PHASE 1: Data Loading & Cleaning for Product Lifecycle Analysis

```
# Step 1: Download necessary Python libraries
!pip install pandas
!pip install numpy
```

```
Requirement already satisfied: pandas in /usr/local/lib/python3.11/dist-packages (2.2.2)
Requirement already satisfied: numpy>=1.23.2 in /usr/local/lib/python3.11/dist-packages (from pandas) (2.0.2)
Requirement already satisfied: python-dateutil>=2.8.2 in /usr/local/lib/python3.11/dist-packages (from pandas) (2.9.0.post0)
Requirement already satisfied: pytz>=2020.1 in /usr/local/lib/python3.11/dist-packages (from pandas) (2025.2)
Requirement already satisfied: tzdata>=2022.7 in /usr/local/lib/python3.11/dist-packages (from pandas) (2025.2)
Requirement already satisfied: six>=1.5 in /usr/local/lib/python3.11/dist-packages (from python-dateutil>=2.8.2->pandas) (1.17.0)
Requirement already satisfied: numpy in /usr/local/lib/python3.11/dist-packages (2.0.2)
```

```
# Step 2: Import necessary Python libraries
import pandas as pd
import numpy as np
```

```
# Step 3: Upload the dataset file
from google.colab import files
uploaded = files.upload()
```

```
Choose Files Productleve…Weekly.csv
• Productlevel_Sales_Transactions_Dataset_Weekly.csv(text/csv) - 2025740 bytes, last modified: 9/7/2025 - 100% done
Saving Productlevel_Sales_Transactions_Dataset_Weekly.csv to Productlevel_Sales_Transactions_Dataset_Weekly.csv
```

```
# Step 4: Load uploaded Dataset
df = pd.read_csv("Productlevel_Sales_Transactions_Dataset_Weekly.csv")
```

```
# Step 5: Drop garbage columns
df = df.drop(columns=[col for col in df.columns if "unnamed" in col.lower() or col.strip() in ["", "94"]])
```

```
# Step 6: Clean column names
df.columns = df.columns.str.strip().str.lower()
```

```
# Step 7: Check the list of column names present in the dataset
print(df.columns)
```

```
Index(['scode', 'pcode', 'price', 'wk0', 'wk1', 'wk2', 'wk3', 'wk4', 'wk5',
       'wk6',
       ...
       'wk94', 'wk95', 'wk96', 'wk97', 'wk98', 'wk99', 'wk100', 'wk101',
       'wk102', 'wk103'],
      dtype='object', length=107)
```

```
# Step 8: Identify ID columns and week columns
id_columns = ['scode', 'pcode', 'price']
week_columns = [col for col in df.columns if col.startswith('wk')]
```

```
# Step 9: Convert from wide to long format
df_long = df.melt(id_vars=id_columns, value_vars=week_columns,
                  var_name='week', value_name='units')
```

```
# Step 10: Extract week number (e.g., wk0 → 0)
df_long['week_num'] = df_long['week'].str.extract(r'(\d+)').astype(int)
```

```
# Step 11: Create sale_date from week number (week 0 = 2022-01-03)
df_long['sale_date'] = pd.to_datetime("2022-01-03") + pd.to_timedelta(df_long['week_num'], unit='W')
```

```
# Step 12: Sort by product and date
df_long = df_long.sort_values(by=['scode', 'sale_date'])
```

```
# Step 13: Add product age (weeks since launch)
df_long['product_age_weeks'] = df_long.groupby('scode')['sale_date'].transform(lambda x: (x - x.min()).dt.days // 7)
```

```
# Step 14: Add cumulative units
df_long['cumulative_units'] = df_long.groupby('scode')['units'].cumsum()
```

```
# Step 15: Add 4-week moving average
df_long['units_ma_4w'] = df_long.groupby('scode')['units'].transform(lambda x: x.rolling(4, min_periods=1).mean())
```

```
# Step 16: Save the cleaned dataset
df_long.to_csv("Cleaned_SKU_Lifecycle.csv", index=False)
print("Cleaned file saved: Cleaned_SKU_Lifecycle.csv")
```

```
Cleaned file saved: Cleaned_SKU_Lifecycle.csv
```

```
# Step 17: Download the Cleaned dataset File
files.download("Cleaned_SKU_Lifecycle.csv")
```

```
# Step 18: Preview
print(df_long.head(10))
```

```
    scode  pcode    price week  units  week_num  sale_date  product_age_weeks  \
0  Store1   SKU1  $24.00   wk0     23         0 2022-01-03                  0
1  Store1   SKU2  $63.00   wk0     23         0 2022-01-03                  0
2  Store1   SKU3  $93.00   wk0      7         0 2022-01-03                  0
3  Store1   SKU4  $48.00   wk0     50         0 2022-01-03                  0
4  Store1   SKU5  $62.00   wk0      8         0 2022-01-03                  0
5  Store1   SKU6  $80.00   wk0     20         0 2022-01-03                  0
6  Store1   SKU7  $95.00   wk0      4         0 2022-01-03                  0
7  Store1   SKU8  $15.00   wk0      8         0 2022-01-03                  0
8  Store1   SKU9  $55.00   wk0     14         0 2022-01-03                  0
9  Store1  SKU10  $69.00   wk0     22         0 2022-01-03                  0

   cumulative_units  units_ma_4w
0                23    23.000000
1                46    23.000000
2                53    17.666667
3               103    25.750000
4               111    22.000000
5               131    21.250000
6               135    20.500000
7               143    10.000000
8               157    11.500000
9               179    12.000000
```

PHASE 2: Product Lifecycle Visualization

Code 1: Single SKU Lifecycle Plot

```
# Code 1: Step 1: Download necessary Python libraries
!pip install pandas
!pip install matplotlib
```

```
Requirement already satisfied: pandas in /usr/local/lib/python3.11/dist-packages (2.2.2)
Requirement already satisfied: numpy>=1.23.2 in /usr/local/lib/python3.11/dist-packages (from pandas) (2.0.2)
Requirement already satisfied: python-dateutil>=2.8.2 in /usr/local/lib/python3.11/dist-packages (from pandas) (2.9.0.post0)
Requirement already satisfied: pytz>=2020.1 in /usr/local/lib/python3.11/dist-packages (from pandas) (2025.2)
Requirement already satisfied: tzdata>=2022.7 in /usr/local/lib/python3.11/dist-packages (from pandas) (2025.2)
Requirement already satisfied: six>=1.5 in /usr/local/lib/python3.11/dist-packages (from python-dateutil>=2.8.2->pandas) (1.17.0)
Requirement already satisfied: matplotlib in /usr/local/lib/python3.11/dist-packages (3.10.0)
Requirement already satisfied: contourpy>=1.0.1 in /usr/local/lib/python3.11/dist-packages (from matplotlib) (1.3.2)
Requirement already satisfied: cycler>=0.10 in /usr/local/lib/python3.11/dist-packages (from matplotlib) (0.12.1)
Requirement already satisfied: fonttools>=4.22.0 in /usr/local/lib/python3.11/dist-packages (from matplotlib) (4.58.4)
Requirement already satisfied: kiwisolver>=1.3.1 in /usr/local/lib/python3.11/dist-packages (from matplotlib) (1.4.8)
Requirement already satisfied: numpy>=1.23 in /usr/local/lib/python3.11/dist-packages (from matplotlib) (2.0.2)
Requirement already satisfied: packaging>=20.0 in /usr/local/lib/python3.11/dist-packages (from matplotlib) (24.2)
Requirement already satisfied: pillow>=8 in /usr/local/lib/python3.11/dist-packages (from matplotlib) (11.2.1)
Requirement already satisfied: pyparsing>=2.3.1 in /usr/local/lib/python3.11/dist-packages (from matplotlib) (3.2.3)
Requirement already satisfied: python-dateutil>=2.7 in /usr/local/lib/python3.11/dist-packages (from matplotlib) (2.9.0.post0)
Requirement already satisfied: six>=1.5 in /usr/local/lib/python3.11/dist-packages (from python-dateutil>=2.7->matplotlib) (1.17.0)
```

```
# Code 1: Step 2: Import necessary Python libraries
import pandas as pd
import matplotlib.pyplot as plt
```

```
# Code 1: Step 3: Load cleaned lifecycle dataset
df = pd.read_csv("Cleaned_SKU_Lifecycle.csv", parse_dates=["sale_date"])
```

```
# Code 1: Step 4: Pick ONE SKU to visualize
sample_sku = df['scode'].unique()[0]
df_sku = df[df['scode'] == sample_sku]
```

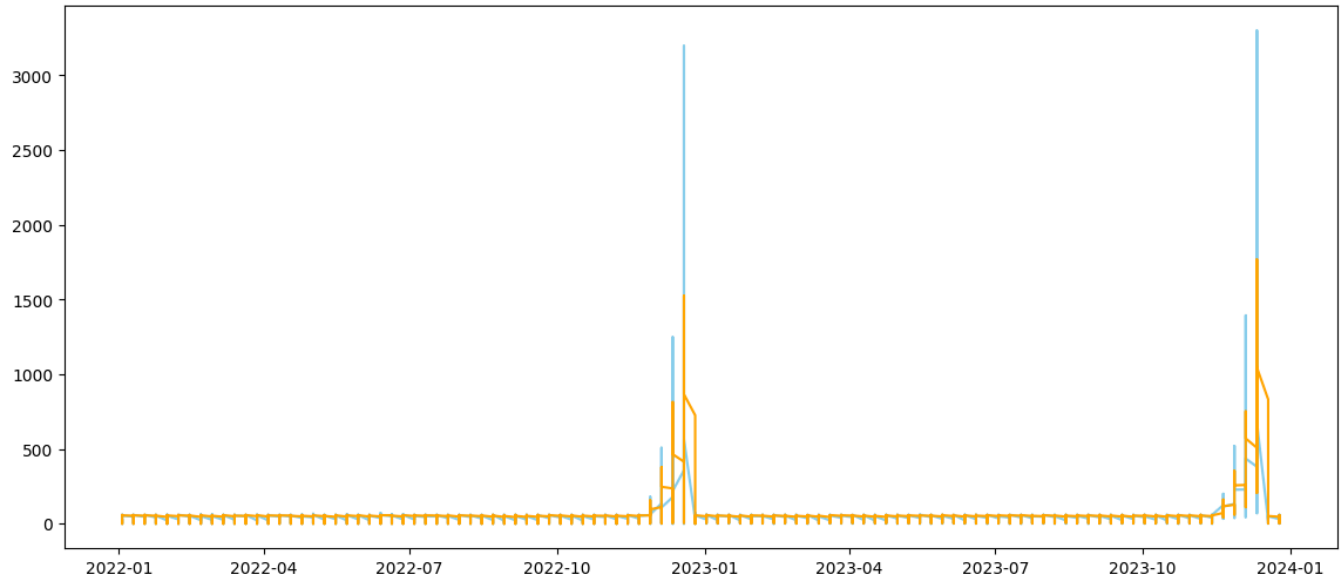
```
# Code 1: Step 5: Add lifecycle stage for each row (based on product age in weeks)

def get_stage(age):
    if age < 10:
```

```
        return 'Introduction'
    elif age < 30:
        return 'Growth'
    elif age < 50:
        return 'Maturity'
    else:
        return 'Decline'

df_sku['stage'] = df_sku['product_age_weeks'].apply(get_stage)
```

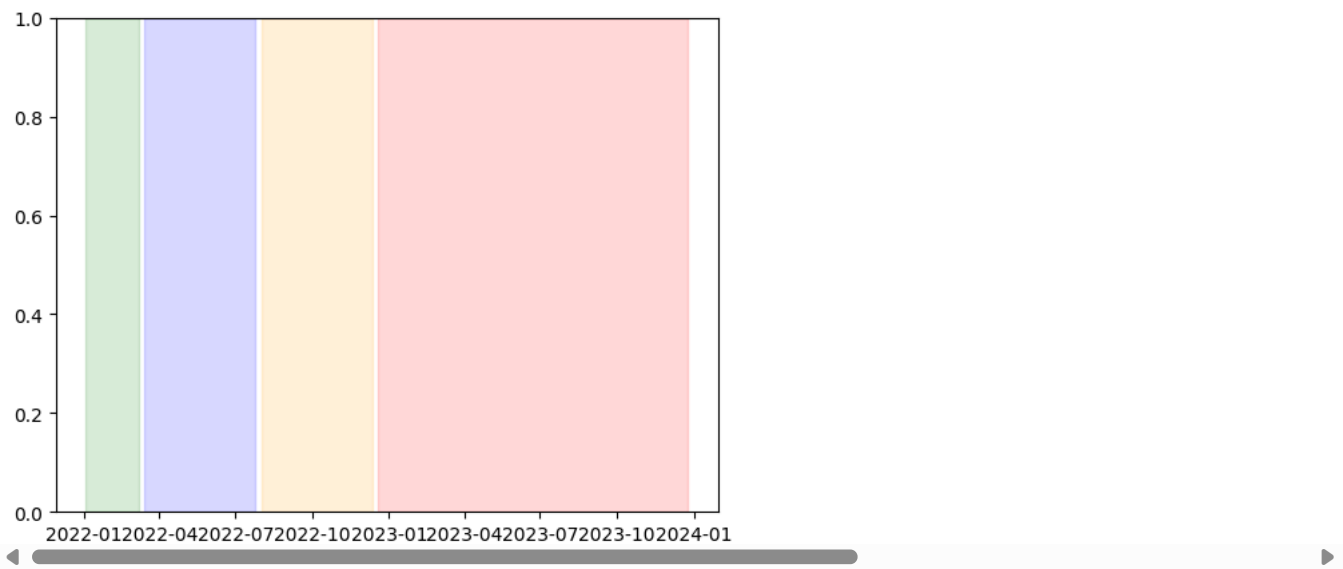
```
/tmp/ipython-input-29-1322080582.py:13: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#returning-a-view-versus
  df_sku['stage'] = df_sku['product_age_weeks'].apply(get_stage)
```

```
# Code 1: Step 6: Plot weekly units & 4-week moving average
plt.figure(figsize=(14, 6))
plt.plot(df_sku['sale_date'], df_sku['units'], label='Weekly Sales', color='skyblue')
plt.plot(df_sku['sale_date'], df_sku['units_ma_4w'], label='4-Week MA', color='orange')
```

```
[<matplotlib.lines.Line2D at 0x7df81eab14d0>]
```

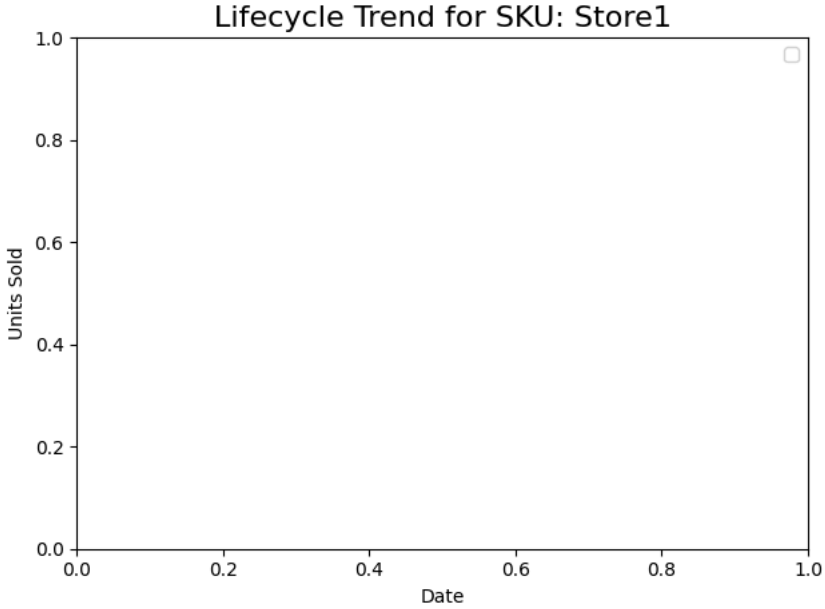



```
# Code 1: Step 7: Shade lifecycle stages
for stage, color in zip(['Introduction', 'Growth', 'Maturity', 'Decline'],
                        ['green', 'blue', 'orange', 'red']):
    stage_data = df_sku[df_sku['stage'] == stage]
    if not stage_data.empty:
        plt.axvspan(stage_data['sale_date'].min(), stage_data['sale_date'].max(),
                    color=color, alpha=0.15, label=stage)
```



```
# Code 1: Step 8: Finalize plot
plt.title(f"Lifecycle Trend for SKU: {sample_sku}", fontsize=16)
plt.xlabel("Date")
plt.ylabel("Units Sold")
plt.legend()
plt.tight_layout()
plt.show()
```

```
/tmp/ipython-input-32-1727778776.py:5: UserWarning: No artists with labels found to put in legend.  Note that artists whose label st
  plt.legend()
```



Code 2: Loop Through Multiple SKUs (Top 5)

```
# Code 2: Step 1: Download necessary Python libraries
!pip install pandas
!pip install matplotlib
```

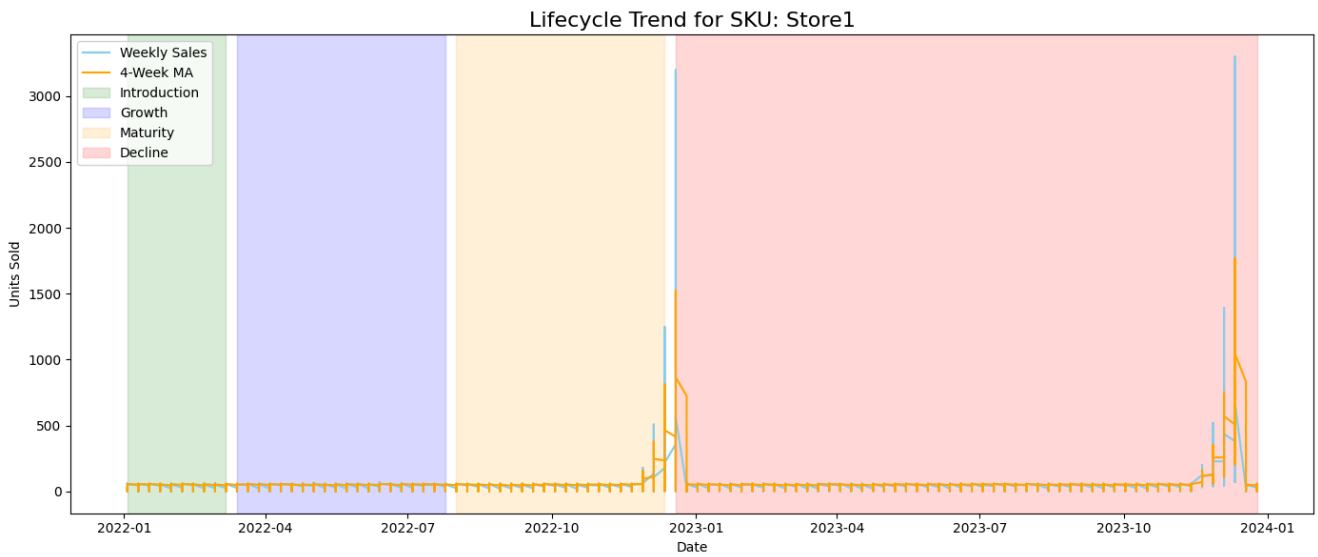
```
Requirement already satisfied: pandas in /usr/local/lib/python3.11/dist-packages (2.2.2)
Requirement already satisfied: numpy>=1.23.2 in /usr/local/lib/python3.11/dist-packages (from pandas) (2.0.2)
Requirement already satisfied: python-dateutil>=2.8.2 in /usr/local/lib/python3.11/dist-packages (from pandas) (2.9.0.post0)
Requirement already satisfied: pytz>=2020.1 in /usr/local/lib/python3.11/dist-packages (from pandas) (2025.2)
Requirement already satisfied: tzdata>=2022.7 in /usr/local/lib/python3.11/dist-packages (from pandas) (2025.2)
Requirement already satisfied: six>=1.5 in /usr/local/lib/python3.11/dist-packages (from python-dateutil>=2.8.2->pandas) (1.17.0)
Requirement already satisfied: matplotlib in /usr/local/lib/python3.11/dist-packages (3.10.0)
Requirement already satisfied: contourpy>=1.0.1 in /usr/local/lib/python3.11/dist-packages (from matplotlib) (1.3.2)
Requirement already satisfied: cycler>=0.10 in /usr/local/lib/python3.11/dist-packages (from matplotlib) (0.12.1)
Requirement already satisfied: fonttools>=4.22.0 in /usr/local/lib/python3.11/dist-packages (from matplotlib) (4.58.4)
Requirement already satisfied: kiwisolver>=1.3.1 in /usr/local/lib/python3.11/dist-packages (from matplotlib) (1.4.8)
Requirement already satisfied: numpy>=1.23 in /usr/local/lib/python3.11/dist-packages (from matplotlib) (2.0.2)
Requirement already satisfied: packaging>=20.0 in /usr/local/lib/python3.11/dist-packages (from matplotlib) (24.2)
Requirement already satisfied: pillow>=8 in /usr/local/lib/python3.11/dist-packages (from matplotlib) (11.2.1)
Requirement already satisfied: pyparsing>=2.3.1 in /usr/local/lib/python3.11/dist-packages (from matplotlib) (3.2.3)
Requirement already satisfied: python-dateutil>=2.7 in /usr/local/lib/python3.11/dist-packages (from matplotlib) (2.9.0.post0)
Requirement already satisfied: six>=1.5 in /usr/local/lib/python3.11/dist-packages (from python-dateutil>=2.7->matplotlib) (1.17.0)
```

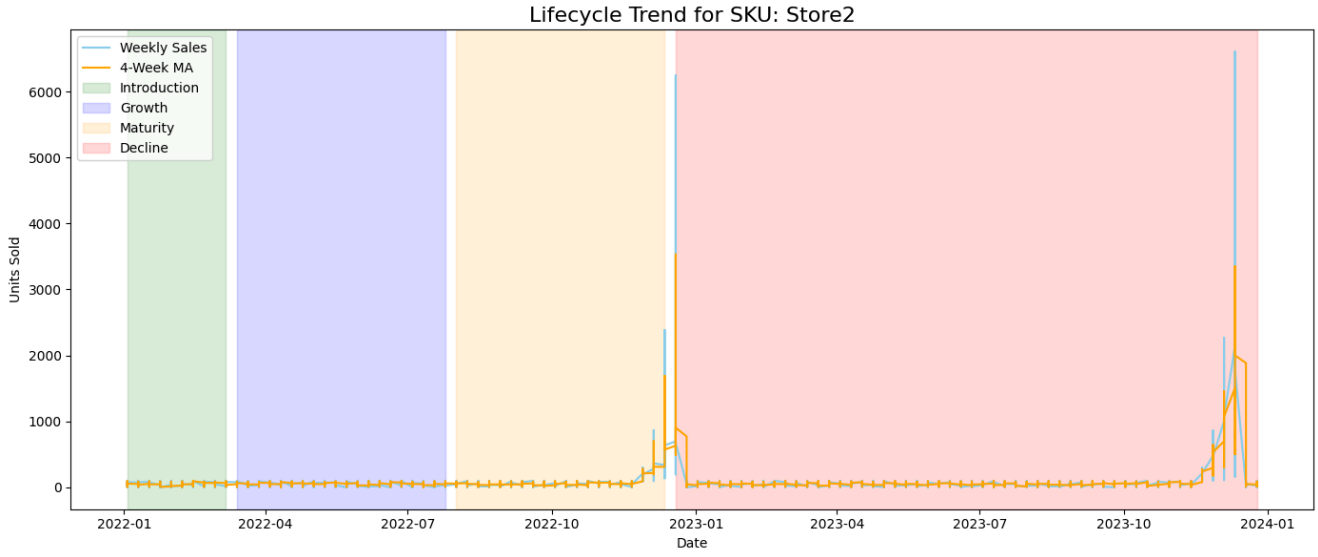
```
# Code 2: Step 2: Import necessary Python libraries
import pandas as pd
import matplotlib.pyplot as plt
```

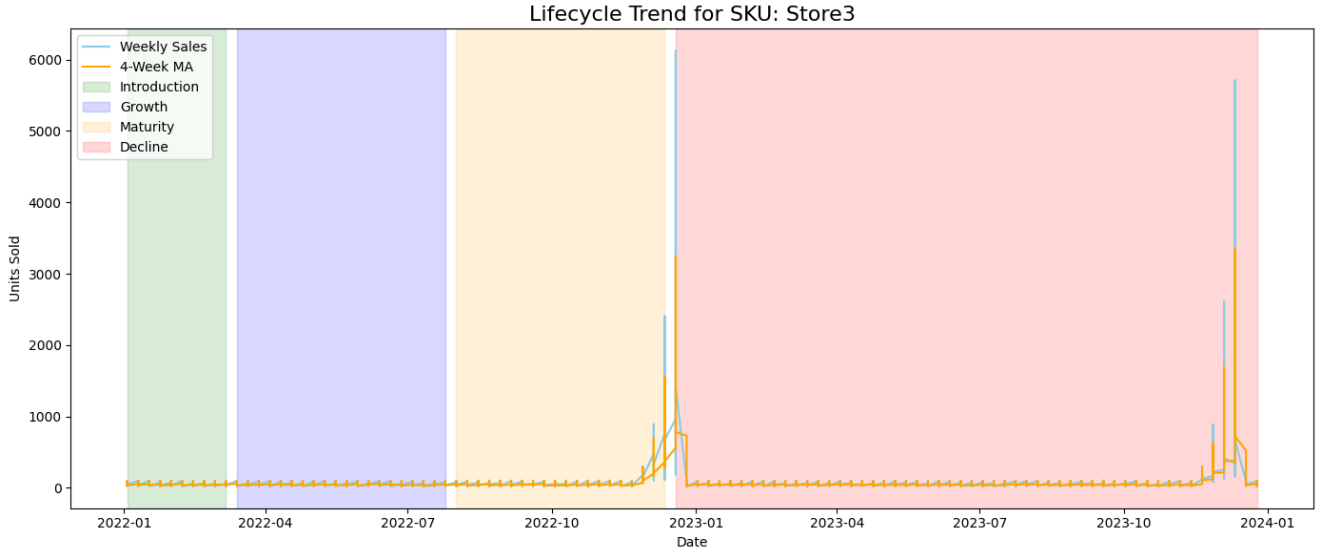
```
# Code 2: Step 3: Load cleaned lifecycle dataset
df = pd.read_csv("Cleaned_SKU_Lifecycle.csv", parse_dates=["sale_date"])
```

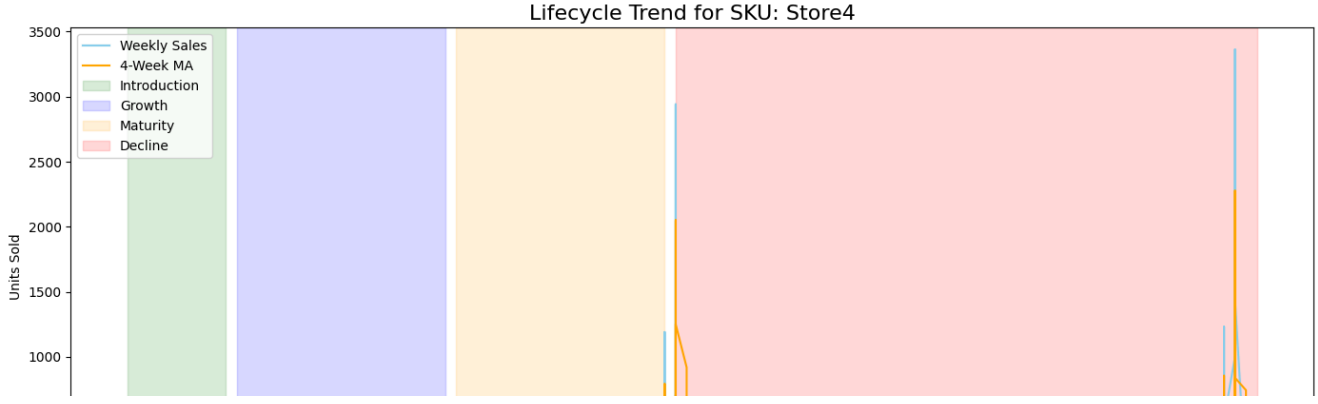
```
# Code 2: Step 4: Define lifecycle stage logic (reused for all SKUs)

def get_stage(age):
    if age < 10:
        return 'Introduction'
    elif age < 30:
        return 'Growth'
    elif age < 50:
        return 'Maturity'
    else:
        return 'Decline'
```

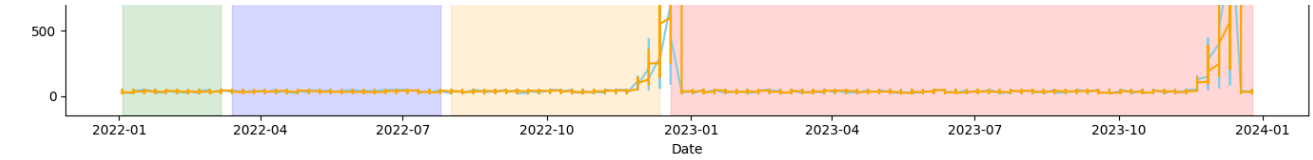
```
df['stage'] = df['product_age_weeks'].apply(get_stage)


# Code 2: Step 5: Get all unique SKUs
sku_list = df['scode'].unique()


# Code 2: Step 6: Loop through first 5 SKUs (change [:5] to full range if needed)

#You can change 20 to any number — even len(sku_list) to loop through all SKUs.

for sku in sku_list[:5]:
    df_sku = df[df['scode'] == sku]

    plt.figure(figsize=(14, 6))
    plt.plot(df_sku['sale_date'], df_sku['units'], label='Weekly Sales', color='skyblue')
    plt.plot(df_sku['sale_date'], df_sku['units_ma_4w'], label='4-Week MA', color='orange')

    for stage, color in zip(['Introduction', 'Growth', 'Maturity', 'Decline'],
                            ['green', 'blue', 'orange', 'red']):
        stage_data = df_sku[df_sku['stage'] == stage]
        if not stage_data.empty:
            plt.axvspan(stage_data['sale_date'].min(), stage_data['sale_date'].max(),
                        color=color, alpha=0.15, label=stage)

    plt.title(f"Lifecycle Trend for SKU: {sku}", fontsize=16)
    plt.xlabel("Date")
    plt.ylabel("Units Sold")
    plt.legend()
    plt.tight_layout()
    plt.show()
```

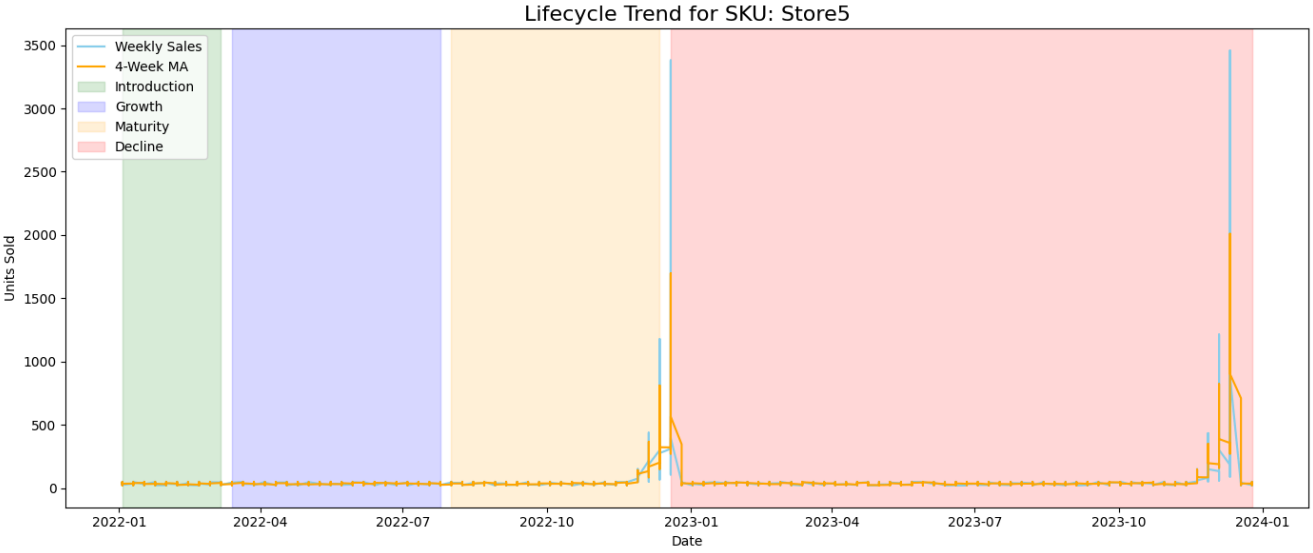

Lifecycle Trend for SKU: Store1
Weekly Sales
4-Week MA
Introduction
Growth
Maturity
Decline
Units Sold
Date
0
500
1000
1500
2000
2500
3000
2022-01
2022-04
2022-07
2022-10
2023-01
2023-04
2023-07
2023-10
2024-01


Lifecycle Trend for SKU: Store2
Weekly Sales
4-Week MA
Introduction
Growth
Maturity
Decline
Units Sold
Date
0
1000
2000
3000
4000
5000
6000
2022-01
2022-04
2022-07
2022-10
2023-01
2023-04
2023-07
2023-10
2024-01


Lifecycle Trend for SKU: Store3
Weekly Sales
4-Week MA
Introduction
Growth
Maturity
Decline
Units Sold
Date
0
1000
2000
3000
4000
5000
6000
2022-01
2022-04
2022-07
2022-10
2023-01
2023-04
2023-07
2023-10
2024-01


Lifecycle Trend for SKU: Store4
Weekly Sales
4-Week MA
Introduction
Growth
Maturity
Decline
Units Sold
1000
1500
2000
2500
3000
3500


500
0
2022-01
2022-04
2022-07
2022-10
2023-01
2023-04
2023-07
2023-10
2024-01
Date


Lifecycle Trend for SKU: Store5
Weekly Sales
4-Week MA
Introduction
Growth
Maturity
Decline
Units Sold
3500
3000
2500
2000
1500
1000
500
0
2022-01
2022-04
2022-07
2022-10
2023-01
2023-04
2023-07
2023-10
2024-01
Date

PHASE 3: SKU-wise Lifecycle Classification

```
# Step 1: Download necessary Python libraries
!pip install pandas
!pip install numpy
```

```
Requirement already satisfied: pandas in /usr/local/lib/python3.11/dist-packages (2.2.2)
Requirement already satisfied: numpy>=1.23.2 in /usr/local/lib/python3.11/dist-packages (from pandas) (2.0.2)
Requirement already satisfied: python-dateutil>=2.8.2 in /usr/local/lib/python3.11/dist-packages (from pandas) (2.9.0.post0)
Requirement already satisfied: pytz>=2020.1 in /usr/local/lib/python3.11/dist-packages (from pandas) (2025.2)
Requirement already satisfied: tzdata>=2022.7 in /usr/local/lib/python3.11/dist-packages (from pandas) (2025.2)
Requirement already satisfied: six>=1.5 in /usr/local/lib/python3.11/dist-packages (from python-dateutil>=2.8.2->pandas) (1.17.0)
Requirement already satisfied: numpy in /usr/local/lib/python3.11/dist-packages (2.0.2)
```

```
# Step 2: Import necessary Python libraries
import pandas as pd
import numpy as np
```

```
# Step 3: Load the cleaned dataset
df_long = pd.read_csv("Cleaned_SKU_Lifecycle.csv", parse_dates=["sale_date"])
```

```
# Step 6: Remove missing or invalid data based on 'units' and ensure non-negative sales
df_long = df_long[df_long['units'].notna()] # Filter by the 'units' column
df_long = df_long[df_long['units'] >= 0]
display(df_long.head()) # Display the head of the filtered dataframe
```

	scode	pcode	price	week	units	week_num	sale_date	product_age_weeks	cumulative_units	units_ma_4w
0	Store1	SKU1	$24.00	wk0	23	0	2022-01-03	0	23	23.000000
1	Store1	SKU2	$63.00	wk0	23	0	2022-01-03	0	46	23.000000
2	Store1	SKU3	$93.00	wk0	7	0	2022-01-03	0	53	17.666667
3	Store1	SKU4	$48.00	wk0	50	0	2022-01-03	0	103	25.750000
4	Store1	SKU5	$62.00	wk0	8	0	2022-01-03	0	111	22.000000

```
# Step 7: Define lifecycle classification function
def classify_lifecycle(df_long):
    results = []

    for (scode, pcode), group in df_long.groupby(['scode', 'pcode']):
        group = group.sort_values('week_num') # Sort by week_num from cleaned data

        # Aggregate weekly sales
        sales_series = group['units'].reset_index(drop=True) # Use 'units' column from cleaned data

        if sales_series.sum() == 0:
            continue  # Skip products with no sales at all

        # Normalize for analysis
        normalized_sales = sales_series / sales_series.max()

        # Define lifecycle stages based on thresholds
        # Ensure indices are within bounds after filtering NaNs
        growth_start_idx = (normalized_sales > 0.2).idxmax() if (normalized_sales > 0.2).any() else 0
        maturity_start_idx = (normalized_sales > 0.7).idxmax() if (normalized_sales > 0.7).any() else growth_start_idx
        decline_start_idx = (normalized_sales[::-1] < 0.3).idxmax() if (normalized_sales[::-1] < 0.3).any() else len(sales_series) - 1
        decline_start_idx = len(sales_series) - 1 - decline_start_idx


        result = {
            'scode': scode,
            'pcode': pcode,
            'intro_week': group['week_num'].min(), # Use week_num
            'growth_start_week': group.iloc[growth_start_idx]['week_num'], # Use week_num
            'maturity_start_week': group.iloc[maturity_start_idx]['week_num'], # Use week_num
            'decline_start_week': group.iloc[decline_start_idx]['week_num'], # Use week_num
            'total_sales': sales_series.sum()
        }
        results.append(result)

    if not results:
        raise ValueError("No valid SKU groups to classify.")

    return pd.DataFrame(results)
```

```
# Step 8: Run lifecycle classification
```

```
# Step 8: Run lifecycle classification
df_lifecycle = classify_lifecycle(df_long)


# Step 9: View the classified lifecycle
df_lifecycle.head()
```

	scode	pcode	intro_week	growth_start_week	maturity_start_week	decline_start_week	total_sales
0	Store1	SKU1	0	48	50	0	4789
1	Store1	SKU10	0	49	101	0	3357
2	Store1	SKU100	0	49	50	0	3285
3	Store1	SKU1000	0	48	50	0	10215
4	Store1	SKU1001	0	47	50	0	8584

Next steps: Generate code with df_lifecycle | View recommended plots | New interactive sheet

PHASE 4: Monthly Sales Aggregation and Visualization

```
# Step 1: Download necessary Python libraries
!pip install pandas
!pip install matplotlib
```

```
Requirement already satisfied: pandas in /usr/local/lib/python3.11/dist-packages (2.2.2)
Requirement already satisfied: numpy>=1.23.2 in /usr/local/lib/python3.11/dist-packages (from pandas) (2.0.2)
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Requirement already satisfied: pytz>=2020.1 in /usr/local/lib/python3.11/dist-packages (from pandas) (2025.2)
Requirement already satisfied: tzdata>=2022.7 in /usr/local/lib/python3.11/dist-packages (from pandas) (2025.2)
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Requirement already satisfied: fonttools>=4.22.0 in /usr/local/lib/python3.11/dist-packages (from matplotlib) (4.58.4)
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Requirement already satisfied: numpy>=1.23 in /usr/local/lib/python3.11/dist-packages (from matplotlib) (2.0.2)
Requirement already satisfied: packaging>=20.0 in /usr/local/lib/python3.11/dist-packages (from matplotlib) (24.2)
Requirement already satisfied: pillow>=8 in /usr/local/lib/python3.11/dist-packages (from matplotlib) (11.2.1)
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Requirement already satisfied: python-dateutil>=2.7 in /usr/local/lib/python3.11/dist-packages (from matplotlib) (2.9.0.post0)
Requirement already satisfied: six>=1.5 in /usr/local/lib/python3.11/dist-packages (from python-dateutil>=2.7->matplotlib) (1.17.0)
```
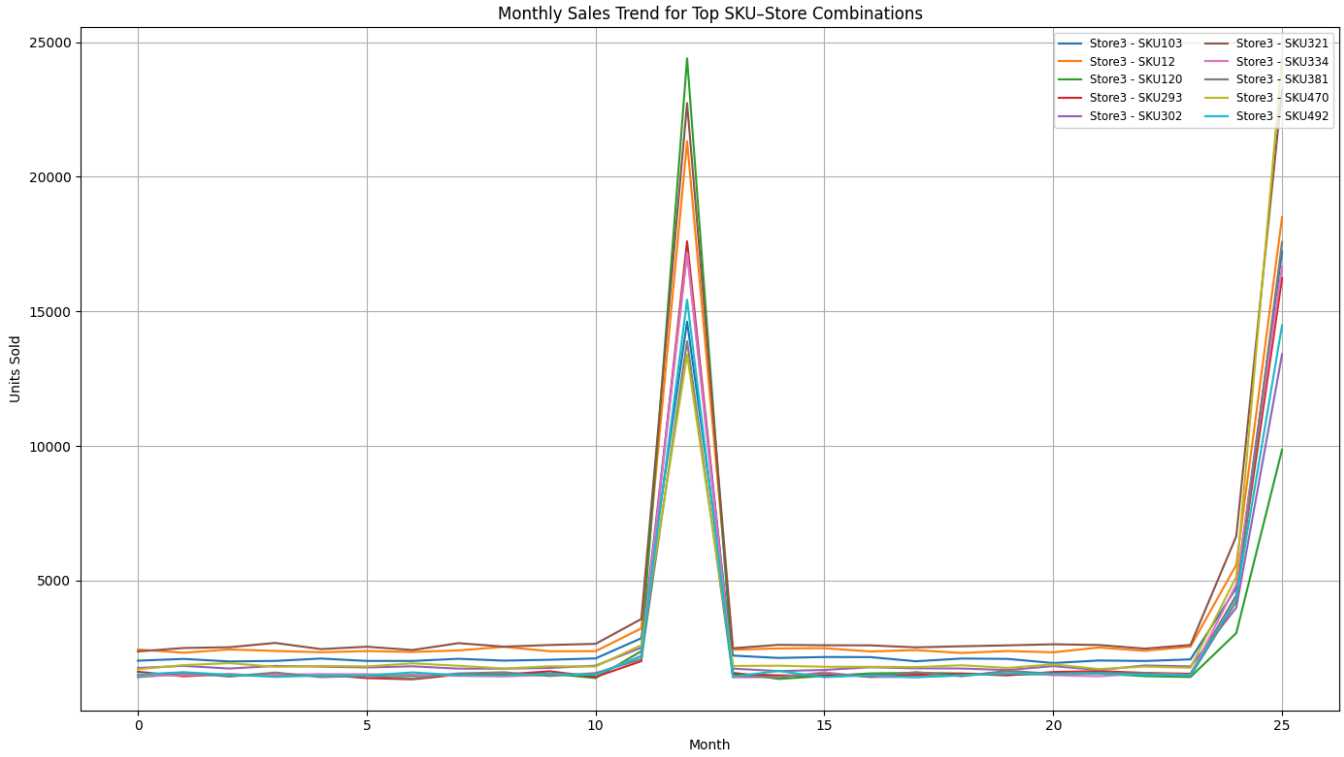

```
# Step 2: Import necessary Python libraries
import pandas as pd
import matplotlib.pyplot as plt


# Step 3: Convert 'week' column (e.g., 'wk0') to integer
df_long['week'] = df_long['week'].str.extract(r'(\d+)').astype(int)


# Step 4: Create a 'month' column by grouping every 4 weeks
df_long['month'] = df_long['week'] // 4


# Step 5: Aggregate monthly sales per SKU (scode + pcode)
monthly_sales = df_long.groupby(['scode', 'pcode', 'month'])['units'].sum().reset_index()


# Step 6: Plot sales trends for top N SKUs (by total sales volume)
top_skus = (
    monthly_sales.groupby(['scode', 'pcode'])['units']
    .sum()
    .sort_values(ascending=False)
    .head(10)  # change this to 20 if needed
    .reset_index()
)


# Step 7: Filter only top SKUs for plotting
filtered_sales = pd.merge(monthly_sales, top_skus, on=['scode', 'pcode'], how='inner', suffixes=('', '_total'))


# Step 8: Plot
plt.figure(figsize=(14, 8))

for (scode, pcode), group in filtered_sales.groupby(['scode', 'pcode']):
    label = f"{scode} - {pcode}"
    plt.plot(group['month'], group['units'], label=label)

plt.title('Monthly Sales Trend for Top SKU-Store Combinations')
```

```
plt.xlabel('Month')
plt.ylabel('Units Sold')
plt.legend(loc='upper right', fontsize='small', ncol=2)
plt.grid(True)
plt.tight_layout()
plt.show()
```



PHASE 5: Lifecycle Stage Labeling and Visualization

```
# Step 1: Download necessary Python libraries
!pip install seaborn
!pip install matplotlib
```

```
Requirement already satisfied: seaborn in /usr/local/lib/python3.11/dist-packages (0.13.2)
Requirement already satisfied: numpy!=1.24.0,>=1.20 in /usr/local/lib/python3.11/dist-packages (from seaborn) (2.0.2)
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Requirement already satisfied: pytz>=2020.1 in /usr/local/lib/python3.11/dist-packages (from pandas>=1.2->seaborn) (2025.2)
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Requirement already satisfied: six>=1.5 in /usr/local/lib/python3.11/dist-packages (from python-dateutil>=2.7->matplotlib!=3.6.1,>=3
Requirement already satisfied: matplotlib in /usr/local/lib/python3.11/dist-packages (3.10.0)
Requirement already satisfied: contourpy>=1.0.1 in /usr/local/lib/python3.11/dist-packages (from matplotlib) (1.3.2)
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Requirement already satisfied: fonttools>=4.22.0 in /usr/local/lib/python3.11/dist-packages (from matplotlib) (4.58.4)
Requirement already satisfied: kiwisolver>=1.3.1 in /usr/local/lib/python3.11/dist-packages (from matplotlib) (1.4.8)
Requirement already satisfied: numpy>=1.23 in /usr/local/lib/python3.11/dist-packages (from matplotlib) (2.0.2)
Requirement already satisfied: packaging>=20.0 in /usr/local/lib/python3.11/dist-packages (from matplotlib) (24.2)
Requirement already satisfied: pillow>=8 in /usr/local/lib/python3.11/dist-packages (from matplotlib) (11.2.1)
Requirement already satisfied: pyparsing>=2.3.1 in /usr/local/lib/python3.11/dist-packages (from matplotlib) (3.2.3)
Requirement already satisfied: python-dateutil>=2.7 in /usr/local/lib/python3.11/dist-packages (from matplotlib) (2.9.0.post0)
Requirement already satisfied: six>=1.5 in /usr/local/lib/python3.11/dist-packages (from python-dateutil>=2.7->matplotlib) (1.17.0)
```
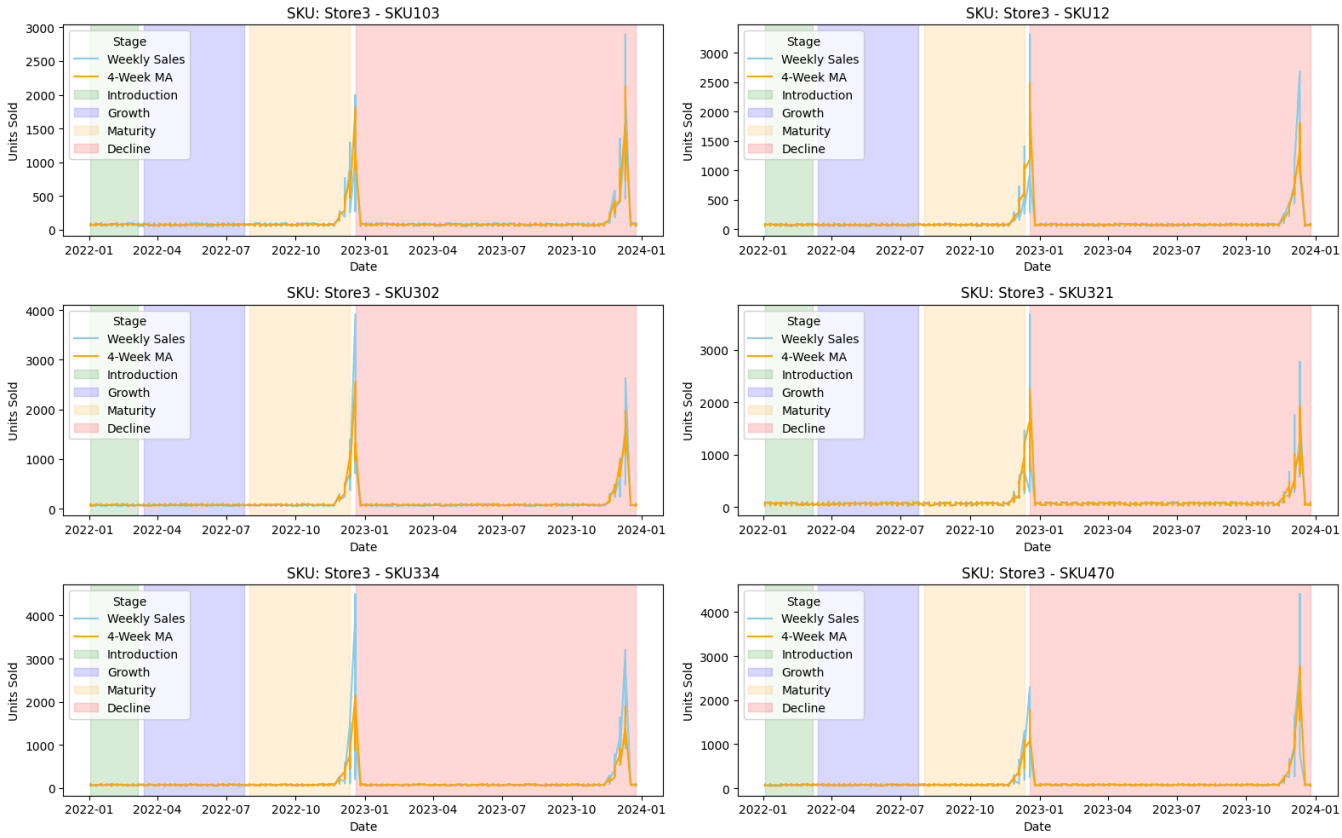

```
# Step 2: Import necessary Python libraries
import seaborn as sns
import matplotlib.pyplot as plt


# Step 3: Choose top N SKUs by total sales
top_skus = (
    df_lifecycle.groupby(['scode', 'pcode'])['total_sales'] # Changed 'units' to 'total_sales'
    .sum()
    .sort_values(ascending=False)
    .head(6)  # adjust top N here
    .reset_index()
)


# Step 4: Filter the lifecycle data to include only those top SKUs
df_top = pd.merge(df_lifecycle, top_skus, on=['scode', 'pcode'], how='inner')


# Step 5: Plot lifecycle stages with color-coded lines

# Merge df_long with top_skus to get weekly sales data for top SKUs
df_plot = pd.merge(df_long, top_skus[['scode', 'pcode']], on=['scode', 'pcode'], how='inner')

# Define lifecycle stage logic (reused for all SKUs)
def get_stage(age):
    if age < 10:
        return 'Introduction'
    elif age < 30:
        return 'Growth'
    elif age < 50:
        return 'Maturity'
    else:
        return 'Decline'

df_plot['lifecycle_stage'] = df_plot['product_age_weeks'].apply(get_stage)


plt.figure(figsize=(16, 10))
for i, ((scode, pcode), group) in enumerate(df_plot.groupby(['scode', 'pcode'])):
    plt.subplot(3, 2, i+1)  # change layout based on N SKUs
    group = group.sort_values('week_num') # Sort by week_num

    # Plot weekly units
    plt.plot(group['sale_date'], group['units'], label='Weekly Sales', color='skyblue')

    # Plot 4-week moving average
    plt.plot(group['sale_date'], group['units_ma_4w'], label='4-Week MA', color='orange')

    # Shade lifecycle stages
    for stage, color in zip(['Introduction', 'Growth', 'Maturity', 'Decline'],
                            ['green', 'blue', 'orange', 'red']):
        stage_data = group[group['lifecycle_stage'] == stage]
        if not stage_data.empty:
            plt.axvspan(stage_data['sale_date'].min(), stage_data['sale_date'].max(),
                        color=color, alpha=0.15, label=stage)


    plt.title(f'SKU: {scode} - {pcode}')
    plt.xlabel('Date')
    plt.ylabel('Units Sold')
    plt.legend(title='Stage', loc='best')

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



PHASE 6: Lifecycle Duration Comparison & Decision Flags

```
# Step 1: Add lifecycle stage to df_long
def get_stage(age):
    if age < 10:
        return 'Introduction'
    elif age < 30:
        return 'Growth'
    elif age < 50:
        return 'Maturity'
    else:
        return 'Decline'

df_long['lifecycle_stage'] = df_long['product_age_weeks'].apply(get_stage)


# Step 2: Count how many weeks each SKU spent in each lifecycle stage
stage_counts = (
    df_long.groupby(['scode', 'pcode', 'lifecycle_stage'])['week_num'] # Changed to use df_long and week_num
    .count()
    .reset_index()
    .rename(columns={'week_num': 'weeks_in_stage'}) # Renamed the counted column
)


# Step 3: Pivot the stages into columns
lifecycle_summary = stage_counts.pivot(
    index=['scode', 'pcode'],
    columns='lifecycle_stage',
    values='weeks_in_stage'
).fillna(0).reset_index()
```

```
# Step 4: Ensure column order
expected_stages = ['Introduction', 'Growth', 'Maturity', 'Decline']
for stage in expected_stages:
    if stage not in lifecycle_summary.columns:
        lifecycle_summary[stage] = 0



# Step 5: Total active weeks
lifecycle_summary['total_weeks'] = lifecycle_summary[expected_stages].sum(axis=1)


# Step 6: Business Decision Rule Logic

def decision_rule(row):
    if row['Decline'] >= 8 and row['Maturity'] <= 4:
        return 'Discontinue'
    elif row['Growth'] >= 6 and row['Maturity'] < 3:
        return 'Promote'
    elif row['Maturity'] >= 10:
        return 'Restock'
    else:
        return 'Monitor'

lifecycle_summary['business_decision'] = lifecycle_summary.apply(decision_rule, axis=1)


# Step 7: Show the output
print(lifecycle_summary.head(10))
```

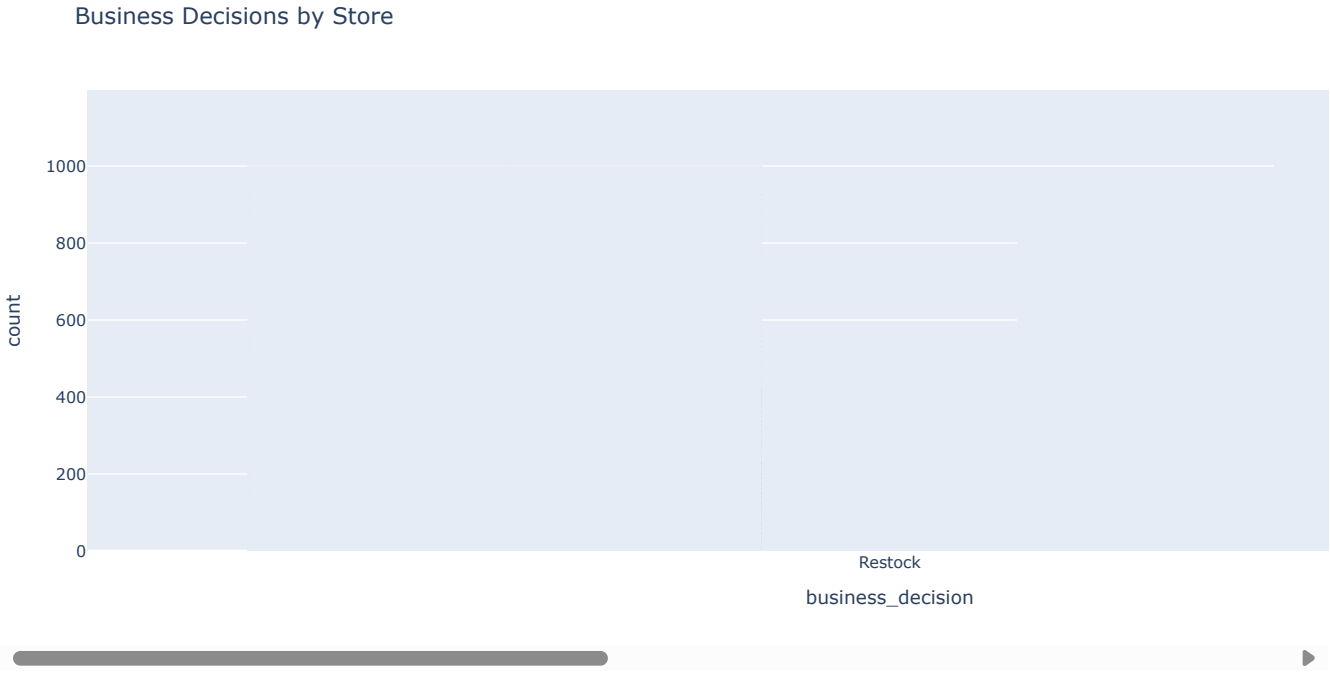
```
lifecycle_stage   scode    pcode  Decline  Growth  Introduction  Maturity  \
0                Store1     SKU1       54      20            10        20
1                Store1    SKU10       54      20            10        20
2                Store1   SKU100       54      20            10        20
3                Store1  SKU1000       54      20            10        20
4                Store1  SKU1001       54      20            10        20
5                Store1  SKU1002       54      20            10        20
6                Store1  SKU1003       54      20            10        20
7                Store1  SKU1004       54      20            10        20
8                Store1  SKU1005       54      20            10        20
9                Store1  SKU1006       54      20            10        20

lifecycle_stage  total_weeks business_decision
0                        104           Restock
1                        104           Restock
2                        104           Restock
3                        104           Restock
4                        104           Restock
5                        104           Restock
6                        104           Restock
7                        104           Restock
8                        104           Restock
9                        104           Restock
```

PHASE 7: Visualization

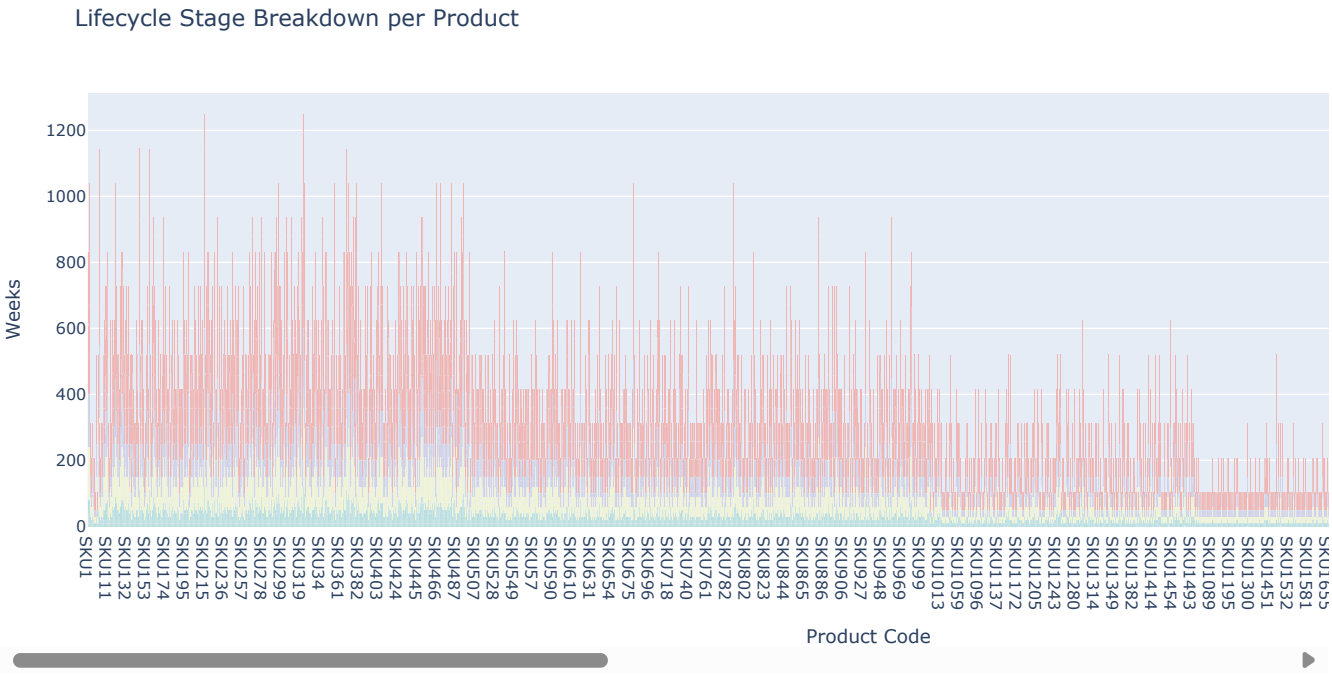
```
# Step 1: Download necessary Python library
!pip install plotly
```

```
Requirement already satisfied: plotly in /usr/local/lib/python3.11/dist-packages (5.24.1)
Requirement already satisfied: tenacity>=6.2.0 in /usr/local/lib/python3.11/dist-packages (from plotly) (8.5.0)
Requirement already satisfied: packaging in /usr/local/lib/python3.11/dist-packages (from plotly) (24.2)
```

```
# Step 2: Import necessary Python library
import plotly.express as px


# Step 3: Bar Chart — Business Decisions by Store
fig = px.bar(
    lifecycle_summary,
    x='business_decision',
    color='scode',
    title='Business Decisions by Store',
    barmode='group'
)
fig.show()
```




```
# Step 4: Stacked Bar – Lifecycle Weeks per SKU
fig = px.bar(
    lifecycle_summary,
    x='pcode',
    y=['Introduction', 'Growth', 'Maturity', 'Decline'],
    title='Lifecycle Stage Breakdown per Product',
    labels={'value':'Weeks', 'pcode':'Product Code'},
    color_discrete_sequence=px.colors.qualitative.Set3
)
fig.update_layout(barmode='stack')
fig.show()
```




```
# Step 4: Pie Chart – Decision Distribution
fig = px.pie(
    lifecycle_summary,
    names='business_decision',
    title='Overall Business Decision Share',
    hole=0.4  # makes it donut-style
)
fig.show()
```