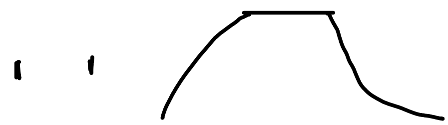
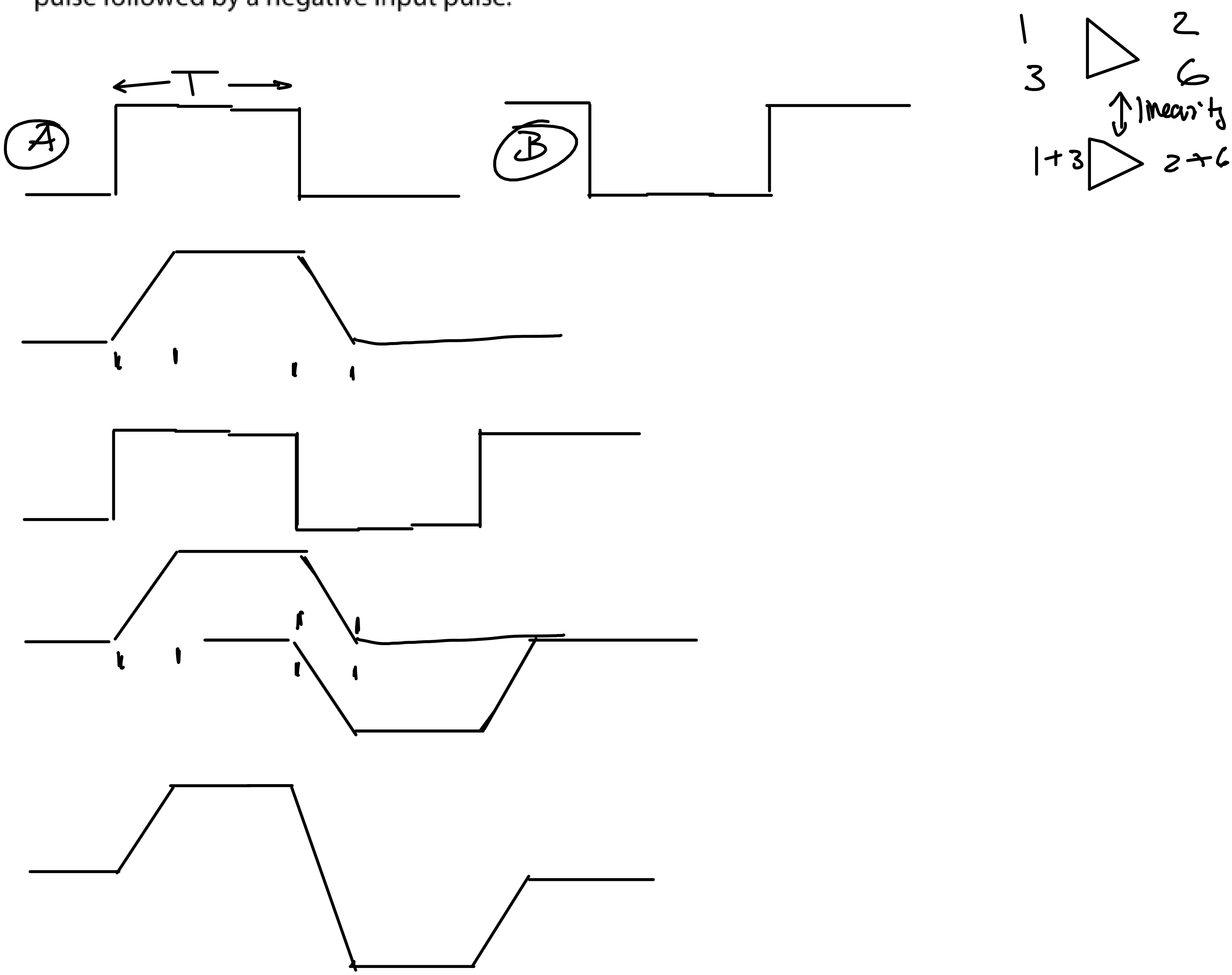
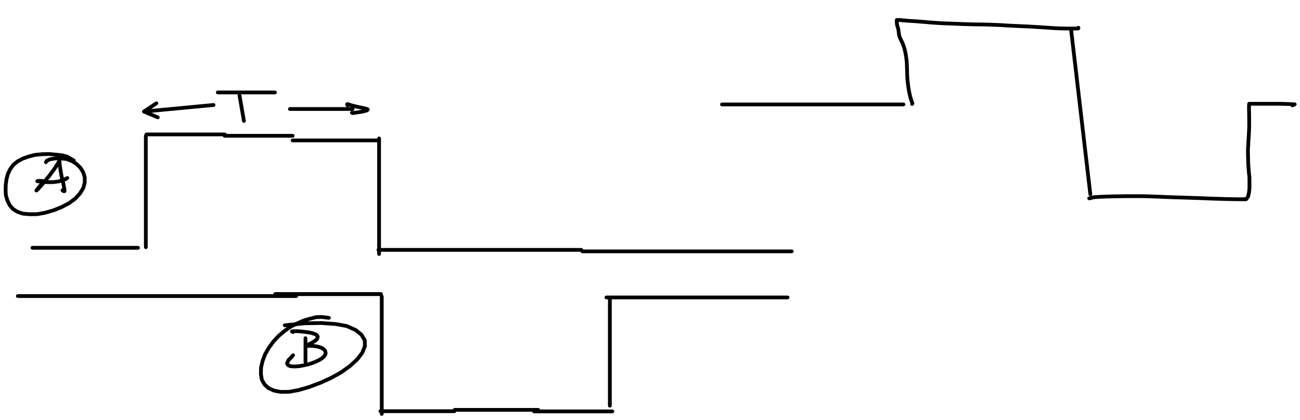
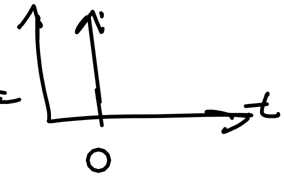
Exercise 1: Draw a square pulse of duration T. Draw the pulse after it has passed through a linear low-pass channel that results in rise and fall times of $T/3$. Draw the output for an input pulse of the opposite polarity. Use the principle of superposition to draw the output of the channel for a positive input pulse followed by a negative input pulse.

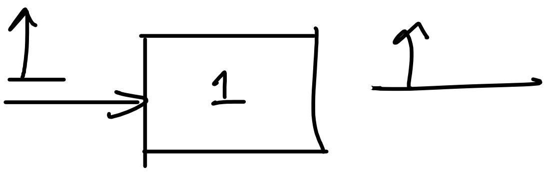




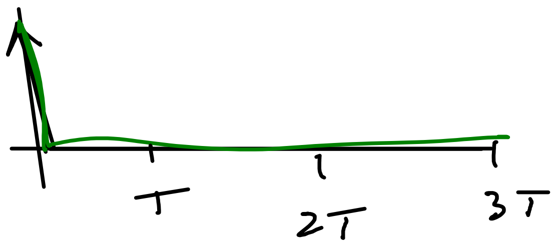


Exercise 2: What is the impulse response of a channel that does not alter its input? Does this impulse response meet the Nyquist condition? Will it result in ISI?

$\delta(t) =$ 

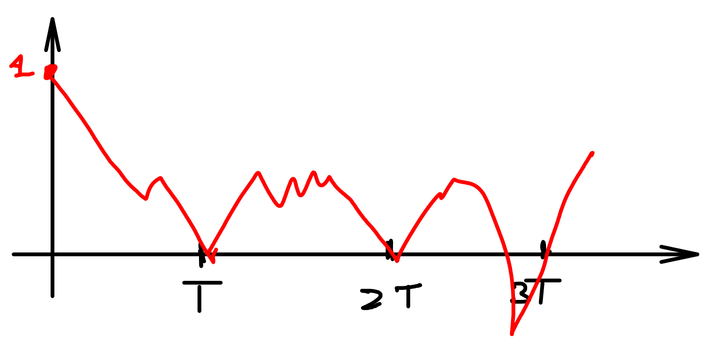


$h(t) = \delta(t)$



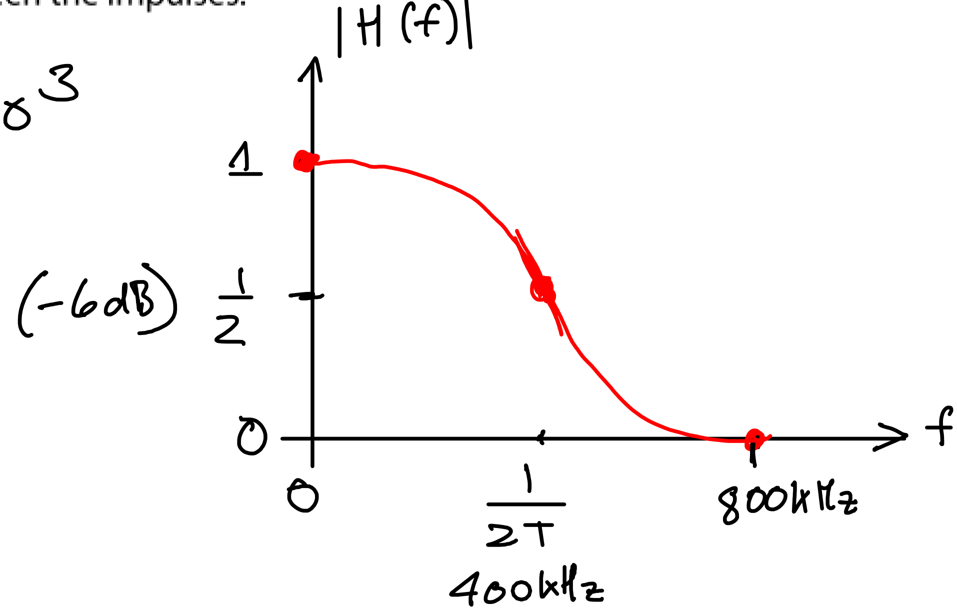
No ISI.

Exercise 3: Draw the impulse response of a channel that meets the Nyquist condition but is composed of straight lines.

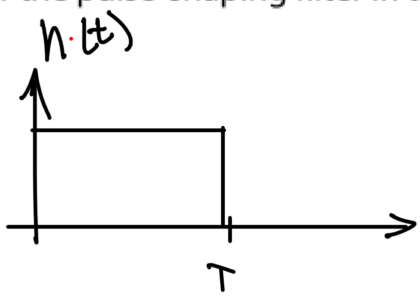


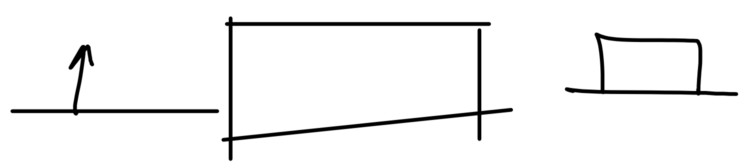
Exercise 4: Draw the magnitude of a raised-cosine transfer function that would allow transmission of impulses at a rate of 800 kHz with no interference between the impulses.

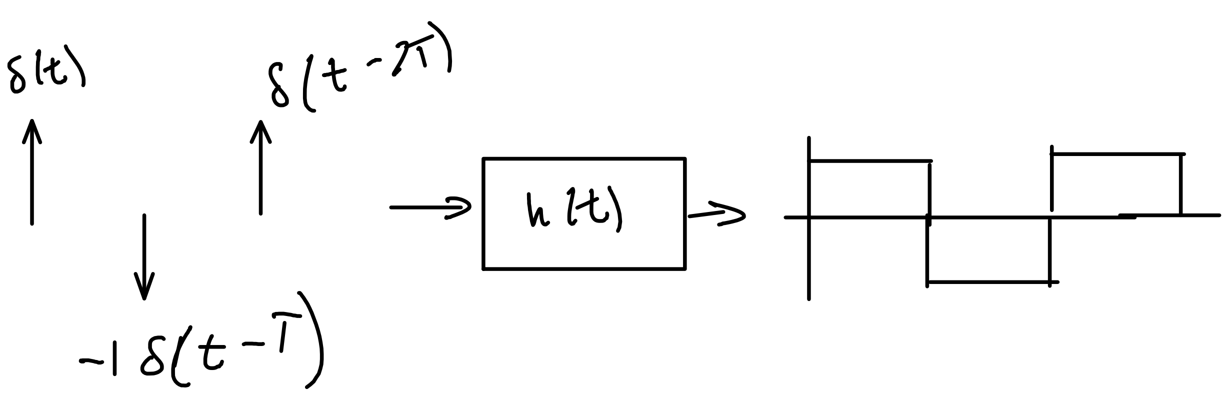
$$\frac{1}{T} = 800 \times 10^3$$



Exercise 5: Draw the impulse response of a filter than converts input impulses to pulses of duration T? Draw the signal after the pulse-shaping filter in the diagram above.







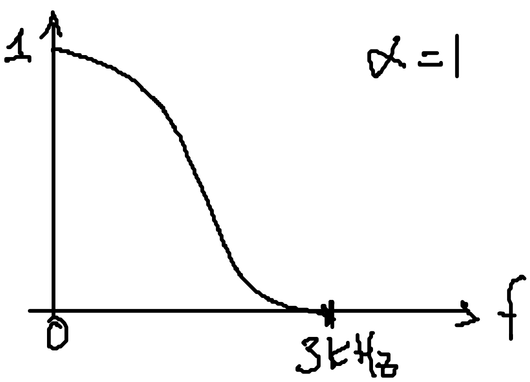
Exercise 6: A channel has a 3 kHz bandwidth and meets the Nyquist non-ISI conditions with $\alpha = 1$. How many levels are required to transmit 24 kb/s over this channel using multi-level signalling?

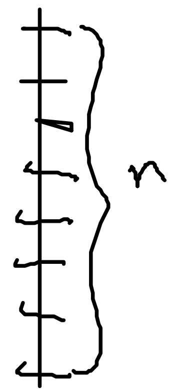
$$\alpha = 2BT - 1$$

$$1 = 2 \cdot 3k \cdot \frac{1}{f_s} - 1$$

$$\frac{2}{2} = \frac{3\,kHz}{f_s}$$

$$f_s = 3\,kHz$$





$$f_b = 24\ kb/s,$$

$$f_{symbol} = 3\ kHz$$

4 → 2 bits

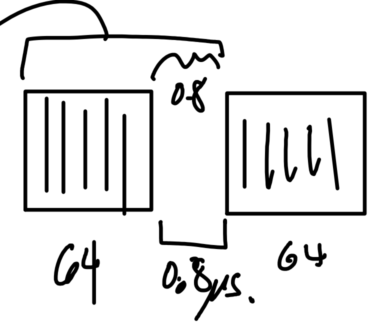
2 → 1 bit

$$n = 2^b$$

$$\frac{f_{bit}}{f_{symbol}} = \frac{24}{3} = 8\ \text{bits/symbol}$$

$\therefore$ need $2^8 = 256$ levels.

Exercise 7: The 802.11g WLAN standard uses OFDM with a sampling rate of 20 MHz, with $N = 64$ and guard interval of $0.8\mu s$. What is the total duration of each OFDM block, including the guard interval? How long is the guard time? in samples



64

20MHz.

$\frac{1}{20\times10^6} = 50ns.$

$64 \times 50 \times 10^{-9}$

$= 3.2\mu s$

total $= 4\mu s$

$T_g = 0.8\mu s$

$N_g = \frac{0.8 \times 10^{-4}}{50 \times 10^{-9}} \approx 16$ samples.

Exercise 8: What is capacity of a binary channel with a BER of $\frac{1}{8}$ (assuming the same BER for 0's and 1's)? BSC

$\log_2 \frac{1}{8} = \log_2 2^{-3} = -3$

fix this

$$C = 1 + (p \log_2 p + (1-p)\log_2(1-p))$$

$p = \frac{1}{8}$

$$C = 1 + \left(\frac{1}{8}\log_2\frac{1}{8} + \left(1-\frac{1}{8}\right)\log_2\left(1-\frac{1}{8}\right)\right)$$

$$= 1 + \left(\frac{1}{8}(-3) + \frac{7}{8}\log_2\left(\frac{7}{8}\right)\right)$$

$$= 1 + \left(\frac{-3}{8} + \frac{7}{8}(-0.2)\right) = 0.46 \text{ bits/channel use}$$

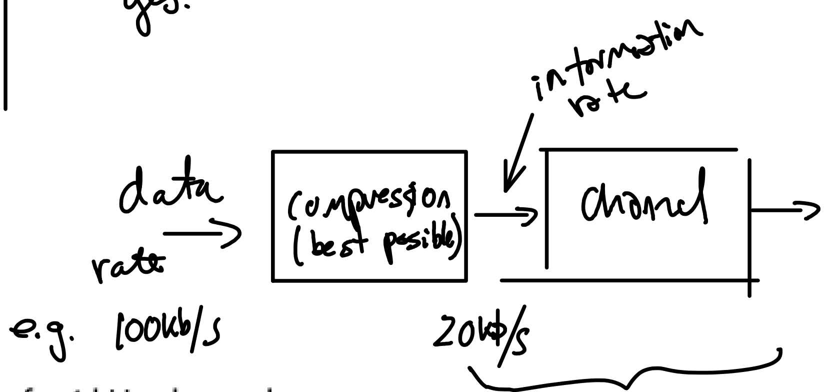
DEG W-VIEW

$$1+\left(\frac{1}{8}\log_2\left(\frac{1}{8}\right)+\frac{7}{8}\text{lo}\right.$$

N1 0.45643556

Exercise 9: Can we use compression to transmit information faster than the (Shannon) capacity of a channel? To transmit data faster than capacity? Explain.

	information rate	data (bits) rate
transmit faster than capacity?	no	yes.



Exercise 10: What is the channel capacity of a 4 kHz channel with an SNR of 30dB?

$$C = B\log_2\left(1+\frac{S}{N}\right)$$

$$= 4000\log_2\left(1+10^{\frac{30}{10}}\right)$$

$$\approx 40\text{kb/s}$$

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$4E3\times\log_2(1+1000)$

N1 39'868.90504

Exercise 11: What do the Nyquist no-ISI criteria and the Shannon Capacity Theorem limit? What channel parameters determine these limits?

	Nyquist No-ISI	Shannon
what does it limit	symbol rate	information rate
what does it depend on?	bandwidth (& symmetry)	depends on channel < BSC – P; AWGN – B, $\frac{S}{N}$

Nyquist <
- sampling $f_s > 2 \times B$ — f_s = sampling rate
- ISI $f_s < 2 \times B$ — f_s = symbol rate