each interrupt now requires 100 μs for the first character plus the time for transferring each remaining character, which adds up to $8 \times 15 = 120$ μs, for a total of 220 μs. The fraction of processor time consumed is $220/2000 = 0.11$