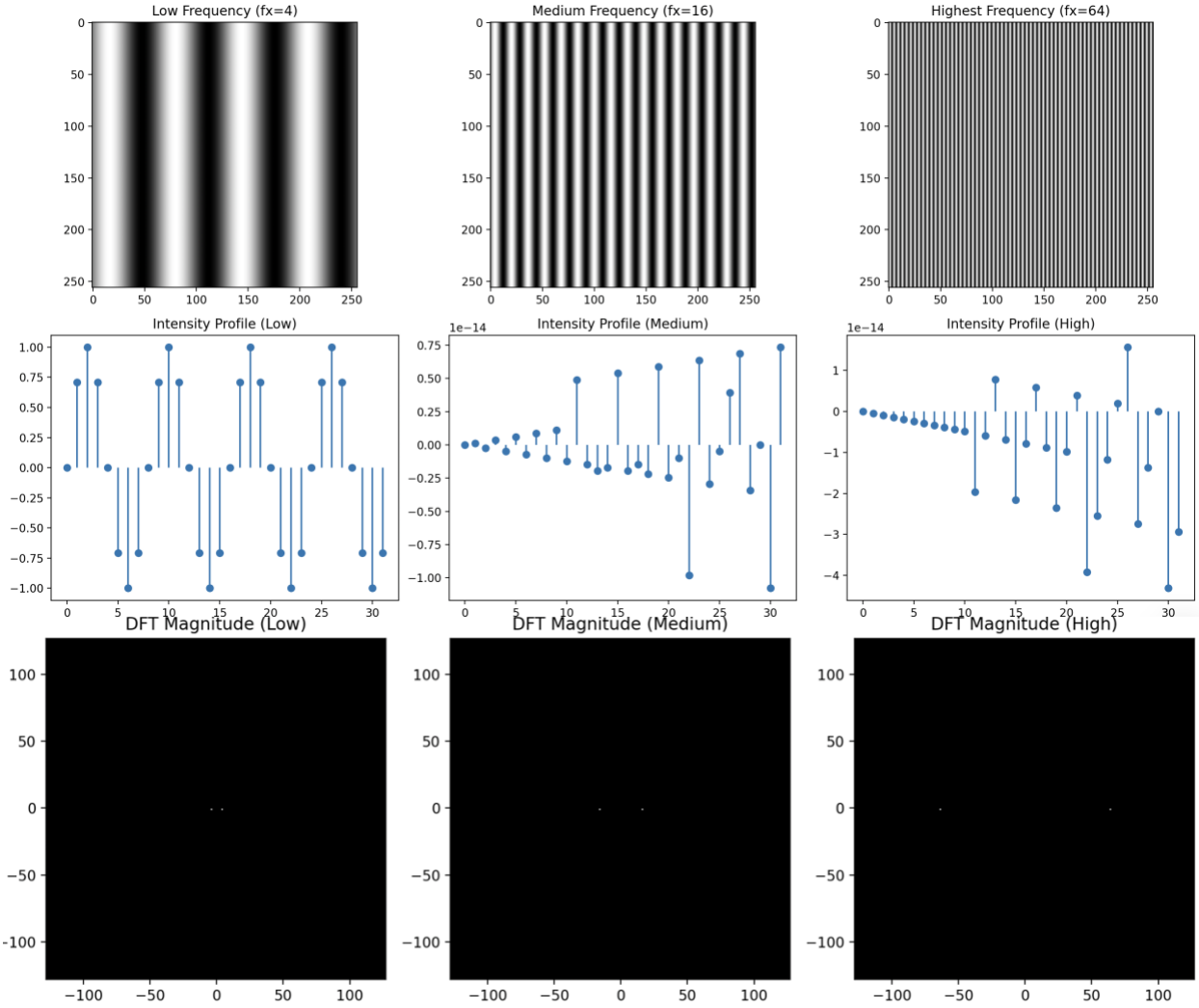
Question 1:



As we can see, the DFT points on the low frequency are closer together. This means that we are dividing the frequency range into smaller intervals. This is what we call a higher frequency resolution.

We see the points spread further apart as the frequency gets higher which means that each DFT point is representing a wider range of frequencies. This allows us to look at the spectral content more broadly as opposed to a lower frequency.

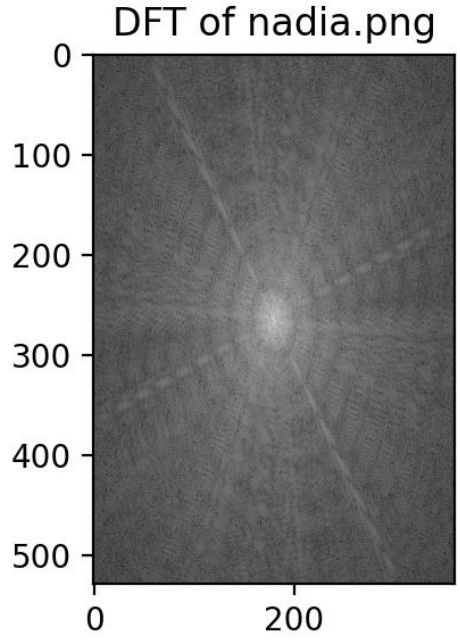
```
import numpy as np
import matplotlib.pyplot as plt


# Define image dimensions
width, height = 256, 256



fx_low = 4  #low freq
```

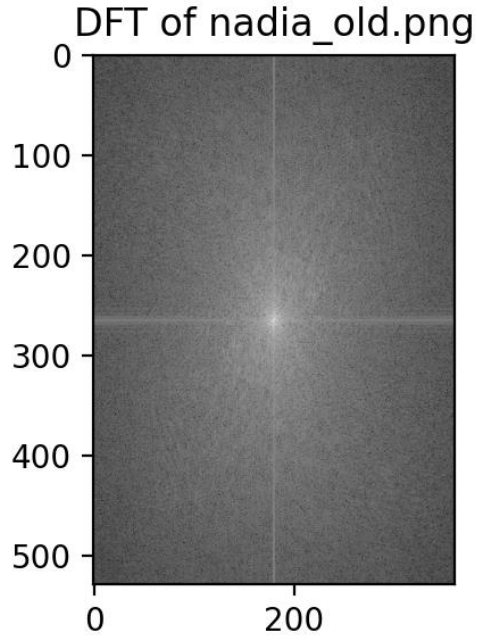
```
fx_medium = 16  # medium freq
fx_high = 64 #high frequency


x = np.linspace(0, 1, width, endpoint=False)
y = np.linspace(0, 1, height, endpoint=False)
x, y = np.meshgrid(x, y)


grating_low = np.sin(2 * np.pi * fx_low * x)
grating_medium = np.sin(2 * np.pi * fx_medium * x)
grating_high = np.sin(2 * np.pi * fx_high * x)

intensity_profile_low_row = np.mean(grating_low, axis=0)
intensity_profile_low_col = np.mean(grating_low, axis=1)

intensity_profile_medium_row = np.mean(grating_medium, axis=0)
intensity_profile_medium_col = np.mean(grating_medium, axis=1)

intensity_profile_high_row = np.mean(grating_high, axis=0)
intensity_profile_high_col = np.mean(grating_high, axis=1)


plt.figure(figsize=(16, 8))

plt.subplot(231)
plt.imshow(grating_low, cmap='gray')
plt.title(f'Low Frequency (fx={fx_low})')

plt.subplot(232)
plt.imshow(grating_medium, cmap='gray')
plt.title(f'Medium Frequency (fx={fx_medium})')

plt.subplot(233)
plt.imshow(grating_high, cmap='gray')
plt.title(f'Highest Frequency (fx={fx_high})')

plt.subplot(234)
```

```
skip = 8
plt.stem(intensity_profile_low_row[::skip], use_line_collection=True, basefmt=" ")
plt.title('Intensity Profile (Low)')

plt.subplot(235)
plt.stem(intensity_profile_medium_row[::skip], use_line_collection=True, basefmt=" ")
plt.title('Intensity Profile (Medium)')

plt.subplot(236)
plt.stem(intensity_profile_high_row[::skip], use_line_collection=True, basefmt=" ")
plt.title('Intensity Profile (High)')

plt.tight_layout()
plt.show()

dft_low = np.fft.fft2(grating_low)
dft_medium = np.fft.fft2(grating_medium)
dft_high = np.fft.fft2(grating_high)

lowspec = np.abs(dft_low)
medspec = np.abs(dft_medium)
highspec = np.abs(dft_high)

plt.figure(figsize=(12, 4))

plt.subplot(131)
plt.imshow(np.fft.fftshift(lowspec), cmap='gray', extent=(-128, 127, -128, 127))
plt.title(f'DFT Magnitude (Low)')

plt.subplot(132)
plt.imshow(np.fft.fftshift(medspec), cmap='gray', extent=(-128, 127, -128, 127))
plt.title(f'DFT Magnitude (Medium)')

plt.subplot(133)
plt.imshow(np.fft.fftshift(highspec), cmap='gray', extent=(-128, 127, -128, 127))
plt.title(f'DFT Magnitude (High)')
```

```
plt.tight_layout()
plt.show()
```

Question 2:



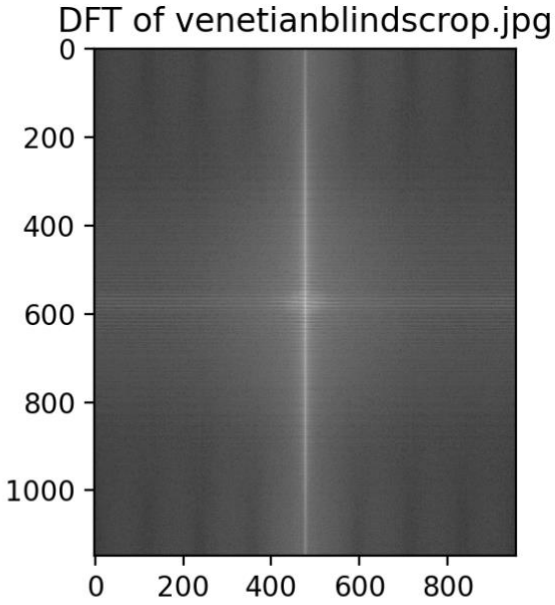


As we can see in the nadia.png DFT, we see that the DFT is bigger and more spread apart as opposed to refined in the nadia_old.png. This is because there is more to be shown in the

nadia_old.png and so the point is more defined, and smaller, meaning the frequency range is being divided into smaller intervals to show more.

```
import cv2
import numpy as np
import matplotlib.pyplot as plt

# Question 2a
nadia_image = cv2.imread("/Users/kasi/Desktop/nadia.png", cv2.IMREAD_GRAYSCALE)
nadia_old_image = cv2.imread("/Users/kasi/Desktop/nadia_old.png", cv2.IMREAD_GRAYSCALE)

# Compute the DFTs of the images
nadia_dft = np.fft.fft2(nadia_image)
nadia_dft_shift = np.fft.fftshift(nadia_dft)
nadia_magnitude_spectrum = np.log(np.abs(nadia_dft_shift) + 1)

nadia_old_dft = np.fft.fft2(nadia_old_image)
nadia_old_dft_shift = np.fft.fftshift(nadia_old_dft)
nadia_old_magnitude_spectrum = np.log(np.abs(nadia_old_dft_shift) + 1)

plt.figure(figsize=(7, 6))

# show nadia.png
plt.subplot(2, 2, 1)
plt.imshow(nadia_image, cmap='gray')
plt.title('nadia.png')
plt.axis('off')

#nadia.png DFT
plt.subplot(2, 2, 2)
plt.imshow(nadia_magnitude_spectrum, cmap='gray')
plt.title('DFT of nadia.png')

# show nadia_old.png
plt.subplot(2, 2, 3)
plt.imshow(nadia_old_image, cmap='gray')
plt.title('nadia_old.png')
plt.axis('off')
```

```
# nadia_old.png DFT
plt.subplot(2, 2, 4)
plt.imshow(nadia_old_magnitude_spectrum, cmap='gray')
plt.title('DFT of nadia_old.png')

plt.tight_layout()
plt.show()
```



In the venetialblindscrop, we can see the lines that are being made in the picure through the DFT. The black lines covering the picture allow for the point to be smaller, as there is less to show, and we can see a straight line as that is what is most apparent in the picture. We see a black line shadow which is depicted in the DFT.

```
import cv2
import numpy as np
import matplotlib.pyplot as plt

# Question 2b
venetianblinds_image = cv2.imread("/Users/kasi/Desktop/venetianblindscrop.jpg", cv2.IMREAD_GRAYSCALE)
```

```
venetianblinds_dft = np.fft.fft2(venetianblinds_image)
venetianblinds_dft_shift = np.fft.fftshift(venetianblinds_dft)
venetianblinds_magnitude_spectrum = np.log(np.abs(venetianblinds_dft_shift) + 1)

plt.figure(figsize=(7, 6))

# show venetianblindscrop.jpg
plt.subplot(2, 2, 1)
plt.imshow(venetianblinds_image, cmap='gray')
plt.title('venetianblindscrop.jpg')
plt.axis('off')

# venetianblindscrop.jpg DFT
plt.subplot(2, 2, 2)
plt.imshow(venetianblinds_magnitude_spectrum, cmap='gray')
plt.title('DFT of venetianblindscrop.jpg')

plt.tight_layout()
plt.show()
```

Question 3:

```
import cv2
import numpy as np
import matplotlib.pyplot as plt
from PIL import Image, ImageFilter

# Question 3
nadia_old_image = cv2.imread("/Users/kasi/Desktop/nadia_old.png", cv2.IMREAD_GRAYSCALE)

image = Image.open(r"/Users/kasi/Desktop/nadia_old.png")
image = image.filter(ImageFilter.GaussianBlur)

gausianimg = cv2.imread(image, cv2.IMREAD_GRAYSCALE)
```

```
nadia_old_dft = np.fft.fft2(nadia_old_image)
nadia_old_dft_shift = np.fft.fftshift(nadia_old_dft)
nadia_old_magnitude_spectrum = np.log(np.abs(nadia_old_dft_shift) + 1)

gausiandft = np.fft.fft2(image)
gausiandftshift = np.fft.fftshift(image)
gausianmag = np.log(np.abs(gausiandftshift) + 1)

plt.figure(figsize=(7, 6))


# show nadia_old.png
plt.subplot(2, 2, 1)
plt.imshow(nadia_old_image, cmap='gray')
plt.title('nadia_old.png')
plt.axis('off')

# nadia_old.png DFT
plt.subplot(2, 2, 2)
plt.imshow(nadia_old_magnitude_spectrum, cmap='gray')
plt.title('DFT of nadia_old.png')



plt.subplot(2,2,3)
plt.imshow(image, cmap='gray')
plt.title('nadia_old filter')
plt.axis('off')

plt.subplot(2, 2, 4)
plt.imshow(gausianmag, cmap='gray')
plt.title('DFT of gausian')

plt.tight_layout()
plt.show()
```