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$$S/N \text{ power at output} = \frac{\text{Source power at O/P } (V_n)}{\text{Noise power } (P_n)}$$

$$\text{Source power at output} = 3981.07 \times 1.67 \times 10^{-16}$$
$$= 6.6 \times 10^{-13}$$

Communication System

Analog Communication

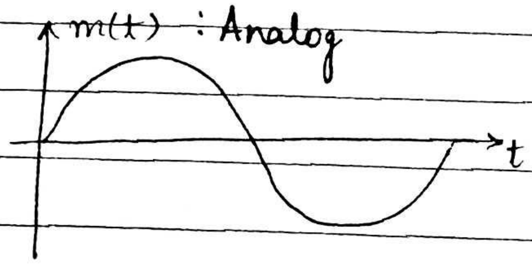
- **Analog Modulation**

Analog signal — m(t) : Analog
— c(t) : Analog

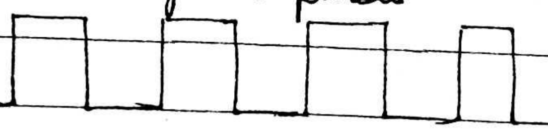
Amplitude Modulation
Angle Modulation — frequency
— phase

- **Pulse Analog Modulation** : It is based on sampling process.
Continuous in amplitude and discrete in time.

m(t) : Analog



c(t) : Rectangular pulses



Pulse Amplitude Modulation (PAM)
Pulse Time Modulation (PTM) — PWM (Width)
— PPM (Position)

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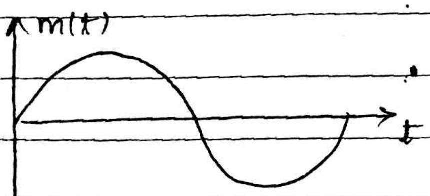
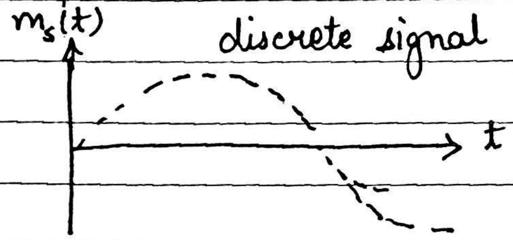
• Pulse Code Modulation (PCM)



$f_s \geq 2f_m$

i) Sampler
ii) Quantizer
iii) Encoder



discrete signal

Continuous in amplitude and discrete in time

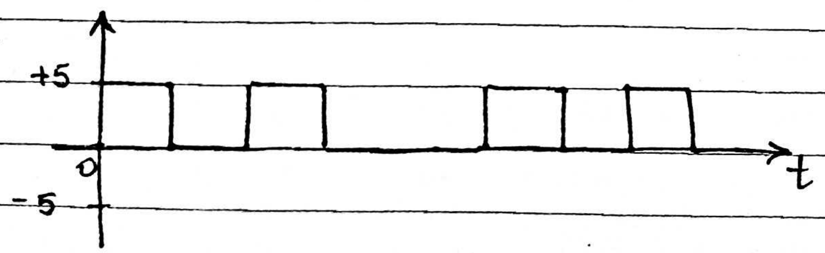
Digital Communication

ASK : Amplitude
FSK : Frequency
PSK — QPSK
(Phase) — (Q/4) PSK

Discrete in time and amplitude.
SK: Shift Key

10100101

Unipolar : RZ (Return to zero)
Bipolar : NRZ



After sampling the signal is discrete in time.

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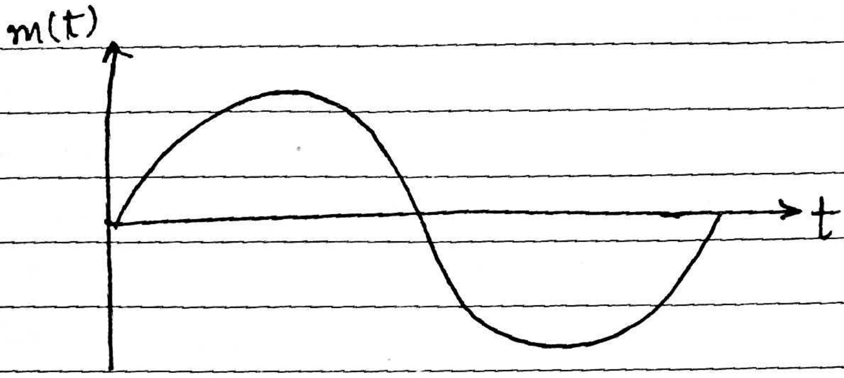
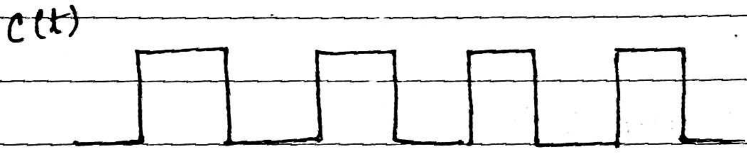
Pulse Analog Modulation





It is a modulation process in which we change some parameters of ~~analog~~ carrier pulse according to m(t).

It is classified into two categories:

i) Pulse Amplitude Modulation (PAM)
ii) Pulse Timing Modulation (PTM)

- Pulse width modulation PWM / PLM / PDM
- Pulse Position Modulation (PPM)

PAM – In which we change amp. of each pulse according to amp. of m(t).

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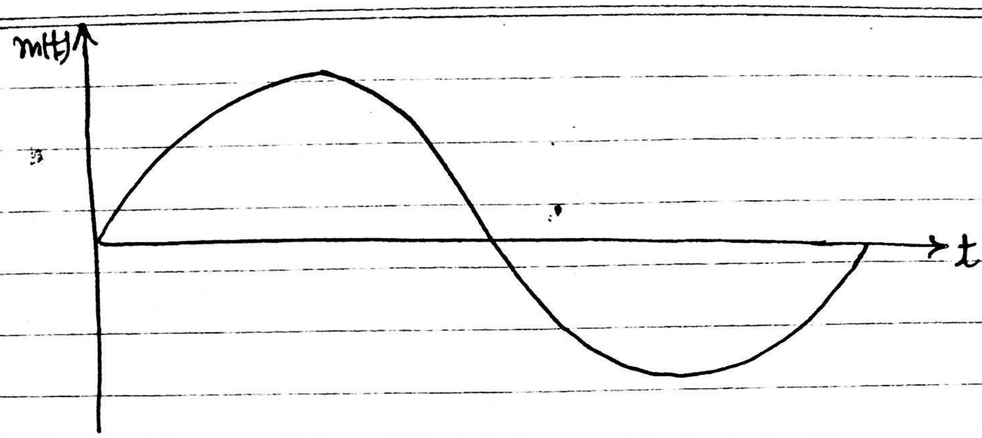
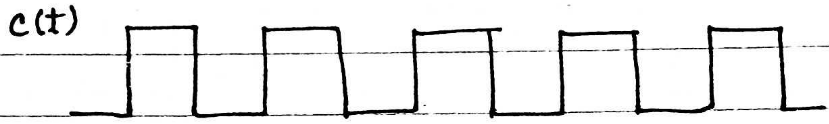
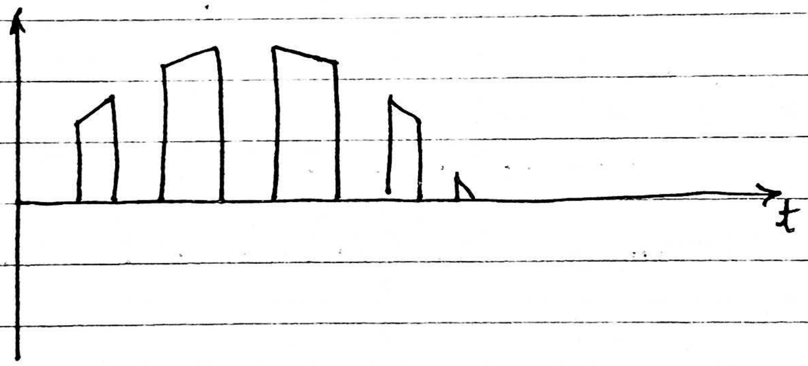
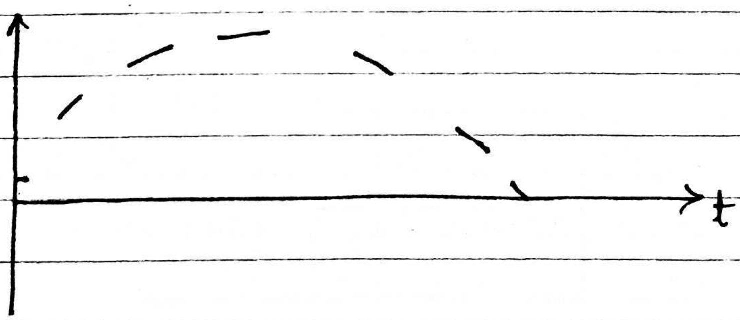


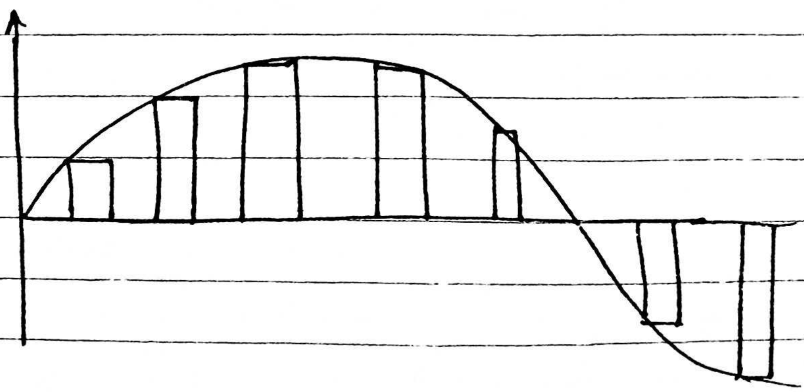


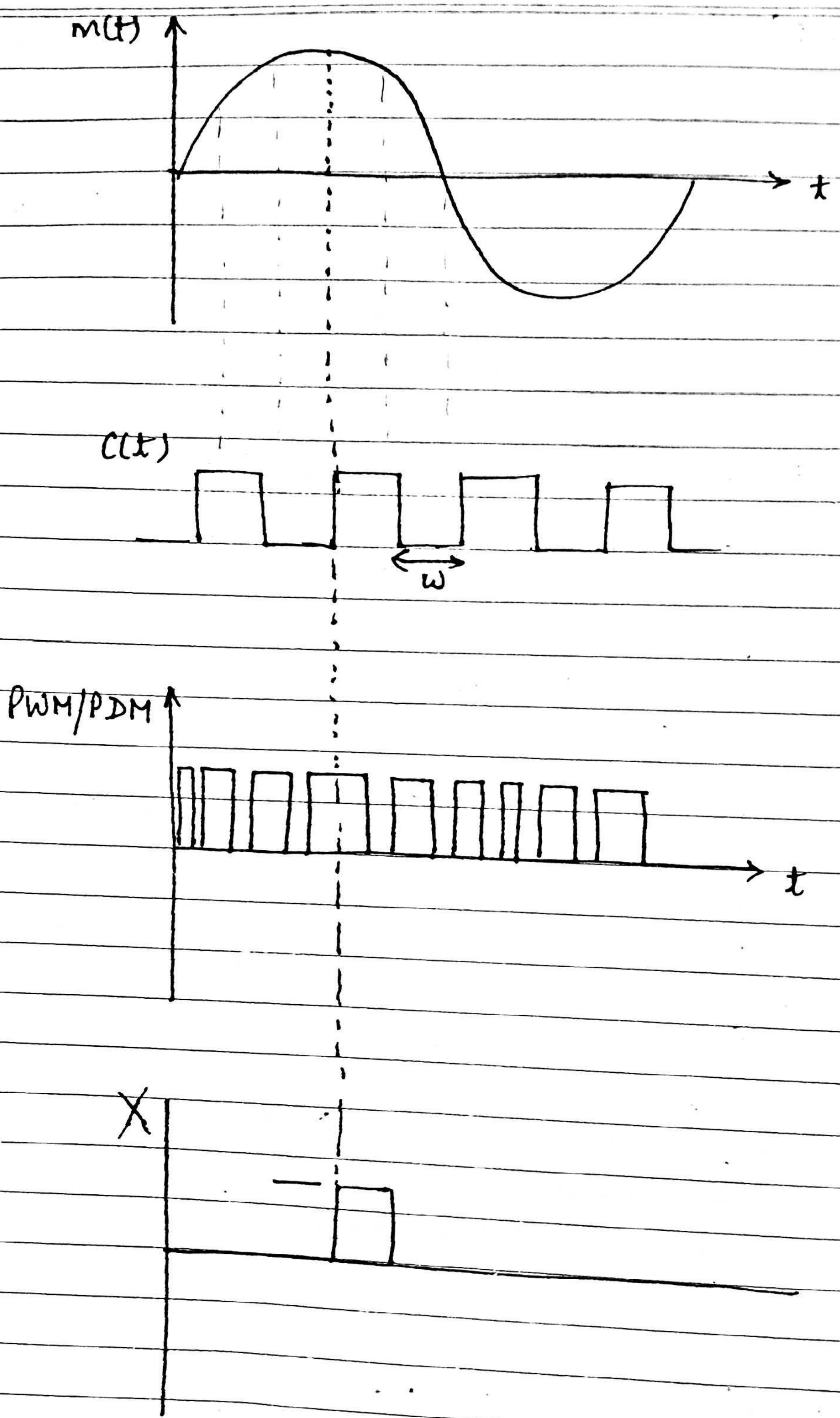


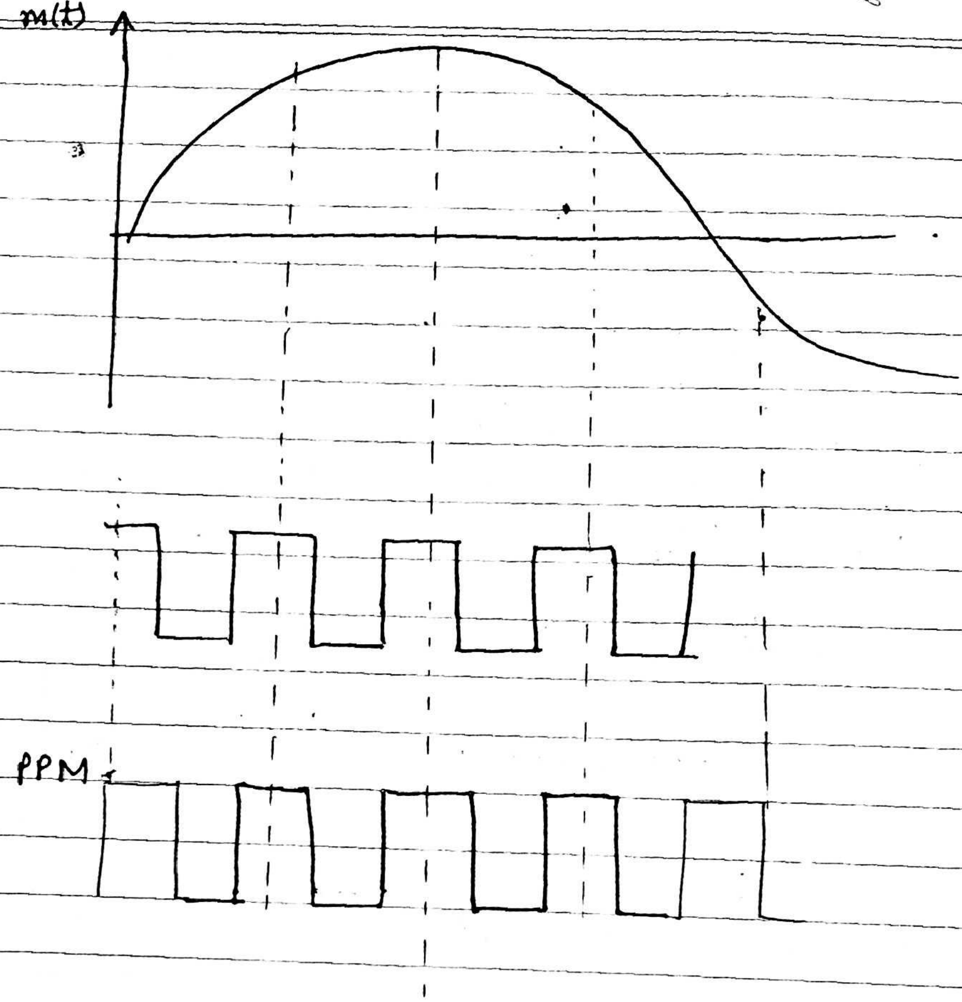
On CRO.



PAM
(Natural)




m(t)
t
c(t)
ω
PWM/PDM
t
X



Sampling Theorem

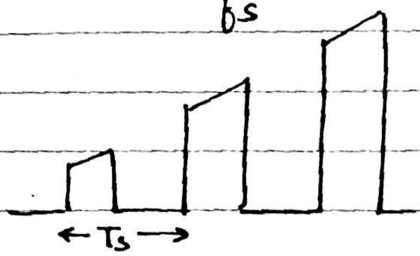
According to sampling theorem a continuous signal can be completely represented in its samples and reconstructed back iff $f_s \geq 2f_m$.

f_s = sampling frequency.
f_m = highest frequency component of $m(t)$.
$2f_m$ = Nyquist Rate

Sampling frequency $\geq$ Nyquist Rate.

Sampling Period (T_s) : The time period between two samples.

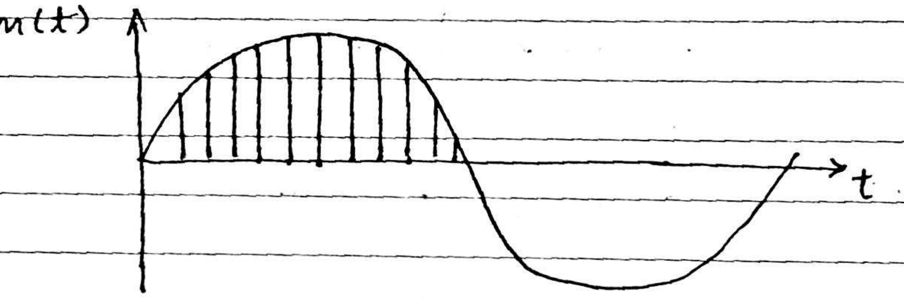
$$T_s = \frac{1}{f_s}$$



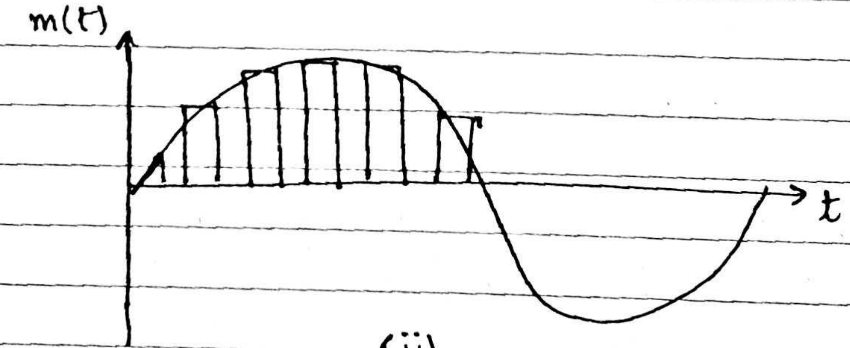
Sampling is of two types:

i) Natural sampling

ii) Flat top sampling.



(i)



(ii)

↓ Analog signal $V_m \cos 2\pi f_m t$

Sampler (S/H) ckt $T_s = 1/f_s$

↓ Discrete time signal $V_m \cos 2\pi f_d \times n$

f_d = frequency of discrete time signal $= \dfrac{f_m}{f_s}$

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Q. Analog signal $5\cos 400\pi t$ is converted in its samples with sampling frequency 600 Hz. Determine discrete time signals.

Soln: $f_d = \frac{f_m}{f_s}$

$$V_m \cos 2\pi f_m t = 5\cos 400\pi t.$$

$$\therefore f_m = 200.$$

$$f_d = \frac{200}{600} = \frac{1}{3}$$

$$\therefore V_m \cos 2\pi f_d \times n = 5\cos 2\pi \times \frac{1}{3} \times n$$

Q.1 A continuous time signal given by $s(t) = 5\cos 200\pi t$.
Find:
a) Minimum sampling rate
b) If sampling frequency is 400 Hz then determine discrete time signal after the sampling.
c) If sampling frequency $f_s = 150$ Hz then determine discrete time signal after the sampling.

Q.2. Determine Nyquist rate for the signal $s(t) = 5\cos 50\pi t + 20\sin 300\pi t - 10\cos 100\pi t$.

Q.3. Find out Nyquist interval for the signal:

$$x(t) = \frac{1}{2\pi} \cos(4000\pi t) \cdot \cos(1000\pi t)$$

Q.4. A digital communication link carries binary coded data represented by samples of input signal $x(t) = 3\cos 600\pi t + 2\cos 1800\pi t$.

i) Determine Nyquist rate

ii) What is resolution of quantisation if samples are quantised ~~into~~ to 1024 different voltage levels.

Soln 4ii) Resolution of quantisation $= \frac{X_{max} - X_{min}}{M-1}$

M = Level of quantisation $= 2^n$

n = no. of bit

If $n = 2$, $M = 2^2 = 4$ = 4 level quantisation

$1024 = 2^n$

$\therefore n = 10$

$M = 2^n$

$X_{max} = 3\times 1 + 2\times 1 = 5$

$X_{min} = 3\times(-1) + 2\times(-1) = -5$

Resolution $= \frac{5+5}{1024-1}$

$= \frac{10}{1023}$

i) ~~Nqo~~ Nyquist Rate $= 2f_m$

$x(t) = 3\cos 600\pi t + 2\cos 1800\pi t$

$= 3\cos \omega_1 t + 2\cos \omega_2 t$

$\omega_1 = 600\pi \Rightarrow f_1 = \frac{600\pi}{2\pi} = 300\text{ Hz}$

$\omega_2 = 1800\pi \Rightarrow f_2 = \frac{1800\pi}{2\pi} = 900\text{ Hz}$

$\therefore 2f_m = 2 \times 900\text{ Hz}$
$= \underline{\underline{1800\text{ Hz}}}$

Soln 1- $S(t) = 5\cos 200\pi t$

a) Minimum sampling rate = Nyquist rate
$= 2 \times 100$
$= \underline{\underline{200\text{ Hz}}}$

b) $f_s = 400\text{ Hz}$
$f_m = 100\text{ Hz}$
$f_d = \frac{f_m}{f_s} = \frac{100}{400} = \frac{1}{4}$

$\therefore$ Discrete time signal $= V_m \cos 2\pi f_d \times n$
$= 5\cos \frac{\pi n}{2}$

c) $f_d = \frac{f_m}{f_s} = \frac{100}{150} = \frac{2}{3}$

Discrete time signal $= V_m \cos 2\pi f_d \times n$
$= 5\cos \frac{4\pi}{3} n$

Soln. 2. $S(t) = 5\cos 50\pi t + 20\sin 300\pi t - 10\cos 100\pi t$
$= 5\cos \omega_1 t + 20 \sin \cancel{300}\,\omega_2 t - 10\cos \omega_3 t$

$\omega_1 = 50\pi \Rightarrow f_1 = \frac{50\pi}{2\pi} = 25\text{ Hz}$