Cargar el framework tensorflow y verificar su versión

In [3]:
```
import tensorflow as tf
# from tensorflow import keras
print(tf.__version__)
```

```
2.8.0
```

MNIST

MNIST es una base de datos de dígitos escritos a mano, que se compone de un conjunto de entrenamiento de 60000 imágenes, y un conjunto de prueba de 10000 imágenes

http://yann.lecun.com/exdb/mnist/

In [4]:
```
digit_mnist = tf.keras.datasets.mnist
(X_train_whole, y_train_whole), (X_test, y_test) = digit_mnist.load_data()
```

In [5]:
```
print(f'Numero de imagenes para entrenamiento {X_train_whole.shape[0]}, de tamaño {X_train_whole.shape[1]}x{X_train_whole.shape[2]}')
print(f'Numero de imagenes para validación {X_test.shape[0]}, de tamaño {X_test.shape[1]}x{X_test.shape[2]}')
```

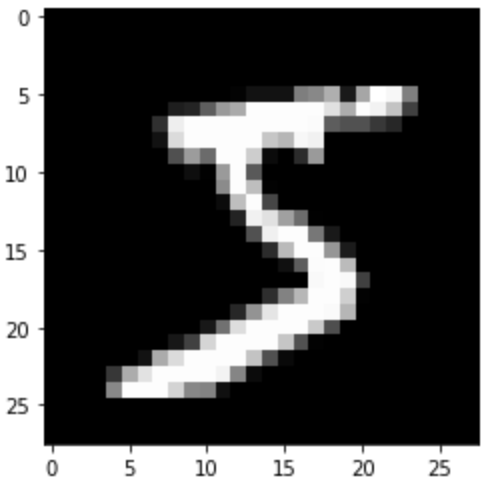
```
Numero de imagenes para entrenamiento 60000, de tamaño 28x28
Numero de imagenes para validación 10000, de tamaño 28x28
```

In [6]:
```
import numpy as np
# linewidth - número de caracteres por línea
np.set_printoptions(linewidth=200)
import matplotlib.pyplot as plt
# Mapa de color: gris
plt.imshow(X_train_whole[0], cmap="gray") # "Blues" "viridis" (G, Y, B)

print(y_train_whole[0])
print(X_test[0])
```

```
5
[[   0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
     0    0    0    0    0    0]
 [   0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
     0    0    0    0    0    0]
 [   0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
     0    0    0    0    0    0]
 [   0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
     0    0    0    0    0    0]
 [   0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
     0    0    0    0    0    0]
 [   0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
     0    0    0    0    0    0]
```

```
[[  0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
    0   0   0   0   0   0]
 [  0   0   0   0   0   0   0  84 185 159 151  60  36   0   0   0   0   0   0   0   0   0   0   0
    0   0   0   0   0   0]
 [  0   0   0   0   0   0   0 222 254 254 254 254 241 198 198 198 198 198 198 198 198 170  52   0
    0   0   0   0   0   0]
 [  0   0   0   0   0   0   0  67 114  72 114 163 227 254 225 254 254 254 250 229 254 254 140   0
    0   0   0   0   0   0]
 [  0   0   0   0   0   0   0   0   0   0   0   0  17  66  14  67  67  67  59  21 236 254 106   0
    0   0   0   0   0   0]
 [  0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0  83 253 209  18   0
    0   0   0   0   0   0]
 [  0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0  22 233 255  83   0   0
    0   0   0   0   0   0]
 [  0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0 129 254 238  44   0   0
    0   0   0   0   0   0]
 [  0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0  59 249 254  62   0   0   0
    0   0   0   0   0   0]
 [  0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0 133 254 187   5   0   0   0
    0   0   0   0   0   0]
 [  0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   9 205 248  58   0   0   0   0
    0   0   0   0   0   0]
 [  0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0 126 254 182   0   0   0   0   0
    0   0   0   0   0   0]
 [  0   0   0   0   0   0   0   0   0   0   0   0   0   0   0  75 251 240  57   0   0   0   0   0
    0   0   0   0   0   0]
 [  0   0   0   0   0   0   0   0   0   0   0   0   0   0  19 221 254 166   0   0   0   0   0   0
    0   0   0   0   0   0]
 [  0   0   0   0   0   0   0   0   0   0   0   0   0   3 203 254 219  35   0   0   0   0   0   0
    0   0   0   0   0   0]
 [  0   0   0   0   0   0   0   0   0   0   0   0   0  38 254 254  77   0   0   0   0   0   0   0
    0   0   0   0   0   0]
 [  0   0   0   0   0   0   0   0   0   0   0   0  31 224 254 115   1   0   0   0   0   0   0   0
    0   0   0   0   0   0]
 [  0   0   0   0   0   0   0   0   0   0   0   0 133 254 254  52   0   0   0   0   0   0   0   0
    0   0   0   0   0   0]
 [  0   0   0   0   0   0   0   0   0   0   0  61 242 254 254  52   0   0   0   0   0   0   0   0
    0   0   0   0   0   0]
 [  0   0   0   0   0   0   0   0   0   0   0 121 254 254 219  40   0   0   0   0   0   0   0   0
    0   0   0   0   0   0]
 [  0   0   0   0   0   0   0   0   0   0   0 121 254 207  18   0   0   0   0   0   0   0   0   0
    0   0   0   0   0   0]
 [  0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
    0   0   0   0   0   0]]
```



Tipo de datos

In [7]:
```
X_train_whole.dtype
```

Out[7]:
```
dtype('uint8')
```

Dataset para entrenamiento

Dividir el conjunto *X_train_whole* en dos conjuntos: el de entrenamiento y el de validación

In [8]:
```
X_valid, X_train = X_train_whole[:12000], X_train_whole[12000:]
y_valid, y_train = y_train_whole[:12000], y_train_whole[12000:]
print(X_train.shape)
print(X_valid.shape)
```

```
(48000, 28, 28)
(12000, 28, 28)
```

In [9]:
```
from sklearn.model_selection import train_test_split

X_train_1, X_test_1, y_train_1, y_test_1 = train_test_split(X_train_whole,
y_train_whole, test_size=0.2, random_state=42)
print(X_train_1.shape)
print(X_test_1.shape)
```

```
(48000, 28, 28)
(12000, 28, 28)
```

Normalización de datos

In [10]:
```
X_train = X_train / 255.0
X_valid = X_valid / 255.0
print(X_valid[0,10,8:15])
```

```
[0.         0.05490196 0.00392157 0.60392157 0.99215686 0.35294118 0.        ]
```

Clases del problema

Dígitos del 0 al 9

Red neuronal (modelo)

Capas

- **Sequential** - SECUENCIA de capas (apiladas) en la red neuronal
- **Dense** - Capa de neuronas densamente conectada
- **Flatten** - Convierte un arreglo bidimensional (matrix) a un vector de una dimensión.

Funciones de activación

- **Relu** Si X>0 devuelve X, si no, devuelve 0
- **Softmax** toma un conjunto de valores, y escoge el más grande.

In [11]:
```
model = tf.keras.models.Sequential()
model.add(tf.keras.layers.Flatten(input_shape=[28,28]))
model.add(tf.keras.layers.Dense(300, activation='relu'))
model.add(tf.keras.layers.Dense(300, activation='relu'))
model.add(tf.keras.layers.Dense(10, activation='softmax'))



model_ = tf.keras.Sequential()
model_.add(tf.keras.layers.Flatten(input_shape=(28, 28)))
model_.add(tf.keras.layers.Dense(512, activation='relu'))
model_.add(tf.keras.layers.Dense(10, activation='softmax'))
```

Número de parámetros

In [12]:
```
model.summary()
model_.summary()
```

```
Model: "sequential"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 flatten (Flatten)           (None, 784)               0

 dense (Dense)               (None, 300)               235500

 dense_1 (Dense)             (None, 300)               90300

 dense_2 (Dense)             (None, 10)                3010

=================================================================
Total params: 328,810
Trainable params: 328,810
Non-trainable params: 0
_________________________________________________________________
Model: "sequential_1"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 flatten_1 (Flatten)         (None, 784)               0

 dense_3 (Dense)             (None, 512)               401920

 dense_4 (Dense)             (None, 10)                5130

=================================================================
Total params: 407,050
Trainable params: 407,050
Non-trainable params: 0
_________________________________________________________________
```

Configuración del modelo

- *optimizer* - Optimizador (https://www.tensorflow.org/api_docs/python/tf/keras/optimizers)

- *loss* - Función de perdida
- *metrics* - Métricas para la evaluación (desempeño) del modelo

In [13]:
```
model.compile(loss='sparse_categorical_crossentropy',
              optimizer = "sgd",
              metrics = ["accuracy"]
              )
```

Entrenamiento del modelo

- epochs - Número de epocas para entrenar el modelo
- validation_data - Conjunto de datos que se emplean para evaluar la perdida al final de cada epoca.
- batch_size - Número de muestras para actualización del gradiente
- verbose - Salida del proceso de entrenamiento (0, 1, 2)

In [14]:
```
history = model.fit(X_train, y_train, epochs=15, validation_data=(X_valid,
y_valid), verbose=1, batch_size=32)
```

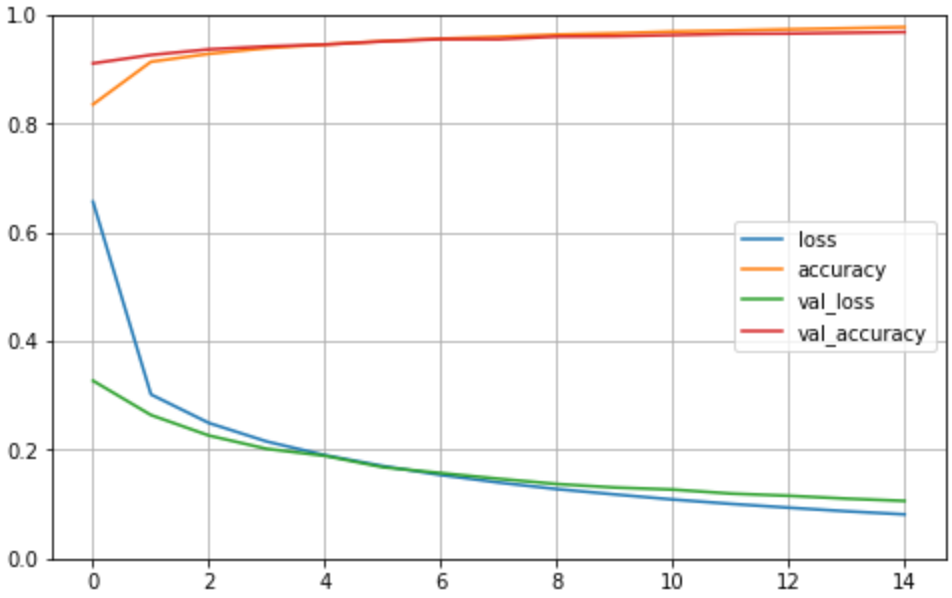
```
Epoch 1/15
1500/1500 [==============================] - 6s 4ms/step - loss: 0.6565 - accuracy: 0.8355
- val_loss: 0.3273 - val_accuracy: 0.9110
Epoch 2/15
1500/1500 [==============================] - 5s 3ms/step - loss: 0.3020 - accuracy: 0.9140
- val_loss: 0.2641 - val_accuracy: 0.9265
Epoch 3/15
1500/1500 [==============================] - 5s 3ms/step - loss: 0.2495 - accuracy: 0.9286
- val_loss: 0.2264 - val_accuracy: 0.9368
Epoch 4/15
1500/1500 [==============================] - 5s 3ms/step - loss: 0.2153 - accuracy: 0.9390
- val_loss: 0.2019 - val_accuracy: 0.9423
Epoch 5/15
1500/1500 [==============================] - 5s 4ms/step - loss: 0.1903 - accuracy: 0.9458
- val_loss: 0.1890 - val_accuracy: 0.9456
Epoch 6/15
1500/1500 [==============================] - 5s 3ms/step - loss: 0.1703 - accuracy: 0.9519
- val_loss: 0.1681 - val_accuracy: 0.9514
Epoch 7/15
1500/1500 [==============================] - 5s 4ms/step - loss: 0.1537 - accuracy: 0.9563
- val_loss: 0.1574 - val_accuracy: 0.9556
Epoch 8/15
1500/1500 [==============================] - 5s 3ms/step - loss: 0.1399 - accuracy: 0.9599
- val_loss: 0.1469 - val_accuracy: 0.9553
Epoch 9/15
1500/1500 [==============================] - 5s 4ms/step - loss: 0.1279 - accuracy: 0.9640
- val_loss: 0.1372 - val_accuracy: 0.9603
Epoch 10/15
1500/1500 [==============================] - 6s 4ms/step - loss: 0.1181 - accuracy: 0.9663
- val_loss: 0.1307 - val_accuracy: 0.9609
Epoch 11/15
1500/1500 [==============================] - 5s 3ms/step - loss: 0.1087 - accuracy: 0.9696
- val_loss: 0.1270 - val_accuracy: 0.9630
Epoch 12/15
1500/1500 [==============================] - 6s 4ms/step - loss: 0.1007 - accuracy: 0.9714
- val_loss: 0.1196 - val_accuracy: 0.9653
Epoch 13/15
```

```
1500/1500 [==============================] - 6s 4ms/step - loss: 0.0937 - accuracy: 0.9737
- val_loss: 0.1156 - val_accuracy: 0.9658
Epoch 14/15
1500/1500 [==============================] - 6s 4ms/step - loss: 0.0870 - accuracy: 0.9756
- val_loss: 0.1103 - val_accuracy: 0.9672
Epoch 15/15
1500/1500 [==============================] - 5s 3ms/step - loss: 0.0813 - accuracy: 0.9778
- val_loss: 0.1061 - val_accuracy: 0.9685
```

In [15]:

```
import pandas as pd
import matplotlib.pyplot as plt

pd.DataFrame(history.history).plot(figsize=(8,5))
plt.grid(True)
plt.gca().set_ylim(0,1)
plt.show()
```



In [16]:

```
model.evaluate(X_test, y_test)
```

```
313/313 [==============================] - 1s 2ms/step - loss: 14.1194 - accuracy: 0.9695
```

Out[16]:

```
[14.119437217712402, 0.9695000052452087]
```

In [20]:

```
!pip install -U notebook-as-pdf
```

```
Collecting notebook-as-pdf
  Downloading notebook_as_pdf-0.5.0-py3-none-any.whl (6.5 kB)
Collecting PyPDF2
  Downloading PyPDF2-2.4.2-py3-none-any.whl (199 kB)
Collecting pyppeteer
  Downloading pyppeteer-1.0.2-py3-none-any.whl (83 kB)
Requirement already satisfied: nbconvert in c:\programdata\anaconda3\lib\site-packages (fr
om notebook-as-pdf) (6.1.0)
Requirement already satisfied: bleach in c:\programdata\anaconda3\lib\site-packages (from
nbconvert->notebook-as-pdf) (4.0.0)
Requirement already satisfied: nbformat>=4.4 in c:\programdata\anaconda3\lib\site-packages
(from nbconvert->notebook-as-pdf) (5.1.3)
Requirement already satisfied: pandocfilters>=1.4.1 in c:\programdata\anaconda3\lib\site-p
```

```
ackages (from nbconvert->notebook-as-pdf) (1.4.3)
Requirement already satisfied: nbclient<0.6.0,>=0.5.0 in c:\programdata\anaconda3\lib\site
-packages (from nbconvert->notebook-as-pdf) (0.5.3)
Requirement already satisfied: jupyterlab-pygments in c:\programdata\anaconda3\lib\site-pa
ckages (from nbconvert->notebook-as-pdf) (0.1.2)
Requirement already satisfied: entrypoints>=0.2.2 in c:\programdata\anaconda3\lib\site-pac
kages (from nbconvert->notebook-as-pdf) (0.3)
Requirement already satisfied: defusedxml in c:\programdata\anaconda3\lib\site-packages (f
rom nbconvert->notebook-as-pdf) (0.7.1)
Requirement already satisfied: jupyter-core in c:\programdata\anaconda3\lib\site-packages
(from nbconvert->notebook-as-pdf) (4.8.1)
Requirement already satisfied: testpath in c:\programdata\anaconda3\lib\site-packages (fro
m nbconvert->notebook-as-pdf) (0.5.0)
Requirement already satisfied: pygments>=2.4.1 in c:\programdata\anaconda3\lib\site-packag
es (from nbconvert->notebook-as-pdf) (2.10.0)
Requirement already satisfied: mistune<2,>=0.8.1 in c:\programdata\anaconda3\lib\site-pack
ages (from nbconvert->notebook-as-pdf) (0.8.4)
Requirement already satisfied: jinja2>=2.4 in c:\programdata\anaconda3\lib\site-packages
(from nbconvert->notebook-as-pdf) (2.11.3)
Requirement already satisfied: traitlets>=5.0 in c:\programdata\anaconda3\lib\site-package
s (from nbconvert->notebook-as-pdf) (5.1.0)
Requirement already satisfied: MarkupSafe>=0.23 in c:\programdata\anaconda3\lib\site-packa
ges (from jinja2>=2.4->nbconvert->notebook-as-pdf) (1.1.1)
Requirement already satisfied: async-generator in c:\programdata\anaconda3\lib\site-packag
es (from nbclient<0.6.0,>=0.5.0->nbconvert->notebook-as-pdf) (1.10)
Requirement already satisfied: nest-asyncio in c:\programdata\anaconda3\lib\site-packages
(from nbclient<0.6.0,>=0.5.0->nbconvert->notebook-as-pdf) (1.5.1)
Requirement already satisfied: jupyter-client>=6.1.5 in c:\programdata\anaconda3\lib\site-
packages (from nbclient<0.6.0,>=0.5.0->nbconvert->notebook-as-pdf) (6.1.12)
Requirement already satisfied: python-dateutil>=2.1 in c:\programdata\anaconda3\lib\site-p
ackages (from jupyter-client>=6.1.5->nbclient<0.6.0,>=0.5.0->nbconvert->notebook-as-pdf)
(2.8.2)
Requirement already satisfied: tornado>=4.1 in c:\programdata\anaconda3\lib\site-packages
(from jupyter-client>=6.1.5->nbclient<0.6.0,>=0.5.0->nbconvert->notebook-as-pdf) (6.1)
Requirement already satisfied: pyzmq>=13 in c:\programdata\anaconda3\lib\site-packages (fr
om jupyter-client>=6.1.5->nbclient<0.6.0,>=0.5.0->nbconvert->notebook-as-pdf) (22.2.1)
Requirement already satisfied: pywin32>=1.0 in c:\programdata\anaconda3\lib\site-packages
(from jupyter-core->nbconvert->notebook-as-pdf) (228)
Requirement already satisfied: jsonschema!=2.5.0,>=2.4 in c:\programdata\anaconda3\lib\sit
e-packages (from nbformat>=4.4->nbconvert->notebook-as-pdf) (3.2.0)
Requirement already satisfied: ipython-genutils in c:\programdata\anaconda3\lib\site-packa
ges (from nbformat>=4.4->nbconvert->notebook-as-pdf) (0.2.0)
Requirement already satisfied: attrs>=17.4.0 in c:\programdata\anaconda3\lib\site-packages
(from jsonschema!=2.5.0,>=2.4->nbformat>=4.4->nbconvert->notebook-as-pdf) (21.2.0)
Requirement already satisfied: six>=1.11.0 in c:\programdata\anaconda3\lib\site-packages
(from jsonschema!=2.5.0,>=2.4->nbformat>=4.4->nbconvert->notebook-as-pdf) (1.16.0)
Requirement already satisfied: setuptools in c:\programdata\anaconda3\lib\site-packages (f
rom jsonschema!=2.5.0,>=2.4->nbformat>=4.4->nbconvert->notebook-as-pdf) (58.0.4)
Requirement already satisfied: pyrsistent>=0.14.0 in c:\programdata\anaconda3\lib\site-pac
kages (from jsonschema!=2.5.0,>=2.4->nbformat>=4.4->nbconvert->notebook-as-pdf) (0.18.0)
Requirement already satisfied: webencodings in c:\programdata\anaconda3\lib\site-packages
(from bleach->nbconvert->notebook-as-pdf) (0.5.1)
Requirement already satisfied: packaging in c:\programdata\anaconda3\lib\site-packages (fr
om bleach->nbconvert->notebook-as-pdf) (21.0)
Requirement already satisfied: pyparsing>=2.0.2 in c:\programdata\anaconda3\lib\site-packa
ges (from packaging->bleach->nbconvert->notebook-as-pdf) (3.0.4)
Requirement already satisfied: typing-extensions in c:\programdata\anaconda3\lib\site-pack
ages (from PyPDF2->notebook-as-pdf) (3.10.0.2)
```

```
Requirement already satisfied: importlib-metadata>=1.4 in c:\programdata\anaconda3\lib\site-packages (from pyppeteer->notebook-as-pdf) (4.8.1)
Requirement already satisfied: certifi>=2021 in c:\programdata\anaconda3\lib\site-packages (from pyppeteer->notebook-as-pdf) (2021.10.8)
Requirement already satisfied: urllib3<2.0.0,>=1.25.8 in c:\programdata\anaconda3\lib\site-packages (from pyppeteer->notebook-as-pdf) (1.26.7)
Requirement already satisfied: tqdm<5.0.0,>=4.42.1 in c:\programdata\anaconda3\lib\site-packages (from pyppeteer->notebook-as-pdf) (4.62.3)
Collecting pyee<9.0.0,>=8.1.0
  Downloading pyee-8.2.2-py2.py3-none-any.whl (12 kB)
Requirement already satisfied: appdirs<2.0.0,>=1.4.3 in c:\programdata\anaconda3\lib\site-packages (from pyppeteer->notebook-as-pdf) (1.4.4)
Collecting websockets<11.0,>=10.0
  Downloading websockets-10.3-cp39-cp39-win_amd64.whl (98 kB)
Requirement already satisfied: zipp>=0.5 in c:\programdata\anaconda3\lib\site-packages (from importlib-metadata>=1.4->pyppeteer->notebook-as-pdf) (3.6.0)
Requirement already satisfied: colorama in c:\programdata\anaconda3\lib\site-packages (from tqdm<5.0.0,>=4.42.1->pyppeteer->notebook-as-pdf) (0.4.4)
Installing collected packages: websockets, pyee, pyppeteer, PyPDF2, notebook-as-pdf
Successfully installed PyPDF2-2.4.2 notebook-as-pdf-0.5.0 pyee-8.2.2 pyppeteer-1.0.2 websockets-10.3
```

In [22]:

```
!pyppeteer-install
```

```
[INFO] Starting Chromium download.

  0%|          | 0.00/137M [00:00<?, ?b/s]
  0%|          | 236k/137M [00:00<00:59, 2.29Mb/s]
  2%|2         | 2.89M/137M [00:00<00:08, 16.2Mb/s]
  3%|3         | 4.53M/137M [00:00<00:15, 8.34Mb/s]
  4%|4         | 5.65M/137M [00:01<00:28, 4.55Mb/s]
  5%|4         | 6.43M/137M [00:01<00:35, 3.65Mb/s]
  5%|5         | 7.00M/137M [00:01<00:40, 3.25Mb/s]
  5%|5         | 7.46M/137M [00:01<00:43, 2.95Mb/s]
  6%|5         | 7.84M/137M [00:02<00:46, 2.79Mb/s]
  6%|5         | 8.17M/137M [00:02<00:49, 2.62Mb/s]
  6%|6         | 8.47M/137M [00:02<00:54, 2.34Mb/s]
  6%|6         | 8.72M/137M [00:02<01:01, 2.10Mb/s]
  7%|6         | 8.95M/137M [00:02<01:01, 2.07Mb/s]
  7%|6         | 9.16M/137M [00:02<01:01, 2.08Mb/s]
  7%|6         | 9.39M/137M [00:02<01:01, 2.08Mb/s]
  7%|7         | 9.63M/137M [00:02<00:59, 2.13Mb/s]
  7%|7         | 9.85M/137M [00:03<01:00, 2.11Mb/s]
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  8%|7         | 10.8M/137M [00:03<00:54, 2.31Mb/s]
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  8%|8         | 11.3M/137M [00:03<00:53, 2.36Mb/s]
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  9%|8         | 12.1M/137M [00:04<00:54, 2.30Mb/s]
  9%|9         | 12.3M/137M [00:04<00:53, 2.32Mb/s]
  9%|9         | 12.6M/137M [00:04<00:54, 2.29Mb/s]
  9%|9         | 12.8M/137M [00:04<00:53, 2.31Mb/s]
 10%|9         | 13.1M/137M [00:04<00:53, 2.30Mb/s]
 10%|9         | 13.3M/137M [00:04<00:55, 2.24Mb/s]
 10%|9         | 13.5M/137M [00:04<00:56, 2.18Mb/s]
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10%|#         | 13.9M/137M [00:04<01:13, 1.67Mb/s]
10%|#         | 14.1M/137M [00:05<01:11, 1.71Mb/s]
10%|#         | 14.3M/137M [00:05<01:09, 1.76Mb/s]
11%|#         | 14.5M/137M [00:05<01:18, 1.56Mb/s]
11%|#         | 14.8M/137M [00:05<01:06, 1.85Mb/s]
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11%|#1        | 15.4M/137M [00:05<00:50, 2.41Mb/s]
11%|#1        | 15.7M/137M [00:05<00:51, 2.35Mb/s]
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12%|#2        | 16.9M/137M [00:06<00:55, 2.16Mb/s]
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13%|#2        | 17.7M/137M [00:06<01:10, 1.70Mb/s]
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14%|#3        | 18.8M/137M [00:07<00:53, 2.22Mb/s]
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19%|#9        | 26.4M/137M [00:11<00:53, 2.08Mb/s]
19%|#9        | 26.6M/137M [00:11<00:52, 2.11Mb/s]
20%|#9        | 26.9M/137M [00:11<00:50, 2.16Mb/s]
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21%|##1       | 29.4M/137M [00:12<00:44, 2.40Mb/s]
22%|##1       | 29.8M/137M [00:12<00:37, 2.84Mb/s]
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23%|##2       | 31.3M/137M [00:13<00:54, 1.96Mb/s]
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24%|##4       | 33.0M/137M [00:14<00:45, 2.29Mb/s]
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28%|##7       | 37.9M/137M [00:16<00:43, 2.25Mb/s]
28%|##7       | 38.2M/137M [00:16<00:43, 2.27Mb/s]
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28%|##8       | 38.6M/137M [00:17<00:43, 2.24Mb/s]
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30%|##9       | 40.8M/137M [00:18<00:43, 2.21Mb/s]
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30%|###       | 41.6M/137M [00:18<00:41, 2.30Mb/s]
31%|###       | 41.9M/137M [00:18<00:41, 2.31Mb/s]
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32%|###1      | 43.5M/137M [00:19<00:46, 2.01Mb/s]
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37%|###6      | 50.6M/137M [00:22<00:38, 2.24Mb/s]
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40%|###9      | 54.3M/137M [00:24<00:47, 1.74Mb/s]
40%|###9      | 54.5M/137M [00:24<00:48, 1.70Mb/s]
40%|####      | 54.8M/137M [00:24<00:42, 1.93Mb/s]
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41%|####      | 55.8M/137M [00:25<00:35, 2.28Mb/s]
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42%|####1     | 57.4M/137M [00:26<00:42, 1.87Mb/s]
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46%|####5     | 62.7M/137M [00:28<00:32, 2.30Mb/s]
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50%|####9     | 68.0M/137M [00:31<00:30, 2.30Mb/s]
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50%|#####     | 68.5M/137M [00:31<00:30, 2.27Mb/s]
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 98%|#########8| 134M/137M [01:01<00:01, 2.22Mb/s]
 98%|#########8| 135M/137M [01:01<00:01, 2.25Mb/s]
 98%|#########8| 135M/137M [01:02<00:00, 2.26Mb/s]
 99%|#########8| 135M/137M [01:02<00:00, 2.25Mb/s]
 99%|#########8| 135M/137M [01:02<00:00, 2.25Mb/s]
 99%|#########8| 136M/137M [01:02<00:00, 2.05Mb/s]
 99%|#########9| 136M/137M [01:02<00:00, 1.84Mb/s]
 99%|#########9| 136M/137M [01:02<00:00, 2.31Mb/s]
100%|#########9| 136M/137M [01:02<00:00, 2.28Mb/s]
100%|#########9| 137M/137M [01:02<00:00, 2.29Mb/s]
100%|#########9| 137M/137M [01:02<00:00, 2.29Mb/s]
100%|##########| 137M/137M [01:02<00:00, 2.17Mb/s]
[INFO] Beginning extraction
[INFO] Chromium extracted to: C:\Users\ASUS\AppData\Local\pyppeteer\pyppeteer\local-chromi
um\588429
```

In [23]:

```
!pip install nbconvert[webpdf]
```

```
Requirement already satisfied: nbconvert[webpdf] in c:\programdata\anaconda3\lib\site-pack
ages (6.1.0)
ERROR: Could not install packages due to an OSError: [WinError 5] Acceso denegado: 'C:\\Pr
ogramData\\Anaconda3\\Lib\\site-packages\\~ebsockets\\speedups.cp39-win_amd64.pyd'
Requirement already satisfied: pygments>=2.4.1 in c:\programdata\anaconda3\lib\site-packag
```

```
es (from nbconvert[webpdf]) (2.10.0)
Requirement already satisfied: nbformat>=4.4 in c:\programdata\anaconda3\lib\site-packages
(from nbconvert[webpdf]) (5.1.3)
Requirement already satisfied: bleach in c:\programdata\anaconda3\lib\site-packages (from
nbconvert[webpdf]) (4.0.0)
Requirement already satisfied: traitlets>=5.0 in c:\programdata\anaconda3\lib\site-package
s (from nbconvert[webpdf]) (5.1.0)
Requirement already satisfied: jinja2>=2.4 in c:\programdata\anaconda3\lib\site-packages
(from nbconvert[webpdf]) (2.11.3)
Requirement already satisfied: pandocfilters>=1.4.1 in c:\programdata\anaconda3\lib\site-p
ackages (from nbconvert[webpdf]) (1.4.3)
Requirement already satisfied: testpath in c:\programdata\anaconda3\lib\site-packages (fro
m nbconvert[webpdf]) (0.5.0)
Requirement already satisfied: jupyter-core in c:\programdata\anaconda3\lib\site-packages
(from nbconvert[webpdf]) (4.8.1)
Requirement already satisfied: nbclient<0.6.0,>=0.5.0 in c:\programdata\anaconda3\lib\site
-packages (from nbconvert[webpdf]) (0.5.3)
Requirement already satisfied: jupyterlab-pygments in c:\programdata\anaconda3\lib\site-pa
ckages (from nbconvert[webpdf]) (0.1.2)
Requirement already satisfied: mistune<2,>=0.8.1 in c:\programdata\anaconda3\lib\site-pack
ages (from nbconvert[webpdf]) (0.8.4)
Requirement already satisfied: defusedxml in c:\programdata\anaconda3\lib\site-packages (f
rom nbconvert[webpdf]) (0.7.1)
Requirement already satisfied: entrypoints>=0.2.2 in c:\programdata\anaconda3\lib\site-pac
kages (from nbconvert[webpdf]) (0.3)
Collecting pyppeteer==0.2.2
  Downloading pyppeteer-0.2.2-py3-none-any.whl (145 kB)
Collecting pyee<8.0.0,>=7.0.1
  Downloading pyee-7.0.4-py2.py3-none-any.whl (12 kB)
Collecting websockets<9.0,>=8.1
  Downloading websockets-8.1.tar.gz (58 kB)
Requirement already satisfied: urllib3<2.0.0,>=1.25.8 in c:\programdata\anaconda3\lib\site
-packages (from pyppeteer==0.2.2->nbconvert[webpdf]) (1.26.7)
Requirement already satisfied: tqdm<5.0.0,>=4.42.1 in c:\programdata\anaconda3\lib\site-pa
ckages (from pyppeteer==0.2.2->nbconvert[webpdf]) (4.62.3)
Requirement already satisfied: appdirs<2.0.0,>=1.4.3 in c:\programdata\anaconda3\lib\site-
packages (from pyppeteer==0.2.2->nbconvert[webpdf]) (1.4.4)
Requirement already satisfied: MarkupSafe>=0.23 in c:\programdata\anaconda3\lib\site-packa
ges (from jinja2>=2.4->nbconvert[webpdf]) (1.1.1)
Requirement already satisfied: async-generator in c:\programdata\anaconda3\lib\site-packag
es (from nbclient<0.6.0,>=0.5.0->nbconvert[webpdf]) (1.10)
Requirement already satisfied: nest-asyncio in c:\programdata\anaconda3\lib\site-packages
(from nbclient<0.6.0,>=0.5.0->nbconvert[webpdf]) (1.5.1)
Requirement already satisfied: jupyter-client>=6.1.5 in c:\programdata\anaconda3\lib\site-
packages (from nbclient<0.6.0,>=0.5.0->nbconvert[webpdf]) (6.1.12)
Requirement already satisfied: python-dateutil>=2.1 in c:\programdata\anaconda3\lib\site-p
ackages (from jupyter-client>=6.1.5->nbclient<0.6.0,>=0.5.0->nbconvert[webpdf]) (2.8.2)
Requirement already satisfied: pyzmq>=13 in c:\programdata\anaconda3\lib\site-packages (fr
om jupyter-client>=6.1.5->nbclient<0.6.0,>=0.5.0->nbconvert[webpdf]) (22.2.1)
Requirement already satisfied: tornado>=4.1 in c:\programdata\anaconda3\lib\site-packages
(from jupyter-client>=6.1.5->nbclient<0.6.0,>=0.5.0->nbconvert[webpdf]) (6.1)
Requirement already satisfied: pywin32>=1.0 in c:\programdata\anaconda3\lib\site-packages
(from jupyter-core->nbconvert[webpdf]) (228)
Requirement already satisfied: jsonschema!=2.5.0,>=2.4 in c:\programdata\anaconda3\lib\sit
e-packages (from nbformat>=4.4->nbconvert[webpdf]) (3.2.0)
Requirement already satisfied: ipython-genutils in c:\programdata\anaconda3\lib\site-packa
ges (from nbformat>=4.4->nbconvert[webpdf]) (0.2.0)
Requirement already satisfied: pyrsistent>=0.14.0 in c:\programdata\anaconda3\lib\site-pac
```

```
kages (from jsonschema!=2.5.0,>=2.4->nbformat>=4.4->nbconvert[webpdf]) (0.18.0)
Requirement already satisfied: setuptools in c:\programdata\anaconda3\lib\site-packages (f
rom jsonschema!=2.5.0,>=2.4->nbformat>=4.4->nbconvert[webpdf]) (58.0.4)
Requirement already satisfied: attrs>=17.4.0 in c:\programdata\anaconda3\lib\site-packages
(from jsonschema!=2.5.0,>=2.4->nbformat>=4.4->nbconvert[webpdf]) (21.2.0)
Requirement already satisfied: six>=1.11.0 in c:\programdata\anaconda3\lib\site-packages
(from jsonschema!=2.5.0,>=2.4->nbformat>=4.4->nbconvert[webpdf]) (1.16.0)
Requirement already satisfied: colorama in c:\programdata\anaconda3\lib\site-packages (fro
m tqdm<5.0.0,>=4.42.1->pyppeteer==0.2.2->nbconvert[webpdf]) (0.4.4)
Requirement already satisfied: webencodings in c:\programdata\anaconda3\lib\site-packages
(from bleach->nbconvert[webpdf]) (0.5.1)
Requirement already satisfied: packaging in c:\programdata\anaconda3\lib\site-packages (fr
om bleach->nbconvert[webpdf]) (21.0)
Requirement already satisfied: pyparsing>=2.0.2 in c:\programdata\anaconda3\lib\site-packa
ges (from packaging->bleach->nbconvert[webpdf]) (3.0.4)
Building wheels for collected packages: websockets
  Building wheel for websockets (setup.py): started
  Building wheel for websockets (setup.py): finished with status 'done'
  Created wheel for websockets: filename=websockets-8.1-cp39-cp39-win_amd64.whl size=62758
sha256=1ad34f427e3755636a070454e50fb8fa94682e0a5806a5b9f63661e3de483462
  Stored in directory: c:\users\asus\appdata\local\pip\cache\wheels\d8\b9\a0\b97b211aeda2e
bd6ac2e43fc300d308dbf1f9df520ed390cae
Successfully built websockets
Installing collected packages: websockets, pyee, pyppeteer
  Attempting uninstall: websockets
    Found existing installation: websockets 10.3
    Uninstalling websockets-10.3:
      Successfully uninstalled websockets-10.3
Consider using the `--user` option or check the permissions.
```

In [24]:

```
!pip install nbconvert[webpdf] --user
```

```
Requirement already satisfied: nbconvert[webpdf] in c:\programdata\anaconda3\lib\site-pack
ages (6.1.0)
Requirement already satisfied: jinja2>=2.4 in c:\programdata\anaconda3\lib\site-packages
(from nbconvert[webpdf]) (2.11.3)
Requirement already satisfied: defusedxml in c:\programdata\anaconda3\lib\site-packages (f
rom nbconvert[webpdf]) (0.7.1)
Requirement already satisfied: jupyter-core in c:\programdata\anaconda3\lib\site-packages
(from nbconvert[webpdf]) (4.8.1)
Requirement already satisfied: nbformat>=4.4 in c:\programdata\anaconda3\lib\site-packages
(from nbconvert[webpdf]) (5.1.3)
Requirement already satisfied: entrypoints>=0.2.2 in c:\programdata\anaconda3\lib\site-pac
kages (from nbconvert[webpdf]) (0.3)
Requirement already satisfied: testpath in c:\programdata\anaconda3\lib\site-packages (fro
m nbconvert[webpdf]) (0.5.0)
Requirement already satisfied: traitlets>=5.0 in c:\programdata\anaconda3\lib\site-package
s (from nbconvert[webpdf]) (5.1.0)
Requirement already satisfied: bleach in c:\programdata\anaconda3\lib\site-packages (from
nbconvert[webpdf]) (4.0.0)
Requirement already satisfied: jupyterlab-pygments in c:\programdata\anaconda3\lib\site-pa
ckages (from nbconvert[webpdf]) (0.1.2)
Requirement already satisfied: pandocfilters>=1.4.1 in c:\programdata\anaconda3\lib\site-p
ackages (from nbconvert[webpdf]) (1.4.3)
Requirement already satisfied: nbclient<0.6.0,>=0.5.0 in c:\programdata\anaconda3\lib\site
-packages (from nbconvert[webpdf]) (0.5.3)
Requirement already satisfied: pygments>=2.4.1 in c:\programdata\anaconda3\lib\site-packag
```

```
es (from nbconvert[webpdf]) (2.10.0)
Requirement already satisfied: mistune<2,>=0.8.1 in c:\programdata\anaconda3\lib\site-pack
ages (from nbconvert[webpdf]) (0.8.4)
Collecting pyppeteer==0.2.2
  Using cached pyppeteer-0.2.2-py3-none-any.whl (145 kB)
Requirement already satisfied: websockets<9.0,>=8.1 in c:\programdata\anaconda3\lib\site-p
ackages (from pyppeteer==0.2.2->nbconvert[webpdf]) (8.1)
Requirement already satisfied: urllib3<2.0.0,>=1.25.8 in c:\programdata\anaconda3\lib\site
-packages (from pyppeteer==0.2.2->nbconvert[webpdf]) (1.26.7)
Collecting pyee<8.0.0,>=7.0.1
  Using cached pyee-7.0.4-py2.py3-none-any.whl (12 kB)
  WARNING: The script pyppeteer-install.exe is installed in 'C:\Users\ASUS\AppData\Roaming
\Python\Python39\Scripts' which is not on PATH.
  Consider adding this directory to PATH or, if you prefer to suppress this warning, use -
--no-warn-script-location.
Requirement already satisfied: tqdm<5.0.0,>=4.42.1 in c:\programdata\anaconda3\lib\site-pa
ckages (from pyppeteer==0.2.2->nbconvert[webpdf]) (4.62.3)
Requirement already satisfied: appdirs<2.0.0,>=1.4.3 in c:\programdata\anaconda3\lib\site-
packages (from pyppeteer==0.2.2->nbconvert[webpdf]) (1.4.4)
Requirement already satisfied: MarkupSafe>=0.23 in c:\programdata\anaconda3\lib\site-packa
ges (from jinja2>=2.4->nbconvert[webpdf]) (1.1.1)
Requirement already satisfied: nest-asyncio in c:\programdata\anaconda3\lib\site-packages
(from nbclient<0.6.0,>=0.5.0->nbconvert[webpdf]) (1.5.1)
Requirement already satisfied: async-generator in c:\programdata\anaconda3\lib\site-packag
es (from nbclient<0.6.0,>=0.5.0->nbconvert[webpdf]) (1.10)
Requirement already satisfied: jupyter-client>=6.1.5 in c:\programdata\anaconda3\lib\site-
packages (from nbclient<0.6.0,>=0.5.0->nbconvert[webpdf]) (6.1.12)
Requirement already satisfied: python-dateutil>=2.1 in c:\programdata\anaconda3\lib\site-p
ackages (from jupyter-client>=6.1.5->nbclient<0.6.0,>=0.5.0->nbconvert[webpdf]) (2.8.2)
Requirement already satisfied: pyzmq>=13 in c:\programdata\anaconda3\lib\site-packages (fr
om jupyter-client>=6.1.5->nbclient<0.6.0,>=0.5.0->nbconvert[webpdf]) (22.2.1)
Requirement already satisfied: tornado>=4.1 in c:\programdata\anaconda3\lib\site-packages
(from jupyter-client>=6.1.5->nbclient<0.6.0,>=0.5.0->nbconvert[webpdf]) (6.1)
Requirement already satisfied: pywin32>=1.0 in c:\programdata\anaconda3\lib\site-packages
(from jupyter-core->nbconvert[webpdf]) (228)
Requirement already satisfied: ipython-genutils in c:\programdata\anaconda3\lib\site-packa
ges (from nbformat>=4.4->nbconvert[webpdf]) (0.2.0)
Requirement already satisfied: jsonschema!=2.5.0,>=2.4 in c:\programdata\anaconda3\lib\sit
e-packages (from nbformat>=4.4->nbconvert[webpdf]) (3.2.0)
Requirement already satisfied: attrs>=17.4.0 in c:\programdata\anaconda3\lib\site-packages
(from jsonschema!=2.5.0,>=2.4->nbformat>=4.4->nbconvert[webpdf]) (21.2.0)
Requirement already satisfied: six>=1.11.0 in c:\programdata\anaconda3\lib\site-packages
(from jsonschema!=2.5.0,>=2.4->nbformat>=4.4->nbconvert[webpdf]) (1.16.0)
Requirement already satisfied: pyrsistent>=0.14.0 in c:\programdata\anaconda3\lib\site-pac
kages (from jsonschema!=2.5.0,>=2.4->nbformat>=4.4->nbconvert[webpdf]) (0.18.0)
Requirement already satisfied: setuptools in c:\programdata\anaconda3\lib\site-packages (f
rom jsonschema!=2.5.0,>=2.4->nbformat>=4.4->nbconvert[webpdf]) (58.0.4)
Requirement already satisfied: colorama in c:\programdata\anaconda3\lib\site-packages (fro
m tqdm<5.0.0,>=4.42.1->pyppeteer==0.2.2->nbconvert[webpdf]) (0.4.4)
Requirement already satisfied: webencodings in c:\programdata\anaconda3\lib\site-packages
(from bleach->nbconvert[webpdf]) (0.5.1)
Requirement already satisfied: packaging in c:\programdata\anaconda3\lib\site-packages (fr
om bleach->nbconvert[webpdf]) (21.0)
Requirement already satisfied: pyparsing>=2.0.2 in c:\programdata\anaconda3\lib\site-packa
ges (from packaging->bleach->nbconvert[webpdf]) (3.0.4)
Installing collected packages: pyee, pyppeteer
Successfully installed pyee-7.0.4 pyppeteer-0.2.2
```

In [ ]: