```
!pip install spacy pandas matplotlib seaborn
!python -m spacy download en_core_web_sm
```

```
Requirement already satisfied: spacy in /usr/local/lib/python3.12/dist-packages (3.8.11)
Requirement already satisfied: pandas in /usr/local/lib/python3.12/dist-packages (2.2.2)
Requirement already satisfied: matplotlib in /usr/local/lib/python3.12/dist-packages (3.10.0)
Requirement already satisfied: seaborn in /usr/local/lib/python3.12/dist-packages (0.13.2)
Requirement already satisfied: spacy-legacy<3.1.0,>=3.0.11 in /usr/local/lib/python3.12/dist-packages (from spacy) (3.0.12)
Requirement already satisfied: spacy-loggers<2.0.0,>=1.0.0 in /usr/local/lib/python3.12/dist-packages (from spacy) (1.0.5)
Requirement already satisfied: murmurhash<1.1.0,>=0.28.0 in /usr/local/lib/python3.12/dist-packages (from spacy) (1.0.15)
Requirement already satisfied: cymem<2.1.0,>=2.0.2 in /usr/local/lib/python3.12/dist-packages (from spacy) (2.0.13)
Requirement already satisfied: preshed<3.1.0,>=3.0.2 in /usr/local/lib/python3.12/dist-packages (from spacy) (3.0.12)
Requirement already satisfied: thinc<8.4.0,>=8.3.4 in /usr/local/lib/python3.12/dist-packages (from spacy) (8.3.10)
Requirement already satisfied: wasabi<1.2.0,>=0.9.1 in /usr/local/lib/python3.12/dist-packages (from spacy) (1.1.3)
Requirement already satisfied: srsly<3.0.0,>=2.4.3 in /usr/local/lib/python3.12/dist-packages (from spacy) (2.5.2)
Requirement already satisfied: catalogue<2.1.0,>=2.0.6 in /usr/local/lib/python3.12/dist-packages (from spacy) (2.0.10)
Requirement already satisfied: weasel<0.5.0,>=0.4.2 in /usr/local/lib/python3.12/dist-packages (from spacy) (0.4.3)
Requirement already satisfied: typer-slim<1.0.0,>=0.3.0 in /usr/local/lib/python3.12/dist-packages (from spacy) (0.21.1)
Requirement already satisfied: tqdm<5.0.0,>=4.38.0 in /usr/local/lib/python3.12/dist-packages (from spacy) (4.67.1)
Requirement already satisfied: numpy>=1.19.0 in /usr/local/lib/python3.12/dist-packages (from spacy) (2.0.2)
Requirement already satisfied: requests<3.0.0,>=2.13.0 in /usr/local/lib/python3.12/dist-packages (from spacy) (2.32.4)
Requirement already satisfied: pydantic!=1.8,!=1.8.1,<3.0.0,>=1.7.4 in /usr/local/lib/python3.12/dist-packages (from spacy)
Requirement already satisfied: jinja2 in /usr/local/lib/python3.12/dist-packages (from spacy) (3.1.6)
Requirement already satisfied: setuptools in /usr/local/lib/python3.12/dist-packages (from spacy) (75.2.0)
Requirement already satisfied: packaging>=20.0 in /usr/local/lib/python3.12/dist-packages (from spacy) (25.0)
Requirement already satisfied: python-dateutil>=2.8.2 in /usr/local/lib/python3.12/dist-packages (from pandas) (2.9.0.post0)
Requirement already satisfied: pytz>=2020.1 in /usr/local/lib/python3.12/dist-packages (from pandas) (2025.2)
Requirement already satisfied: tzdata>=2022.7 in /usr/local/lib/python3.12/dist-packages (from pandas) (2025.3)
Requirement already satisfied: contourpy>=1.0.1 in /usr/local/lib/python3.12/dist-packages (from matplotlib) (1.3.3)
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Requirement already satisfied: kiwisolver>=1.3.1 in /usr/local/lib/python3.12/dist-packages (from matplotlib) (1.4.9)
Requirement already satisfied: pillow>=8 in /usr/local/lib/python3.12/dist-packages (from matplotlib) (11.3.0)
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Requirement already satisfied: six>=1.5 in /usr/local/lib/python3.12/dist-packages (from python-dateutil>=2.8.2->pandas) (1.
Requirement already satisfied: charset_normalizer<4,>=2 in /usr/local/lib/python3.12/dist-packages (from requests<3.0.0,>=2.
Requirement already satisfied: idna<4,>=2.5 in /usr/local/lib/python3.12/dist-packages (from requests<3.0.0,>=2.13.0->spacy)
Requirement already satisfied: urllib3<3,>=1.21.1 in /usr/local/lib/python3.12/dist-packages (from requests<3.0.0,>=2.13.0->
Requirement already satisfied: certifi>=2017.4.17 in /usr/local/lib/python3.12/dist-packages (from requests<3.0.0,>=2.13.0->
Requirement already satisfied: blis<1.4.0,>=1.3.0 in /usr/local/lib/python3.12/dist-packages (from thinc<8.4.0,>=8.3.4->spac
Requirement already satisfied: confection<1.0.0,>=0.0.1 in /usr/local/lib/python3.12/dist-packages (from thinc<8.4.0,>=8.3.4
Requirement already satisfied: click>=8.0.0 in /usr/local/lib/python3.12/dist-packages (from typer-slim<1.0.0,>=0.3.0->spacy
Requirement already satisfied: cloudpathlib<1.0.0,>=0.7.0 in /usr/local/lib/python3.12/dist-packages (from weasel<0.5.0,>=0.
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Requirement already satisfied: MarkupSafe>=2.0 in /usr/local/lib/python3.12/dist-packages (from jinja2->spacy) (3.0.3)
Requirement already satisfied: wrapt in /usr/local/lib/python3.12/dist-packages (from smart-open<8.0.0,>=5.2.1->weasel<0.5.0
Collecting en-core-web-sm==3.8.0
  Downloading https://github.com/explosion/spacy-models/releases/download/en_core_web_sm-3.8.0/en_core_web_sm-3.8.0-py3-none
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 12.8/12.8 MB 86.2 MB/s eta 0:00:00
✓ Download and installation successful
You can now load the package via spacy.load('en_core_web_sm')
⚠ Restart to reload dependencies
If you are in a Jupyter or Colab notebook, you may need to restart Python in
order to load all the package's dependencies. You can do this by selecting the
'Restart kernel' or 'Restart runtime' option.
```

```
import pandas as pd
import spacy
from collections import Counter
import matplotlib.pyplot as plt
import seaborn as sns
```

```
nlp = spacy.load("en_core_web_sm")
```

```
df = pd.read_csv("arxiv_data.csv")
df.head()
```

	titles	summaries	terms
0	Survey on Semantic Stereo Matching / Semantic ...	Stereo matching is one of the widely used tech...	['cs.CV', 'cs.LG']
1	FUTURE AI: Guiding Principles and Consensus Re...	The recent advancements in artificial intellig...	['cs.CV', 'cs.AI', 'cs.LG']

```
abstracts = df['summaries'].dropna().tolist()
```

```
abstracts = abstracts[:200]   # take small subset for lab
```

```
sample_text = abstracts[0]
doc = nlp(sample_text)

for token in doc:
    print(token.text)
```

```
Stereo
matching
is
one
of
the
widely
used
techniques
for
inferring
depth
from


stereo
images
owing
to
its
robustness
and
speed
.
It
has
become
one
of
the
major


topics
of
research
since
it
finds
its
applications
in
autonomous
driving
,


robotic
navigation
,
3D
reconstruction
,
and
many
other
fields
.
```

```
tokens = [token.text for token in doc if not token.is_stop and not token.is_punct]
tokens
```

```
['Stereo',
 'matching',
 'widely',
 'techniques',
 'inferring',
 'depth',
```

```
 '\n',
 'stereo',
 'images',
 'owing',
 'robustness',
 'speed',
 'major',
 '\n',
 'topics',
 'research',
 'finds',
 'applications',
 'autonomous',
 'driving',
 '\n',
 'robotic',
 'navigation',
 '3D',
 'reconstruction',
 'fields',
 'Finding',
 'pixel',
 '\n',
 'correspondences',
 'non',
 'textured',
 'occluded',
 'reflective',
 'areas',
 'major',
 '\n',
 'challenge',
 'stereo',
 'matching',
 'Recent',
 'developments',
 'shown',
 'semantic',
 'cues',
 '\n',
 'image',
 'segmentation',
 'improve',
 'results',
 'stereo',
 'matching',
 '\n',
 'deep',
 'neural',
 'network',
 'architectures',
```

```
docs = [nlp(text) for text in abstracts]
```

```
noun_phrases = []

for doc in docs:
    for chunk in doc.noun_chunks:
        noun_phrases.append(chunk.text.lower())

np_freq = Counter(noun_phrases)
np_freq.most_common(10)
```

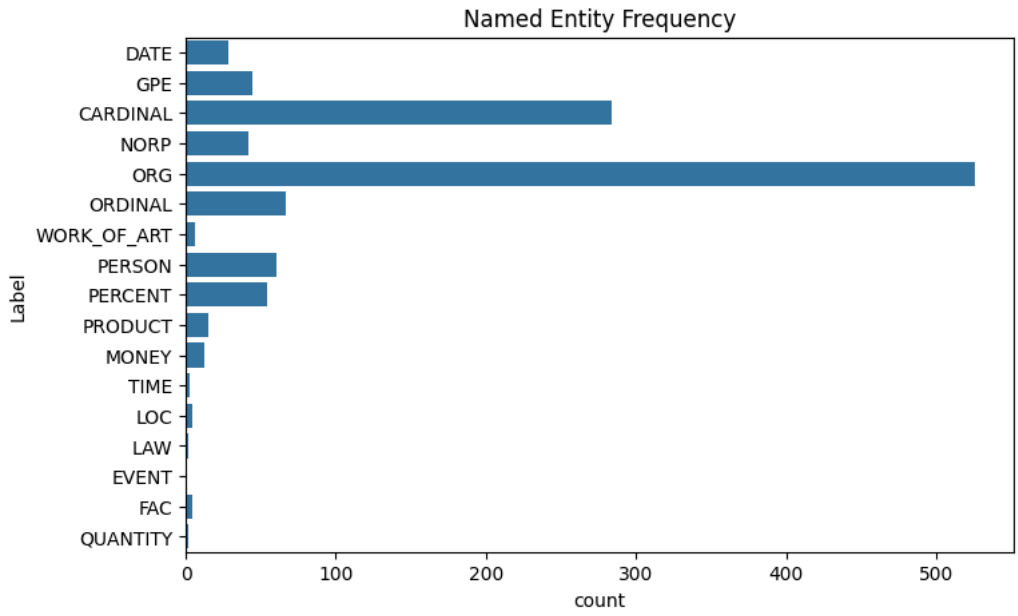
```
[('we', 540),
 ('which', 172),
 ('that', 144),
 ('it', 120),
 ('this paper', 74),
 ('the-art', 72),
 ('our method', 50),
 ('image segmentation', 47),
 ('this work', 47),
 ('medical image segmentation', 37)]
```

```
entities = []

for doc in docs:
    for ent in doc.ents:
        entities.append((ent.text, ent.label_))

entity_df = pd.DataFrame(entities, columns=["Entity", "Label"])
entity_df.head()
```

	Entity	Label
0	today	DATE
1	AI	GPE
2	AI	GPE
3	AI	GPE
4	five	CARDINAL

Next steps: Generate code with entity_df | New interactive sheet

```
plt.figure(figsize=(8,5))
sns.countplot(y="Label", data=entity_df)
plt.title("Named Entity Frequency")
plt.show()
```




```
from spacy.matcher import Matcher

matcher = Matcher(nlp.vocab)

pattern = [
    {"POS": "ADJ"},
    {"POS": "NOUN"}
]

matcher.add("TECH_TERM", [pattern])
```

```
matches = []

for doc in docs:
    for match_id, start, end in matcher(doc):
        matches.append(doc[start:end].text.lower())

Counter(matches).most_common(10)
```

```
[('medical image', 98),
 ('semantic segmentation', 49),
 ('deep learning', 39),
 ('medical images', 25),
 ('experimental results', 21),
 ('contextual information', 17),
 ('neural networks', 16),
 ('extensive experiments', 16),
 ('neural network', 16),
 ('contrastive learning', 15)]
```

```
top_np = dict(np_freq.most_common(10))

plt.figure(figsize=(10,5))
plt.bar(top_np.keys(), top_np.values())
```

```
plt.bar(top_np.keys(), top_np.values())
plt.xticks(rotation=45)
plt.title("Top Noun Phrases")
plt.show()
```