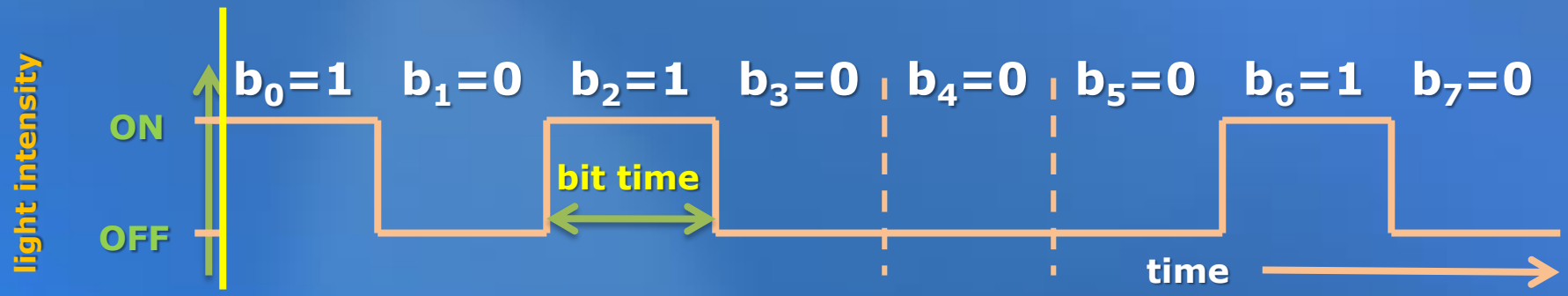
Continuous vs Discrete Time Waveforms

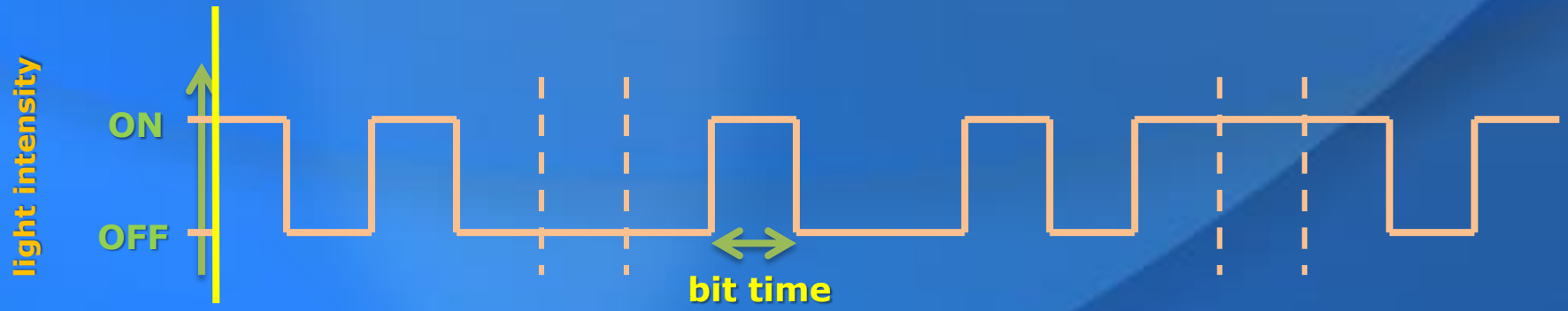
Recap

Representing Bit Sequences as Waveforms

- A bit sequence can be encoded by changing the value of the physical variable over time.

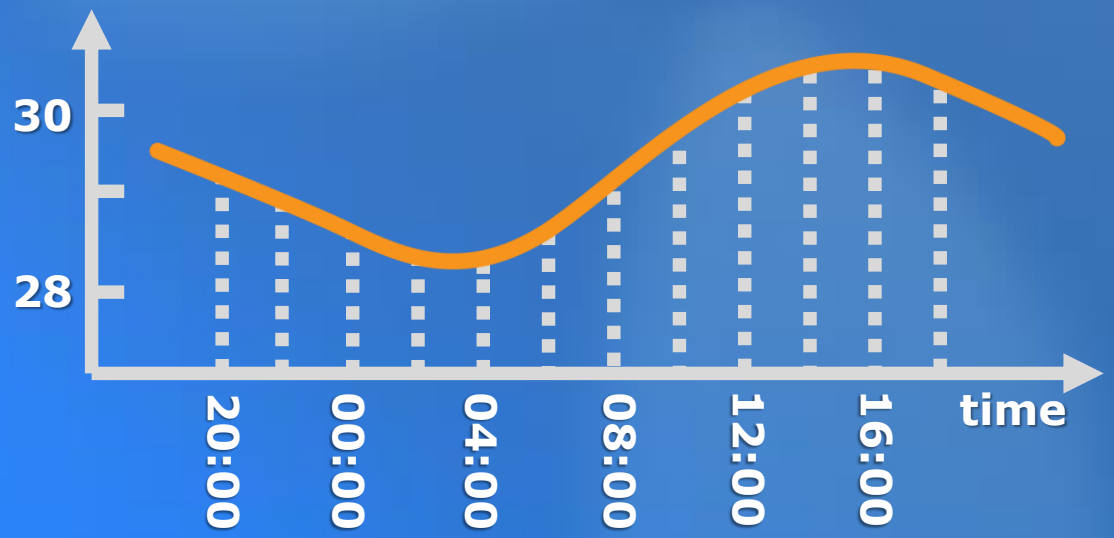


- Each bit is encoded by holding the state constant over a length of time, known as the bit time.
- The shorter the bit time, the faster we can transmit information (bits)

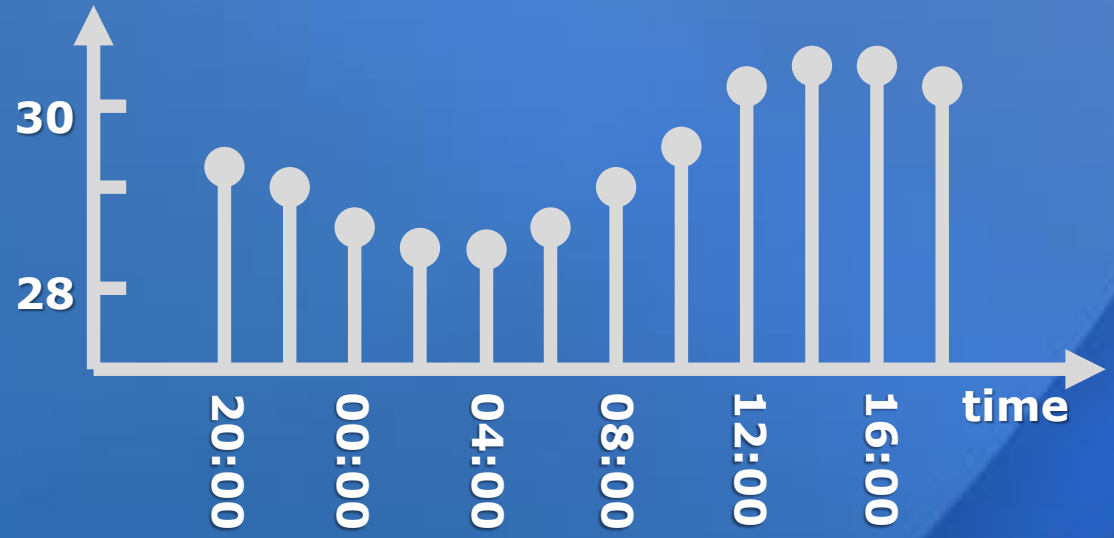


Continuous and Discrete Time Signals

Air Temperature in Clear Water Bay



Temperature Records from HK Observatory



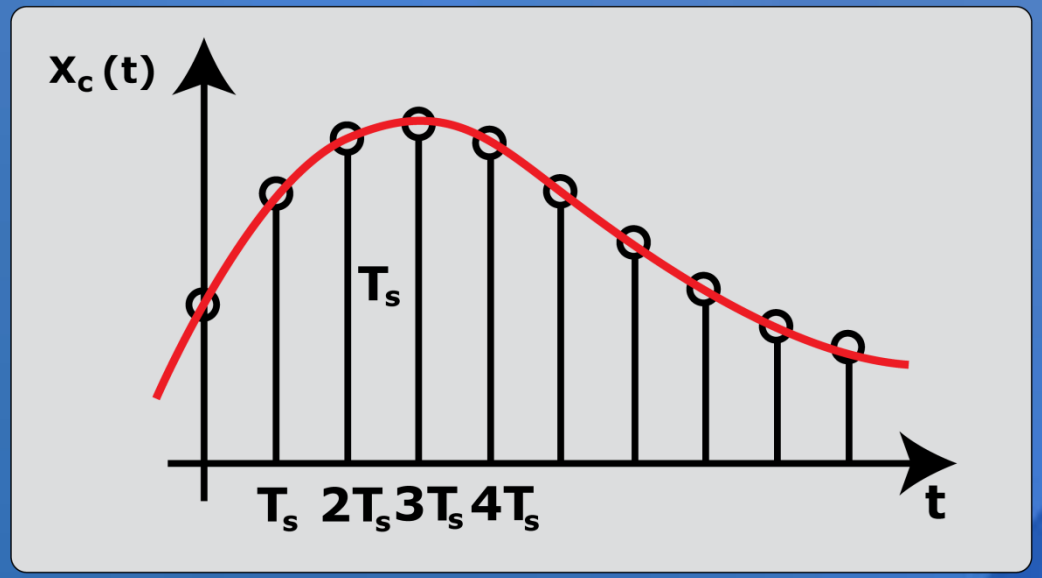
A Continuous Time (CT) signal has a known value for all points in a time interval.

A Discrete Time (DT) signal has a known value only at a discrete (discontinuous) set of time points.

Sampling: Continuous to Discrete

- Obtain discrete time waveform by sampling a continuous time waveform $x_c(t)$ at regular intervals in time.

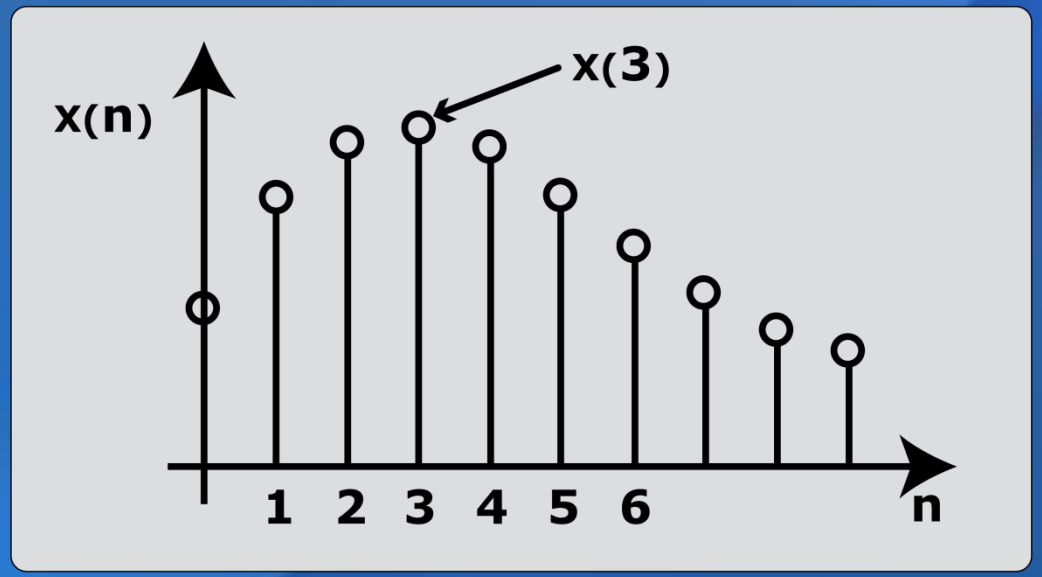
  T_s = sample period



- Index each sample by an integer sample number, n.
- The nth sample corresponds to the waveform at time

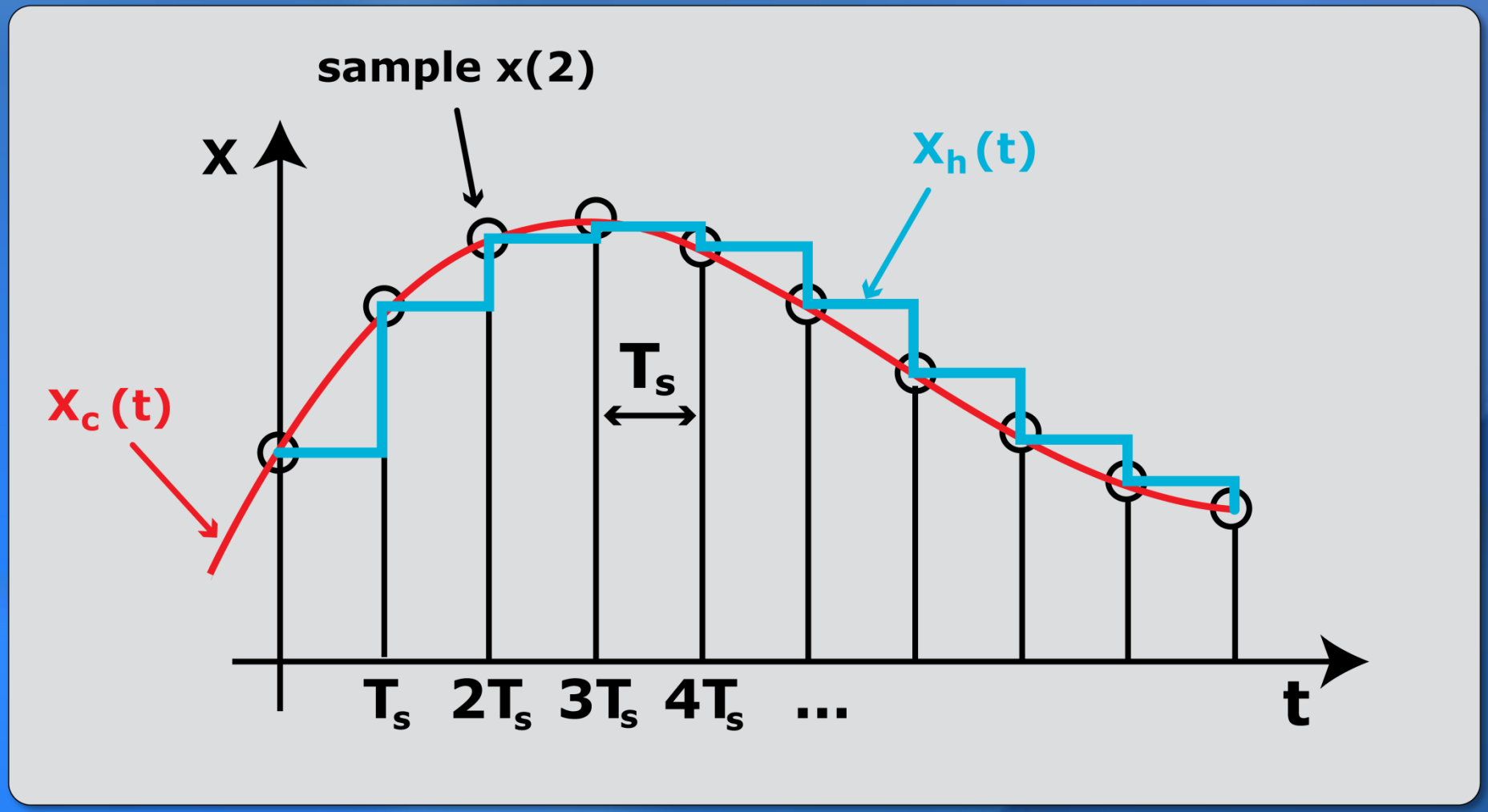
  $t = nT_s$

  Example: $x(n) = x_c(nT_s)$



Discrete to Continuous Time

Given sample x(n), we can obtain a continuous time waveform $x_h(t)$ by holding the waveform at x(n) between times nT_s, and $(n+1)T_s$.



Sampling Period vs. Frequency

T_s = sample period (time interval between samples)
Typical unit: seconds (s, sec)

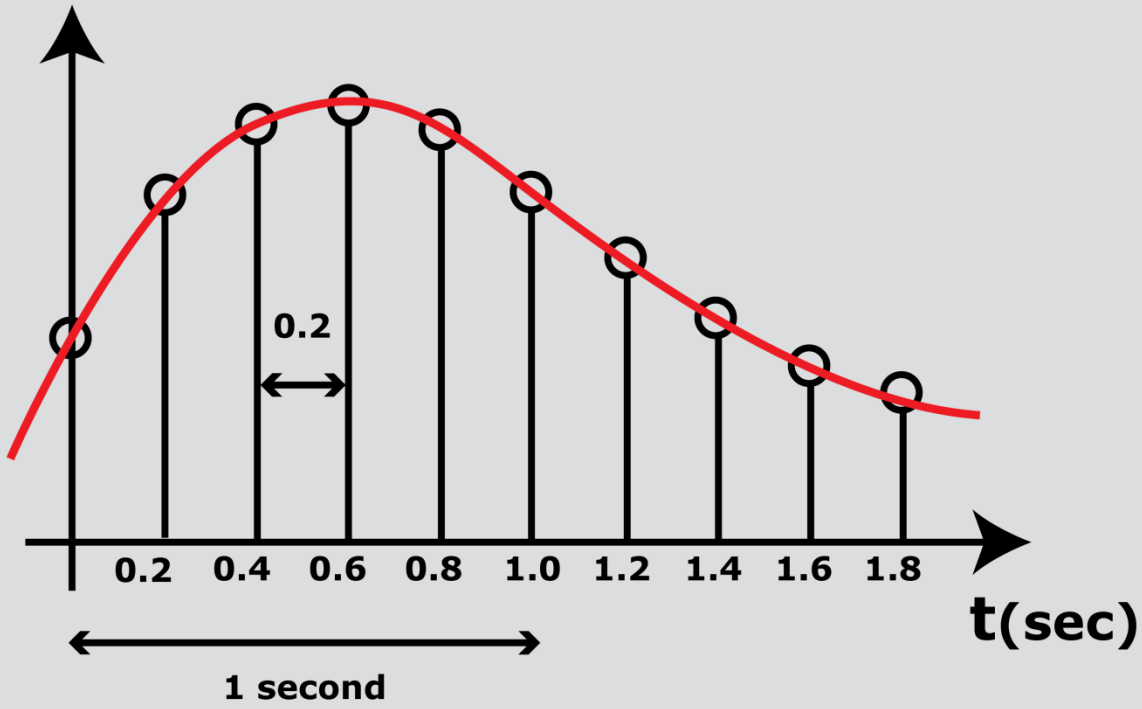
F_s = sampling frequency or rate (number of samples in a fixed period of time)
Typical unit: Hertz (Hz, samples per second)

Relationship : $F_s = \frac{1}{T_s}$

Example: $T_s = 0.2$ sec

$$F_s = \frac{1 \text{ sample}}{0.2 \text{ sec}}$$

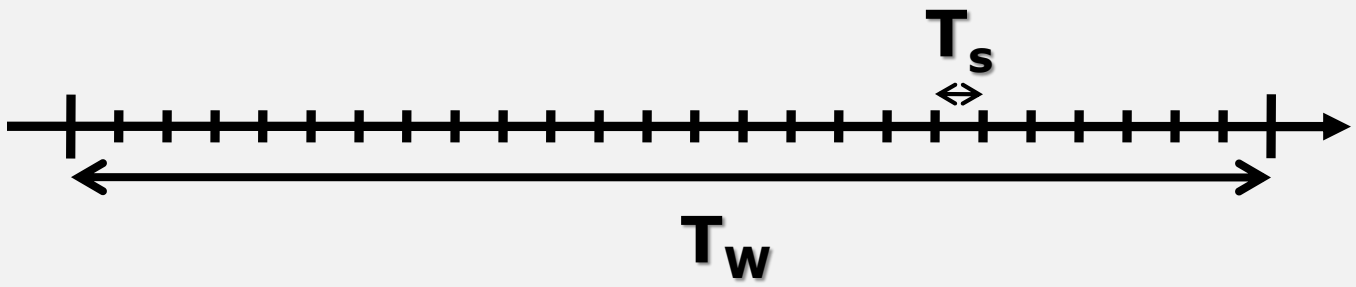
$$= 5 \frac{\text{samples}}{\text{sec}} = 5\text{Hz}$$



Number of Samples

Sampling a signal of length T_w with a sample period T_s results in N samples where

$$N = \frac{T_w}{T_s} = T_w \cdot F_s$$



Tradeoff:

A higher sample frequency is

- **Good: Less information lost since less time between samples**
- **Bad: More storage needed since more samples for a given length of time**