Exercise 2

In this exercise, we will analyze COVID-19 hospital admissions in the UK, and you will fit an exponential curve to understand the rise in hospital admissions in a six week period from late November to early January.

The data is in a file called `data_2021-Feb-14.csv` (comma-separated-values format). It was downloaded from the official website for UK COVID-19 data.

In [1]:
```
# If you are running this on Google Colab, uncomment and run the following lines; ot
# from google.colab import drive
# drive.mount('/content/drive')
```

In [2]:
```
import math
import numpy as np
import matplotlib.pyplot as plt
import pandas as pd
```

We will use `pandas`, a library for data analysis in Python to load and view the data. Pandas uses a structure called a *data frame* to represent and manipulate data tables. All the required commands are included here, so you won't need to learn Pandas for this exercise. But if you are interested in learning more, this is a good place to start.

In [3]:
```
df_hosp = pd.read_csv('data_2021-Feb-14.csv')  # Create a data frame by loading data
# If running on Google Colab change path to '/content/drive/MyDrive/IB-Data-Science/

df_hosp.head(3)   #display the first three rows
```

Out[3]:

	date	newAdmissions	cumulativeAdmissions
0	23/03/2020	1273	4876
1	24/03/2020	1720	6596
2	25/03/2020	2085	8681

The command `pd.read_csv` loads the data onto a data frame. We have used the `.head()` command to display the top 3 rows of the data frame.

We can also display a random sample of rows from the data frame using `.sample()`, or the last few rows using `.tail()`.

In [4]:
```
df_hosp.tail(3)
```

Out[4]:

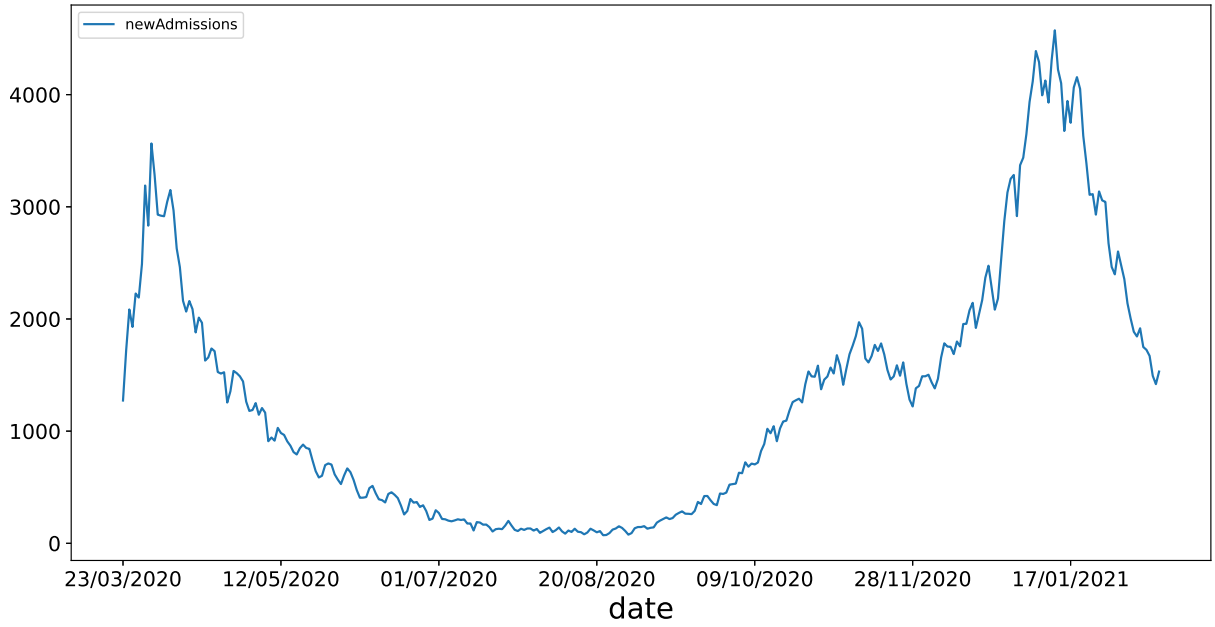
	date	newAdmissions	cumulativeAdmissions
326	12/02/2021	1493	424849
327	13/02/2021	1419	426268
328	14/02/2021	1531	427799

You can plot one column against another by just using their column names. Let us plot the newAdmissions column versus date.

In [5]:
```
plt.rcParams['figure.figsize'] = [14, 7]
plt.rcParams['axes.titlesize'] = 20
plt.rcParams['axes.labelsize'] = 20
```

```
plt.rcParams['xtick.labelsize'] = 14
plt.rcParams['ytick.labelsize'] = 14

df_hosp.plot(x='date', y='newAdmissions')
plt.show()
```



Note the sharp increase in hospital admissions from late Novemeber to early January (the rise of the 'new variant'). We now extract the rows spanning the dates 28 November to 10 January into a data frame called `df_part`

In [6]:
```
df_part = df_hosp[250:294]
df_part.head(2)
```

Out[6]:

	date	newAdmissions	cumulativeAdmissions
250	28/11/2020	1220	220585
251	29/11/2020	1382	221967

In [7]:
```
df_part.tail(2)
```

Out[7]:

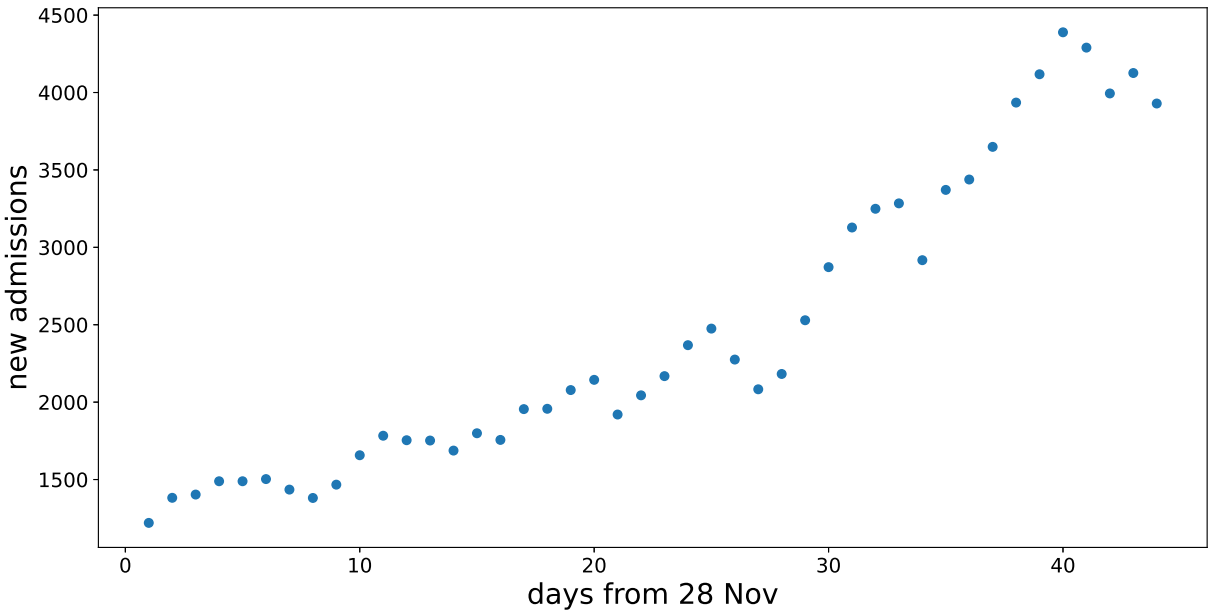
	date	newAdmissions	cumulativeAdmissions
292	09/01/2021	4126	323260
293	10/01/2021	3929	327189

We now convert the `newAdmissions` column to a numpy array `yvals`

In [8]:
```
yvals = np.array(df_part['newAdmissions'])
N = np.size(yvals)
xvals = np.linspace(1,N,N) #an array containing the values 1,2....,N
```

2a) Plot the data `yvals` vs `xvals` in a scatterplot

In [9]:
```
plt.scatter(xvals, yvals)
plt.ylabel("new admissions")
plt.xlabel("days from 28 Nov")
plt.show()
```



2b) Fit an exponential model to the data

From our knowledge of how the virus spreads, we know that the number of infections, hospital admissions etc. should (roughly) follow an exponential curve. We would therefore like to fit a model of the form $y = c_1 e^{c_2 x}$, where y is the number of admissions on day x.

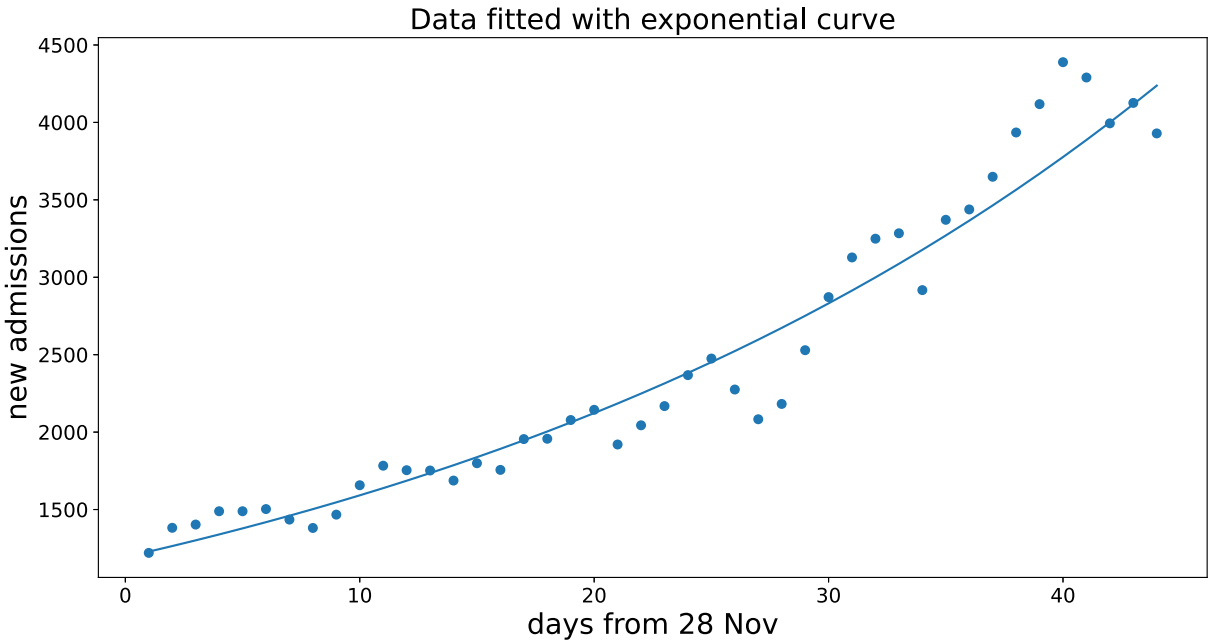
Note that this is a linear model on a log-scale for y. That is, $\log y = \log c_1 + c_2 x$.

- Fit a linear model for $\log(\text{yvals})$ vs xvals, and print the values of c_1 and c_2
- Plot the fit $y = c_1 e^{c_2 x}$ along with the scatterplot of the data

In [11]:
```
# Get coeffecients of exponential fit
c2, logc1 = np.polyfit(xvals, np.log(yvals), 1)
c1 = np.exp(logc1)
print(f"c1: {c1:.3g}\tc2: {c2:.3g}")

# plot
plt.plot(xvals, c1 * np.exp(c2 * xvals))
plt.scatter(xvals, yvals)
plt.ylabel("new admissions")
plt.xlabel("days from 28 Nov")
plt.title("Data fitted with exponential curve")
plt.show()
```

```
c1: 1.19e+03    c2: 0.0288
```



2c) Estimate the weekly growth rate in hospital admissions (in \%) over this period

Hint : According to the model, admissions increase every 7 days by a factor of $(c_1 e^{c_2(x+7)})/(c_1 e^{c_2 x}) = e^{7c_2}$.

In [12]:
```
# compute and print weekly growth rate (in %)
print(f"Weekly growth rate: {np.exp(7*c2):.3g}")
```

```
Weekly growth rate: 1.22
```

In [ ]: