In [1]:
```
pip install matplotlib
```

```
Requirement already satisfied: matplotlib in ./.conda/envs/my5920_env/lib/python3.1
0/site-packages (3.10.0)
Requirement already satisfied: contourpy>=1.0.1 in ./.conda/envs/my5920_env/lib/pyth
on3.10/site-packages (from matplotlib) (1.3.1)
Requirement already satisfied: cycler>=0.10 in ./.conda/envs/my5920_env/lib/python3.
10/site-packages (from matplotlib) (0.12.1)
Requirement already satisfied: fonttools>=4.22.0 in ./.conda/envs/my5920_env/lib/pyt
hon3.10/site-packages (from matplotlib) (4.56.0)
Requirement already satisfied: kiwisolver>=1.3.1 in ./.conda/envs/my5920_env/lib/pyt
hon3.10/site-packages (from matplotlib) (1.4.8)
Requirement already satisfied: numpy>=1.23 in ./.conda/envs/my5920_env/lib/python3.1
0/site-packages (from matplotlib) (2.2.3)
Requirement already satisfied: packaging>=20.0 in ./.conda/envs/my5920_env/lib/pytho
n3.10/site-packages (from matplotlib) (24.2)
Requirement already satisfied: pillow>=8 in ./.conda/envs/my5920_env/lib/python3.10/
site-packages (from matplotlib) (11.1.0)
Requirement already satisfied: pyparsing>=2.3.1 in ./.conda/envs/my5920_env/lib/pyth
on3.10/site-packages (from matplotlib) (3.2.1)
Requirement already satisfied: python-dateutil>=2.7 in ./.conda/envs/my5920_env/lib/
python3.10/site-packages (from matplotlib) (2.9.0.post0)
Requirement already satisfied: six>=1.5 in ./.conda/envs/my5920_env/lib/python3.10/s
ite-packages (from python-dateutil>=2.7->matplotlib) (1.16.0)
Note: you may need to restart the kernel to use updated packages.
```

In [ ]:
```
#problem 1.1
```

In [2]:
```
import torch
import torchvision
import torchvision.transforms as transforms
from torch.utils.data import Subset

# Define the transform to normalize
transform = transforms.Compose([
    transforms.ToTensor(),  #image to tensor
    transforms.Normalize((0.1307,), (0.3081,))  # Normalize with mean and std of MN
])

# loading the MNIST dataset
mnist_dataset = torchvision.datasets.MNIST(root='./data', train=True, download=True

# Create a subset of 1,000 samples
subset_indices = torch.randperm(len(mnist_dataset))[:1000]  # Randomly select 1,000
mnist_subset = Subset(mnist_dataset, subset_indices)

# Checking sample shape and label
sample_image, sample_label = mnist_subset[0]
print(f"Image Shape: {sample_image.shape}, Label: {sample_label}")
```

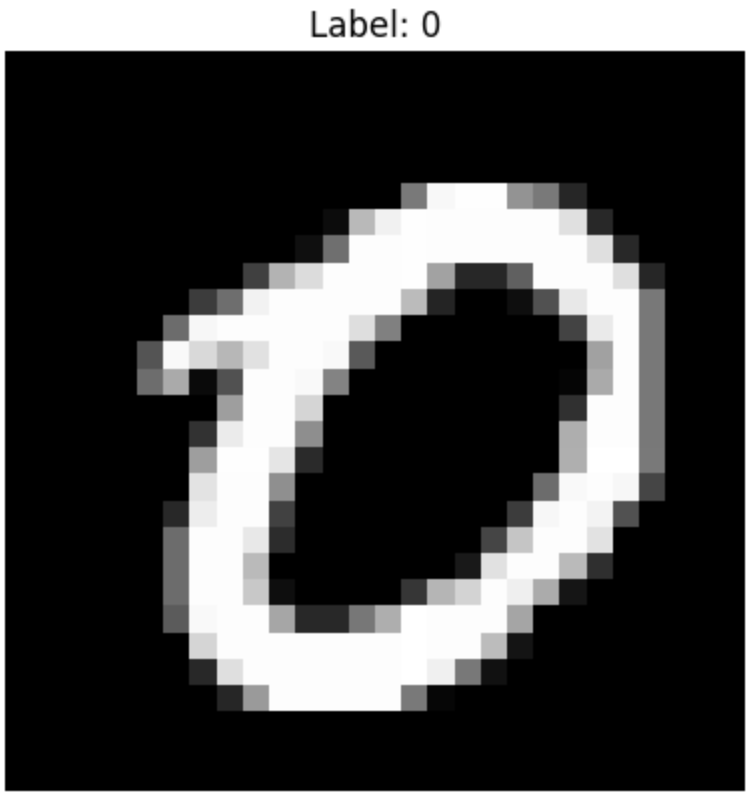
```
Image Shape: torch.Size([1, 28, 28]), Label: 8
```

In [16]:
```
pip install pillow
```

```
Requirement already satisfied: pillow in ./.conda/envs/my5920_env/lib/python3.10/sit
e-packages (11.1.0)
Note: you may need to restart the kernel to use updated packages.
```

In [ ]:

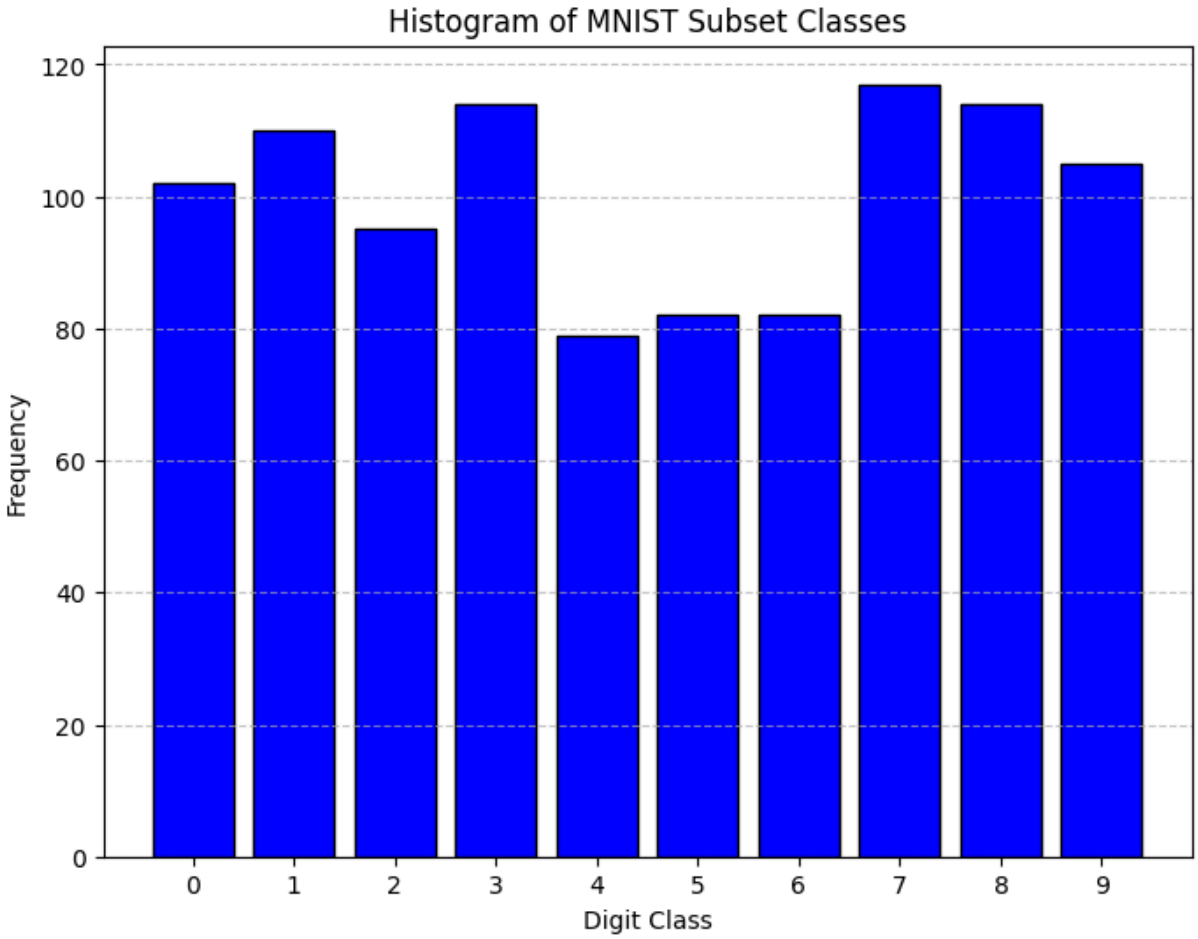
In [3]:
```python
import matplotlib.pyplot as plt
import torchvision.transforms as transforms

# a sample image from the MNIST subset
image, label = mnist_subset[1]  # First image from the subset

# Convert from tensor (C, H, W) to (H, W) and plot
plt.imshow(image.squeeze(), cmap='gray')  # Remove channel dimension and display
plt.title(f"Label: {label}")
plt.axis("off")
plt.show()
```



In [ ]:
```python
#problem 1.2
```

In [4]:
```python
import matplotlib.pyplot as plt
# Extract labels from the subset
labels = [mnist_subset[i][1] for i in range(len(mnist_subset))]

# Plot histogram of class distribution
plt.figure(figsize=(8, 6))
plt.hist(labels, bins=range(11), align='left', rwidth=0.8, color='blue', edgecolor=
plt.xticks(range(10))  # Digits 0-9
plt.xlabel("Digit Class")
plt.ylabel("Frequency")
```

```
plt.title("Histogram of MNIST Subset Classes")
plt.grid(axis='y', linestyle='--', alpha=0.7)
plt.show()
```



In [ ]:
```
#problem 1.3
```

In [25]:
```
pip install einops
```

```
Collecting einops
  Downloading einops-0.8.1-py3-none-any.whl.metadata (13 kB)
Downloading einops-0.8.1-py3-none-any.whl (64 kB)
Installing collected packages: einops
Successfully installed einops-0.8.1
Note: you may need to restart the kernel to use updated packages.
```

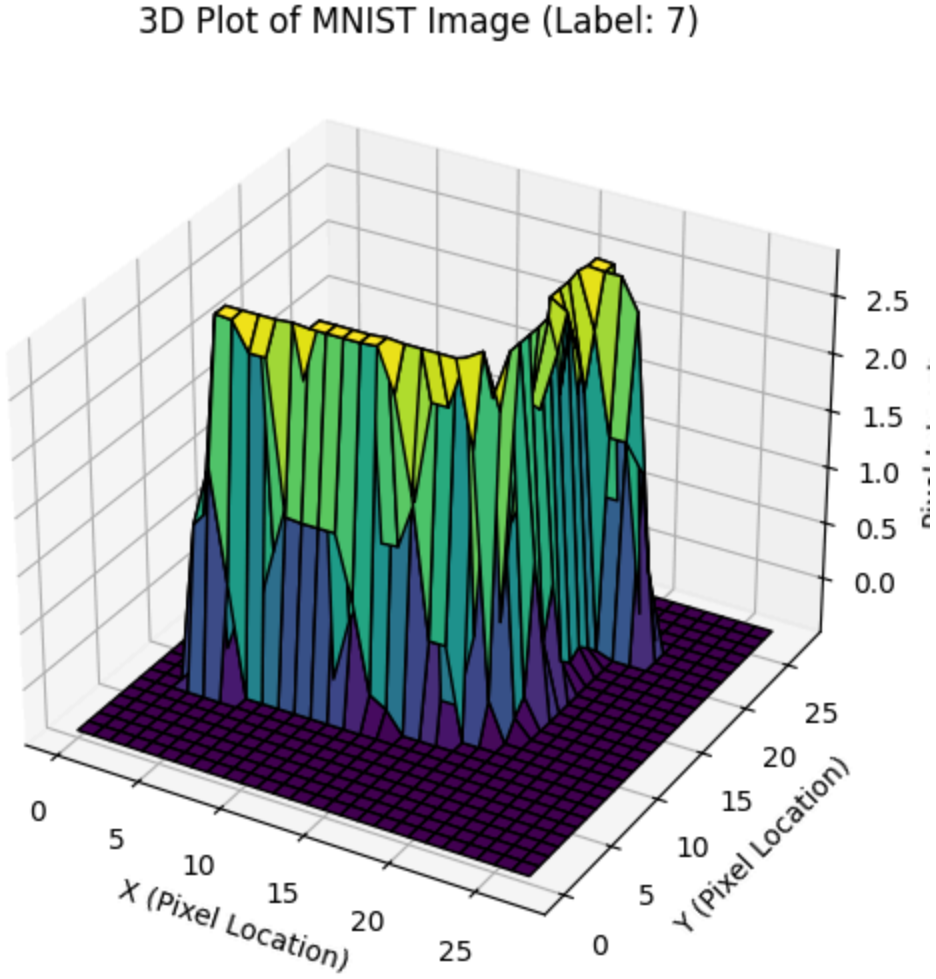
In [5]:
```
from torch.utils.data import Subset, DataLoader
from einops import rearrange

# Extract images and labels from the subset
images = torch.stack([mnist_subset[i][0] for i in range(len(mnist_subset))])
labels = torch.tensor([mnist_subset[i][1] for i in range(len(mnist_subset))])

# Reshape using einops: [1000, 1, 28, 28] → [40, 25, 1, 28, 28]
batch_size = 25
batched_images = rearrange(images, '(b s) c h w -> b s c h w', s=batch_size)
batched_labels = rearrange(labels, '(b s) -> b s', s=batch_size)
```

In [6]:
```
print("Batched Image Shape:", batched_images.shape)
print("Batched Label Shape:", batched_labels.shape)
```

```
Batched Image Shape: torch.Size([40, 25, 1, 28, 28])
Batched Label Shape: torch.Size([40, 25])
```

In [ ]:
```
#problem 1.4
```

In [7]:
```
import torch
import torchvision
import torchvision.transforms as transforms
import numpy as np
import matplotlib.pyplot as plt
from mpl_toolkits.mplot3d import Axes3D


# Randomly select one image sample
random_idx = torch.randint(0, len(mnist_dataset), (1,)).item()
image, label = mnist_dataset[random_idx]

# Convert the image tensor to a NumPy array
image_np = image.squeeze().numpy()  # Shape: (28, 28)

# Generate x, y grid coordinates
x = np.arange(28)
y = np.arange(28)
X, Y = np.meshgrid(x, y)

# Plot the 3D surface
fig = plt.figure(figsize=(8, 6))
ax = fig.add_subplot(111, projection='3d')

# Create the surface plot
ax.plot_surface(X, Y, image_np, cmap='viridis', edgecolor='k')

# Labels and title
ax.set_xlabel("X (Pixel Location)")
ax.set_ylabel("Y (Pixel Location)")
ax.set_zlabel("Pixel Intensity")
ax.set_title(f"3D Plot of MNIST Image (Label: {label})")

plt.show()
```



In [39]:
```
pip install pandas
```

```
Collecting pandas
  Downloading pandas-2.2.3-cp310-cp310-manylinux_2_17_x86_64.manylinux2014_x86_64.wh
l.metadata (89 kB)
Requirement already satisfied: numpy>=1.22.4 in ./.conda/envs/my5920_env/lib/python
3.10/site-packages (from pandas) (2.2.3)
Requirement already satisfied: python-dateutil>=2.8.2 in ./.conda/envs/my5920_env/li
b/python3.10/site-packages (from pandas) (2.9.0.post0)
Collecting pytz>=2020.1 (from pandas)
  Downloading pytz-2025.1-py2.py3-none-any.whl.metadata (22 kB)
Collecting tzdata>=2022.7 (from pandas)
  Downloading tzdata-2025.1-py2.py3-none-any.whl.metadata (1.4 kB)
Requirement already satisfied: six>=1.5 in ./.conda/envs/my5920_env/lib/python3.10/s
ite-packages (from python-dateutil>=2.8.2->pandas) (1.16.0)
Downloading pandas-2.2.3-cp310-cp310-manylinux_2_17_x86_64.manylinux2014_x86_64.whl
(13.1 MB)
   ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 13.1/13.1 MB 116.5 MB/s eta 0:00:00
Downloading pytz-2025.1-py2.py3-none-any.whl (507 kB)
Downloading tzdata-2025.1-py2.py3-none-any.whl (346 kB)
Installing collected packages: pytz, tzdata, pandas
Successfully installed pandas-2.2.3 pytz-2025.1 tzdata-2025.1
Note: you may need to restart the kernel to use updated packages.
```

In [ ]:
```
#problem 2.2.1
```

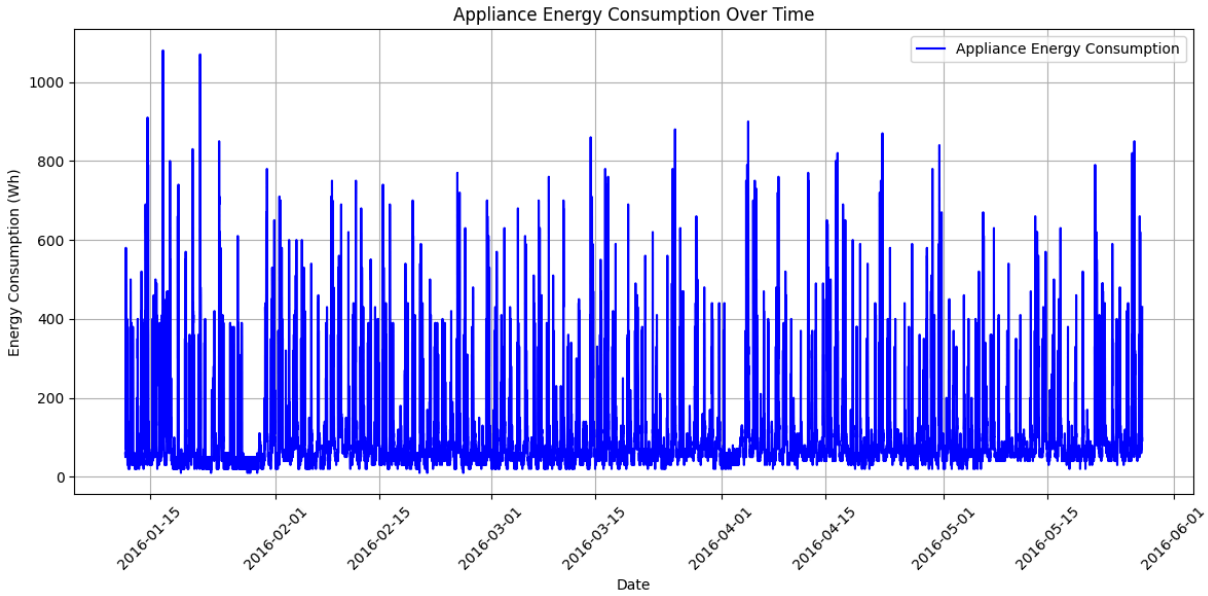
In [10]:
```
# Load the dataset (replace with the correct path to the file)
df = pd.read_csv('energydata_complete.csv')

# Display the first few rows to inspect the data structure
print(df.head())

# Convert the 'date' column to datetime type
df['date'] = pd.to_datetime(df['date'])
```

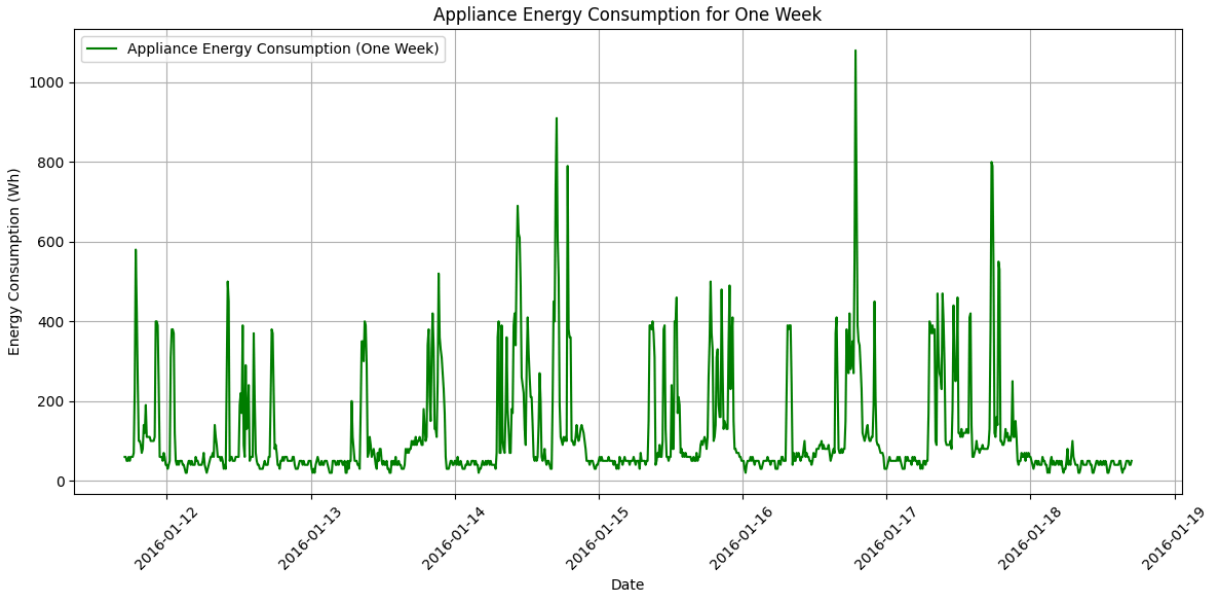
```
                 date  Appliances  lights     T1       RH_1    T2       RH_2  \
0 2016-01-11 17:00:00          60      30  19.89  47.596667  19.2  44.790000
1 2016-01-11 17:10:00          60      30  19.89  46.693333  19.2  44.722500
2 2016-01-11 17:20:00          50      30  19.89  46.300000  19.2  44.626667
3 2016-01-11 17:30:00          50      40  19.89  46.066667  19.2  44.590000
4 2016-01-11 17:40:00          60      40  19.89  46.333333  19.2  44.530000

      T3       RH_3         T4  ...          T9   RH_9     T_out  Press_mm_hg  \
0  19.79  44.730000  19.000000  ...   17.033333  45.53  6.600000        733.5
1  19.79  44.790000  19.000000  ...   17.066667  45.56  6.483333        733.6
2  19.79  44.933333  18.926667  ...   17.000000  45.50  6.366667        733.7
3  19.79  45.000000  18.890000  ...   17.000000  45.40  6.250000        733.8
4  19.79  45.000000  18.890000  ...   17.000000  45.40  6.133333        733.9

   RH_out  Windspeed  Visibility  Tdewpoint        rv1        rv2
0    92.0   7.000000   63.000000        5.3  13.275433  13.275433
1    92.0   6.666667   59.166667        5.2  18.606195  18.606195
2    92.0   6.333333   55.333333        5.1  28.642668  28.642668
3    92.0   6.000000   51.500000        5.0  45.410389  45.410389
4    92.0   5.666667   47.666667        4.9  10.084097  10.084097

[5 rows x 29 columns]
```

In [8]:
```
import pandas as pd
import matplotlib.pyplot as plt

# Load the dataset (replace with the correct path to the file)
df = pd.read_csv('energydata_complete.csv')

# Display the first few rows to inspect the data structure
print(df.head())

# Convert the 'date' column to datetime type
df['date'] = pd.to_datetime(df['date'])

# Plotting energy consumption over the entire period
plt.figure(figsize=(12, 6))
plt.plot(df['date'], df['Appliances'], label='Appliance Energy Consumption', color=
plt.xlabel('Date')
plt.ylabel('Energy Consumption (Wh)')
plt.title('Appliance Energy Consumption Over Time')
plt.grid(True)
plt.legend()
plt.xticks(rotation=45)
plt.tight_layout()
plt.show()
```

```
# Plotting energy consumption for one week (let's choose the first week)
start_date = df['date'].min()
end_date = start_date + pd.Timedelta(weeks=1)

# Filter the data for this one-week period
df_one_week = df[(df['date'] >= start_date) & (df['date'] < end_date)]

# Plot the energy consumption for this week
plt.figure(figsize=(12, 6))
plt.plot(df_one_week['date'], df_one_week['Appliances'], label='Appliance Energy Co
plt.xlabel('Date')
plt.ylabel('Energy Consumption (Wh)')
plt.title('Appliance Energy Consumption for One Week')
plt.grid(True)
plt.legend()
plt.xticks(rotation=45)
plt.tight_layout()
plt.show()
```

```
                 date  Appliances  lights     T1       RH_1    T2       RH_2  \
0  2016-01-11 17:00:00          60      30  19.89  47.596667  19.2  44.790000
1  2016-01-11 17:10:00          60      30  19.89  46.693333  19.2  44.722500
2  2016-01-11 17:20:00          50      30  19.89  46.300000  19.2  44.626667
3  2016-01-11 17:30:00          50      40  19.89  46.066667  19.2  44.590000
4  2016-01-11 17:40:00          60      40  19.89  46.333333  19.2  44.530000

      T3       RH_3         T4  ...         T9   RH_9     T_out  Press_mm_hg  \
0  19.79  44.730000  19.000000  ...  17.033333  45.53  6.600000        733.5
1  19.79  44.790000  19.000000  ...  17.066667  45.56  6.483333        733.6
2  19.79  44.933333  18.926667  ...  17.000000  45.50  6.366667        733.7
3  19.79  45.000000  18.890000  ...  17.000000  45.40  6.250000        733.8
4  19.79  45.000000  18.890000  ...  17.000000  45.40  6.133333        733.9

   RH_out  Windspeed  Visibility  Tdewpoint        rv1        rv2
0    92.0   7.000000   63.000000        5.3  13.275433  13.275433
1    92.0   6.666667   59.166667        5.2  18.606195  18.606195
2    92.0   6.333333   55.333333        5.1  28.642668  28.642668
3    92.0   6.000000   51.500000        5.0  45.410389  45.410389
4    92.0   5.666667   47.666667        4.9  10.084097  10.084097

[5 rows x 29 columns]
```



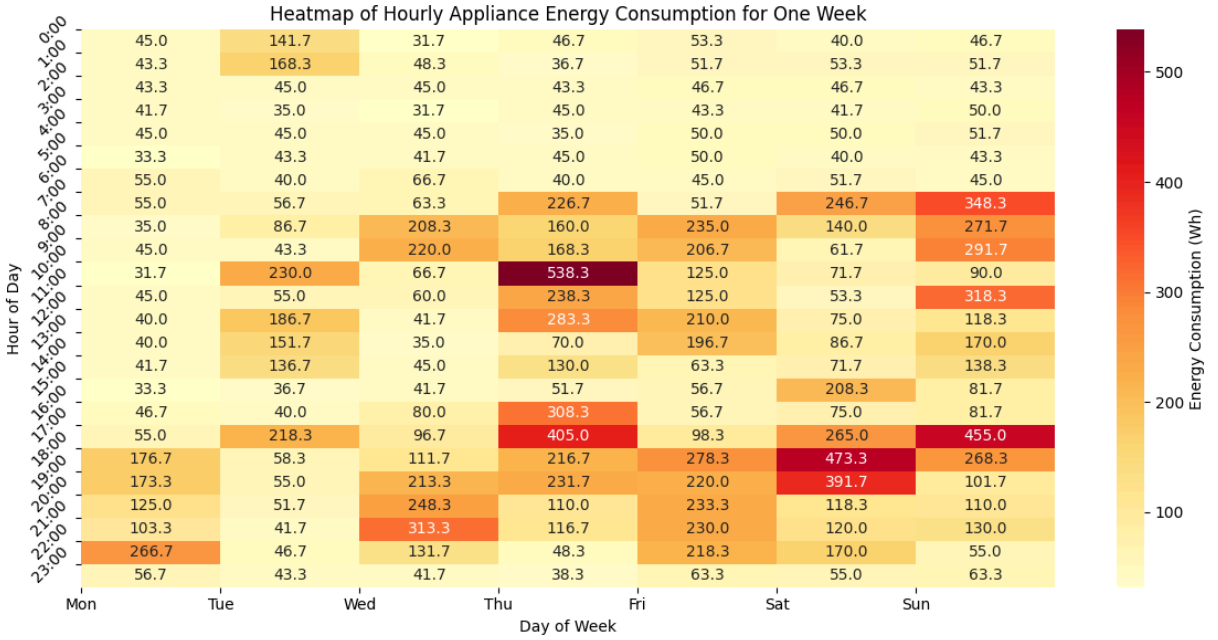


In [ ]:
```
#problem 2.2.2
```

In [16]:
```
import seaborn as sns

# Select the data for one week (e.g., the first 7 days of data)
start_date = df['date'].min()
end_date = start_date + pd.Timedelta(weeks=1)

# Filter data for the one-week period
df_one_week = df[(df['date'] >= start_date) & (df['date'] < end_date)]

# Set the 'date' column as the index for resampling
df_one_week.set_index('date', inplace=True)

# Resample the data to hourly averages (since the data is in 10-minute intervals)
df_hourly = df_one_week['Appliances'].resample('H').mean()

# Create a new DataFrame for the heatmap, which will be structured by hour of the d
df_heatmap = df_hourly.groupby([df_hourly.index.hour, df_hourly.index.weekday]).mea
```

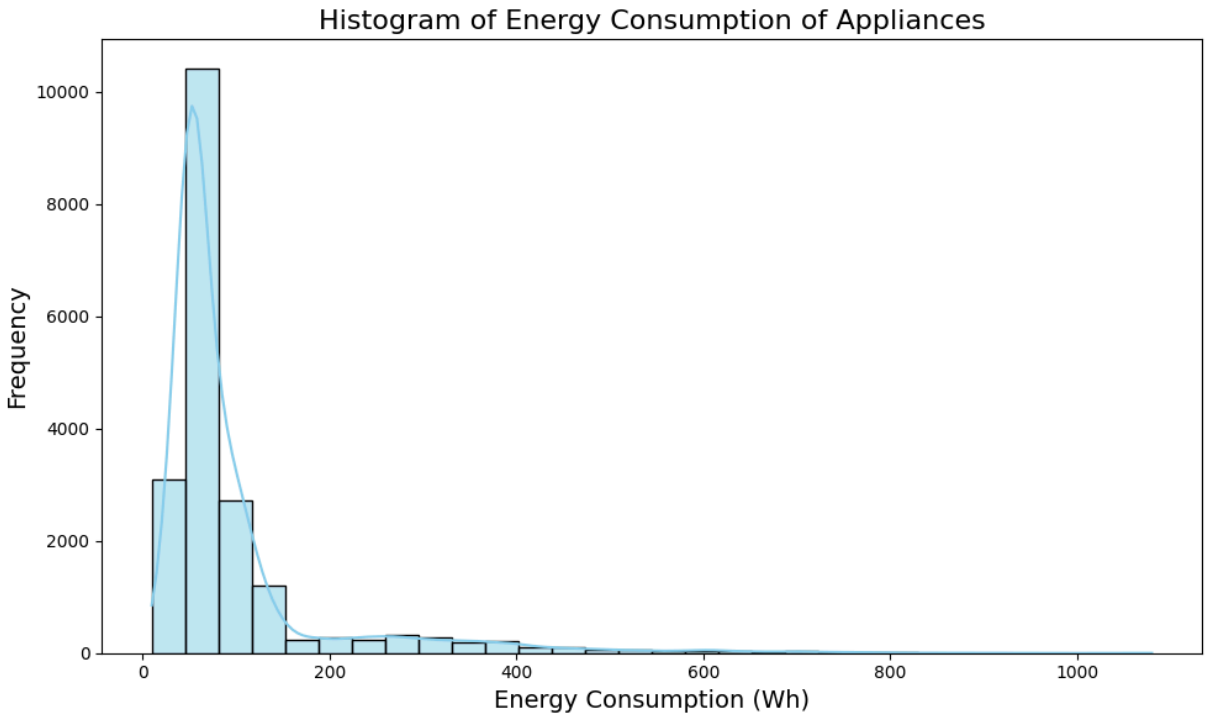
```
# Plotting the heatmap
plt.figure(figsize=(12, 6))
sns.heatmap(df_heatmap, cmap='YlOrRd', annot=True, fmt='.1f', cbar_kws={'label': 'E
plt.ylabel('Hour of Day')
plt.xlabel('Day of Week')
plt.title('Heatmap of Hourly Appliance Energy Consumption for One Week')
plt.yticks(ticks=range(0, 24), labels=[f'{i}:00' for i in range(24)], rotation=45)
plt.xticks(ticks=range(7), labels=['Mon', 'Tue', 'Wed', 'Thu', 'Fri', 'Sat', 'Sun']
plt.tight_layout()
plt.show()
```

```
/tmp/ipykernel_513178/345016752.py:14: FutureWarning: 'H' is deprecated and will be
removed in a future version, please use 'h' instead.
  df_hourly = df_one_week['Appliances'].resample('H').mean()
```



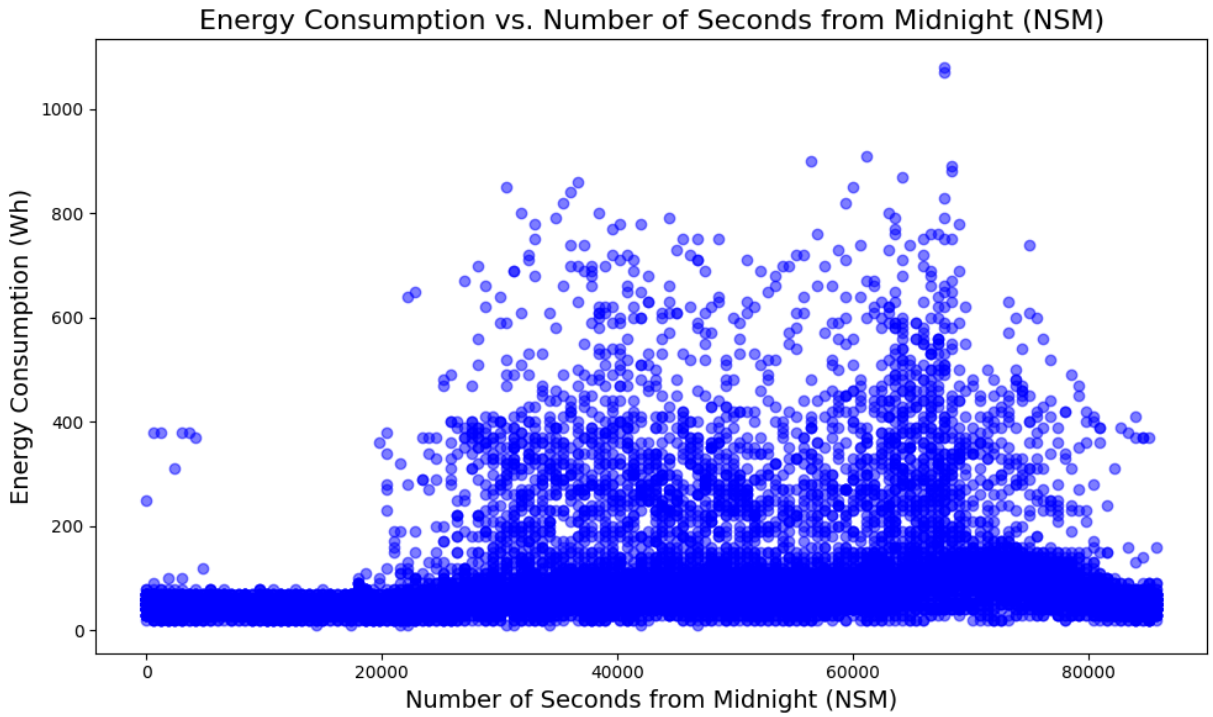
In [ ]:
```
#problem 2.2.3
```

In [45]:
```
# Plotting the histogram of energy consumption
plt.figure(figsize=(10, 6))
sns.histplot(df['Appliances'], bins=30, kde=True, color='skyblue', edgecolor='black

# Adding titles and labels
plt.title('Histogram of Energy Consumption of Appliances', fontsize=16)
plt.xlabel('Energy Consumption (Wh)', fontsize=14)
plt.ylabel('Frequency', fontsize=14)

# Show the plot
plt.tight_layout()
plt.show()
```



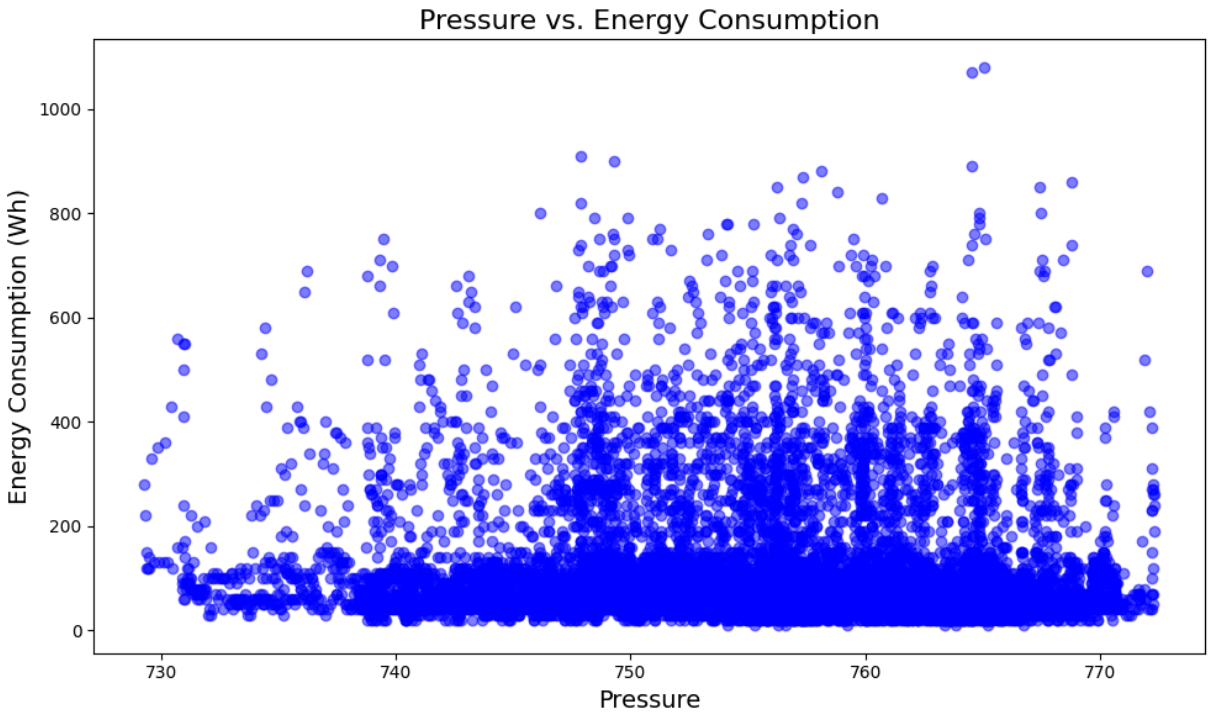
In [ ]:
```
#problem 2.2.4
```

In [46]:
```
# Convert 'date' to datetime
df['date'] = pd.to_datetime(df['date'])

# Extract the time part from the 'date' column
df['time'] = df['date'].dt.time

# Calculate the number of seconds from midnight for each entry
df['NSM'] = df['date'].dt.hour * 3600 + df['date'].dt.minute * 60 + df['date'].dt.s

# Plotting energy consumption vs. NSM (number of seconds from midnight)
plt.figure(figsize=(10, 6))
plt.scatter(df['NSM'], df['Appliances'], alpha=0.5, color='blue')

# Adding titles and labels
plt.title('Energy Consumption vs. Number of Seconds from Midnight (NSM)', fontsize=
plt.xlabel('Number of Seconds from Midnight (NSM)', fontsize=14)
plt.ylabel('Energy Consumption (Wh)', fontsize=14)

# Show the plot
plt.tight_layout()
plt.show()
```



In [ ]:
```
#problem 2.2.5
```

In [47]:
```
plt.figure(figsize=(10, 6))
plt.scatter(df['Press_mm_hg'], df['Appliances'], alpha=0.5, color='blue')

# Adding titles and labels
plt.title('Pressure vs. Energy Consumption', fontsize=16)
plt.xlabel('Pressure', fontsize=14)
plt.ylabel('Energy Consumption (Wh)', fontsize=14)

# Show the plot
plt.tight_layout()
plt.show()
```



In [ ]:
```
## problem 2.2.6

##Press mm Hg (pressure) and NSM (time of day) are the main determinants of energy
##Press mm Hg controls energy needs through atmospheric conditions, whereas NSM inf
```

In [2]:
```
pip install scipy
```

```
Collecting scipy
  Downloading scipy-1.15.2-cp310-cp310-manylinux_2_17_x86_64.manylinux2014_x86_64.wh
l.metadata (61 kB)
Requirement already satisfied: numpy<2.5,>=1.23.5 in ./.conda/envs/my5920_env/lib/py
thon3.10/site-packages (from scipy) (2.2.3)
Downloading scipy-1.15.2-cp310-cp310-manylinux_2_17_x86_64.manylinux2014_x86_64.whl
(37.6 MB)
   ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 37.6/37.6 MB 140.8 MB/s eta 0:00:0000:01
Installing collected packages: scipy
Successfully installed scipy-1.15.2
Note: you may need to restart the kernel to use updated packages.
```

In [ ]:
```
#Problem 3
```

In [3]:
```
import pandas as pd
import numpy as np
from scipy.stats import kurtosis, skew

# Load the data (modify delimiter based on file structure)
file_path = "airfoil_self_noise.dat"  # Replace with actual file path
data = pd.read_csv(file_path, delim_whitespace=True, header=None)

# Assign column names (assuming there are six columns based on the description)
column_names = [
    "Frequency (Hz)",
    "Angle of Attack (°)",
```

```
    "Chord Length (m)",
    "Free-stream Velocity (m/s)",
    "Suction Side Displacement Thickness (m)",
    "Scaled Sound Pressure Level (dB)"
]
data.columns = column_names

# Compute descriptive statistics
stats = {}
for column in data.columns:
    stats[column] = {
        "Mean": np.mean(data[column]),
        "Variance": np.var(data[column], ddof=1),
        "Standard Deviation": np.std(data[column], ddof=1),
        "Median": np.median(data[column]),
        "Kurtosis": kurtosis(data[column]),
        "Skewness": skew(data[column]),
        "Range": np.ptp(data[column])
    }

# Convert to DataFrame for better visualization
stats_df = pd.DataFrame(stats).T
print(stats_df)
```

```
                                          Mean      Variance  \
Frequency (Hz)                     2886.380572  9.938717e+06
Angle of Attack (°)                   6.782302  3.502424e+01
Chord Length (m)                      0.136548  8.749868e-03
Free-stream Velocity (m/s)           50.860745  2.425116e+02
Suction Side Displacement Thickness (m)   0.011140  1.729287e-04
Scaled Sound Pressure Level (dB)    124.835943  4.759146e+01

                                   Standard Deviation       Median  \
Frequency (Hz)                           3152.573137  1600.000000
Angle of Attack (°)                         5.918128     5.400000
Chord Length (m)                            0.093541     0.101600
Free-stream Velocity (m/s)                 15.572784    39.600000
Suction Side Displacement Thickness (m)     0.013150     0.004957
Scaled Sound Pressure Level (dB)            6.898657   125.721000

                                   Kurtosis  Skewness         Range
Frequency (Hz)                     5.685722  2.134951  19800.000000
Angle of Attack (°)               -0.415568  0.688476     22.200000
Chord Length (m)                  -1.038504  0.457001      0.279400
Free-stream Velocity (m/s)        -1.562743  0.235617     39.600000
Suction Side Displacement Thickness (m)  2.207539  1.700465      0.058011
Scaled Sound Pressure Level (dB)  -0.317132 -0.418534     37.607000
```

```
/tmp/ipykernel_488093/32569673.py:7: FutureWarning: The 'delim_whitespace' keyword i
n pd.read_csv is deprecated and will be removed in a future version. Use ``sep='\s
+'`` instead
  data = pd.read_csv(file_path, delim_whitespace=True, header=None)
```