1.

```
>> function y = square(frequency, duration, sampling_rate)
    t = 0:1/sampling_rate:duration-1/sampling_rate;
    y = sign(sin(2 * pi * frequency * t));
end
function y = triangle(frequency, duration, sampling_rate)
    t = 0:1/sampling_rate:duration-1/sampling_rate;
    y = 2 * abs(2 * (t * frequency - floor(t * frequency + 0.5))) - 1;
end
function y = gaussian_noise(mean_val, std_dev, num_samples)
    y = mean_val + std_dev * randn(1, num_samples);
end
>>
```

```
>> ds = 1; % Duration
fs = 1000; % Sampling frequency
freq = 5; % Frequency
sq_wave = square(freq, ds, fs);
tri_wave = triangle(freq, ds, fs);
gauss_noise = gaussian_noise(ds, fs);

figure;
subplot(3,1,1);
histogram(sq_wave);
title(' Square Wave Histogram');

subplot(3,1,2);
histogram(tri_wave);
title(‘ Triangle Wave Histogram ');

subplot(3,1,3);
histogram(gauss_noise);
title('Gaussian Noise Histogram');
```

```
>> N = length(sq_wave);

figure;
subplot(3,1,1);
histogram(sq_wave, 'Normalization', 'probability');
title('Normalized Histogram of Square Wave');
xlabel('Value'); ylabel('Frequency / N');

subplot(3,1,2);
histogram(tri_wave, 'Normalization', 'probability');
title('Normalized Histogram of Triangle Wave');
xlabel('Value'); ylabel('Frequency / N');

subplot(3,1,3);
histogram(gauss_noise, 'Normalization', 'probability');
title('Normalized Histogram of Gaussian Noise');
xlabel('Value'); ylabel('Frequency / N');
```

Square
Mean = 0 Standard Deviation = 1

Triangle
Mean = 0 Standard Deviation = 0.578

Gauss Noise
Mean = 0 Standard Deviation = 1

Loren
Grey

Problem Set # 2

1. ADC

a) $\Delta V = \frac{V_{max} - V_{min}}{N} = \frac{2.55 - 0}{255 + 1} = \frac{2.55}{256} = 0.00996$

zero

$\boxed{\Delta V \approx 0.01 V}$ or 10mV

b) $\Delta V = \frac{4.095 - 0}{4095 + 1} = \frac{4.095}{4096} \approx 0.0009998$

$\boxed{\Delta V \approx 0.001 V}$ or 1mV

c) $\Delta V < 1mV$ $[0,12]V$

$\frac{12V}{2^N} < 1mV \to 0.001V \cdot 2^N \to \frac{12}{0.001} = 12000 < 2^N$

$\frac{12V}{0.001V} < \frac{0.001V}{0.001V} \cdot 2^N$ $\quad \log_2 12000 < N$

$= 13.56$

$2^{14} = \boxed{16,389 \text{ levels}}$ $\quad \boxed{N \approx 14}$

d) 2.52 V $[0,5]V$ 2048 levels

$\Delta V = \frac{5v}{2048} = 0.0024414$

$\text{Count} = \frac{2.52}{.0024414} = 1032.1946$

$= \boxed{1032 \text{ counts}}$

DAC

a) 256 counts $[0,5]V$ $\Delta V = 9.8mV$

signal amp = count $\cdot \Delta V$

$= 256 \cdot 0.0098v$

$= 2.5088v$

$\boxed{\text{Signal Amp} \approx 2.51V}$ $\quad 0 < 2.51 < 5$

b) 2048 counts $[0,5]V$ max count = 4095

signal amp $= \frac{2048}{4095} \times 5V$

$= 0.5 \times 5$

$\boxed{\text{Sig Amp} = 2.5V}$ $\quad 0 < 2.5 < 5$

c) 128 counts max count = 511 0.25V

$V_{max} = \frac{\text{analog} \times \text{max counts}}{\text{counts}} = \frac{0.25v \cdot 5.11}{128} = 0.997V \approx \boxed{V_{max} \approx 1.0V}$

2.

a) sr = 500 kHz sf = 50kHz

Analog sig freq = Digital sig freq

$\boxed{\text{digital sf} = 50kHz}$

b) $f_{Nyquist} = \frac{f_s}{2}$

$= \frac{500}{2} = 250 kHz = f_{Nyquist}$

digital signal frequency $= \boxed{0 Hz}$

c) $f_{dig} = f_a - f_s = 750 - 500$

$= \boxed{250 kHz}$

d) $f_a = f_{analog} - f_s N \quad N = \frac{f_{analog}}{f_s} = \frac{1000}{5} = 2$

$= 1000 - 2(500) = 1000 - 1000$

$= \boxed{0 Hz}$

3. $V_{in} = 3.3V$ $f = 25MHz$ $w = 2\pi \cdot 25 \times 10^6$

$\left(\frac{V_{out}}{V_{in}}\right)^2 \left(\frac{1}{\sqrt{1+(wRC)^2}}\right)^2$

$\left(\frac{.33}{3.3}\right)^2 = \frac{1}{1+(wRC)^2} = \left(\frac{1}{10}\right)^2 = 0.01$

$\sqrt{(wRC)^2} = \frac{1}{.01} - 1 = \sqrt{99}$

$wRC = \sqrt{99} \rightarrow \frac{RC}{R} = \frac{\sqrt{99}}{w} \cdot \frac{1}{R} \rightarrow C = \frac{\sqrt{99}}{wR}$

$C = \frac{\sqrt{99}}{2\pi \cdot 25 \times 10^6}$

$\boxed{C = 6.334 \times 10^{-8}}$

4. $V_{in} = 3.3V$ $f = 10MHz$ $R = 10k\Omega$

$\frac{V_{out}}{V_{in}} = \frac{0.33}{0.3} = 0.1 = \frac{(wRC)^2}{\sqrt{1+(wRC)^2}}$

$(wRC)^2 = 0.01(1 + (wRC)$

$(1 - 0.01)(wRC)^2 = 0.01$

$\frac{0.99(wRC)^2}{0.99} = \frac{0.01}{0.99}$

$\sqrt{(wRC)^2} = \sqrt{0.0101}$

$wRC = 0.1$

$C = \frac{0.1}{wR} = \frac{0.1}{(2\pi \times 10 \times 10^6)(10{,}000)}$

$\boxed{C = 1.59 \times 10^{-3} F}$

5. Bonus

a) $\tan\theta = {}^{-1}(wRC)$

$\theta = \tan^{-1}(wRC)$

$wRC = 2\pi \cdot 25 \times 10^6$

$= \tan^{-1}(2\pi \cdot 25 \times 10^6)$

$\boxed{\theta = -84.3 \text{ or } -1.47 \text{ rad}}$

b) $\theta = \tan^{-1}(wRC)$

$= \tan^{-1}(2\pi \cdot 10 \cdot 10^6)$

$\boxed{\theta = 89.9° \text{ or } 1.57 \text{ rad}}$