6.1.1 Which of the following are signal processing systems (we shall use x for inputs and y for outputs)? Explain.

1. The identity $\mathbf{y} = \mathbf{x}$

This is obviously a signal processing system. If x is a signal, then y will necessarily be one. It can be easily implemented for both analog and digital signals by a wire and an assignment statement respectively.

2. The constant $\mathbf{y} = \mathbf{k}$ irrespective of x

This would usually be considered a signal processing system with no inputs and a single output. The problem is that the output has infinite energy, and is not really a physical signal. However, as in all such cases, we understand that the true meaning is that the output signal is constant over the observation time (and presumably zero for times in the far past and future), and thus has finite energy.

3. $\mathbf{y} = \pm\sqrt{\mathbf{x}}$

As stated y is not well defined since it has two different values, and is thus not a signal. However, we can consider $\pm\sqrt{x}$ to be a signal processing system with a single input and two outputs, one $y^{[1]} = +\sqrt{x}$ and the other $y^{[2]} = \pm\sqrt{x}$. The only question that remains is what happens if $x(t) < 0$ for some t. Then y would be imaginary, while true signals are always real-valued. So we must either require the input values to be positive, or specify that if $x(t) < 0$ then $y(t) = 0$ (or some other behavior), or state that we are allowing imaginary signals.

4. A device that inputs a pizza and outputs a list of its ingredients

Neither a pizza nor a list of ingredients is a signal. The list could easily be made into one, e.g. by taking it in ASCII form and sending it over a modem (although this signal would not be uniquely defined). However, I do not know of any way to send change a pizza into a signal. You might think of taking a picture and scanning it, but that would probably not leave enough information to enable finding the ingredients. If anyone comes up with a way of representing a pizza as a signal I would be glad to change the answer (and eat the pizza).

5. $\mathbf{y} = \sin(\frac{\mathbf{1}}{\mathbf{t}})$

This is a system with no inputs and one output (a generator). However, as discovered in exercise 2.1.1-11 the output signal is not defined at $t = 0$, nor is it 'well-behaved' in the vicinity of $t = 0$. If we do not accept the output as a signal, then we do not accept this as a system.

6. $\mathbf{y(t) = \int_{-\infty}^{t} x(t)}$

The *integrator* $\int_0^t x(t)$ is frequently used in DSP (see section 7.3) as is, in fact, a filter. The variant starting from $t = -\infty$ requires us to have been around before the big bang, which is definitely a problem. So we must restrict this system to signals of finite duration.

7. The Fourier transform

The FT is *not* a signal processing system. It does not input a signal and output a signal, rather it inputs the time domain *representation* of a signal and outputs the frequency domain representation of the same signal. Representations are completely different from signals. For example, we can not consider what a FT does to the frequency domain of a signal (i.e. think of $s(\omega)$ as input)!

8. A television

A television is a system that inputs a complex radio frequency signal that it receives at its input connector, and outputs a 2D signal (the picture on the screen). Even if we don't want to consider 2D signals, the output can be considered as a 1D signal composed of all the scan lines separated by special signals telling the TV to move the beam back to the left and down one line.

9. A D/A converter

This system inputs a *digital* signal and outputs an *analog* one. No where in our definition did we require both input and output signals to be either analog or digital. So this is a valid signal processing system.