1. Derive the convolution integral from first principles (as outlined in class) given by \( y(t) = \int_{-\infty}^{\infty} x(\tau)h(t - \tau) \, d\tau \), where \( h(t) \) is the impulse response of a LTI system, \( x(t) \) the input and \( y(t) \) the output.

2. For each of the systems described by the input output relationships below, determine which of the following properties apply to the system: Memoryless(M), causal(C), linear(L), time-invariant(TI), stable(S). Justify your answers.
   (a) \( y(t) = \sin(t + 1)x(t) \)
   (b) \( y[n] = x[2 - n] + 1 \)

3. Consider a continuous time system with the following input \( x(t) \) and impulse response \( h(t) \),

\[
x(t) = \begin{cases} 
1 & 0 < t < 2 \\
-1 & 2 < t < 4 \\
0 & \text{otherwise}
\end{cases}
\]

and \( h(t) = \exp(-2t)u(t) \)

   (a) Compute the output of the system \( y(t) = x(t) * h(t) \)
   (b) Is the system stable? Is the system causal?

4. A signal \( x(t) \) is periodic with period \( T = 10^{-3} \). The Fourier series coefficients for \( x(t) \) are given by

\[
a_k = \begin{cases} 
\frac{1}{2j} & k > 0 \\
0 & k = 0 \\
\frac{1}{2} & \text{otherwise}
\end{cases}
\]

Find the average power in the signal \( x(t) \), \( \frac{1}{T} \int_{0}^{T} |x(t)|^2 \). Hint: Use Parseval’s relationship!

5. Let \( x(t) = \exp(-at)u(t) \), where \( u(t) \) is the unit step function. Find the Fourier transform of the following signals.
   (a) \( x(t) \)
   (b) \( y(t) = x(t + 5) \)
   (c) \( z(t) = x(t) \sin(2\pi 40t) \)
6. Evaluate the Fourier transform of the damped sinusoidal wave \( g(t) = \exp(-t) \sin(2\pi f_c t) u(t) \), where \( u(t) \) is the unit step function.

7. Show that the overall system function \( H(s) \) for the feedback system in FIGURE 7 is given by
\[
H(s) = \frac{F(s)}{1 - F(s)G(s)}.
\]

8. A signal \( x(t) \) of finite energy is applied to a square-law device whose output is defined by \( y(t) = x^2(t) \). The spectrum of \( x(t) \) is limited to the frequency interval \(-W \leq f \leq W\). Hence show that the spectrum of \( y(t) \) is limited to \(-2W \leq f \leq 2W\).