Task 2: Data Handling

Read the entire Lunar Prospector dataset, and demonstrate the ability to isolate and sum data based on location and altitude by producing summed spectra for the following conditions: All data, collected at 100 km altitude (±10 km), collected within

	Latitude	Longitude
0	0° to 30°	-45° to 0°
1	-15° to 15°	20° to 40°
2	20° to 45°	90° to 120°

In [4]:
```python
# Importing libraries to download required data
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
from sklearn.preprocessing import MinMaxScaler
import struct
```

Using files retrieved from Task 1

Performing Data Manipulation for Spacecraft Altitude ~100km (+/- 10)

In [2]:
```python
# Determining the .dat and .lbl files available locally.

import os

directory = './Task1'  # Replace with your directory path
files = os.listdir(directory)

dat_files = []
lbl_files = []
for file in files:
    if file.endswith('.dat'):
        dat_files.append(file)
    elif file.endswith('.lbl'):
        lbl_files.append(file)
```

In [6]:
```python
data_0 = []
data_1 = []
data_2 = []

# Iterating through all .dat and .lbl files.
for i in dat_files:
    if i[:-4] + ".lbl" in lbl_files:
        filename = f"./Task1/{i[:-4]}.lbl"
        datafilename = f"./Task1/{i}"
    else:
        continue

    # Define the record format for the label file
    label_format = [
        ("PDS_VERSION_ID", "23s"),
        ("RECORD_TYPE", "23s"),
        ("RECORD_BYTES", "23s"),
        ("FILE_RECORDS", "23s"),
        ("^TABLE", "23s"),
        ("DATA_SET_NAME", "59s"),
        ("DATA_SET_ID", "33s"),
        ("PRODUCT_ID", "23s"),
        ("PRODUCT_TYPE", "23s"),
        ("PRODUCT_VERSION_ID", "23s"),
        ("SPACECRAFT_NAME", "23s"),
        ("INSTRUMENT_NAME", "23s"),
        ("TARGET_NAME", "23s"),
        ("START_TIME", "23s"),
        ("STOP_TIME", "23s"),
        ("SPACECRAFT_CLOCK_START_COUNT", "23s"),
        ("SPACECRAFT_CLOCK_STOP_COUNT", "23s"),
        ("PRODUCT_CREATION_TIME", "23s")
    ]

    # Define the record format for the data file
    data_format = [
        ("accepted_spectrum", "512f"),
        ("rejected_spectrum", "512f"),
        ("deadtime", "f"),
        ("overload", "f"),
        ("grs_temperature", "f"),
        ("earth_received_time", "f"),
        ("spacecraft_altitude", "f"),
        ("subspacecraft_latitude", "f"),
        ("subspacecraft_longitude", "f")
    ]

    # Open the data file for reading
    with open(filename, "r") as f:
        label = {}
        for line in f:
            # Ignoring all comments in the .lbl file.
            if line.strip() and not line.startswith("#"):
                # Splitting lines and reading values for corresponding labels
                parts = line.split("=", 1)
                if len(parts) == 2:
                    key = parts[0].strip()
                    value = parts[1].strip()
                    label[key] = value

    # Read the data file
    with open(datafilename, "rb") as f:
        for i in range(int(label["FILE_RECORDS"])):
            record = {}
            for field, format in data_format:
                bytes = f.read(struct.calcsize(format))
                value = struct.unpack(format, bytes)[0]
                # Separate condition for accepted and rejected spectrum as they 512 data items.
                if field == "accepted_spectrum" or field == "rejected_spectrum":
                    value = struct.unpack(format, bytes)
                record[field] = value

            if record["spacecraft_altitude"] <= 110 and record["spacecraft_altitude"] >= 90:
                if (record["subspacecraft_latitude"] <= 30 and record["subspacecraft_latitude"] >= 0) and ((record["subspa
                    data_0.append(record)
                elif (record["subspacecraft_latitude"] <= 15 and record["subspacecraft_latitude"] >= -15) and (record["sub
                    data_1.append(record)
                elif (record["subspacecraft_latitude"] <= 45 and record["subspacecraft_latitude"] >= 20) and (record["subs
                    data_2.append(record)
```

In [7]:
```python
df_0 = pd.DataFrame(data_0)
print("GRS Data for Spacecraft Latitude between 0° to 15° and Spacecraft Longitude between 315° to 360°")
df_0.to_csv("./Task2/dataset_0.csv", index = False)
```

```
GRS Data for Spacecraft Latitude between 0° to 15° and Spacecraft Longitude between 315° to 360°
```

In [8]:
```python
df_1 = pd.DataFrame(data_1)
print("GRS Data for Spacecraft Latitude between -15° to 15° and Spacecraft Longitude between 20° to 40°")
df_1.to_csv("./Task2/dataset_1.csv", index = False)
```

```
GRS Data for Spacecraft Latitude between -15° to 15° and Spacecraft Longitude between 20° to 40°
```

In [9]:
```python
df_2 = pd.DataFrame(data_2)
print("GRS Data for Spacecraft Latitude between 20° to 45° and Spacecraft Longitude between 90° to 120°")
df_2.to_csv("./Task2/dataset_2.csv", index = False)
```

```
GRS Data for Spacecraft Latitude between 20° to 45° and Spacecraft Longitude between 90° to 120°
```

In [10]:
```python
size_df_0 = len(df_0.index)
size_df_1 = len(df_1.index)
size_df_2 = len(df_2.index)
print(f"Length of Dataframe 0: {size_df_0}")
print(f"Length of Dataframe 1: {size_df_1}")
print(f"Length of Dataframe 2: {size_df_2}")
```

```
Length of Dataframe 0: 11247
Length of Dataframe 1: 0
Length of Dataframe 2: 5760
```

In [11]:
```python
# Only saving first 5760 data points.

df_0 = pd.DataFrame(data_0)
df_0[:size_df_2].to_csv("./Task2/dataset_0.csv", index = False)
```

In [12]:
```python
# Finding the sum of all accepted_spectrums, and inserting an additional column in the dataframe.

def find_sum_spectrum(filename):
    data = pd.read_csv(f"./Task2/{filename}.csv")
    sum_accepted_spectrum = []
    for i in range(len(data.index)):
        temp = data["accepted_spectrum"][i].lstrip("(").rstrip(")").split(",")
        temp = [float(j.strip()) for j in temp]
        sum_accepted_spectrum.append(sum(temp))
    data["sum_accepted_spectrum"] = sum_accepted_spectrum
    data.to_csv(f"./Task2/{filename}.csv", index = False)
```

In [13]:
```python
find_sum_spectrum("dataset_0")
data_0 = pd.read_csv("./Task2/dataset_0.csv")
data_0
```

Out[13]:

	accepted_spectrum	rejected_spectrum	deadtime	overload	grs_temperature	earth_received_time	spacecraft_altitude	subspacecr
0	(0.059857144951820374, 4.258054256439209, 9.53...	(0.059857144951820374, 4.258054256439209, 9.53...	0.047658	24570.0	-27.952522	19.267281	100.860367	
1	(0.1345735490322113, 9.528481483459473, 10.582...	(0.1345735490322113, 9.528481483459473, 10.582...	0.047459	24631.0	-27.739590	19.267653	100.597282	
2	(0.14937223494052887, 10.571464538574219, 10.5...	(0.14937223494052887, 10.571464538574219, 10.5...	0.047082	24379.0	-27.739590	19.268023	100.334076	
3	(0.13429120182991028, 9.499791145324707, 8.448...	(0.13429120182991028, 9.499791145324707, 8.448...	0.047076	24364.0	-28.165455	19.268393	100.071236	
4	(0.05956161767244339, 4.2240118980407715, 6.32...	(0.05956161767244339, 4.2240118980407715, 6.32...	0.046727	24558.0	-28.165455	19.268763	99.808449	
...	...	...	...	...	...	...	...	
5755	(0.16589322686195374, 3.7230684757232666, 8.23...	(0.16589322686195374, 3.7230684757232666, 8.23...	0.044877	20451.0	-29.027073	172.204544	92.097832	
5756	(0.16589200496673584, 3.6334869861602783, 5.97...	(0.16589200496673584, 3.6334869861602783, 5.97...	0.044687	20493.0	-28.810837	172.204910	92.128632	
5757	(0.2765313386917114, 5.9522929191589355, 7.226...	(0.2765313386917114, 5.9522929191589355, 7.226...	0.044737	20567.0	-28.380028	172.205276	92.170128	
5758	(0.05527983978390694, 1.4047527313232422, 7.18...	(0.05527983978390694, 1.4047527313232422, 7.18...	0.044424	20261.0	-27.952522	172.205643	92.214012	
5759	(0.11056573688983917, 2.3620033264160156, 2.32...	(0.11056573688983917, 2.3620033264160156, 2.32...	0.044337	20531.0	-27.739590	172.206024	92.266891	

5760 rows × 10 columns

In [14]:
```python
find_sum_spectrum("dataset_2")
data_2 = pd.read_csv("./Task2/dataset_2.csv")
data_2
```

Out[14]:

	accepted_spectrum	rejected_spectrum	deadtime	overload	grs_temperature	earth_received_time	spacecraft_altitude	subspacecraf
0	(0.44003915786743164, 6.70444393157959, 10.529...	(0.44003915786743164, 6.70444393157959, 10.529...	0.042389	24390.0	-28.594601	23.739517	109.052765	2
1	(0.3760599195957184, 5.522027015686035, 7.6545...	(0.3760599195957184, 5.522027015686035, 7.6545...	0.042238	24315.0	-28.165455	23.739887	109.240410	2
2	(0.6761290431022644, 9.521135330200195, 6.3743...	(0.6761290431022644, 9.521135330200195, 6.3743...	0.042248	24572.0	-28.165455	23.740257	109.425026	2
3	(0.6768850088119507, 9.4700345993042, 5.736340...	(0.6768850088119507, 9.4700345993042, 5.736340...	0.042291	24363.0	-28.380028	23.740627	109.597282	2
4	(0.2254400998353958, 3.359696388244629, 5.3455...	(0.2254400998353958, 3.359696388244629, 5.3455...	0.041987	24526.0	-28.594601	23.740999	109.767807	2
...	...	...	...	...	...	...	...	
5755	(86.4678955078125, 7.077210903167725, 5.489294...	(86.4678955078125, 7.077210903167725, 5.489294...	0.040580	21300.0	-27.739590	353.732635	92.277367	3
5756	(82.23342895507812, 4.852571964263916, 8.46331...	(82.23342895507812, 4.852571964263916, 8.46331...	0.040863	21506.0	-27.952522	353.733002	92.866493	4
5757	(100.3415756225586, 8.451204299926758, 3.51515...	(100.3415756225586, 8.451204299926758, 3.51515...	0.040826	21617.0	-27.952522	353.733368	93.456970	4
5758	(77.74969482421875, 9.08340072631836, 7.711343...	(77.74969482421875, 9.08340072631836, 7.711343...	0.040446	21459.0	-28.165455	353.733734	94.055443	4
5759	(86.93685913085938, 2.7890379428863525, 7.3091...	(86.93685913085938, 2.7890379428863525, 7.3091...	0.040285	21476.0	-28.165455	353.734100	94.655266	4

5760 rows × 10 columns

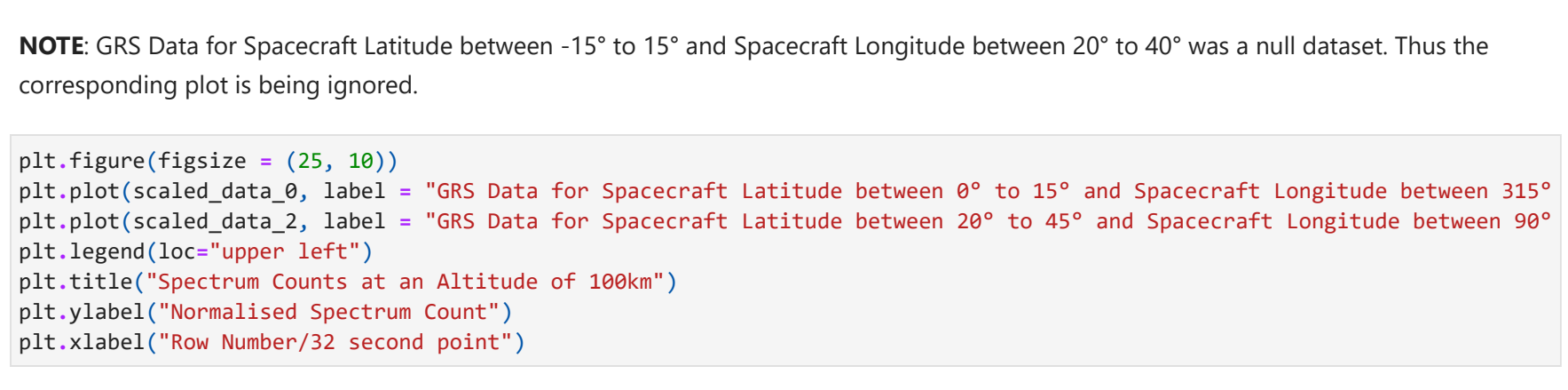
In [15]:
```python
# Normalising the data for plotting.
scaler = MinMaxScaler()
np_data_0 = np.array(data_0["sum_accepted_spectrum"])
np_data_0 = np_data_0.reshape(-1,1)
scaled_data_0 = scaler.fit_transform(np_data_0)

np_data_2 = np.array(data_2["sum_accepted_spectrum"])
np_data_2 = np_data_2.reshape(-1,1)
scaled_data_2 = scaler.fit_transform(np_data_2)
```

Visualising the captured spectra

NOTE: GRS Data for Spacecraft Latitude between -15° to 15° and Spacecraft Longitude between 20° to 40° was a null dataset. Thus the corresponding plot is being ignored.

In [16]:
```python
plt.figure(figsize = (25, 10))
plt.plot(scaled_data_0, label = "GRS Data for Spacecraft Latitude between 0° to 15° and Spacecraft Longitude between 315°
plt.plot(scaled_data_2, label = "GRS Data for Spacecraft Latitude between 20° to 45° and Spacecraft Longitude between 90°
plt.legend(loc="upper left")
plt.title("Spectrum Counts at an Altitude of 100km")
plt.ylabel("Normalised Spectrum Count")
plt.xlabel("Row Number/32 second point")
```

Out[16]:
```
Text(0.5, 0, 'Row Number/32 second point')
```



Performing Data Manipulation for Spacecraft Altitude ~30km (+/- 3)

In [17]:
```python
data_0 = []
data_1 = []
data_2 = []

# Iterating through all .dat and .lbl files.
for i in dat_files:
    if i[:-4] + ".lbl" in lbl_files:
        filename = f"./Task1/{i[:-4]}.lbl"
        datafilename = f"./Task1/{i}"
    else:
        continue

    # Define the record format for the label file
    label_format = [
        ("PDS_VERSION_ID", "23s"),
        ("RECORD_TYPE", "23s"),
        ("RECORD_BYTES", "23s"),
        ("FILE_RECORDS", "23s"),
        ("^TABLE", "23s"),
        ("DATA_SET_NAME", "59s"),
        ("DATA_SET_ID", "33s"),
        ("PRODUCT_ID", "23s"),
        ("PRODUCT_TYPE", "23s"),
        ("PRODUCT_VERSION_ID", "23s"),
        ("SPACECRAFT_NAME", "23s"),
        ("INSTRUMENT_NAME", "23s"),
        ("TARGET_NAME", "23s"),
        ("START_TIME", "23s"),
        ("STOP_TIME", "23s"),
        ("SPACECRAFT_CLOCK_START_COUNT", "23s"),
        ("SPACECRAFT_CLOCK_STOP_COUNT", "23s"),
        ("PRODUCT_CREATION_TIME", "23s")
    ]

    # Define the record format for the data file
    data_format = [
        ("accepted_spectrum", "512f"),
        ("rejected_spectrum", "512f"),
        ("deadtime", "f"),
        ("overload", "f"),
        ("grs_temperature", "f"),
        ("earth_received_time", "f"),
        ("spacecraft_altitude", "f"),
        ("subspacecraft_latitude", "f"),
        ("subspacecraft_longitude", "f")
    ]

    # Open the data file for reading
    with open(filename, "r") as f:
        label = {}
        for line in f:
            # Ignoring all comments in the .lbl file.
            if line.strip() and not line.startswith("#"):
                # Splitting lines and reading values for corresponding labels
                parts = line.split("=", 1)
                if len(parts) == 2:
                    key = parts[0].strip()
                    value = parts[1].strip()
                    label[key] = value

    # Read the data file
    with open(datafilename, "rb") as f:
        for i in range(int(label["FILE_RECORDS"])):
            record = {}
            for field, format in data_format:
                bytes = f.read(struct.calcsize(format))
                value = struct.unpack(format, bytes)[0]
                # Separate condition for accepted and rejected spectrum as they 512 data items.
                if field == "accepted_spectrum" or field == "rejected_spectrum":
                    value = struct.unpack(format, bytes)
                record[field] = value

            if record["spacecraft_altitude"] <= 33 and record["spacecraft_altitude"] >= 27:
                if (record["subspacecraft_latitude"] <= 30 and record["subspacecraft_latitude"] >= 0) and ((record["subspa
                    data_0.append(record)
                elif (record["subspacecraft_latitude"] <= 15 and record["subspacecraft_latitude"] >= -15) and (record["sub
                    data_1.append(record)
                elif (record["subspacecraft_latitude"] <= 45 and record["subspacecraft_latitude"] >= 20) and (record["subs
                    data_2.append(record)
```

In [18]:
```python
df_0 = pd.DataFrame(data_0)
print("GRS Data for Spacecraft Latitude between 0° to 15° and Spacecraft Longitude between 315° to 360°")
df_0.to_csv("./Task2/dataset_30_0.csv", index = False)
```

```
GRS Data for Spacecraft Latitude between 0° to 15° and Spacecraft Longitude between 315° to 360°
```

In [19]:
```python
df_1 = pd.DataFrame(data_1)
print("GRS Data for Spacecraft Latitude between -15° to 15° and Spacecraft Longitude between 20° to 40°")
df_1.to_csv("./Task2/dataset_30_1.csv", index = False)
```

```
GRS Data for Spacecraft Latitude between -15° to 15° and Spacecraft Longitude between 20° to 40°
```

In [20]:
```python
df_2 = pd.DataFrame(data_2)
print("GRS Data for Spacecraft Latitude between 20° to 45° and Spacecraft Longitude between 90° to 120°")
df_2.to_csv("./Task2/dataset_30_2.csv", index = False)
```

```
GRS Data for Spacecraft Latitude between 20° to 45° and Spacecraft Longitude between 90° to 120°
```

In [21]:
```python
size_df_0 = len(df_0.index)
size_df_1 = len(df_1.index)
size_df_2 = len(df_2.index)
print(f"Length of Dataframe 0: {size_df_0}")
print(f"Length of Dataframe 1: {size_df_1}")
print(f"Length of Dataframe 2: {size_df_2}")
```

```
Length of Dataframe 0: 3814
Length of Dataframe 1: 0
Length of Dataframe 2: 353
```

In [22]:
```python
# Only saving first 353 data points.

df_0 = pd.DataFrame(data_0)
df_0[:size_df_2].to_csv("./Task2/dataset_30_0.csv", index = False)
```

In [23]:
```python
# Finding the sum of all accepted_spectrums, and inserting an additional column in the dataframe.

def find_sum_spectrum(filename):
    data = pd.read_csv(f"./Task2/{filename}.csv")
    sum_accepted_spectrum = []
    for i in range(len(data.index)):
        temp = data["accepted_spectrum"][i].lstrip("(").rstrip(")").split(",")
        temp = [float(j.strip()) for j in temp]
        sum_accepted_spectrum.append(sum(temp))
    data["sum_accepted_spectrum"] = sum_accepted_spectrum
    data.to_csv(f"./Task2/{filename}.csv", index = False)
```

In [24]:
```python
find_sum_spectrum("dataset_30_0")
data_0 = pd.read_csv("./Task2/dataset_30_0.csv")
data_0
```

Out[24]:

	accepted_spectrum	rejected_spectrum	deadtime	overload	grs_temperature	earth_received_time	spacecraft_altitude	subspacecraft_lati
0	(80.27505493164062, 7.864253520965576, 5.85379...	(80.27505493164062, 7.864253520965576, 5.85379...	0.048514	20078.0	-27.739590	401.769440	29.336782	29.38
1	(80.20308685302734, 12.072466850280762, 4.8685...	(80.20308685302734, 12.072466850280762, 4.8685...	0.047990	20204.0	-28.165455	401.769836	29.239254	27.66
2	(98.31763458251953, 9.062939643859863, 5.85398...	(98.31763458251953, 9.062939643859863, 5.85398...	0.049535	20347.0	-28.165455	401.770203	29.141975	25.93
3	(94.47620391845703, 8.801506042480469, 4.27207...	(94.47620391845703, 8.801506042480469, 4.27207...	0.048282	20216.0	-28.165455	401.770569	29.046320	24.20
4	(76.4569091796875, 7.29782772064209, 4.2856612...	(76.4569091796875, 7.29782772064209, 4.2856612...	0.047233	20041.0	-28.165455	401.770935	28.951334	22.47
...	...	...	...	...	...	...	...	
348	(68.43344116210938, 11.797538757324219, 7.9513...	(68.43344116210938, 11.797538757324219, 7.9513...	0.049052	20349.0	-27.739590	404.396515	27.952957	19.93
349	(57.69916534423828, 6.1498799324035645, 7.2323...	(57.69916534423828, 6.1498799324035645, 7.2323...	0.049112	20403.0	-27.739590	404.396881	27.614576	18.20
350	(82.50407409667969, 8.552437782287598, 8.10984...	(82.50407409667969, 8.552437782287598, 8.10984...	0.049300	20242.0	-27.739590	404.397247	27.276386	16.47
351	(90.73033142089844, 12.681635856628418, 5.6068...	(90.73033142089844, 12.681635856628418, 5.6068...	0.048471	20529.0	-27.316959	404.471680	30.038397	29.32
352	(83.34210968017578, 6.355706691741943, 5.49126...	(83.34210968017578, 6.355706691741943, 5.49126...	0.047852	20081.0	-27.739590	404.472046	29.705776	27.59

353 rows × 10 columns

In [25]:
```python
find_sum_spectrum("dataset_30_2")
data_2 = pd.read_csv("./Task2/dataset_30_2.csv")
data_2
```

Out[25]:

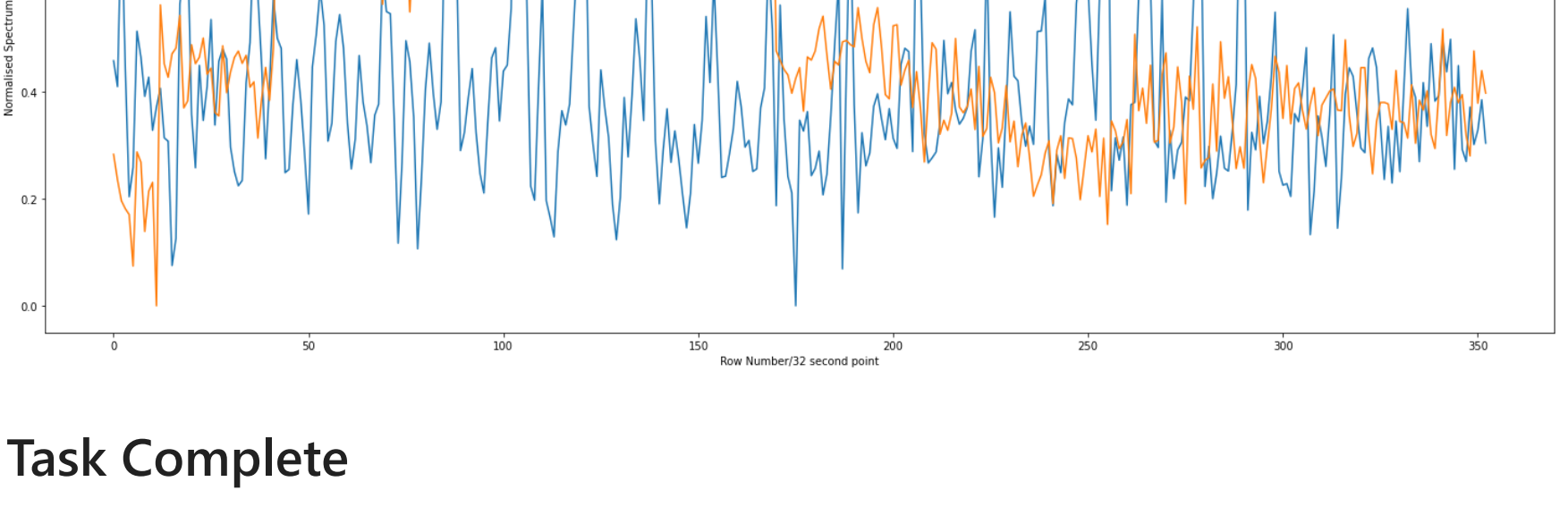
	accepted_spectrum	rejected_spectrum	deadtime	overload	grs_temperature	earth_received_time	spacecraft_altitude	subspacecraft_
0	(0.4210492968559265, 5.647581100463867, 4.7276...	(0.4210492968559265, 5.647581100463867, 4.7276...	0.042097	19866.0	-28.165455	366.613770	32.960361	44
1	(0.20875993371009827, 2.944854497909546, 7.518...	(0.20875993371009827, 2.944854497909546, 7.518...	0.042291	19785.0	-27.739590	366.691528	32.819054	44
2	(0.2790878713130951, 3.7693264484405518, 3.769...	(0.2790878713130951, 3.7693264484405518, 3.769...	0.042317	19755.0	-27.739590	366.691925	32.903481	43
3	(0.34918999671936035, 4.665788173675537, 2.829...	(0.34918999671936035, 4.665788173675537, 2.829...	0.042519	19881.0	-28.165455	366.692291	32.993580	41
4	(0.0717214047908783, 1.0283143520355225, 3.762...	(0.0717214047908783, 1.0283143520355225, 3.762...	0.042042	19809.0	-28.594601	366.925629	32.964504	43
...	...	...	...	...	...	...	...	
348	(60.52996063232422, 7.233383655548096, 2.99431...	(60.52996063232422, 7.233383655548096, 2.99431...	0.042886	19613.0	-27.739590	572.174927	28.133152	44
349	(57.47968673706055, 6.234445095062256, 3.88042...	(57.47968673706055, 6.234445095062256, 3.88042...	0.043367	19441.0	-27.739590	572.251587	27.266169	42
350	(60.249290466308594, 7.284313678741455, 7.6448...	(60.249290466308594, 7.284313678741455, 7.6448...	0.043208	19463.0	-27.739590	572.251953	27.648499	43
351	(93.34359741210938, 7.129873752593994, 6.59584...	(93.34359741210938, 7.129873752593994, 6.59584...	0.043903	19715.0	-27.316959	572.329041	27.058599	43
352	(67.62007904052734, 7.787262439727783, 6.69792...	(67.62007904052734, 7.787262439727783, 6.69792...	0.043608	19837.0	-27.528275	572.329407	27.433182	44

353 rows × 10 columns

In [26]:
```python
# Normalising the data for plotting.
scaler = MinMaxScaler()
np_data_0 = np.array(data_0["sum_accepted_spectrum"])
np_data_0 = np_data_0.reshape(-1,1)
scaled_data_0 = scaler.fit_transform(np_data_0)

np_data_2 = np.array(data_2["sum_accepted_spectrum"])
np_data_2 = np_data_2.reshape(-1,1)
scaled_data_2 = scaler.fit_transform(np_data_2)
```

In [27]:
```python
plt.figure(figsize = (25, 10))
plt.plot(scaled_data_0, label = "GRS Data for Spacecraft Latitude between 0° to 15° and Spacecraft Longitude between 315°
plt.plot(scaled_data_2, label = "GRS Data for Spacecraft Latitude between 20° to 45° and Spacecraft Longitude between 90°
plt.legend(loc="upper left")
plt.title("Spectrum Counts at an Altitude of 30km")
plt.ylabel("Normalised Spectrum Count")
plt.xlabel("Row Number/32 second point")
```

Out[27]:
```
Text(0.5, 0, 'Row Number/32 second point')
```



Task Complete

The corresponding data manipulation has been performed and the graphs have been plotted for GRS data collected at an altitude of 100km and 30km.

Kindly note that certain outputs while fetching the data have been cleared. Only necessary outputs have been displayed