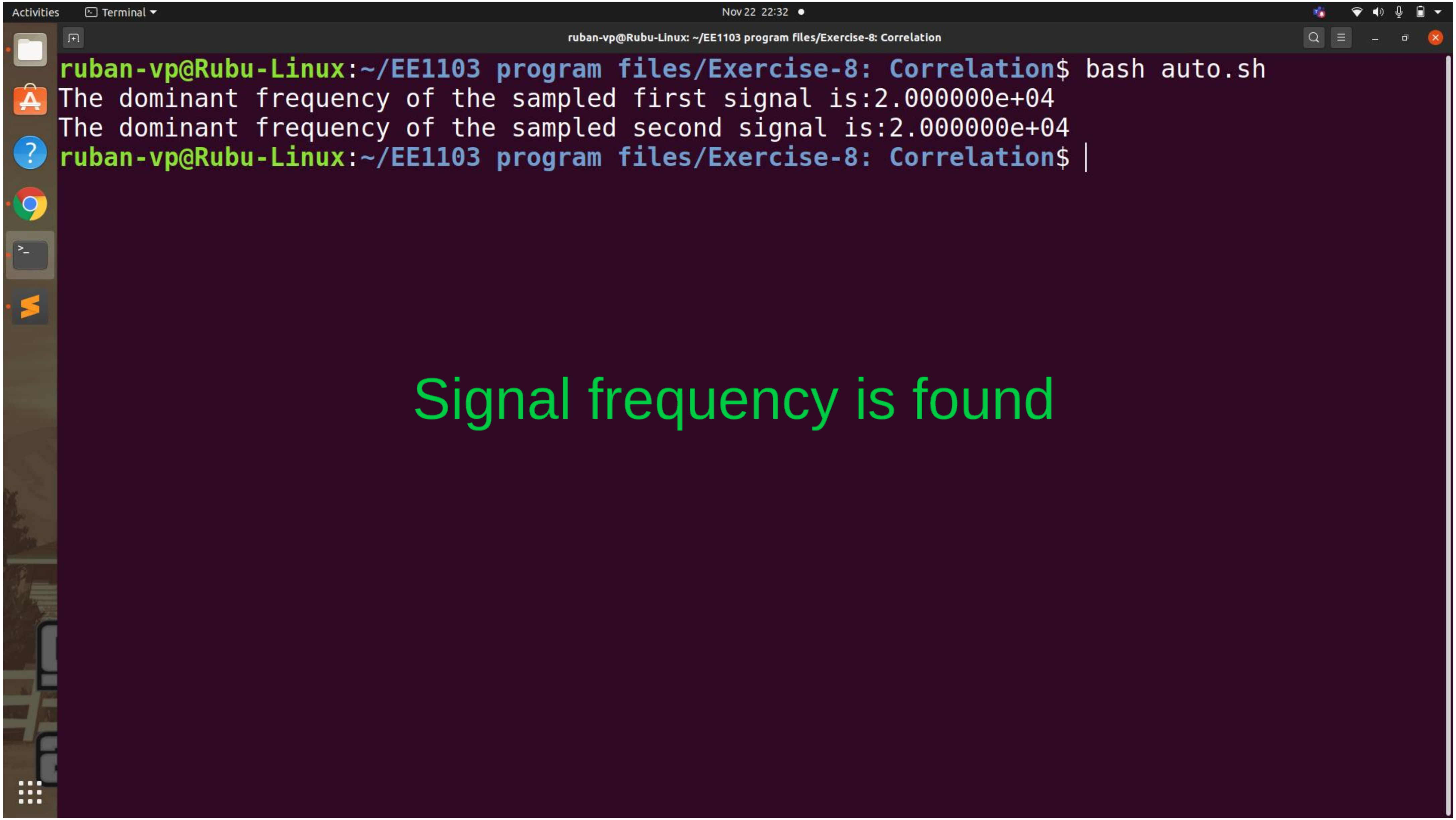
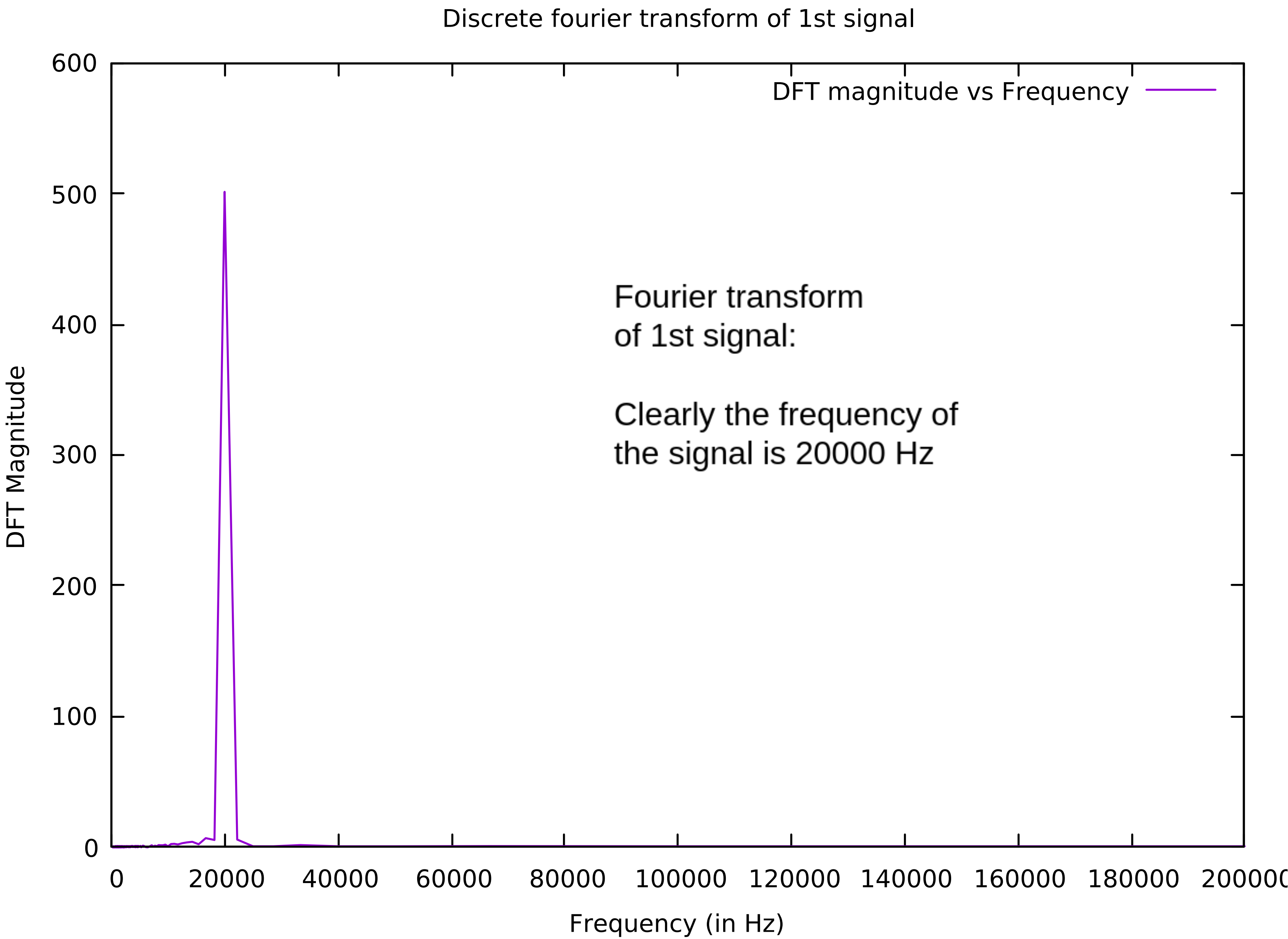
Companion bash script

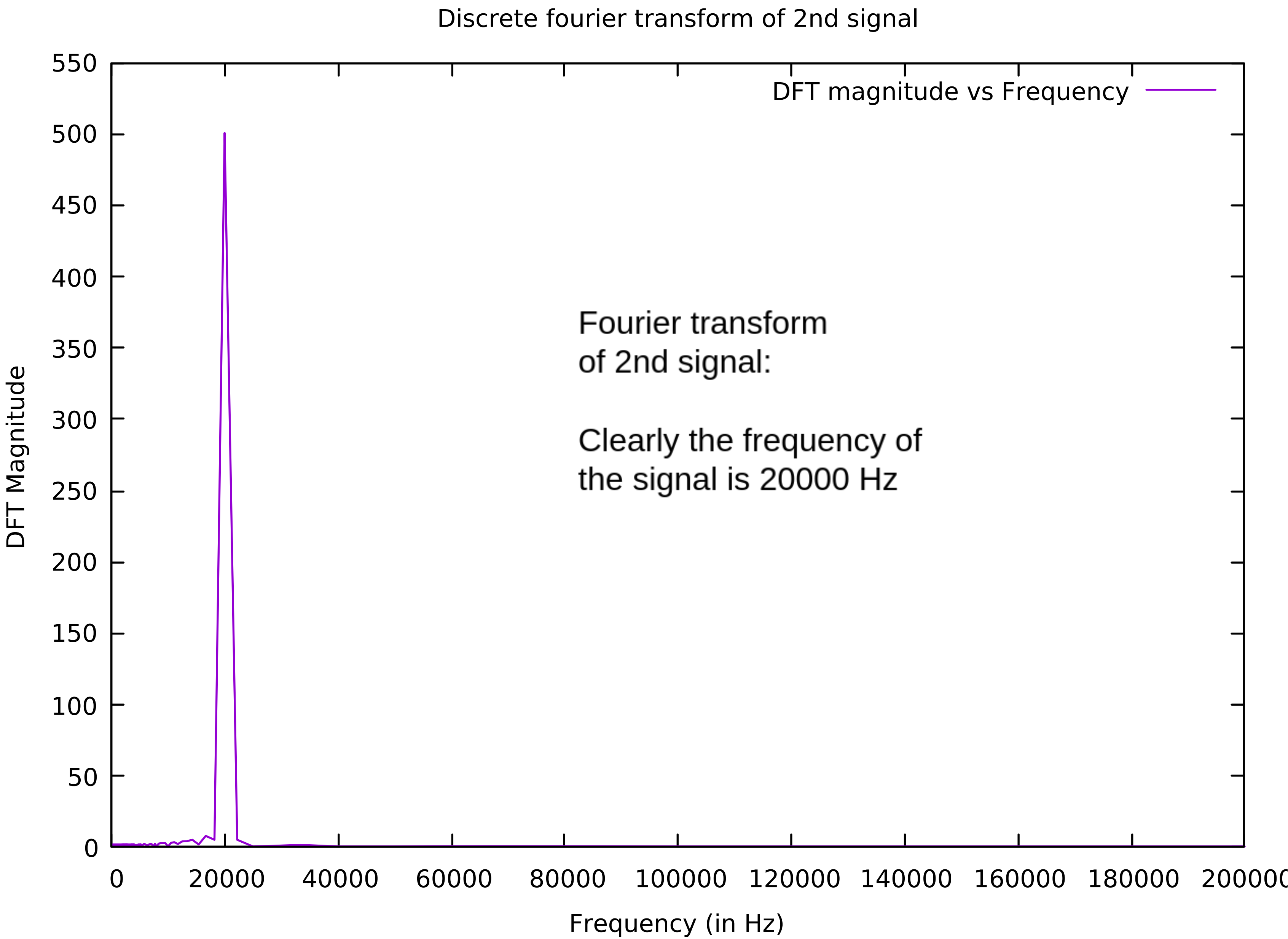
~/EE1103 program files/Exercise-8: Correlation/auto.sh - Sublime Text (UNREGISTERED)

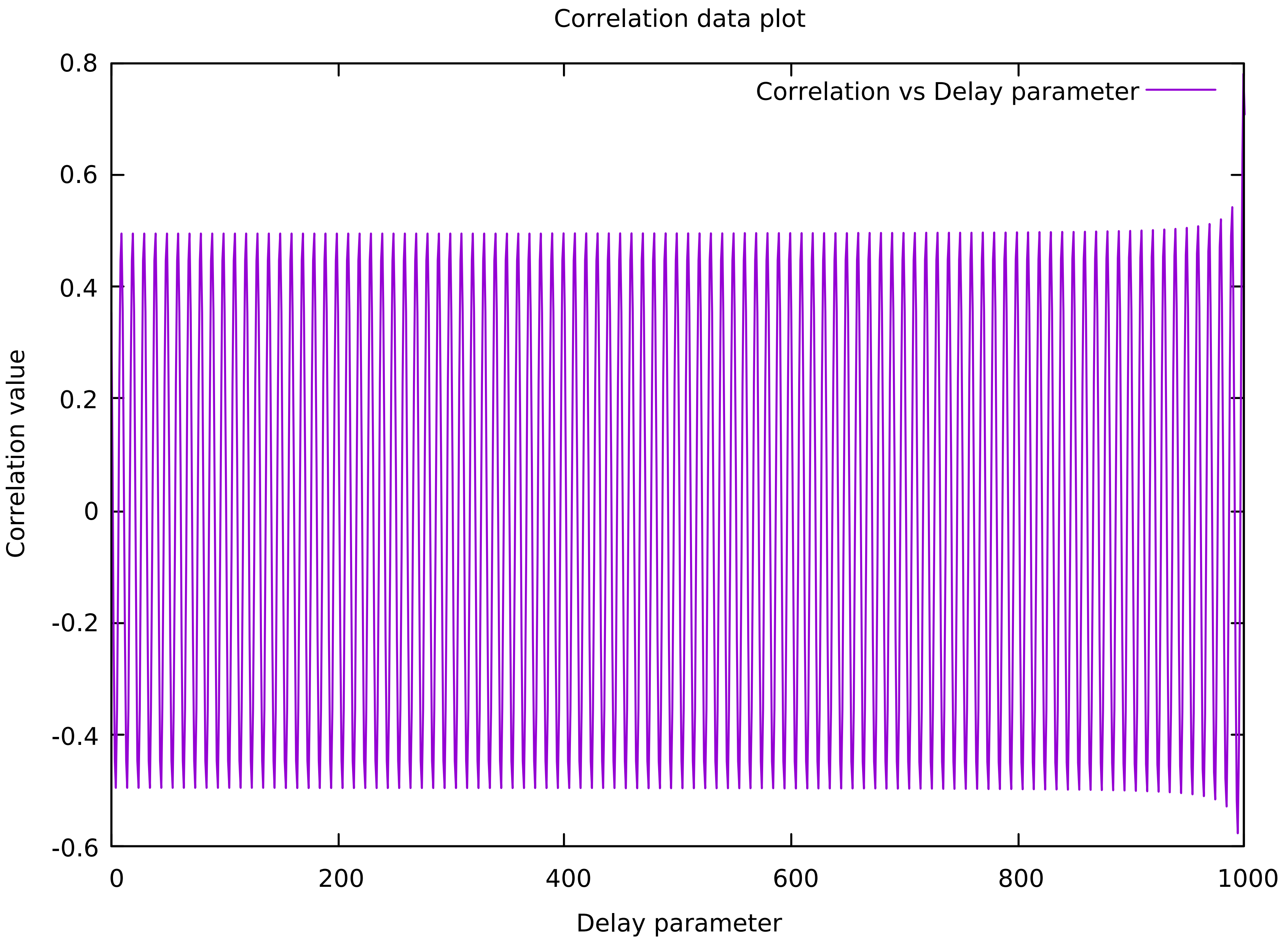
```bash
#!/bin/bash

grep -v '#' data_4_corr.txt | awk '{print $1"\t"$2"\t"$3}' > newdata.txt
# The file is filtered of any field names containing columns

gcc correlation.c -lm  # The executable file of the C code is created

./a.out newdata.txt 1 > temp1.txt      # Fourier data of 1st signal
./a.out newdata.txt 2 > temp2.txt      # Fourier data of 2nd signal
./a.out newdata.txt 3 > temp3.txt      # Correlation data

# The common frequency of the discrete signals are found and printed
awk ' BEGIN{big=0; domfreq=0;} {if($2>=big){big=$2; domfreq=$1;}} END{printf "The dominant frequency of the sampled first signal is:" domfreq"\n";}' temp1.txt
awk ' BEGIN{big=0; domfreq=0;} {if($2>=big){big=$2; domfreq=$1;}} END{printf "The dominant frequency of the sampled second signal is:" domfreq"\n";}' temp2.txt

# The DFT plot of 1st signal is plotted
gnuplot -persist <<-EOFMarker
set title 'Discrete fourier transform of 1st signal'
set xlabel 'Frequency (in Hz)'
set ylabel 'DFT Magnitude'
plot 'temp1.txt' with lines title 'DFT magnitude vs Frequency'
EOFMarker

# The DFT plot of 2nd signal is plotted
gnuplot -persist <<-EOFMarker
set title 'Discrete fourier transform of 2nd signal'
set xlabel 'Frequency (in Hz)'
set ylabel 'DFT Magnitude'
plot 'temp2.txt' with lines title 'DFT magnitude vs Frequency'
EOFMarker

# The correlation plot is plotted
gnuplot -persist <<-EOFMarker
set title 'Correlation data plot'
set xlabel 'Delay parameter'
set ylabel 'Correlation value'
plot 'temp3.txt' with lines title 'Correlation vs Delay parameter'
EOFMarker

```

Line 40, Column 1 — Tab Size: 4 — Bourne Again Shell (bash)


Activities
Terminal
Nov 22 22:32
ruban-vp@Rubu-Linux: ~/EE1103 program files/Exercise-8: Correlation
ruban-vp@Rubu-Linux:~/EE1103 program files/Exercise-8: Correlation$ bash auto.sh
The dominant frequency of the sampled first signal is:2.000000e+04
The dominant frequency of the sampled second signal is:2.000000e+04
ruban-vp@Rubu-Linux:~/EE1103 program files/Exercise-8: Correlation$
Signal frequency is found


Discrete fourier transform of 1st signal
DFT magnitude vs Frequency
Fourier transform
of 1st signal:
Clearly the frequency of
the signal is 20000 Hz
DFT Magnitude
Frequency (in Hz)
0
100
200
300
400
500
600
0
20000
40000
60000
80000
100000
120000
140000
160000
180000
200000


Discrete fourier transform of 2nd signal
DFT magnitude vs Frequency
Fourier transform
of 2nd signal:
Clearly the frequency of
the signal is 20000 Hz
DFT Magnitude
Frequency (in Hz)
0
50
100
150
200
250
300
350
400
450
500
550
0
20000
40000
60000
80000
100000
120000
140000
160000
180000
200000



Correlation data plot
Correlation vs Delay parameter
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
Correlation value
0
200
400
600
800
1000
Delay parameter

THEORY:

It is given that the functions are sinusoids of same frequency. So let:

$$x(t) = \cos(\omega t + A)$$
$$y(t) = \cos(\omega t + A + \phi) \quad \left(\phi = \text{phase diff.}\right)$$

$$R_{xy}(\tau) = \int_{-\infty}^{\infty} \cos(\omega t + A) \cos(\omega t + A + \phi + \omega\tau)\, dt$$

$$= \underbrace{\int_{-\infty}^{\infty} \cos^2(\omega t + A) \cos(\phi + \omega\tau)\, dt}_{\text{Term 1}} + \underbrace{\int_{-\infty}^{\infty} \cos(\omega t + A) \sin(\omega t + A) \sin(\phi + \omega\tau)\, dt}_{\text{Term 2}}$$

In term 1 we have: $\displaystyle \int_{-\infty}^{\infty} \frac{\cos(\phi + \omega\tau)\, dt}{2} + \int_{-\infty}^{\infty} \frac{\cos(2\omega t + 2A)\cos(\phi + \omega\tau)\, dt}{2}$

$$= \frac{\cos(\phi + \omega\tau)}{2} \int_{-\infty}^{\infty} dt + 0 \quad \left(\text{or atleast near zero}\right)$$

The limits become 0 to $(N-\bar{\tau}) \cdot T_{sample}$ where N is the number of samples and $\bar{\tau}$ is delay parameter τ upon Tsample ($\bar{\tau} = \tau / T_{sample}$). So our terms become:

$$\text{Term 1} = \frac{\cos(\phi + \omega\tau)(N-\bar{\tau})(T_{sample})}{2} + \bar{p} \quad (\bar{p} \rightarrow 0)$$

$$\text{Term 2} \rightarrow 0$$

$$\therefore \bar{R}_{xy}(\tau) = \frac{R_{xy}(\tau)}{(N-\bar{\tau})(T_{sample})} = \frac{\cos(\phi + \omega\tau)}{2} + \bar{\bar{p}} \quad (\bar{\bar{p}} \rightarrow 0)$$

So this metric is a cosine function of τ. This metric reaches a maximum when:

$$\phi + \omega\tau = 2n\pi$$

$$\therefore \phi = 2n\pi - \omega\tau_{max} \quad (\tau_{max} = \tau_{max} \cdot T_{sample})$$

For this particular dataset: $A = 0$, $\phi = 45°$.

$$\therefore \omega\tau_{max} = 2\pi - 45° = 315°$$

Answer obtained for $\omega\tau_{max} = 324°$.

Hence ϕ obtained $= 360° - 324°$
$= 36°$

We get this result because of a reasonable sampling time. To get more accurate result, we need a much smaller sampling time.

Period to sampling time ratio:

Frequency obtained $= 20,000$ HZ

T_Sample $= 5 \times 10^{-6}$ s

$$\therefore, \frac{T\_Period}{T\_sample} = \frac{1/20,000}{5 \times 10^{-6}} = \frac{0.5 \times 10^{-4}}{5 \times 10^{-6}}$$

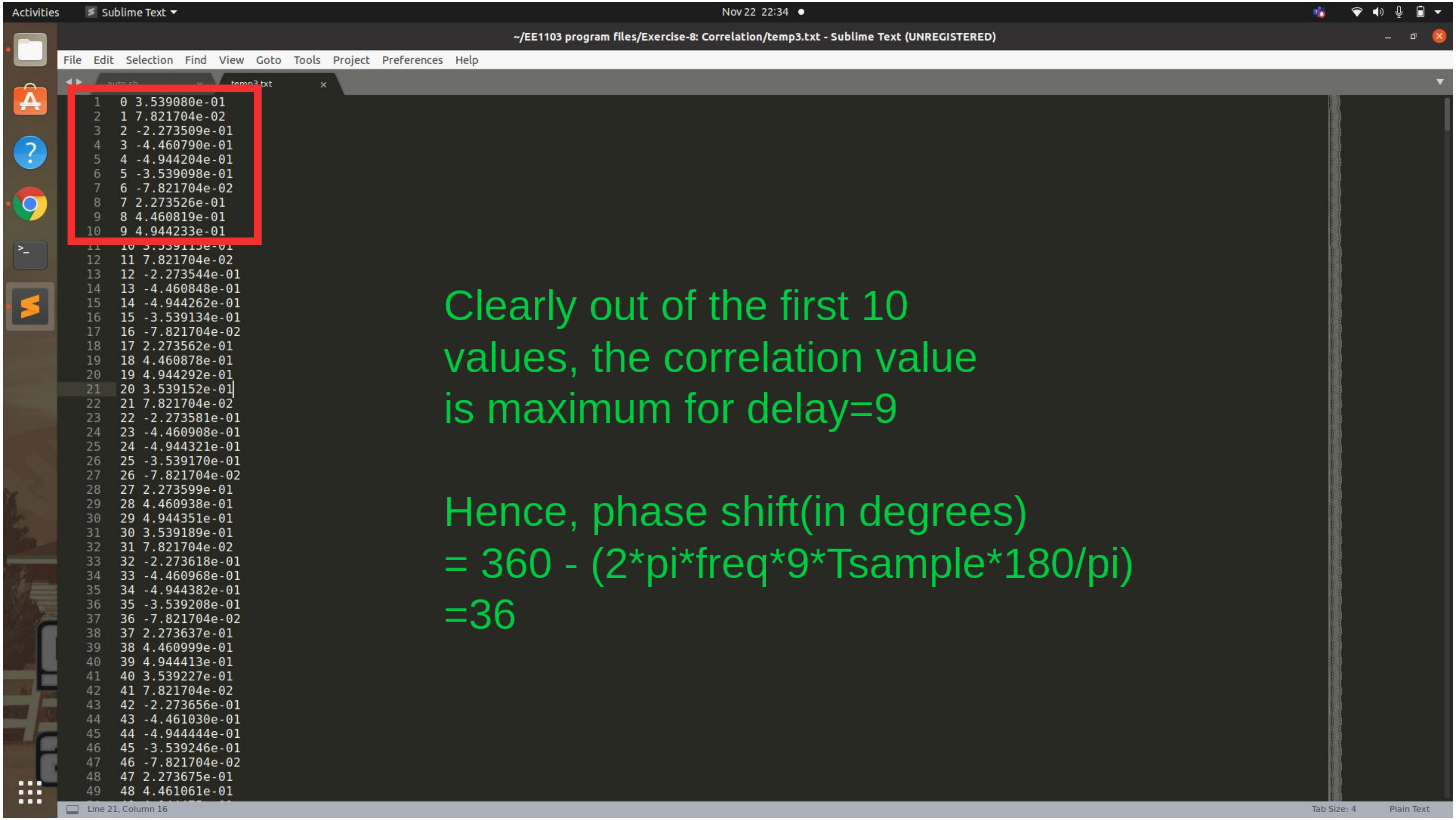
$$= 10$$

Phase shift b/w the signals:

$$R_{xy}(\tau) = \int_{-\infty}^{\infty} \cos(\omega t + A) \cos(\omega t + A + \phi + \omega \tau)\, dt$$

Clearly $R_{xy}(\tau)$ is also periodic with frequency 'ω'. (To be precise, it is $\overline{R_{xy}}(\tau) = \frac{R_{xy}(\tau)}{(N - \bar{\tau})(T_{sample})}$)

Hence, if we look at the first 10 datapoints of the correlation data, we'll get the phase.


Activities
Sublime Text
Nov 22 22:34
~/EE1103 program files/Exercise-8: Correlation/temp3.txt - Sublime Text (UNREGISTERED)
File Edit Selection Find View Goto Tools Project Preferences Help
temp3.txt
0 3.539080e-01
1 7.821704e-02
2 -2.273509e-01
3 -4.460790e-01
4 -4.944204e-01
5 -3.539098e-01
6 -7.821704e-02
7 2.273526e-01
8 4.460819e-01
9 4.944233e-01
11 7.821704e-02
12 -2.273544e-01
13 -4.460848e-01
14 -4.944262e-01
15 -3.539134e-01
16 -7.821704e-02
17 2.273562e-01
18 4.460878e-01
19 4.944292e-01
20 3.539152e-01
21 7.821704e-02
22 -2.273581e-01
23 -4.460908e-01
24 -4.944321e-01
25 -3.539170e-01
26 -7.821704e-02
27 2.273599e-01
28 4.460938e-01
29 4.944351e-01
30 3.539189e-01
31 7.821704e-02
32 -2.273618e-01
33 -4.460968e-01
34 -4.944382e-01
35 -3.539208e-01
36 -7.821704e-02
37 2.273637e-01
38 4.460999e-01
39 4.944413e-01
40 3.539227e-01
41 7.821704e-02
42 -2.273656e-01
43 -4.461030e-01
44 -4.944444e-01
45 -3.539246e-01
46 -7.821704e-02
47 2.273675e-01
48 4.461061e-01
Line 21, Column 16
Tab Size: 4
Plain Text
Clearly out of the first 10
values, the correlation value
is maximum for delay=9
Hence, phase shift(in degrees)
= 360 - (2*pi*freq*9*Tsample*180/pi)
=36

From the data, we can see the max. occurs at $\tau = 9$. Hence:

$$\text{phase difference} = \phi = 2\pi - \omega\tau$$

$$= 360^\circ - \left(2 \times \pi \times 20000 \times 9 \times 5 \times 10^{-6} \times \frac{180}{\pi}\right)$$

$$= 360^\circ - \left(40000 \times 9 \times 5 \times 10^{-6} \times 180\right)$$

$$= 360^\circ - \left(\frac{4 \times 9 \times 5 \times 18}{10}\right) = 360^\circ - (324^\circ)$$

$$= 36^\circ //.$$