EE 321 HOME ASSIGNMENT

submitted by:

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Q) $$y[n] = \sum_{m=0}^{n-1} \frac{x[m]}{\alpha^{n-m}} \quad \text{for } n \geq 0 \quad \sim (1)$$

where $x[n]$ = Power delivered to heating element

$y[n]$ = temperature of food

α is thermal diffusivity ($\alpha = 2$ for this problem)

or, $$y[n] = \frac{1}{\alpha} x[n-1] + \frac{1}{\alpha^2} x[n-2] + \dots \quad \text{for } n \geq 0 \quad \sim (2)$$

or, $$y[n] = \frac{1}{\alpha} x[n-1] + \frac{1}{\alpha} y[n-1] \quad \text{for } n \geq 0 \quad - (3)$$

Part i. food is initially at room temperature

so, $y[n] = 0$

its given in question that temperature of 0 means room temperature

putting value $y[n] = 0$ in (3)

$$x[n-1] + y[n-1] = 0$$
$$-x[n-1] \Rightarrow +y[n-1]$$

n starting at $n=1$;

so, $-x[0] = y[0]$
$-x[1] = y[1]$
$\vdots$

we can conclude that at room temperature, all power delivered to heating element ~~converting~~ ~~it~~ is contributing in temperature rising of food. No heat loss

Initially system is at rest. Also, the temperature of food at any instant is only depends on power supply at that instant (2)

Part ii) for impulse response of filter h[n]

assume the impulse signal given as: $x[0]=1$, else $x[n]=0$,

Setting the input $x[n]$ to $\delta[n] = [1, 0, 0, \ldots]$, we compute, for $n = 0, 1, 2 \ldots$

$$y[n] = h[n] = \frac{1}{2}\delta[n-1] + \frac{1}{2^2}\delta[n-2] + \ldots$$

$$y[0] = 0$$

$$y[1] = \frac{1}{2}$$

$$y[2] = \frac{1}{2^2}$$

$$y[3] = \frac{1}{2^3}$$

$\vdots$

So,

$$h[n] = \frac{1}{2^n}u[n] - \delta[n]$$

we can confirm this by: $h[n] = \int H(z) z^{-1} dz$

$$y(n) = \frac{1}{2}x[n-1] + \frac{1}{2}y[n-1]$$

Taking z transform

$$Y(z) = z^{-1}X(z) + \frac{1}{2}z^{-1}Y(z)$$

$$(2 - z^{-1})Y(z) = z^{-1}X(z) \quad - (4)$$

$$\frac{Y(z)}{X(z)} = H(z) = \frac{z^{-1}}{2-z^{-1}} \text{ or } \frac{1}{2z-1}$$

$$\frac{H(z)}{z} = \frac{1}{z(2z-1)} = \frac{2z-(2z-1)}{z(2z-1)}$$

$$= \left(\frac{2}{(2z-1)} - \frac{1}{z}\right)$$

$$H(z) = \frac{\cancel{2}z}{\cancel{2}(z-\frac{1}{2})} - 1$$

$$z^{-}\{H(z)\} = z^{-1}\left\{\frac{z}{z-\frac{1}{2}}\right\} - z^{-1}\{1\}$$

$$\boxed{h[n] = \left(\frac{1}{2}\right)^n u[n] - \delta[n]}$$

Part iii) we see that the impulse response decays to zero $(2^n = \infty)$ but never reaches zero $(n \neq 0)$, so this is indeed an IIR filter

Part iv) from equation (4);

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

put $z = \exp(j\omega)$ and remember that in discrete time systems the low frequencies are at $2n\pi$ $(n = 0, 1, 2, \ldots)$ and high frequencies occur at $(2n+1)\pi$; this is just a consequence of periodic behaviour

$$H(z) = \frac{e^{-j\omega}}{2 - e^{-j\omega}} \quad \text{at} \quad z = e^{j\omega}$$

when $\omega = 0$; $H(z) = 1$ and when $\omega = \pi$; $H(z) = -1/3$

at low frequencies the system provides higher gain as compare to the gain at high frequencies

we can also see this by plotting graph of $H(j\omega)$

$$H(z) = \frac{1}{2z - 1}$$

$$= \frac{(z+1) - (z-1)}{3(z-1) + (z+1)}$$

$$= \frac{1 - \left(\frac{z-1}{z+1}\right)}{3\left(\frac{z-1}{z+1}\right) + 1}$$

By using bilinear transformation

$$\left(\frac{z-1}{z+1}\right) = s$$

$$H(z) \longleftrightarrow H(s)$$

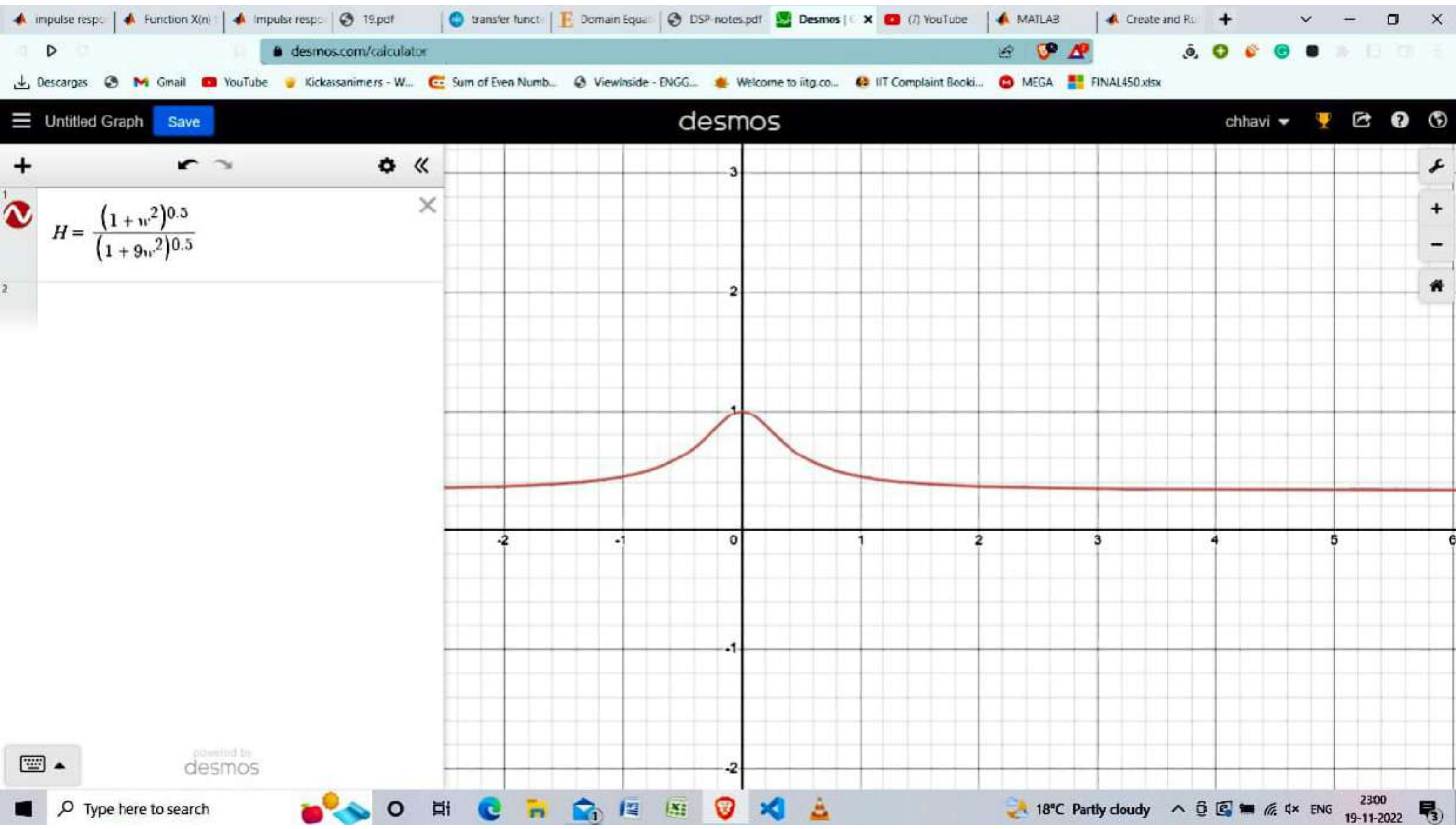
$$H(s) = \frac{1 - s}{3s + 1}$$

$$H(j\omega) = \frac{1 - j\omega}{3(j\omega) + 1}$$

magnitude of $H(j\omega)$

$$|H(j\omega)| = \frac{\sqrt{1+\omega^2}}{\sqrt{1+9\omega^2}}$$

on plotting magnitude v/s frequency graph, we can see that preferable filter is low pass filter.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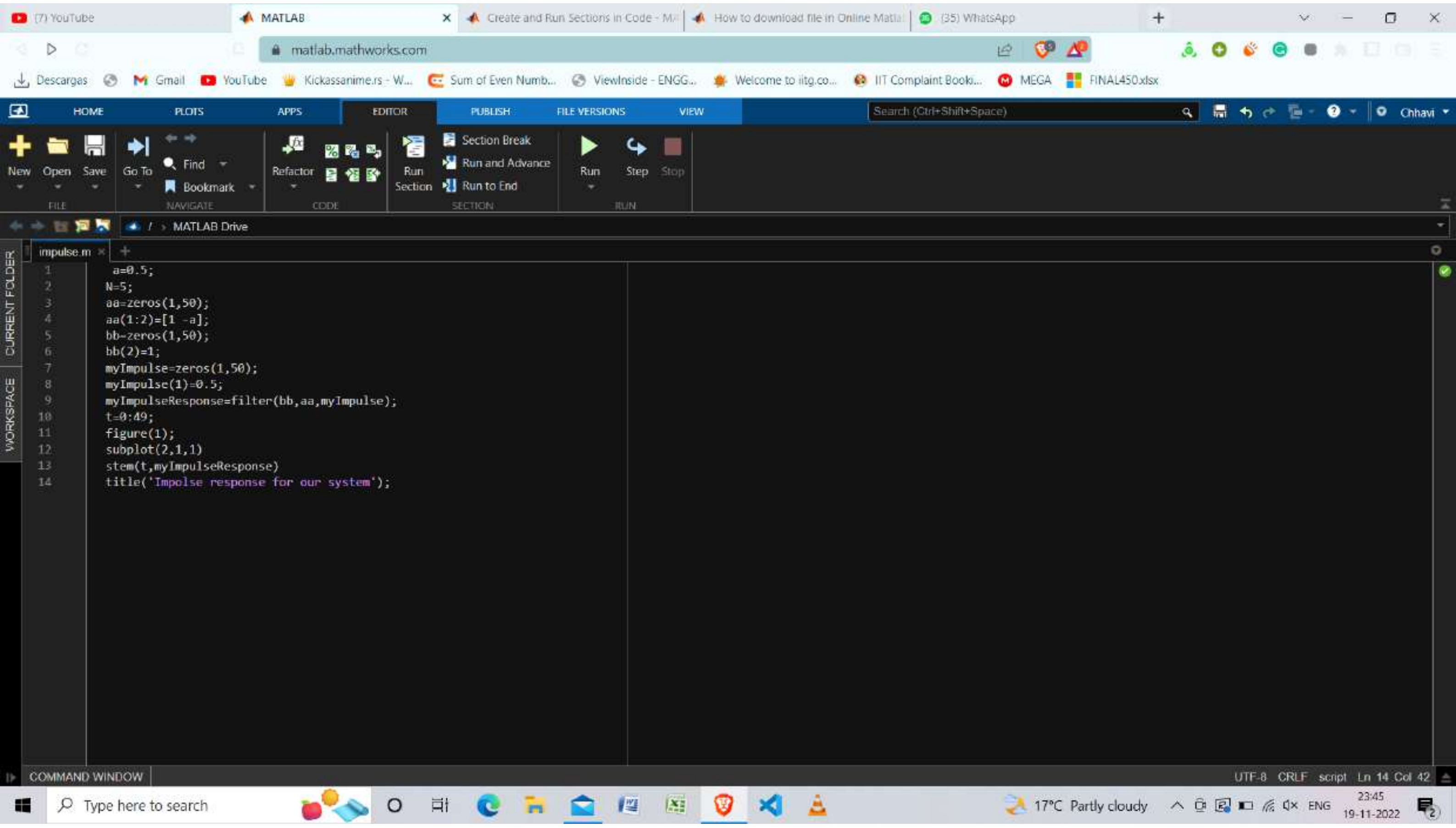
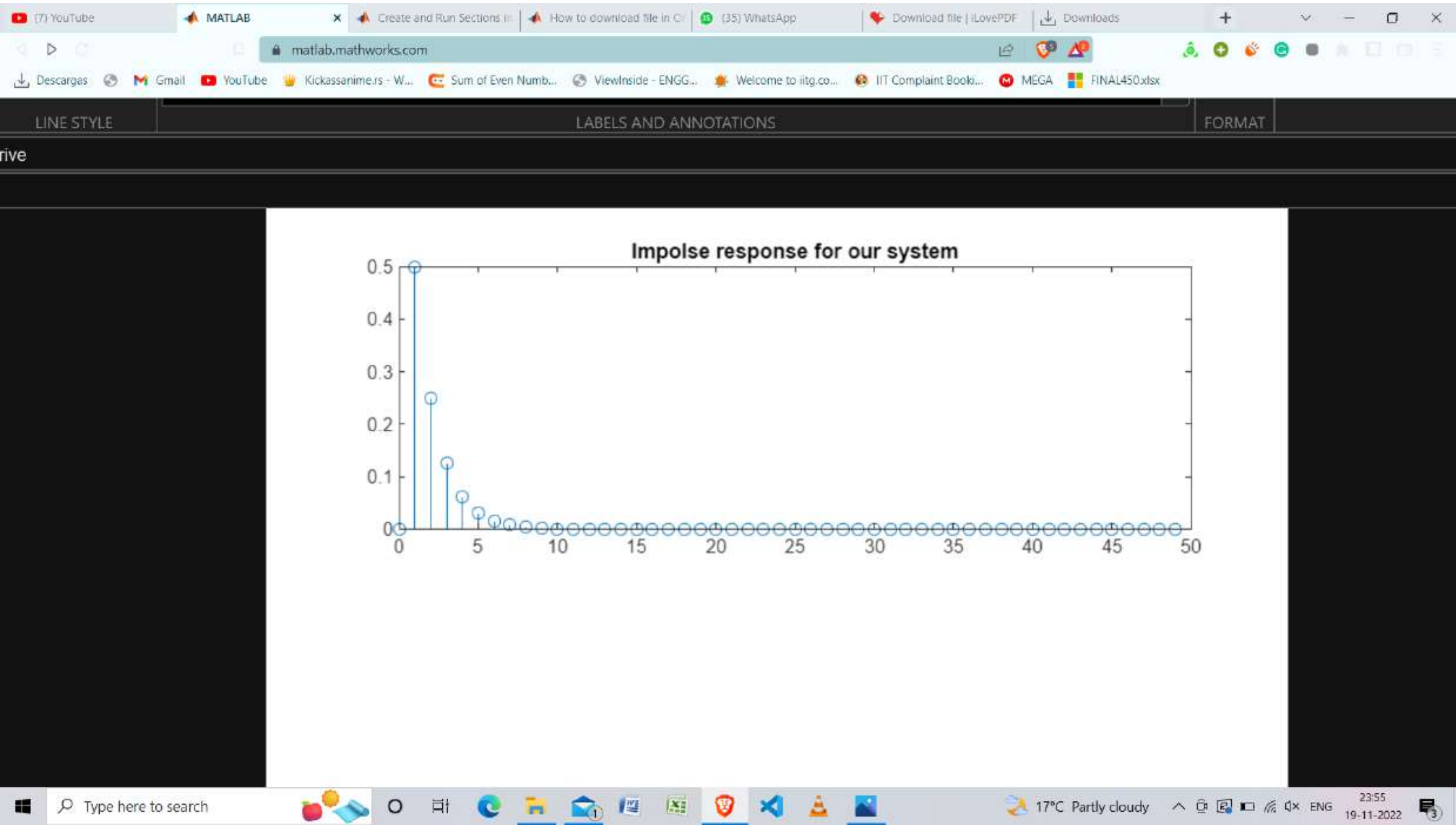

impulse.m
a=0.5;
N=5;
aa=zeros(1,50);
aa(1:2)=[1 -a];
bb=zeros(1,50);
bb(2)=1;
myImpulse=zeros(1,50);
myImpulse(1)=0.5;
myImpulseResponse=filter(bb,aa,myImpulse);
t=0:49;
figure(1);
subplot(2,1,1)
stem(t,myImpulseResponse)
title('Impolse response for our system');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