Lab 10 SNS

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Task 1

Part a

Date :

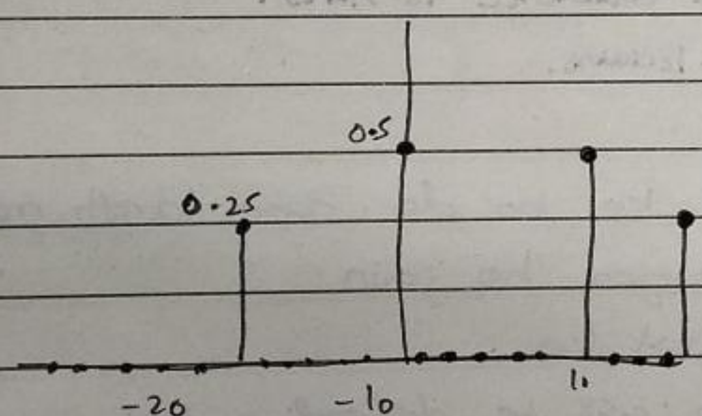
Task 1:

$$x[n] = \cos[10 w_0 n] + 0.5\cos[14 w_0 n]$$

$$= \frac{e^{j10w_0n} + e^{-j10w_0n}}{2} + \frac{1}{2}\left(\frac{e^{j14w_0n} + e^{-j14w_0n}}{2}\right)$$

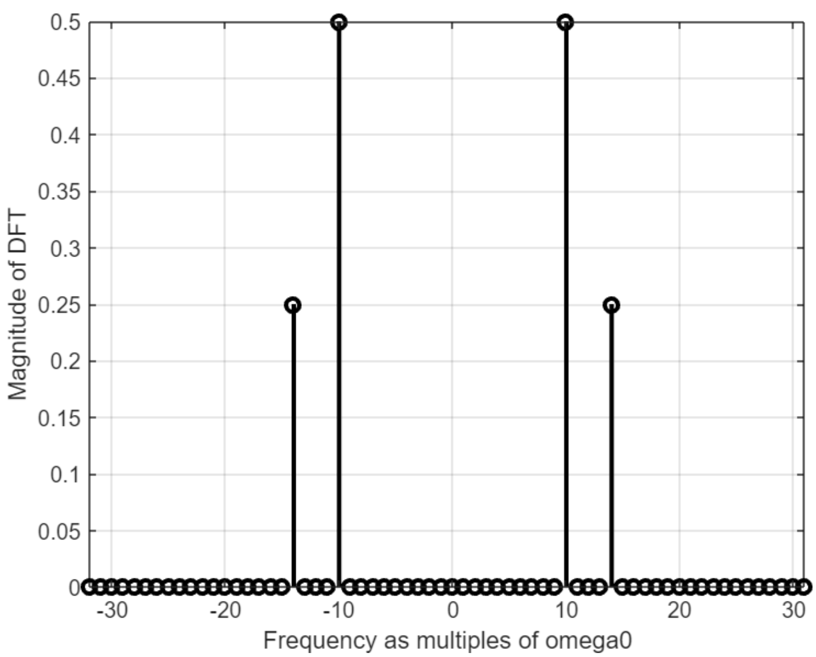
$$x[n] = \frac{1}{2}\left(e^{j10 2\pi f_0 n} + e^{-j10 2\pi f_0 n}\right) + \frac{1}{4}\left(e^{j14 2\pi f_0 n} + e^{-j14 2\pi f_0 n}\right)$$

$$A = \begin{cases} \frac{1}{2}, & f = |10| f_0 \\ 1/4, & f = |14| f_0 \end{cases}$$



Part b

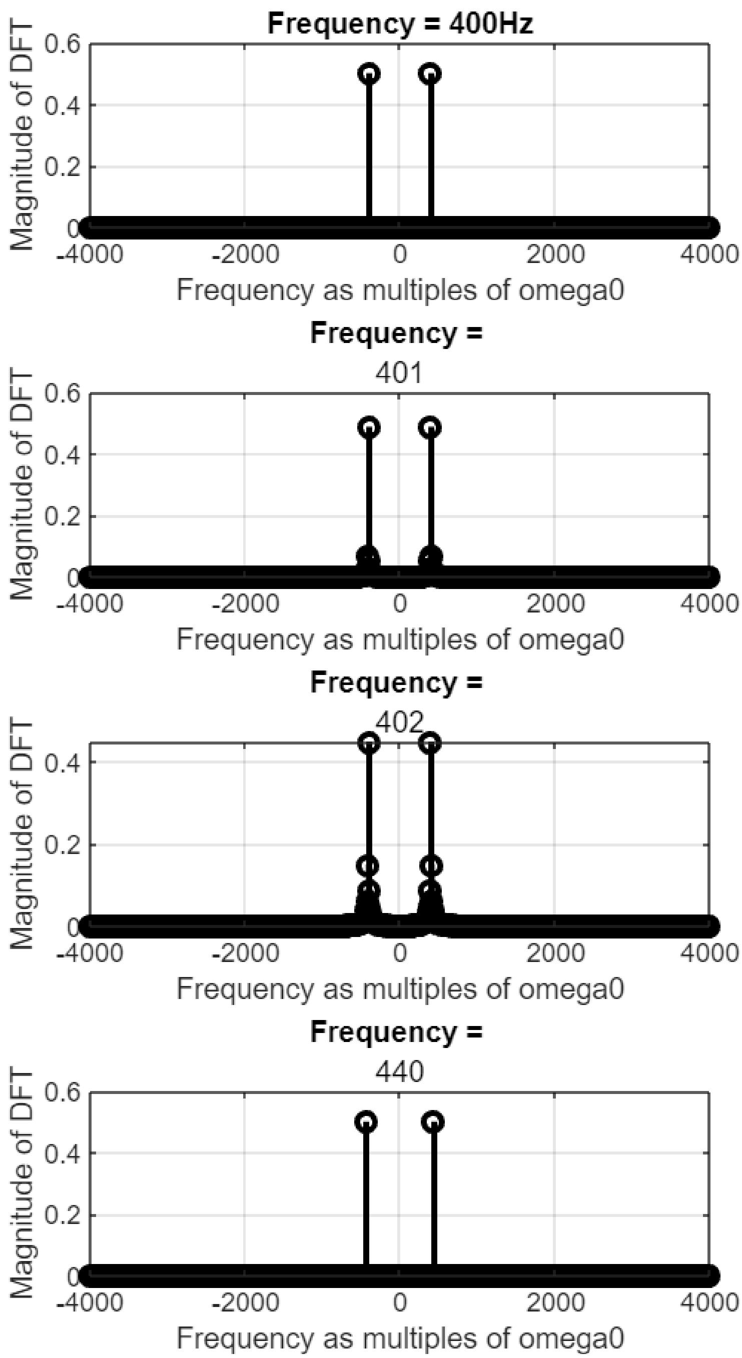
```
clc; clear; close all;
P = 64;
w0 = 2*pi/P;
n = 0:P-1;
x = cos(10*w0*n) + 0.5*cos(14*w0*n); %Finite-time signal
hx = fft(x); %Compute the DFT of x
shx = fftshift(hx);
stem(-P/2:P/2-1,abs(shx)/P,'k','LineWidth',2);
ylabel('Magnitude of DFT');
xlabel('Frequency as multiples of omega0');
axis([-P/2 P/2-1 0 inf]);
grid;
```



In this code we analyze finite time signal which consists of two cosine waves with frequencies of 10 cycles per 64 samples and 14 cycles per 64 samples firstly we generate signal the signal and then its dft is found using fft. then dft is shifted such that zero frequency component comes In center. Then the resulting magnitude spectrum is plotted against frequency indices scaled by the fundamental frequency.

Task 2

```
clc; clear; close all;
f = 400;
fs = 8000;
n = 1000;
m = (0:(n-1))/fs;
x = sin(2*pi*f*m);
hx = fft(x);
shx = fftshift(hx);
fHz = abs(shx)/n;
fshift = (-n/2:n/2-1)*(fs/n);
figure('Position', [100, 100, 500, 1000]);
subplot 411
stem(fshift,fHz,'k','LineWidth',2);
title('Frequency = 400Hz')
ylabel('Magnitude of DFT');
xlabel('Frequency as multiples of omega0');
grid;
subplot 412
wave(401, n);
subplot 413
wave(402, n);
subplot 414
wave(440, n);
```

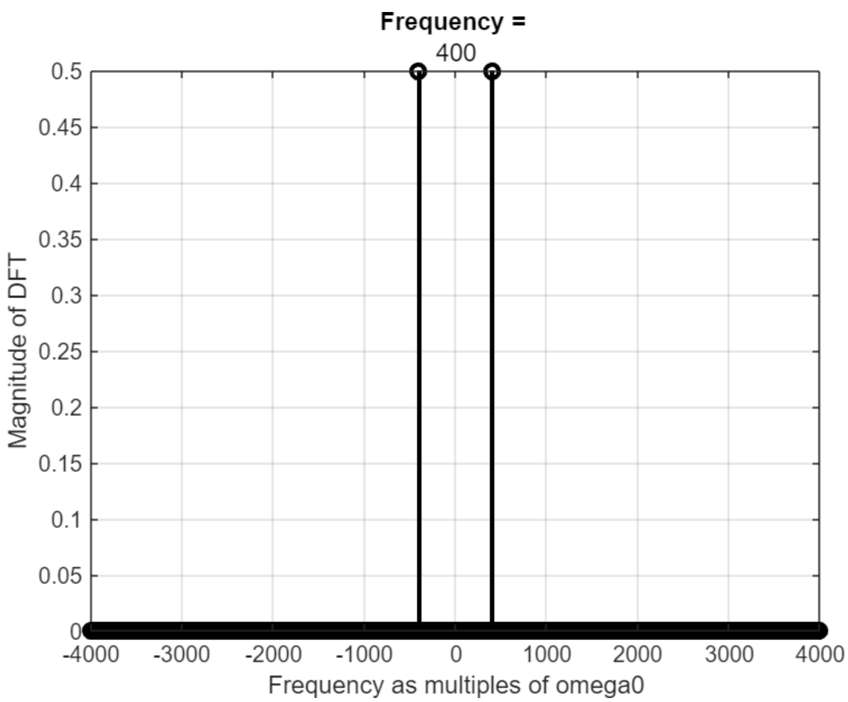


Frequency = 400Hz
Frequency =
401
Frequency =
402
Frequency =
440
Magnitude of DFT
Frequency as multiples of omega0
0
0.2
0.4
0.6
-4000
-2000
2000
4000

Observation:

The frequency 400Hz has a evenly distributed graph because the number of samples i.e. 8000 when divided by its frequency value give a whole number, whereas in the case of f = 401 and f = 402, the division yields a non-integer number whose decimal part is distributed among the neighbouring points. This, however, does not occur in the case of 440Hz because it is a special frequency of the music note A4 and MATLAB caters its case separately.

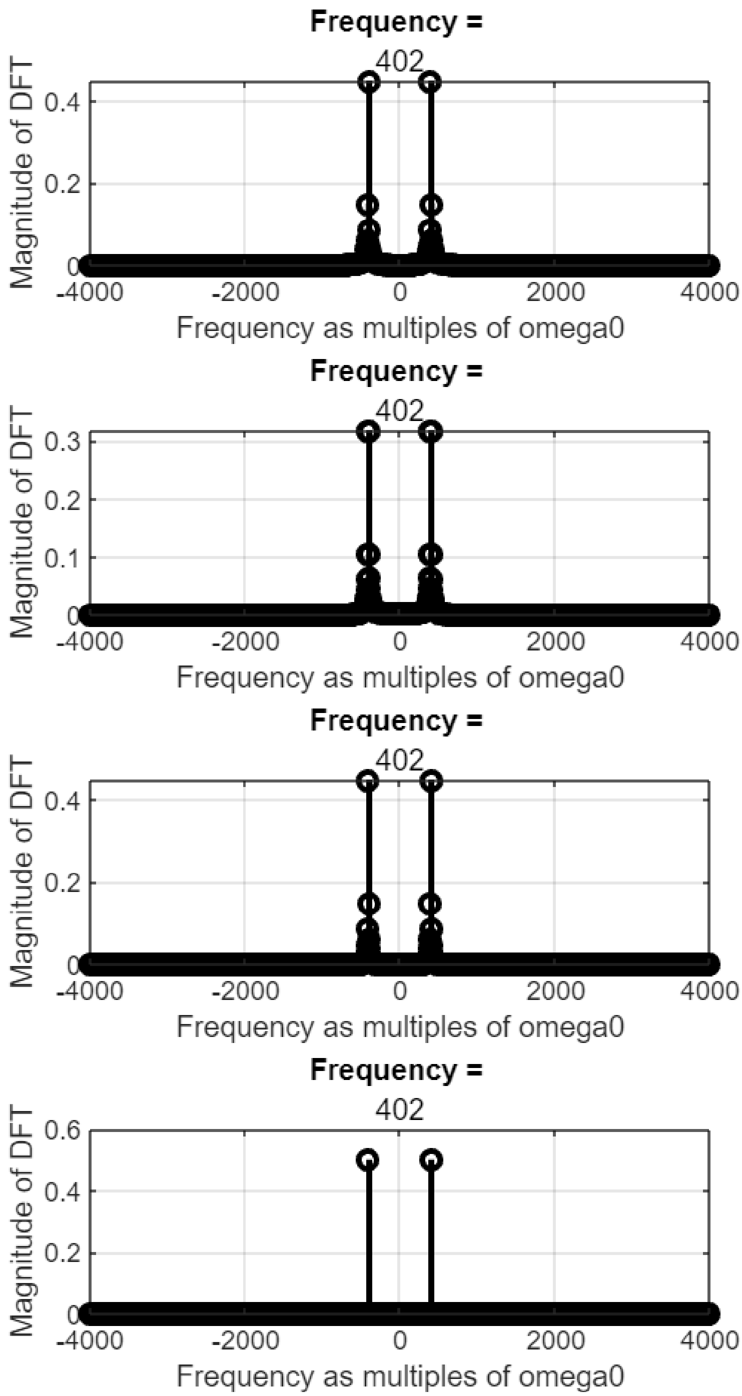
```
figure;
wave(400, 1500);
```



Observation:

Increasing the number of points does not have any effect on the graph.

```
figure('Position', [100, 100, 500, 1000]);
subplot 411
wave(402, 1000);
subplot 412
wave(402, 2000);
subplot 413
wave(402, 3000);
subplot 414
wave(402, 4000);
```



Frequency =
402
Magnitude of DFT
0.4
0.2
0
-4000
-2000
0
2000
4000
Frequency as multiples of omega0
Frequency =
402
Magnitude of DFT
0.3
0.2
0.1
0
-4000
-2000
0
2000
4000
Frequency as multiples of omega0
Frequency =
402
Magnitude of DFT
0.4
0.2
0
-4000
-2000
0
2000
4000
Frequency as multiples of omega0
Frequency =
402
Magnitude of DFT
0.6
0.4
0.2
0
-4000
-2000
0
2000
4000
Frequency as multiples of omega0

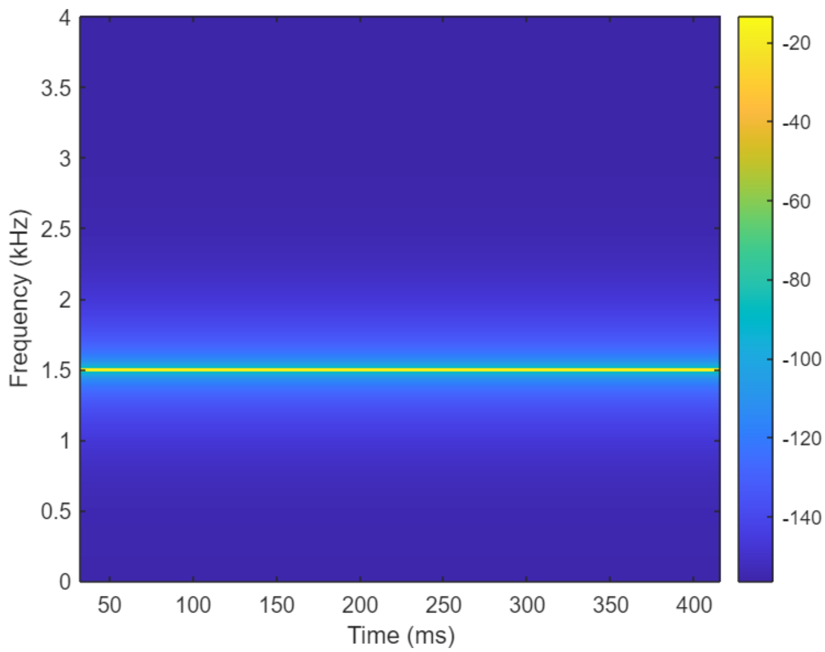
Observation:

Increasing the number of samples leads to a more focused representation of the fundamental frequency component which neglects the other frequency components present in the signal. This shows that there is a trade-off between frequency resolution and the ability to detect multiple frequency components when analyzing signals using Fourier transforms.

Task 3

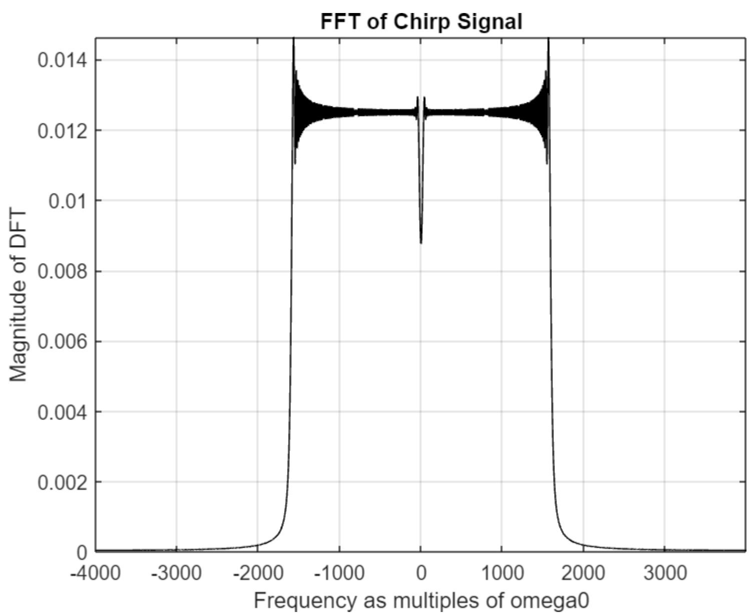
Test code

```
clc; clear; close all;
fs=8000;
xx = cos(3000*pi*(0:1/fs:0.5));
spectrogram(xx,1024,[],1024,fs,'yaxis');
colorbar
```



Code

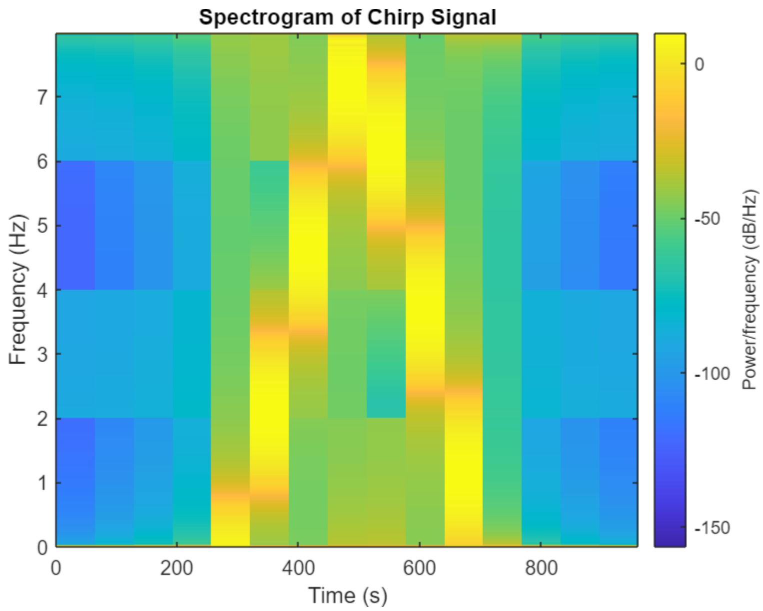
```
clc; clear; close all;
fs = 8000; % Sampling frequency (Hz)
n = fs;
t = (0:(n-1))/fs; % Time vector
x = sin(2*pi*800*t.^2); % Chirp signal
hx = fft(x,n);
shx = fftshift(hx);
figure;
plot(-n/2:n/2-1,abs(shx)/n,'k');
title('FFT of Chirp Signal')
ylabel('Magnitude of FFT');
xlabel('Frequency as multiples of omega0');
axis([-n/2 n/2-1 0 inf]);
grid;
```



Observation:

The FFT of the chirp signal shows us the different frequencies that exist inside of it.

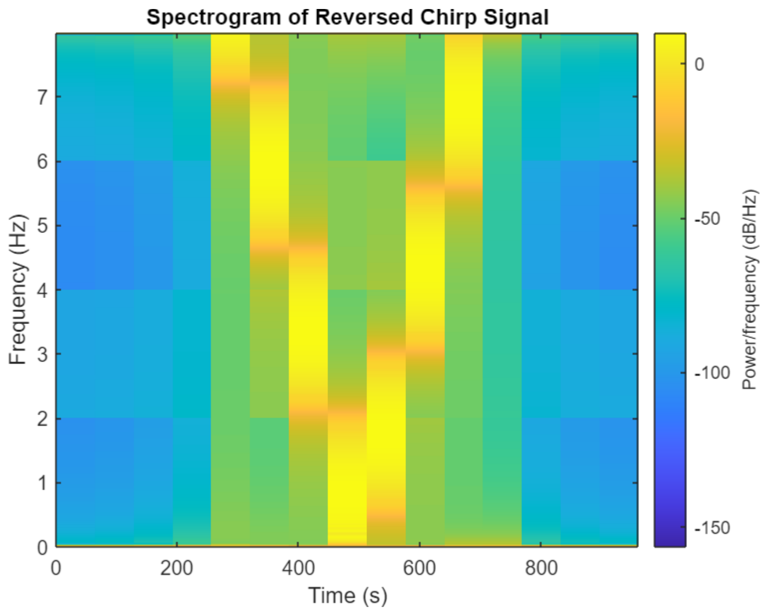
```
windowLength = 512;
fftLength = 1024;
spectrogram(shx, windowLength, 0, fftLength, fs, 'yaxis');
title('Spectrogram of Chirp Signal');
xlabel('Time (s)');
ylabel('Frequency (Hz)');
```



Observation:

The spectrogram of the signal shows us the variation in frequencies inside by the signal with respect to time and it uses different colors to indicate the intensity of the signal at those frequencies. It helps us analyze the changes in the local frequency content as opposed to global frequency content.

```
%Spectrogram of Reversed Signal
x_reversed = x(8000:-1:1);
hx = fft(x_reversed,n);
shx = fftshift(hx);
figure;
spectrogram(shx, windowLength, 0, fftLength, fs, 'yaxis');
title('Spectrogram of Reversed Chirp Signal');
xlabel('Time (s)');
ylabel('Frequency (Hz)');
```



Observation:

The spectrogram of the reversed chirp signal reveals the variation in frequency content over time, with frequencies decreasing instead of increasing due to the reversal of the signal.

```
function wave(f, n)
fs = 8000;
m  =  (0:(n-1))/fs;
x = sin(2*pi*f*m);
hx = fft(x,  n);
shx = fftshift(hx);
fHz = abs(shx)/n;
fshift = (-n/2:n/2-1)*(fs/n);
stem(fshift,fHz,'k','LineWidth', 2)
title('Frequency = ', num2str(f));
ylabel('Magnitude of DFT');
xlabel('Frequency as multiples of omega0');
grid;
end
```

Lab 10: Frequency Spectrum

Habib University

EE-252 Signal and Systems

Name: Student ID

Marks distribution:

<table>
<tr><td></td><td></td><td>LR2</td><td>LR5</td><td>LR9</td><td>AR4</td><td>AR7</td></tr>
<tr><td rowspan="3">In-Lab</td><td>Task 1</td><td>2</td><td>4</td><td>6</td><td rowspan="3">12</td><td></td></tr>
<tr><td>Task 2</td><td>8</td><td>16</td><td>8</td><td>2</td></tr>
<tr><td>Task 3</td><td>4</td><td>8</td><td>8</td><td>2</td></tr>
<tr><td colspan="2">Max Marks = 80</td><td>14</td><td>28</td><td>22</td><td>12</td><td>4</td></tr>
</table>

Marks obtained:

<table>
<tr><td></td><td></td><td>LR2</td><td>LR5</td><td>LR9</td><td>AR4</td><td>AR7</td></tr>
<tr><td rowspan="3">In-Lab</td><td>Task 1</td><td></td><td></td><td></td><td rowspan="3"></td><td></td></tr>
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<tr><td colspan="2">Max Marks =</td><td></td><td></td><td></td><td></td><td></td></tr>
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