# COMP.SGN.100 Introduction to Signal Processing
# Exercise 9: Task 1, 2

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## Task 1

EXERCISE 9

TASK 1

$$h(n) = \delta(n) + \delta(n-2)$$

z-transform of the given impulse response is

$$H(z) = 1 + z^{-2}$$

Frequency response would be :

$$H(e^{i\omega}) = 1 + e^{-2i\omega}$$

Simplify this by taking $e^{-i\omega}$ as common factor

$$H(e^{i\omega}) = e^{-i\omega}\left[e^{i\omega} + e^{-i\omega}\right]$$

Applying Euler's Formula i.e, $e^{ix} = \cos(x) + i\sin(x)$

$$H(e^{i\omega}) = e^{-i\omega}\left[\cos(\omega) + i\sin(\omega) + \cos(-\omega) + i\sin(-\omega)\right]$$

$$H(e^{i\omega}) = e^{-i\omega}\left[\cos(\omega) + \cancel{i\sin(\omega)} + \cos(\omega) - \cancel{i\sin(\omega)}\right]$$

$$= e^{-i\omega}\left[2\cos(\omega)\right]$$

Phase response is same as phase angle of complex term $e^{-i\omega} = -\omega$

$$T(\omega) = \frac{-d(\omega)}{d\omega} = -1$$

Phase response is linear as group delay is côstant.

## Task 2

EXERCISE 9

TASK 2

a) $F_s = 16000\,Hz$

Passband Frequency $= f_p = 4000\,Hz$

Stopband Frequency $= f_s = 5000\,Hz$

Normalized $f_p$ and $f_s$ would be:

$$f_p = \frac{4000}{16000} = \frac{1}{4}$$

$$f_s = \frac{5000}{16000} = \frac{5}{16}$$

Transition bandwidth $= \Delta f = f_s - f_p$

$$= \frac{5}{16} - \frac{1}{4}$$

$$\Delta f = \frac{5-4}{16} = \frac{1}{16}$$

(i) Rectangular Window Coefficients:

$$N = \frac{0.9}{\Delta f} = 0.9 \times 16 = 14.4 = 15$$

(ii) Hanning Window Coefficients:

$$N = \frac{3.1}{\Delta f} = 3.1 \times 16 = 49.6 = 51$$

(iii) Hamming Window Coefficients:

$$N = \frac{3.3}{\Delta f} = 3.3 \times 16 = 52.8 = 53$$

(iv) Blackman Window Coefficients:

$$N = \frac{5.5}{\Delta f} = 5.5 \times 16 = 88$$