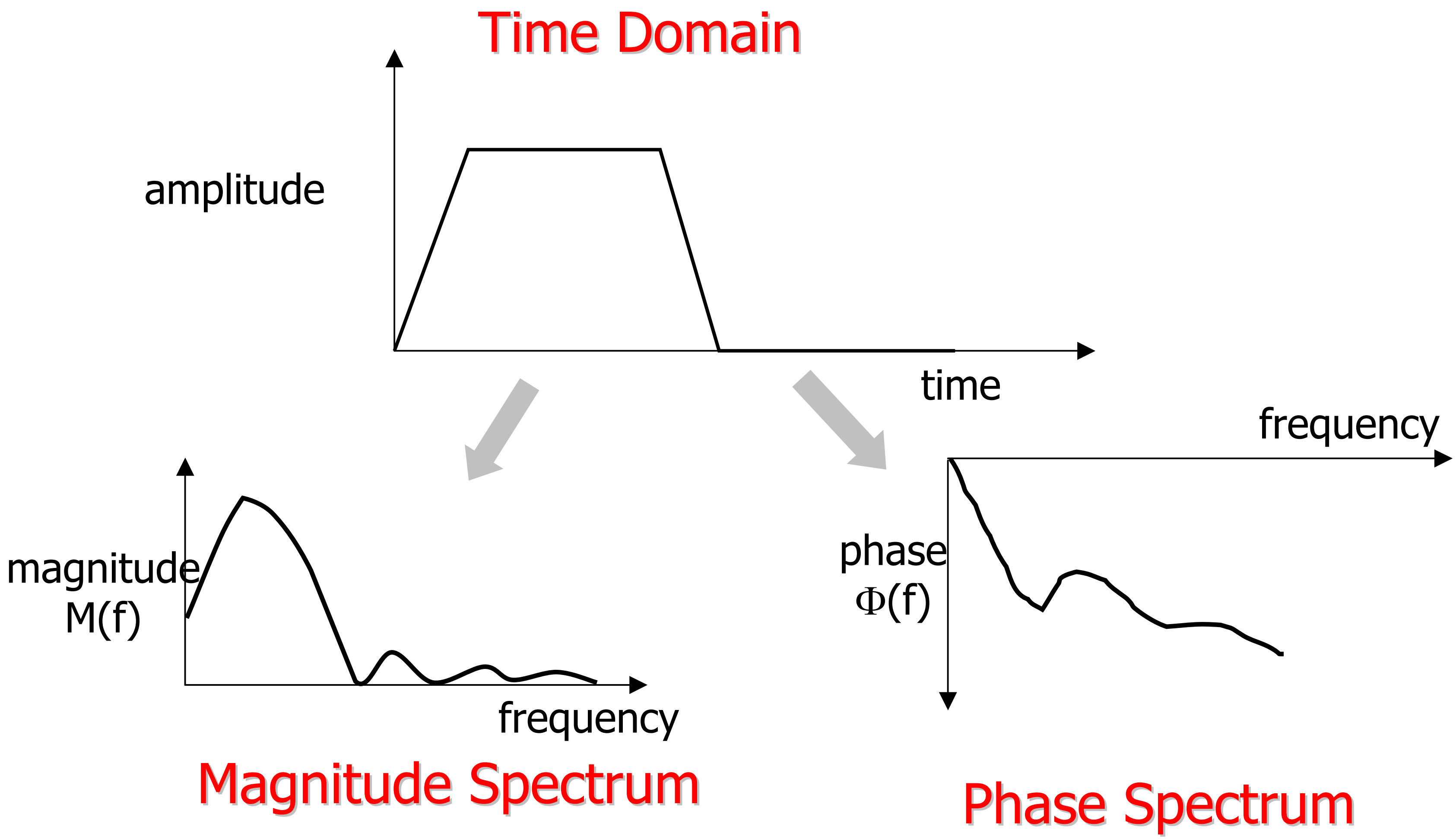
Discrete Fourier Transform

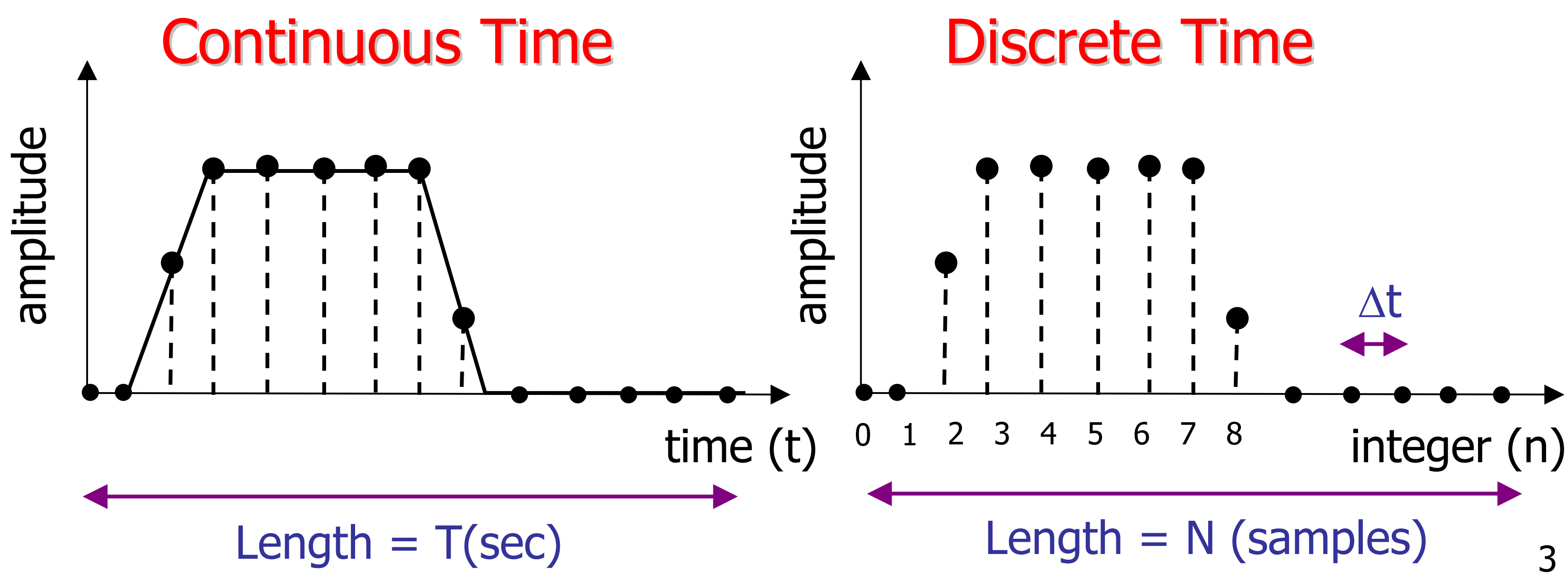
Fourier Transform

- It is a mathematical function to convert a signal in time domain to frequency domain



Discrete Fourier Transform

- Digital signal processing requires signals to be in discrete form
- Continuous signal x(t) is sampled at discrete intervals (based on Nyquist sampling) to obtain a discrete signal x[n], where n is an integer



Discrete Fourier Transform

$$X[k] = \sum_{n=0}^{N} x[n] e^{-j\frac{2\pi kn}{N}}$$

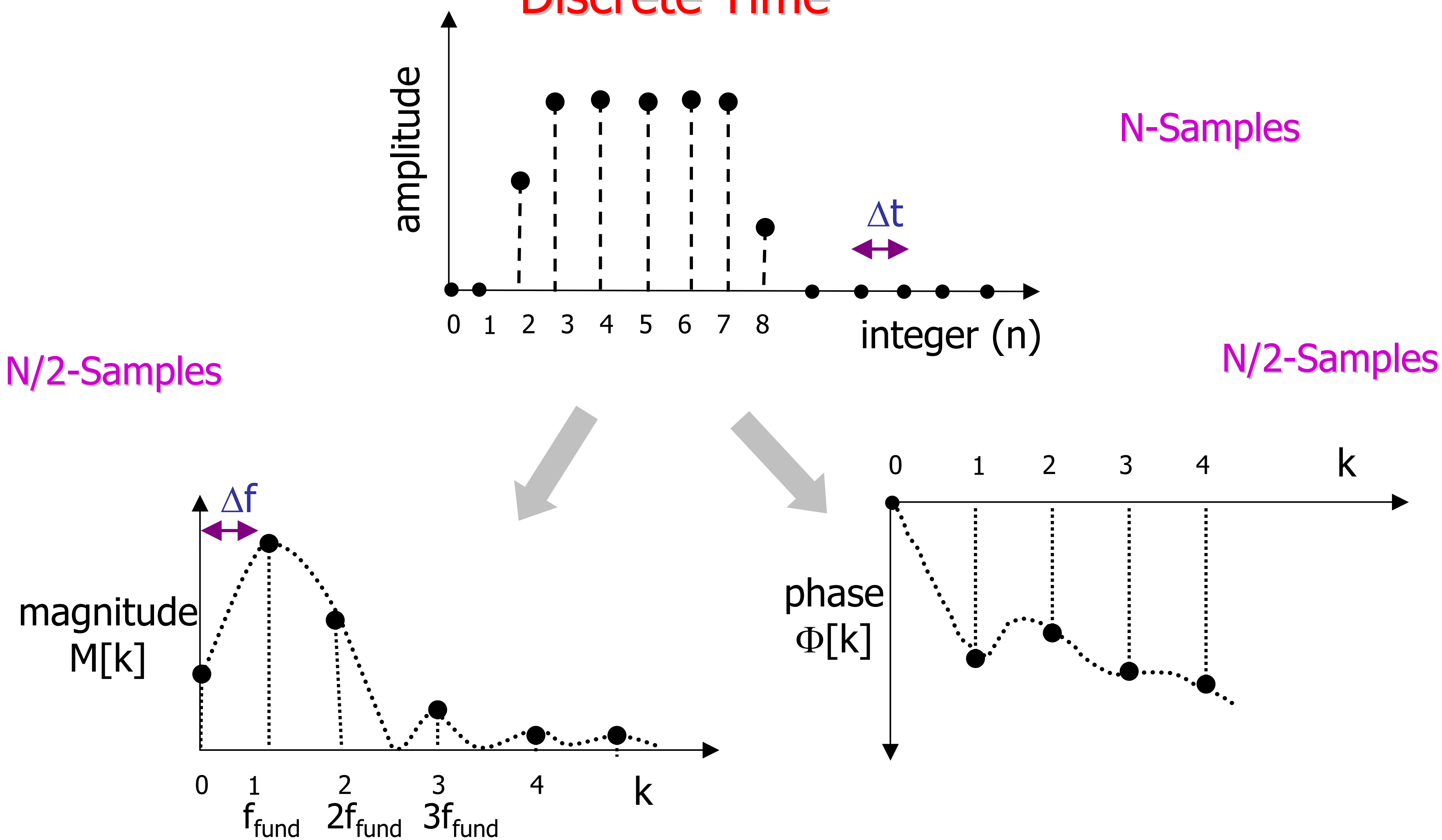
where k is an integer representing frequency values 0,1,2,3….N/2

X[k] represents the DFT of x[n]

Property: For any real signal with N samples we need only N/2 frequencies to completely represent the signal in frequency domain

Discrete Fourier Transform

Discrete Time



Magnitude Spectrum

Phase Spectrum

Discrete Fourier Transform

$$X[k]=\sum_{n=0}^{N}x[n]e^{-j\frac{2\pi kn}{N}}=\underbrace{\sum_{n=0}^{N}x[n]\cos\left(\frac{2\pi kn}{N}\right)}-j\underbrace{\sum_{n=0}^{N}x[n]\sin\left(\frac{2\pi kn}{N}\right)}$$

Real Part *R[k]* Imaginary Part *I[k]*

$$R[k]=\sum_{n=0}^{N}x[n]\cos\left(\frac{2\pi kn}{N}\right)$$ for k=0,1,2...num_freq

$$I[k]=\sum_{n=0}^{N}x[n]\sin\left(\frac{2\pi kn}{N}\right)$$ for k=0,1,2...num_freq

Rectangular to Polar Coordinates

$$X[k] = R[k] - jI[k]$$

Rectangular Coordinates

$$\left.\begin{aligned} M[k] &= \sqrt{R[k]^2 + I[k]^2} \\ \phi[k] &= \tan^{-1}\left(\frac{-I[k]}{M[k]}\right) \end{aligned}\right\}$$

Polar Coordinates

Project Details

- <u>What is given to you?</u>
  - Input file containing x[n] and number of samples N
  - Number of frequencies for which the DFT (M[k] and Φ[k]) has to be computed (k=0,1,2…num_freq)
  - Fundamental frequency, f_{fund}. Rest of the frequencies are integer multiple of the fundamental frequency

input.txt

```
6
1.532E-2
4.324E-5
5.233E-0
4.324E-5
5.233E-0
4.324E-5
```

N (integer)

x[n] (N-floating point numbers)

asm_pgm_name <input_file> <fundamental_freq> <num_frequencies>

Project Details

- What is required from you?
  - Compute DFT of the given waveform x[n], which means compute R[k] and I[k] for frequencies for k=0,1,2…num_freq
  - Convert R[k] and I[k] into polar coordinates (you may use C-function atan2(y,x)) which will give you M[k] and Φ[k]
  - Compute the frequency values

    freq = k*fundamental_frequency
  - Print the result in three column format as:

    M[k] Φ[k]   frequency

Project Details

M(k) *Magnitude Spectrum*	**Φ(k)** *Phase Spectrum*	**frequency** (K*fund_freq)
N/2 values of M(k)	N/2 values of Φ(k)	N/2 values of frequency

output.txt