1. Plot the time-domain waveforms of the following signals which are expressed in terms of the rectangular function \( \Pi(x) = \begin{cases} 
1, & -0.5 \leq x \leq 0.5 \\
0, & \text{otherwise} 
\end{cases} \) : (a) \( h(t) = \Pi \left( \frac{t}{2T} \right) \); (b) \( x(t) = \Pi \left( \frac{t}{2T} \right) - \Pi \left( \frac{t-2T}{2T} \right) \); (c) \( y(t) = \Pi(t) \ast \Pi(t) = \int_{-\infty}^{\infty} \Pi(t-\tau) \cdot \Pi(\tau) \, d\tau \); (15%)

2. For a sinusoidal message signal \( m(t) = 2 \cdot \cos(2\pi f_0 \cdot t) \) with \( f_0 = 10^3 \) Hz, (a) what is the period of the message signal; (b) what is the amplitude of the message signal; (c) what is the type of modulation when the transmitted signal is given by \( x(t) = m(t) \cdot \cos(2\pi f_c \cdot t) \) \( (f_c = 10^4 \) Hz); (d) what is the type of modulation when the transmitted signal is given by \( x(t) = (4 + m(t)) \cdot \cos(2\pi f_c \cdot t) \); (e) what is the type of modulation when the transmitted signal is given by \( x(t) = 2 \cdot \cos \left( 2\pi f_c t + 2\pi f_d \cdot \int_{-\infty}^{t} m(\tau) \, d\tau \right) \) \( (f_d = 10^3 \) Hz). (25%)

3. Find the correctness of the following statements or equations by answering right or wrong: (for example: \( 2 > 1 \), the answer is wrong) (40%)

(a) \( 2 \cos(2\pi f_c \cdot t) \cdot \cos(2\pi f_0 \cdot t) = \cos(2\pi (f_c + f_0) t) + \cos(2\pi (f_c - f_0) t) \);
(b) the Gaussian probability density function with mean \( m_n \neq 0 \) and variance \( \sigma_n^2 \) is given by \( f_{\mathcal{N}}(n_0) = \frac{1}{\sqrt{2\pi \cdot \sigma_n^2}} \exp \left( -\frac{n_0^2}{2\sigma_n^2} \right) \);
(c) \( \frac{1}{\sqrt{2\pi \cdot \sigma_n^2}} \int_{0}^{\infty} \exp \left( -\frac{n_0^2}{2\sigma_n^2} \right) \, dn_0 = 0.5 \);
(d) \( \int_{0}^{\infty} \exp \left( -\frac{n_0^2}{2\sigma_n^2} \right) \, dn_0 > \int_{-\infty}^{\infty} \exp \left( -\frac{n_0^2}{2\sigma_n^2} \right) \, dn_0 \);
(e) \( \text{Re} \left( (s_i(t) + j \cdot s_Q(t)) \cdot e^{j2\pi f_c} \right) = s_i(t) \cdot \cos(2\pi f_c \cdot t) + s_Q(t) \cdot \sin(2\pi f_c \cdot t) \);
(f) the maximum data transmission rate (bps) of the Wi-Fi (802.11a) is higher than that of the USB 2.0 (Universal Serial Bus);
(g) for a random variable $X$ with a probability density function $f_x(x)$, the mean of $X$ is given by $E[X] = \int_{-\infty}^{\infty} x \cdot f_x(x) \, dx$;

(h) for two signals $x_1(t) = \cos(2\pi \cdot 1000 \cdot t)$ and $x_2(t) = \cos(2\pi \cdot 21000 \cdot t)$, we have $x_1(n \cdot T_s) = x_2(n \cdot T_s)$ when $T_s = \frac{1}{10000}$;

(i) Mbps is the acronym (縮寫) of megabits per second;

(j) AWGN is the acronym of asynchronous window general network;

(Hint: $e^{j2\pi f_c t} = \cos(2\pi f_c t) + j \cdot \sin(2\pi f_c t)$, $\text{Re}\{e^{j2\pi f_c t}\} = \cos(2\pi f_c t)$)

4. Find the wrong statement (only one) in the following statements: (4%)
   (a) 3G mobile communication system use CDMA technology;
   (b) DVB-T digital video broadcast system use OFDM technology;
   (c) 3G mobile communication system use Turbo Convolutional coding;
   (d) AGC is the acronym of Automatic Gain Control;
   (e) Bluetooth use the OFDM technology.

5. Find the wrong equation (only one) in the following equations: (4%)
   (a) $\text{var}(x) = E[X^2] - (E[X])^2$ (the variance of a random variable $X$);
   (b) $X(f) = \mathcal{F}\{x(t)\} = \int_{-\infty}^{\infty} x(t) \cdot e^{-j2\pi f t} \, dt$ (the Fourier transform);
   (c) $X(\omega) = DFT\{x[n]\} = \sum_{n=-\infty}^{\infty} x[n] \cdot e^{j2\pi \omega n}$ (the discrete-time Fourier transform);
   (d) $y(t) = h(t) * x(t) = \int_{-\infty}^{\infty} h(t - \tau) \cdot x(\tau) \, d\tau = x(t) * h(t)$ (Linear convolution);
   (e) $Y(f) = \mathcal{F}\{y(t) = h(t) * x(t)\} = \mathcal{F}\{x(t)\} * \mathcal{F}\{h(t)\}$.

6. Explain the following terms: (12%)
   (a) Code-division multiplexing;
   (b) OFDMA;
   (c) dBm.